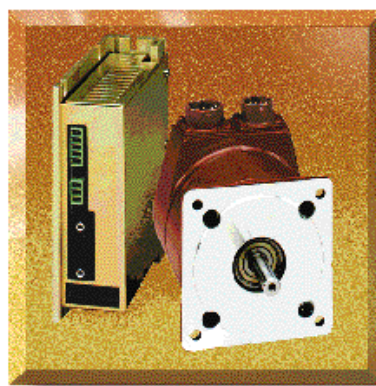
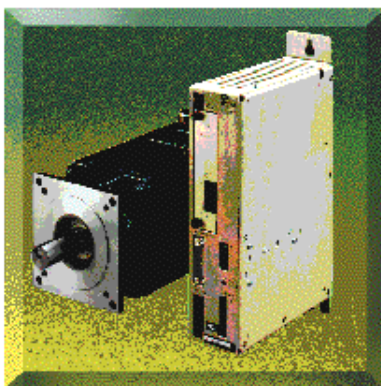


Motion Control Solutions



Motion Control Solutions

from a supplier
who understands
your business



ISO 9001-1994 Cert #003049



Semiconductor
fabrication and
electronics assembly

Packaging, converting
and graphic arts



Automated
materials handling

What's the driving force behind Pacific Scientific's Motion Technology Division? Integrated industrial know-how.

We know you can choose from many automation suppliers who speak fluent control product specifications.

- But how many of them speak with a firm grasp of *your* specialized process, based on factory floor experience?
- How many motion control suppliers let you work on open platforms with the accessibility of Windows™ based software?
- How many offer you the credential of an ISO 9001 registered quality assurance system?

We do. *That's* why Pacific Scientific MTD should be your automation partner.



Multi-axis control



- Breaking the hardware barrier: industry's first *soft* motion controller
- SERCOS compatibility for open, digital communications between controls and drives over a noise immune, optical fiber ring
- Open platform, PC-based distributed control
- Advanced Motion Language™, an event driven multi-tasking motion control language with a graphical Windows™-based development environment



Windows™-based Advanced
Motion Language™

- AML seamlessly integrates graphics with vital text for clarity of control
- AML's object-based, event driven nature provides an intuitive representation of your machine design



Brushless servo systems



Stepper systems

- Modular drive designs feature option cards for cost effective setup and easy digital or analog interface to controls
- Highly integrated chip level technology delivers compact, economical functionality
- Patented digital drive circuitry offers outstanding performance advantages and interface flexibility



Digital brushless servo drives



Microstepping drives



General information

This section is filled with basic technical information and accessories to make your job easier.



PacSizit®! for Windows™
sizing/selection software

Inside the back cover...

Systems integration

Get a unique extension of MTD's integrated industrial know-how: expert systems integration. Our Automation Intelligence subsidiary will bring practical factory floor experience to your machine control solution.



Multi-Axis Control

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WHY CHOOSE PACIFIC SCIENTIFIC?

At Pacific Scientific's Motion Technology Division, you'll find an experienced engineering and sales team: one that's at home on your factory floor.

These are people who appreciate the demands placed on your machinery. People who consider how motion control solutions will contribute to your production goals.

MTD has earned its reputation for technically superior products, for strong service and support, and for solutions which are cost effective and reliable.

This is why Pacific Scientific MTD should be your automation partner. Because, in specialized applications like yours, it takes specific experience to deliver true solutions.

HISTORY OF QUALITY

The Motion Technology Division is a core business unit of Pacific Scientific Company, whose customers are the worldwide manufacturing, process; aerospace, and energy industries. Throughout the company's 75 year history, Pacific Scientific has been committed to providing quality products.

MTD's design and manufacturing facilities are certified under the stringent ISO 9001 guidelines, assuring you of documented product and service quality.

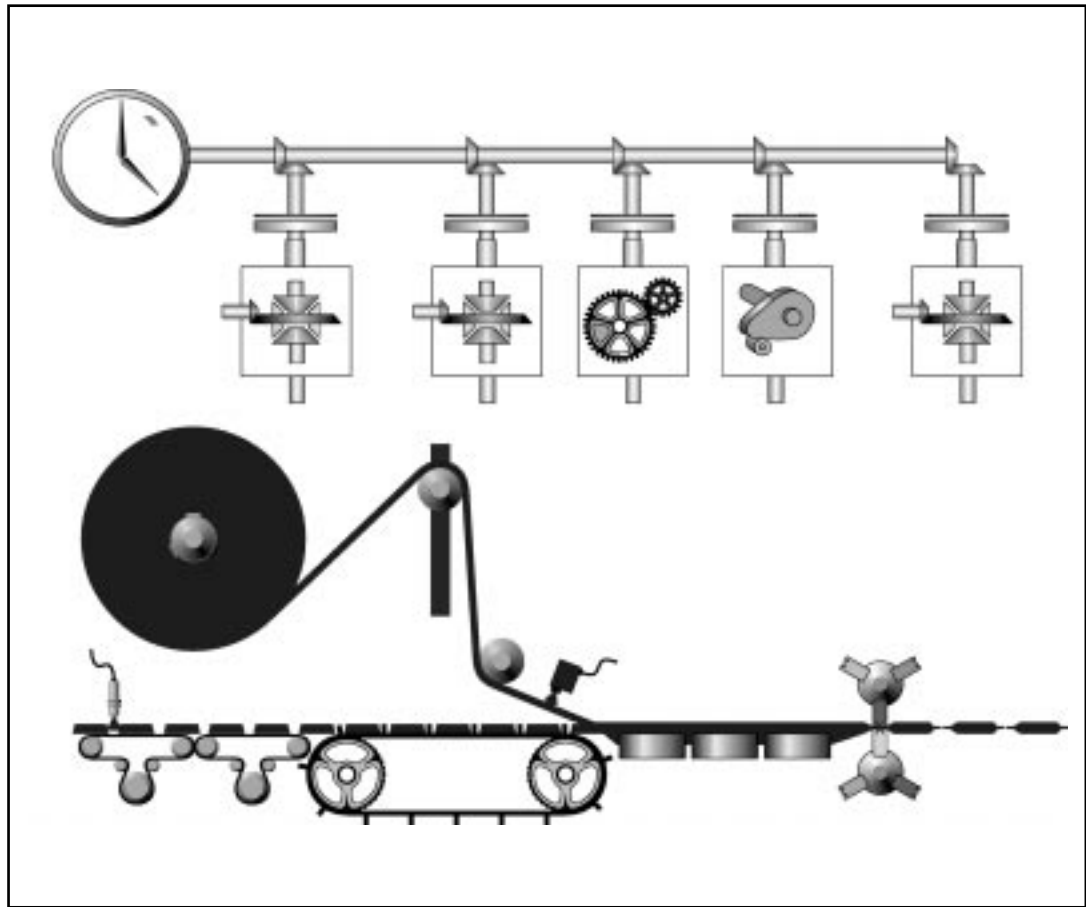
GLOBAL PERSPECTIVE

MTD's distribution and technical support network is established in 33 countries. Manufacturing is conducted in North America and Europe.

MTD's global outlook extends to technology trends and standards which give our customers the competitive edge in a world marketplace. For example, MTD is the first U.S. manufacturer of product supporting the internationally accepted SERCOS standard for digital controller-to-drive communications.

PRODUCTS AND SERVICES

This catalog describes our brushless servo, stepper, and multi-axis motion control product offerings. For more information, contact Pacific Scientific MTD today!



MULTI-AXIS CONTROL

ADVANCED MOTION LANGUAGE (AML)

SECTION OVERVIEW . . . MULTI-AXIS CONTROL

HOW TO USE THIS SECTION

This section contains a variety of information about Pacific Scientific's advanced line of software-based, multi-axis products. An extensive description of the Advanced Motion Language (AML) is included along with an AML command summary. Also included in this section is a brief overview of SERCOS, the internationally accepted protocol for digital communication between motion controllers and associated drives.

The table of contents below will help you locate the information that you require.

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MULTI-AXIS MOTION CONTROLLER

In contrast to proprietary hardware products, AML is industry's first full-featured multi-axis controller designed as a software product capable of operating on multiple PC-compatible platforms.

AML generates all motion control and I/O commands. These commands are communicated to multiple intelligent servo drives and I/O stations, using the SERCOS International Standard.

The task of loop closure (position, velocity, and current) is off-loaded to the servo drive. This allows the AML controller to deal with more complex machine operations, such as drive coordination, I/O control, and communications.

FEATURES OF AML CONTROLLER

- Industry's first "soft" multi-axis motion controller
- Multi-tasking operating system
- Event-driven programming language
- Intuitive, object-oriented approach to programming
- Electronically links two or more axes, known as "drive trains"
- Synchronous control of up to 32 servo axes
- Uses the SERCOS international communications standard
- Controls a variety of I/O systems
- Electronic gearing:
 - Axis to axis
 - Axis to external encoder
 - Axis to virtual axis
- High speed registration control:
 - Position capture in hardware
 - Automatic or manual correction
- CAM profile generation, up to 4 CAM profiles per axis:
 - User defined profiles
 - Calculated profiles
- Programmable limit switch functions (PLS), up to 16 PLSs per axis:
 - Position or distance based
 - User-definable response

FEATURES OF AML DEVELOPMENT ENVIRONMENT

- Graphical, Windows™ -based environment
- Powerful debugger which allows the user to set breakpoints and view and change variables.
- "Smart" editor which helps to minimize syntax errors

FEATURES OF THE SERCOS STANDARD

- Provides digital control using an international standard with multi-vendor support
- High speed fiber-optic control of servo motors and I/O
- Path planning rates for servo motors beginning at 1 msec
- Mundane task of loop closure off-loaded to an intelligent drive
- Fiber optic communication for reliable, noise-free environment
- 32-bit position and velocity commands and feedback
- Extensive built-in access to drive status and operating parameters
- 2 or 4 Mbaud operation
- Synchronous control of up to 32 axes of motion

MOTION CONTROL FUNCTIONS

AML supports the basic elements of general motion control, including:

- Relative and absolute moves
- Electronic gearing
- CAM profiling
- Registration
- Programmable limit switches

Each real-world motion control element, such as a sensor, motor, or drive train, is represented as a predefined component of AML, known as an object. These objects provide the user with an intuitive way to interact with motion control functions.

MULTI-AXIS MOTION CONTROLLER (Cont.)

STRUCTURED, EVENT-DRIVEN PROGRAMMING

Since AML executes in a multi-tasking environment, applications can be written as a collection of small modules. Each module handles a particular function and responds to specific, user-defined events within the machine.

This modular, event-driven approach simplifies program design and debugging by allowing the user to focus on subsections rather than the entire machine. Also, AML code can be reused on a variety of projects, giving the OEM-user an easy way to add optional features to a system.

DATA TRANSFER

AML allows the exchange of data with a variety of other control devices. This can be accomplished through standard DDE protocol using Ethernet or RS232, or a variety of PLC protocols. For example, this data transfer might be used for recipe download from a PLC and for status and diagnostics on an operator interface.

EDITING

The AML development environment includes a "smart" editor which translates each line of code as it is entered. If a syntax error occurs, the user is notified in a separate message box. Also, the AML Editor automatically formats each line, which increases maintainability of the code.

DEBUGGING

The AML development environment also includes a powerful on-line debugger. With the AML Debugger, the user can step through a motion control application, set breakpoints, and view and change variables—all within a graphical, easy to use interface.

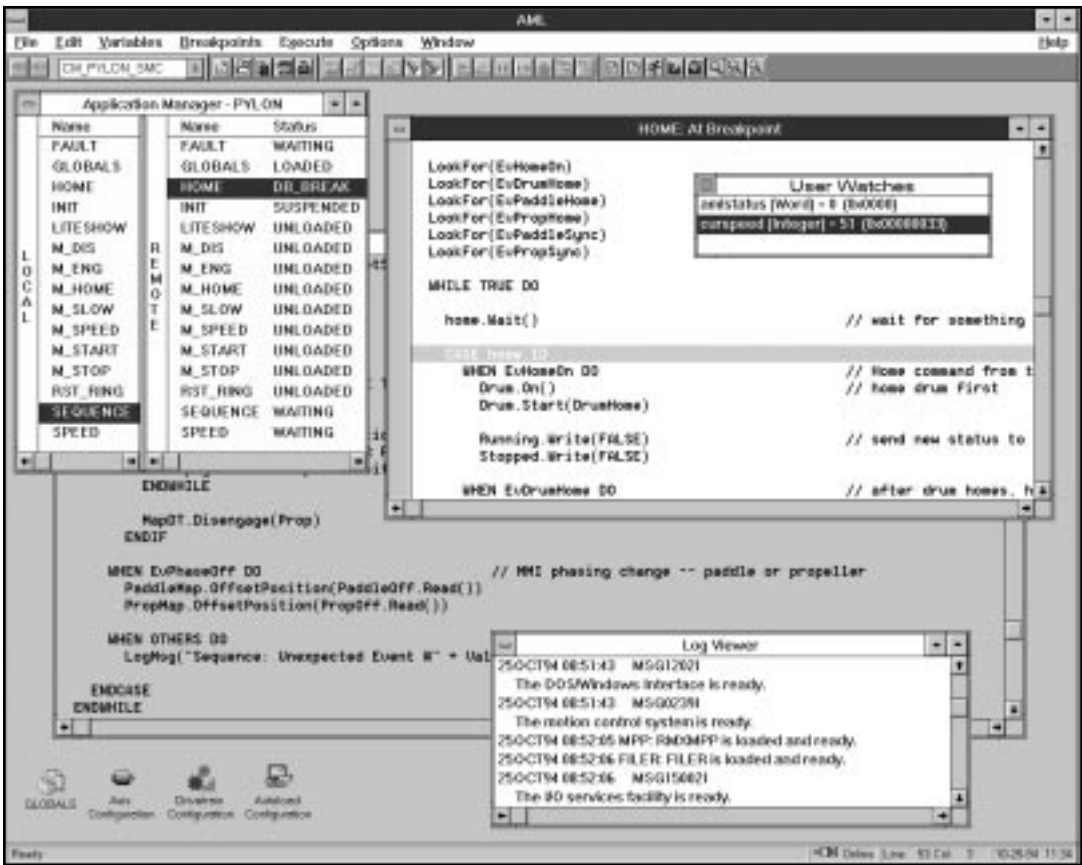


Figure A-1. AML Development Environment

AML FUNCTION CALL SUMMARY

In addition to motion control objects, AML supports numerous data types, arrays and standard programming constructs, such as loop control and function calls. This page lists the function calls provided by AML, divided into the appropriate categories.

<i>Bit Functions</i>	<i>Module Control</i>
ClrBit	LoadModule
GetBit	FaultModule
SetBit	ResumeModule
	ResumeMultitasking
	SuspendModule
	SuspendMultitasking
	UnloadModule
<i>Math</i>	<i>STRINGS and ARRAYS</i>
Abs	ArrayDimensions
Acos	ArrayDimensionSize
Asin	CopyString
Atan	DeleteSubstring
Ceiling	InsertString
Cos	MaxStringLength
Cosh	StringLength
Exp	StringIndex
Floor	StringToValue
Ln	ValueToString
Log10	
Mod	
Rand	
SeedRand	
Sin	
Sinh	<i>Time And Date</i>
Sqrt	Delay
Tan	GetDate
Tanh	GetElapsedMsecs
<i>Event Handling</i>	<i>Ring Command</i>
Ignore	SetRingState
LookFor	
<i>Message Logging</i>	
LogMsg	
LogDebugMsg	
SetLogDebugFlag	
SetLogID	
SetLogIDFlag	

AML OBJECT SUMMARY

An AML **object** is a real-world declaration that provides the user with a way to assign attributes and operations to the defined object. All AML objects correspond to real-world motion control elements, such as a motor. Associated with each object are data members and methods. A **data member** is a predefined parameter that relates to an object. A **method** is comparable to a function call. It either commands an action on an object, requests information about an object, or requests notification when the object reaches a specific state.

MOTOR

Data Members

DefaultAccel
DefaultDecel
DefaultSpeed
Error

Methods

ChangeAccel
ChangeDecel
DisableOTLimits
EnableOTLimits
GetAccel
GetCommandPosition
GetCommandSpeed
GetCycle
GetDecel
GetHomeMode
GetFaultStatus
GetMaxAccel
GetMaxDecel
GetMaxPositionLimit
GetMaxSpeed
GetMaxTorque
GetMinPositionLimit
GetMotionStatus
GetMoveStatus
GetPosition
GetPositionError
GetPositionErrorLimit
GetSpeed
GetTorque
GetType
Halt
IncEndpoint
IncSpeed
NotifyFaultAs
Off
On
ReadHomeSwitch
SetCycle
SetHomeMode
SetMaxAccel
SetMaxDecel
SetMaxPositionLimit
SetMaxSpeed
SetMaxTorque
SetMinPositionLimit
SetPositionErrorLimit
SetUnits
Start
Stop

JOG_MOVE

Data Members

Accel
Decel
Error
Speed

Methods

NotifyCompleteAs
NotifySpeedAs

ABS_MOVE

Data Members

Accel
Decel
Endpoint
Error
Mode
Speed

Methods

NotifyCompleteAs
NotifySpeedAs

REL_MOVE

Data Members

Accel
Decel
Distance
Error
Speed

Methods

NotifyCompleteAs
NotifySpeedAs

HOME_MOVE

Data Members

Accel
Decel
Error
Position
Speed

Methods

NotifyHomeAs

DRIVE_TRAIN

Data Members

Error

Methods

Add
Disengage
Engage
Off
On
Remove

GEARED_PROFILE

Data Members

Error

Methods

Activate
GetSlavePosition
Remove
SetRatio

CALCULATED_PROFILE

Data Members

Error

Methods

Activate
CalcProfile
GetMasterPosition
GetSlavePosition
OffsetPhase
OffsetPosition
Remove

AML OBJECT SUMMARY (Cont.)

FILE_DEFINED_PROFILE

<i>Data Members</i>
Error
<i>Methods</i>
Activate
GetMasterPosition
GetSlavePosition
LoadFile
OffsetPhase
OffsetPosition
Remove

USER_DEFINED_PROFILE

<i>Data Members</i>
Error
<i>Methods</i>
Activate
AddPoint
EndList
GetMasterPosition
GetSlavePosition
OffsetPhase
OffsetPosition
Remove

EVENT

<i>Data Members</i>
Error
ID
Position
Position2
Time
Wval
<i>Methods</i>
Send
Wait

IO_ANALOG

<i>Data Members</i>
Deadband
Error
HighAlarm
LowAlarm
Offset
Scale

<i>Methods</i>
IsInAlarm
NotifyChangeAs
NotifyHighAlarmAs
NotifyLowAlarmAs
Read
Write

IO_BOOLEAN

<i>Data Members</i>
Error
<i>Methods</i>
NotifyOffAs
NotifyOnAs
Read
Write

PLS

<i>Data Members</i>
AutoRepeat
Error
IsPending
<i>Methods</i>
Clear
NotifyFireAs
SetDistance
SetPosition

REGISTRATION

<i>Data Members</i>
AutoRepeat
Error
<i>Methods</i>
Disable
Enable
NotifyRegistrationAs

SetEdge
REGISTRATION_CORRECTION

<i>Data Members</i>
AutoRepeat
Error
MakeCorrection
<i>Methods</i>
ApplyCorrection
Disable
Enable
NotifyCorrectionAs
SetCorrectionDistance
SetCorrectionLimit
SetEdge
SetEventsPerCycle
SetTargetPosition

TIMER

<i>Data Members</i>
AutoRepeat
Error
<i>Methods</i>
Clear
GetTime
NotifyFireAs
SetTime

IDN

<i>Data Members</i>
Error
<i>Methods</i>
CancelCommand
GetAttributes
GetList
GetMax
GetMin
GetName
GetString
GetUnits
GetValue
IssueCommand
SetList
SetString
SetValue

THE SERCOS STANDARD

SERCOS: SERIAL REALTIME COMMUNICATIONS SYSTEM

SERCOS is an internationally accepted protocol for digital communication between motion controllers and associated drives and I/O. The benefits of the SERCOS standard include:

- An open system specification
- Significantly reduced installation costs
- Reliable, noise-free environment with fiber optics
- Superior 32-bit performance
- Precise synchronization of axes

SERCOS TOPOLOGY

A SERCOS system consists of a SERCOS master node and one or more SERCOS slave nodes. The fiber optic cable connects the master and slave nodes in a ring configuration. Information is sent around the SERCOS ring in the form of telegrams. The exact contents of each telegram are user-configurable.

TELEGRAMS

The SERCOS standard uses the following three telegrams:

- Master Synchronization Telegram
- Master Data Telegram
- Amplifier Telegram

Each of these telegrams are transmitted across the fiber optic cable at a set interval (T_{cyc}). The T_{cyc} is determined by the number of axes under control and the information making up the AT and MDT.

MASTER SYNCHRONIZATION TELEGRAM (MST)

The MST is a transmission from the SERCOS master controller to each slave node on the fiber optic ring. Each node is “slaved” to this transmission, which provides for precise synchronization of all control loop calculations on the network. The time between two MSTs is defined as the T_{cyc} .

MASTER DATA TELEGRAM (MDT)

The MDT is also sent from the SERCOS master controller to each slave on the ring. This telegram contains new position, velocity and torque commands for each slave. There is only one MDT per SERCOS cycle.

AMPLIFIER TELEGRAM (AT)

The AT is a real-time transmission from each slave node on the ring to the SERCOS controller. This telegram typically contains actual position, actual velocity and actual torque information about the particular axis. There is one AT per axis on the network.

A portion of both the MDT and AT for each axis is dedicated to the service channel, which allows data to be transmitted between the master and slaves. The service channel is only used when required by the application for activities such as drive configuration, tuning, and diagnostic messages; it is analogous to an asynchronous communication link from the master to each slave.

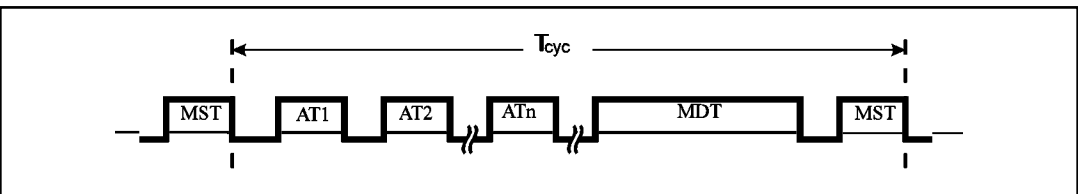


Figure A-2. SERCOS Telegrams

SERCOS-DISTRIBUTED, MULTI-AXIS CONTROL

AML applications are designed to run on Pacific Scientific's SERCOS-based motion controllers, known as programmable Motion Controllers (MCs). MCs are self-contained, industrial personal computers in a compact form factor that provide PC/AT software compatibility.

With this distributed architecture, drives can be mounted locally to the motor, again minimizing field wiring of motor power and feedback cables.

The following system diagram displays a three axis servo system with a SERCOS I/O station. Note that the elimination of wiring, such as analog velocity commands and encoder feedback signals, significantly reduces field installation costs and trouble-shooting. The fiber optic cable can run up to 250 feet and fiber optic command signals are transmitted at a rate of 4MB.

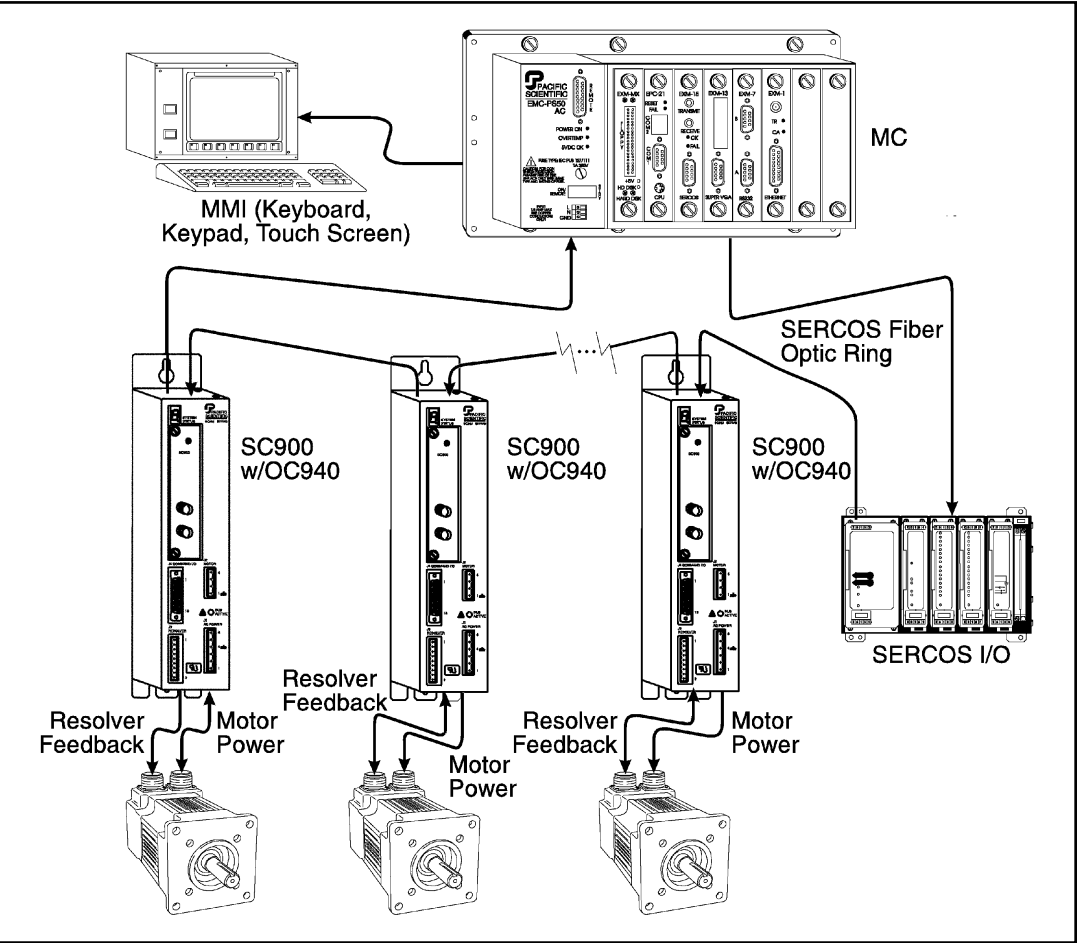


Figure A-3. System Configuration

"SOFT" MOTION CONTROL STRATEGY

In today's industrial control marketplace, software products are the way of the future. However, the motion control industry has traditionally been limited to proprietary technologies. Pacific Scientific's Motion Technology Division is committed to proliferating open platform, software-based solutions for motion control users.

AML provides a software solution in which users are no longer limited to specific hardware platforms.

Similarly, the motion control industry is best served by an open, digital interface specification such as SERCOS. With the SERCOS distributed architecture, the controller no longer has dedicated, proprietary hardware. Users are no longer restricted

to a single source for both drives and controls. Instead, components can be selected based solely on the application need.

As shown in Figure A-4, the only "hardware" required by AML is a single SERCOS interface integrated circuit incorporated into a standard industrial personal computer.

The combination of AML and the open architecture of SERCOS provide a comprehensive, cost-effective and powerful solution to motion control.

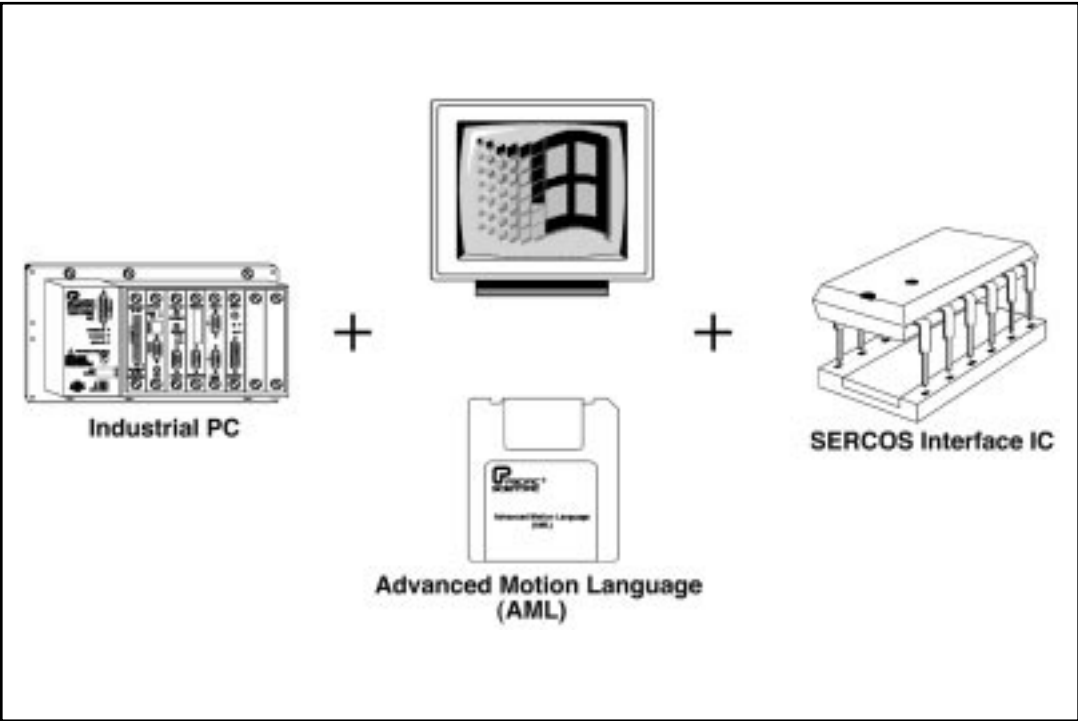


Figure A-4. Pacific Scientific's Motion Control Strategy

ORDERING AND TECHNICAL SUPPORT

ORDERING

To order an AML package and/or a set of AML documentation, contact Pacific Scientific and ask for:

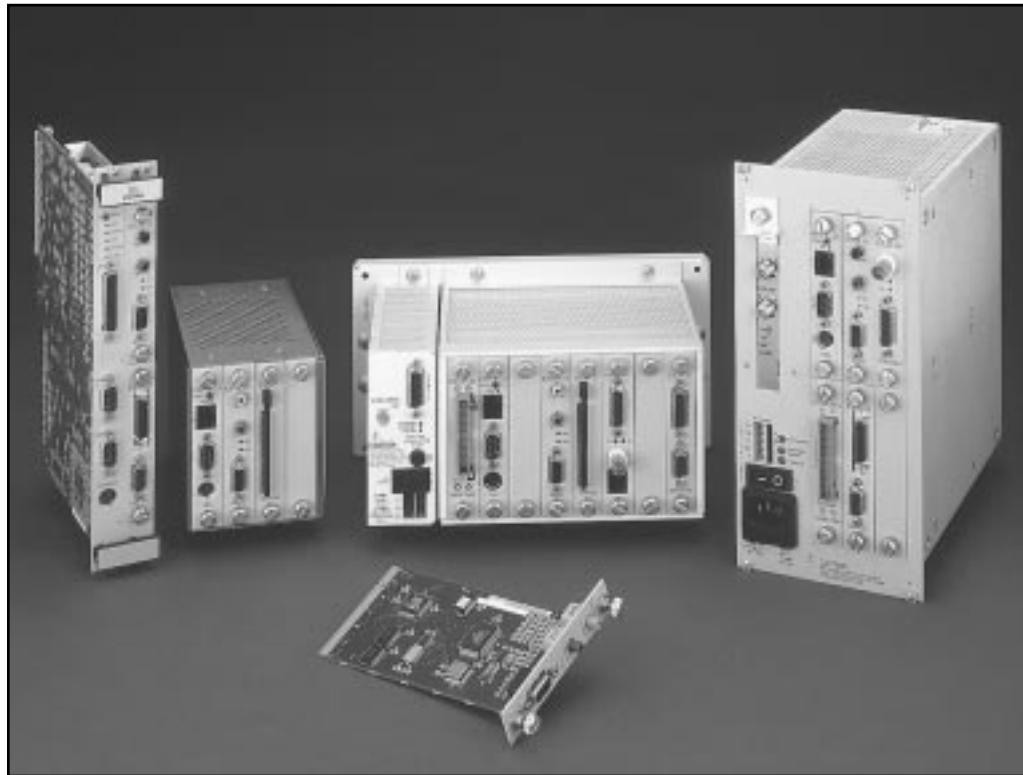
AML Development Package: SMC-AML
(includes one set of manuals)

AML Manual Set: SMC-AML-MNL

APPLICATION SUPPORT

Pacific Scientific has an experienced application engineering support team dedicated to serving the customer. Also, extensive AML training classes are provided in a "state-of-the-art" training facility.

For more information on AML or for a copy of the AML training schedule, contact Pacific Scientific.



MULTI-AXIS MOTION CONTROLLERS

MC800 MOTION CONTROLLER

Pacific Scientific's Advanced Motion Language (AML) is industry's first truly soft motion controller which allows the user to migrate the controller to a wide variety of hardware platforms. One such platform is the MC800, a stand-alone, general purpose motion controller which provides many benefits by combining powerful software with industry-standard hardware. The use of the SERCOS standard allows synchronized control of up to 32 axes of servo motors and I/O stations, and the ISA bus provides access to the large number of option cards available for the PC/AT.

SERCOS is an international open standard which defines a digital interconnection between intelligent servo drives, I/O stations, and controllers. The powerful Advanced Motion Language (See page A-3) allows programmers a high degree of flexibility for handling complex motion profiles and motion specific I/O. Furthermore, the MC800 can easily handle the tasks of complete machine control with its variety of PLC and I/O interfacing options. The combination of AML, the MC800 and the SERCOS interface provide a powerful, cost effective, and maintainable control system.

As a complementary product to the SC900 family of digital servo drives, the MC800 creates uniformity of packaging for controller and drives that in turn makes cabinet design and esthetics attractive to designers and users alike. The variety of PLC and field I/O connectivity options makes the MC800 a seamless integration into any motion control application, while the fiber optic drive connection ensures that installation is simple and maintenance is minimal.

For customers seeking a cost effective motion control solution that utilizes the SERCOS standard, the MC800 is the ideal product.

MC800 Features

- **Easy to Use.** The MC800 comes completely configured per specification; the only connections required of the user are power and the SERCOS fiber optics.
- **SC900 Series Component.** The MC800 was designed to complement the SC900 family of servo drives. The height and depth exactly match that of the SC9x2, SC9x3, and SC9x4. This makes for clean panel layouts.
- **Expandable.** The MC800 has 3 standard ISA slots available for user options.
- **Cost Effective.** The MC800 comes in many configurations including a new low-cost 2 axis unit, making it ideal for any application.
- **Powerful.** The MC800 utilizes all of the software features of the MC26 controller, including AML and field I/O.

System Features

- Synchronous control of up to 32 servo axes
- Uses the SERCOS international motion control standard
- Advanced capabilities such as:
 - Virtual axis support
 - Point-to-point and coordinated motion control
 - Variety of I/O options
 - Variety of PLC communications options
 - AML programming language for application development.



Typical Applications

The MC800 is ideally suited for applications in the following industries:

- Packaging
- Converting
- Textiles
- Printing.

The SERCOS Standard

The MC800 controller is fully compatible with the SERCOS (Serial Real-time COMMunications System) Interface standard. SERCOS is an internationally accepted protocol for digital communication between drives and controllers. Characteristics include:

- Digital control using an international standard with multi-vendor support
- High speed fiber optic control of servo motors and I/O
- Path planning rates for servo motors beginning at 1 ms
- Mundane task of loop closure offloaded to an intelligent drive
- Fiber optic communication for reliable, noise-free environment
- 32 bit position and velocity commands and feedback
- Extensive built-in access to drive status and operating parameters
- 2 or 4 Mbaud communication rate.

GENERAL

Temperature	
Operating	0° to 60°C
Storage	–20° to 85°C
Humidity	
Operating	5-95% (non-condensing)
Storage	5-95% (non-condensing)
Vibration	2.4g (max) 5-500 Hz

Diagram illustrating the dimensions and layout of the MicroSeries chassis. The overall depth is 8.735" (to front of faceplate). The overall width is 14.50". The chassis height is 5.25". The chassis width is 13.75". The chassis is labeled "PACIFIC SCIENTIFIC" and "MICROSERIES". The internal layout includes:

- Top Section:** CPU, Spare, ISA-ISA, Spare, Spare.
- Second Section:** KeyBoard/SC27 type, Transmit, Receive.
- Third Section:** Com1 DDB/Male, Com2 DDB/Male.
- Bottom Section:** Com1 DDB/Male, Com2 DDB/Male.
- Internal Components:** OFFON, CAUTION (High Voltage, High Temperature, Repairs by qualified personnel only), Fuse (part 425V), CPU, N, L, M5 Chassis Ground Stud (1.25" diameter).
- Notes:** 1. 85-20011 DMM, 85-20012 DMM, 85-20013 DMM, 85-20014 DMM, 85-20015 DMM, 85-20016 DMM, 85-20017 DMM, 85-20018 DMM, 85-20019 DMM, 85-20020 DMM, 85-20021 DMM, 85-20022 DMM, 85-20023 DMM, 85-20024 DMM, 85-20025 DMM, 85-20026 DMM, 85-20027 DMM, 85-20028 DMM, 85-20029 DMM, 85-20030 DMM, 85-20031 DMM, 85-20032 DMM, 85-20033 DMM, 85-20034 DMM, 85-20035 DMM, 85-20036 DMM, 85-20037 DMM, 85-20038 DMM, 85-20039 DMM, 85-20040 DMM, 85-20041 DMM, 85-20042 DMM, 85-20043 DMM, 85-20044 DMM, 85-20045 DMM, 85-20046 DMM, 85-20047 DMM, 85-20048 DMM, 85-20049 DMM, 85-20050 DMM, 85-20051 DMM, 85-20052 DMM, 85-20053 DMM, 85-20054 DMM, 85-20055 DMM, 85-20056 DMM, 85-20057 DMM, 85-20058 DMM, 85-20059 DMM, 85-20060 DMM, 85-20061 DMM, 85-20062 DMM, 85-20063 DMM, 85-20064 DMM, 85-20065 DMM, 85-20066 DMM, 85-20067 DMM, 85-20068 DMM, 85-20069 DMM, 85-20070 DMM, 85-20071 DMM, 85-20072 DMM, 85-20073 DMM, 85-20074 DMM, 85-20075 DMM, 85-20076 DMM, 85-20077 DMM, 85-20078 DMM, 85-20079 DMM, 85-20080 DMM, 85-20081 DMM, 85-20082 DMM, 85-20083 DMM, 85-20084 DMM, 85-20085 DMM, 85-20086 DMM, 85-20087 DMM, 85-20088 DMM, 85-20089 DMM, 85-20090 DMM, 85-20091 DMM, 85-20092 DMM, 85-20093 DMM, 85-20094 DMM, 85-20095 DMM, 85-20096 DMM, 85-20097 DMM, 85-20098 DMM, 85-20099 DMM, 85-20100 DMM, 85-20101 DMM, 85-20102 DMM, 85-20103 DMM, 85-20104 DMM, 85-20105 DMM, 85-20106 DMM, 85-20107 DMM, 85-20108 DMM, 85-20109 DMM, 85-20110 DMM, 85-20111 DMM, 85-20112 DMM, 85-20113 DMM, 85-20114 DMM, 85-20115 DMM, 85-20116 DMM, 85-20117 DMM, 85-20118 DMM, 85-20119 DMM, 85-20120 DMM, 85-20121 DMM, 85-20122 DMM, 85-20123 DMM, 85-20124 DMM, 85-20125 DMM, 85-20126 DMM, 85-20127 DMM, 85-20128 DMM, 85-20129 DMM, 85-20130 DMM, 85-20131 DMM, 85-20132 DMM, 85-20133 DMM, 85-20134 DMM, 85-20135 DMM, 85-20136 DMM, 85-20137 DMM, 85-20138 DMM, 85-20139 DMM, 85-20140 DMM, 85-20141 DMM, 85-20142 DMM, 85-20143 DMM, 85-20144 DMM, 85-20145 DMM, 85-20146 DMM, 85-20147 DMM, 85-20148 DMM, 85-20149 DMM, 85-20150 DMM, 85-20151 DMM, 85-20152 DMM, 85-20153 DMM, 85-20154 DMM, 85-20155 DMM, 85-20156 DMM, 85-20157 DMM, 85-20158 DMM, 85-20159 DMM, 85-20160 DMM, 85-20161 DMM, 85-20162 DMM, 85-20163 DMM, 85-20164 DMM, 85-20165 DMM, 85-20166 DMM, 85-20167 DMM, 85-20168 DMM, 85-20169 DMM, 85-20170 DMM, 85-20171 DMM, 85-20172 DMM, 85-20173 DMM, 85-20174 DMM, 85-20175 DMM, 85-20176 DMM, 85-20177 DMM, 85-20178 DMM, 85-20179 DMM, 85-20180 DMM, 85-20181 DMM, 85-20182 DMM, 85-20183 DMM, 85-20184 DMM, 85-20185 DMM, 85-20186 DMM, 85-20187 DMM, 85-20188 DMM, 85-20189 DMM, 85-20190 DMM, 85-20191 DMM, 85-20192 DMM, 85-20193 DMM, 85-20194 DMM, 85-20195 DMM, 85-20196 DMM, 85-20197 DMM, 85-20198 DMM, 85-20199 DMM, 85-20200 DMM, 85-20201 DMM, 85-20202 DMM, 85-20203 DMM, 85-20204 DMM, 85-20205 DMM, 85-20206 DMM, 85-20207 DMM, 85-20208 DMM, 85-20209 DMM, 85-20210 DMM, 85-20211 DMM, 85-20212 DMM, 85-20213 DMM, 85-20214 DMM, 85-20215 DMM, 85-20216 DMM, 85-20217 DMM, 85-20218 DMM, 85-20219 DMM, 85-20220 DMM, 85-20221 DMM, 85-20222 DMM, 85-20223 DMM, 85-20224 DMM, 85-20225 DMM, 85-20226 DMM, 85-20227 DMM, 85-20228 DMM, 85-20229 DMM, 85-20230 DMM, 85-20231 DMM, 85-20232 DMM, 85-20233 DMM, 85-20234 DMM, 85-20235 DMM, 85-20236 DMM, 85-20237 DMM, 85-20238 DMM, 85-20239 DMM, 85-20240 DMM, 85-20241 DMM, 85-20242 DMM, 85-20243 DMM, 85-20244 DMM, 85-20245 DMM, 85-20246 DMM, 85-20247 DMM, 85-20248 DMM, 85-20249 DMM, 85-20250 DMM, 85-20251 DMM, 85-20252 DMM, 85-20253 DMM, 85-20254 DMM, 85-20255 DMM, 85-20256 DMM, 85-20257 DMM, 85-20258 DMM, 85-20259 DMM, 85-20260 DMM, 85-20261 DMM, 85-20262 DMM, 85-20263 DMM, 85-20264 DMM, 85-20265 DMM, 85-20266 DMM, 85-20267 DMM, 85-20268 DMM, 85-20269 DMM, 85-20270 DMM, 85-20271 DMM, 85-20272 DMM, 85-20273 DMM, 85-20274 DMM, 85-20275 DMM, 85-20276 DMM, 85-20277 DMM, 85-20278 DMM, 85-20279 DMM, 85-20280 DMM, 85-20281 DMM, 85-20282 DMM, 85-20283 DMM, 85-20284 DMM, 85-20285 DMM, 85-20286 DMM, 85-20287 DMM, 85-20288 DMM, 85-20289 DMM, 85-20290 DMM, 85-20291 DMM, 85-20292 DMM, 85-20293 DMM, 85-20294 DMM, 85-20295 DMM, 85-20296 DMM, 85-20297 DMM, 85-20298 DMM, 85-20299 DMM, 85-20300 DMM, 85-20301 DMM, 85-20302 DMM, 85-20303 DMM, 85-20304 DMM, 85-20305 DMM, 85-20306 DMM, 85-20307 DMM, 85-20308 DMM, 85-20309 DMM, 85-20310 DMM, 85-20311 DMM, 85-20312 DMM, 85-20313 DMM, 85-20314 DMM, 85-20315 DMM, 85-20316 DMM, 85-20317 DMM, 85-20318 DMM, 85-20319 DMM, 85-20320 DMM, 85-20321 DMM, 85-20322 DMM, 85-20323 DMM, 85-20324 DMM, 85-20325 DMM, 85-20326 DMM, 85-20327 DMM, 85-20328 D

ISA-15A MOTION CONTROLLER PACKAGE

Pacific Scientific's Advanced Motion Language (AML) is industry's first truly soft motion controller which allows the user to migrate the controller to a wide variety of hardware platforms, including virtually any PC/AT compatible computer. The ISA-15A provides the means to implement AML and SERCOS motion control on a standard ISA bus AT compatible PC.

The ISA-15A combines the AML runtime software and a SERCOS interface card which, together, make expandable, multi-axis motion control available using standard PC hardware.

SERCOS is an international open standard which defines a digital interconnection between intelligent servo drives, I/O stations, and controllers. The ISA-15A package allows a standard PC to become a SERCOS controller.

The benefits of this software solution are obvious. No hardware format in existence can keep up with the constantly evolving PC market; by utilizing the PC as its platform, AML's growth potential is virtually unlimited. As the PC standard produces faster and more powerful systems, AML's capabilities increase with the advancing hardware platforms.

ISA-15A Features

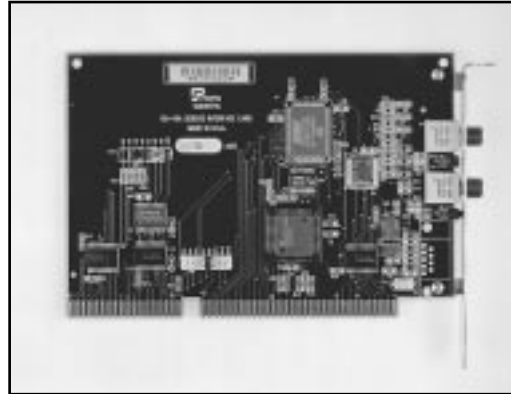
- **Portable.** Turns virtually any PC into a 32-axis SERCOS motion controller when used with AML.
- **Standard.** Brings together the standards of the PC/AT, SERCOS, and the ISA bus to create a flexible system.
- **Powerful.** Works in conjunction with other software packages from Pacific Scientific and other manufacturers to configure extremely capable systems.
- **Excellent Value.** Pricing of this product makes it competitive at any axis count.

System Features

- Synchronous control of up to 32 servo axes
- Uses the SERCOS international motion control standard
- Advanced capabilities such as:
 - Virtual axis support
 - Point-to-point and coordinated motion control
 - Variety of I/O options
 - Variety of PLC communications options
 - AML programming language for application development.

Alternate Hardware Platforms

The SERCOS controller card is also available for the VME and EXM hardware platforms.



Typical Applications

The ISA-15A is ideally suited for applications in the following industries:

- Packaging
- Converting
- Textiles
- Printing.

The SERCOS Standard

The ISA-15A controller is fully compatible with the SERCOS (Serial Real-time Communications System) Interface standard. SERCOS is an internationally accepted protocol for digital communication between drives and controllers. Characteristics include:

- Digital control using an international standard with multi-vendor support
- High speed fiber optic control of servo motors and I/O
- Path planning rates for servo motors beginning at 1 ms
- Mundane task of loop closure offloaded to an intelligent drive
- Fiber optic communication for reliable, noise-free environment
- 32 bit position and velocity commands and feedback
- Extensive built-in access to drive status and operating parameters
- 2 or 4 Mbaud communication rate.



HOW TO ORDER...

ISA-15A CONTROLLER PACKAGE

Catalog Model Number:	ISA - 15 - 08 - 01
Number of Axes:	
02 - Maximum of 2 Axes	
04 - Maximum of 4 Axes	
08 - Maximum of 8 Axes	
12 - Maximum of 12 Axes	
Factory Designations:	
01 - Any other designation is factory assigned	

GENERAL

Power ISA Bus Supplied

Form Factor 1/2 length, 16 bit card

Temperature:

Operating 0° to 60°C

Storage-20° to 85°C

Humidity:

Operating 5-95% (non-condensing)

Storage 5-95% (non-condensing)

MC26 MOTION CONTROLLER

Pacific Scientific multi-axis motion controllers are self-contained, compact motion control systems that provide PC/AT software compatibility in an industrially hardened controller platform.

The MC26's personal computer-based platform replaces dependence on proprietary motion controllers. Now you can take advantage of the ever-increasing power and performance of the PC marketplace, while maintaining your investment in applications software which runs on this PC architecture.

Each chassis comes with slots available for user options. In addition, one type of 6-slot chassis comes with an integral floppy drive and another accommodates a standard PC/AT card. These alternate platforms create a wide range of options for connectivity or additional control options.

MC26 Features

- **Flexible.** MC26s are able to function either as a stand-alone controller for an entire machine or as a peripheral to a programmable controller.
- **Compact.** The MC26 is offered in a 10.2" x 5.5" x 6.5" DIN rail mountable form factor and a 6U Eurocard form factor.
- **Rugged design.** The MC26 features extended temperature, shock, and vibration specifications.
- **Variety of options.** The following options can be mounted in the MC26's 6 or 8 slot chassis:
 - RS232 Serial Ports (EXM-7)
 - Ethernet Controller (EXM-10)
 - Super VGA Card (EXM-13)
 - Digital I/O Card (EXM-19)
 - External Encoder Interface Card (EXM-27)

System Features

- Synchronous control of up to 32 servo axes
- Uses the SERCOS international communications standard
- Advanced capabilities such as:
 - External encoder support
 - Virtual master support
 - Point-to-point and coordinated motion control
 - Various I/O options
 - Various PLC communications options
 - AML programming language for application development



Typical Applications

The MC26 is ideally suited to applications in the following industries:

- Packaging
- Converting
- Textile
- Printing

SERCOS Standard

MC26 controllers are fully compatible with the SERCOS (Serial Real-time Communications System) Interface Standard. SERCOS is an internationally accepted protocol for digital communication between drives and controllers. Characteristics include:

- Digital control using an international standard with multi-vendor support
- High speed fiber-optic control of servo motors and I/O
- Path planning rates for servo motors beginning at 1 msec
- Mundane task of loop closure off-loaded to an intelligent drive
- Fiber optic communication for reliable, noise-free environment
- 32-bit position and velocity commands and feedback
- Extensive built-in access to drive status and operating parameters
- 2 or 4 Mbaud operation



GENERAL...MC26 CONTROLLERS

Microprocessor	50 Mhz 486 DX2
Power	85-264 VAC, 47-440 Hz
Temperature	
Operating	0° to 60°C
Storage	-40° to 85°C
Humidity	
Operating	5-95% (non-condensing)
Storage	5-95% (non-condensing)
Vibration	
Operating	.015" peak to peak 2.5g(max.) 5-2000 Hz
Storage	.030" peak to peak 5g (max.) 5-2000 Hz
Shock	
Operating	.30g 11 msec duration
Storage	50g 11 msec duration

* Upper temperature limit degrades 2C per 1000 ft. elevation. Maximum elevation 10,000 ft.

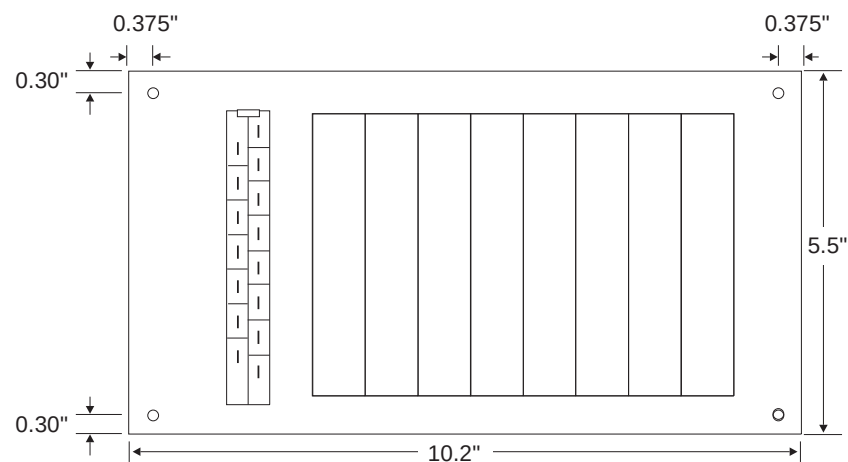
HOW TO ORDER...MC26 CONTROLLERS

Catalog Model Number:	MC26 - 200 - 08XXXXX - 01
CPU Type:	
MC26 - Motion Controller, 486DX2, 50Mhz.	
System Memory:	
2 - 8MB RAM	
Non-Volatile Storage Media:	
0 - Fixed Disk	
1 - Fixed Disk + PCMCIA Memory Card Adapter + SRAM	
Chassis Type:	
0 - 10.2" x 5.5" x 6.5" with 5 EXM slots	
1 - 10.2" x 5.5" x 6.5" with integral floppy drive, 3 EXM slots	
2 - 4.6" x 10.5" x 8.7" with 1 ISA slot, 2 EXM slots, Rack Mount	
3 - 7.8" x 10.5" x 11.7" with 1 ISA slot, 2 EXM slots, Panel Mount	
Number Of Axes:	
04 - Maximum of 4 Axes	
08 - Maximum of 8 Axes	
12 - Maximum of 12 Axes	
16 - Maximum of 16 Axes	
24 - Maximum of 24 Axes	
32 - Maximum of 32 Axes	
User Options:	
A - EXM-7: Two RS232 Serial Ports	
B - EXM-10: Ethernet Controller	
C - EXM-13: Super VGA Card	
D - EXM-19: Digital I/O Card (16 In / 8 Out)	
E - EXM-19: Digital I/O Card (8 In / 16 Out)	
F - EXM-27: External Encoder Interface	
Factory designations:	
01 - Any other designation is factory assigned.	



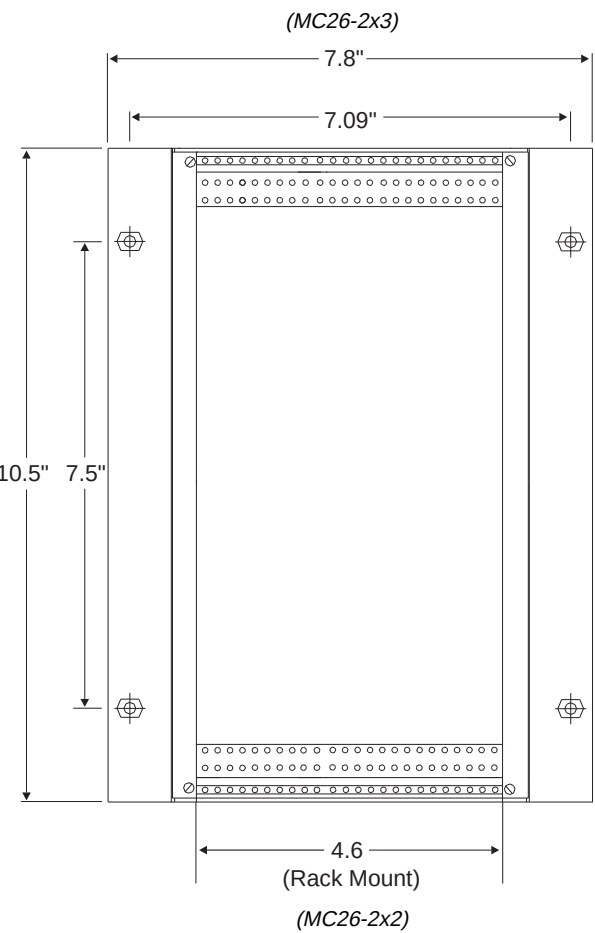
Dimensions

MC26-2x0/2x1



Configuration	Depth
MC26-2x0	6.5"
MC26-2x1	6.5"

MC26-2x2/2x3



Configuration	Depth
MC26-2x2	8.7"
MC26-2x3	11.7"

MULTI-AXIS HARDWARE OPTIONS

You can purchase various EXM options along with your motion controller, including:

- A digital I/O card (EXM-19)
- An external encoder interface (EXM-27).

EXM-19 Digital I/O

The EXM-19 card is a 24 bit, optically-isolated I/O card (8I/16O or 16I/8O). Up to 4 cards per controller (96 I/O) are allowed.

An 8255 PPI is used for control of three 8-bit ports, designated as A, B and C. The EXM-19-FFOOF A and C ports are for output and the B port is for input. The EXM-19-FFOOO B and C ports are for input and the A port is for output.

EXM-19 Specifications

Power consumption/24 line	5 V @ 0.64 A (max.) 5 V @ 0.40 A (typical)
Opto-isolated input	
LED forward voltage	± 1.2V Typical
Serial resistance	470 Ω
On current	> ±1.5 mA
Off current	< ±40µA
Maximum current	± 40 mA
Opto-isolated output	
Maximum opto-isolator power dissipation rating	150mW
On voltage @ 1mA	0.4V maximum
Off current	1.0µA maximum
Off voltage maximum	+35V/-6V

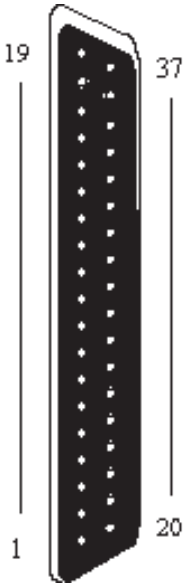


MULTI-AXIS HARDWARE OPTIONS (Cont.)

EXM-19 Pinouts

The EXM-19 contains a single DB-37 male connector. Pinouts are:

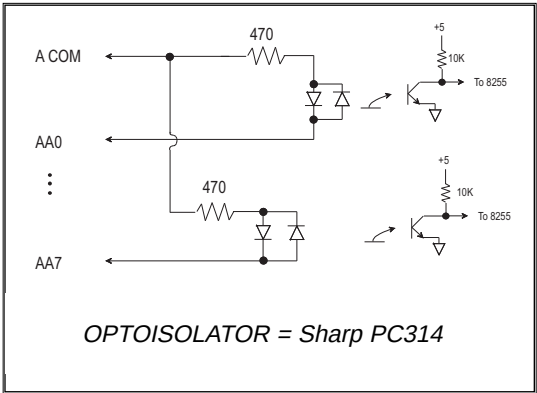
Pin	Signal	Pin	Signal
1	INT IN B	20	INT IN A
2	INT EN B	21	INT EN
3	AB7	22	AC7
4	AB6	23	AC6
5	AB5	24	AC5
6	AB4	25	AC4
7	AB3	26	AC3
8	AB2	27	AC2
9	AB1	28	AC1
10	AB0	29	AC0
11	C COM	30	AA7
12	Not used	31	AA6
13	B COM	32	AA5
14	Not used	33	AA4
15	A COM	34	AA3
16	Not used	35	AA2
17	GND	36	AA1
18	Fused +5V	37	AA0



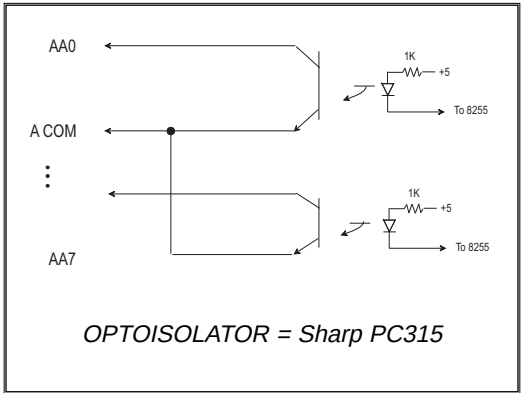
EXM-19 Opto-Isolators

The following schematic figures depict the workings of the opto-isolators used in the EXM-19:

Typical OPTO Input:



Typical OPTO Output:



MULTI-AXIS HARDWARE OPTIONS (Cont.)

EXM-27 External Encoder

The EXM-27 is a 32-bit encoder-counter card with one high speed position latch input and eight additional lines of digital I/O.

The EXM-27 includes a standard DB-9 pin connector for connecting the external encoder and position latch input, and a female DB-15 for connecting auxiliary optically-isolated I/O (4 inputs, 4 outputs).

EXM-27 Specifications

Input type	Incremental AB quadrature, optically isolated, differential
Decode modes	4X quadrature, 2X quadrature, 1X quadrature
Maximum input frequency (A, B)	
Differential-totem-pole	2.0 MHz
Single ended-totem-pole	500 KHz
Differential/single ended-open collector	200 KHz
Position latch input	
Optically isolated, sinking or sourcing	+5 to +30V
Turn-on time	<= 300 ns
Turn-off time	<= 3.0 microseconds
Position latch pulse width (high or low)	3.0 us (minimum)
Encoder supply input	+5 to +15 VDC, reverse polarity protected

EXM-27 I/O Specifications

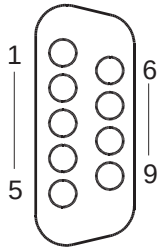
Digital inputs	Sinking or sourcing, +5 to +30 VDC
Digital outputs	Sourcing from +5 to +30 VDC, rated at 20mA maximum continuous current each, short-circuit protected
Digital output supply	+5 to +30 VDC

MULTI-AXIS HARDWARE OPTIONS (Cont.)

EXM-27 Pinouts

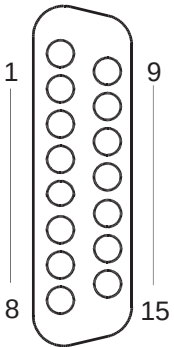
The EXM-27's female DB-9 encoder connector is defined as:

Pin	Signal
1	Encoder A input
2	Encoder /A input
3	Encoder B input
4	Encoder /B input
5	Position latch +
6	Position latch -
7	Encoder supply +
8	Encoder supply -
9	Ground (shield)



The EXM-27's female DB-15 encoder connector is defined as:

Pin	Signal
1	Input 1 +
2	Input 1 -
3	Input 2 +
4	Input 2 -
5	Input 3 +
6	Input 3 -
7	Input 4 +
8	Input 4 -
9	Output1
10	Output2
11	Output3
12	Output4
13	Output supply +
14	No connection
15	Ground (shield)

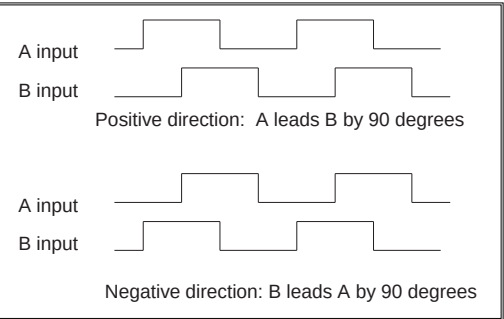


EXM-27 Encoder Inputs

You can use the EXM-27 card with a single-ended or differential input incremental quadrature encoder. Maximum performance is achieved using a quadrature encoder in 4X decode mode with differential inputs.

The encoder signals for channels A and B are connected to the A and B inputs respectively. When the encoder is rotating or moving in the positive direction, the A signal should lead the B signal by 90 degrees. When rotating or moving in the negative direction, the B signal should lead the A signal by 90 degrees.

The following figure illustrates this:



DIOFACE I/O

Pacific Scientific also offers a complete SERCOS I/O solution. The DIOFACE I/O field station is ideal for control of a variety of analog and digital I/O types. The DIOFACE design is modular, consisting of a base unit with a number of plug-in positions for power supplies and communication modules with the SERCOS Interface. The remaining slots are available for digital and analog I/O modules which can be arranged to suit the application.

The modularity of DIOFACE allows fast installation and detachment of the connected sensors and actuators and guarantees an economical set-up of the field I/O station since you only install what is necessary. The DIOFACE module carrier meets strict European EMC regulations (EN 500 81-2 and EN 500 82-2), ensuring that data communication is reliable under heavy electronic noise conditions.

Features

- Data Rates at 2 Mbaud
- Modular design
- Compact DIN Rail Mountable Form Factor
- Variable I/O Capacity (6, 8, 10, 12 Slot Racks Available)
- Extended Temperature, Shock and Vibration Specifications

Benefits

In conventional control systems, all I/O points are individually connected to the PLC. These numerous connections raise installation costs and decrease serviceability. The technology of the decentralized field I/O station provides the following advantages:

- Expansion and simplification of control systems
- Reduction of wiring and hardware cost
- Modular design for production facilities
- Separate testing of individual modules



Module Base Units

The following modules can be plugged into the DIOFACE module carrier:

- **Power supplies**, providing control voltage for the individual modules. All power supplies guarantee an effective electrical isolation of 4.5 kV.
- **Communication modules**, providing a SERCOS interface between all digital and analog I/O modules of a station and the MC26.
- **Digital input modules**, providing access by the MC26 to monitor all digital sensors, including switches, proximity switches, and photocells.
- **Digital output modules**, allowing the MC26 to control all digital actuators or provide handshake signals to another control device (PLC or display unit).
- **Analog input modules**, each with 4 channels providing an input range of -10 VDC to +10 VDC, available in a choice of 8 or 12-bit resolution per channel.
- **Analog output modules**, each with 4 channels providing an output range of -10 VDC to +10 VDC with 12-bit resolution per channel.

Only the power supply and communication module have defined positions. Arrangement of the other I/O modules is up to you.

GENERAL...ALL I/O MODULES

Width	1.3"
Height	5.8"
Depth	6"
Temperature	
Operating	0° to 60°C
Storage	-20° to 80°C

GENERAL...BASE UNITS

	Part Numbers			
	SIO-BU-06-00	SIO-BU-08-00	SIO-BU-10-00	SIO-BU-12-00
Number of slots	6	8	10	12
Width	8.7"	11.8"	14.4"	17.2"
Height	6.1"	6.1"	6.1"	6.1"
Depth	2.8"	2.8"	2.8"	2.8"

SPECIFICATIONS...COMMUNICATION MODULES

	Part Numbers	
	SIO-CM-00-00	SIO-CM-00-01
Bus connection	SERCOS	SERCOS
Transmission rate	2 Mbaud	2 Mbaud
Transmission medium	plastic FOC	plastic FOC
Enable input port	24 VDC	—
Signal output port	switch relay,	—
	1.25kVA/120W	

SPECIFICATIONS...POWER SUPPLIES

	Part Numbers			
	SIO-PS-01-02	SIO-PS-02-02	SIO-PS-01-01	SIO-PS-02-03
Input Port				
Rated Operating Voltage	115 VAC	115 VAC	24 VDC	230 VAC
Operating Voltage Range	103V-127V	103V -127V	20-30 VDC	207-253 VAC
Rated Frequency	60 Hz	60Hz	N/A	50-60 Hz
Output Port				
Output Voltage 1	24 VDC	24 VDC	24 VDC	24 VDC
Output Current 1	200 mA	500 mA	500 mA	500 mA
Output Voltage 2	5 VDC	5 VDC	5 VDC	5 VDC
Output Current 2	1000 mA	1500 mA	500 mA	1500 mA
Slots	1	2	1	2

SPECIFICATIONS...DIGITAL INPUT

	Part Numbers			
	SIO-DI-16-01	SIO-DI-32-01	SIO-DI-16-03	SIO-DI-16-02
Input Channels	16	32	16	16
Rated Input Voltage	24 VDC	24 VDC	230 VAC	115 VAC
Range Of Input Voltage - Low	0-5 VDC	0-5 VDC	0-65 VAC	0-65 VAC
Range Of Input Voltage - High	13-30 VDC	13-30 VDC	170-250 VAC	170-250 VAC
Input Capacity Per Channel (max.)	210 mW	210 mW	110 mW	110 mW
Total Input Capacity (max.)	3.36 W	4.45 W	1.76 mW	1.76 mW
Turn-on Time (max.)	250 usec	250 usec	9 msec	9 msec
Turn-off Time (max.)	5 usec	5 usec	8 msec	8 msec
Pinout Reference	16-DIG-IN	32-DIG-IN	16-DIG-IN	16-DIG-IN

SPECIFICATIONS...DIGITAL OUTPUT

	Part Numbers		
	SIO-DO-16-01	SIO-DO-32-01	SIO-DO-16-11
Output Channels	16	32	16
Rated Input Voltage	24 VDC	24 VDC	24 VDC
Operating Voltage	19-30 VDC	19-30 VDC	19-30 VDC
Output Current Per Channel (max.)	0.5 A	0.5 A	2.0 A
Switching Frequency (max.)	24 Hz	24 Hz (max.)	12 Hz
Short-Circuit Protected	yes	no	yes
Turn-On Time (max.)	100 usec	500 msec (max.)	100 msec (max.)
Turn-Off Time (max.)	1 msec	msec (max.)	1 msec (max.)
Pinout Reference	16-DIG-OUT	32-DIG-OUT	16-DIG-OUT

SPECIFICATIONS...ANALOG INPUT

	Part Numbers	
	SIO-AI-04-01	SIO-AI-04-11
Input Channels	4	4
Interface	±10 VDC	±10 VDC
Resolution	8 bit	12 bit
Operating Voltage	19-30 VDC	19-30 VDC
Pinout Reference	4 AN-IN-8B	4 AN-IN-12B

SPECIFICATIONS...ANALOG OUTPUT

	Part Number
	SIO-AO-04-11
Output Channels	4
Interface	±10 VDC
Resolution	12 bit
Conversion Time	< 60 usec
Operating Voltage	19-30 VDC
Pinout Reference	4 AN-OUT-12B

PINOUTS...DIOFACE I/O

	Digital Input		Digital Output		Analog Input		Analog Output
Designation	16-DIG-IN	32-DIG-IN	16-DIG-OUT	32-DIG-OUT	4 AN-IN-8B	4 AN-IN-12B	4 AN-OUT-12
Terminal #							
1		Channel 1	(1-4)	Channel 1			
2		Channel 2	(1-4)	Channel 2			
3		Channel 3	Channel 1	Channel 3	0 VDC	+24 VDC	+24 VDC
4		Channel 4	Channel 2	Channel 4	0 VDC	+24 VDC	+24 VDC
5	Channel 1	Channel 5	Channel 3	Channel 5	Channel 4-		Channel 1+
6	Channel 2	Channel 6	Channel 4	Channel 6	Channel 4+	Channel 1+	Channel 1-
7	Channel 3	Channel 7	(5-8)	Channel 7	Channel 3-	Channel 1-	Channel 2+
8	Channel 4	Channel 8	(5-8)	Channel 8	Channel 3+		Channel 2-
9	Channel 5	Channel 9	Channel 5	Channel 9	Channel 2-		Channel 3+
10	Channel 6	Channel 10	Channel 6	Channel 10	Channel 2+	Channel 2+	Channel 3-
11	Channel 7	Channel 11	Channel 7	Channel 11	Channel 1-	Channel 2-	Channel 4+
12	Channel 8	Channel 12	Channel 8	Channel 12	Channel 1+		Channel 4-
13	(1-8)	Channel 13	(1-16)	Channel 13	+24 VDC	0 VDC	0 VDC
14	(1-8)	Channel 14	(1-26)	Channel 14	-24 VDC	0 VDC	0 VDC
15		Channel 15			Channel 15		
16		Channel 16			Channel 16		
17		(1-16)	(9-12)	(1-16)			
18		(1-16)	(9-12)	(1-16)			
19	Channel 9	Channel 17	Channel 9	Channel 17			
20	Channel 10	Channel 18	Channel 10	Channel 18			Channel 4-
21	Channel 11	Channel 19	Channel 11	Channel 19			Channel 4+
22	Channel 12	Channel 20	Channel 12	Channel 20			
23	Channel 13	Channel 21	(13-18)	Channel 21			
24	Channel 14	Channel 22	(13-18)	Channel 22			Channel 3-
25	Channel 15	Channel 23	Channel 13	Channel 23			Channel 3+
26	Channel 16	Channel 24	Channel 14	Channel 24			
27	(9-16)	Channel 25	Channel 15	Channel 25			
28	(9-16)	Channel 26	Channel 16	Channel 26			
29		Channel 27			Channel 27		
30		Channel 28			Channel 28		
31		Channel 29			Channel 29		
32		Channel 30			Channel 30		
33		Channel 31			Channel 31		
34		Channel 32			Channel 32		
35		(17-32)			(17-32)		
36		(17-32)			(17-32)		

HOW TO ORDER...DIOFACE I/O

Ordering Information		
Device Type	Part Number	Description
Base Units	SIO-BU-06-00	Base Unit, 6 Slots
	SIO-BU-08-00	Base Unit, 8 Slots
	SIO-BU-10-00	Base Unit, 10 Slots
	SIO-BU-12-00	Base Unit, 12 Slots
Power Supplies	SIO-PS-01-02	Power Supply, 115 VAC, 1 Slot
	SIO-PS-02-02	Power Supply, 115 VAC, 2 Slot
	SIO-PS-02-03	Power Supply, 230 VAC, 1 Slot
	SIO-PS-01-01	Power Supply, 24 VDC, 1 Slot
Communications Modules	SIO-CM-00-00	SERCOS Communication Module, Standard
	SIO-CM-00-01	SERCOS Communication Module with External Enable
Digital Input	SIO-DI-16-01	Digital Input, 16 x 24 VDC
	SIO-DI-32-01	Digital Input, 32 x 24 VDC
	SIO-DI-16-02	Digital Input, 16 x 115 VAC
	SIO-DI-16-03	Digital Input, 16 x 230 VAC
Digital Output	SIO-DO-16-01	Digital Output, 16 x 24 VDC, 0.5A/Channel
	SIO-DO-32-01	Digital Output, 32 x 24 VDC, 0.5A/Channel
	SIO-DO-16-11	Digital Output, 16 x 24 VDC, 2A/Channel
Analog Input	SIO-AI-04-01	Analog Input, 4 Channel, 8-bit, +/-10VDC
	SIO-AI-04-11	Analog Input, 4 Channel, 12-bit, +/-10VDC
Analog Output	SIO-AO-04-11	Analog Output, 4 Channel, 12-bit, +/-10VDC

NOTE: A complete unit consists of one Base Unit, one Power Supply, one Communications Module, and selected I/O modules.

All Modules except selected power supplies take only a single slot in the Base Unit.



BRUSHLESS SERVO SYSTEMS

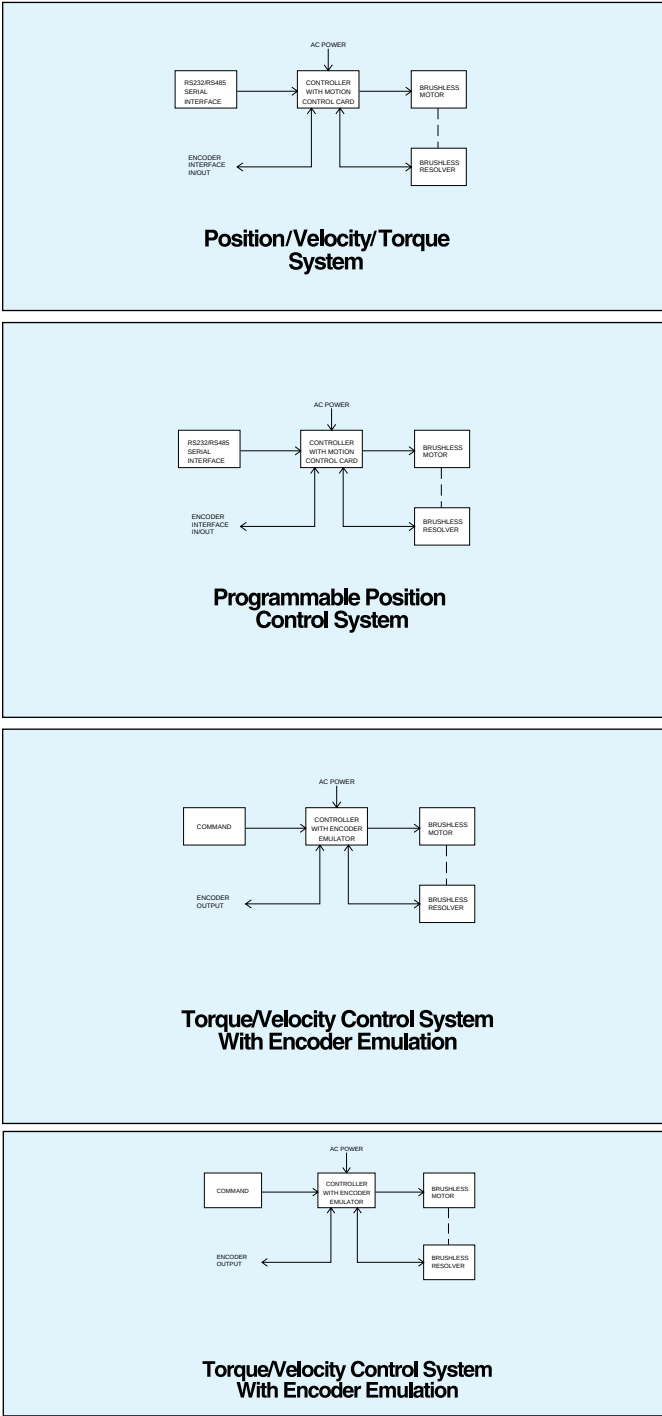
SELECTION OVERVIEW. . .CONTROLLERS

HOW TO USE THIS SECTION

Use the system selection overview (right) as a guide to selecting the level of control you require. Controllers are listed by family/series and functionality.

The table of contents below will help you find the controllers and motors to help you complete your system.

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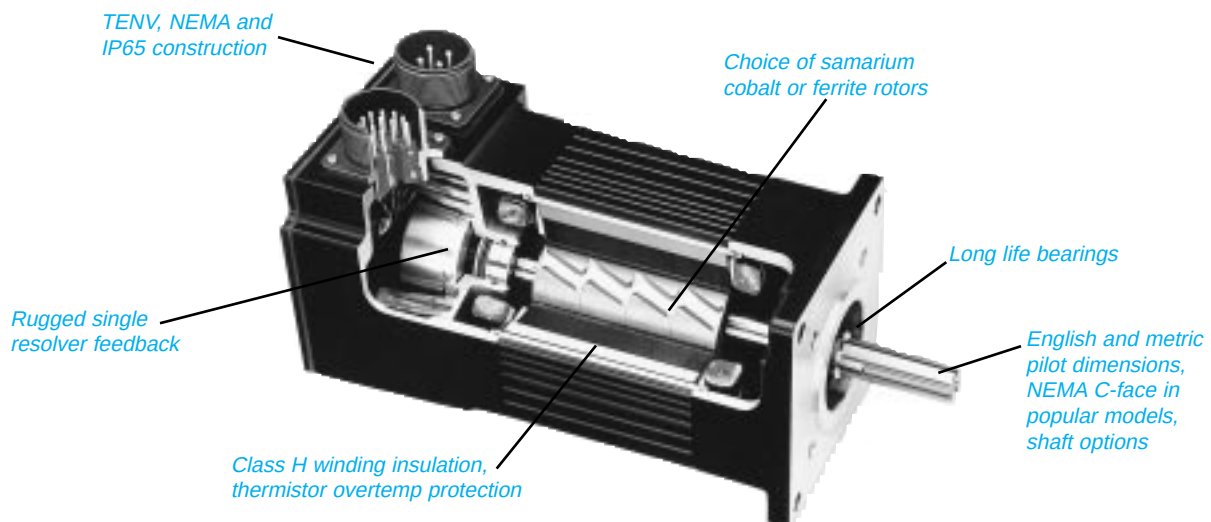
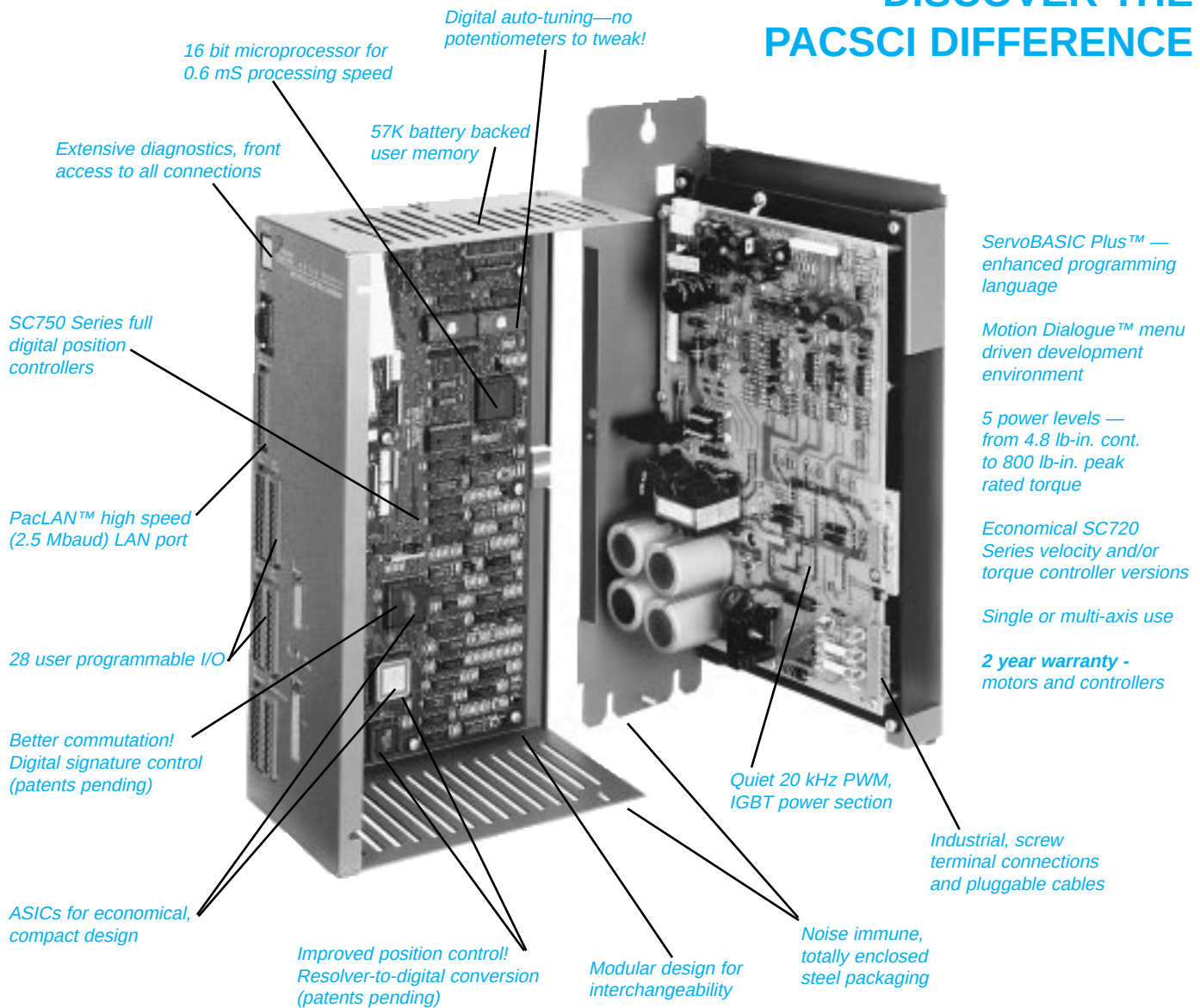


...Brushless Servo Systems

Brushless Servo Motors

				R20 Series	R30 Series	R40 Series	F40 Series	R60 Series	R80 Series		
				Frame Size (in.)							
				2	3.25	4.25	4.25	5.75	7.5		
				Max. Continuous Rated Torque (lb-in.)							
Features				Brushless Servo Controllers				Speed (rpm)		Page	
	• Velocity loop (speed) control • Torque (current) control • Velocity or torque output proportional to ±10V input • Velocity control: user closes position loop • Controller generates encoder outputs from single resolver • Position loop control: user supplies encoder, step/dir signals for command • Digital velocity control: user supplies commands via RS232	SC900 Series	SC902	7.1 / 6000	30 / 1500	33 / 1500	43 / 1000			B-6	
			SC903		23 / 3000	61 / 1500	48 / 1500			B-6	
			SC904			50 / 3000	43 / 3000	156 / 1000		B-6	
			SC905					146 /	424 /	B-6	
	• Position loop control • Integral programmable position control • Programming in PacSci ServoBASIC <i>Plus</i>™ • 85K nonvolatile program storage • Programmable I/O • Electronic (master/slave) gearing • Local Area Network. . . PacLAN™	SC750 Series	SC752	7.1 / 6000	30 / 1500	33 / 1500	43 / 1000			B-27	
			SC753		23 / 3000	61 / 1500	48 / 1500			B-27	
			SC754			50 / 3000	43 / 3000	156 / 1000		B-27	
			SC755					146 / 2000	424 / 1000	B-27	
			SC756						300 /	B-27	
	• Velocity loop (speed) control • Torque (current) control • Velocity or torque output proportional to ±10V input • Velocity control: user closes position loop • Torque control: user closes velocity and/or position loop • Controller generates encoder outputs from single resolver	SC720 Series	SC722	7.1 / 6000	30 / 1500	33 / 1500	43 / 1000			B-48	
			SC723		23 / 3000	61 / 1500	48 / 1500			B-48	
			SC724			50 / 3000	43 / 3000	156 / 1000		B-48	
			SC725					146 / 2000	424 / 100	B-48	
			SC726						300 /	B-48	
	• Velocity loop (speed) control • Torque (current) control • Velocity or torque output proportional to ±10V input • Velocity control: user closes position loop • Torque control: user closes velocity and/or position loop	SC400 Series	SC402		30 / 1500	33 / 1500				B-60	
			SC403		23 / 3000	61 / 1500				B-60	

DISCOVER THE PACSCI DIFFERENCE



BRUSHLESS SERVO CONTROLLERS

From full-featured to economical OEM packages, Pacific Scientific has the right brushless servo controller for your performance and cost requirements.

We are pleased to introduce the SC900, our newest family of high-performance brushless servo controllers. The SC930 is the first series of this family to be released. This “state of the art” controller is fully digital and very flexible. It can function as a velocity or torque loop commanded by a standard analog ($\pm 10V$) signal. Because it is digital, it also has the capability of following a digital velocity command entered through the serial port or following a position command entered in step- and -direction or quadrature encoder format. As an extension of this digital flexibility, these drives have 6 mappable, bi-directional I/Os. These I/O points can be used to simulate real world functionality such as Clutch/Brake, Over Travel Limits, and Soft Start Acceleration.

This family mates to all of Pacific Scientific high performance brushless motors using reliable resolver feedback devices.



The SC700 family incorporates design inputs from over 3,000 industrial motion control users. You'll find the SC700 simple to apply and maintain, plenty rugged for the factory floor, and flexible to meet your changing needs.

For plug & play system, specify our SC750 Series digital position controllers. Autotuning makes setup a breeze. Programming is easy in the PacSci ServoBASIC *Plus*™ environment. And our proprietary digital control techniques mean you don't have to sacrifice performance for digital convenience.

Our latest generation SC720 Series torque/velocity controllers let you close the loop with your own position controller or PLC servo module. All parameters are readily adjusted through a removable personality module. The SC720 simplifies control by generating quadrature position feedback and communication signals from a single motor-mounted resolver.



The SC400 Series torque/velocity controllers offer economical and space-saving alternatives and are specifically designed for use with popular 3.25" and 4.25" frame motors. With PacSci, you never have to settle for too much—or too little—servo controller.

And remember, PacSci always stands behind its controllers and motors with a 2 year warranty.

SC900 SERIES

Peak torque range:
10 to 800 in-lb. (1.1 to 90 Nm)

Digital Servo Drive

1.1 kW to 9 kW continuous power
2.2 kW to 18 kW peak power

FEATURES

- All digital DSP-based
- Standard analog and digital interfaces
 - $\pm 10V$ Analog interface—Velocity or torque control
 - Step/Direction Digital interface—Position or velocity control
 - Step Up/Step Down interface—Position or velocity control
 - Quadrature Encoder Digital interface—Electronic gearing follower
- Removable option card for flexibility
 - RS-232/485 serial interface
 - SERCOS multi-axis fiber optic interface
 - Expanded I/O
 - Field firmware upgrade
- Personality parameters in base drive or on removable option card (EEPROM)
- Digital auto-tuning for easy set-up—no pots to tweak
- All system and application parameters set in software and can be saved in EEPROM
- Single resolver feedback survives hostile environments
- Optionally used incremental encoder and/or commutation
- Quadrature encoder outputs up to 16,384 PPR
- Digital and analog I/O
- Total front access to clearly marked connectors
- Extensive protection circuits and diagnostics to ease set-up
- Inaudible, high frequency, Digital PWM sine wave current control

When combined with Pacific Scientific's brushless servo motors, the SC900 Series drives provide continuous torques ranging from 4.8 lb-in to 451 lb-in and peak torques from 10 lb-in to 800 lb-in. Standard motor power and resolver feedback cables are available to complete your motion control system and provide reliable, trouble-free startup and operation.

APPLICATIONS

- Packaging Machinery
- Electronic Assembly Equipment
- Material Handling
- Robotics
- X-Y Tables and Slides
- Specialty Machinery
- Multi-axis Systems

PRODUCT DESCRIPTION

The Pacific Scientific SC900 Series is a family of next generation digital, servo drives. These drives utilize a single DSP to close the current, velocity, and position loops. All system and application parameters are set in software to insure repeatability and to eliminate drift. The SC900 Series is available in four power levels, all with integral power supplies and shunt regulators.

The base SC900 unit includes several command interface features. A standard $\pm 10V$ analog interface is available to command motor torque or velocity. Two standard stepper interfaces, step/direction and Step Up/Step Down, are also available to command motor position or velocity. The drive can also be used in an electronic gearing follower mode by using the quadrature encoder input.



Various option cards are available to increase the functionality of the base SC900 drive. The option card is required to set the base SC900 parameters, but can be removed once set up is complete. All option cards have the capability to replace the base drive's personality parameter non-volatile storage and provide removable personality parameter storage. The option cards also allow SC900 firmware upgrades, which eliminates the need to disassemble equipment or the drive when upgrading.

RS-232/485 Serial Interface OC930 Option Card

This card allows the user to program the various SC900 set-up parameters using an IBM-compatible PC. It also allows the SC900 to be connected to any host computer containing RS-232/485 communications capability.

SERCOS Interface OC940 Option Card

This card adds SERCOS (SErial Real-time COmmunications System) fiber optic communication capability to the SC900. See pages B-21–B-26 for more details.

Programmable Single Axis Position Control OC950 Option Card

This card allows the user to program the option card to increase functionality of the base SC900 drive. See pages B-19 & B-20 for more details.

DIGITAL RESOLVER-TO-DIGITAL CONVERSION

A patented Digital Resolver-to-Digital Converter called DRDC provides industry leading 24-bit-per-revolution position resolution. This very high position resolution yields an all digital velocity control with smoothness indistinguishable from an all analog control. U.S. Patent 5,162,798.


©
SC900 Controllers
are UL Recognized
(File E137798)

SIGNATURE CURRENT CONTROL

The SC900 Series utilizes signature control, a proprietary form of brushless motor sinusoidal commutation. This current control technique significantly reduces ripple torques due to harmonics in the motor's back EMF wave form. By tailoring the sinusoidal current's wave shape or "signature" to match the motor's back EMF, electro-magnetic ripple torque is reduced to $\pm 2\%$ or less. In your application, this results in excellent machine precision and smoothness with high throughput capability. This proprietary commutation control also provides exceptional high-speed motor control.

FULL DIGITAL CONTROL

The combination of DSP, DRDC, and ASICs (Application Specific Integrated Circuits) give the SC900 its all digital advantage. An all digital implementation reduces component count to increase reliability while reducing cost, eliminates analog drift, eliminates imprecise potentiometer adjustments, reduces size, and increases flexibility.

AUTOTUNING

In many applications, the Autotuning feature will automatically set the servo system compensation parameters. You won't need oscilloscopes, meters, or other instruments—just a personal computer—to set up your system. The system allows you to select the type of performance desired.

IGBT PWM POWER STAGE

Insulated Gate Bipolar Transistor (IGBT) technology is used in the power stage of every SC900 Series drive. This technology makes exceptionally efficient use of PWM frequencies above the audible range. As a direct result, motor operation is more efficient and the annoyance of audible PWM noise is eliminated.

I/O

- Differential $\pm 10\text{V}$ analog input
- 2 $\pm 5\text{V}$ Analog outputs
- 6 Bi-directional input/outputs, TTL or 24V logic compatible
- Encoder quadrature output
- Encoder quadrature input (Step/Direction, Step Up/Step Down)
- Enable input
- +5Vdc @ 200 mA user output

COMMUNICATIONS

- OC930 Serial Option Card
 - RS-232 9600 Baud
 - RS-485 9600 Baud, 32 node
- OC940 SERCOS Option Card

OPERATING FEATURES

- Smooth, digital, high bandwidth position/velocity/torque control
- Transformerless, direct 120/240 Vac line operation
- IGBT PWM output stage
- Fully enclosed, panel mount package

ADJUSTMENTS

- All adjustments made in software

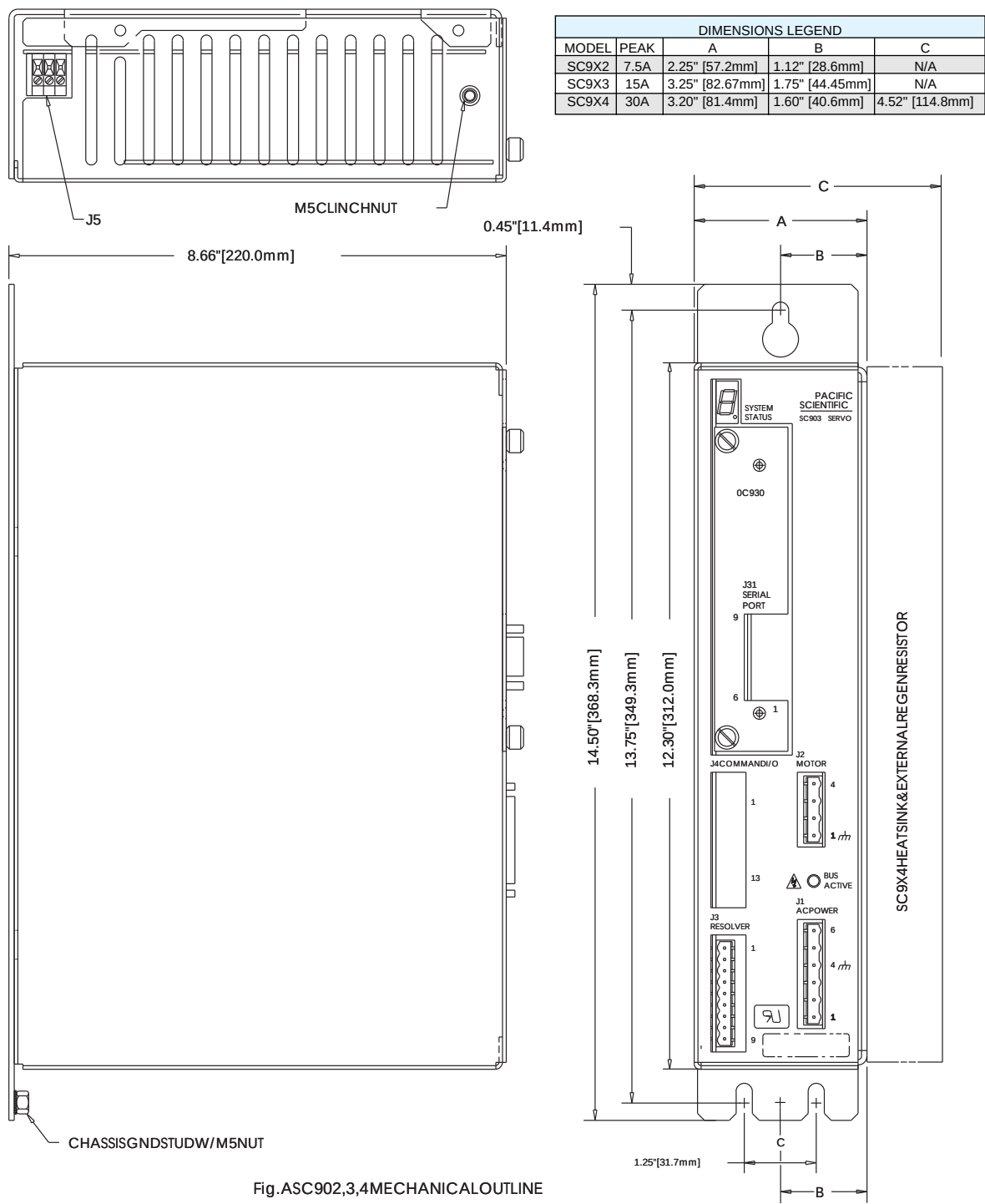
PROTECTION/DIAGNOSTICS

- 7 segment status display
- In-rush current limiting
- Control Power Fuse
- Output short circuit protection
- Overtemperature protection, motor and drive
- IT protection
- Under voltage protection
- Excessive regeneration protection

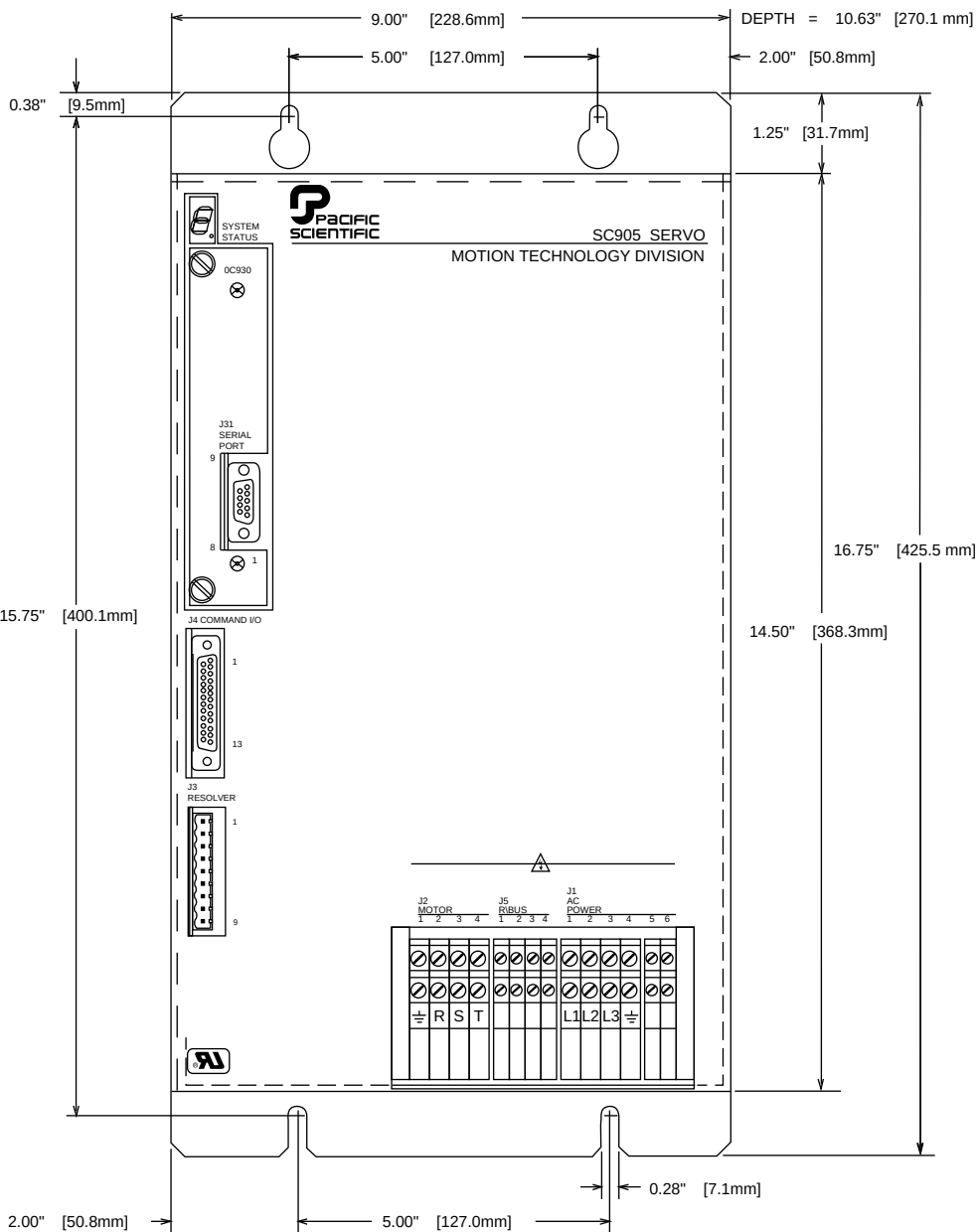
AGENCY APPROVAL

- UL recognized – 508C (Type R) – file #E137798
- Meets CSA Standard, C22.2 #142-M1987
- Meets IEC Vibration Standard, #68-2-6

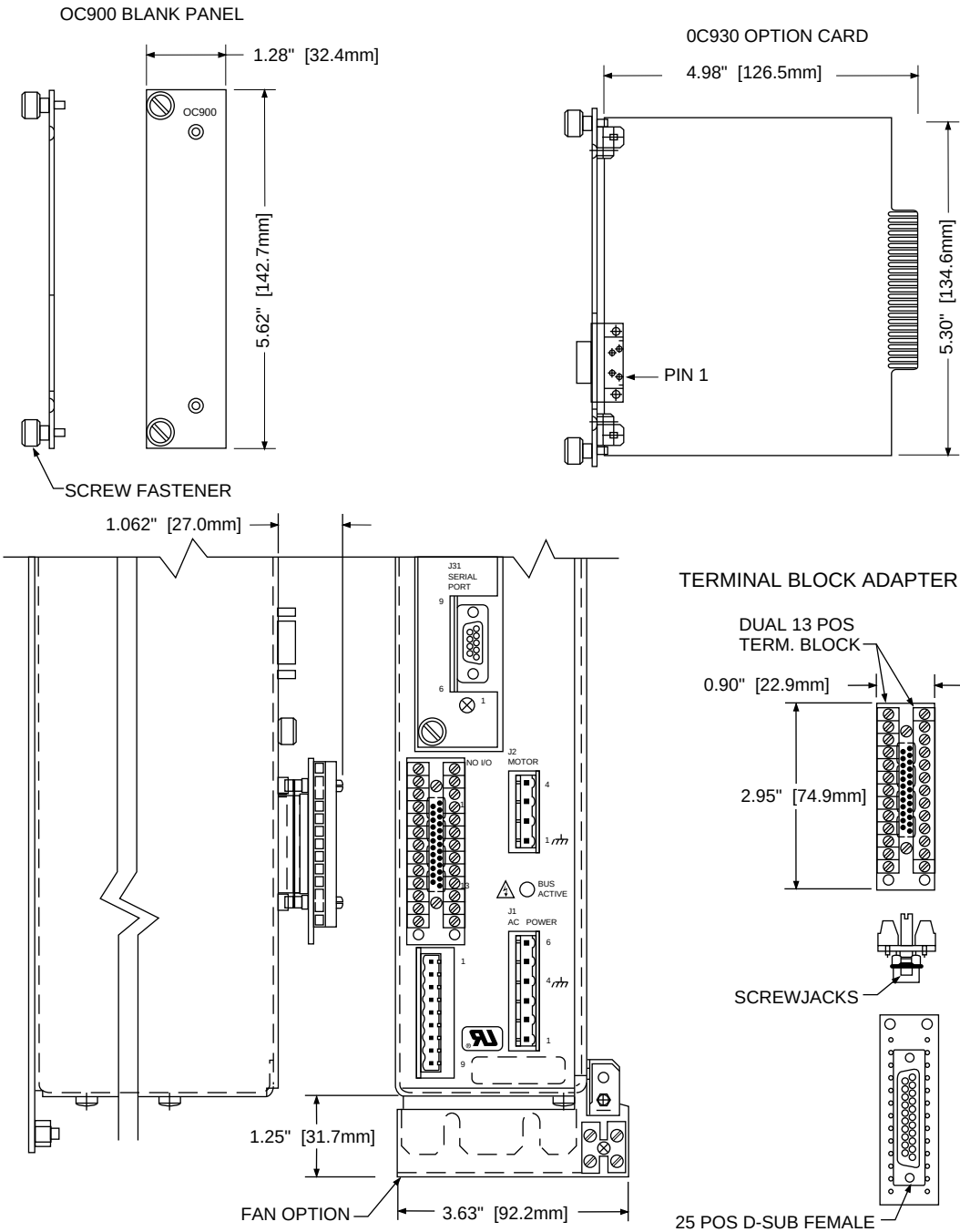
SC902, 903 and 904



SC905



SC900 SERIES OPTIONS



GENERAL...SC900 Digital Drives

Analog Input Command	
Range	±13.5V velocity or torque
Resolution	≥14 bits
Offset	Adjustable to zero
Offset drift	100 µV/°C typical
Digital Input Command	
Modes	Step/Direction, Step Up/Step Down, Quadrature Encoder
Maximum input frequency	
Step/Direction, Pulse Forward/Reverse	1 MHz
Quadrature Encoder	833 kHz
Current Loop	
Bandwidth	1500 Hz maximum
Update period	62.5 µS
Velocity Loop	
Bandwidth	400 Hz maximum
Update period	250 µS
Command resolution	<0.001 rpm
Feedback accuracy	0.05% worst case
Feedback ripple	0.75% p-p at 1000 rpm (drive only) 3% p-p at 1000 rpm (with 20 arcmin resolver)
Feedback Resolution	0.014 rpm
Range	0 to 30,000 rpm
Position Loop	
Bandwidth	100 Hz maximum
Update period	1 mS
Command resolution	65,536 steps/rev (16 bits/rev)
Feedback accuracy	±5.3 arcmin (drive only) ±25 arcmin (with 20 arcmin resolver)
Feedback Resolution	16,777,216 (24 Bits/Rev)
Encoder Output Signals	
Type	Quadrature with marker pulse, differential TTL line driver
Resolution	128 to 16384 PPR by powers of 2 125 to 16,000 PPR by powers of 2
Maximum output frequency	833 kHz
Marker pulse width	1 quadrature pulse nominal
Serial Port (Serial Comm Option Card)	
Type	RS-232, RS-485
Baud rate	9600 baud
Maximum RS-485 nodes	32
Dedicated I/O	Enable 5V or 24V compatible
Programmable I/O	6 bi-directional 5V or 24V compatible, 2 analog outputs
Mating connectors	
	Power-screw terminal Signal-screw terminal or D-connectors

ENVIRONMENTAL . . . SC900 Digital Drives

Storage temperature	- 40°C to 70°C
Operating temperature	
Full ratings	0°C to 50°C
Derated convection 	25°C to 60°C
Derated forced air 	50°C to 60°C
Altitude	1500m (5000 ft.)
Humidity	10% to 90%, non-condensing

 Linearly derate output power and output current from full rating at 25°C to 53% at 60°C.

 Linearly derate output power and output current from full rating at 50°C to 66% at 60°C.

POWER DATA. . .SC900 Digital Drives

	SC9x2	SC9x3	SC9x4	SC9x5
Input Voltage Control logic power Bus power (with 240 Vac, 3 phase)	90 to 264 Vac, 50/60 Hz, 1 phase 120/240 Vac (+ 10%, -15%) 50/60 Hz, 1 or 3 phase			
Input Current Control logic power Bus power	500 mA max. @ 120 Vac, 250 mA max. @ 240 Vac. 4.5 A _{rms} 9 A _{rms} 18 A _{rms} 29 A _{rms} (@6kW)			
Peak Output Current (0-p) [△] 5 Seconds, up to full 50°C	7.5 A	15 A	30 A	60 A
Continuous Output current (0-p) [△] 25°C Convection cooling 50°C Forced air cooling 50°C Convection cooling	3.75 A 3.75 A 2.5 A	7.5 A 7.5 A 5.0 A	15 A 15 A 10 A	30 A 30 A 30 A
Peak Output Power @ 240 Vac [△] 1 second, up to full 50°C	2.2 kW	4.5 kW	9 kW	18 kW
Continuous Output Power @240 Vac three phase 25°C Convection cooling 50°C Forced air cooling 50°C Convection cooling @240 Vac single phase [△] 25°C Convection cooling 50°C Forced air cooling 50°C Convection cooling	1.1 kW 1.1 kW 0.75 kW 0.80 kW 0.80 kW 0.55 kW	2.2 kW 2.2 kW 1.5 kW 1.6 kW 1.6 kW 1.1 kW	4.5 kW 4.5 kW 3.0 kW 2.3 kW 2.3 kW 1.5 kW	9 kW 9 kW 9 kW N/A N/A N/A
Power Stage Efficiency @ P_{cont}	>95%	>96%	>97%	>97%
Shunt Regulator Power Peak power (300 mSec) Continuous power 25°C Convection cooling 50°C Forced air cooling 50°C Convection cooling Maximum external regen duty cycle Bus capacitance energy absorption from 320V nominal bus	3.0 kW 20 W 25 W 20 W 16% 15 Joules	6.0 kW 40 W 50 W 40 W 12% 15 Joules	12 kW 100 W 125 W 100 W 6% 30 Joules	20 kW 200 W 200 W 200 W 10% 50 Joules
Output Current Ripple Frequency f_s	20 kHz	20 kHz	20 kHz	20 kHz
Minimum Motor Inductance L-I	2.6 mH	1.3 mH	.7 mH	0.3 mH
Maximum Motor Power Cable Length	50 m/164ft	50 m/164ft	50m/164ft	50m/164ft

- [△] For standard 120 Vac single phase operation, derate the Peak and Continuous Output Power ratings by 40%. Consult factory for 120 Vac bus voltage doubled customization specifications. Although possible, single phase operation of the SC9x4 and SC9x5 is not recommended.
- [△] Currents are the Zero-To-Peak of a Sinewave. Multiply by 0.707 to get RMS current values.

PARAMETERS. . .SC900 Digital Drives

Parameter (Partial List)	Description
Current Loop	
KIP	Current loop proportional gain (V/A)
ILMTPLUS	Plus current limit (%)
ILMTMINUS	Minus current limit (%)
COMMOFF	Commutation offset angle (Deg)
COMMSRC	Selects commutation feedback device
POLECOUNT	Motor pole count
ITTHRESH	Threshold for drive IT protection (%)
VBUSTHRESH	Threshold for low motor bus fault (V)
Velocity Loop	
KVP	Velocity loop proportional gain (A/rad/sec)
KVI	Velocity loop integral gain (Hz)
AFR0, ARF1	Anti-resonance filter break frequencies (Hz)
ARZ0, ARZ1	Anti-resonance zero frequencies (Hz)
Position Loop	
KPP	Position loop proportional gain (Hz)
KVFF	Velocity feed forward gain (%)
Block Type	
BLKTYPE = 0	Analog command torque block
BLKTYPE = 1	Analog command velocity block
BLKTYPE = 2	Incremental command position block
BLKTYPE = 4	Digital frequency command torque block
BLKTYPE = 5	Digital frequency command velocity block
With OC930	
BLKTYPE = 2	Serial port command position block
BLKTYPE = 8	Serial port command velocity block
Feedback Source	
REMOTEFB = 0	Use motor shaft resolver for position feedback
REMOTEFB = 1	Use encoder input for position feedback
REMOTEFB = 2	Use encoder input for position and velocity feedback
Encoder Output	
ENCOUT	Encoder output resolution (PPR)
Encoder Input	
ENCIN	Encoder input resolution (PPR)
ENCMODE	Encoder input mode, quadrature/step, dir/Up, Dn
Digital I/O	
BDIOMap1-6	Selects input or output function for each BDIO
Analog Out	
DMxMAP	Selects signal for channel x
DMxGain	Set output volt per signal unit
DMxF0	Low pass filter in Hz for channel x

SC900 SERIES RECOMMENDED MOTOR/DRIVE SYSTEMS [△]

In addition to the motors shown, a series of explosion-proof brushless servo motors are available. These motors are UL Listed (File 150845). Contact your PacSci distributor or Pacific Scientific direct for detailed technical information.

Peak stall torque T_{PS} [△] lb-in./Nm	Peak rated torque T_{PR} [△] lb-in./Nm	Cont. stall torque T_{CS} lb-in./Nm	Cont. rated torque T_{CR} lb-in./Nm	Rated Speed W_R [△] rpm	Inertia $\times 10^{-3}$ [△] lb-in-S ² / kgm ² J	Servo-motor Dia. or Width/height inch/mm	Servo-motor Length inch/mm	Inductance line-line L mH	Servo motor model	Servo-drive model [△]
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With R Series (low inertia, high performance) motors

10/ 1.1	6.5/ .7	4.8/ .5	2.5/ .3	8000	0.12/ .014	2.00/ 50.8	7.38/187.5	5.3	R22HENA-R1-NS-NV-01	SC932AN-001-01
14/ 1.6	8/ .9	7.6/ .9	5.2/ .6	8000	0.15/ .017	2.00/ 50.8	8.38/212.9	6.5	R23HENA-R1-NS-NV-01	SC932AN-001-01
17/ 1.9	10/ 1.1	9.2/ 1.0	7.1/ .8	6000	0.18/ .020	2.00/ 50.8	9.38/238.3	6.5	R24HENA-R1-NS-NV-01	SC932AN-001-01
27/ 3.0	25/ 2.8	14/ 1.6	10/ 1.1	4000	0.55/ .062	3.25/ 82.6	7.09/180.1	23.0	R32GENC-R2-NS-NV-00	SC932AN-001-01
27/ 3.0	25/ 2.8	14/ 1.6	6/ .7	7000	0.55/ .062	3.25/ 82.6	7.09/180.1	5.8	R32HENC-R2-NS-NV-00	SC933AN-001-01
36/ 4.0	33/ 3.7	21/ 2.4	16/ 1.8	3000	0.74/ .084	3.25/ 82.6	8.09/205.5	22.0	R33GENC-R2-NS-NV-00	SC932AN-001-01
36/ 4.0	25/ 2.8	21/ 2.4	10/ 1.1	6000	0.74/ .084	3.25/ 82.6	8.09/205.5	5.6	R33HENC-R2-NS-NV-00	SC933AN-001-01
45/ 5.0	42/ 4.7	27/ 3.0	24/ 2.7	2800	0.92/ .104	3.25/ 82.6	9.09/230.9	30.0	R34JENC-R2-NS-NV-00	SC932AN-001-01
45/ 5.0	38/ 4.3	27/ 3.0	16/ 1.8	4000	0.92/ .104	3.25/ 82.6	9.09/230.9	7.5	R34KENC-R2-NS-NV-00	SC933AN-001-01
54/ 6.0	53/ 5.9	32/ 3.6	30/ 3.4	2000	1.11/ .125	3.25/ 82.6	10.09/256.3	42.0	R35JENC-R2-NS-NV-00	SC932AN-001-01
54/ 6.0	48/ 5.4	32/ 3.6	23/ 2.6	3000	1.11/ .125	3.25/ 82.6	10.09/256.3	10.5	R35KENC-R2-NS-NV-00	SC933AN-001-01
66/ 7.4	50/ 5.6	33/ 3.7	33/ 3.4	1800	1.90/ .215	4.25/108.0	8.34/211.8	53.0	R43GENA-R2-NS-NV-00	SC932AN-001-01
66/ 7.4	60/ 6.7	33/ 3.7	31/ 3.5	3000	1.90/ .215	4.25/108.0	8.34/211.8	13.3	R43HENA-R2-NS-NV-00	SC933AN-001-01
106/11.9	95/10.6	48/ 5.4	46/ 5.2	2000	2.70/ .305	4.25/108.0	9.84/249.9	4.9	R45GENA-R2-NS-NV-00	SC933AN-001-01
106/11.9	95/10.6	48/ 5.4	43/ 4.8	4000	2.70/ .305	4.25/108.0	9.84/249.9	20.0	R45HENA-R2-NS-NV-00	SC934AN-001-01
142/15.9	120/13.4	64/ 7.2	61/ 6.8	1500	3.50/ .395	4.25/108.0	11.34/288.1	25.0	R46GENA-R2-NS-NV-00	SC933AN-001-01
142/15.9	120/13.4	64/ 7.2	50/ 5.6	3000	3.50/ .395	4.25/108.0	11.34/288.1	6.2	R46HENA-R2-NS-NV-00	SC934AN-001-01
150/16.8	125/14.0	70/ 7.8	58/ 6.5	3000	7.10/ .818	5.75/146.1	9.36/237.7	8.9	R63GENA-R2-NS-NV-00	SC934AN-001-01
150/16.8	142/15.9	70/ 7.8	38/ 4.3	6000	7.10/ .818	5.75/146.1	9.36/237.7	2.2	R63HENA-R2-NS-NV-00	SC935AN-001-01
240/26.9	230/25.8	115/12.9	102/11.4	1700	11.10/1.28	5.75/146.1	11.36/288.5	13.7	R65GENA-R2-NS-NV-00	SC934AN-001-01
240/26.9	200/22.4	115/12.9	90/10.1	3000	11.10/1.28	5.75/146.1	11.36/288.5	3.4	R65HENA-R2-NS-NV-00	SC935AN-001-01
340/38.1	305/34.2	168/18.8	156/17.5	1000	15.10/1.74	5.75/146.1	13.36/339.3	18.2	R67GENA-R2-NS-NV-00	SC934AN-001-01
340/38.1	330/37.0	168/18.8	146/16.4	2000	15.10/1.74	5.75/146.1	13.36/339.3	4.6	R67HENA-R2-NS-NV-00	SC935AN-001-01
300/33.6	280/31.4	190/21.3	125/14.0	3800	39.10/4.50	7.50/190.5	10.93/277.6	3.2	R84GENA-R2-NS-NV-00	SC935AN-001-01
410/45.9	395/44.2	276/30.1	225/25.2	2000	58.10/6.69	7.50/190.5	12.93/328.4	3.6	R86GENA-R2-NS-NV-00	SC935AN-001-01
540/60.5	525/58.8	357/28.8	325/36.4	1500	76.10/8.77	7.50/190.5	14.93/379.2	4.0	R88GENA-R2-NS-NV-00	SC935AN-001-01
800/89.6	730/81.8	451/50.5	424/47.5	1200	95.10/10.96	7.50/190.5	16.93/430.0	7.4	R8AGENA-R2-NS-NV-00	SC935AN-001-01

With F Series (medium inertia for load matching) motors [△]

60/ 6.8	50/ 5.6	33/ 3.7	32/ 3.6	1500	9.20/1.04	4.25/108.0	8.34/211.8	49.0	F43GENA-R2-NS-NV-00	SC932AN-001-01
60/ 6.8	50/ 5.6	33/ 3.7	31/ 3.5	3000	9.20/1.04	4.25/108.0	8.34/211.8	12.0	F43HENA-R2-NS-NV-00	SC933AN-001-01
80/ 9.0	65/ 7.3	48/ 5.4	48/ 5.4	1000	13.70/1.55	4.25/108.0	9.84/249.9	69.0	F45FENA-R2-NS-NV-00	SC932AN-001-01
80/ 9.0	65/ 7.3	48/ 5.4	47/ 5.3	2000	13.70/1.55	4.25/108.0	9.84/249.9	17.0	F45GENA-R2-NS-NV-00	SC933AN-001-01
115/13.0	88/ 9.9	63/ 7.1	61/ 6.9	1500	17.70/2.00	4.25/108.0	11.34/288.1	24.0	F46GENA-R2-NS-NV-00	SC933AN-001-01
115/13.0	88/ 9.9	63/ 7.1	56/ 6.3	3000	17.70/2.00	4.25/108.0	11.34/288.1	6.0	F46HENA-R2-NS-NV-00	SC934AN-001-01

[△] See page A-56 for definitions of ratings.

[△] Peak torque ratings are for 5 seconds.

[△] Rated speed is provided for operation on 240 Vac 3-phase line. Reduce to approximately 85% for 240 Vac 1-phase line operation and to 40% for 120 Vac 1-phase line operation.

[△] Includes primary feedback inertia.

[△] Model numbers shown include full accessory kit and OC930-001 serial communications card. These models *do not include* the 240 Vac fan option. See "How to Order" on page B-18 for more information.

[△] Each system requires one feedback and one motor power cable.

CONNECTION DIAGRAM . . . SC900 Series Digital Drives

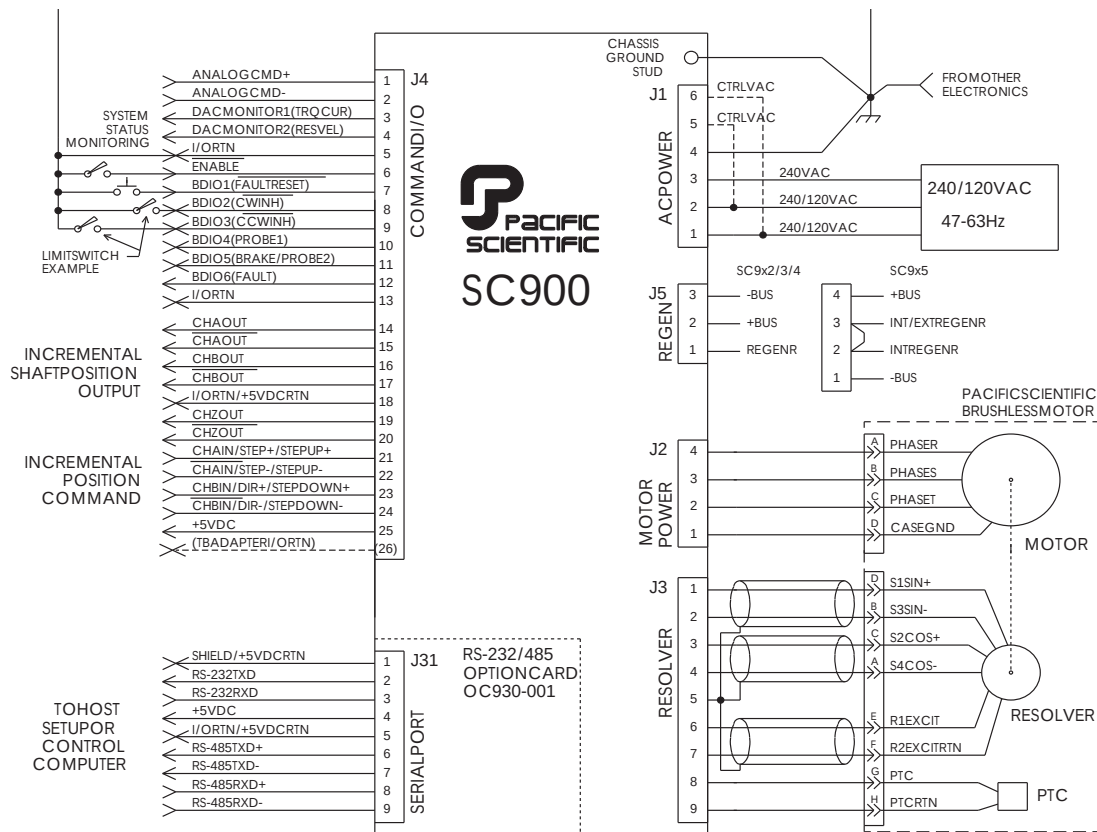


Table 2: Status LED Code List

0	No faults, power stage disabled, bus voltage OK.
8	No faults, power stage enabled, bus voltage OK.
8 < Alternating	No faults, power stage enabled, CcInh active preventing CCW motion
8 > Alternating	No faults, power stage enabled, CwInh active preventing CW motion
8 n Alternating	No faults, power stage enabled, CwInh and CcInh both active preventing motion.
1 Blinking	Velocity feedback (VelFB) over speed
2 Blinking	Motor over temperature
3 Blinking	Drive over temperature
4 Blinking	Drive I*t
5 Blinking	SC9x3: Line-neutral over current
6 Blinking	Control $\pm 12V$ under voltage
7 Blinking	Output over current or Bus over voltage
9 Blinking	Shunt regulator overload
A Blinking	Bus over voltage detected by DSP
b Blinking	Auxiliary +5V low
C Blinking	Not assigned
D Blinking	Not assigned
*E	Processor throughput fault
*E Blinking	Control power ac line dip or power up self test failure
E 1 Blinking	Bus under voltage, bus voltage < VBUSTHRESH*
E 2 Blinking	Ambient temperature too low
E 3 Blinking	Encoder commutation alignment failed (Only for CommSrc = 1)
E 4 Blinking	Software and non-volatile memory versions not compatible
*E 5 Blinking	Control card hardware not compatible with software version
E 6 Blinking	Drive transitioned from unconfigured to configured while enabled
F 1 Blinking	Position following error fault
F 3 Blinking	Parameter memory error
U C Blinking	Unconfigured drive

* These fault states can not be reset with the Fault Reset function and require the line control power to be cycled.

SC900 DIGITAL DRIVES . . . System Connection Diagrams

±10 V analog interface-- velocity or torque control

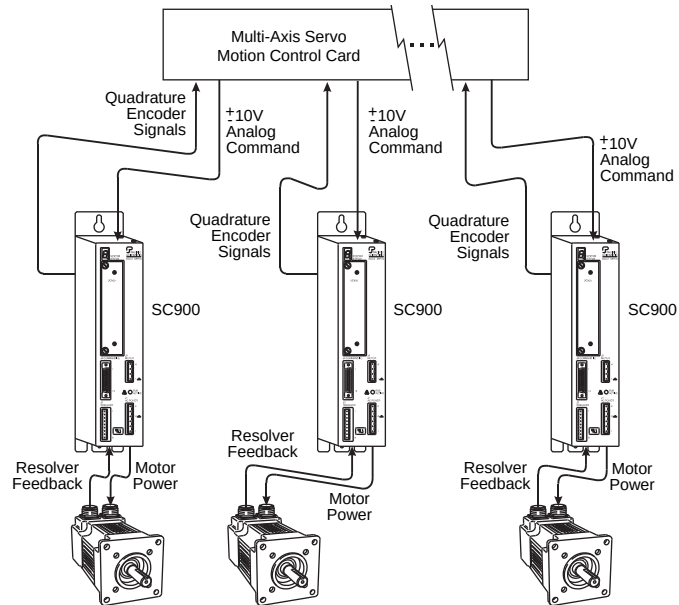


Figure B-1

This multi-axis application utilizes a typical multi-axis motion control card. The motion control card generates ± 10 V analog commands for each axis drive. These analog commands control either motor torque or motor velocity. If the control card is commanding torque, the system's velocity loop is closed in the motion control card. If the control card is commanding velocity, the drive closes the velocity loop in the system. The SC900 drive generates quadrature encoder feedback signals from the motor's resolver. These quadrature encoder signals are used by the motion control card to close the system's position loop and to execute the motion profiles.

step/direction digital interface--velocity or position control

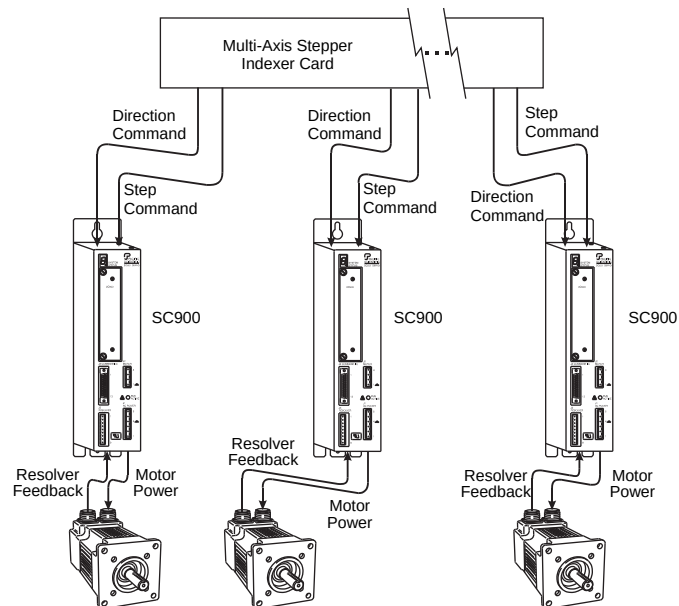


Figure B-2

This multi-axis application utilizes a typical multi-axis stepper indexer card. The indexer generates step and direction commands for each axis drive. These commands control the velocity and position of the servo systems. The drive closes the current, velocity and position loops. Position commands are received via the step and direction interface.

SC900 DIGITAL DRIVES . . . System Connection Diagrams

host computer
digital interface—
velocity, torque
or position control

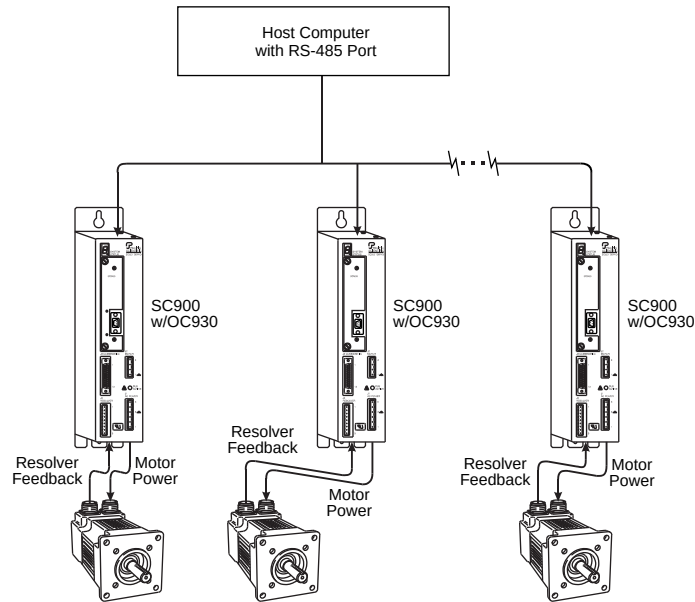


Figure B-3

This multi-axis application utilizes a computer equipped with a serial port. The computer generates velocity, torque or position commands. In that the 9600 Baud serial communications is not very fast, this configuration is best suited for slowly changing or "set and forget" types of applications. It is economical and easy to install. For fast changing applications, refer to Figures B-1 and B-2 (page B-16) and B-4 below.

SERCOS distributed
multi-axis control—
velocity, torque or
position control
(available soon)

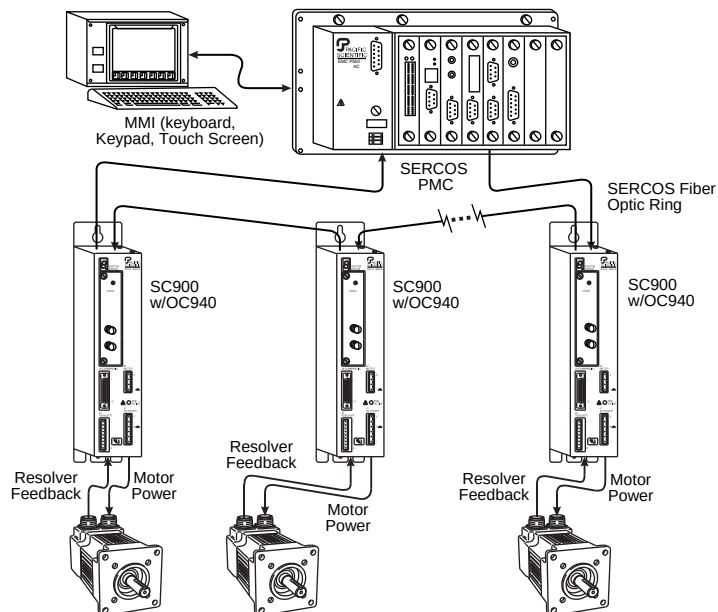


Figure B-4

This multi-axis application utilizes a SERCOS control and SERCOS compatible drives (slaves). SERCOS (**S**ERIAL **R**ealtime **C**OMMUNICATIONS **S**ystem) provides a **distributed** multi-axis control topology and is a digital interface international standard. The traditional multi-axis control topology is centralized as shown in Figure B-1 (page B-16). The distributed SERCOS topology is analogous to a network of PCs while the traditional centralized approach is analogous to a mainframe with dumb terminals.

HOW TO ORDER . . . SC900 Digital Drive . . . Base Drive

MODEL NUMBER CODE	SC	9	0	3	N	N	-	00	1	-	01
Servo Drive Family Designation _____											
Option Card Designator _____											
0 = No option card installed											
3 = OC930-001-00 Serial Port Option Card installed											
4 = OC940-001-01 SERCOS Interface Option Card installed											
5 = OC950-50X-01 Programmable Option Card installed											
(X – See Customization Code below)											
Power Level _____											
2 = 7.5 A peak, 3.75 A continuous @ 25°C											
3 = 15 A peak, 7.5 A continuous @ 25°C											
4 = 30 A peak, 15 A continuous @ 25°C											
5 = 60 A peak, 30 A continuous @ 50°C											
Accessories Option _____											
N = No accessory kit											
A = Basic connector kit, manual(s)											
T = Terminal block adapter connector kit, manual(s)											
Fan Kit Option _____											
N = No fan, convection cooled											
2 = 240 Vac Fan, forced air cooled											
1 = 120 Vac Fan, forced air cooled											
Customization Code, Factory assigned) _____											
001= Standard Unit											
NOTE: The following customization codes are only valid when ordering an SC950.											
501= OC950 32Kx8 NV RAM, without PacLAN											
502= OC950 128Kx8 NV RAM, without PaacLAN											
503= OC950 32Kx8 NV RAM, with PacLAN											
504= OC950 128Kx8 NV RAM, with PacLAN											
Firmware _____											
01= Standard base servo software											

NOTE: Base Servo drive includes Information Sheet. Manual and accessories ordered separately or included by using the **Accessories Option** designator.

HOW TO ORDER . . . SC900 Digital Drive . . . Drive Accessories

Accessory	Description	Order Number
Option Cards:		
Blank panel	This is a blank panel to cover an unused option card slot.	OC900-001
Firmware upgrade	This option card allows easy plug-in upgrading of the SC900 firmware and allows removable personality.	OC900-002-01
Serial communications	This option card adds RS-232/485 serial communications to the base SC900. Suffix -00 is standard, -01 includes base unit firmware upgrade. Includes 3-1/2" floppy disk with PC communications utility.	OC930-001-0x
SERCOS interface	This option card adds SERCOS interface capability to the base SC900.	OC940-001-01
Programmable	This option card adds programmable functionality to the base SC900.	OC950-50X-01
Connector Kits:		
All mating connectors w/D-sub	Includes all mating connectors for base unit. Screw terminal blocks for power and D-sub for signal. X designates drive power level.	CA90x
All mating connectors w/D-sub to TB adapter	Includes all mating connectors for base unit. Screw terminal blocks for power and D-sub to screw terminal adapter modules for signal.	CA90x-TB
Fan Kits:		
Fan kit for SC9x2/3/4	Adds forced air cooling to the SC9x2, SC9x3, SC9x4. Suffix -002 is for 240 Vac 50/60 Hz, -001 is for 120 Vac 60 Hz.	OF902-00x
Fan kit for SC9x3/4	Adds forced air cooling to the SC9x3/4. Suffix -002 is for 240 Vac 50/60 Hz, -001 is for 120 Vac 60 Hz.	OF903-00x OF903-00x OF904-00x
Manuals:		
SC900 base drive	Hardware reference manual for SC900 base drives.	MA900
OC930 option card	Hardware/software reference manuals for the serial communications option card.	MA930
OC940 option card	Hardware/software reference manuals for the SERCOS interface option card.	MA940
OC950 option card	Hardware/software reference manuals for the programmable single axis option card	MA950

HOW TO ORDER . . . SC900 Series Recommended Motor/Drive Systems

See Recommended Motor/Drives Systems table on page B-14 for performance information and model numbers for servo motor/drive combinations. Order motors and drives as separate part numbers.

OC950 OPTION CARD

Programmable Single Axis Position Control Option Card

FEATURES

- New Windows® Development Environment
- Compiled ServoBasic™ Software
- Powerful Interactive Debugger
- Intel™ MicroController Inside
- 21 Programmable and Configurable I/O
- Optional Connection to Opto-22 I/O
- Optional PacLAN™ Local Area Network
- 32K NV Memory w/Optional 128K Available
- 8 Programmable Limit Switches w/Module
- Fully Adjustable Motion Profile Parameters
- Interrupts on Motion & Program Variables

BASIC PROGRAMMING LANGUAGE

Since first introducing a standard software programming tool like BASIC in a drive 1987, Pacific Scientific has continued to enhance the functionality and ease of use. The fourth generation OC950 and Windows® development with motion functions like RunSpeed and IndexDist integrated with standard While:Wend and For:Next statements to give you true motion programming flexibility. Why not use a language you know already?

WINDOWS DEVELOPMENT ENVIRONMENT

This development environment lets you program in modular blocks that can easily be re-used time and time again. The easy to use editor and powerful debugger with program variable watch windows make troubleshooting easy. Easy to use as a simple word processor, yet the structured text language controls the most complex machines.



CONFIGURABLE BI-DIRECTIONAL I/O

The OC950 has 21 digital I/O ports. These ports can be configured as either inputs or outputs. The ServoBasic program also has access to the SC900 base drive's six I/O for a total of 27 ports. The days of not having the right mix of inputs and outputs are over. This I/O can be used to interface to your PLC, or control machine sensors and other control devices. For fully flexible industrial I/O the OC950 ports are Opto-22 compatible.



FEATURES WHEN COMBINED WITH THE SC900 FAMILY OF BRUSHLESS SERVO DRIVES

- Completely Digital Set-Up and Tuning
- DSP Based Servo Control Algorithms
- Encoder Input and Encoder Output
- Analog Input and Two Analog Outputs
- Two High Speed Registration Inputs
- Digital Fault Code Information
- Full Protection and Diagnostics
- Ability to Run Linear Motors
- Exclusive Signature Current Control
- Patented DRDC Resolver ASIC
- Full Range of Servo Motors up to 800 lb-in

LOCAL AREA NETWORK OPTION

In addition to the standard RS232/485 Serial interfaces the OC950 can be ordered with Pacific Scientific's PacLAN™ interface. This is ideal for networking drives together. It is a 2.5 Mbaud token passing communications port where all variables and real time motor information can be passed from drive to drive. Connect up to 250 drives together with PacLAN™ and you still have your serial ports left over to communicate with your Man Machine Interface!

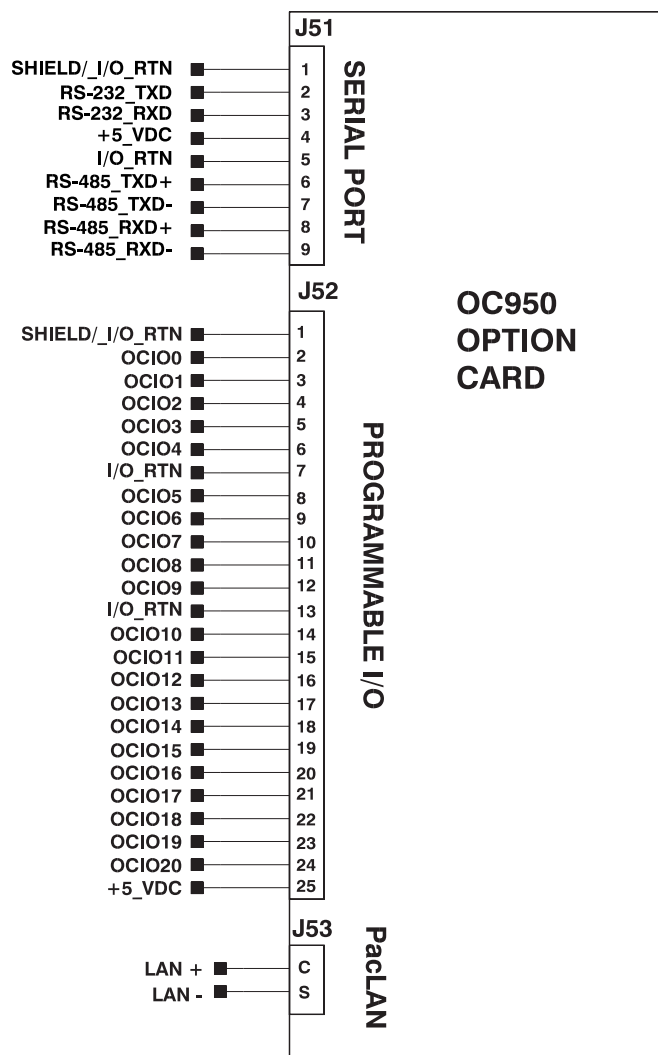
BUY ONLY WHAT YOU NEED

Like the rest of the SC900 Series products, the OC950 can be ordered with or without options. Modular ordering allows you to build up the options that suit your needs and not pay for extras you won't use. Even the Windows Development Environment is a one time purchase item for the cost conscious OEM.

ServoBASIC Plus™

For details on Pacific Scientific's ServoBASIC Plus™ software, see pages B-35 through B-39. For programming examples using this language, see pages B-40 through B-47.

DIMENSIONS in. (metric dimensions for ref. only)



HOW TO ORDER . . .OC950 Programmable Single Axis Option Card

Programmable Option Card

OC950-50X-01 (where X determines the hardware options)

- 501 - OC950 32Kx8 NV RAM, without PacLAN
- 502 - OC950 128Kx8 NV RAM, without PacLAN
- 503 - OC950 32Kx8 NV RAM, with PacLAN
- 504 - OC950 128Kx8 NV RAM, with PacLAN

Manuals

OC950 Option Card

MA950-IDE - Hardware/Software reference manuals - plus Integrated Development Environment on 3.5" PC Disk

Connector Kits

CA950-IO - OC950 Industrial I/O Rack interface adapter board

OC940 OPTION CARD

OC940 OPTION CARD DIGITAL FIBER OPTIC Single Axis SERCOS Option Card

FEATURES

- Fiber optic noise free environment.
- 32-bit performance
- SERCOS interface
- Intel™ MicroController inside
- 8 optically isolated inputs
- 8 optically isolated outputs
- Simplified interconnect
- Intelligent drive

When combined with the SC900 servo drive the OC940 option card is designed for use in distributed, multi-axis motion control systems utilizing the SERCOS (Serial Realtime Communications System) digital interface international standard. SERCOS replaces the +/- 10 volt analog servo command interface with a high speed, digital, fiber optic link. The SERCOS standard allows bi-directional flow of information. The control sends position, velocity and torque commands and the drive reports actual data back.

SERCOS

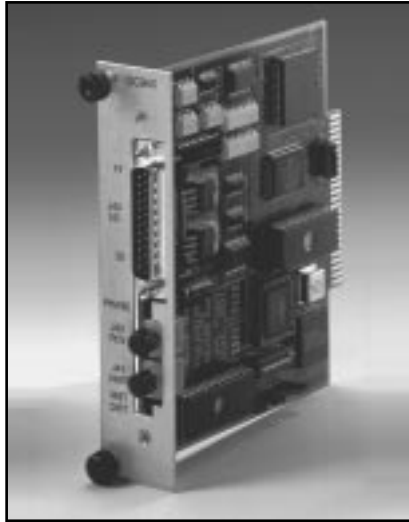
SERCOS is an open fiber optic based controller to digital drive interface international standard. The SERCOS interface is designed to communicate closed loop data serially in real time for high performance motion control systems. The SC900 control is a digital drive incorporating low cost digital signal processors (DSPs) that when combined with the OC940 option card exploit the most current innovations in motion control to date.

NOISE FREE ENVIRONMENT

A single fiber optic cable ring is the only connection necessary between the motion controller and the drives. Cable lengths of up to 100 meters can be achieved between controller and drive without any concern of signal corruption.

SIMPLIFIED INTERCONNECT

When compared to a conventional multi-axis motion system the OC940 offers a much simpler approach. A typical analog system requires many low voltage interconnects between the drive and controller. The troublesome task of running numerous wires throughout conduit and debugging them is reduced to running a single fiber optic cable. The wiring between motor and drive can be done local to where the motor is being used.



OPTICALLY ISOLATED I/O

The OC940 comes standard with 8 configurable optically isolated inputs and 8 optically isolated outputs. The I/O is 5 Vdc to 30 Vdc compatible.

INTELLIGENT DRIVE

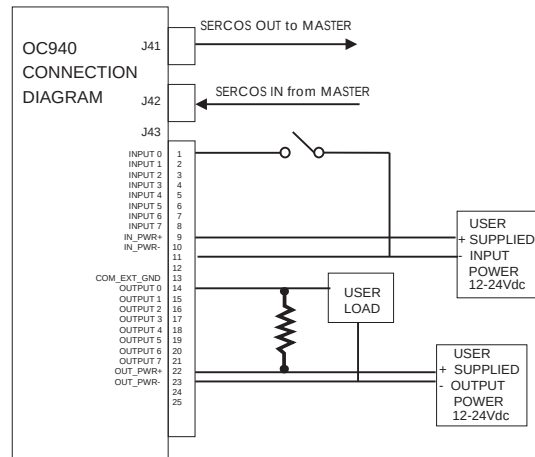
The OC940 closes all its loops locally. The position, velocity and torque blocks are maintained within the drive. This allows the motion controller to be freed up to generate the motion profiles. Up to 16 axes of motion profiles can be updated every 2 mSeconds.

This 2 mSecond update rate should not be confused with the servo loop update rates. The servo loop update rates are controlled by the drives local processor. In traditional centralized systems, the profile generator update rate is typically not specified since this interface is buried within the controller.

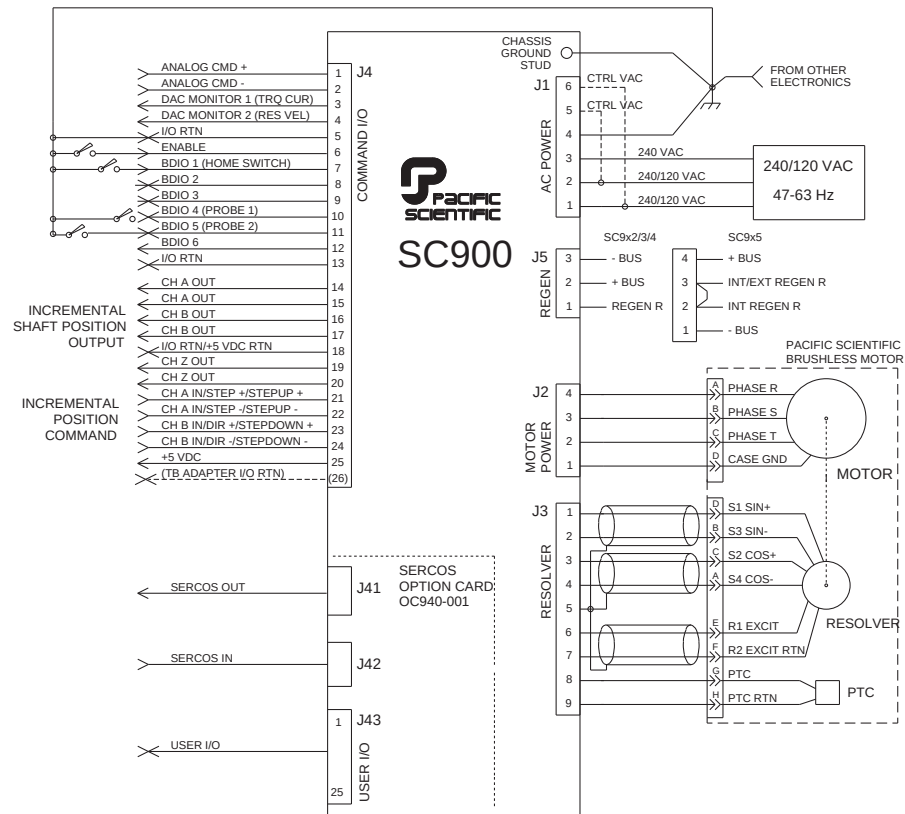
HOW TO ORDER

The OC940 option card is designed to plug in to any SC900 servo drive. See page B-22 for more details.

CONNECTION DIAGRAM. . .Model OC940



CONNECTION DIAGRAM. . .Model SC940



HOW TO ORDER . . .OC940 Single Axis Option Card

SERCOS Option Card

OC940-001-01

SERCOS Option Card for SC900 Drives

Manuals

OC940 Option Card

MA940

Hardware & Software Reference Manual

Connector Kits

CA940

All mating connectors with D-sub signal connector

CA940-TB

All mating connectors with D-sub to terminal block adapter.

HOW SERCOS WORKS-AN OVERVIEW

The SERCOS interface is implemented using a master-slave configuration, interconnected unidirectionally over a fiber optic cable, in a ring structure. The data transfer rate is 4 Mbits/s with an update time of 2 msec.

The Pacific Scientific/Automation Intelligence programmable motion controller (or similar controller) is the master and the brushless drives with SERCOS option cards are the slaves. The motion controller controls the flow of information by sending out a synchronization "heartbeat" called the MST every 2 msec. See Figure B-5. All the slaves sequentially receive the MST.

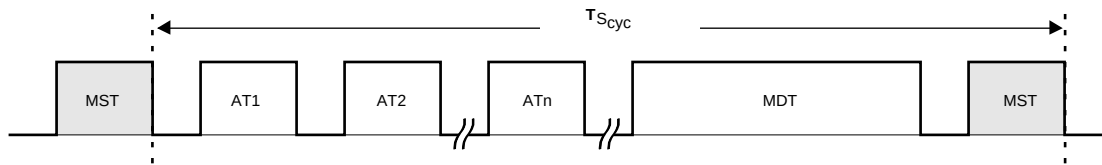


Figure B-5. SERCOS Master Synchronization Telegram-MST

The drives internally synchronize themselves to the MST clock and send back current drive information to the master during "time slot" intervals. This current drive information is contained in the Amplifier Telegram, or AT. (See Figure B-6). The AT is configurable, although it typically consists of time-critical data such as actual position, velocity and torque.

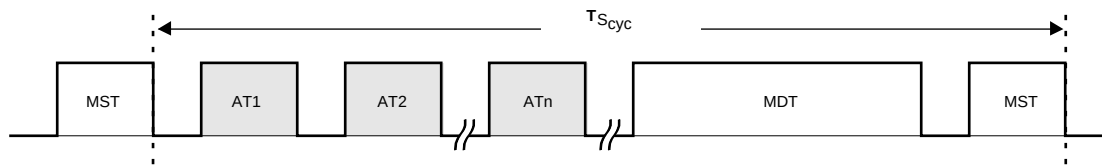


Figure B-6. SERCOS Amplifier Telegram-AT

At the end of each cycle, a Master Data Telegram, or MDT is sent to the slaves. See Figure B-7. The new command values for each drive on the ring are contained in this MDT.

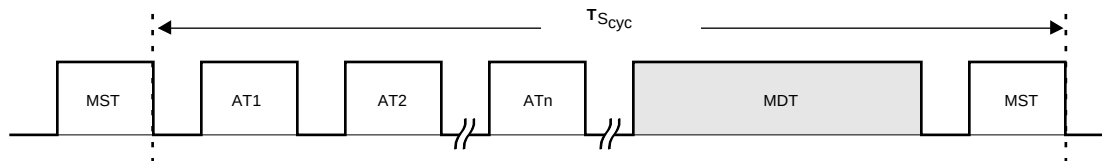


Figure B-7. Master Data Telegram-MDT

IDENTIFICATION NUMBERS (IDN)

- All parameters defined as IDNs
 - 32-bit integers
 - Lists of other IDNs
 - 16-bit Words
 - Text
- IDN Definition Includes
 - Value
 - Description
 - Attributes
 - Min, Max
 - Units
- The SERCOS Option Card supports the following IDNs as defined by the SERCOS standard. The SERCOS host controller and its software allow setting and reading of these IDNs.
 - 1 Control Unit Cycle Time (Tncvc)
 - 2 SYSTEM Interface Cycle Time (Tscvc)
 - 3 Minimum AT Transmit Starting Time (Tlmin)
 - 4 Transmit/Receive Transition Time (TATMT)
 - 5 Minimum Feedback Acquisition Time (T4min)
 - 6 AT Transmission Starting Time (TI)
 - 7 Feedback Acquisition Starting Time (T4)
 - 8 Command Valid Time (T3)
 - 9 Beginning Address in Master Data Telegram
 - 10 Length of Master Data Telegram
 - 11 Class 1 Diagnostics
 - 14 Interface Status
 - 15 Telegram Type Parameter
 - 16 Custom Amplifier Telegram Configuration List
 - 17 IDN List of all Operation Data
 - 24 Configuration List of the Master Data Telegram
 - 32 Primary Mode of Operation
 - 40 Velocity Feedback Value
 - 41 Homing Velocity
 - 42 Homing Acceleration
 - 43 Velocity Polarity Parameter
 - 44 Scaling of Velocity Data
 - 45 Scaling Factor for Velocity Data
 - 46 Scaling Exponent for Velocity Data
 - 47 Position Command Value
 - 51 Position Feedback Value 1 (Motor Feedback)
 - 52 Actual Position Feedback 1-Reference Distance
 - 55 Position Polarity Parameters
 - 76 Position Data Scaling Method
 - 77 Linear Position Data Scaling Factor
 - 78 Linear Position Data Scaling Factor Exponent
 - 79 Rotational Position Resolution
 - 88 Receive to Receive Recovery Time (TMTSY)
 - 89 MDT Transmit Starting Time (T2)
 - 90 Command Value Transmit Time (TMTSG)
 - 95 Diagnostic Message
 - 99 Reset Class 1 Diagnostics
 - 103 Modulo Value
 - 108 Feedrate Override
 - 123 Feed Constant
 - 127 Communications Phase 3 Transition Check
 - 128 Communications Phase 4 Transition Check
 - 130 Actual Position Value Probe 1 Positive Edge
 - 131 Actual Position Value Probe 1 Negative Edge
 - 138 Bipolar Acceleration
 - 147 Homing Parameter
 - 148 Drive-Controlled Homing Procedure Command
 - 160 Scaling Method for Acceleration Data
 - 161 Scaling Factor for Acceleration Data
 - 162 Scaling Exponent for Acceleration Data
 - 169 Probe Control Parameter
 - 170 Probing Cycle Procedure Command
 - 185 Length of the Configurable Data Record in the AT
 - 186 List of the Configurable Data Record in the MDT
 - 187 List of the Configurable data in the AT
 - 188 List of the Configurable data in the MDT
 - 301 Allocation of Real-Time Control Bit 1
 - 303 Allocation of Real-Time Control Bit 2
 - 305 Allocation of Real-Time Status Bit 1
 - 307 Allocation of Real-Time Status Bit 2
 - 400 Home Switch
 - 401 Probe 1
 - 403 Position Feedback Value Status
 - 405 Probe 1 Enabled
 - 409 Probe 1 Positive Latched
 - 410 Probe 1 Negative Latched

DIAGNOSTIC DATA

In addition to the real-time transmission between the control and drives, SERCOS also provides advanced diagnostic and fault information on the same fiber optic cable. Non time-critical data such as set up parameters, tuning coefficients and homing functions are available through the SERCOS service channel without connecting to any additional I/O. Also incorporated is an oscilloscope function that digitally captures and stores noise-free torque, velocity and position samples for later analysis.

GENERAL MOTION CONTROL

SERCOS was originally developed for machine tool applications. Later, SERCOS has evolved for general motion control and can control typical requirements such as:

- Point-to-point moves
- Electronic gearing
- Electronic CAM profiles
- Registration
- Measurements
- Electronic drive trains

USER CONNECTIONS

- On SERCOS Option Card
 - J41 SERCOS out to master
 - J42 SERCOS in from master
 - J43 8 inputs, 8 outputs
 - Opto input power
 - Opto output power
- On Host Servo Drive
 - J3 Resolver Feedback and Motor PTC
 - J2 Motor Power
 - J1 AC Input
 - J5 Regen
 - J4-6 Enable
 - J4-7 Home Input
 - J4-10 Probe 1
 - J4-11 Probe 2

ADDRESS SELECTION DIP SWITCH

- Eight switches used for selecting the OC940 SERCOS address. Each servo drive on the SERCOS ring must be assigned a unique address.

SERCOS—QUESTIONS AND ANSWERS

What is SERCOS?

SERCOS (**S**ERIAL **R**eal-time **C**OMMUNICATION **S**ystem) is an open fiber optic based controller to digital drive interface international standard. The SERCOS interface is designed to communicate closed loop data serially in real time for high performance motion control systems.

Why a digital standard?

Today, the purely digital drive system is becoming more prevalent. The digital servo drive has no analog circuits and uses no analog feedback loops. Incorporating low cost, high-performance digital signal processors (DSPs), this technology offers enhanced capability well beyond analog drives. But to fully exploit its potential, a well-defined and standardized digital interface must also be specified. The reason is that if a digital motion controller must control a digital drive, through an analog signal, resolution is sacrificed and noise sensitivity becomes an issue. Even if both digital units operate internally with numerical precision of 32 bits, A/D and D/A conversion typically occurs only at 12 to 16-bits, introducing electrical noise and thereby limiting the full capabilities of the drive.

What are the advantages of an open interface?

Proprietary, vendor specific digital interfaces have existed since the 1980s. However, they restrict the user to a single source for both drives and control. This limits the user's ability to select components based on application need and creates a substantial support burden when equipment from various suppliers must be maintained. Obviously, the motion control industry is best served in the long run by an open interface specification.

Who developed the standard?

SERCOS was initiated in 1987 by a group of European machine builders who were concerned about the impending problems of multiple digital interfaces. One of the stated goals of SERCOS is to ensure that the exchange of data required for utilizing digital drives does not obstruct individual development of drives and controls. It was developed jointly by the German Machine Tool Builders Association and the German Electrical and Electronic Manufacturers Association. These two associations have assembled major manufacturers of motors, drives and CNCs into a joint working group. Companies who have joined in the SERCOS working group include Pacific Scientific/Automation Intelligence, AEG, ABB, AMK, Baumuller, Bosch, Indramat, and Siemens.

How is SERCOS implemented?

The transmission medium is plastic fiber optic cable, implemented in a fiber optic ring currently running at 4 MB/s. The current SERCOS implementation permits up to 32 drives to be connected to one fiber optic ring with a position profile update time of 2 ms. The topology is a ring structure in which MASTER and SLAVES are connected unidirectionally. The MASTER controls and synchronizes the ring and a SLAVE can service one or multiple drives.

What about cost?

At the end of 1993, a SERCOS application specific integrated circuit (ASIC) was introduced. It simplifies product designs incorporating the SERCOS interface by handling the low-level protocol SERCOS communication link. The host control writes to a dual-port RAM in the ASIC, which then handles messaging, timing, and communications with the drives. The use of the ASIC raises the data transfer rate to 4 Mbits/s and reduces the per node cost of the interface. Calculations show that the costs for a SERCOS interface correspond to those of an analog interface for the same drive. There are significant savings with respect to the controls, since a number of drives can be connected to each SERCOS interface.

What are other advantages?

Beyond the obvious advantages of an open digital interface, the physical implementation is simple to install and maintain and will operate reliably in the factory environment with up to a 100m interconnection path between units.

The immense requirements for conduit, wiring and terminations, which are normally associated with an analog interface, are eliminated with SERCOS. So are the long manhour requirements typically associated with installing an analog interface. The fiber itself is the sole connection between the controller and the drives. Since everything runs along a single fiber network, cable and termination cost is virtually non-existent. In fact, fiber's inherent noise immunity means that it can even run in the same conduit that carries high voltage enabling.

Is SERCOS close to adoption?

The Draft International Standard (DIS) has been submitted to the IEC. It is expected to be published as an international standard soon.

Is SERCOS just for machine tool/CNC applications?

Although originally envisioned and developed as a CNC to digital drive interface, this specification has proven itself to be widely applicable as an interface between general motion controls and digital drives. Industry has come to realize that all the basic primitives of general motion control can be implemented in a SERCOS ring—opening up vast new market potential.

SERCOS can be used effectively and efficiently to implement the following classes of general motion control functions:

- Point-to-Point Moves
- Electronic Gearing
- Electronic Cam Profiling
- Registration/Measurement
- Electronic Drive Trains

Where is SERCOS Specification headed?

Recently, industry has come to realize that all the basic primitives of general motion control can be implemented in a SERCOS ring, dispelling the myth that SERCOS is a viable standard only for CNC and machine tools. Numerous servo drive manufacturers have products either on the market or under development. With ASIC availability and IEC standardization, the technology will become more widely accepted in the motion control industry.

SC750 SERIES*

Digital Programmable Position Controllers 3.8A to 60A continuous current 7.5A to 120A peak

- Full digital control—featuring advanced commutation and position control methods
- Rugged single resolver feedback
- Digital auto-tuning for easy setup—no potentiometers to tweak
- Easy, flexible programming in ServoBASIC Plus™
- Turbo option features 50% faster program execution and 85K of program and data non-volatile user memory
- Extensive diagnostics to ease troubleshooting
- Total front access to clearly marked connections
- High speed (2.5 Mbaud) Local Area Network (PacLAN™) allows multiple axes to share information quickly
- 28 user programmable I/Os
- Standard 24K non-volatile user memory
- Inaudible, high frequency PWM current control
- Single and multi-axis use
- UL recognition

The SC750 Series brings fully digital, intelligent motion control to unforgiving industrial environments. In terms of reliability and performance, the SC750 anticipates real-world requirements.

Numerous technical innovations (patents pending) provide the SC750 with enormous application flexibility. These breakthroughs give you the best of both worlds: performance advantages previously limited to an analog implementation with digital precision, drift-free setup and operation.

Our ServoBASIC Plus™ software lets you program application-specific solutions with a high degree of comfort and confidence. Due to modular design, programming, wiring, setup and operation procedures are identical for all SC750 Series models.

With five power levels, the SC750 Series provides a position control capability to complement the SC720 torque/velocity controllers. When used in combination with Pacific Scientific brushless servo motors, SC750 Series controllers provide continuous torques ranging from 4.8 lb-in. to 451 lb-in. and peak torques from 10 lb-in. to 800 lb-in.

Standard motor power and feedback cables are available to complete your motion control system and provide reliable, troublefree startup and operation.

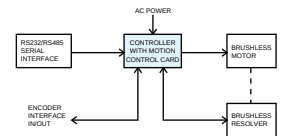
DIGITAL RESOLVER-TO-DIGITAL CONVERSION

A proprietary Resolver-to-Digital Conversion (RDC) process, Digital Resolver-to-Digital Conversion (DRDC) provides high-resolution digital velocity and position information for the SC750's microprocessor.

This technique (U.S. patent 5,162,798) has been implemented with dedicated digital signal processing (DSP) hardware for fast response. DRDC is the heart of the SC750's digital implementation.

Prior to DRDC, PacSci had refrained from the digital velocity loop compromise. Previous digital techniques offered freedom from drift and potentiometer setup—at the expense of excellent low speed smoothness and stiffness offered by analog tachometer feedback. With DRDC, motion control users can have the performance and setup capabilities they need.

Peak torque range:
10.0 to 800 lb-in.
(1.1 to 90 Nm)



SC750 Controllers
are UL Recognized
(File E137798)

SIGNATURE CURRENT CONTROL

The SC750 Series utilizes a patented Signature current control, a new, proprietary form of brushless motor commutation.

Brushless motors typically have a sinusoidal back EMF curve. However, this back EMF curve is never a pure sine wave. The result is torque ripple when the motor is driven with sinusoidal currents.

Pacific Scientific's Signature current control significantly reduces ripple torques due to distortion in the motor's back EMF waveform. By tailoring the sinusoidal current's wave shape or "signature" to match the motor's back EMF, ripple torque is reduced to $\pm 2\%$ or less.

Signature current control produces extremely low torque ripple at low speeds while retaining excellent high speed torque—a combination previously unavailable. In your application, this means excellent machine precision and smoothness with high throughput capability.

APPLICATION SPECIFIC INTEGRATED CIRCUITS

Application-specific integrated circuits (ASICs) make many of the SC750's powerful enhancements feasible on the factory floor. ASICs are cost effective and increase reliability by reducing component part count.

FULL DIGITAL CONTROL

All parameters required for system setup are digitally set in software. The SC750 Series has no potentiometers to tweak and no components to change.

Digital control assures reliable, repeatable, driftfree machine setup. Firmware running on a 16 bit microprocessor, coupled with the dedicated DRDC hardware, implements the DSP algorithms necessary for tight servo control.

**See pages B-6 through B-26 for information on the next generation Servo Position Control.*

AUTOTUNING

In many applications, the autotuning feature will automatically set up the servo compensation parameters. You won't need oscilloscopes, meters or other instruments—just a personal computer—to set up your system. The system allows you to select the type of performance desired.

DIAGNOSTIC PROGRAMS

Numerous diagnostic programs are included to ease the task of system integration into your machine. These diagnostics also simplify troubleshooting.

LOCAL AREA NETWORK

... PacLAN™

A 2.5 Mbaud, token passing communications port allows multiple axes to communicate and share information at high speed. PacLAN™ also serves as an expansion port for support of future SC750 enhancements.

The PacLAN port utilizes CRC error detection, message acknowledgement and a fully isolated cable driver for industrially reliable communications, even in high noise environments. See the programming example on page B-47.

IGBT PWM POWER STAGE

Insulated gate bipolar transistor (IGBT) technology is used in the power stage of every SC750 Series Controller. This technology makes exceptionally efficient use of high PWM frequencies (20 kHz). As a direct result, motor operation is more efficient and the annoyance of audible PWM noise is eliminated.

EXPANDABLE USER MEMORY

24K of battery-packed RAM user memory is standard for non-volatile storage of programs and setup variables.

For complex applications, the SC750 Turbo option offers 50% faster ServoBASIC *Plus* execution speed and provides 85K of battery backed RAM user memory. See "How to Order" on page B-34.

EXTENSIVE I/O

- 16 user programmable inputs
- 12 user programmable outputs
- Analog input
- Analog output
- 4 dedicated control inputs
- 5 dedicated control outputs

COMMUNICATIONS

- RS-232 interface, 9600 baud
- RS-485/422 interface, 9600 baud. Multidrop, up to full RS-485 capacity (32 nodes)
- PacLAN 2.5 Mbaud industrial Local Area Network allows interconnecting and sharing information among up to 254 nodes/axes

OPERATING FEATURES

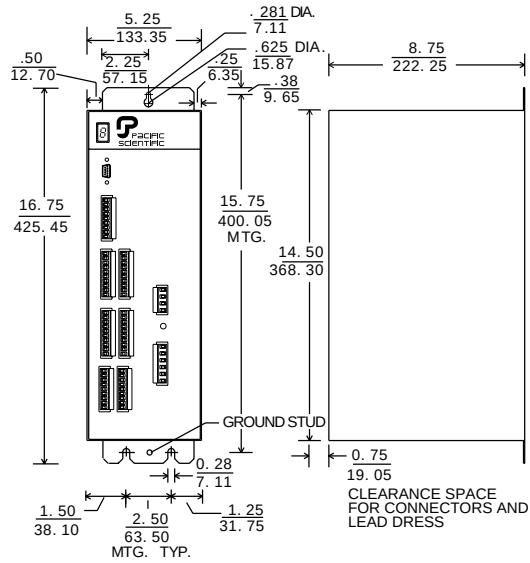
- Smooth, high bandwidth position/velocity/torque control
- Transformerless, direct 240/120 Vac line operation
- IGBT PWM output stage
- Phoenix pluggable, screw terminal connections
- Fully enclosed, panel mount package
- Integral, directional dynamic braking

ADJUSTMENTS

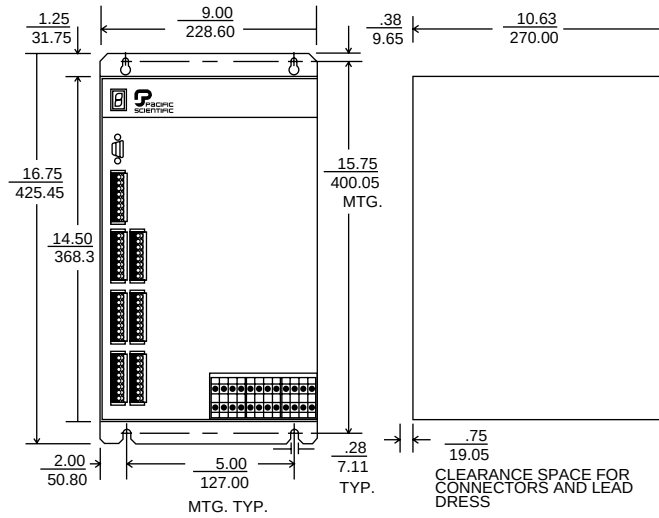
- 8 position DIP switch for PacLAN address
- No adjustments are required since all parameters are set in software

PROTECTION/DIAGNOSTICS

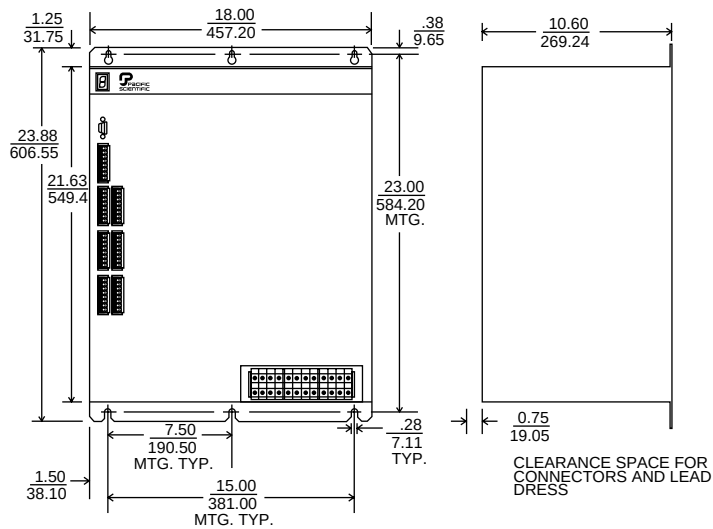
- 7 segment status/fault display
- Front access test points
- Inrush current limiting
- Fully fused
- MOV protected input
- Output short circuit protection
- Overtemperature protection, controller and motor
- I²T protection
- Programmable 4 bit fault code output



SC752/SC753



SC754/SC755



SC756

**See pages B-6 through B-26 for information on the next generation Servo Position Control.*

GENERAL . . . SC750 Series Controllers*

Efficiency (50% output voltage, rated cont. current)	>95%
Form factor	<1.01
Current loop bandwidth	.1500 to 3000Hz
Input command	.RS-232 or RS-485/422, PacLAN port
Output ripple frequency ($\pm 15\%$)	.20 kHz
Position resolution	.65,536 steps/rev (16 bit)
Position accuracy (drive only)	
Standard	± 22 arcmin
Optional	± 4 arcmin
Velocity range (drive only)	.0 to 12,000 RPM
Analog input	± 12 Vdc range, 16 bit @200 Hz bandwidth or 14 bit @1000 Hz bandwidth, 0.25% linearity, $50\mu\text{V}/^\circ\text{C}$ drift, fully monotonic, 60 mV offset, 100 Kohm input impedance
Analog output	± 5 Vdc range, 12 bit, updated every 0.4 mS, fully monotonic, 50 ohm source impedance
Control inputs	.Enable Fault reset Inhibit + Inhibit -
Control outputs	.Fault Current monitor Commutation signal Two +5V @250 mA max.
Programmable inputs	.12 general purpose 2 general purpose/fast 2 general purpose/counter Optically isolated, 5 to 24 Vdc logic, sourcing; fast inputs have $5\mu\text{S}$ max. capture time
Programmable outputs	.11 general purpose 1 general purpose/PWM 5 to 24 Vdc logic, open collector sinking, up to 100 mA
Encoder Emulation	
Modes	.Encoder output Encoder input Step/direction input
Encoder output mode	.Quadrature with marker pulse, differential TTL line driver, software selectable resolution—500, 512, 1000, 1024, 2000, 2048, 4096, 16,384 PPR, 750 kHz max.
Encoder input mode	.Quadrature with marker pulse, differential TTL line receivers, 750 kHz max.
Step/direction mode	.Differential TTL line receivers, 750 kHz max.
Mating connectors (furnished)	.All plug-in mating connectors
Storage temperature	-.55°C to 70°C
Operating temperature	
Full ratings	.0°C to 50°C
Derated Δ	.50°C to 60°C
Altitude	.5000 ft. (1500 m)
Humidity	.10% to 90%, non-condensing
Weight	.SC752, 13 lbs. SC753, 16 lbs. SC754/755, 40 lbs SC756, 90 lbs.

Δ Linearly derate the continuous current and power ratings to 70% at 60°C.

*See pages B-6 through B-26 for information on the next generation Servo Position Control.

POWER DATA. . .SC750 Series Controllers*

	SC752	SC753	SC754	SC755	SC756
Input voltage Control logic power Bus power	90 to 264 Vac, 47 to 63 Hz, 1 phase 120 Vac (+ 10%, -15%)/ 240 Vac (+ 10%, -15%), 47 to 63 Hz, 1 or 3 phase				
Bus Voltage (with 240 Vac input) (with 120 Vac input)	320 Vdc 160 Vdc				
Input current  Control logic power Bus current (RMS) (230 Vac, 3-phase)	500 mA max. @ 115 Vac, 250 mA max. @ 230 Vac.				
	4.5 A _{rms}	9 A _{rms}	18 A _{rms}	29 A _{rms} (@6kW)	38 A _{rms} (@ 12kW)
Output current @ 50° C  Peak (5 seconds) Continuous (stall)	7.5 A 3.8 A	15 A 7.5 A	30 A 15 A	60 A 30 A 	120 A 60 A
Output power (min. @ 50° C) Peak (5 seconds) 230 Vac, 3-phase 230 Vac, 1-phase Continuous 230 Vac, 3-phase 230 Vac, 1-phase	2.2 kW 2.0 kW 1.1 kW 0.8 kW	4.5 kW 4.0 kW 2.2 kW 1.6 kW	9 kW n/a 4.5 kW n/a	18 kW n/a 9 kW n/a	36 kW n/a 18 kW n/a
Shunt regulator power Peak Continuous	3 kW 20 W	6 kW 40 W	20 kW 200 W	20 kW 200 W	40 kW 500 W

 Currents shown are the peak of a sinewave. Multiply by 0.707 to get RMS current value.

 The SC755 can be configured for 40 A continuous (stall).

 Input current is specified with unit operating at continuous rated output power.

*See pages B-6 through B-26 for information on the next generation Servo Position Control.

SC750 SERIES RECOMMENDED MOTOR/CONTROLLER SYSTEMS[△]

Peak stall torque T_{PS} [△] lb-in./Nm	Peak rated torque T_{PR} [△] lb-in./Nm	Cont. stall torque T_{CS} lb-in./Nm	Cont. rated torque T_{CR} lb-in./Nm	Rated Speed W_R [△] rpm	Inertia $x 10^{-3}$ [△] lb-in-S ² / kgm ² J	Servo-motor Dia. or Width/height inch/mm	Servo-motor Length inch/mm	Inductance line-line L mH	Servo-motor model	Servo-Controller model [△]
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With R Series (low inertia, rare earth magnet) motors

10/ 1.1	6.5/ .7	4.8/ .5	2.5/ .3	8000	0.12/ .014	2.00/ 50.8	7.38/187.5	5.3	R22HENA-R1-NS-NV-01	SC752A-001-01
14/ 1.6	8/ .9	7.6/ .9	5.2/ .6	8000	0.15/ .017	2.00/ 50.8	8.38/212.9	6.5	R23HENA-R1-NS-NV-01	SC752A-001-01
17/ 1.9	10/ 1.1	9.2/ 1.0	7.1/ .8	6000	0.18/ .020	2.00/ 50.8	9.38/238.3	6.5	R24HENA-R1-NS-NV-01	SC752A-001-01
27/ 3.0	25/ 2.8	14/ 1.6	10/ 1.1	4000	0.55/ .062	3.25/ 82.6	7.09/180.1	23.0	R32GENC-R2-NS-NV-00	SC752A-001-01
27/ 3.0	25/ 2.8	14/ 1.6	6/ .7	7000	0.55/ .062	3.25/ 82.6	7.09/180.1	5.8	R32HENC-R2-NS-NV-00	SC753A-001-01
36/ 4.0	33/ 3.7	21/ 2.4	16/ 1.8	3000	0.74/ .084	3.25/ 82.6	8.09/205.5	22.0	R33GENC-R2-NS-NV-00	SC752A-001-01
36/ 4.0	25/ 2.8	21/ 2.4	10/ 1.1	6000	0.74/ .084	3.25/ 82.6	8.09/205.5	5.6	R33HENC-R2-NS-NV-00	SC753A-001-01
45/ 5.0	42/ 4.7	27/ 3.0	24/ 2.7	2800	0.92/ .104	3.25/ 82.6	9.09/230.9	30.0	R34JENC-R2-NS-NV-00	SC752A-001-01
45/ 5.0	38/ 4.3	27/ 3.0	16/ 1.8	4000	0.92/ .104	3.25/ 82.6	9.09/230.9	7.5	R34KENC-R2-NS-NV-00	SC753A-001-01
54/ 6.0	53/ 5.9	32/ 3.6	30/ 3.4	2000	1.11/ .125	3.25/ 82.6	10.09/256.3	42.0	R35JENC-R2-NS-NV-00	SC752A-001-01
54/ 6.0	48/ 5.4	32/ 3.6	23/ 2.6	3000	1.11/ .125	3.25/ 82.6	10.09/256.3	10.5	R35KENC-R2-NS-NV-00	SC753A-001-01
66/ 7.4	50/ 5.6	33/ 3.7	33/ 3.4	1800	1.90/ .215	4.25/108.0	8.34/211.8	53.0	R43GENA-R2-NS-NV-00	SC752A-001-01
66/ 7.4	60/ 6.7	33/ 3.7	31/ 3.5	3000	1.90/ .215	4.25/108.0	8.34/211.8	13.3	R43HENA-R2-NS-NV-00	SC753A-001-01
106/11.9	95/10.6	48/ 5.4	46/ 5.2	2000	2.70/ .305	4.25/108.0	9.84/249.9	4.9	R45GENA-R2-NS-NV-00	SC753A-001-01
106/11.9	95/10.6	48/ 5.4	43/ 4.8	4000	2.70/ .305	4.25/108.0	9.84/249.9	20.0	R45HENA-R2-NS-NV-00	SC754A-001-01
142/15.9	120/13.4	64/ 7.2	61/ 6.8	1500	3.50/ .395	4.25/108.0	11.34/288.1	25.0	R46GENA-R2-NS-NV-00	SC753A-001-01
142/15.9	120/13.4	64/ 7.2	50/ 5.6	3000	3.50/ .395	4.25/108.0	11.34/288.1	6.2	R46HENA-R2-NS-NV-00	SC754A-001-01
150/16.8	125/14.0	70/ 7.8	58/ 6.5	3000	7.10/ .818	5.75/146.1	9.36/237.7	8.9	R63GENA-R2-NS-NV-00	SC754A-001-01
150/16.8	142/15.9	70/ 7.8	38/ 4.3	6000	7.10/ .818	5.75/146.1	9.36/237.7	2.2	R63HENA-R2-NS-NV-00	SC755A-001-01
240/26.9	230/25.8	115/12.9	102/11.4	1700	11.10/1.28	5.75/146.1	11.36/288.5	13.7	R65GENA-R2-NS-NV-00	SC754A-001-01
240/26.9	200/22.4	115/12.9	90/10.1	3000	11.10/1.28	5.75/146.1	11.36/288.5	3.4	R65HENA-R2-NS-NV-00	SC755A-001-01
340/38.1	305/34.2	168/18.8	156/17.5	1000	15.10/1.74	5.75/146.1	13.36/339.3	18.2	R67GENA-R2-NS-NV-00	SC754A-001-01
340/38.1	330/37.0	168/18.8	146/16.4	2000	15.10/1.74	5.75/146.1	13.36/339.3	4.6	R67HENA-R2-NS-NV-00	SC755A-001-01
300/33.6	280/31.4	190/21.3	125/14.0	3800	39.10/4.50	7.50/190.5	10.93/277.6	3.2	R84GENA-R2-NS-NV-00	SC755A-001-01
300/33.6	270/30.2	190/21.3	45/ 5.0	6000	39.10/4.50	7.50/190.5	10.93/277.6	0.8	R84HENA-R2-NS-NV-00	SC756A-001-01
410/45.9	395/44.2	276/30.1	225/25.2	2000	58.10/6.69	7.50/190.5	12.93/328.4	3.6	R86GENA-R2-NS-NV-00	SC755A-001-01
410/45.9	365/40.9	276/30.1	120/13.4	4000	58.10/6.69	7.50/190.5	12.93/328.4	0.9	R86HENA-R2-NS-NV-00	SC756A-001-01
540/60.5	525/58.8	357/28.8	325/36.4	1500	76.10/8.77	7.50/190.5	14.93/379.2	4.0	R88GENA-R2-NS-NV-00	SC755A-001-01
540/60.5	500/56.0	357/28.8	205/23.0	3000	76.10/8.77	7.50/190.5	14.93/379.2	1.0	R88HENA-R2-NS-NV-00	SC756A-001-01
800/89.6	730/81.8	451/50.5	424/47.5	1200	95.10/10.96	7.50/190.5	16.93/430.0	7.4	R8AGENA-R2-NS-NV-00	SC755A-001-01
800/89.6	720/80.6	451/50.5	300/33.6	2000	95.10/10.96	7.50/190.5	16.93/430.0	1.9	R8AHENA-R2-NS-NV-00	SC756A-001-01

With F Series (medium inertia, ferrite magnet) motors[△]

56/ 6.3	34/ 3.8	32/ 3.6	25/ 2.8	1500	9.20/1.04	4.25/108.0	8.34/211.8	49.0	F43GENA-R2-NS-NV-00	SC752A-001-01
60/ 6.7	30/ 3.4	32/ 3.6	22/ 2.5	3000	9.20/1.04	4.25/108.0	8.34/211.8	12.0	F43HENA-R2-NS-NV-00	SC753A-001-01
84/ 9.4	55/ 6.2	46/ 5.2	43/ 4.8	1000	13.70/1.55	4.25/108.0	9.84/249.9	69.0	F45FENA-R2-NS-NV-00	SC752A-001-01
84/ 9.4	45/ 5.0	46/ 5.2	38/ 4.3	2000	13.70/1.55	4.25/108.0	9.84/249.9	17.0	F45GENA-R2-NS-NV-00	SC753A-001-01
121/13.6	62/ 6.9	61/ 6.8	48/ 5.4	1500	17.70/2.00	4.25/108.0	11.34/288.1	24.0	F46GENA-R2-NS-NV-00	SC753A-001-01
121/13.6	60/ 6.7	61/ 6.8	43/ 4.8	3000	17.70/2.00	4.25/108.0	11.34/288.1	6.0	F46HENA-R2-NS-NV-00	SC754A-001-01

[△] See page B-73 for definitions of ratings.

[△] Peak torque ratings are for 5 seconds.

[△] Rated speeds are for 230 Vac, 3 phase operation.
Derate to approximately 85% for 240 Vac, 1 phase operation.
Derate to 40% for 115 Vac, 1 phase operation.

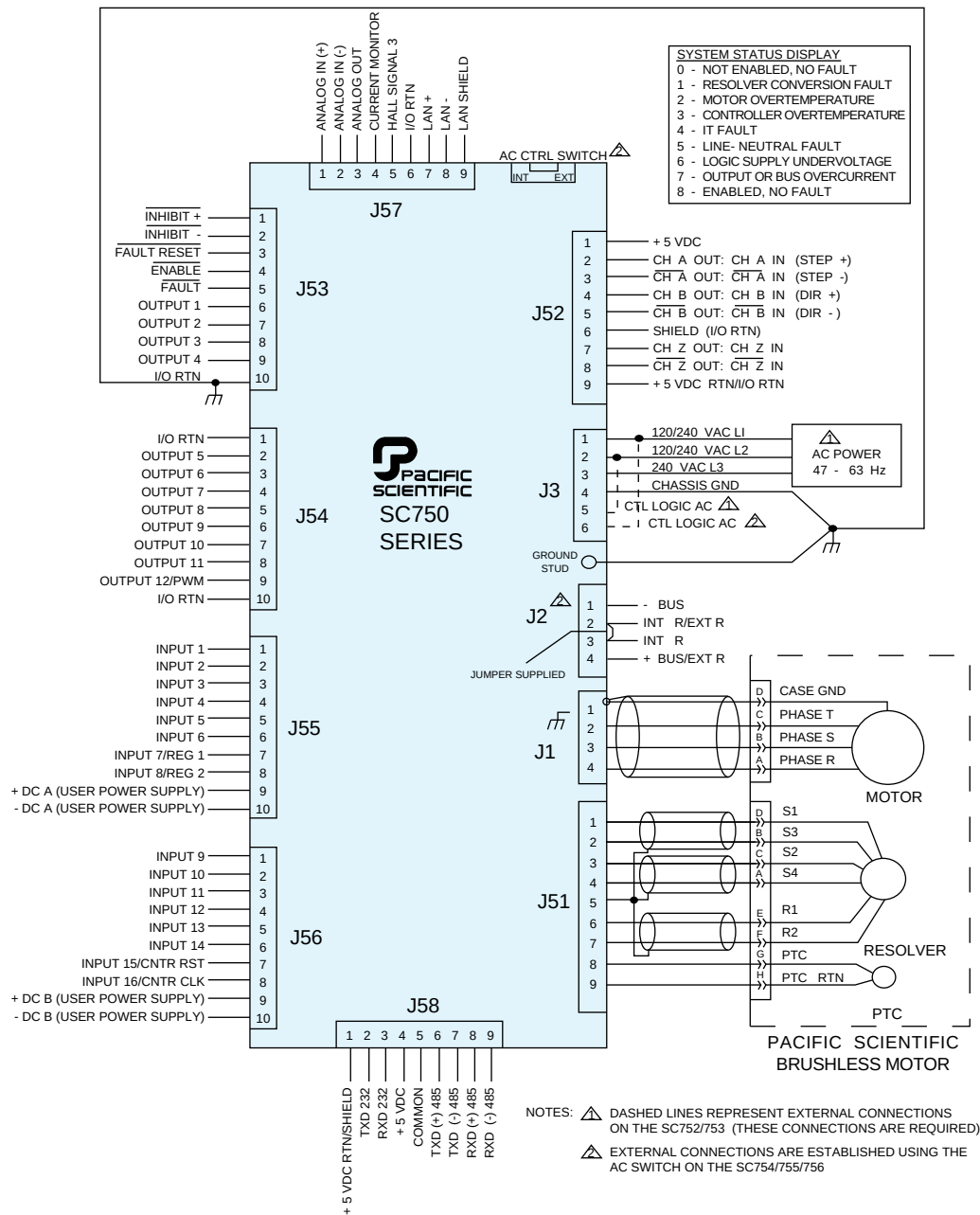
[△] Includes primary feedback inertia.

[△] Controller model numbers are for 12 bit resolution option.
See "How to Order" on page B-34.

[△] Each system requires one feedback and one motor power cable.

**See pages B-6 through B-26 for information on the next generation Servo Position Control.*

CONNECTION DIAGRAM . . . SC750 Series Controllers*



*See pages B-6 through B-26 for information on the next generation Servo Position Control.

HOW TO ORDER . . . SC750 Series Controllers*

To order an SC750 Series brushless servo motor controller, designate the power level and position accuracy desired. The next three digits are a controller customization code, which is factory assigned. It is also used to specify any customer requested modifications. The final two digits specify the desired software option.

For a standard SC750 Series controller with a power rating of 15A cont., 30A peak, the following model number would be ordered:

MODEL NUMBER CODE		SC	7	5	4	A-001-01
Servo controller	_____					
Series	_____					
Function code	_____					
5=position controller (resolver)						
Power level code	_____					
2=3.8A cont./7.5A peak						
3=7.5A cont./15A peak						
4=15A cont./30A peak						
5=30A cont./60A peak						
6=60A cont./120A peak						
Option code	_____					
A=12 bit RDC (± 22 arcmin, 1024 ppr)						
B=14 bit RDC (± 4 arcmin, 4096 ppr)						
Customization code	_____					
Factory assigned, 001=standard unit						
Suffix code	_____					
-01=PacSci ServoBASIC <i>Plus</i> [™] programming language with 24K user memory						
-02=PacSci ServoBASIC <i>Plus</i> [™] programming language with 100K user memory and faster processor						

HOW TO ORDER . . . SC750 Series Recommended Motor/Controller Systems

See the Recommended Motor/Controller Systems table on page B-32 for performance information and model numbers for servo motor/controller combinations. Order motors and controllers as separate part numbers. See brushless servo motor section for additional motor specifications and information.

*See pages B-6 through B-26 for information on the next generation Servo Position Control.



PACIFIC SCIENTIFIC'S ServoBASIC *Plus*™

Pacific Scientific developed ServoBASIC™ as a subset of the popular GWBASIC by adding motion control commands.. With the ServoBASIC™ language, intelligent motion control became accessible to users with little or no programming experience.

First introduced in 1987, ServoBASIC™ has helped engineers do sophisticated motion and machine control in thousands of applications. The second generation ServoBASIC Plus™ was introduced with the SC750 family of drives. The SC750 ServoBASIC Plus™ was the logical progression of the original breakthrough, enhanced through field experience and faster microprocessors. The third generation of ServoBASIC Plus™ fits on the OC950 option card for the SC900 family of all digital servo drives. Each generation of ServoBASIC™ has expanded flexibility and functionality, increased execution speed, and simplified programming. Throughout each generation we have retained the familiar syntax and program flow of ServoBASIC, so you don't have to learn a new language to access the enhanced power and flexibility.

Advantages of the OC950 third generation ServoBASIC Plus™

- 5 times faster program execution than previous generation• 27 fully programable bidirectional digital inputs/outputs• 8 programmable position limit switches
- PacLAN™ inter drive communications is optional• Fully integrated Windows program development environment
- Enhanced program modularity:
 - Arguments to subroutines
 - Local variables
 - User defined functions
 - Fast multi-way branches
 - Multi dimensional array variables
- Full interactive debugger

ABORT.MOTION

Stops motor motion while allowing continued program execution.

ABS

Converts the associated value (x) to an absolute value.

ACCEL.GEAR

Sets the commanded acceleration rate when gearing is turned ON. The specified acceleration rate is used until GEARLOCK is achieved. ACCEL.GEAR is independent of DECEL.GEAR.

ACCEL.RATE

Sets the maximum commanded acceleration rate when speed is increased.

ACCEL.TYPE

Determines the use of constant acceleration or S-Curve velocity profiles.

AD.OFFSET

Specifies the level of a signal summed with the digitized value of the analog input channel, in volts.

ADF0

Sets the analog input channel's filter break frequency.

ANALOG.IN

Contains the digitized value of the analog input channel, in volts, of J57-1 relative to J57-2.

ANALOG.OUT

Sets the voltage level of the analog output channel.

ARF0

The first anti-resonant filter break frequency.

ARF1

The second anti-resonant filter break frequency.

ASC()

Returns a numeric value that is the ASCII code for the first character of the string expression.

ATAN

Returns the arctangent of x in radians.

AUTOSTART

Specifies the automatic execution of a user program as soon as the servo controller has AC power applied.

AXIS.ADDR

Indicates the RS-485 or multidrop address set by switch S1 on the controller.

AXIS.INTR

Indicates the axis address number of the source address of a LANINTERRUPT.

BEEP

Transmits a speaker beep command to the serial port.

BLKTYPE

Specifies configuration as a position, velocity or torque block.

CALL

Transfers program execution to a BASIC subroutine.

CCWINH

Indicates the current state of the CCWINH (INH-) input.

CCWOT

Sets the counter-clockwise overtravel limit.

CHRS()

Converts an ASCII code to its equivalent character.

CINT()

Converts x to an integer by rounding the fractional portion.

CLS

Clears the screen display of a terminal.

CMDGAIN

Controls the scale factor of the analog input signal to the servo loops for BLKTYPE=0, 1, or 3.

CONST

Declares numeric constants to be used in place of numeric values.

COS()

Returns the cosine of its argument which must be in radians.

COUNTER

Specifies the current count of the hardware event counter feature using discrete input 16.

COUNTSPERREV

Specifies the resolution of the position control.

CWINH

Indicates the current state of the CWINH (INH+) input.

CWOT

Sets the clockwise overtravel limit.

DACMAP

Specifies the signal sent to the monitor DAC driving the analog output channel.

DACMON

Contains the value of the selected, filtered variable output to the analog output channel.

DECEL.GEAR

Sets the deceleration rate commanded when gearing is turned OFF. The specified deceleration rate is used until geared motion has stopped. ACCEL.GEAR is independent of DECEL.GEAR.

DECEL.RATE

Sets the maximum deceleration rate commanded when speed is decreased.

DIM

Specifies and allocates storage for variables and arrays.

DIR

Sets the direction the motor turns when a GO.VEL function is executed.

DMF0

Sets the analog output channel's filter break frequency.

DMGAIN

Specifies the multiplicative scale factor applied to analog output signal when DACMAP=0.

ENABLE

Allows or prevents power flow to the motor.

ENABLED

Indicates whether the controller is enabled.

ENC.FREQ

Contains the frequency in quadrature pulses per second of the external encoder input averaged over a 128 msec interval for filtering.

ENC.IN

Specifies the line count of the encoder being used for electronic gearing.

PACSCI SERVOBASIC *Plus*™ COMMAND SUMMARY

VERSION 2.7... Cont.

ENC.OUT

Selects the direction of encoder ports and selects emulated encoder line count when the bidirectional encoder ports are set to "transmit."

ENCPOS

Indicates the position of the external encoder.

END

Marks the end of a program, subroutine, IF...THEN...ELSE block structure or interrupt service routine.

EXIT

Used to exit a subroutine, an interrupt, FOR...NEXT or WHILE...WEND block structure.

FAULTCODE

Indicates the status of the controller.

FIX()

Returns the truncated integer part of x.

FOR...NEXT

Allows a series of statements to be executed in a loop a given number of times.

FVEL.ERR

Indicates the velocity servo error signal, in RPM, after it has been processed by the anti-resonant filter section.

FWV

Indicates the controller firmware version number.

GEARERROR

Specifies the amount of position lag that accumulates when electronic gearing is turned on.

GEARING

Turns electronic gearing on or off and sets allowed direction of motion.

GEARLOCK

Indicates slave axis velocity is synchronized with the master, when performing electronic gearing.

GO.ABS

Causes the motor to move to the position specified by TARGET.POS.

GO.HOME

Moves the motor shaft to the electrical home position.

GO.INCR

Moves the motor shaft an incremental index from the current position.

GO.VEL

Moves the motor shaft at a constant speed.

GOSUB...RETURN

Branches program execution to a subroutine, executes it, and returns.

GOTO

Causes software to jump to a specific label and continue executing.

HEX\$()

Converts a long integer to a hexadecimal ASCII string.

ICMD

Indicates the commanded motor torque current in amperes.

IFB

Indicates the measured motor current amplitude in amperes.

IF...THEN...ELSE

Statements control program execution based on the evaluation of numeric expressions.

ILC

Sets the current loop proportional gain.

ILMT.MINUS

Sets the maximum allowable current in the counter-clockwise direction.

ILMT.PLUS

Sets the maximum allowable current in the clockwise direction.

INDEX.DIST

Sets the distance which the motor rotates during each incremental index.

INKEY\$()

Returns one character read from the serial port's buffer.

IN.POS.LIMIT

Specifies the tolerance of commanded position minus action position within which region the position limit flag will be set.

IN.POSITION

Indicates whether or not the motor has achieved commanded position.

INPn

Reads the state of an individual discrete input.

INPUT

Reads a character string received by the serial communications port, terminated by a carriage return.

INPUTS

Reads the state of discrete inputs.

INSTR()

Provides the location of a substring within a string.

INT()

Truncates an expression to a whole number.

INTERRUPT

Marks the beginning and the end of an interrupt service routine.

INTR.{source label}

Used to enable and disable the interrupts.

IPEAK

Contains the peak current rating of the controller in amperes.

IFT0

Specifies the corner frequency of the low pass filter implementing the IT controller thermal protection circuit.

IT.FILT

Contains the output of the I*T controller thermal protection filter circuit.

IT.THRESH

Designates the threshold (trip level) at which the IT thermal protection triggers an overcurrent fault.

KPP

Sets the proportional gain of the position loop in Hz.

KTEFF

Torque constant of the system in lb-in/amp.

KVFF

Sets the proportion of velocity feedforward signal added to the velocity command from differentiated position command.

KVI

Sets the integral gain of the velocity servo loop.

PACSCI SERVOBASIC *Plus*™ COMMAND SUMMARY

VERSION 2.7...Cont.

KVP

Sets the proportional gain of the velocity servo loop.

LANFLT(1-32)[axis]

Shared user floating point variables for inter-axis communication. 32 variables per controller on the PacLAN network.

LANFLT(n) [axis#]

An array of 32 floating point variables globally accessible over PacLAN.

LANINT(1-32) [axis]

Shared user integer variables for inter-axis communication. 32 variables per controller on the PacLAN network.

LANINT(n) [axis#]

An array of 32 integer variables globally accessible over PacLAN.

LANINTERRUPT [axis#]

Invokes an interrupt to the PacLAN controller specified by [AXIS#].

LCASE\$()

Converts expression to lower case characters.

LEFT\$()

Returns a string of the leftmost characters of a string.

LEN()

Returns the number of characters in the string.

LTRIMS()

Removes the leading blank characters from a string expression.

LOG()

Returns natural logarithm value.

LOG10()

Returns base 10 logarithm of expression.

LOGGEDON

Indicates that the controller has been selected as the enabled multidrop subsystem by the multidrop master.

MID\$()

Replaces a portion of a string with another string.

MODEL

Indicates the servo controller model number.

MOVING

Indicates when a commanded motion profile has been completed.

OUTn

Sets the state of the individual discrete output.

OUTPUTS

Specifies the state of the discrete outputs.

PAUSE

Causes the program to pause the amount of time specified by the PAUSE.TIME variable.

PAUSE.TIME

Defines the length of time delay during a pause statement.

POLECOUNT

Matches the controller for the appropriate motor pole count.

POS.CHKn

Specifies the position at which outputs 1, 2 and 3 are switched to the polarity designated by POS.CHKn.OUT.

POS.CHKn.OUT

Used in conjunction with POS.CHKn to implement position check n.

POS.COMMAND

Contains the current position command.

POS.ERROR

Equal to the difference between the position command and the actual position.

POSITION

Indicates the actual motor position.

PRINT

Displays output on the terminal screen while the program is running.

PULSES.IN

Specifies the number of input encoder counts used for selecting an exact gear ratio.

PULSES.OUT

Specifies the number of resolver counts the motor will move for a specified number of encoder counts.

PWM12

Specifies the function of discrete output 12/PWM as a Pulse Width Modulated (PWM) signal and controls the duty cycle.

RATIO

Sets the electronic gearing ratio (rev/rev) between the encoder shaft and the motor shaft.

REG.DIST

Sets the distance that is moved automatically when a resolver registration input is applied.

REG.ENCPOS

Records the encoder position when an encoder registration input triggers.

REG.FLAG

Indicates that the registration input has triggered.

REG.FUNC

Specifies whether REG.DIST is the distance that is moved automatically when a resolver registration input is applied.

REG.MODE

Specifies the discrete input signal used to trigger and latch the encoder and resolver positions during registration.

REG.POS

Records the motor position when a resolver registration input triggers.

REG.RESPOS

Records the resolver position relative to the motor housing when a resolver registration input triggers.

REM or '

Designates explanatory remarks or comments in the program.

RESPOS

Contains the mechanical orientation of the resolver relative to the motor housing.

RESTART

Re-initializes the servo controller and commences execution after encountering an interrupt or program execution has become nested within levels of subroutines.

PACSCI SERVOBASIC *Plus*™ COMMAND SUMMARY

VERSION 2.7...Cont.

RIGHT\$()

Returns the rightmost characters of the string.

RUN.SPEED

Sets the maximum speed used in making an incremental or an absolute move.

RVEL

Indicates the actual speed at which the motor shaft is rotating.

SGN()

Returns the sign of x.

SIN()

Returns the sine of its argument in radians.

SPACES\$()

Returns a string of spaces.

SQR()

Returns the square root of an expression.

STATUS[axis#]

A read-only software variable that can be used within a program to determine if an external axis is connected to PacLAN.

STEPPDIR

Specifies response to either quadrature encoder signals or step and direction input signals when electronic gearing is in use.

STOP

Stops the execution of the program.

STR\$()

Returns a string representation of the value of a numeric expression.

STRING\$()

Returns a string containing the specified number of occurrences of a character.

SUB

Defines the beginning and ending of a subroutine.

SWAP

Exchanges the values of two variables.

TAN()

Returns the tangent of its argument in radians.

TARGET.POS

Sets the target position used with the GO.ABS function.

TIME

Contains the current value, in seconds, of a free running timer that is maintained by the internal software.

TMENABLEn

Enables or disables the programmable timers.

TMOUTn

Indicates the state of an output controlled by a programmable timer.

TMRSET

Specifies the operation of the programmable timers.

UCASE\$()

Converts value to upper case.

UPD.MOVE

Updates a move in progress with new variables.

VAL()

Returns the numerical value of the string.

VEL.CMD

Indicates the net velocity servo loop command signal in RPM.

VEL.ERR

Indicates the velocity servo error signal in RPM.

VELOCITY

Indicates the actual speed at which the motor shaft is rotating averaged over a 128 msec interval.

WHEN

Used for very fast output response to certain input conditions.

WHEN.ANALOG.IN

Records the digitized value of the analog input channel, in volts, at the time the WHEN statement is satisfied.

WHEN.DACMON

Records the value of the selected, filtered variable output to the analog output channel at the time the WHEN statement is satisfied.

WHEN.ENCPOS

Records the encoder position at the time the WHEN statement is satisfied.

WHEN.ICMD

Records the commanded motor torque current, in amperes, at the time the WHEN statement is satisfied.

WHEN.IFB

Records the measured motor current amplitude, in amperes, at the time the WHEN statement is satisfied.

WHEN.PCMD

Specifies the motor position when the WHEN condition is satisfied.

WHEN.POS

Set to the value of POSITION when the WHEN condition is satisfied.

WHEN.RESPOS

Records the resolver's mechanical orientation relative to the motor housing at the time the WHEN statement is satisfied.

WHEN.RVEL

Records the raw motor velocity at the time the WHEN statement is satisfied.

WHEN.TIME

Records the variable TIME at the time the WHEN statement is satisfied.

WHEN.VELCMD

Records the net velocity servo loop command signal, in rpm, at the time the WHEN statement is satisfied.

WHILE...WEND

Tells the program to execute a series of statements as long as an expression after the WHILE statement is true.

WVSHF

Integer composed of the ASCII codes for the characters in the name of the motor back EMF wave shape that the controller is using to shape the motor current.

The following arithmetic operators are supported:

ADDITION +

DIVISION /

EXPONENTIATION ^

MODULO DIVISION %

MULTIPLICATION *

SUBTRACTION -

PROGRAMMING EXAMPLES. . .PacSci ServoBASIC Plus™

These are actual program elements demonstrating the power of PacSci ServoBASIC Plus™ to easily program complex motion profiles.

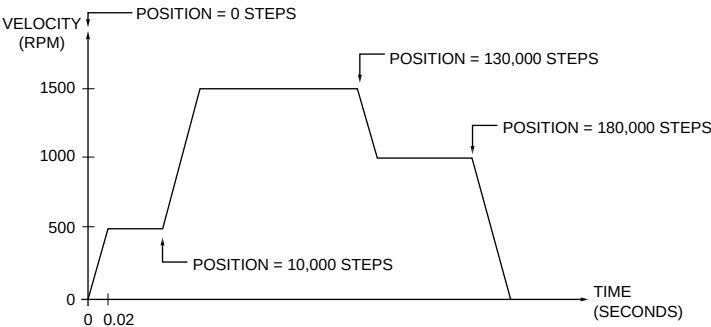
There's so much functionality in PacSci ServoBASIC Plus that you may never need to tap its full potential. If there's a software solution to your problem, our applications engineering people will find it.

BASIC PROGRAMMING EXAMPLES

EXAMPLE 1...Velocity change on position events

This program produces a multiple level velocity profile. Velocity changes are initiated based upon position events.

Program line	Comments
SETUP:	
ACCEL.RATE = 25000	SET ACCEL RATE TO 25,000 RPM/S
DECEL.RATE = 25000	SET DECEL RATE TO 25,000 RPM/S
RUN.SPEED = 500	SET RUN SPEED TO 500 RPM
IN.POS.LIMIT = 10	SET IN POSITION LIMIT TO ± 10 STEPS
HOME:	
GO.HOME	GO TO HOME POSITION
WHILE IN.POSITION < >1	WAIT FOR HOMING COMPLETE
WEND	
PROFILE:	
GO.VEL	START PROFILE, GO TO 500 RPM
RUN.SPEED = 1500	SET RUN SPEED TO 1500 RPM
WHILE POSITION <10000	WAIT FOR POSITION OF 10,000 STEPS
WEND	
GO.VEL	GO TO 1500 RPM
RUN.SPEED = 1000	SET RUN SPEED TO 1000 RPM
WHILE POSITION <130000	WAIT FOR POSITION OF 130,000 STEPS
WEND	
GO.VEL	GO TO 1000 RPM
RUN.SPEED = 0	SET RUN SPEED TO 0 RPM
WHILE POSITION <180000	WAIT FOR POSITION OF 180,000 STEPS
WEND	
GO.VEL	GO TO 0 RPM
END	END PROGRAM

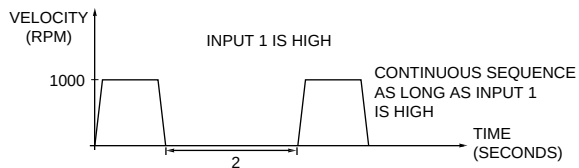


BASIC PROGRAMMING EXAMPLES (Cont.)

Example 2. .Jump on input

Here, the IF. .THEN command is used to test a discrete input and take action depending upon the state of the input. The jumps in the program depend upon the state of Input 1.

Program line	Comments
SETUP:	
ACCEL.RATE = 10000	SET ACCEL TO 10,000 RPM/S
DECEL.RATE = 10000	SET DECEL RATE TO 10,000 RPM/S
RUN.SPEED = 1000	SET RUN SPEED TO 1,000 RPM
INDEX.DIST = 70000	SET INDEX DISTANCE TO 70,000 STEPS
READINPUT:	
IF INP1 THEN	IF INPUT 1 IS HIGH
PAUSE.TIME = 2	SET PAUSE TIME TO 2 SECONDS
GO.INCR	DO INDEX MOVE
WHILE MOVING = 1:WEND	WAIT TO COMPLETE MOVE
PAUSE	PAUSE 2 SECONDS
GOTO READINPUT	GO BACK TO READ INPUT 1 AGAIN
ELSE	IF INPUT 1 IS LOW
PAUSE.TIME = 1	SET PAUSE TIME TO 1 SECOND
FOR X = 1 TO 3	SET UP LOOP TO COUNT 3 INDEXES
GO.INCR	DO INDEX MOVE
WHILE MOVING = 1:WEND	WAIT TO COMPLETE MOVE
PAUSE	PAUSE 1 SECOND
NEXT	LOOP UNTIL 3 INDEXES COMPLETE
END IF	END IF. .THEN. .ELSE BLOCK
END	END PROGRAM



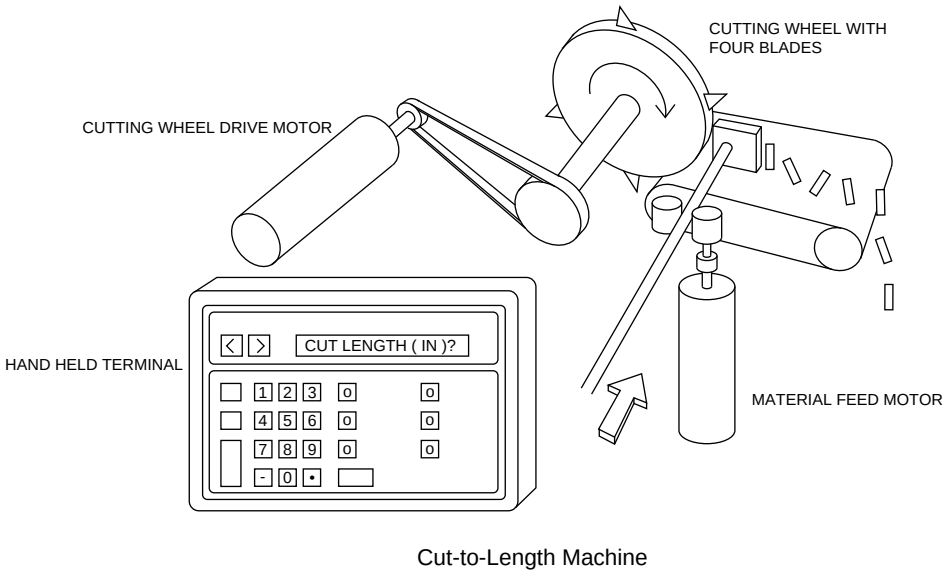
BASIC PROGRAMMING EXAMPLES (Cont.)
EXAMPLE 3. .Cut-to-length operation

In this application, a rotary cut-to-length machine uses a short PacSci ServoBASIC *Plus*™ program to control independent cutting wheel and material feed axes.

This program drives an industrial terminal, such as the PacSci T10. The user is prompted for feed rate in inches per second and desired cut length in inches. The program then computes the required feed roll motor velocity based on feed roller diameter.

The cutting wheel motor runs at the computed speed as long as Input 1 is True. If Input 1 is brought False, the motor stops and the user is prompted for a new value.

Program line	Comments
SETUP:	
ACCEL.RATE = 10000	SET ACCEL TO 10,000 RPM/S
DECEL.RATE = 10000	SET DECEL RATE TO 10,000 RPM/S
DIR = 1	SET DIRECTION TO COUNTER CLOCKWISE
ENABLE = 1	SOFTWARE MOTOR ENABLE ON
PROMPTINPUTS:	
INPUT "FEED RATE (IN/SEC)";FEEDRATE	PROMPT USER FOR INPUT
INPUT "CUT LENGTH (IN)";CUTLENGTH	PROMPT USER FOR INPUT
PROFILE:	
RUN.SPEED = 75*FEEDRATE/CUTLENGTH	CALCULATE RUN SPEED
WHILE INP = 0	WHILE INPUT 1 IS LOW
GO.VEL	RUN AT CALCULATED SPEED
WEND	
ABORT.MOTION	STOP WHEN INPUT 1 IS HIGH
GOTO PROMPTINPUTS	PROMPT USER FOR NEW PARAMETERS



BASIC PROGRAMMING EXAMPLES (Cont.)

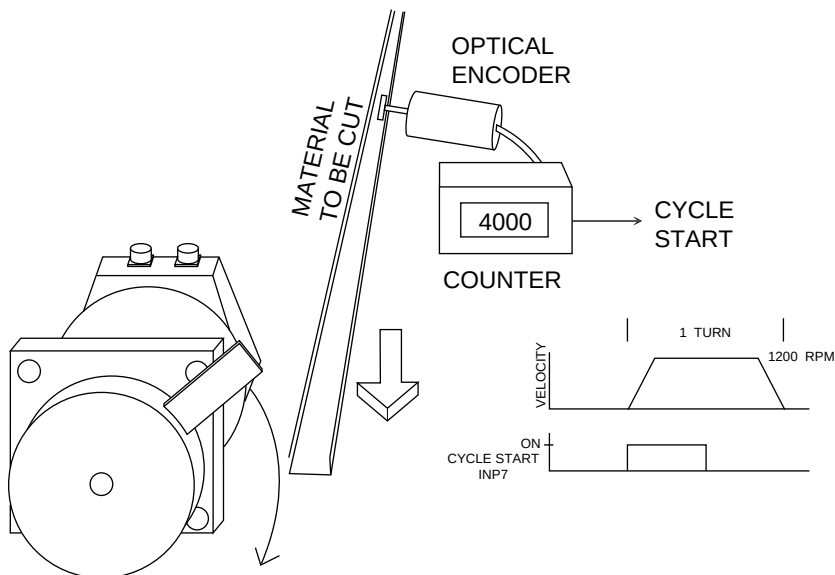
EXAMPLE 4. . .Using WHEN for rapid response

The PacSci ServoBASIC *Plus*™ instruction WHEN will help you achieve high speed response to inputs.

This program rotates a cutting blade one full revolution on the off-to-on transition of input INP7. WHEN ensures that the incremental move is initiated within one millisecond of the input transition.

Typically, the cut command is derived from an encoder and counter, which measure length of material passing the blade.

Program line	Comments
SETUP:	
ACCEL.RATE = 40000	SET ACCEL TO 40,000 RPM/S
DECEL.RATE = 40000	SET DECEL RATE TO 40,000 RPM/S
RUN.SPEED = 1200	SET RUN SPEED TO 1200 RPM
INDEX.DIST = 4096	SET INDEX DISTANCE TO 4096 STEPS
IN.POS.LIMIT = 100	SET IN POSITION LIMIT TO ± 100 STEPS
OUTPUTS = 4095	SET ALL OUTPUTS OFF (HIGH)
PAUSE.TIME = 1	SET PAUSE TIME TO 1 SECOND
ENABLE = 1	SOFTWARE MOTOR ENABLE ON
NOTENABLED:	
WHILE ENABLE = 0	IF ENABLE INPUT IS NOT ACTIVE
OUT1 = 0	BLINK OUTPUT 1 ON (LOW)
PAUSE	FOR 1 SECOND
OUT1 = 1	AND OFF (HIGH)
PAUSE	FOR 1 SECOND
WEND	UNTIL ENABLE INPUT IS ACTIVATED
MOVE:	
OUT7 = 0	TURN OUTPUT 7 ON (LOW)
WHILE INP7 = 0:WEND	WAIT FOR INPUT 7 TO GO HIGH
WHEN INP7 = 0, GO.INCR	MOVE WHEN INPUT 7 GOES LOW
OUT7 = 1	TURN OUTPUT 7 OFF (HIGH)
WHILE IN.POSITION < >1:WEND	WAIT FOR MOVE COMPLETE
GOTO MOVE	GO BACK TO MOVE



ADVANCED PROGRAMMING EXAMPLES (Cont.)

EXAMPLE 5. . Programmable limit switches (cont. on next page)

The following program generates a motion profile typical of transfer line slide drives.

Because absolute positioning is required, homing to a mechanical home limit switch is initiated by an off-to-on transition of input INP7. The mechanical home limit switch is connected to INP1. The SEEK_HOME subroutine supports the mechanical homing operation and establishes the zero position (POS.COMMAND = 0) electrical reference.

Outputs OUT2 and OUT3 are programmed as “programmable limit switches” using the POS.CHK commands. They indicate, within two milliseconds, whether actual position is above or below specified values.

For example, OUT2 could signal the bed drive that the tool is fully withdrawn and the workpiece can now be transferred to the next station.

OUT4 is programmed to be on whenever the tool is in the workpiece. Such an output might be used to control cooling fluid.

The HOME block initiates the homing function on a high to low transition of input 7. In the SETLIMITS block, the function of the limit switches is established.

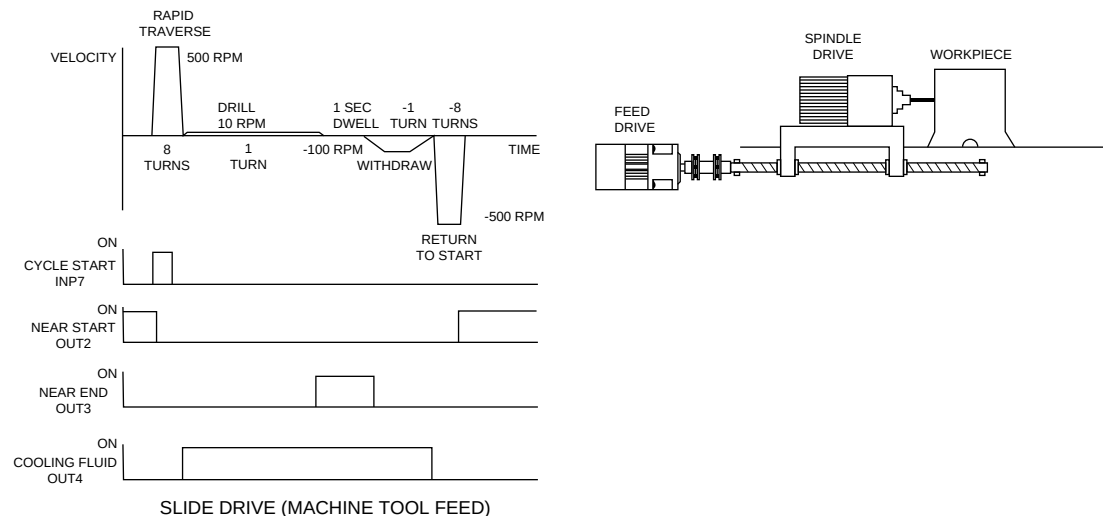
TRANSFER LINE SLIDE DRIVE PROGRAM

Program line	Comments
INITIALSETUP:	
ACCEL.RATE = 10000	SET ACCEL TO 10,000 RPM/S
DECEL.RATE = 10000	SET DECEL RATE TO 10,000 RPM/S
RUN.SPEED = 100	SET RUN SPEED TO 100 RPM
OUTPUTS = 4095	SET ALL OUTPUTS OFF (HIGH)
PAUSE.TIME = 1	SET PAUSE TIME TO 1 SECOND
POS.CHK1.OUT = 0	TURN OFF POSITION CHECK 1
POS.CHK2.OUT = 0	TURN OFF POSITION CHECK 2
POS.CHK3.OUT = 0	TURN OFF POSITION CHECK 3
DIR = 1	SET DIRECTION TO COUNTER CLOCKWISE
ENABLE = 1	SOFTWARE MOTOR ENABLE ON
NOTENABLED:	
WHILE ENABLED < > 1	IF ENABLE INPUT IS NOT ACTIVE
OUT1 = 0	BLINK OUTPUT 1 ON (LOW)
PAUSE	FOR 1 SECOND
OUT1 = 1	AND OFF (HIGH)
PAUSE	FOR 1 SECOND
WEND	UNTIL ENABLE INPUT IS ACTIVATED
HOME:	
OUT7 = 0	TURN ON (LOW) OUTPUT 7
WHILE INP7 = 0:WEND	WAIT FOR INPUT 7 TO GO HIGH
WHILE INP7 = 1:WEND	WAIT FOR INPUT 7 TO RETURN LOW
OUT7 = 1	TURN OFF (HIGH) OUTPUT 7
DIR = 1	
RUN.SPEED = 1000	
CALL SEEK_HOME	
SET LIMITS:	
POS.CHK2 = 8392	SET POSITION CHECK 2 AT 8392 STEPS
POS.CHK3 = 44856	SET POSITION CHECK 3 AT 44,856 STEPS
POS.CHK2.OUT = 11	OUTPUT 2 ON WHEN POSITION < POS.CHK2
POS.CHK3.OUT = 10	OUTPUT 3 ON WHEN POSITION > POS.CHK3
MOVETOSTART:	
ACCEL.RATE = 10000	SET ACCEL TO 10,000 RPM/S
RUN.SPEED = 500	SET RUN SPEED TO 500 RPM
TARGET.POS = 8192	SET TARGET POSITION TO 8192 STEPS
IN.POS.LIMIT = 10	SET IN POSITION LIMIT TO ± 10 STEPS
OUT4 = 1	TURN OUTPUT 4 OFF (HIGH)
GOSUB ABSMOVE	GO TO MOVE SUBROUTINE
OUT7 = 0	TURN OUTPUT 7 ON (LOW)
WHILE INP7 = 0:WEND	WAIT FOR INPUT 7 TO GO HIGH
OUT7 = 1	TURN OUTPUT 7 OFF (HIGH)
RAPIDTRAVERSE:	
ACCEL.RATE = 10000	SET ACCEL RATE TO 10,000 RPM/S
RUN.SPEED = 500	SET RUN SPEED TO 500 RPM
TARGET.POS = 40960	SET TARGET POSITION TO 40,960 STEPS
IN.POS.LIMIT = 50	SET IN POSITION LIMIT TO ± 50 STEPS
OUT4 = 1	TURN OUTPUT 4 OFF (HIGH)
GOSUB ABSMOVE	GO TO MOVE SUBROUTINE

ADVANCED PROGRAMMING EXAMPLES (Cont.)

EXAMPLE 5. . .Programmable limit switches (cont. from prev. page)

Program line	Comments
DRILL:	
ACCEL.RATE = 1000	SET ACCEL RATE TO 1000 RPM/S
RUN.SPEED = 10	SET RUN SPEED TO 10 RPM
TARGET.POS = 45056	SET TARGETED POSITION TO 45,056 STEPS
IN.POS.LIMIT = 5	SET IN POSITION LIMIT TO ± 5 STEPS
OUT4 = 0	TURN OUTPUT 4 ON (LOW)
GOSUB ABSMOVE	GO TO MOVE SUBROUTINE
PAUSE	PAUSE FOR 1 SECOND
WITHDRAW:	
ACCEL.RATE = 1000	SET ACCEL RATE TO 1000 RPM/S
RUN.SPEED = 100	SET RUN SPEED TO 100 RPM
TARGET.POS = 40910	SET TARGET POSITION TO 40,910 STEPS
IN.POS.LIMIT = 50	SET IN POSITION LIMIT TO ± 50 STEPS
OUT4 = 0	TURN OUTPUT 4 ON (LOW)
GOSUB ABSMOVE	GO TO MOVE SUBROUTINE
GOTO MOVETOSTART	GO BACK TO START
GO.ABS	DO ABSOLUTE MOVE
WHILE NOT IN.POSITION:WEND	WAIT UNTIL MOVE COMPLETE
RETURN	RETURN TO GOSUB
END	
SIMPLIFIED SEEK_HOME ROUTINE	
REM HOME SWITCH IS ACTIVE ON FALLING EDGE (CLOSES). THIS ROUTINE	
REM COMMANDS MOTION UNTIL SWITCH SIGNAL GOES LOW, THEN REVERSES	
REM DIRECTION AND DETERMINES LOCATION OF LOW-TO-HIGH	
REM SWITCH SIGNAL (OPENING SWITCH) AND	
REM ESTABLISHES ELECTRICAL HOME (POS.COMMAND = 0).	
SUB SEEK_HOME	
GO.VEL	
RUN.SPEED = 0	
WHEN INP1 = 0, GO.VEL	
WHILE MOVING = 1:WEND	
IF DIR = 1 THEN DIR = 0 ELSE DIR = 1	
RUN.SPEED = 5	
GO.VEL	
RUN.SPEED = 0	
WHEN INP1 = 1, GO.VEL	
POS.COMMAND = POS.COMMAND = WHEN.PCMD	
END SUB	

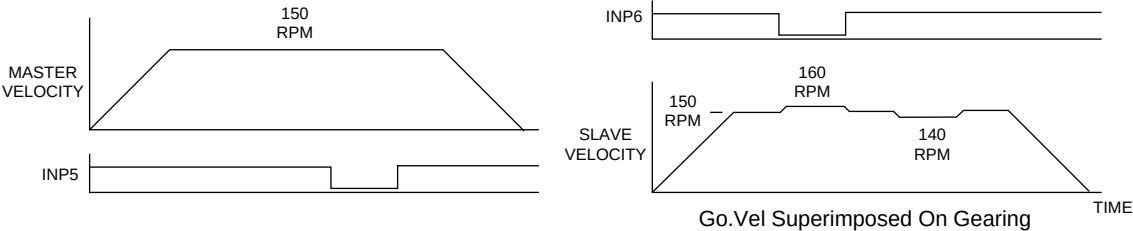


ADVANCED PROGRAMMING EXAMPLES (Cont.)

EXAMPLE 6. . .Electronic gearing

In electronic gearing, a slave axis is electronically geared to a master. The master has a 1024 line encoder and is used in quadrature to produce 4096 transitions per revolution. The slave accepts 4096 transitions per revolution for a one to one ratio with the master. Electronic gearing is activated by an off to on transition of INP7.

Program line	Comments
SETUP:	
OUTPUTS = 4095	TURN ALL OUTPUTS OFF (HIGH)
GEARING = 0	TURN ALL ELECTRONIC GEARING OFF
ENC.OUT = 1024	SET FOR 1024 PPR ENCODER
RATIO = 1	SET ELECTRONIC GEAR RATIO TO 1:1
ACCEL.RATE = 10000	SET ACCEL TO 10,000 RPM/S
DECEL.RATE = 100000	SET DECEL RATE TO 100,000 RPM/S
RUN.SPEED = 10	SET RUN SPEED TO 10 RPM
OUT7 = 0	TURN OUTPUT 7 ON (LOW)
PAUSE.TIME = 1	SET PAUSE TIME TO 1 SECOND
ENABLE = 1	SOFTWARE MOTOR ENABLE ON
NOTENABLED:	
WHILE ENABLED < > 1	IF ENABLE INPUT IS NOT ACTIVE
OUT1 = 0	BLINK OUTPUT 1 ON (LOW)
PAUSE	FOR 1 SECOND
OUT1 = 1	AND OFF (HIGH)
PAUSE	FOR 1 SECOND
WEND	UNTIL ENABLE INPUT IS ACTIVATED
GEARINGON:	
WHILE INP7 = 0:WEND	WAIT FOR INPUT 7 TO GO HIGH
WHILE INP7 = 1:WEND	WAIT FOR INPUT 7 TO RETURN LOW
GEARING = 1	TURN ELECTRONIC GEARING ON
OUT7 = 1	TURN OUTPUT 7 OFF (HIGH)
OUT5 = 0	TURN OUTPUT 5 ON (LOW)
OUT6 = 0	TURN OUTPUT 6 ON (LOW)
DIRECTION:	
IF INP6 = 0 THEN	IF INPUT 6 IS LOW, SET
DIR = 0	DIRECTION OF 10 RPM VELOCITY TO CW
GO.VEL	SUPERIMPOSE 10 RPM ONTO GEARING
GOTO DIRECTION	GO BACK TO LOOK AT INPUT 6
END IF	END IF. . .THEN BLOCK
IF INP5 = 0 THEN	IF INPUT 5 IS LOW, SET
DIR = 0	DIRECTION OF 10 RPM VELOCITY TO CCW
GO.VEL	SUPERIMPOSE 10 RPM ONTO GEARING
GOTO DIRECTION	GO BACK TO LOOK AT INPUT 6
END IF	END IF. . .THEN BLOCK
ABORT.MOTION	STOP SUPERIMPOSED 10 RPM VELOCITY
GOTO DIRECTION	GO BACK TO LOOK AT INPUT 6



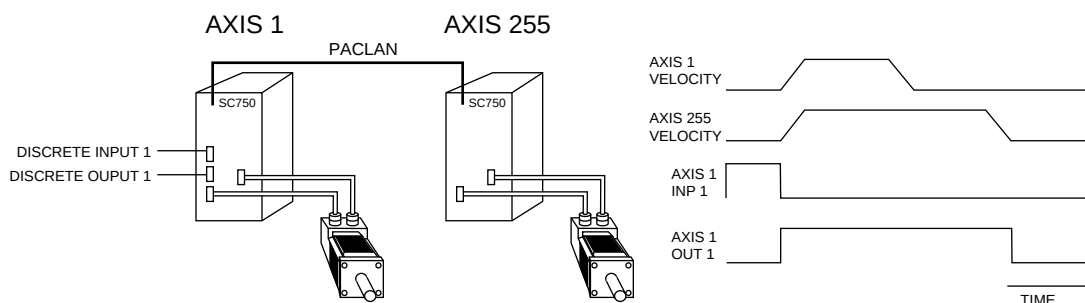
ADVANCED PROGRAMMING EXAMPLES (Cont.)

EXAMPLE 7. . PacLAN™ Multi-axis position control capability using SC750 single axis digital position controllers

The PacLAN™ enhancement is a local area network (LAN) system that allows multiple single axis SC750 controllers to be integrated to provide effective and economical solutions to many multi-axis motion control applications. SC750 controllers networked via PacLAN provide distributed motion control and replace centralized multi-axis controllers. Using PacLAN, information can be exchanged with any SC750 controller on the network. Easy application monitoring and adjustments are made using a single operator interface or a host computer.

The 2.5 megabaud PacLAN allows up to 255 axes (nodes) to communicate and share information at distances up to 500 feet. PacLAN is a token passing communications port that utilizes CRC error detection, message acknowledgement, rugged twinaxial cabling and a fully transformer-isolated cable driver for reliable communications in high noise industrial environments.

This example shows the ease of synchronized motion in two axes with an input to the first axis.

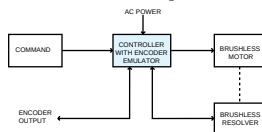


The program for axis 1 waits for a one-to-zero transition of its discrete input 1 before initiating a ten turn incremental move. Similarly, axis 255 waits for the same transition to initiate a 20 turn incremental move. The program in axis 255 indicates that it is looking at an input to axis 1 by using the variable name "INP1[1]." The bracketed "1" is a call to PacLAN to fetch the data from axis 1 over the network. The network is also used to insure that both axes are in position before another move can be initiated.

AXIS 1		AXIS 255	
Program line	Comments	Program line	Comments
OUTPUTS = 4095	TURN OFF ALL OUTPUTS	ACCEL.RATE = 10000	SETUP AXIS 255 MOVE PARAMETERS
ACCEL.RATE = 10000	SETUP AXIS 1 MOVE PARAMETERS	DECEL.RATE = 10000	
DECEL.RATE = 10000		RUN.SPEED = 500	
RUN.SPEED = 500		INDEX.DIST = 20 * 4096	
INDEX.DIST = 10 * 4096		IN.POS.LIMIT = 10	
IN.POS.LIMIT = 10		PAUSE.TIME = .1	ENABLE AXIS 255 CONTROLLER
PAUSE.TIME = .1	ENABLE AXIS 1 CONTROLLER	ENABLE = 1	
ENABLE = 1		PAUSE	
PAUSE		WHILE 1 = 1	MAIN PROGRAM LOOP
WHILE 1 = 1	MAIN PROGRAM LOOP	WHILE INP1[1] = 0:WEND	DO INCREMENTAL MOVE ON HIGH-TO-LOW TRANSITION OF AXIS 1'S INP1
OUT1 = 0	TELL THE WORLD BOTH AXES ARE HOLDING POSITION	WHILE INP1[1] = 1:WEND	
WHILE INP1 = 0:WEND	DO INCREMENTAL MOVE ON HIGH-TO-LOW TRANSITION OF INP1	GO.INCR	
WHILE INP1 = 1:WEND		WHILE((IN.POSITION = 0) OR (IN.POSITION [1] = 0))	WAIT TILL BOTH AXES ARE AT POSITION
OUT1 = 1	INDICATE MOTION IN PROCESS	WEND	
GO.INCR	INITIATE MOVE	WEND	
WHILE((IN.POSITION = 0) OR (IN.POSITION [255] = 0))	WAIT TILL BOTH AXES ARE AT POSITION	END	MAIN PROGRAM
WEND			
WEND			
END	MAIN PROGRAM		

SC720 SERIES*

Analog Torque/Velocity or Digital
Position Command Controllers
3.8A to 60A continuous current
7.5A to 120A peak




SC720 Controllers
are UL Recognized
(File E137798)

- Economical analog control with integral power supply
- Removable analog or digital personality module for easy setup and maintenance
- Digital personality module accepts step and direction or quadrature encoder position commands for connection to an indexer or for electronic gearing
- Single and multi-axis use
- Total front access to clearly marked connections
- Quadrature encoder output signals derived from single resolver feedback
- Inaudible, high frequency PWM current control
- 5 power levels
- 7 segment controller status display
- UL recognition

Designed specifically for use in harsh industrial environments, SC720 Series controllers provide economical velocity or torque control. Five power levels, SC722 through SC726, are ideal for use with Pacific Scientific's full torque range of brushless servo motors, R20 through R80 Series.

When used in combination with Pacific Scientific motors, SC720 Series controllers provide continuous torque ranging from 4.8 lb-in. to 451 lb-in. and peak torque from 10 lb-in. to 800 lb-in.

Thanks to modular design, wiring, setup and operating procedures are identical for all models in the SC720 Series. Standard motor power and feedback cables are available to assure reliable, troublefree system startup and operation.

INPUT POWER FEATURES

Each SC720 model is a stand-alone, 4-quadrant controller equipped with an internal power supply and shunt regulator. Separate AC inputs are provided for control logic and bus power.

The control logic can be powered while power is removed from the motor, placing the motor in a safe state while preventing loss of encoder or fault information. Control logic power can be 90-264 Vac single phase. Bus power can be 120 Vac single phase or 240 Vac single or three phase on the SC722 and SC723 and is 240 Vac three phase on the SC724, SC725 and SC726.

SINGLE RESOLVER FEEDBACK

The SC720 Series uses a single frameless resolver mounted on the motor shaft for rugged, reliable feedback. The resolver provides all necessary feedback information for commutation, velocity and position control.

Position feedback information from the resolver is processed by the drive electronics to produce signals which emulate an incremental encoder. These quadrature encoder output signals are available for use by an external position controller, including PLC servo modules.

The outputs are differential line drivers and have selectable resolution of up to 1024 pulses per revolution (4096 PPR optional).

Pacific Scientific offers resolver equipped, brushless rare earth and ferrite magnet servo motors ideal for use with the SC720.

PERSONALITY MODULE

The personality module contains all motor and application-specific drive settings and parameters. Easily removed and installed, these modules simplify setup, installation and maintenance while reducing spare part requirements.

All adjustments on the Analog Personality Module are potentiometers, jumpers or switches. All adjustments on the Digital Personality Module are set by a computer over a serial communications port and stored in EEPROM.

The Analog Personality Module allows for analog command of motor shaft torque or velocity. The Digital Personality Module allows for these same modes plus digital position commands in step and direction or quadrature format. These commands may be used for electronic gearing or come from

Peak torque range:
10.0 to 800 lb-in.
(1.1 to 90 Nm)



an indexer for position profiling or multi-axis control. The Digital Personality Module also features automated setup of adjustments and the ability to change adjustment settings via the serial port while the controller is operating.

The SERCOS Personality Module allows access to the Pacific Scientific multi-axis controller via the SERCOS standard fiber optic communication interface.

ADVANCED POWER CIRCUITRY

Insulated gate bipolar transistor (IGBT) technology in the SC720's output stage achieves high bandwidth 20 kHz PWM control. IGBTs simultaneously reduce circuit complexity, cost and package size.

A proprietary custom integrated circuit performs the processing for motor commutation and drive protection. This custom IC further reduces cost and size, while increasing reliability.

OPERATING FEATURES

- Smooth, high bandwidth velocity/torque control
- Transformerless, direct 240/120 Vac single or three phase line operation
- IGBT PWM output stage
- Phoenix screw terminal connections
- Fully enclosed, panel mount package
- Integral, directional dynamic braking

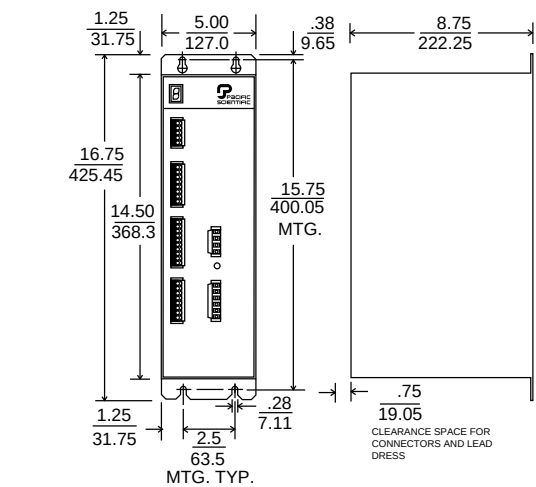
ADJUSTMENTS

- All adjustments are on the personality module
- Analog Personality Module option uses potentiometers, jumpers and a DIP switch—Digital Personality Module option stores all adjustment settings in EEPROM
- Loop adjustments:
 - Velocity loop gain
 - Anti-resonance filter
 - Command gain
 - Offset
 - Current limit
 - Position loop gain (digital option only)
 - Position command gain (digital option only)
- Selection settings:
 - Velocity/torque/position control select
 - Tachometer gradient (4 settings)
 - Emulated encoder PPR (4 settings)
 - 4 or 8 pole motor selection

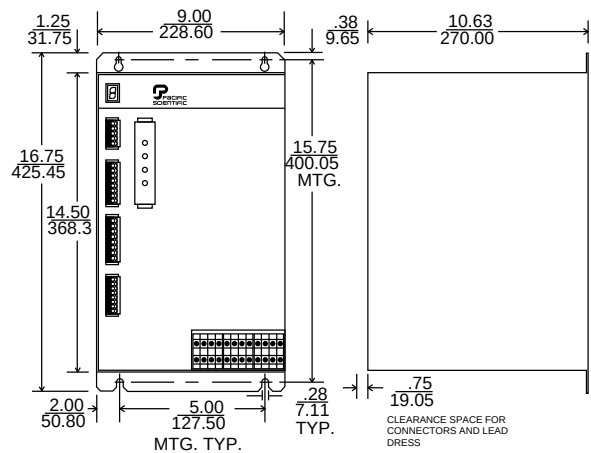
PROTECTION/DIAGNOSTICS

- 7 segment status/fault code display
- Front access test points
- Inrush current limiting
- Fully fused
- MOV protected input
- Output short circuit protection
- Overtemperature protection, controller and motor
- I * T protection
- 3 bit fault code output

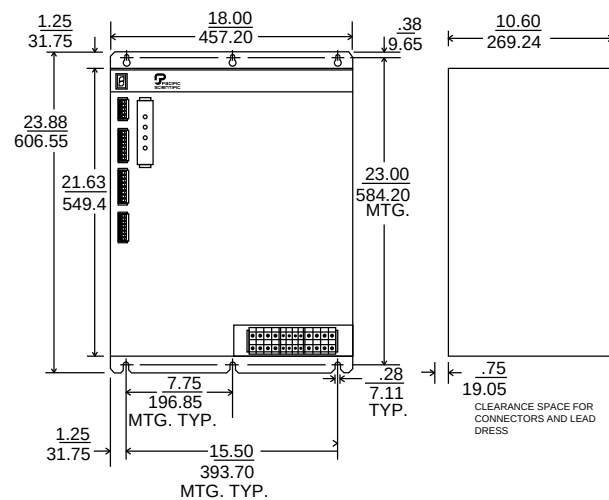
DIMENSIONS in.
mm (metric dimensions for ref. only)*



SC722/SC723



SC724/SC725



SC726

*See pages B-6 through B-26 for information on the next generation Servo Position Control.

GENERAL. . .SC720 Series Controllers*

Efficiency (50% output voltage, rated cont. current)	.> 95%
Form factor	< 1.01
Current loop bandwidth	.750 to 3000 Hz
Velocity offset	.Adjustable to zero
Velocity offset drift (referred to input)	.50 μ V/°C
Velocity input command	. $\pm$ 10V
Output ripple frequency ($\pm$ 15%)	.20 kHz
Feedback	.Brushless resolver
Tachometer gradients (switch selectable) ($\pm$ 2.5%)	.1 V/kRPM, 8000 RPM max. 2 V/kRPM, 4000 RPM max. 4 V/kRPM, 2000 RPM max. 8 V/kRPM, 1000 RPM max.
Tachometer ripple (max.)	
Drive only	.3% p-p
With standard PacSci motor	.5% p-p
Encoder output resolutions (switch selectable)	
Standard	.500, 512, 1000, 1024 PPR, $\pm$ 22 arcmin accuracy
Optional (3000 RPM max. speed)	.2048, 4096 PPR, $\pm$ 4 arcmin accuracy
Control inputs	.Enable Reset Inhibit + Inhibit -
Test points (front panel)	.Velocity command Tach monitor Current command Current monitor Commutation signal
Fault output	.3 bit fault code, open collector
Digital Personality Module communications	.9600 baud
Interfacing connectors (furnished)	.All plug-in mating connectors
Storage temperature	-.55°C to 70°C
Operating temperature	
Full ratings	.0°C to 50°C
Derated $\triangle$	.50°C to 60°C
Altitude	.5000 ft. (1500 m)
Humidity	.10% to 90%, non-condensing
Weight	.SC722, 13 lbs. SC723, 16 lbs. SC724/725, 40 lbs. SC726, 90 lbs.

$\triangle$ Linearly derate the continuous current and power ratings to 70% at 60°C.
 $\triangle$ With "B" version of drive, line count less than 2048 is not available.

POWER DATA. . .SC720 Series Controllers

	SC722	SC723	SC724	SC725	SC726
Input voltage					
Control logic power	90 to 264 Vac, 47 to 63 Hz, 1 phase				
Bus power	120 Vac (+10%, -15%)/ 240 Vac (+10%, -15%), 47 to 63 Hz, 1 or 3 phase			240 Vac (+ 10%, -15%), 47 to 63 Hz, 3 phase	
Bus Voltage					
(with 240 Vac input)	320 Vdc				
(with 120 Vac input)	160 Vdc				
Input current $\triangle$					
Control logic power	500 mA max. @ 120 Vac, 250 mA max. @ 240 Vac.				
Bus current (RMS) (240 Vac, 3-phase)	4.5 A _{rms}	9 A _{rms}	18 A _{rms}	29 A _{rms} (@6kW)	38 A _{rms} (@12kW)
Output current @ 50°C $\triangle$					
Peak (5 seconds)	7.5 A	15 A	30 A	60 A	120 A
Continuous (stall)	3.8 A	7.5 A	15 A	30 A $\triangle$	60 A
Output power (min. @ 50°C)					
Peak (5 seconds)					
240 Vac, 3-phase	2.2 kW	4.5 kW	9 kW	18 kW	36kW
240 Vac, 1-phase	2.0 kW	4.0 kW	n/a	n/a	n/a
Continuous					
240 Vac, 3-phase	1.1 kW	2.2 kW	4.5 kW	9 kW	18 kW
240 Vac, 1-phase	0.8 kW	1.6 kW	n/a	n/a	n/a
Shunt regulator power					
Peak	3 kW	6 kW	20 kW	20 kW	40 kW
Continuous	20 W	40 W	200 W	200 W	500 W

$\triangle$ Currents ratings are defined as the maximum value of a 6-step waveform.
 $\triangle$ The SC725 can be configured for 40 A continuous (stall).

$\triangle$ Input current is specified with unit operating at continuous rated output power.

SC720 SERIES RECOMMENDED MOTOR/CONTROLLER SYSTEMS *

Peak stall torque T_{PS} lb-in./Nm	Peak rated torque T_{PR} lb-in./Nm	Cont. stall torque T_{CS} lb-in./Nm	Cont. rated torque T_{CR} lb-in./Nm	Rated Speed W_r rpm	Inertia $x 10^{-3}$ lb-in-S ² / kgm ² J	Servo-motor Dia. or Width/height inch/mm	Servo-motor Length inch/mm	Inductance line-line L mH	Servo-motor model	Servo-Controller model 
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With R Series (low inertia,rare earth magnet) motors

10/ 1.1	6.5/ .7	4.8/ .5	2.5/ .3	8000	0.12/ .014	2.00/ 50.8	7.38/187.5	5.3	R22HENA-R1-NS-NV-01	SC722A-001-PM72005
14/ 1.6	8/ .9	7.6/ .9	5.2/ .6	8000	0.15/ .017	2.00/ 50.8	8.38/212.9	6.5	R23HENA-R1-NS-NV-01	SC722A-001-PM72004
17/ 1.9	10/ 1.1	9.2/ 1.0	7.1/ .8	6000	0.18/ .020	2.00/ 50.8	9.38/238.3	6.5	R24HENA-R1-NS-NV-01	SC722A-001-PM72004
27/ 3.0	25/ 2.8	14/ 1.6	10/ 1.1	4000	0.55/ .062	3.25/ 82.6	7.09/180.1	23.0	R32GENC-R2-NS-NV-00	SC722A-001-PM72008
27/ 3.0	25/ 2.8	14/ 1.6	6/ .7	7000	0.55/ .062	3.25/ 82.6	7.09/180.1	5.8	R32HENC-R2-NS-NV-00	SC723A-001-PM72004
36/ 4.0	33/ 3.7	21/ 2.4	16/ 1.8	3000	0.74/ .084	3.25/ 82.6	8.09/205.5	22.0	R33GENC-R2-NS-NV-00	SC722A-001-PM72008
36/ 4.0	25/ 2.8	21/ 2.4	10/ 1.1	6000	0.74/ .084	3.25/ 82.6	8.09/205.5	5.6	R33HENC-R2-NS-NV-00	SC723A-001-PM72004
45/ 5.0	42/ 4.7	27/ 3.0	24/ 2.7	2800	0.92/ .104	3.25/ 82.6	9.09/230.9	30.0	R34JENC-R2-NS-NV-00	SC722A-001-PM72012
45/ 5.0	38/ 4.3	27/ 3.0	16/ 1.8	4000	0.92/ .104	3.25/ 82.6	9.09/230.9	7.5	R34KENC-R2-NS-NV-00	SC723A-001-PM72008
54/ 6.0	53/ 5.9	32/ 3.6	30/ 3.4	2000	1.11/ .125	3.25/ 82.6	10.09/256.3	42.0	R35JENC-R2-NS-NV-00	SC722A-001-PM72012
54/ 6.0	48/ 5.4	32/ 3.6	23/ 2.6	3000	1.11/ .125	3.25/ 82.6	10.09/256.3	10.5	R35KENC-R2-NS-NV-00	SC723A-001-PM72008
66/ 7.4	50/ 5.6	33/ 3.7	33/ 3.4	1800	1.90/ .215	4.25/108.0	8.34/211.8	53.0	R43GENA-R2-NS-NV-00	SC722A-001-PM72012
66/ 7.4	60/ 6.7	33/ 3.7	31/ 3.5	3000	1.90/ .215	4.25/108.0	8.34/211.8	13.3	R43HENA-R2-NS-NV-00	SC723A-001-PM72008
106/11.9	95/10.6	48/ 5.4	46/ 5.2	2000	2.70/ .305	4.25/108.0	9.84/249.9	4.9	R45GENA-R2-NS-NV-00	SC723A-001-PM72012
106/11.9	95/10.6	48/ 5.4	43/ 4.8	4000	2.70/ .305	4.25/108.0	9.84/249.9	20.0	R45HENA-R2-NS-NV-00	SC724A-001-PM72012
142/15.9	120/13.4	64/ 7.2	61/ 6.8	1500	3.50/ .395	4.25/108.0	11.34/288.1	25.0	R46GENA-R2-NS-NV-00	SC723A-001-PM72012
142/15.9	120/13.4	64/ 7.2	50/ 5.6	3000	3.50/ .395	4.25/108.0	11.34/288.1	6.2	R46HENA-R2-NS-NV-00	SC724A-001-PM72008
150/16.8	125/14.0	70/ 7.8	58/ 6.5	3000	7.10/ .818	5.75/146.1	9.36/237.7	8.9	R63GENA-R2-NS-NV-00	SC724A-001-PM72007
150/16.8	142/15.9	70/ 7.8	38/ 4.3	6000	7.10/ .818	5.75/146.1	9.36/237.7	2.2	R63HENA-R2-NS-NV-00	SC725A-001-PM72003
240/26.9	230/25.8	115/12.9	102/11.4	1700	11.10/1.28	5.75/146.1	11.36/288.5	13.7	R65GENA-R2-NS-NV-00	SC724A-001-PM72012
240/26.9	200/22.4	115/12.9	90/10.1	3000	11.10/1.28	5.75/146.1	11.36/288.5	3.4	R65HENA-R2-NS-NV-00	SC725A-001-PM72008
340/38.1	305/34.2	168/18.8	156/17.5	1000	15.10/1.74	5.75/146.1	13.36/339.3	18.2	R67GENA-R2-NS-NV-00	SC724A-001-PM72016
340/38.1	330/37.0	168/18.8	146/16.4	2000	15.10/1.74	5.75/146.1	13.36/339.3	4.6	R67HENA-R2-NS-NV-00	SC725A-001-PM72012
300/33.6	280/31.4	190/21.3	125/14.0	3800	39.10/4.50	7.50/190.5	10.93/277.6	3.2	R84GENA-R2-NS-NV-00	SC725A-001-PM72008
300/33.6	270/30.2	190/21.3	45/ 5.0	6000	39.10/4.50	7.50/190.5	10.93/277.6	0.8	R84HENA-R2-NS-NV-00	SC726A-001-PM72004
410/45.9	395/44.2	276/30.1	225/25.2	2000	58.10/6.69	7.50/190.5	12.93/328.4	3.6	R86GENA-R2-NS-NV-00	SC725A-001-PM72012
410/45.9	365/40.9	276/30.1	120/13.4	4000	58.10/6.69	7.50/190.5	12.93/328.4	0.9	R86HENA-R2-NS-NV-00	SC726A-001-PM2009
540/60.5	525/58.8	357/28.8	325/36.4	1500	76.10/8.77	7.50/190.5	14.93/379.2	4.0	R88GENA-R2-NS-NV-00	SC725A-001-PM72012
540/60.5	500/56.0	357/28.8	205/23.0	3000	76.10/8.77	7.50/190.5	14.93/379.2	1.0	R88HENA-R2-NS-NV-00	SC726A-001-PM72009
800/89.6	730/81.8	451/50.5	424/47.5	1200	95.10/10.96	7.50/190.5	16.93/430.0	7.4	R8AGENA-R2-NS-NV-00	SC725A-001-PM72016
800/89.6	720/80.6	451/50.5	300/33.6	2000	95.10/10.96	7.50/190.5	16.93/430.0	1.9	R8AHENA-R2-NS-NV-00	SC726A-001-PM72013

With F Series (medium inertia, ferrite magnet) motors

56/ 6.3	34/ 3.8	32/ 3.6	25/ 2.8	1500	9.20/1.04	4.25/108.0	8.34/211.8	49.0	F43GENA-R2-NS-NV-00	SC722A-001-PM72032
60/ 6.7	30/ 3.4	32/ 3.6	22/ 2.5	3000	9.20/1.04	4.25/108.0	8.34/211.8	12.0	F43HENA-R2-NS-NV-00	SC723A-001-PM72028
84/ 9.4	55/ 6.2	46/ 5.2	43/ 4.8	1000	13.70/1.55	4.25/108.0	9.84/249.9	69.0	F45FENA-R2-NS-NV-00	SC722A-001-PM72036
84/ 9.4	45/ 5.0	46/ 5.2	38/ 4.3	2000	13.70/1.55	4.25/108.0	9.84/249.9	17.0	F45GENA-R2-NS-NV-00	SC723A-001-PM72032
121/13.6	62/ 6.9	61/ 6.8	48/ 5.4	1500	17.70/2.00	4.25/108.0	11.34/288.1	24.0	F46GENA-R2-NS-NV-00	SC723A-001-PM72032
121/13.6	60/ 6.7	61/ 6.8	43/ 4.8	3000	17.70/2.00	4.25/108.0	11.34/288.1	6.0	F46HENA-R2-NS-NV-00	SC724A-001-PM72028

 See page B-73 for definitions of ratings.

 Peak torque ratings are for 5 seconds

 Rated speeds are for 240 Vac, 3 phase operation.
Derate to approximately 85% for 240 Vac, 1 phase operation.
Derate to 40% for 120 Vac, 1 phase operation.

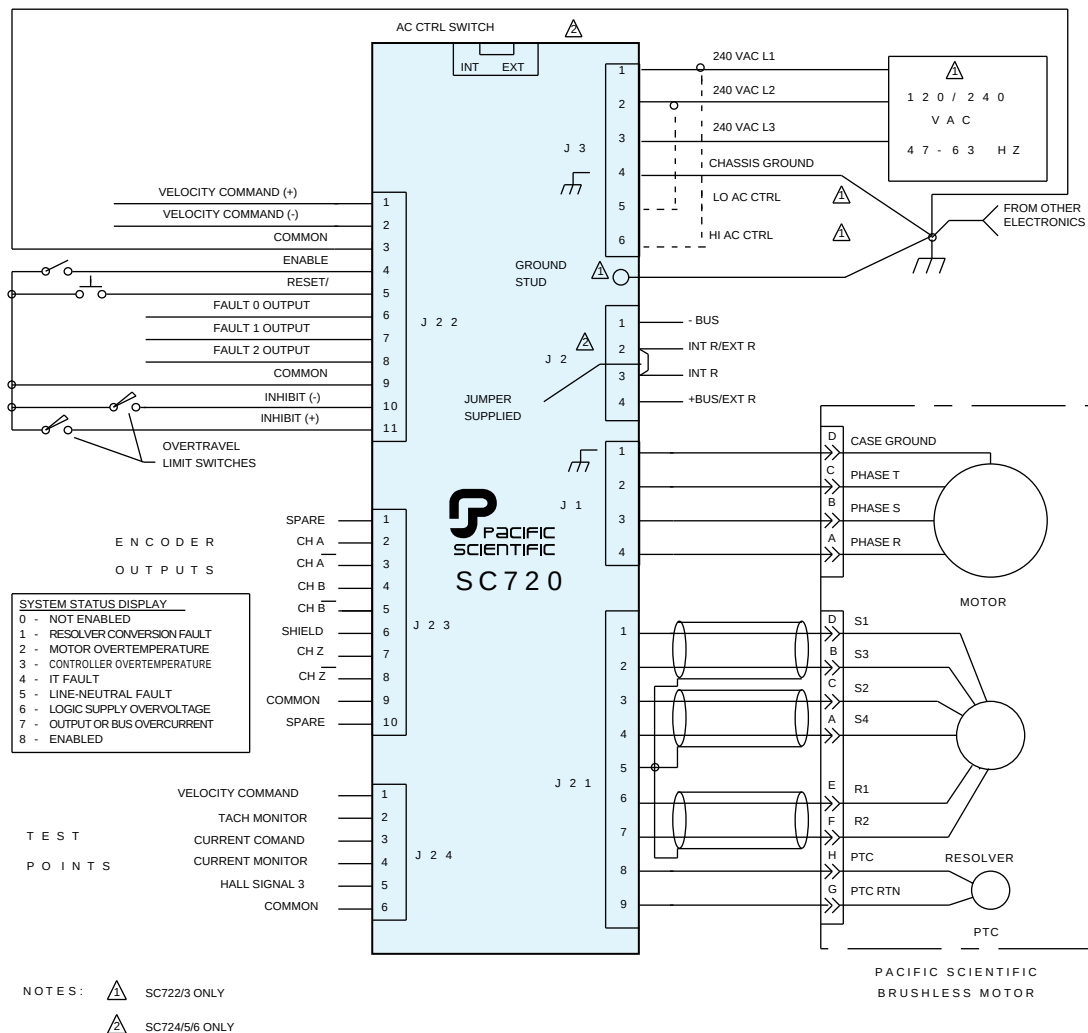
 Includes primary feedback inertia.

 Controller model numbers are for 12 bit resolution option. See How to Order, page B-53.

 Each system requires one feedback and one motor power cable. See Section D for more information.

**See pages B-6 through B-26 for information on the next generation Servo Position Control.*

CONNECTION DIAGRAM. . SC720 Series Controllers*



*See pages B-6 through B-26 for information on the next generation Servo Position Control.

HOW TO ORDER . . .SC720 Series Controllers*

SC720 Series servo controllers must be used with the appropriate personality module. Since the personality module is dependent on the specific motor used, a factory code is assigned.

To find the appropriate personality module model number, refer to the Recommended Motor/Controller Systems table on page B-51.

MODEL NUMBER CODE	Controller with personality module
Servo controller _____	SC 7 2 X X-001-PM72XXX
Series _____	
Function code _____ 2=torque/velocity controller w/encoder emulator (resolver)	
Power level code _____ 2=3.8A cont./7.5A peak 3=7.5A cont./15A peak 4=15A cont./30A peak 5=30A cont./60A peak 6=60A cont./120A peak	
Option code _____ A=12 bit RDC (±22 arcmin, 1024 ppr) B=14 bit RDC (±4 arcmin, 4096 ppr) △	
Customization code _____ Factory assigned, 001=standard unit	
Suffix code, Personality module designator _____ PM72 followed by "XXX" for factory assigned motor/controller ID=Analog setup and adjustment type. . . see tables on page B-51. PM73 followed by 001 for standard model or "XXX" for factory assigned application-specific motor/controller ID=Digital setup and adjustment type. PM74 followed by 001 for standard model or "XXX" for factory assigned application-specific motor/controller. 10 = SERCOS Personality Module	

HOW TO ORDER...SC720 Series Recommended Motor/Controller Systems

See the Recommended Motor/Controller Systems table on page B-51 for performance information and model numbers for servo motor/controller combinations. Order motors and controllers as separate part numbers. See brushless servo motor section for additional motor specifications and information.

△ SERCOS Personality Module not available with this option.

*See pages B-6 through B-26 for information on the next generation Servo Position Control.

SC720 SERIES*

PERSONALITY MODULES

Personality modules contain all motor and application-specific drive settings and parameters. Easily removed and installed from the front of the drive, these modules simplify setup, installation and maintenance while reducing spares requirements.

ANALOG PERSONALITY MODULE (APM)

Drives with analog personality modules are designed for use in conventional multi-axis systems utilizing $\pm 10V$ analog velocity or torque commands and quadrature encoder position feedback. This module provides analog command of motor shaft torque or velocity. Application and motor parameters are set in the module using DIP switches, jumpers, and potentiometers. Additional parameter adjustments can be implemented as factory options. The module contains:

- Compensation potentiometers for:
 - velocity offset
 - command gain
 - loop gain
 - current limit
- Switch settings for:
 - tachometer scaling for velocity loop
 - velocity or torque block selection
 - encoder line count selection
 - four or eight motor-pole selection
- Velocity loop compensation range jumper selection
- Anti-resonance low pass filter time constant jumper selection
- Spare jumper positions for adding components for non-standard compensation

In these systems, the position loop is generally closed in a motion control card while the drive closes the velocity and current loops. In some instances, the position and velocity loops are closed in the motion control card and only the current loop is closed in the drive. The motion profile planning and generation is done in the motion control card.

HOW TO ORDER SC720 SERIES DRIVES WITH AN ANALOG PERSONALITY MODULE (APM)

The SC720 drives must be used with a personality module. Since the personality module is dependent on the specific motor used, a factory code is assigned. To find the specific drive/APM combination, refer to the Recommended Motor/Controller Systems table on page B-51. The analog personality module designation is suffix number added to the ServoDrive model. PM72XXX is the suffix for the SC720 drives. For example, a SC722A-001-PM72005 is the correct drive/APM to order for use with the R22HENA-R1-NS-NV-01 servo motor. The drive/APM, motor and cabling are ordered as separate part numbers.

Place orders through your nearest Pacific Scientific Motion Control Distributor or call the factory direct for assistance in placing an order.

DIGITAL PERSONALITY MODULE (DPM)

Drives with digital personality modules are for multi-axis systems utilizing $\pm 10V$ velocity or torque commands and quadrature encoder position feedback. All adjustments on this module are set by a computer over a serial communications port and stored in EEPROM. Combined with DPM Dialogue™, a menu driven software support package which runs on your IBM PC or PC clone, this module provides the same modes as the analog module plus digital position commands in step and direction or quadrature format. These commands may be used for electronic gearing or come from an indexer for position profiling or multi-axis control. The module also features automated setup of adjustments and the ability to change adjustment settings via the serial port while the drive is operating. The module contains:

- All digital setup of the current loop, velocity loop and (when utilized) position loop. There are no pots, DIP switches, plug-on jumpers or components to alter when setting up the servo loops. All parameters are downloaded using an RS-232 or RS-485 port and can be saved in non-volatile memory.
- Automatic drive setup using DPM Dialogue.
- Simplified uploading, downloading, and disk storage of DPM parameters for easy cloning and backup documentation.
- Follower operation in electronic gearing applications.
- Position control using Step and Direction inputs. This means that your SC720 may be driven directly from most stepper indexers.
- Precise readout of motor velocity and position using the serial link and DPM Dialogue.

In these systems, the position loop is generally closed in a motion control card while the drive closes the velocity and current loops. In some instances, the position and velocity loops are closed in the motion control card and only the current loop is closed in the drive. The motion profile planning and generation is done in the motion control card.

Drives with these modules can also be used in multi-axis systems utilizing a stepper indexer which supports Step and Direction outputs. In these systems, the position loop is closed in the drive/DPM along with the velocity and current loop. The motion profile planning and generation is done in the stepper indexer.

This module also allows the drive to be used as a follower axis in electronic gearing applications. In these systems, the position loop is closed in the drive/DPM along with the velocity and current loop.

The SC720 drives generate quadrature encoder feedback signals from the motor's resolver. These quadrature encoder signals are used by the motion control card to close the system's position loop and to execute the motion profiles. In systems utilizing a stepper indexer for motion control, the encoder feedback signals may or may not be used by the indexer for position verification or closure of the position loop. In electronic gearing applications, these encoder feedback signals may be used to command a follower axis.

Application and motor parameters are set on this module (which is a plug in unit) for easy installation and maintenance. Parameters are all set via the modules serial port using the DPM Dialogue program supplied with the module.

**See pages B-6 through B-26 for information on the next generation Servo Position Control.*

HOW TO ORDER SC720 SERIES DRIVES WITH A DIGITAL PERSONALITY MODULE (DPM) (Cont.)

The SC720 drives must be used with a personality module. The digital personality module designation is a suffix added to the servo controller model number. PM73001 is the suffix for the SC720 drives. For example, an SC722A-001-PM73001 is the correct drive/DPM to order for use with the R22HENA-R1-NS-NV-01 servo motor. The DPMs will always be identified as PM73001 unless they are customer specific. In these cases, sequential numbers beyond 001 will indicate a special set up for a special motor via the DPM Dialogue database.

The drive, DPM, motor and cabling are ordered as separate part numbers.

Place orders through your nearest Pacific Scientific Motion Control Distributor or call the factory direct for assistance in placing an order.

SERCOS PERSONALITY MODULE (SPM)

Drives with SERCOS personality modules are designed for use in distributed, multi-axis motion control systems utilizing the SERCOS (**S**erial **R**ealtime **C**ommunications **S**ystem) digital interface International standard. SERCOS replaces the ± 10 volt analog servo command interface with a high speed, digital, fiber optic communications link. SERCOS is the only open, fiber optic communications system with the high speed performance required to link machine controllers with multiple digital drives. The SERCOS standard allows the control to command position, velocity, or torque of the motor/drive via the fiber optic ring. The SERCOS ring also supports the flow of information from the drive back to the control. Actual motor position, velocity, torque and drive status are examples of the information which the control can obtain from the drive. The benefits of SERCOS technology are:

- Open system specification
- Significantly reduced installed system cost
- Reliable noise free environment using fiber optics
- Superior 32-bit performance

The SERCOS module contains all the hardware and software necessary to connect the SC720 Series drives as slaves on the SERCOS fiber optic ring. This allows the drives to be used as components in state-of-the-art multi-axis motion control systems. Application and motor parameters are set on the personality module via the SERCOS fiber optic ring using the drive set-up program supplied with the SERCOS control.

A single fiber optic cable ring is the only connection necessary between the control and the drives. This reduces installation costs and simplifies design and maintenance. This single cable not only provides command information to all the drives but also provides drive status information to the control. This allows the control to act on drive status information and make this information available to the machine operator.

A SERCOS based system offers many benefits over a conventional centralized multi-axis control system,

especially in applications where motors and drives are not conveniently located in a central location. The fiber optic network eliminates noise and ground loop problems thereby easing installation and maintenance. This module:

- Offers compatibility with the SERCOS digital interface international standard for digital servo drives.
- Provides a communications interface so that up to 32 SC720 servo drives can be controlled by a SERCOS master across a single fiber optic ring. For applications requiring more than 32 axes, additional SERCOS rings may be configured and synchronized from the SERCOS master.
- Eliminates costly and difficult to install low voltage signal wiring associated with conventional analog servo interfaces.
- Provides 100% electrical isolation between motion controller (SERCOS master) and servo drive subsystem through the use of fiber optics.
- Supports SERCOS telegram cycle time of 2 milliseconds in either the position or velocity control mode.

The SERCOS topology takes advantage of processing power resident in the drives. Microprocessors and/or DSPs in the drive handle the processor intensive tasks of closing the position, velocity, and current loops. In the distributed topology, processor power is matched to the complexity level of the application. As the axis count of the system increases, processor power is incrementally added automatically with the addition of each drive. In the centralized topology, these processor intensive servo loop closure tasks must be handled by the central controller. This central control must possess the processor power to handle the worst case system. In many instances, there will be unused (and costly) processor power.

Servo loop closures must be done at fairly high update rates to achieve good performance. For the distributed SERCOS system, this is done in the drive by its internal processor. The SERCOS controller is freed from this burden and its processor is dedicated to running the user's motion control program and doing the generation of motion profiles. Motion profiles are updated every 2 mS by the SERCOS controller and transmitted to the SERCOS compatible drives on the fiber optic ring. Up to 16 drives can have their position updated at this 2 mS rate.

This 2 mS profile generator update rate should not be confused with the servo loop closure update rates. Servo loop updates occur at a faster rate within the drive's local processor. In traditional centralized systems, this profile generator update rate is typically not specified since this interface is buried within the controller.

In a typical industrial machine, position loop response is 20 Hz maximum because of mechanical limitations. A 20 Hz position loop has an 8 mS response time. The position command to the drive is being updated every 2 mS. The drive interpolates these 2 mS position updates at a 0.5 mS rate. Both the position command update and the interpolation between these updates are occurring at rates significantly faster than those required by the mechanical system. This illustrates that a 2 mS position profile update is sufficiently fast for a vast majority of applications. In instances where there are fewer than 16 drives on the ring, the update time can be decreased. For example, 8 drives on a ring can be updated at 1 mS or 4 drives on a ring can be updated at 0.5 mS.

HOW SERCOS WORKS-AN OVERVIEW

The SERCOS interface is implemented using a master-slave configuration, interconnected unidirectionally over a fiber optic cable, in a ring structure. The data transfer rate is 4 MBits/s with an update time of 2 msec.

The Pacific Scientific/Automation Intelligence programmable motion controller (or similar controller) is the master and the brushless drives with SERCOS personality modules are the slaves. The motion controller controls the flow of information by sending out a synchronization "heartbeat" called the MST every 2 msec. See Figure B-5. All the slaves sequentially receive the MST.

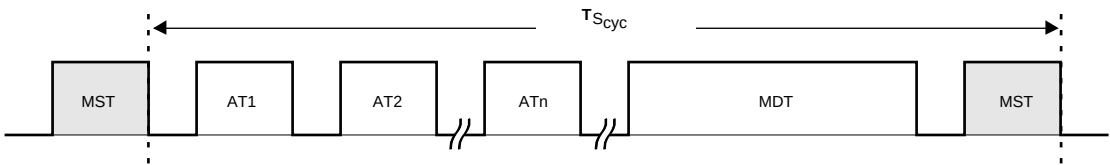


Figure B-5. SERCOS Master Synchronization Telegram-MST

The drives internally synchronize themselves to the MST clock and send back current drive information to the master during "time slot" intervals. This current drive information is contained in the Amplifier Telegram, or AT. (See Figure B-6). The AT is configurable, although it typically consists of time-critical data such as actual position, velocity and torque.

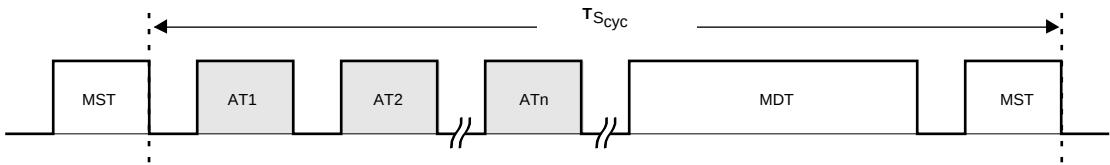


Figure B-6. SERCOS Amplifier Telegram-AT

At the end of each cycle, a Master Data Telegram, or MDT is sent to the slaves. See Figure B-7. The new command values for each drive on the ring are contained in this MDT.

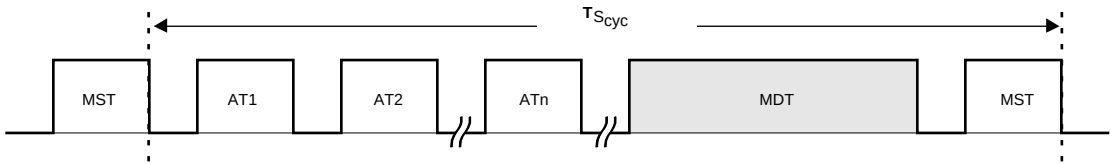


Figure B-7. Master Data Telegram-MDT

IDENTIFICATION NUMBERS (IDN)

- All parameters defined as IDNs
 - 32-bit integers
 - Lists of other IDNs
 - 16-bit Words
 - Text
- IDN Definition Includes
 - Value
 - Description
 - Attributes
 - Min, Max
 - Units
- The SERCOS Personality Module supports the following IDNs as defined by the SERCOS standard. The SERCOS host controller and its software allow setting and reading of these IDNs.
 - 1 Control Unit Cycle Time (TNcvc)
 - 2 SYSTEM Interface Cycle Time (Tscvc)
 - 3 Minimum AT Transmit Starting Time (Tlmin)
 - 4 Transmit/Receive Transition Time (TATMT)
 - 5 Minimum Feedback Acquisition Time (T4min)
 - 6 AT Transmission Starting Time (TI)
 - 7 Feedback Acquisition Starting Time (T4)
 - 8 Command Valid Time (T3)
 - 9 Beginning Address in Master Data Telegram
 - 10 Length of Master Data Telegram
 - 11 Class 1 Diagnostics
 - 14 Interface Status
 - 15 Telegram Type Parameter
 - 16 Custom Amplifier Telegram Configuration List
 - 17 IDN List of all Operation Data
 - 24 Configuration List of the Master Data Telegram
 - 32 Primary Mode of Operation
 - 40 Velocity Feedback Value
 - 41 Homing Velocity
 - 42 Homing Acceleration
 - 43 Velocity Polarity Parameter
 - 44 Scaling of Velocity Data
 - 45 Scaling Factor for Velocity Data
 - 46 Scaling Exponent for Velocity Data
 - 47 Position Command Value
 - 51 Position Feedback Value 1 (Motor Feedback)
 - 52 Actual Position Feedback 1-Reference Distance
 - 55 Position Polarity Parameters
 - 76 Position Data Scaling Method
 - 77 Linear Position Data Scaling Factor
 - 78 Linear Position Data Scaling Factor Exponent
 - 79 Rotational Position Resolution
 - 88 Receive to Receive Recovery Time (TMTSY)
 - 89 MDT Transmit Starting Time (T2)
 - 90 Command Value Transmit Time (TMTSG)
 - 95 Diagnostic Message
 - 99 Reset Class 1 Diagnostics
 - 103 Modulo Value

108 Feedrate Override
123 Feed Constant
127 Communications Phase 3 Transition Check
128 Communications Phase 4 Transition Check
130 Actual Position Value Probe 1 Positive Edge
131 Actual Position Value Probe 1 Negative Edge
138 Bipolar Acceleration
147 Homing Parameter
148 Drive-Controlled Homing Procedure Command
160 Scaling Method for Acceleration Data
161 Scaling Factor for Acceleration Data
162 Scaling Exponent for Acceleration Data
169 Probe Control Parameter
170 Probing Cycle Procedure Command
185 Length of the Configurable Data Record in the AT
186 List of the Configurable Data Record in the MDT
187 List of the Configurable data in the AT
188 List of the Configurable data in the MDT
301 Allocation of Real-Time Control Bit 1
303 Allocation of Real-Time Control Bit 2
305 Allocation of Real-Time Status Bit 1
307 Allocation of Real-Time Status Bit 2
400 Home Switch
401 Probe 1
403 Position Feedback Value Status
405 Probe 1 Enabled
409 Probe 1 Positive Latched
410 Probe 1 Negative Latched

DIAGNOSTIC DATA

In addition to the real-time transmission between the control and drives, SERCOS also provides advanced diagnostic and fault information on the same fiber optic cable. Non time-critical data such as set up parameters, tuning coefficients and homing functions are available through the SERCOS service channel without connecting to any additional I/O. Also incorporated is an oscilloscope function that digitally captures and stores noise-free torque, velocity and position samples for later analysis.

GENERAL MOTION CONTROL

SERCOS was originally developed for machine tool applications. Later, SERCOS has evolved for general motion control and can control typical requirements such as:

- Point-to-point moves
- Electronic gearing
- Electronic CAM profiles
- Registration
- Measurements
- Electronic drive trains

USER CONNECTIONS

- On SERCOS Personality Module
 - J41 Front Panel Cross Connect Cable. This connector is used with the Pacific Scientific supplied cable to connect the SPM to the host servo drive (SC720 Series) J22 front panel connector. The following signals are brought across on this cable:
 - ENABLE
 - RESET
 - INHIBIT+
 - INHIBIT-
 - FAULT0
 - FAULT1
 - FAULT2
- On Host Servo Drive
 - J21 Resolver Feedback and Motor PTC
 - J22 Front Panel Cross Connect to SPM (goes to J41 on SPM)
 - J23 Encoder Emulation Outputs plus **PROBE** and **HOME**
 - J23-1 PROBE Input
 - J23-10 HOME Input
 - J24 Test Points plus **USER ENABLE**
 - J24-1 USER ENABLE Input
 - J1 AC Power
 - J2 Motor Power

ADDRESS SELECTION DIP SWITCH

- Eight switches used for selecting the SPM SERCOS address. Each servo drive on the SERCOS ring must be assigned a unique address.

HOW TO ORDER SC720 SERIES DRIVES WITH A SERCOS PERSONALITY MODULE (SPM)

For an SPM, PM74001 is the suffix for the SC720 drives. For example, an SC722A-001-PM74001 is the correct drive/DPM to order for use with the R22HENA-R1-NS-NV-01 servo motor. The drive/SPM, motor and cabling are ordered as separate part numbers.

SERCOS—QUESTIONS AND ANSWERS

What is SERCOS?

SERCOS (**S**erial **R**eal-time **C**ommunication **S**ystem) is an open fiber optic based controller to digital drive interface international standard. The SERCOS interface is designed to communicate closed loop data serially in real time for high performance motion control systems.

Why a digital standard?

Today, the purely digital drive system is becoming more prevalent. The digital servo drive has no analog circuits and uses no analog feedback loops. Incorporating low cost, high-performance digital signal processors (DSPs), this technology offers enhanced capability well beyond analog drives. But to fully exploit its potential, a well-defined and standardized digital interface must also be specified. The reason is that if a digital motion controller must control a digital drive, through an analog signal, resolution is sacrificed and noise sensitivity becomes an issue. Even if both digital units operate internally with numerical precision of 32 bits, A/D and D/A conversion typically occurs only at 12 to 16-bits, introducing electrical noise and thereby limiting the full capabilities of the drive.

What are the advantages of an open interface?

Proprietary, vendor specific digital interfaces have existed since the 1980s. However, they restrict the user to a single source for both drives and control. This limits the user's ability to select components based on application need and creates a substantial support burden when equipment from various suppliers must be maintained. Obviously, the motion control industry is best served in the long run by an open interface specification.

Who developed the standard?

SERCOS was initiated in 1987 by a group of European machine builders who were concerned about the impending problems of multiple digital interfaces. One of the stated goals of SERCOS is to ensure that the exchange of data required for utilizing digital drives does not obstruct individual development of drives and controls. It was developed jointly by the German Machine Tool Builders Association and the German Electrical and Electronic Manufacturers Association. These two associations have assembled major manufacturers of motors, drives and CNCs into a joint working group. Companies who have joined in the SERCOS working group include Pacific Scientific/Automation Intelligence, AEG, ABB, AMK, Baumuller, Bosch, Indramat, and Siemens.

How is SERCOS implemented?

The transmission medium is plastic fiber optic cable, implemented in a fiber optic ring currently running at 4 MB/s. The current SERCOS implementation permits up to 32 drives to be connected to one fiber optic ring with a position profile update time of 2 ms. The topology is a ring structure in which MASTER and SLAVES are connected unidirectionally. The MASTER controls and synchronizes the ring and a SLAVE can service one or multiple drives.

What about cost?

At the end of 1993, a SERCOS application specific integrated circuit (ASIC) was introduced. It simplifies product designs incorporating the SERCOS interface by handling the low-level protocol SERCOS communication link. The host control writes to a dual-port RAM in the ASIC, which then handles messaging, timing, and communications with the drives. The use of the ASIC raises the data transfer rate to 4 Mbits/s and reduces the per node cost of the interface. Calculations show that the costs for a SERCOS interface correspond to those of an analog interface for the same drive. There are significant savings with respect to the controls, since a number of drives can be connected to each SERCOS interface.

What are other advantages?

Beyond the obvious advantages of an open digital interface, the physical implementation is simple to install and maintain and will operate reliably in the factory environment with up to a 100m interconnection path between units.

The immense requirements for conduit, wiring and terminations, which are normally associated with an analog interface, are eliminated with SERCOS. So are the long manhour requirements typically associated with installing an analog interface. The fiber itself is the sole connection between the controller and the drives. Since everything runs along a single fiber network, cable and termination cost is virtually non-existent. In fact, fiber's inherent noise immunity means that it can even run in the same conduit that carries high voltage enabling.

Is SERCOS close to adoption?

The Draft International Standard (DIS) has been submitted to the IEC. It is expected to be published as an international standard soon.

Is SERCOS just for machine tool/CNC applications?

Although originally envisioned and developed as a CNC to digital drive interface, this specification has proven itself to be widely applicable as an interface between general motion controls and digital drives. Industry has come to realize that all the basic primitives of general motion control can be implemented in a SERCOS ring—opening up vast new market potential.

SERCOS can be used effectively and efficiently to implement the following classes of general motion control functions:

- Point-to-Point Moves
- Electronic Gearing
- Electronic Cam Profiling
- Registration/Measurement
- Electronic Drive Trains

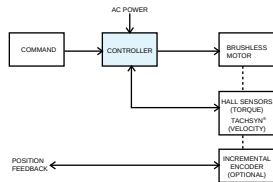
Where is SERCOS Specification headed?

Recently, industry has come to realize that all the basic primitives of general motion control can be implemented in a SERCOS ring, dispelling the myth that SERCOS is a viable standard only for CNC and machine tools. Numerous servo drive manufacturers have products either on the market or under development. With ASIC availability and IEC standardization, the technology will become more widely accepted in the motion control industry.

SC400 SERIES

Analog Torque or Velocity Controllers
350 W to 2.2 kW continuous power;
1 kW to 4.5 kW peak

Peak torque range:
27 to 142 lb-in.
(3.0 to 16 Nm)



- Ideal for use with your position controller
- 120 Vac or 240 Vac operation
- Inaudible, high frequency PWM current control
- Easy analog interfacing
- Optional clutch brake style interface
- Panel mount
- Integral power supply
- UL and ETL Recognition

SC400 Series controllers provide economical analog torque/velocity control of low to medium power brushless servo motors.

Two models provide continuous rated torques ranging from 10.1 lb-in. to 61 lb-in. and peak rated torques ranging from 25 lb-in. to 120 lb-in. when used in combination with Pacific Scientific brushless servo motors.

COMPACT AND RELIABLE PERFORMANCE

Each is a stand-alone, 4-quadrant controller with integral power supply. Derotated current loop control contributes to high speed performance.

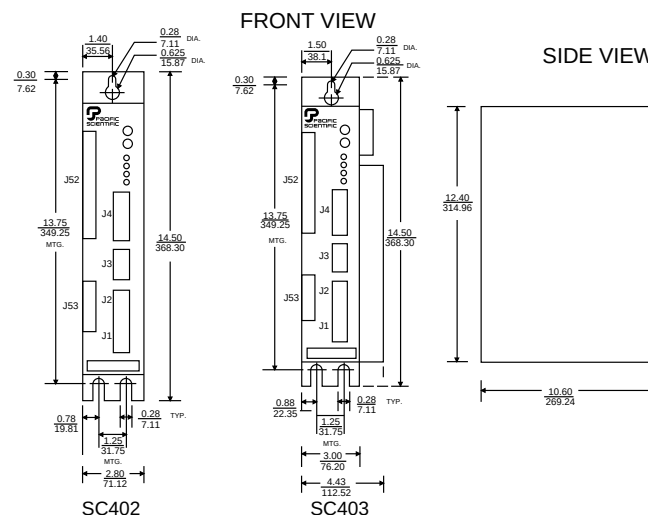
SC400 controllers feature insulated gate bipolar transistor (IGBT) output stages. A proprietary custom integrated circuit performs processing for system protection and motor commutation control. Both contribute to increased reliability, while reducing unit cost and package size.

Commutation and velocity control signals are derived from a single Tachsyn® feedback device. Pacific Scientific rare earth brushless servo motors are available with high reliability Tachsyn transducers for velocity control and Hall sensors for torque control.

OPERATING FEATURES

- Smooth, high bandwidth velocity control
- Derotated 6-step current loop
- Transformerless, direct 240/120 Vac line operation
- Convection cooled
- IGBT PWM output stage

DIMENSIONS in. (metric dimensions mm for ref. only)



ADJUSTMENTS

- Velocity loop gain
- Velocity command gain
- Velocity offset
- Current limit
- Selection jumpers:
 - Velocity/torque control select
 - 2 velocity compensation networks
 - 1 user installable compensation network

PROTECTION/DIAGNOSTICS

- Inrush current limiting
- MOV protected output
- Output short circuit protection
- Controller overtemperature shutdown
- Motor overtemperature sensor input
- Fully fused

GENERAL. . .SC400 Series Controllers

Efficiency (@ rated continuous power)	> 90%
Form factor	< 1.01
Current loop bandwidth	3 kHz max.
Velocity offset	adjustable to zero
Velocity offset drift (referred to input)	50 μ V/°C typical
Velocity input command	$\pm$ 10V
Output ripple frequency	20 kHz (SC402) or 15 kHz (SC403)
Fault output	open collector, 30 Vdc, 25 mA sink
Operating temperature	
Full ratings	0°C to 50°C
Derated Δ	50°C to 60°C
Storage temperature	-55°C to 70°C
Humidity	10% to 90%, non-condensing
Altitude	5000 feet (1500 meters)
Δ Linearly derate the continuous current and power ratings to 70% at 60°C.	

POWER DATA. . .SC400 Series Controllers

	SC402	SC403
Input voltage	120/240 Vac (+10%, -15%); 1- or 3-phase; 47-63 Hz	
Input current Δ		
240 Vac, 3-phase input	4.2 A _{rms}	8.9 A _{rms}
240 Vac, 1-phase input	5.8 A _{rms}	12.4 A _{rms}
120 Vac, 1-phase input	5.8 A _{rms}	12.4 A _{rms}
Bus voltage (nominal)		
240 Vac models	320 Vdc	320 Vdc
120 Vac models	160 Vdc	160 Vdc
Output current Δ		
Peak	7.0A	15.0A
Continuous (stall)		
240 Vac models	3.5A	7.5A
120 Vac models	4.2A	7.5A
Output power		
Peak		
240 Vac input	2000W	4500W
120 Vac input	1000W	2250W
Continuous		
240 Vac, 3-phase input	1000W	2250W
240 Vac, 1-phase input	700W	1575W
120 Vac, 1-phase input	350W	800W
Shunt regulator		
Peak power	3000W	6000W
Continuous power	20W	40W

Δ Input current is specified with unit operating at continuous rated output power.
 Δ Current ratings are defined as the maximum value of a 6-step waveform.

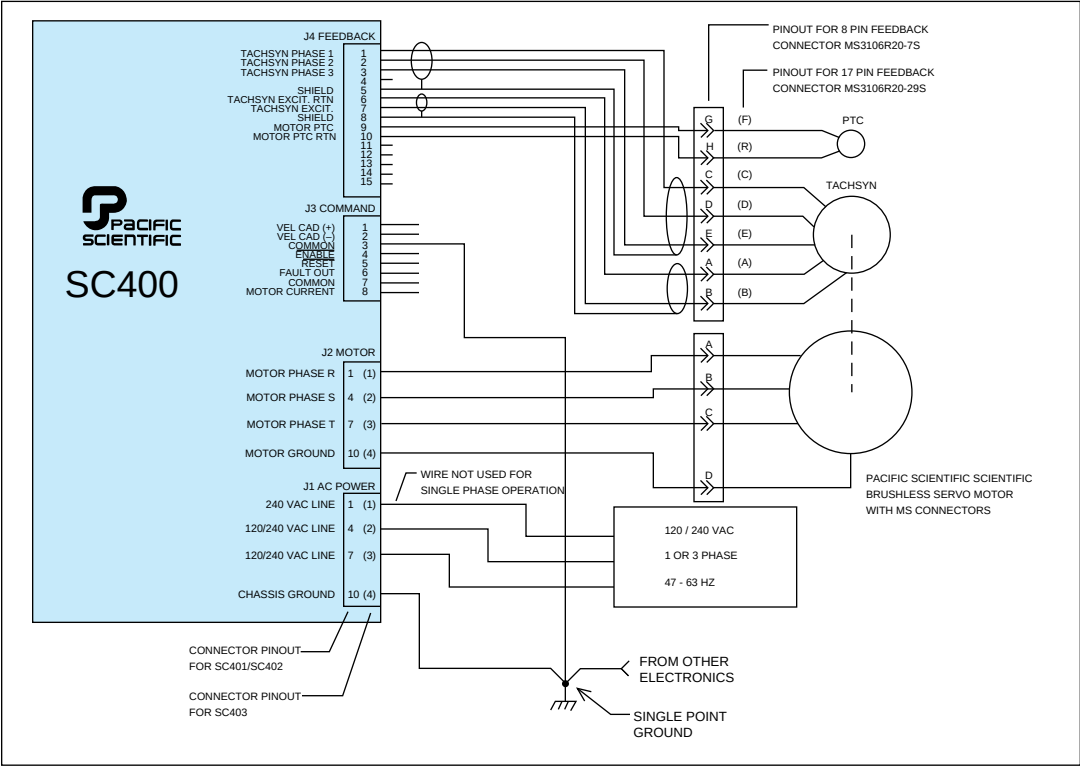
SC400 Series Recommended Motor/Controller Systems Δ

See performance curves beginning on page B-74.

Peak stall torque T_{PS} Δ lb-in./Nm	Peak rated torque T_{PR} Δ lb-in./Nm	Cont. stall torque T_{CS} lb-in./Nm	Cont. rated torque T_{CR} lb-in./Nm	Rated Speed W_R Δ rpm	Inertia x 10 ³ Δ lb-in-S ² / kgm ² J	Servo motor Width/height inch/mm	Servo motor Length inch/mm	Inductance line-line L mH	Servo motor model	Servo-Controller model Δ
27/ 3.0	25/ 2.8	14/ 1.5	10/ 1.1	4000	0.46/ .052	3.25/ 82.6	7.09/180.1	23.0	R32GENC-TS-NS-NV-00	SC402-011-T3
28/ 3.1	25/ 2.8	14/ 1.5	6/ 0.7	7000	0.46/ .052	3.25/ 82.6	7.09/180.1	5.8	R32HENC-TS-NS-NV-00	SC403-012-T2
36/ 4.0	33/ 3.7	21/ 2.3	16/ 1.8	3000	0.65/ .074	3.25/ 82.6	8.09/205.5	22.0	R33GENC-TS-NS-NV-00	SC402-011-T3
39/ 4.3	25/ 2.8	21/ 2.3	10/ 1.1	6000	0.65/ .074	3.25/ 82.6	8.09/205.5	5.6	R33HENC-TS-NS-NV-00	SC403-012-T2
45/ 5.0	43/ 4.8	27/ 3.0	24/ 2.7	2800	0.83/ .094	3.25/ 82.6	9.09/230.9	30.0	R34JENC-TS-NS-NV-00	SC402-012-T4
48/ 5.3	38/ 4.2	27/ 3.0	16/ 1.8	4000	0.83/ .094	3.25/ 82.6	9.09/230.9	7.5	R34KENC-TS-NS-NV-00	SC403-012-T3
54/ 6.0	53/ 5.9	32/ 3.6	30/ 3.3	2000	1.02/ .115	3.25/ 82.6	10.09/256.3	42.0	R35JENC-TS-NS-NV-00	SC402-012-T4
59/ 6.6	48/ 5.3	32/ 3.6	23/ 2.5	3000	1.02/ .115	3.25/ 82.6	10.09/256.3	10.5	R35KENC-TS-NS-NV-00	SC403-002-T3
66/ 7.4	50/ 5.6	33/ 3.4	33/ 3.7	1800	1.81/ .205	4.25/108.0	8.34/211.8	53.0	R43GENA-TS-NS-NV-00	SC402-012-T4
71/ 7.9	66/ 7.4	33/ 3.4	31/ 3.4	3000	1.81/ .205	4.25/108.0	8.34/211.8	13.3	R43HENA-TS-NS-NV-00	SC403-002-T3
106/11.9	95/10.6	48/ 5.3	46/ 5.1	2000	2.61/ .294	4.25/108.0	9.84/259.9	20.0	R45GENA-TS-NS-NV-00	SC403-002-T4
142/15.9	120/13.4	64/ 7.1	61/ 6.8	1500	3.41/ .385	4.25/108.0	11.34/288.1	25.0	R46GENA-TS-NS-NV-00	SC403-013-T4

Notes: All of the systems listed have a shunt regulator installed in the controller.
 Δ Peak torque ratings are for 5 seconds.
 Δ Rated speeds are for 240 Vac, 3-phase operation. Derate to approximately 85% for 240 Vac, 1-phase operation. Derate to 40% for 120 Vac, 1-phase operation.
 Δ Includes primary feedback inertia.
 Δ Each system requires one feedback and one motor power cable.

CONNECTION DIAGRAM. . .SC400 Series Controllers



HOW TO ORDER. . .SC400 Series Controllers

To order an SC400 Series brushless servo motor controller, designate the power level desired. The middle three digits are a controller customization code, which is factory assigned. This code specifies any customization components required to match the controller to the motor. It is also used to specify any customer requested modifications. The final two digits specify the desired feedback configuration.

MODEL NUMBER CODE

Servo controller _____

Series _____

Function code _____
0=torque/velocity controller (Hall sensors/Tachsyn®)

Power level code _____
2=3.8A cont./7.5A peak
3=7.5A cont./15A peak

Customization code _____
Factory assigned, 001=standard unit

Suffix code _____
Blank=Hall sensors interface
T1=Tachsyn® processor, 0.5 V/Krpm tach gradient
T2=Tachsyn® processor, 1.0 V/Krpm tach gradient
T3=Tachsyn® processor, 2.0 V/Krpm tach gradient
T4=Tachsyn® processor, 4.0 V/Krpm tach gradient
T5=Tachsyn® processor, 8.0 V/Krpm tach gradient

SC 4 0 X-001-T1

HOW TO ORDER. . .SC400 Series Recommended Motor/Controller Systems

See the Recommended Motor/Controller Systems table on page B-61 for performance information and model numbers for servo motor/controller combinations. Order motors and controllers as separate part numbers. See brushless servo motor section for additional motor specifications and information.



DIGITAL SERVO SYSTEMS

DIGITAL SERVO DRIVE

FEATURES

- Four power levels: 100 Watts, 200 Watts, 400 Watts, and 750 Watts continuous output shaft power when combined with matching motors
- Integral power supply and regeneration function
- All digital setup (no pots)
- DSD Dialog for Windows for easy setup using your PC
- Built-in display and keypad for fault diagnostics and setup without a terminal or PC
- Position mode (set\direction, step-up, setup-down or quadrature command), velocity mode (analog input or programmable internal velocity command), torque mode, and mixed mode. In mixed mode the Control-Mode-Select input is used to switch between position and velocity, position and torque, and velocity and torque modes.
- Step and direction control allows brushless servo performance with inexpensive indexer front end
- Programmable acceleration and deceleration limits in velocity mode
- Individual analog CW and CCW torque limits for position and velocity control modes
- Clutch-brake replacement
- Encoder outputs with adjustable resolution (as high as 2500 line or 10,000 quadrature counts per revolution) for external position control
- Auto-Tuning to eliminate tuning problems in many applications
- CW and CCW overtravel limit inputs
- Optically isolated discrete inputs and outputs
- Dynamic braking when power removed or optionally, when disabled
- Velocity and motor current (torque) outputs and test point

APPLICATIONS

- Packaging Machinery
- Electronic Assembly Equipment
- Material Handling
- Robotics
- X-Y Tables and Slides
- Specialty Machinery
- Multi-Axis Systems

PRODUCT DESCRIPTION

The Pacific Scientific DSD Series is a family of next generation digital servo drives. These all digital drives are capable of closing the current, velocity, and position loops. All system and application parameters are set in software to insure repeatability and to eliminate drift. The DSD Series is available in four power levels, all with integral power supplies and shunt regulators.

The base DSD unit includes several command interface features. A standard $\pm 10V$ analog interface is available to command motor torque or velocity. A count up / count down or step/direction interface is available for easy interfacing to standard stepper indexers.



FULL DIGITAL CONTROL

An all digital implementation reduces component count while increasing reliability, reducing cost, eliminate analog drift, eliminate imprecise potentiometer adjustments, reduce size, and increase flexibility.

AUTOTUNING

In many applications, the Autotuning feature will automatically set the servo system compensation parameters. You will not need oscilloscopes, meters, or other instruments - just a personal computer- to set up your system. The system allows you to select the type of performance desired.

I/O

- Differential $\pm 10V$ Analog Input 2 $\pm 5V$ Analog Outputs
- Encoder Quadrature Output
- Encoder Quadrature Input (Step/Direction, Count Up/Count Down)
- Enable Input

OPERATING FEATURES

- Smooth, digital, high bandwidth position/velocity/torque control
- Fully enclosed, panel mount package

ADJUSTMENTS

- All adjustments made in software

AGENCY APPROVAL

- Submittal to UL and subsequent recognition is pending

PROTECTION/DIAGNOSTICS

- 7 segment status display
- In-rush current limiting
- Control Power Fuse
- Output short circuit protection
- Overtemperature protection, motor and drive
- IT protection
- Under voltage protection
- Excessive regeneration protection

GENERAL...Basic Specifications...Drive

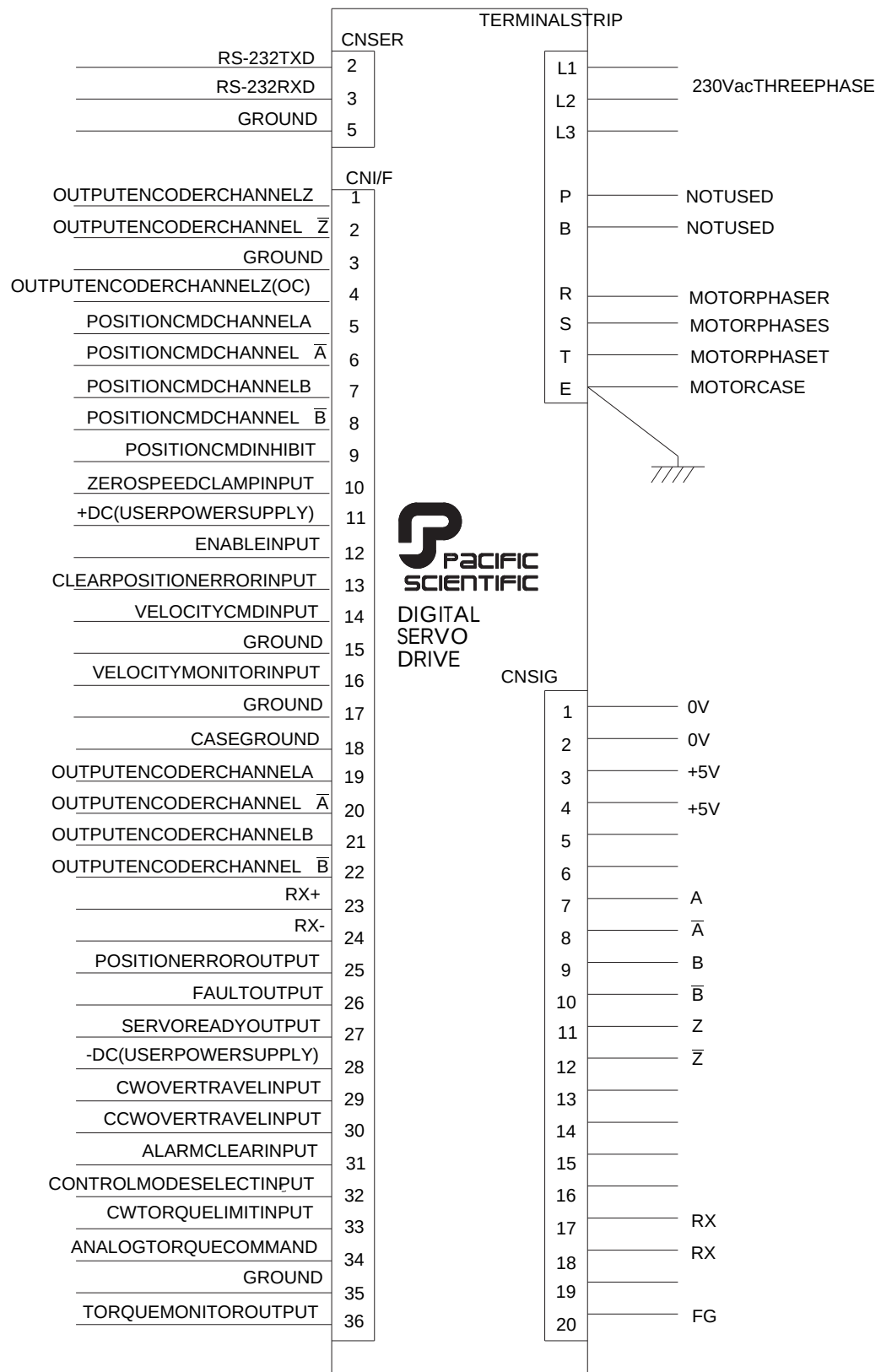
Power Source Input	
200V	Three phase 200V ~ 230V + 10% /-15% 50 / 60Hz
Analog Input Command	
Range	±10 V velocity or torque
Resolution	12 bits
Digital Input Command	
Modes	Step/Direction, Count Up/Down, Quadrature encoder
Maximum Input Frequency	
Step/Direction, Count Up/Down	500kHz
Quadrature Encoder	500 kHz Post Quadrature Frequency (125 kHz/channel)
Encoder Output Signals	
Type	Quadrature with Marker Pulse, differential TTL line driver
Resolution	2500 P/r line count
Marker Pulse Width	1 quadrature pulse nominal
Control Method	IGBT PWM (Sine Wave Control)
Feedback	Incremental encoder (2,500 P/r Standard) Differential line drive
Environmental	
Storage Temperature	-20°C to 80°C (free from dew)
Operating Temperature	0°C - 50°C (full rating) 1
Humidity	Working/Storage: 90% or less
Vibration	Not more than 4.9m / s2(0.5G), 10-60Hz (not used continuously at the resonance point)
Altitude	1500 m (5000 ft.)

(Note¹: Linearly derate output power from full rating at 40°C to 75% of full rating at 50°C if 230 V single phase power is used)

Functions	
Control Mode	1. Analogue Speed Control 2. Position Control 3. Torque Control 4. Position • Speed Control 5. Position • Torque Vontrol 6. Speed • Torque Control
Integrated Functions	
Regeneration	Regeneration resistance integrated
Dynamic Brake Function	1. If disabled 2. If fault occurs 3. If power source is lost 4. During deceleration while CW or CCW drive inhibit input becomes valid
Automated Gain Tuning Function	Integrated (according to applicable motor type)
Soft Start/Stop Function	0~10s / 1000r / min (Set by parameter)
Zero Speed Clamp	Servo lock mode is obtained by inputting speed zero clamp command. (in speed control mode)
Alarm Data Trace Back Function	Traceable back to last 8 alarms (including present alarm)
Communication Function by RS-232C	Windows based setup / communication utility available for IBM compatible computer running Windows 3.1 or greater
Protection	

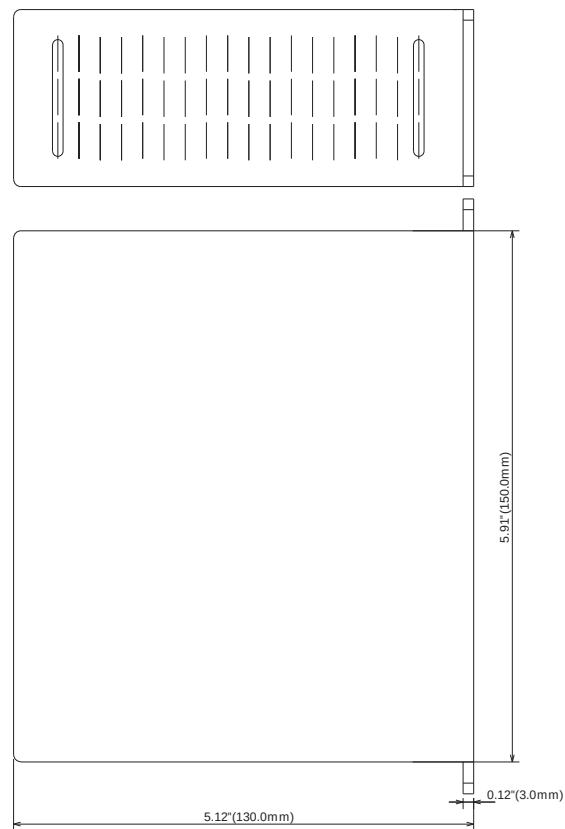
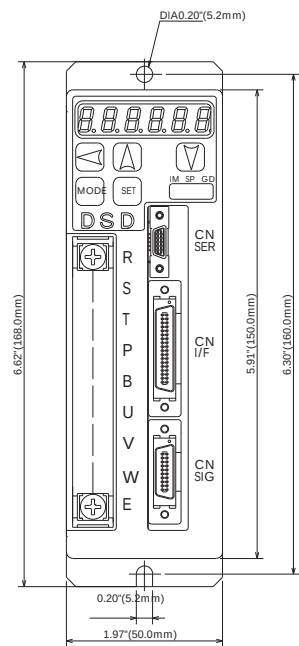
Description	Fault Code	Description	Fault Code
Over Voltage	.12	Over Speed	.26
Under Voltage	.13	Invalid Ratio	.27
Over Current	.14	Position Error Overflow	.29
Over Load (I*t)	.16	EEPROM Fault	.36
Encoder	.22	Simultaneous OverTravel	.38
Excessive Position Error	.24		

DIGITAL SERVO DRIVE...Connection Diagram

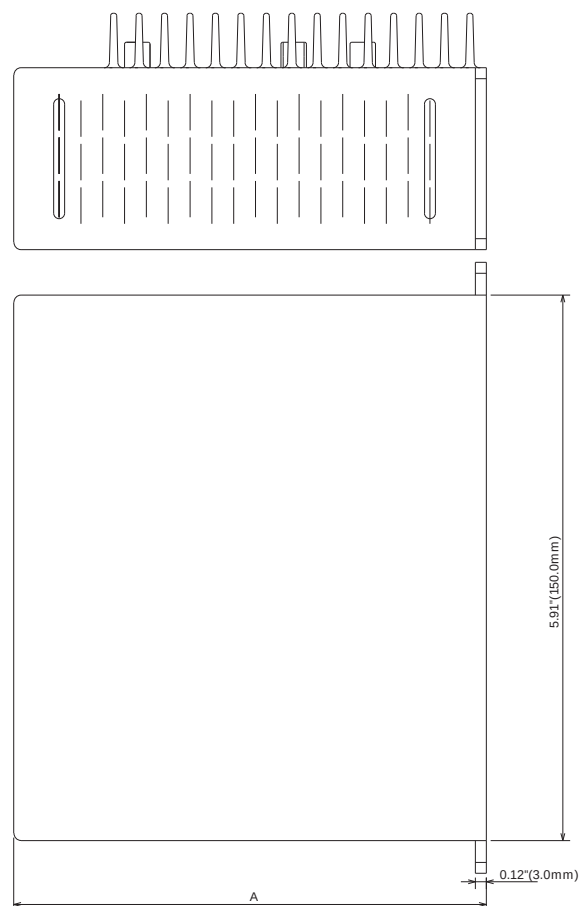
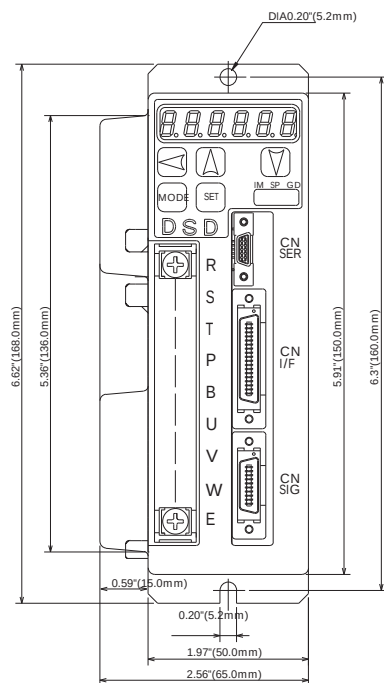


DIMENSIONS in. (metric dimensions for ref. only)

100 AND 200 WATT DRIVE



400 AND 750 WATT DRIVE



ModelNo.	A
DSD40-2A-001	5.12" (130.0mm)
DSD75-2A-001	6.70" (170.0mm)

DIGITAL SERVO MOTOR

FEATURES

- Compact Size
- Rare earth (Neodymium) Magnets provide high accel;acceleration capabilities
- Unique Stator Winding Process provides increased torque/frame size and reduced cost
- Four Power Levels
100, 200, 400 and 750 Watts continuous
3-21 lb-in at 3000 RPM
- Three different frame sizes
1.5, 2.3 and 3.2 inches
38, 60 and 80mm
- Standard Shafts include Flats or keyways
- Shaft Seals and Brakes available upon request
- Rugged Industrial Package



PRODUCT DESCRIPTION

This series of all highly Efficient and Compact Brushless Servo Motors extends Pacific Scientific's Power range down to 100 Watts continuous. This high performance series of motors features Neodymium magnets and a unique stator winding process which combine to produce excellent torque per frame size while keeping costs to as minimum.

These motors are offered with standard flats or keyways on the shafts and in three different frame sizes ranging from 1.5 - 3.2 inches.

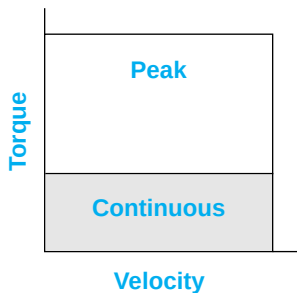
APPLICATIONS

- Packaging Machinery
- Electronic Assembly Equipment
- Material Handling
- Robotics
- X-Y Tables and Slides
- Specialty machinery
- Multi-axis Systems
- Stepper Replacement

GENERAL...Basic Specifications...Motor

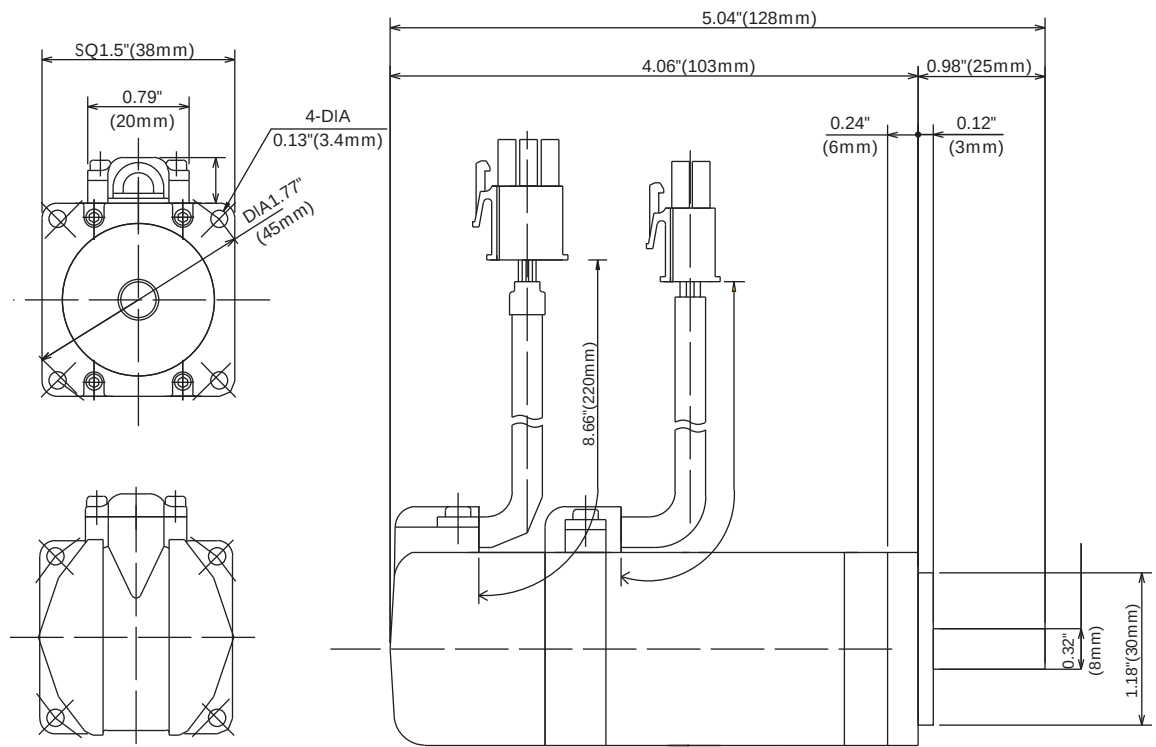
Rated Output Watts		100	200	400	750
Torque (lb-in/N*m)	Rated	2.84/0.32	5.67/0.64	11.51/1.3	21.24/2.4
	Max	8.41/0.95	16.91/1.19	33.63/3.8	63.28/7.15
Rotor Inertia (10-3 lb-in-s ²) / (x10-4 kgm ²)	W/O Brake	.056/.063	.15/.17	.33/.37	1.17/1.33
	W/Brake	.059/.067	.17/.20	.35/.40	1.25/1.41
Speed (rpm)	Rated	3000			
	Max.	5000			
Brake		DC 24V			
Encoder		Incremental 2500 PPR			
Poles		8			
Ambient Condition		Working Temperature: 0~40°C			
Weight (lbs)	W/O brake	0.53	1.17	2.12	6.84
	W/brake	0.97	1.61	3.09	8.16

SPEED TORQUE CURVES

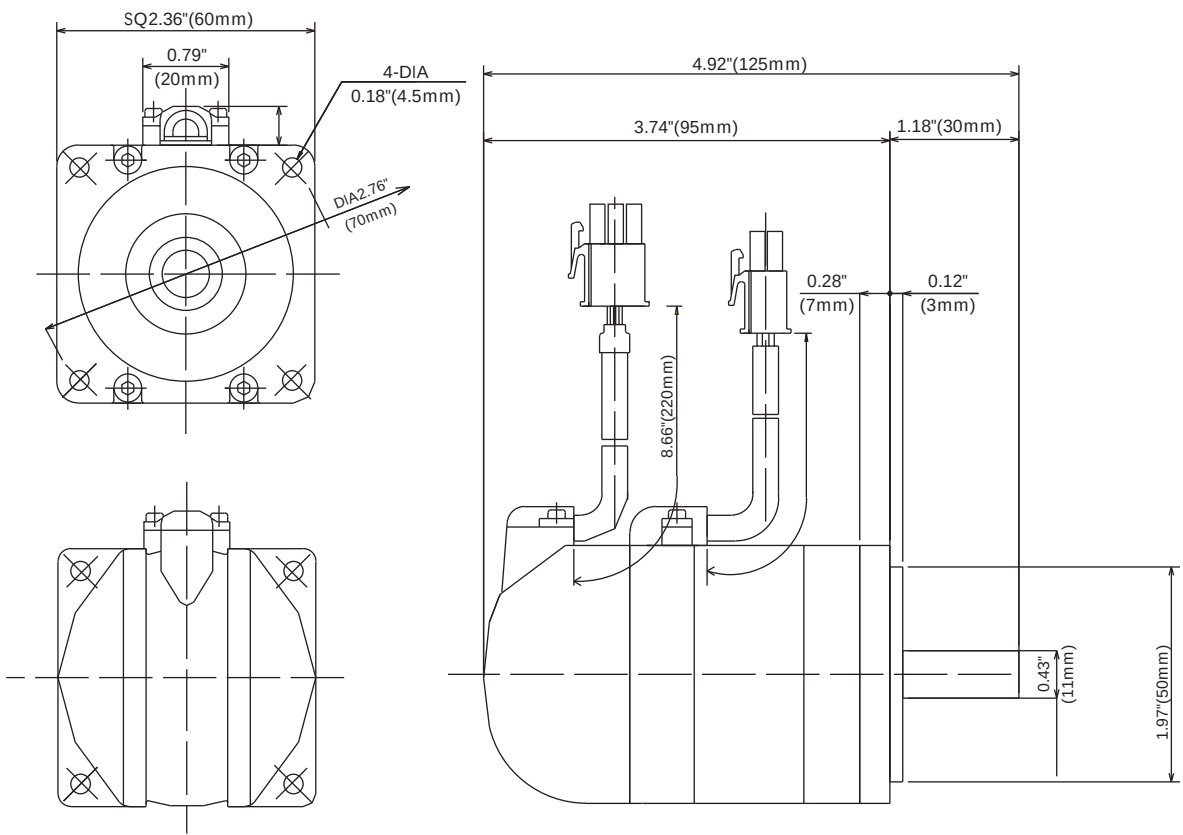


Power Watts	Peak Torque lb-in.	Continuous Torque lb-in.	Rated Speed RPM
100	8.41	2.84	3000
200	16.91	5.67	3000
400	33.63	11.51	3000
750	63.28	21.24	3000

100 WATT MOTOR

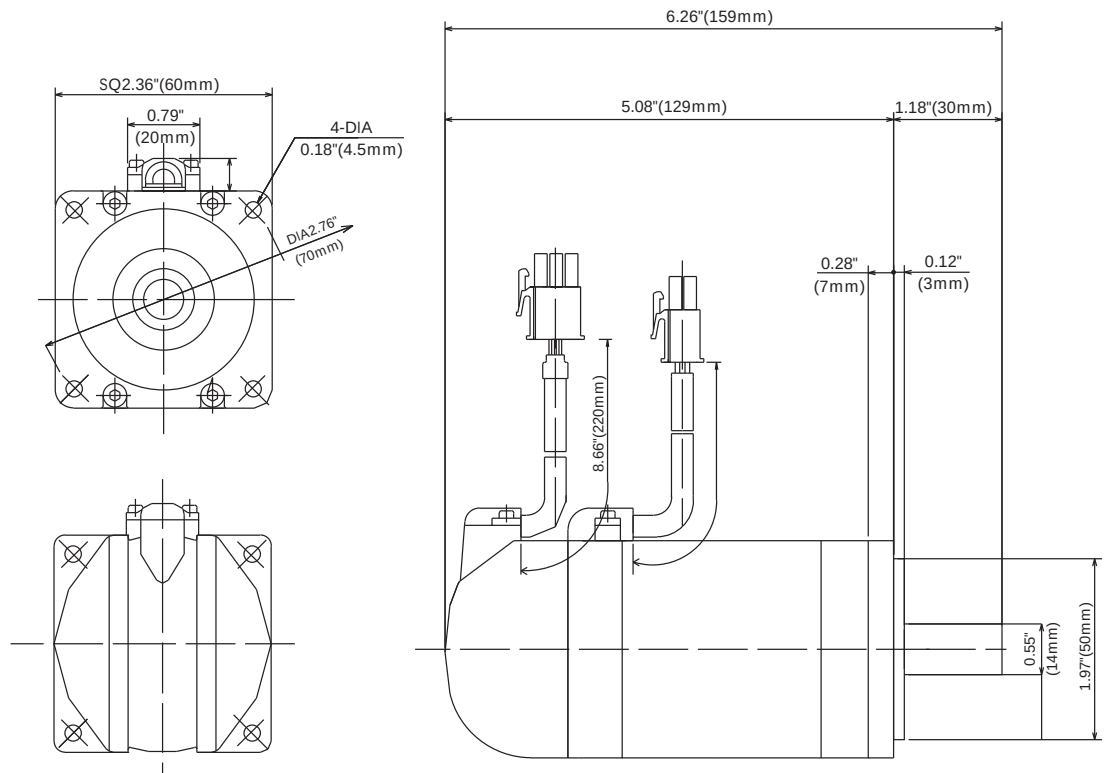


200 WATT MOTOR

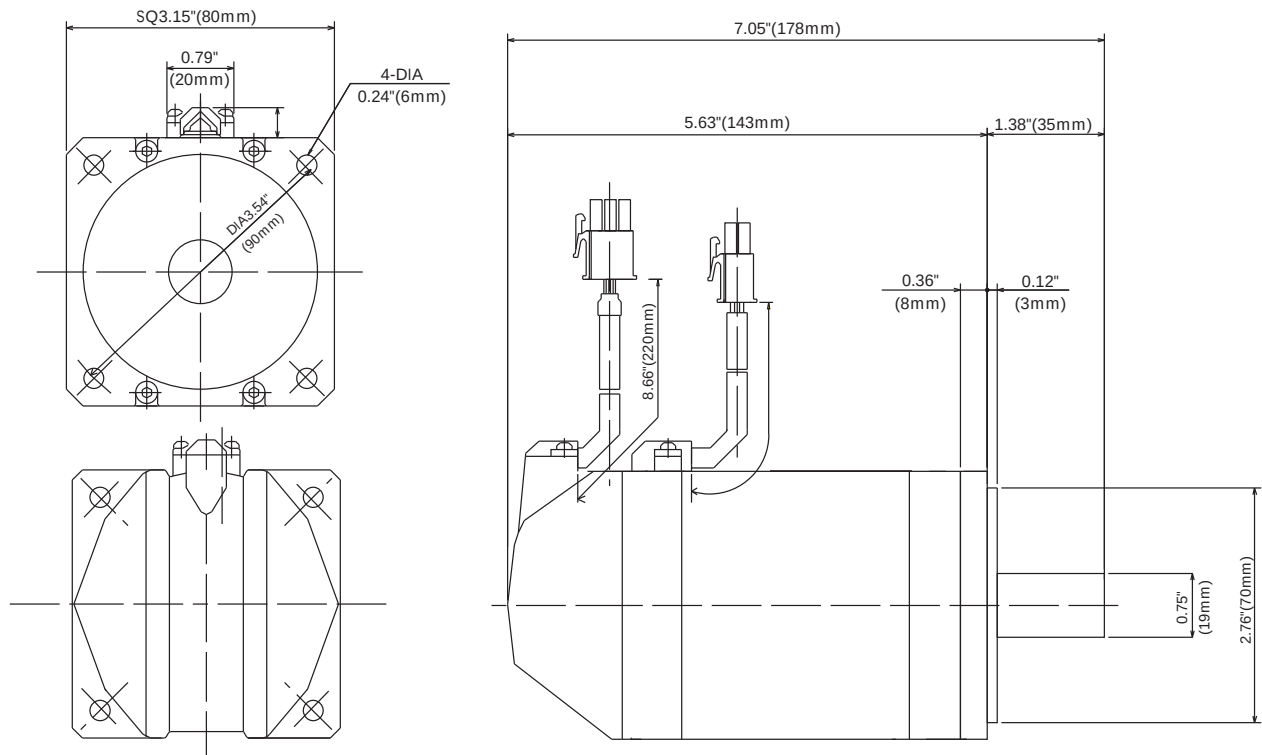


DIMENSIONS in. (metric dimensions for ref. only)

400 WATT MOTOR



750 WATT MOTOR



HOW TO ORDER . . .Digital Servo Drive . . . Base Drive

MODEL NUMBER CODE

DSD102A-001

System Type (Family):

Brushless Digital Servo Drive (DSD)

Power Level Designator:

Specifies Drive Power Ratings (ie. 100 Watt = Motor Power Input)
10 - 100 Watts
20 - 200 Watts
40 - 400 Watts
75 - 750 Watts

AC Line Voltage Designator:

2 - 230 v AC, 1Φ Operation

Encoder Option Designator:

A - 2500 Pulses/Revolution, Incremental Encoder Standard

Customization Code:

Factory Assigned Customization Code
001 - Standard Unit

HOW TO ORDER . . .Digital Servo Motor . . . Base Motor

MODEL NUMBER CODE

DSM102NA-001

System Type (Family):

Brushless Digital Servo Motor (DSM)

Power Level Designator:

Specifies Drive Power Ratings
10 - 100 Watts
20 - 200 Watts
40 - 400 Watts
75 - 750 Watts

AC Line Voltage Designator:

2 - 230 v AC, 1Φ Operation

Motor Options Designator:

200, 400 and 750 Watt Motors			100 Watt Motor			List Price Adder			
Code	Oil Seal	Brake	Code	Oil Seal	Brake	100 Watt	200 Watt	400 Watt	750 Watt
E	no	no	N	no	no	0.00	0.00	0.00	0.00
F	no	yes	P	no	yes	295.00	330.00	335.00	355.00
G	yes	no	Q	yes	no	40.00	40.00	40.00	40.00
H	yes	yes	R	yes	yes	335.00			
Note: All 200, 400 and 750 Watt Motors Supplied with Keyway			Note: All 100 Watt Motors Supplied with Double Flats						

Encoder Option Designator:

A - 2500 Pulses/Revolution, Incremental Encoder Standard

Customization Code:

Factory Assigned Customization Code
001 - Standard Unit

HOW TO ORDER...DSS Series Recommended Motor/Drive

MODEL NUMBER CODE

DSD10-10

System Type (Family):

Brushless Digital Servo System (DSS)

Power Level Designator:

Specifies Drive and Motor Power Ratings
10 - 100 Watts, 230 v AC
20 - 200 Watts, 230 v AC
40 - 400 Watts, 230 v AC
75 - 750 Watts, 230 v AC

Cable Length Designator:

Specifies Length of Motor Power & Feedback Cables
10 - 10 Foot Cables
20 - 20 Foot Cables
30 - 30 Foot Cables
60 - 60 Foot Cables

ACCESSORIES:

Accessory	Description
MA-DSD	User Manual and Software Development Tool (3.5" disk)
CS-232-DSD	Serial Cable (6' only)
CP-D1-xx-DSD	Motor Power Cable (labor and connectors) Each Foot Includes spade lugs for customer AC power (xx - indicates length in whole foot increments)
CF-D1-xx-DSD	Motor Feedback Cable (labor and connectors) Each Foot. (xx - indicates length in whole foot increments)
CIO-DSD	I/O Cable, 36p HD Connector to Flying Leads (5 foot)

NOTE: All systems include each of the following....

- Brushless Servo Drive, 230 v AC (power level determined by the part number)
- Brushless Servo Motor w/ Encoder Feedback (power level determined by the part number)
- Motor Feedback Cable (length determined by the part number)
- Motor Power Cable (length determined by the part number)
- Spade Lugs for AC Input (Power cable not included)
- RS232 Serial Cable (6 foot)
- I/O Cable Adapter, 36 pin High Density Connector to Flying Leads (5 foot)
- Manual (MADSD)
- PC Setup/Communications Utility for Windows (3 Disk)

BRUSHLESS SERVO SYSTEM PERFORMANCE

System torque/speed curves on the following pages are designed to help you select the optimum brushless servo motor/controller combination.

The nominal values in these curves illustrate performance for the recommended motor/controller systems.

Want to size and select a brushless servo motor/controller on your IBM PC® or IBM compatible microcomputer? Ask PacSci or your local distributor for a copy of the Windows™- based PacSizit™ diskette.

MOTION CONTROL SYSTEM PERFORMANCE CURVES

The performance characteristics of a brushless servo system (motor/controller combination) are described by a torque/speed operating envelope. As shown below, the shaded areas of the curve indicate the continuous duty and intermittent duty zones of the system.

CONTINUOUS DUTY ZONE

The continuous duty zone is bordered by the maximum continuous torque line and the system voltage line.

The continuous torque line is set by the motor's maximum rated temperature. The system voltage line is set by the voltage rating of the controller, the line voltage supplied, and the motor winding.

The system can operate on a continuous basis anywhere within this area, assuming the motor ambient temperature is 25°C or less and the motor is mounted to the specified heat sink. Refer to the Test Conditions on the pages that follow.

INTERMITTENT DUTY ZONE

The intermittent duty zone is bordered by the peak torque line and the system voltage line.

The peak torque line is set by the controller's peak current rating, which the controller can produce for a limited time. Refer to the Rating Data on the pages that follow.

The system voltage line is set by the voltage rating of the controller, the line voltage applied, and the motor winding.

Operation in the intermittent zone must be limited to a duty cycle which will produce an RMS system torque falling within the continuous duty area. The RMS torque value is defined by the magnitude of the intermittent torque and the percentage of time spent at that torque.

ADDITIONAL REFERENCES

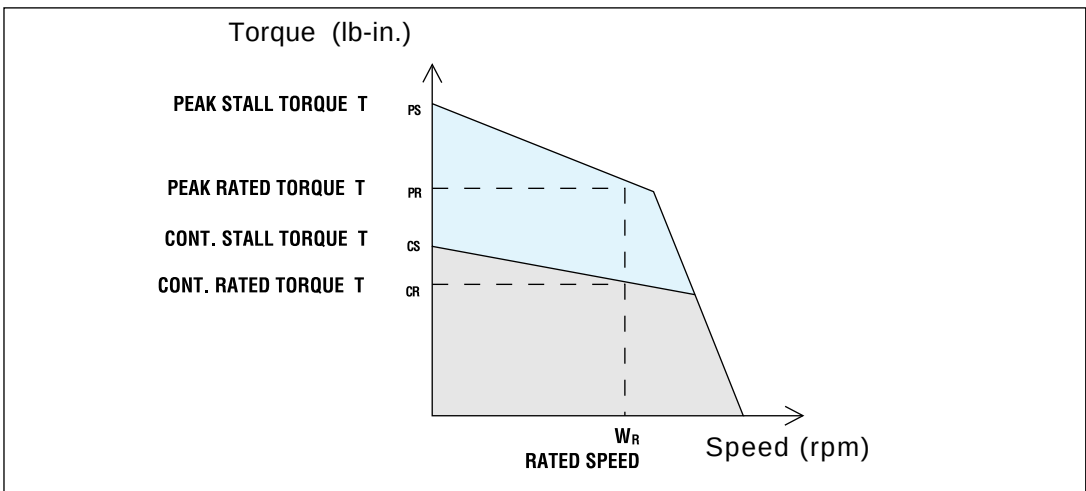
On the pages that follow, each individual system curve has reference points adjacent to the torque axis. In addition to rating points for peak (T_{PS}) and continuous torque (T_{CS}) ratings at stall, each curve has:

Rated speed (W_R)

Continuous torque at rated speed (T_{CR})

Peak torque at rated speed (T_{PR})

These points are provided as references for use in comparing and sizing systems. The ratings at these reference points are also provided in the Recommended Motor/Controller Systems tables with the controller specifications.

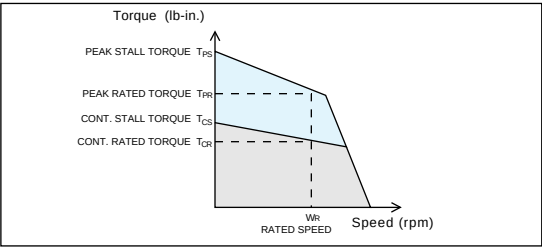


continuous duty

intermittent duty

SYSTEMS PERFORMANCE CURVES

The performance curves show the continuous and intermittent duty performance with the selected motors shown in the recommended motor/controller systems tables. The rating points on the curves are the same as those in the tables and are provided as references for use in comparing and sizing systems.



continuous duty intermittent duty

SYSTEMS CURVES. . .SC4x2, SC7x2 or SC9x2 with R20 Series motors

Up to 7.1
lb-in. (0.8 Nm)
Cont. rated torque
@ 6000 rpm

2 in. "R" Motor

Rating Data

- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 240 Vac 3-phase line. Reduce to approximately 85% for 240 Vac 1-phase line operation and to 40% for 120 Vac 1-phase line operation.

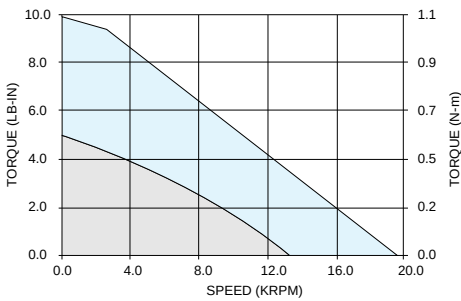
Test Conditions

- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" heat sink.
- 25°C ambient.

continuous duty intermittent duty

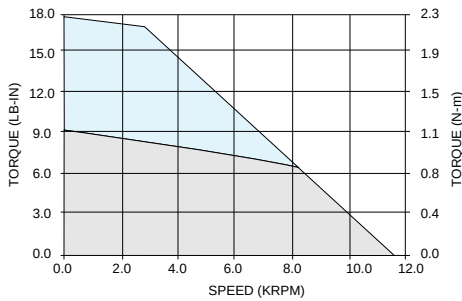
R22H MOTOR

Reference Points	
T _{PS}	10.0
T _{PR}	6.5
T _{CS}	4.8
T _{CR}	2.5
W _R	8,000



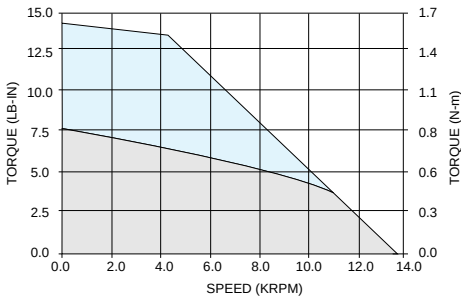
R24H MOTOR

Reference Points	
T _{PS}	17.0
T _{PR}	10.0
T _{CS}	9.2
T _{CR}	7.1
W _R	6,000



R23H MOTOR

Reference Points	
T _{PS}	14.0
T _{PR}	8.0
T _{CS}	7.6
T _{CR}	5.2
W _R	8,000



SYSTEMS CURVES. . . SC9x2/SC9x3, SC4x2/SC4x3
and SC7x2/SC7x3
with R30 motors

Up to 23
lb-in. (2.6 Nm)
Cont. rated torque
@ 3000 rpm

3.25 in. "R" Motor

Rating Data

- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 240 Vac 3-phase line. Reduce to approximately 85% for 240 Vac 1-phase line operation and to 40% for 120 Vac 1-phase line operation.

Test Conditions

- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" heat sink.
- 25°C ambient.

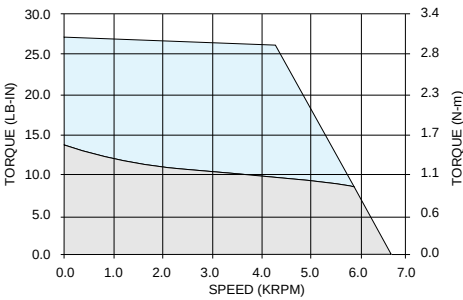
continuous duty

intermittent duty

SC9x2, SC4x2 or SC7x2
and these motors

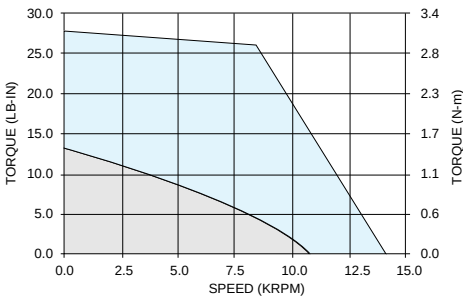
R32G
MOTOR

Reference Points	
T _{PS}	27.0
T _{PR}	25.0
T _{CS}	14.0
T _{CR}	10.1
W _R	4,000



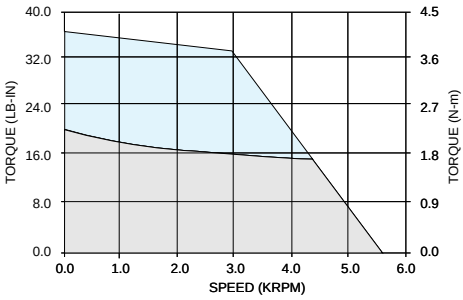
R32H
MOTOR

Reference Points	
T _{PS}	27.0
T _{PR}	25.0
T _{CS}	14.0
T _{CR}	6.0
W _R	7,000



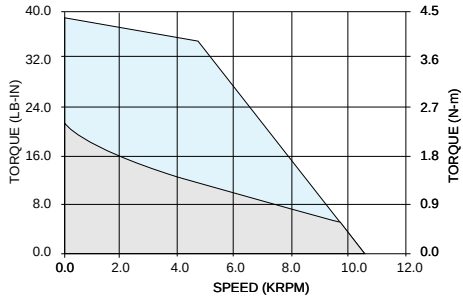
R33G
MOTOR

Reference Points	
T _{PS}	36.0
T _{PR}	33.0
T _{CS}	21.0
T _{CR}	16.0
W _R	3,000



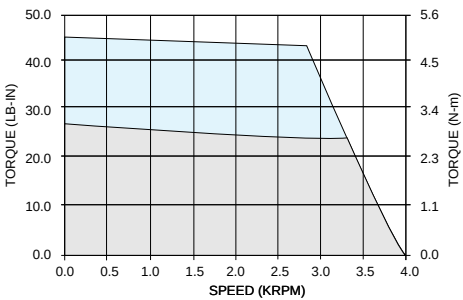
R33H
MOTOR

Reference Points	
T _{PS}	39.0
T _{PR}	25.0
T _{CS}	21.0
T _{CR}	10.0
W _R	6,000



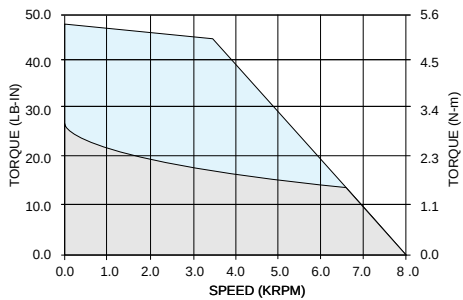
R34J
MOTOR

Reference Points	
T _{PS}	45.0
T _{PR}	42.0
T _{CS}	27.0
T _{CR}	24.0
W _R	2,800



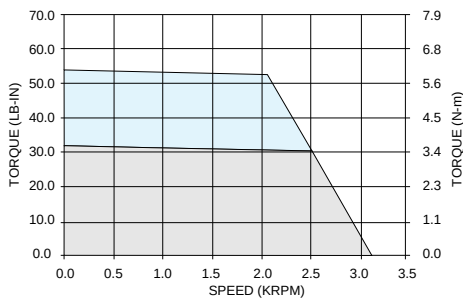
R34K
MOTOR

Reference Points	
T _{PS}	48.0
T _{PR}	38.0
T _{CS}	27.0
T _{CR}	16.0
W _R	4,000



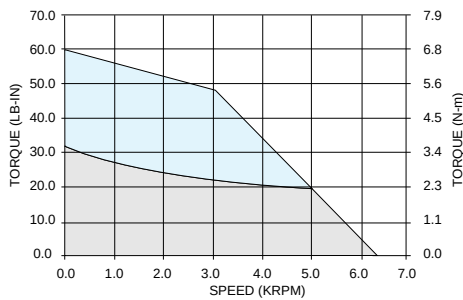
R35J
MOTOR

Reference Points	
T _{PS}	54.0
T _{PR}	53.0
T _{CS}	32.0
T _{CR}	30.0
W _R	2,000



R35K
MOTOR

Reference Points	
T _{PS}	59.0
T _{PR}	48.0
T _{CS}	32.0
T _{CR}	23.0
W _R	3,000



**SYSTEMS CURVES. . .SC9x2/SC9x3, SC4x2/SC4x3
SC7x2/SC7x3
with R40 motors**

Up to 61
lb-in. (6.8 Nm)
Cont. rated torque
@ 1500 rpm

4.25 in. "R" Motor

Rating Data

- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 240 Vac 3-phase line. Reduce to approximately 85% for 240 Vac 1-phase line operation and to 40% for 120 Vac 1-phase line operation.

Test Conditions

- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" heat sink.
- 25°C ambient.

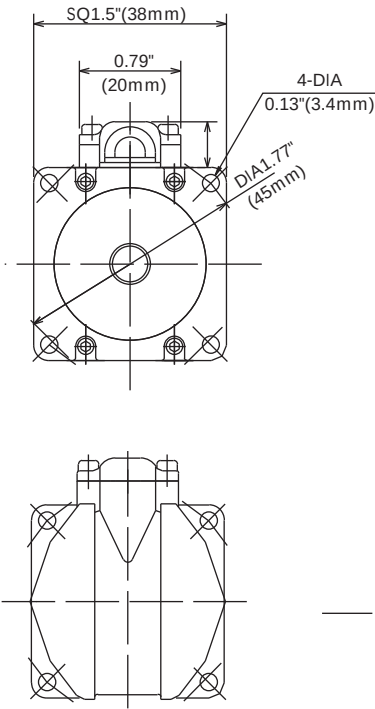
■ continuous duty ■ intermittent duty

SC9x2, SC4x2 or SC7x2

**SC9x3, SC4x3 or SC7x3
and these motors**

**R43G
MOTOR**

Reference Points	
T _{PS}	66.0
T _{PR}	50.0
T _{CS}	33.0
T _{CR}	33.0
W _R	1,800



**R43H
MOTOR**

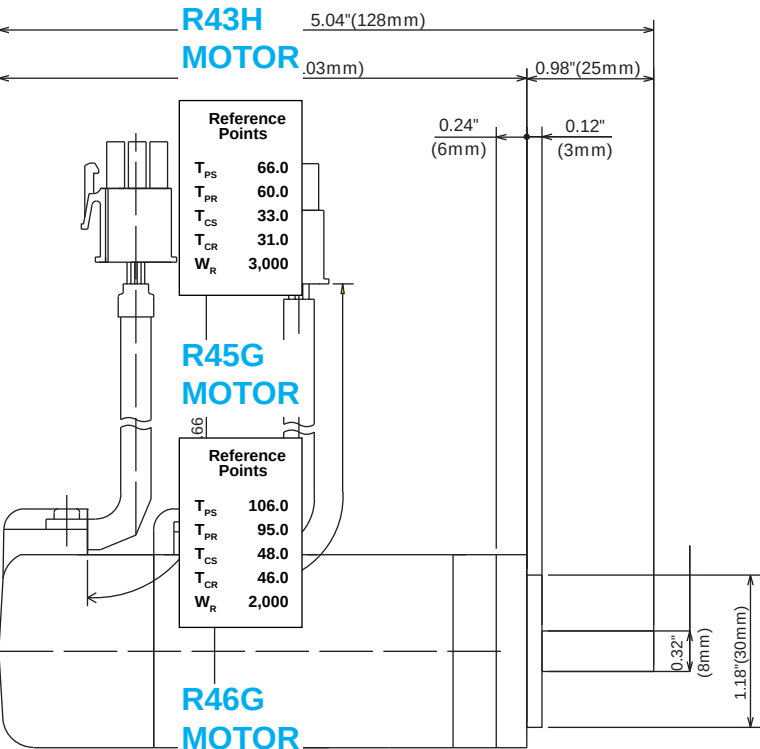
Reference Points	
T _{PS}	66.0
T _{PR}	60.0
T _{CS}	33.0
T _{CR}	31.0
W _R	3,000

**R45G
MOTOR**

Reference Points	
T _{PS}	106.0
T _{PR}	95.0
T _{CS}	48.0
T _{CR}	46.0
W _R	2,000

**R46G
MOTOR**

Reference Points	
T _{PS}	142.0
T _{PR}	120.0
T _{CS}	64.0
T _{CR}	61.0
W _R	1,500



SYSTEMS CURVES. . . SC9x2/SC9x3/SC9x4,
with F40 Series motors
(ferrite magnets)

Up to 48
lb-in. (5.4 Nm)
Cont. rated torque
@ 1500 rpm

4.25 in. "F" Motor

Rating Data

- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 240 Vac 3-phase line. Reduce to approximately 85% for 240 Vac 1-phase line operation and to 40% for 120 Vac 1-phase line operation.

Test Conditions

- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" heat sink.
- 25°C ambient.
- 0.175 x 10e⁻³ lb-in-S² used for feedback inertia.

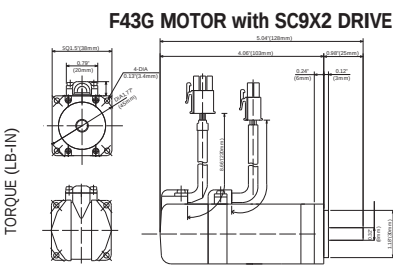
continuous duty intermittent duty

SC9x2, SC9x4 and these motors

SC9x3 and these motors

F43G
MOTOR

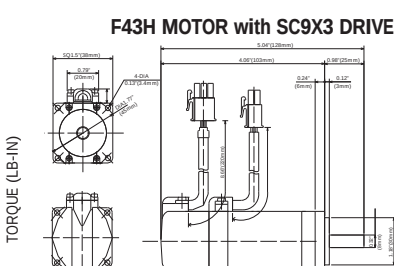
Reference Points	
T _{PS}	60.0
T _{PR}	50.0
T _{CS}	33.0
T _{CR}	32.0
W _R	1,500
W _{NL}	3,000



SPEED (Krpm) 320 VDC BUS

F43H
MOTOR

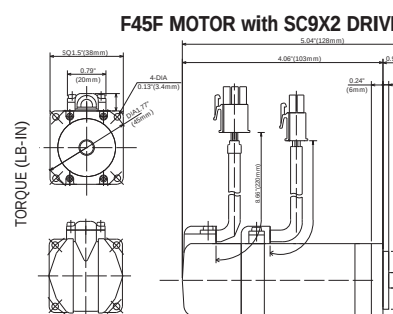
Reference Points	
T _{PS}	60.0
T _{PR}	50.0
T _{CS}	33.0
T _{CR}	31.0
W _R	3,000
W _{NL}	5,600



SPEED (Krpm) 320 VDC BUS

F45F
MOTOR

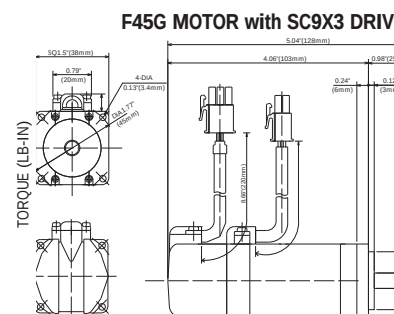
Reference Points	
T _{PS}	80.0
T _{PR}	65.0
T _{CS}	48.0
T _{CR}	48.0
W _R	1,000
W _{NL}	1,900



SPEED (Krpm) 320 VDC BUS

F45G
MOTOR

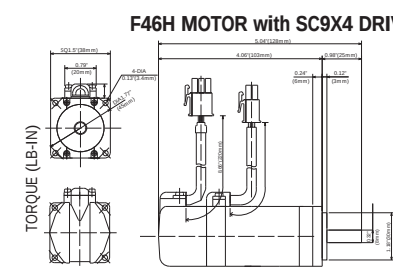
Reference Points	
T _{PS}	80.0
T _{PR}	65.0
T _{CS}	48.0
T _{CR}	47.0
W _R	2,000
W _{NL}	3,800



SPEED (Krpm) 320 VDC BUS

F46H
MOTOR

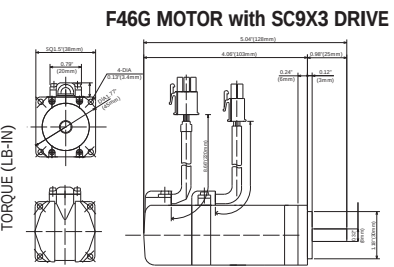
Reference Points	
T _{PS}	115.0
T _{PR}	88.0
T _{CS}	63.0
T _{CR}	61.0
W _R	1,500
W _{NL}	2,800



SPEED (Krpm) 320 VDC BUS

F46G
MOTOR

Reference Points	
T _{PS}	115.0
T _{PR}	88.0
T _{CS}	63.0
T _{CR}	56.0
W _R	3,000
W _{NL}	5,600



SPEED (Krpm) 320 VDC BUS

SYSTEMS CURVES. . .SC9x4 and SC7x4 with
R40 Series motors

Up to 50
lb-in. (5.6 Nm)
Cont. rated torque
@ 3000 rpm

4.25 in. "R" Motor

Rating Data

- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 240 Vac 3-phase line. Reduce to approximately 85% for 240 Vac 1-phase line operation and to 40% for 120 Vac 1-phase line operation.

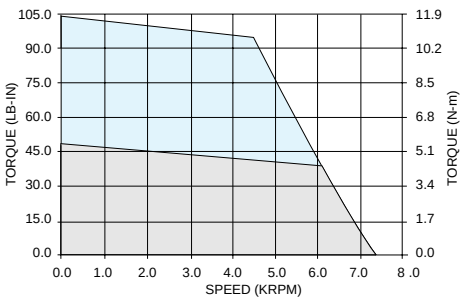
Test Conditions

- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" heat sink.
- 25°C ambient.

continuous duty intermittent duty

R45H
MOTOR

Reference Points	
T _{PS}	106.0
T _{PR}	95.0
T _{CS}	48.0
T _{CR}	43.0
W _R	4,000



SYSTEMS CURVES. . .SC9x4 and SC7x4 with F40 Series
Motors (ferrite magnets)

Up to 43
lb-in. (5.0 Nm)
Cont. rated torque
@ 3000 rpm

4.25 in. "F" Motor

Rating Data

- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 240 Vac 3-phase line. Reduce to approximately 85% for 240 Vac 1-phase line operation and to 40% for 120 Vac 1-phase line operation.

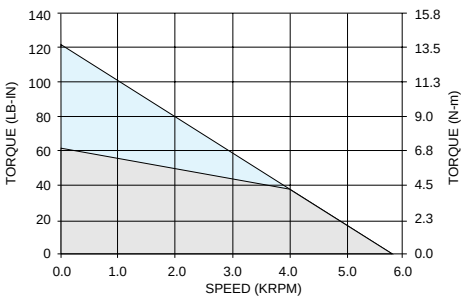
Test Conditions

- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" heat sink.
- 25°C ambient.

continuous duty intermittent duty

F46H
MOTOR

Reference Points	
T _{PS}	121.0
T _{PR}	60.0
T _{CS}	61.0
T _{CR}	43.0
W _R	3,000



SYSTEMS CURVES. . .SC9x4/SC9x5 and SC7x4/SC7x5
with R60 Series motors

Up to 146
lb-in. (16.5 Nm)
Cont. rated torque
@ 2000 rpm

5.75 in. "R" Motor

Rating Data

- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 240 Vac 3-phase line. Reduce to approximately 85% for 240 Vac 1-phase line operation and 40% for 120 Vac 1-phase line operation.

Test Conditions

- Motor operated at rated winding temperature, mounted to a 18" x 18" x 1/2" heat sink.
- 25°C ambient.

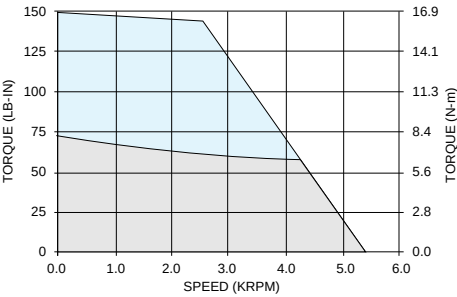
continuous duty intermittent duty

SC9x4 or SC7x4 and these motors

SC9x5 or SC7x5 and these motors

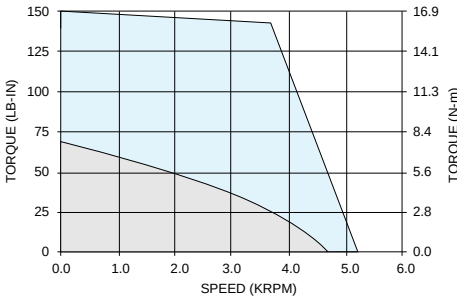
R63G
MOTOR

Reference Points	
T _{PS}	150.0
T _{PR}	125.0
T _{CS}	70.0
T _{CR}	58.0
W _R	3,000



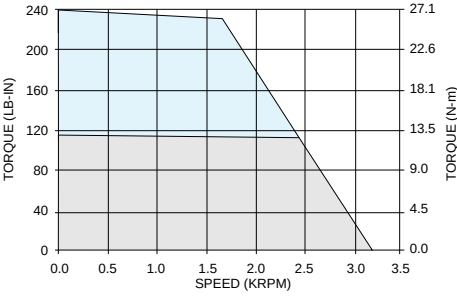
R63H
MOTOR

Reference Points	
T _{PS}	150.0
T _{PR}	142.0
T _{CS}	70.0
T _{CR}	38.0
W _R	6,000



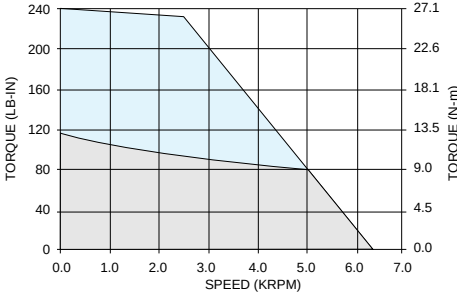
R65G
MOTOR

Reference Points	
T _{PS}	240.0
T _{PR}	230.0
T _{CS}	115.0
T _{CR}	102.0
W _R	1,700



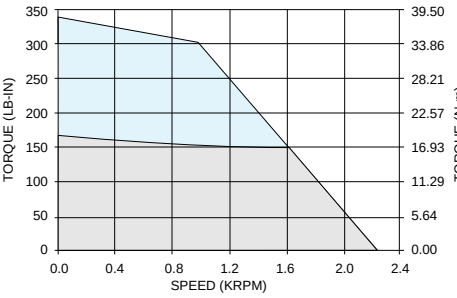
R65H
MOTOR

Reference Points	
T _{PS}	240.0
T _{PR}	200.0
T _{CS}	115.0
T _{CR}	90.0
W _R	3,000



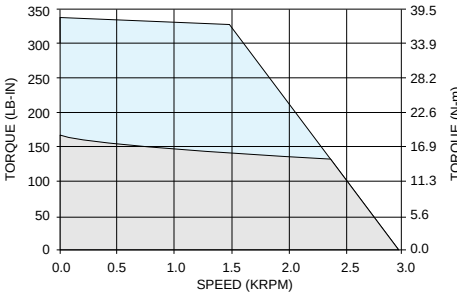
R67G
MOTOR

Reference Points	
T _{PS}	340.0
T _{PR}	305.0
T _{CS}	168.0
T _{CR}	156.0
W _R	1,000



R67H
MOTOR

Reference Points	
T _{PS}	340.0
T _{PR}	330.0
T _{CS}	168.0
T _{CR}	146.0
W _R	2,000



**SYSTEMS CURVES. . .SC9x5 and SC7x5/SC7x6
with R80 Series motors**

Up to 300
lb-in. (33.9Nm)
Cont. rated torque
@ 2000 rpm

7.5 in. "R" Motor

Rating Data

- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 240 Vac 3-phase line.

Test Conditions

- Motor operated at rated winding temperature, mounted to a 18" x 18" x 1/2" heat sink.
- 25°C ambient.

continuous duty

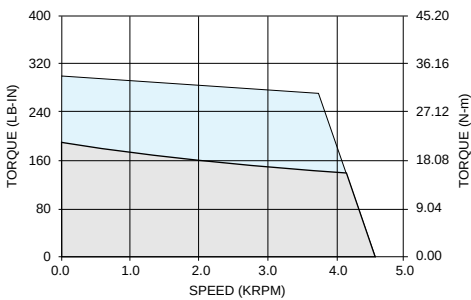
intermittent duty

SC9x5 or SC7x5 and these motors

SC7x6 and these motors

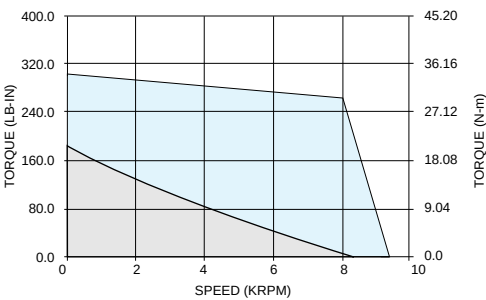
**R84G
MOTOR**

Reference Points	
T _{PS}	300.0
T _{PR}	280.0
T _{CS}	190.0
T _{CR}	125.0
W _R	3,800



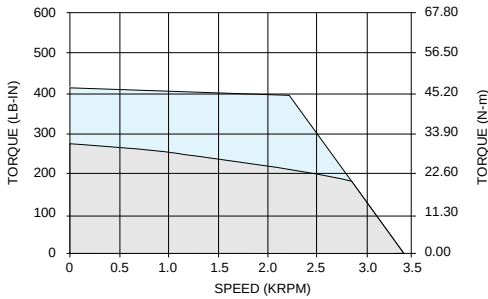
**R84H
MOTOR**

Reference Points	
T _{PS}	300.0
T _{PR}	270.0
T _{CS}	190.0
T _{CR}	45.0
W _R	6,000



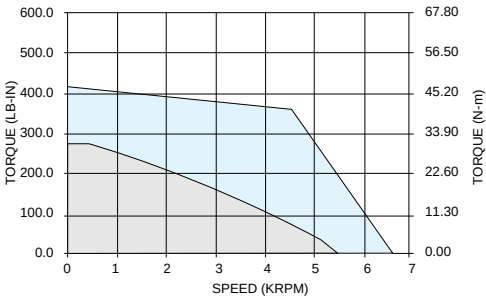
**R86G
MOTOR**

Reference Points	
T _{PS}	410.0
T _{PR}	395.0
T _{CS}	276.0
T _{CR}	225.0
W _R	2,000



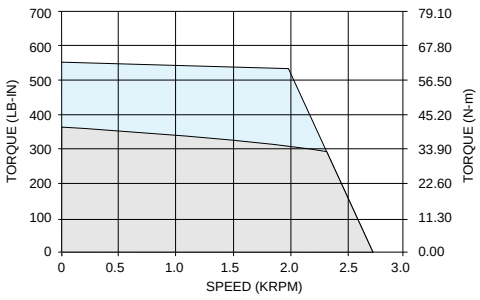
**R86H
MOTOR**

Reference Points	
T _{PS}	410.0
T _{PR}	365.0
T _{CS}	276.0
T _{CR}	120.0
W _R	4,000



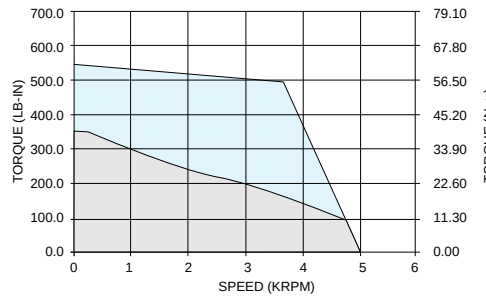
**R88G
MOTOR**

Reference Points	
T _{PS}	540.0
T _{PR}	525.0
T _{CS}	357.0
T _{CR}	325.0
W _R	1,500



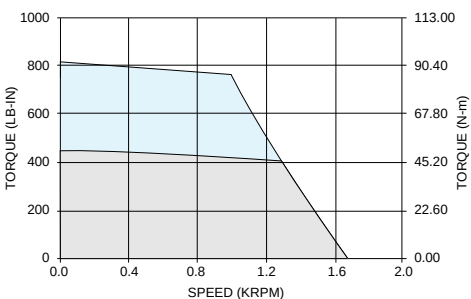
**R88H
MOTOR**

Reference Points	
T _{PS}	540.0
T _{PR}	500.0
T _{CS}	357.0
T _{CR}	205.0
W _R	3,000



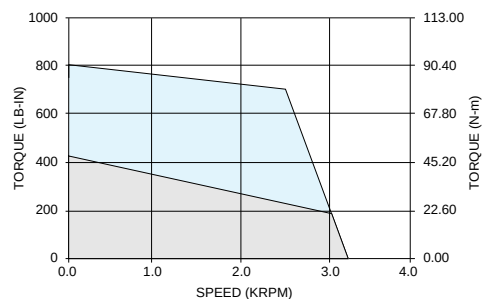
**R8AG
MOTOR**

Reference Points	
T _{PS}	800.0
T _{PR}	730.0
T _{CS}	451.0
T _{CR}	424.0
W _R	1,200



**R8AH
MOTOR**

Reference Points	
T _{PS}	800.0
T _{PR}	720.0
T _{CS}	451.0
T _{CR}	300.0
W _R	2,000





BRUSHLESS SERVO MOTORS

Pacific Scientific brushless servo motors are built for a long, maintenance-free, service life. So once installed, you probably won't have to look at them again.

That's because there's more to these motors than meets the eye. Like long life bearings, in TENV, NEMA and IP65 waterproof housings. All backed by a 2 year warranty.

However you measure performance, PacSci motors have the muscle. From high torque-to-inertia rare earth to flux-focusing ferrite magnetics for matching high inertia loads. From low thermal resistance for maximum power ratings to anti-cog magnet design for smooth, low speed performance.

Whatever your control scheme, PacSci brushless motors can close the loop. From single resolver feedback to a full selection of primary and secondary feedback transducers. From mounting options to application-specific windings. All in all, PacSci offers JIT delivery on over 10,000 motor configurations.



FEATURES

- Troublefree, brushless construction
- Rare earth magnetics provide high torque-to-inertia ratios for fast accel/decel
- Flux-focusing ferrite magnetics for matching higher inertial loads
- Low thermal resistance for maximum power rating per frame size
- High torque over wide speed range
- Location flexibility, with no need to provide brush maintenance access
- Reduced EMI through elimination of brushes and brush arcing
- Anti-cog magnet design for smooth low speed performance
- Rugged TENV, NEMA and IP65 waterproof construction for washdown requirements
- **2 year warranty**

PERFORMANCE

Series	Continuous stall torque–lb-in. (Nm)	Peak torque–lb-in. (Nm)
R20	up to 9.2 (1.04)	up to 100 (11.3)
R30	up to 32 (3.6)	up to 160 (18.1)
F40	up to 61 (6.9)	up to 155 (17.5)
R40	up to 64 (7.2)	up to 270 (30.5)
R60	up to 168 (19)	up to 555 (63)
R80	up to 451 (51)	up to 1757 (198)

GENERAL SPECIFICATIONS

Magnet types	samarium cobalt, or ferrite (F40 Series only)
Sealed housing construction (all motors)	TENV, NEMA and IP65 [△]
Terminations	MS connectors
Thermal protection	positive-temperature-coefficient (PTC) thermistor
Frame construction	
R20 Series (2" OD)	round
R30 Series (3.25" width/height)	square
F40 Series (4.25" width/height)	square
R40 Series (4.25" width/height)	square
R60 Series (5.75" width/height)	square
R80 Series (7.5" width/height)	square

PRIMARY FEEDBACK OPTIONS[△]

- Tachsyn[®] transducer
- Frameless resolver, transmitter type
- Hall sensors

SECONDARY FEEDBACK OPTIONS[△]

- 500-, 1000-, and 1024-line optical incremental encoders

OTHER OPTIONS

- English or metric mounting and shaft configurations
- Shaft seals
- High-speed/high-current (low torque constant) or low-speed/low-current (high torque constant) windings

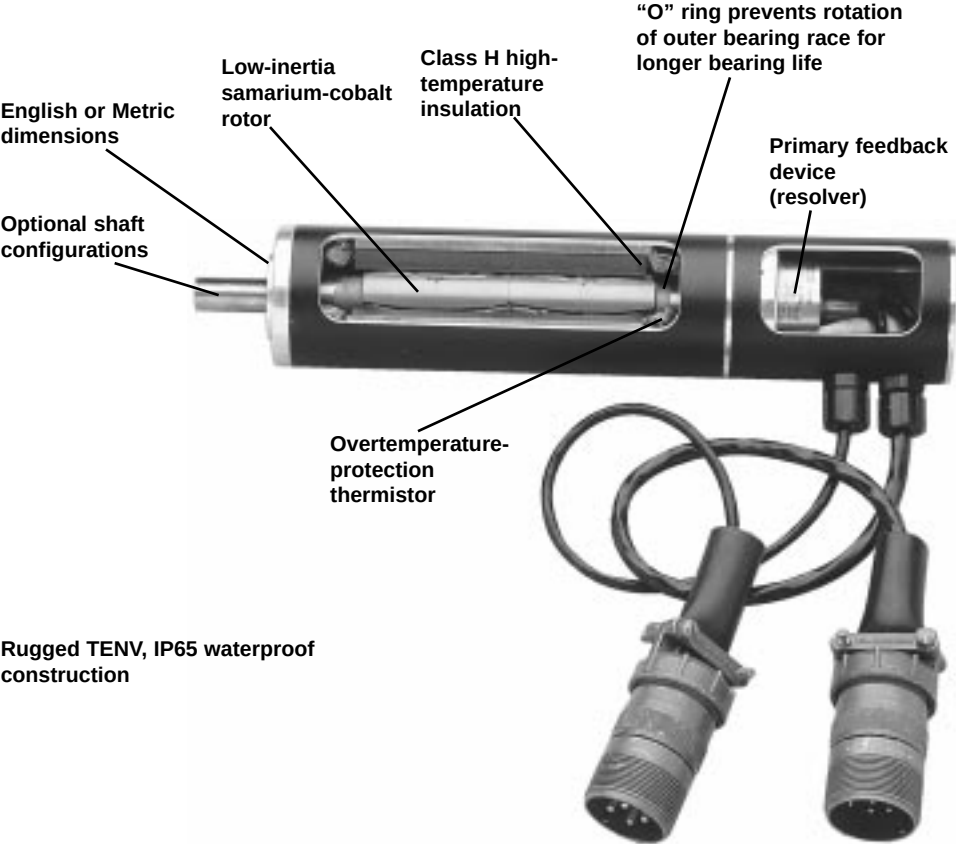
[△] For detailed sealing information, see individual motor specifications.

[△] For detailed information on primary feedback devices, see Section D.

[△] For detailed information on the secondary feedback device, see Section D.

R SERIES

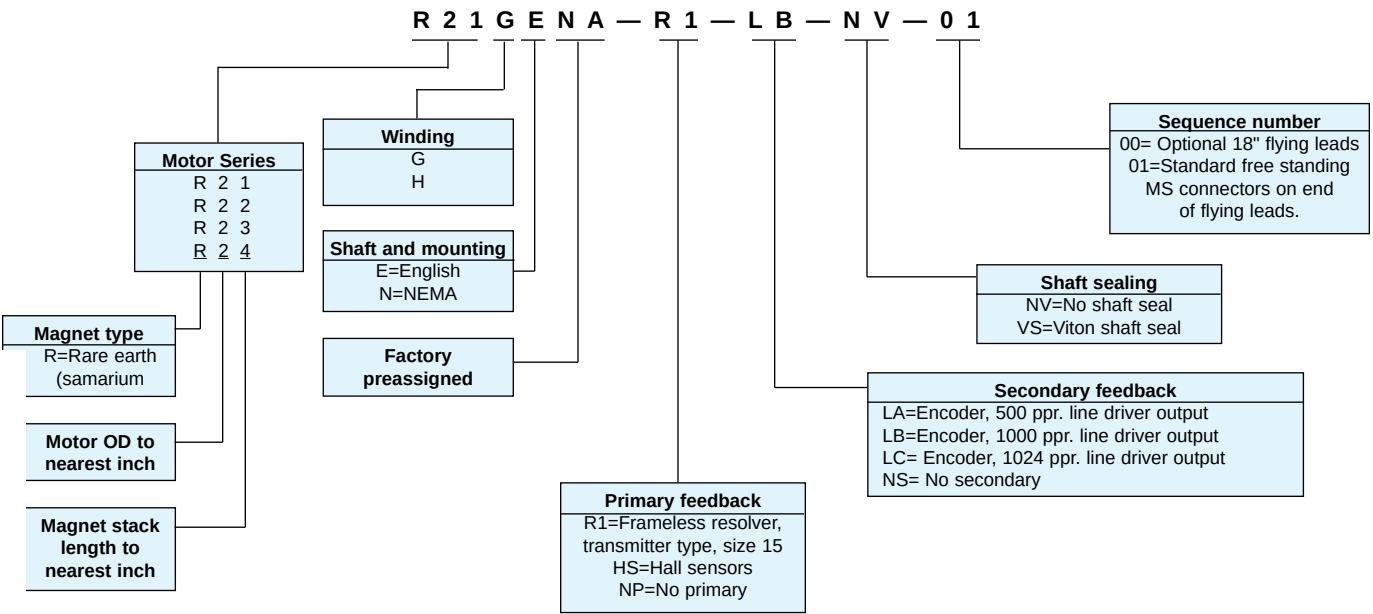
2" OD round-frame motor



Rugged TENV, IP65 waterproof construction

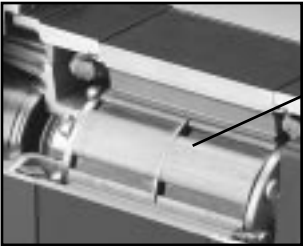
MODEL NUMBER CODE. . .R20 Series

To construct a motor listing, select the combination of features required and put all the coded information in the proper sequence. Please account for all entries. Include the factory-preassigned "N" and "A" as noted. The model number shown is an example of a properly specified motor.



R AND F SERIES

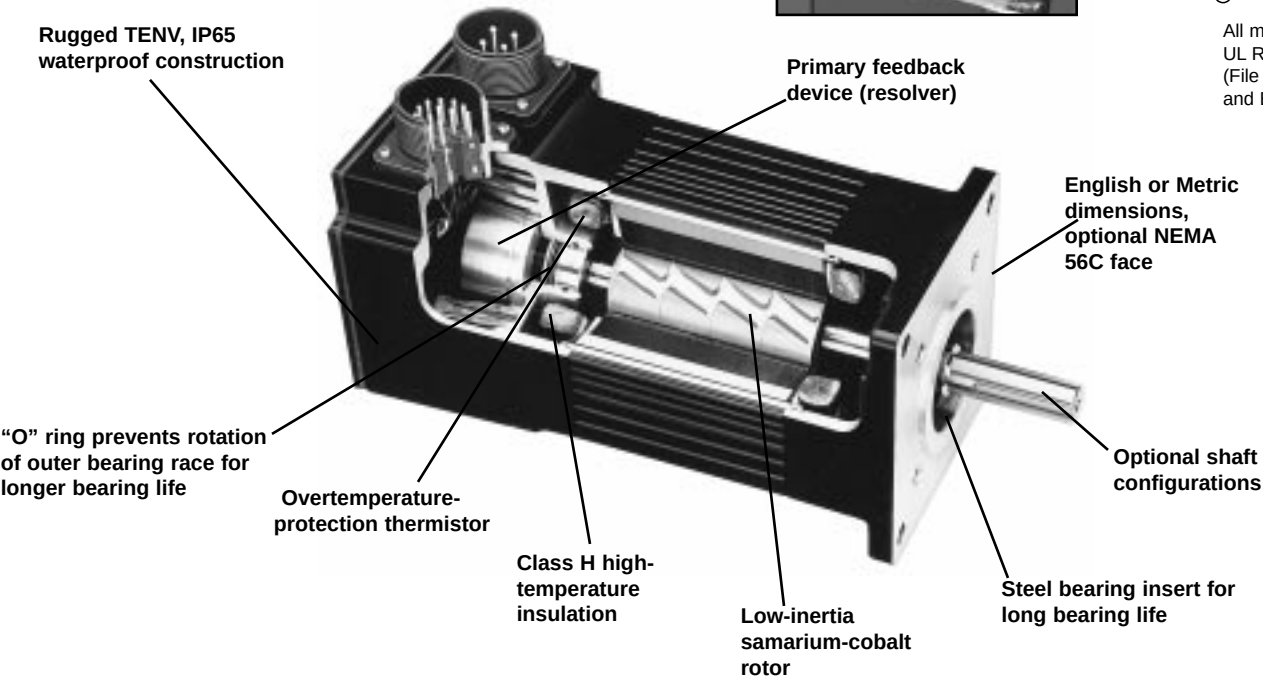
3.25", 4.25", 5.75", and 7.5" square-frame



Medium inertia ferrite rotor- F40 series only

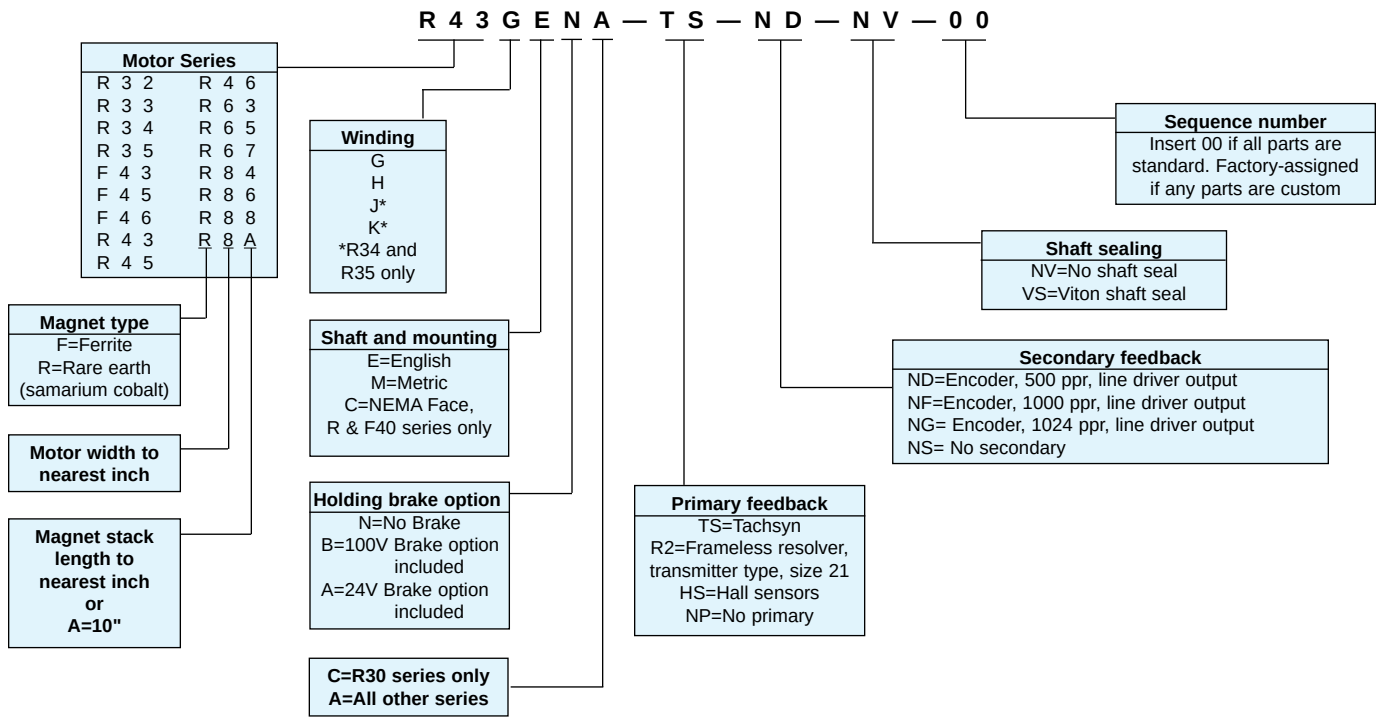


All motors are UL Recognized (File E103510 and E61960)



MODEL NUMBER CODE. . .R30/F40/R40/R60/R80 Series

To construct a motor listing, select the combination of features required and put all the coded information in the proper sequence. Please account for all entries. The model number shown is an example of a properly specified motor.



R20 SERIES

2" OD (round frame)

2.8 to 9.2 lb-in. (.32 to 1.04 Nm)
continuous (stall) torque;
25 to 100 lb-in. (2.8 to 11.3 Nm) peak

- Troublefree brushless construction
- Long life at high shaft speeds
- Samarium cobalt permanent magnets for maximum torque to inertia
- Low rotor inertia for rapid accel/decel
- Low thermal resistance for maximum power ratings
- Full torque over wide speed range
- Anti-cog magnet design for low speed smoothness

R20 Series brushless servo motors feature exceptionally high torque to inertia ratios for excellent acceleration and deceleration. The samarium cobalt motors deliver high torque over a wide speed range-up to 18,000 RPM. The R20's compact round frame design and 18" leads with MS connectors provide mounting flexibility where space is restricted. Brushless design assures long life and low maintenance in high cycle rate applications.



PERFORMANCE FEATURES

- Selection of primary and secondary feedback devices
- Convenient MS-type connectors on 18" leads
- Rugged TENV, NEMA and IP65 waterproof construction for washdown requirements
- Long life bearings. Outer races won't turn. Front locked and rear held by O-ring.

TYPICAL APPLICATIONS

- X-Y tables
- Automated fastening
- Linear actuators
- Drill spindles
- Wire bonders
- Robotics
- Tape drives
- Coil winders
- Wafer spinners
- High speed printers
- Computer equipment

CHARACTERISTICS

Motor parameters and winding data. See system curves beginning on page B-73 for typical torque/speed performance.

English								Metric							
Parameter	Symbol	Units	R21	R22	R23	R24		Symbol	Units	R21	R22	R23	R24		
Continuous Stall Torque ^Δ	T _{CS}	lb-in.	2.8	4.8	7.6	9.2		T _{CS}	Nm	.32	.54	.86	1.04		
Peak Torque ^Δ	T _{PK}	lb-in.	25	50	75	100		T _{PK}	Nm	2.8	5.6	8.5	11.3		
Inertia (motor only)	J _M	lb-in. sec ² x10 ⁻³	.062	.098	.130	.160		J _M	kgm ² x10 ⁻³	.007	.011	.015	.018		
Static friction (max.)	T _f	lb-in.	.10	.17	.24	.31		T _f	Nm	.011	.019	.027	.035		
Viscous damping coefficient	K _{DV}	lb-in./Krpm	.03	.04	.05	.07		K _{DV}	Nm/Krpm	.0034	.0045	.0057	.0079		
Thermal resistance	R _{TH}	°C/Watt	1.65	1.43	1.27	1.14		R _{TH}	°C/Watt	1.65	1.43	1.27	1.14		
Thermal time constant ^Δ	τ _{TH}	min.	8	12	15	17		τ _{TH}	min.	8	12	15	17		
Weight (motor only)	W	lbs	1.5	2.1	2.8	3.4		M (mass)	kg	.68	.95	1.3	1.5		

Winding data	Symbol	Units	G	H	G	H	G	H	G	H	Symbol	Units	G	H	G	H	G	H
Torque constant ^Δ ^Δ (line-line)	K _t peak	lb-in./A	3.4	1.7	3.3	1.6	4.6	2.3	5.5	2.8	K _t peak	Nm/A	.38	.19	.37	.18	.52	.26
Voltage constant ^Δ (line-line)	K _e peak	V/Krpm	40	20	38	19	54	27	65	33	K _e peak	V/rad/sec	.38	.19	.37	.18	.52	.26
Continuous stall current ^Δ	I _{CS}	A	.9	1.8	1.7	3.3	1.8	3.7	1.8	3.7	I _{CS}	A	.9	1.8	1.7	3.3	1.8	3.7
Current at peak torque ^Δ	I _{PK}	A	16	32	33	65	35	70	39	77	I _{PK}	A	16	32	33	66	35	70
Resistance (line-line)	R _c cold	Ohms	62	16	22	5.4	20	4.9	22	5.5	R _c cold	Ohms	62	16	22	5.4	20	4.9
Resistance (line-line) ^Δ	R _h hot	Ohms	86	21	33	8.1	30	7.3	33	8.2	R _h hot	Ohms	86	21	33	8.1	30	7.3
Inductance (line-line)	L	mH	47	12	21	5.3	26	6.5	26	6.5	L	mH	47	12	21	5.3	26	6.5

Note: All values at 25°C unless otherwise noted.

^Δ Windings at 155°C. Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum sink.

^Δ Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum sink.

^Δ Peak value of a sinusoidal waveform. See Section D. Multiply given value by 0.95 to obtain hot values.

^Δ For torque linearity, see Section D.

^Δ Caution: For peak torques or peak currents greater than 3x the continuous rating, consult the factory for thermal considerations.

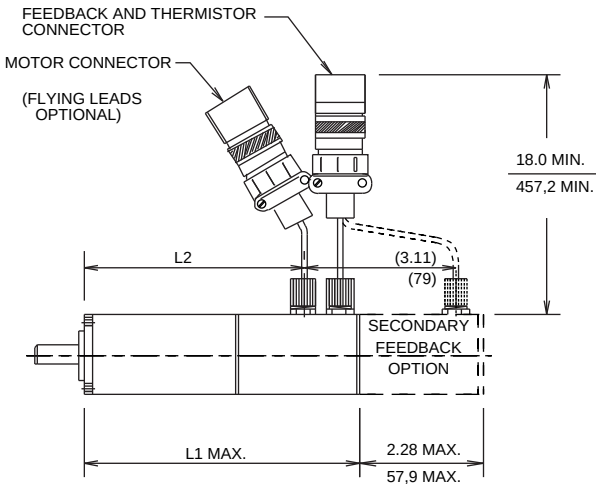
Specifications. . .motor sealing

Motor waterproofing in accordance with NEMA MG1-1.26, part E and IP65 with exception of shaft.

Shaft seal Optional, providing sealing to above specifications. Periodic lubrication required to maintain integrity of seal.

DIMENSIONS. . R20 Series

SIDE VIEW



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.	L2 REF.
R21	6.38	(4.93)
R22	7.38	(5.93)
R23	8.38	(6.93)
R24	9.38	(7.93)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

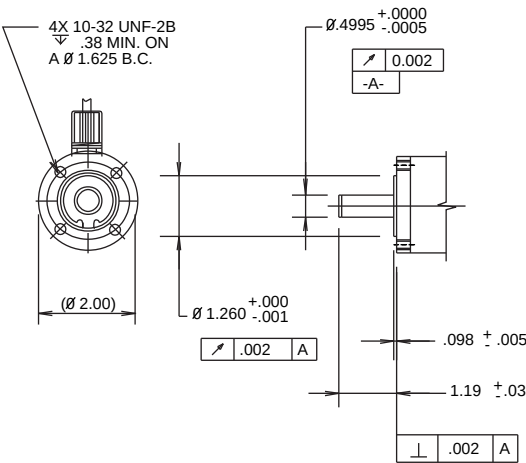
MODEL NUMBER	L1 MAX.	L2 REF.
R21	162.1	(125.2)
R22	187.5	(150.6)
R23	212.9	(176.0)
R24	238.3	(201.4)

Note: L1 includes primary feedback device.

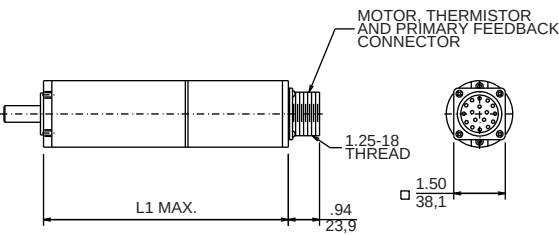
MOUNTING AND SHAFT OPTIONS

FRONT VIEW

ENGLISH (INCHES)

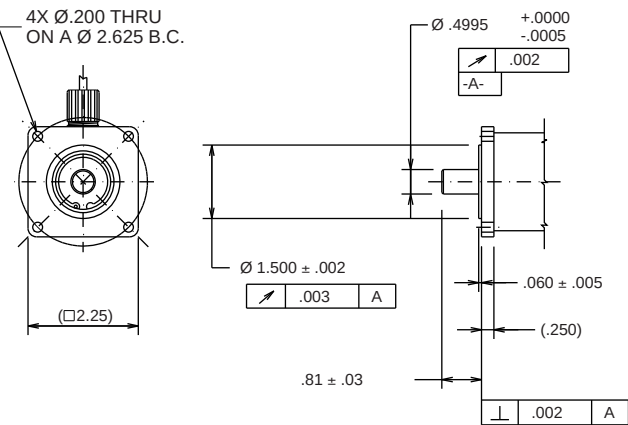


REAR MOUNTED MS CONNECTOR OPTION



- NOTE:
1. Available for motors with primary feedback only
 2. MS connector is the same as used for the primary and secondary on square brushless motors.

NEMA 23 (INCHES)



CONNECTORS

R20 SERIES CONNECTORS	
MOTOR	MS3101A20-4P
PRIMARY FEEDBACK	MS3101A20-7P
PRIMARY PLUS SECONDARY FEEDBACK	MS3101A20-29P

NOTE:
 $\varnothing$.2500 SHAFT OPTION IS AVAILABLE. CONSULT APPLICATION ENGINEERING.

R30 SERIES

3.25" width/height (square frame)

14 to 32 lb-in. (1.6 to 3.6 Nm)
continuous (stall) torque;
66 to 160 lb-in. (7.4 to 18.1Nm) peak

- Troublefree brushless construction
- Long life bearing system
- Samarium cobalt permanent magnets for maximum torque to inertia
- Low rotor inertia for rapid accel/decel
- Low thermal resistance for maximum power ratings
- Full torque over wide speed range
- Anti-cog magnet design for low speed smoothness
- UL recognition

R30 Series brushless servo motors have samarium cobalt magnets for high torque to inertia ratios and high torque throughout a wide speed range.

The compact 3" square frame size is ideal for speed and position control applications requiring maximum performance in minimum space.

Brushless design assures long life and low maintenance in high cycle rate applications.



All motors are
UL Recognized
(Files E103510
and E61960)

PERFORMANCE FEATURES

- Selection of primary and secondary feedback devices
- Optional holding brake
- Convenient MS-type connectors
- Rugged TENV, NEMA and IP65 waterproof construction for washdown requirements
- Long life bearings. Outer races won't turn. Front locked (in steel insert) and rear held by O-ring.

TYPICAL APPLICATIONS

- X-Y tables
- Automated fastening
- Linear actuators
- Drill spindles
- Wire bonders
- Robotics
- Coil winders
- Wafer spinners
- Packaging machinery
- Mail handling equipment

CHARACTERISTICS

Motor parameters and winding data. See system curves beginning on page B-73 for typical torque/speed performance.

English							Metric						
Parameter	Symbol	Units	R32	R33	R34	R35	Symbol	Units	R32	R33	R34	R35	
Continuous Stall Torque ^Δ	T _{CS}	lb-in.	14	21	27	32	T _{CS}	Nm	1.6	2.4	3.0	3.6	
Peak Torque ^Δ	T _{PK}	lb-in.	66	98	130	160	T _{PK}	Nm	7.4	11.0	14.7	18.1	
Inertia (motor only) ^Δ	J _M	lb-in. sec²x10 ⁻³	.45	.64	.82	1.01	J _M	kgm²x10 ⁻³	.051	.072	.093	.114	
Static friction (max.)	T _f	lb-in.	.23	.31	.39	.47	T _f	Nm	.026	.035	.044	.053	
Viscous damping coefficient	K _{DV}	lb-in./Krpm	.04	.06	.09	.11	K _{DV}	Nm/Krpm	.0045	.0068	.010	.012	
Thermal resistance	R _{TH}	° C/Watt	.93	.84	.76	.70	R _{TH}	° C/Watt	.93	.84	.76	.70	
Thermal time constant ^Δ	τ _{TH}	min.	20	23	26	29	τ _{TH}	min.	20	23	26	29	
Weight (motor only)	W	lbs	5.5	7.1	8.7	10.2	M (mass)	kg	2.5	3.2	3.9	4.6	

Winding data	Symbol	Units	G	H	G	H	J	K	J	K	Symbol	Units	G	H	G	H	J	K	J	K
Torque constant ^Δ ^Δ (line-line)	K _t peak	lb-in./A	4.4	2.2	5.9	3.0	7.9	4.0	9.9	4.9	K _t peak	Nm/A	.49	.24	.67	.33	.89	.44	1.12	.56
Voltage constant ^Δ (line-line)	K _E peak	V/Krpm	52	26	70	35	93	47	117	58	K _E peak	V/rad/sec	.49	.24	.67	.33	.89	.44	1.12	.56
Continuous stall current ^Δ	I _{CS}	A	3.6	7.1	3.9	7.8	3.7	7.5	3.6	7.3	I _{CS}	A	3.6	7.1	3.9	7.8	3.7	7.5	3.6	7.3
Current at peak torque ^Δ	I _{PK}	A	32	64	35	70	35	71	35	71	I _{PK}	A	32	64	35	70	35	71	35	71
Resistance (line-line)	R _C cold	Ohms	7.3	1.8	6.9	1.7	8.1	2.0	9.2	2.3	R _C cold	Ohms	7.3	1.8	6.9	1.7	8.1	2.0	9.2	2.3
Resistance (line-line) ^Δ	R _H hot	Ohms	10.9	2.7	10.3	2.5	12.2	3.1	13.9	3.5	R _H hot	Ohms	10.9	2.7	10.3	2.5	12.2	3.1	13.9	3.5
Inductance (line-line)	L	mH	23	5.8	22	5.6	30	7.5	42	10.5	L	mH	23	5.8	22	5.6	30	7.5	42	10.5

Note: All values at 25°C unless otherwise noted.

^Δ Windings at 155°C. Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum sink.

^Δ Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum sink.

^Δ Peak value of a sinusoidal waveform. See Section D. Multiply given value by 0.95 to obtain hot values.

^Δ For torque linearity, see Section D.

^Δ Add holding brake inertia, if applicable.

^Δ Caution: For peak torques or peak currents greater than 3x the continuous rating, consult the factory for thermal considerations.

Specifications. . .optional holding brake

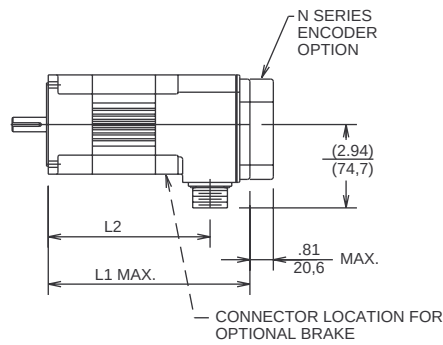
Voltage 100, 24 Vdc
Current 0.21A
Static holding torque (min.) . . 32 lb-in./3.6 Nm
Weight adder 2.5 lbs/1.1 kg
Inertia 034 lb-in-sec² x 10⁻³/.0039 kgm² x 10⁻³

Specifications. . .motor sealing

Motor waterproofing in accordance with NEMA MG1-1.26, part E and IP65 with exception of shaft.
Shaft seal Optional, providing sealing to above specifications. Periodic lubrication required to maintain integrity of seal.

DIMENSIONS. . R30 Series

SIDE VIEW



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R32	7.09	(5.62)
R33	8.09	(6.62)
R34	9.09	(7.62)
R35	10.09	(8.62)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

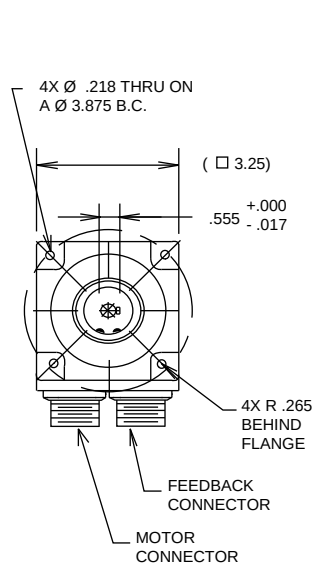
MODEL NUMBER	L1 MAX.*	L2 REF.*
R32	180.1	(142.7)
R33	205.5	(168.1)
R34	230.9	(193.5)
R35	256.3	(218.9)

Note: L1 includes primary feedback device.

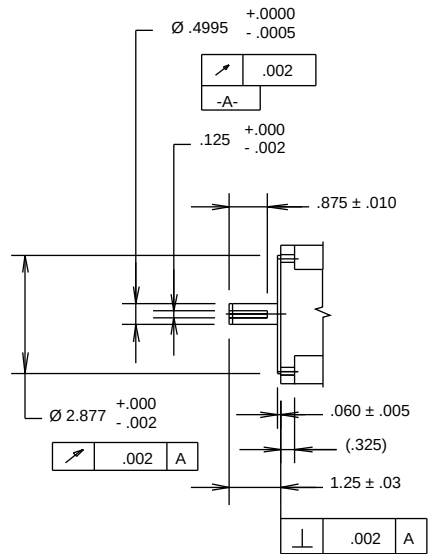
*Add 2.22 in/56.4 mm for brake option.

MOUNTING AND SHAFT OPTIONS

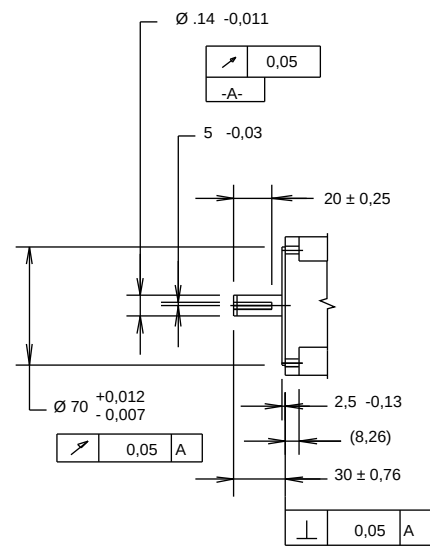
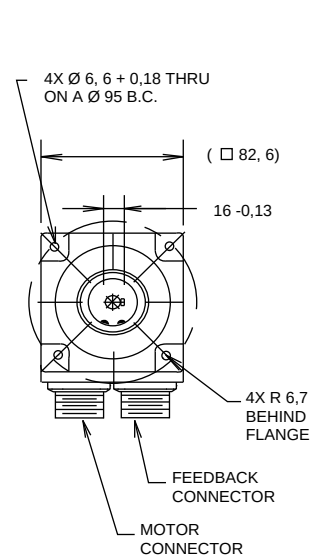
FRONT VIEW



ENGLISH (INCHES)



METRIC (MILLIMETERS)



CONNECTORS

R30 SERIES CONNECTORS	
MOTOR	MS3102E20-4P
PRIMARY FEEDBACK	MS3102E20-7P
PRIMARY PLUS BRAKE	MS3102E14S-9P

R40 SERIES

4.25" width/height (square frame)

33 to 64 lb-in. (3.7 to 7.2 Nm)
continuous (stall) torque;
135 to 270 lb-in. (15.2 to 30.5 Nm) peak

- Troublefree brushless construction
- Long life bearing system
- Samarium cobalt permanent magnets for maximum torque to inertia
- Low rotor inertia for rapid accel/decel
- Mounting interchangeability with F40 Series ferrite magnet brushless motors
- Low thermal resistance for maximum power ratings
- Full torque over wide speed range
- Anti-cog magnet design for low speed smoothness
- UL recognition

R40 Series brushless servo motors have samarium cobalt magnets for high torque to inertia ratios. They produce excellent continuous and peak torques. Smooth operation at low speeds, rapid acceleration and deceleration, and high torque production throughout wide speed ranges characterize these popular motors. Brushless design assures long life and low maintenance in high cycle rate applications.



All motors are
UL Recognized
(Files E103510
and E61960)

PERFORMANCE FEATURES

- Selection of primary and secondary feedback devices
- Optional holding brake
- Convenient MS-type connectors
- Rugged TENV, NEMA and IP65 waterproof construction for washdown requirements
- Long life bearings. Outer races won't turn. Front locked (in steel insert) and rear held by O-ring.

TYPICAL APPLICATIONS

- Axis and spindle drives
- Press feeds
- Textile machines
- Packaging machinery
- Robotics
- Machine tools
- Coil winders
- Mail handling equipment

CHARACTERISTICS

Motor parameters and winding data. See system curves beginning on page B-73 for typical torque/speed performance.

English						Metric					
Parameter	Symbol	Units	R43	R45	R46	Symbol	Units	R43	R45	R46	
Continuous Stall Torque [△]	T _{CS}	lb-in.	33	48	64	T _{CS}	Nm	3.7	5.4	7.2	
Peak Torque [△]	T _{PK}	lb-in.	135	200	270	T _{PK}	Nm	15.2	22.5	30.5	
Inertia (motor only) [△]	J _M	lb-in.-sec ²	.0018	.0026	.0034	J _M	kgm ² x10 ⁻³	.20	.29	.38	
Static friction (max.)	T _f	lb-in.	.26	.33	.39	T _f	Nm	.029	.037	.044	
Viscous damping coefficient	K _{DV}	lb-in./Krpm	.10	.14	.17	K _{DV}	Nm/Krpm	.011	.016	.019	
Thermal resistance	R _{TH}	°C/Watt	.72	.61	.52	R _{TH}	°C/Watt	.72	.61	.52	
Thermal time constant [△]	τ _{TH}	min.	19	29	35	τ _{TH}	min.	19	29	35	
Weight (motor only)	W	lbs	15	20	25	M (mass)	kg	6.8	9.1	11.3	

Winding data	Symbol	Units	G	H	G	H	G	H	Symbol	Units	G	H	G	H	G	H
Torque constant [△] [△] (line-line)	K _t peak	lb-in./A	10.8	5.4	8.1	4.1	10.8	5.4	K _t peak	Nm/A	1.22	.61	.91	.45	1.22	.61
Voltage constant [△] (line-line)	K _e peak	V/Krpm	128	64	96	48	128	64	K _e peak	V/rad/sec	1.22	.61	.91	.45	1.22	.61
Continuous stall current [△]	I _{CS}	A	3.5	6.9	6.7	13.4	6.7	13.5	I _{CS}	A	3.5	6.9	6.7	13.4	6.7	13.5
Current at peak torque [△]	I _{PK}	A	27	53	53	106	53	106	I _{PK}	A	27	53	53	106	53	106
Resistance (line-line)	R _c cold	Ohms	10.0	2.5	3.2	.81	3.7	.93	R _c cold	Ohms	10.0	2.5	3.2	.81	3.7	.93
Resistance (line-line) [△]	R _h hot	Ohms	15.1	3.7	4.8	1.2	5.6	1.4	R _h hot	Ohms	15.1	3.7	4.8	1.2	5.6	1.4
Inductance (line-line)	L	mH	53	13.3	20	4.9	25	6.2	L	mH	53	13.3	20	4.9	25	6.2

Note: All values at 25°C unless otherwise noted.

[△] Windings at 155°C. Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum sink.

[△] Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum sink.

[△] Peak value of a sinusoidal waveform. See Section D. Multiply given value by 0.95 to obtain hot values.

[△] For torque linearity, see Section D.

[△] Add holding brake inertia, if applicable.

[△] Caution: For peak torques or peak currents greater than 3x the continuous rating, consult the factory for thermal considerations.

Specifications. . .optional holding brake

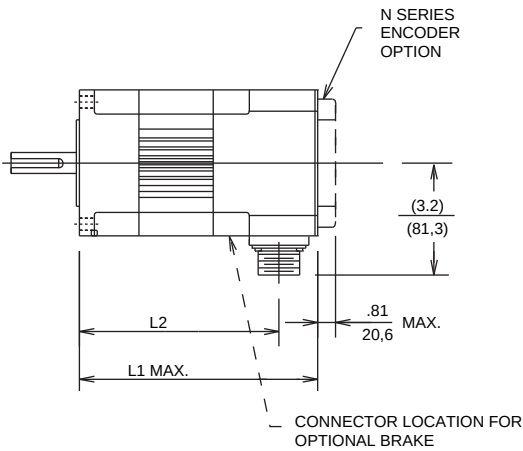
Voltage 100, 24 Vdc
Current 0.22A
Static holding torque (min.) . . 72 lb-in./8.1 Nm
Weight adder 4 lbs/1.8 kg
Inertia 0005 lb-in sec²/.056 kgm² x 10⁻³

Specifications. . .motor sealing

Motor waterproofing in accordance with NEMA MG1-1.26, part E and IP65 with exception of shaft.
Shaft seal Optional, providing sealing to above specifications. Periodic lubrication required to maintain integrity of seal.

DIMENSIONS. . R40 Series

SIDE VIEW



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R43	8.4	(7.01)
R45	9.9	(8.51)
R46	11.4	(10.01)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R43	213.4	(178.1)
R45	251.5	(216.2)
R46	289.6	(254.3)

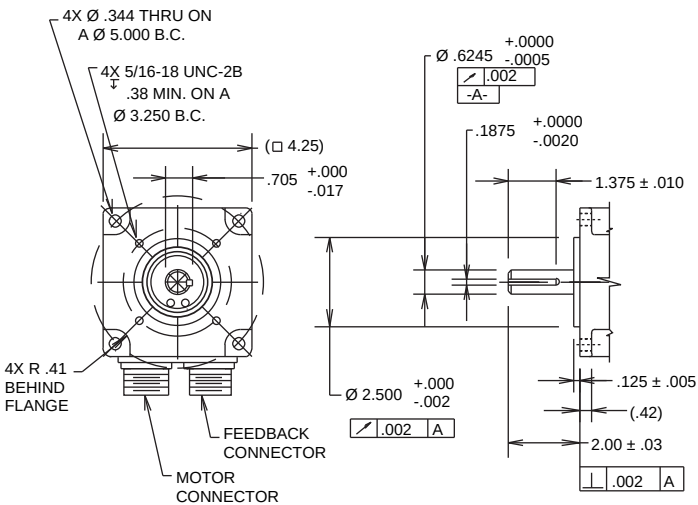
Note: L1 includes primary feedback device.

*Add 2.44 in./62.0 mm for brake option.

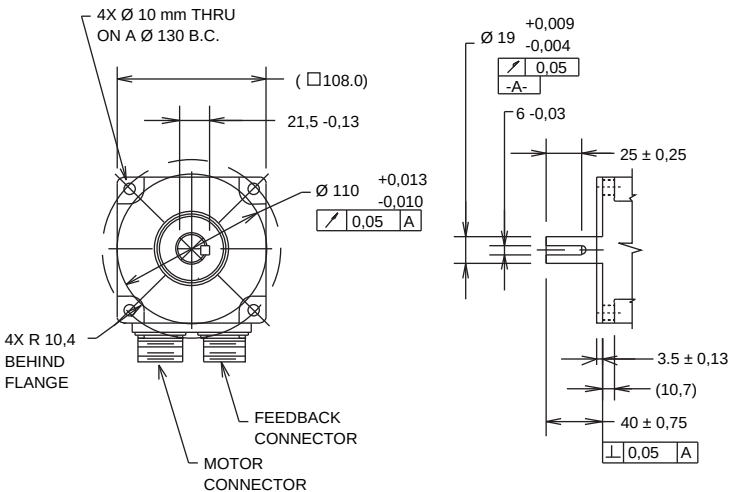
MOUNTING AND SHAFT OPTIONS

FRONT VIEW

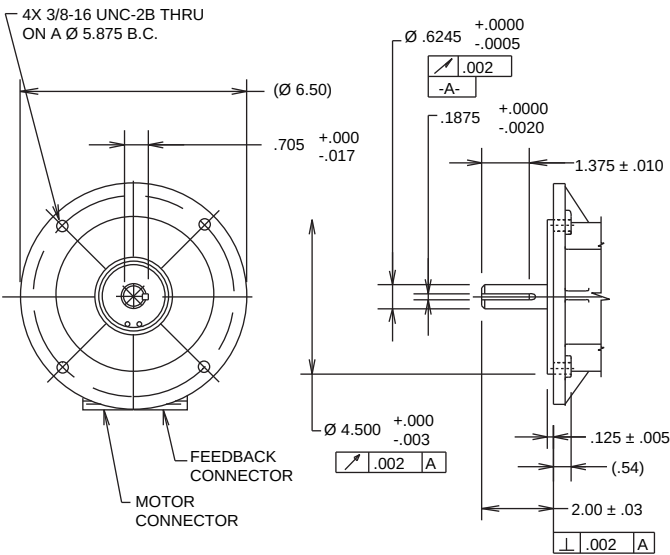
ENGLISH (INCHES)



METRIC (MILLIMETERS)



NEMA 56C (INCHES)



CONNECTORS

R40 SERIES CONNECTORS	
MOTOR	MS3102E20-4P
PRIMARY FEEDBACK	MS3102E20-7P
PRIMARY PLUS SECONDARY FEEDBACK	MS3102E20-29P
BRAKE	MS3102E14S-9P

F40 SERIES

4.25" width/height (square frame)

32 to 61 lb-in. (3.6 to 6.9Nm)
continuous (stall) torque;
81 to 155 lb-in. (9.2 to 17.5 Nm) peak

- Troublefree brushless construction
- Extended range of motor inertias for better high inertia load matching
- Mounting interchangeability with R40 Series rare earth magnet servo motors
- Long life bearing system
- Low thermal resistance for maximum power ratings
- High torque over wide speed range
- Anti-cog magnet design for low speed smoothness
- UL recognition

F40 Series brushless servo motors utilize ferrite magnetics to improve system response by closely matching motor inertia to load inertia.

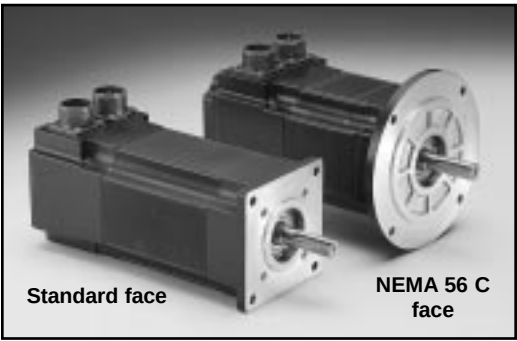
These motors are more easily compensated in applications with higher inertial loads than low inertia motors. F40 Series motors are suitable for direct drive applications and can eliminate costly gearing.

EFFICIENT MAGNET DESIGN

A unique flux-focusing rotor design optimizes ferrite magnet characteristics to achieve good torque production. The resulting continuous torques are equivalent to rare earth motors of the same physical size. Cogging torque is virtually eliminated.

Compared to conventional ferrite magnet rotors, the F40 Series exhibits a high tolerance to demagnetization.

No demagnetization occurs at 3 times continuous stall current, and less than 3% reduction in K_t is experienced at 4 times continuous stall current.



All motors are
UL Recognized
(Files E103510
and E61960)

PERFORMANCE FEATURES

- Selection of primary and secondary feedback devices
- Optional holding brake
- Convenient MS-type connectors
- Rugged TENV, NEMA and IP65 waterproof construction for washdown requirements
- Long life bearings. Outer races won't turn. Front locked (in steel insert) and rear held by O-ring.

TYPICAL APPLICATIONS

- Axis and spindle drives
- Press feeds
- Textile machines
- Packaging machinery
- Material handling systems
- Assembly equipment
- Machine tools
- Coil winders

CHARACTERISTICS

Motor parameters and winding data. See system curves beginning on page B-73 for typical torque/speed performance.

English						Metric					
Parameter	Symbol	Units	F43	F45	F46	Symbol	Units	F43	F45	F46	
Continuous stall torque Δ	T_{CS}	lb-in.	32	46	61	T_{CS}	Nm	3.6	5.2	6.9	
Peak torque Δ	T_{PK}	lb-in.	81	117	155	T_{PK}	Nm	9.2	13.2	17.5	
Inertia (motor only) Δ	J_M	lb-in.-sec ²	.00936	.0137	.0179	J_M	kgm ² x10 ⁻³	1.06	1.55	2.02	
Static friction (max.)	T_f	lb-in.	.70	1.0	1.3	T_f	Nm	.08	.11	.15	
Viscous damping coefficient	K_{DV}	lb-in./Krpm	.18	.26	.30	K_{DV}	Nm/Krpm	.020	.030	.034	
Thermal resistance	R_{TH}	°C/Watt	.84	.73	.61	R_{TH}	°C/Watt	.84	.73	.61	
Thermal time constant Δ	τ_{TH}	min.	30	34	42	τ_{TH}	min.	30	34	42	
Weight (motor only)	W	lbs	16.6	22	27.4	M (mass)	kg	7.5	10	12.5	

Winding data	Symbol	Units	G	H	F	G	G	H	Symbol	Units	G	H	F	G	G	H
Torque constant Δ Δ (line-line)	K_t peak	lb-in./A	10.8	5.4	16.3	8.1	11.0	5.5	K_t peak	Nm/A	1.22	.61	1.84	.92	1.24	.62
Voltage constant Δ (line-line)	K_E peak	V/Krpm	128	64	193	96	130	65	K_E peak	V/rad/sec	1.22	.61	1.84	.92	1.24	.62
Continuous stall current Δ	I_{CS}	A	3.6	7.2	3.4	6.8	6.8	13.6	I_{CS}	A	3.6	7.2	3.4	6.8	6.8	13.6
Current at peak torque Δ	I_{PK}	A	10.8	21.6	10.2	20.4	20.4	40.8	I_{PK}	A	10.8	21.6	10.2	20.4	20.4	40.8
Resistance (line-line)	R_C cold	Ohms	7.7	1.9	10.1	2.5	3.1	.78	R_C cold	Ohms	7.7	1.9	10.1	2.5	3.1	.78
Resistance (line-line) Δ	R_H hot	Ohms	11.6	2.9	15.2	3.8	4.7	1.18	R_H hot	Ohms	11.6	2.9	15.2	3.8	4.7	1.18
Inductance (line-line)	L	mH	49	12	69	17	24	6	L	mH	49	12	69	17	24	6

Note: All values at 25°C unless otherwise noted.

Δ Windings at 155°C. Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum sink.

Δ Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum sink.

Δ Peak value of a sinusoidal waveform. See Section D. Multiply given value by 0.86 to obtain hot values.

Δ For torque linearity, see Section D.

Δ Add holding brake inertia, if applicable.

Δ Caution: For peak torques or peak currents greater than 3x the continuous rating, consult the factory for thermal considerations.

Specifications...optional holding brake

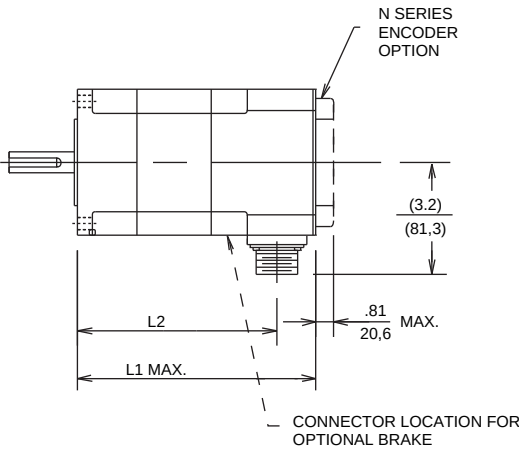
Voltage 100, 24 Vdc
Current 0.22A
Static holding torque (min.) 72 lb-in./8.1 Nm
Weight adder 4 lbs./1.8 kg
Inertia 0005 lb-in sec²/.056 kgm² x 10⁻³

Specifications...motor sealing

Motor waterproofing in accordance with NEMA MG1-1.26, part E and IP65 with exception of shaft.
Shaft seal Optional, providing sealing to above specifications. Periodic lubrication required to maintain integrity of seal.

DIMENSIONS. . F40 Series

SIDE VIEW



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
F43	8.4	(7.01)
F45	9.9	(8.51)
F46	11.4	(10.01)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

MODEL NUMBER	L1 MAX.*	L2 REF.*
F43	213.4	(178.1)
F45	251.5	(216.2)
F46	289.6	(254.3)

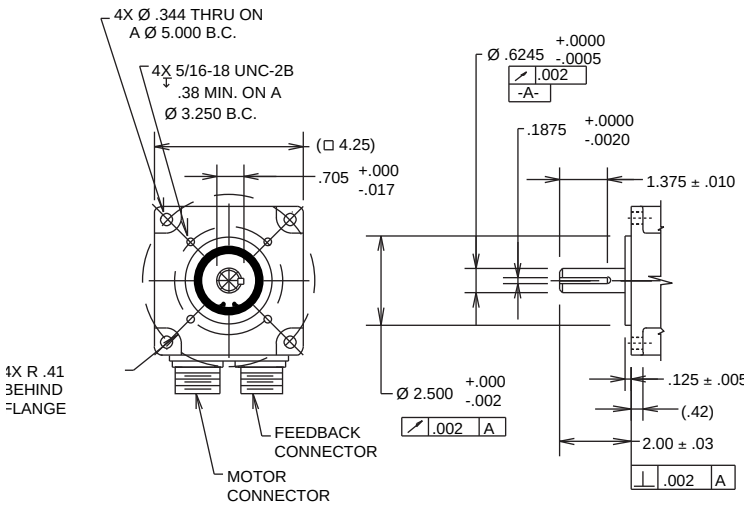
Note: L1 includes primary feedback device.

*Add 2.44 in./62.0 mm for brake option.

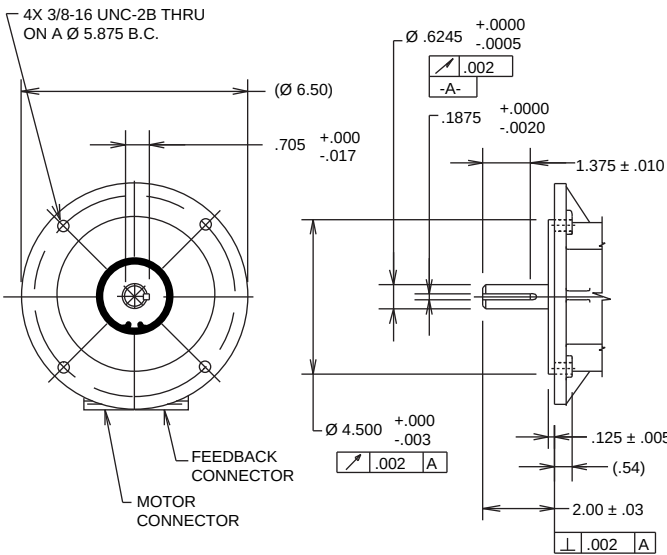
MOUNTING AND SHAFT OPTIONS

FRONT VIEW

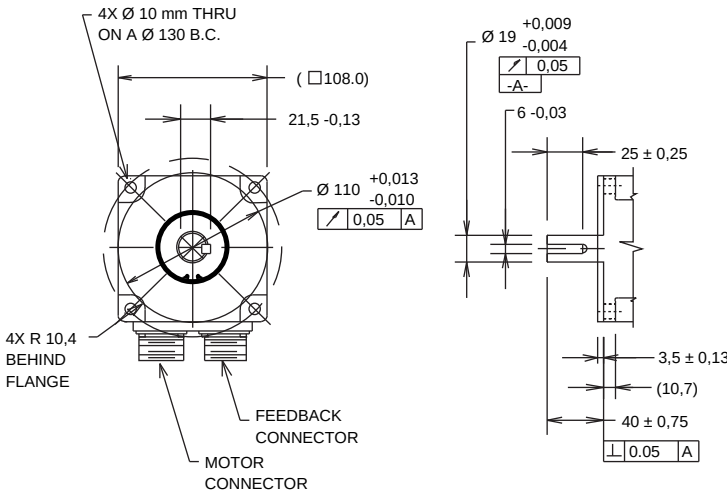
ENGLISH (INCHES)



NEMA 56C (INCHES)



METRIC (MILLIMETERS)



CONNECTORS

F40 SERIES CONNECTORS	
MOTOR	MS3102E20-4P
PRIMARY FEEDBACK	MS3102E20-7P
PRIMARY PLUS SECONDARY FEEDBACK	MS3102E20-29P
BRAKE	MS3102E14S-9P

R60 SERIES

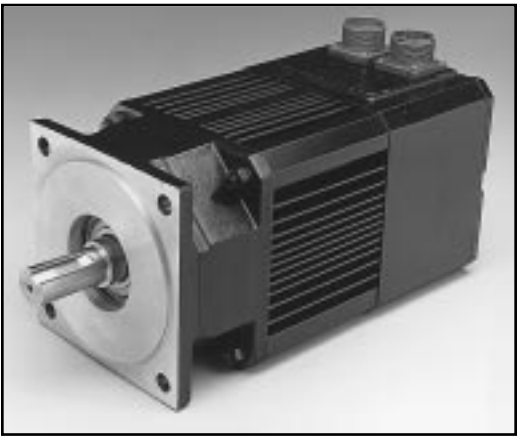
5.75" width/height (square frame)

70 to 168 lb-in. (8 to 19 Nm)
continuous (stall) torque;
230 to 555 lb-in. (26 to 63 Nm) peak

- Troublefree brushless construction
- Long life bearing system
- Samarium cobalt permanent magnets for maximum torque to inertia
- Low rotor inertia for rapid accel/decel
- Low thermal resistance for maximum power ratings
- High torque over wide speed range
- Anti-cog magnet design for low speed smoothness
- UL recognition

Built for heavy duty applications, R60 Series brushless servo motors exhibit excellent torque, speed and/or velocity characteristics.

Samarium cobolt rotors, long life bearings and brushless construction assure maximum performance and service life.



All motors are
UL Recognized
(Files E103510
and E61960)

PERFORMANCE FEATURES

- Selection of primary and secondary feedback devices
- Optional holding brake
- Convenient MS-type connectors
- Rugged TENV, NEMA and IP65 waterproof construction for washdown requirements
- Long life bearings. Outer races won't turn. Front locked (in steel insert) and rear held by O-ring.

TYPICAL APPLICATIONS

- Axis and spindle drives
- Press feeds
- Textile machines
- Packaging machinery
- Robotics
- Transfer lines
- Machine tools
- Mail handling equipment

CHARACTERISTICS

Motor parameters and winding data. See system curves beginning on page B-73 for typical torque/speed performance.

English							Metric						
Parameter	Symbol	Units	R63	R65	R67		Symbol	Units	R63	R65	R67		
Continuous stall torque Δ	T_{CS}	lb-in.	70	115	168		T_{CS}	Nm	8	13	19		
Peak torque Δ	T_{PK}	lb-in.	230	400	555		T_{PK}	Nm	26	45	63		
Inertia (motor only) Δ	J_M	lb-in.-sec ²	.007	.011	.015		J_M	kgm ² x10 ⁻³	.79	1.24	1.69		
Static friction (max.)	T_f	lb-in.	1.4	2.3	3.2		T_f	Nm	.16	.26	.36		
Viscous damping coefficient	K_{DV}	lb-in./Krpm	.41	.66	.92		K_{DV}	Nm/Krpm	.046	.075	.104		
Thermal resistance	R_{TH}	°C/Watt	.51	.42	.30		R_{TH}	°C/Watt	.51	.42	.30		
Thermal time constant Δ	τ_{TH}	min.	19	36	72		τ_{TH}	min.	19	36	72		
Weight (motor only)	W	lbs	29	39	49		M (mass)	kg	13	18	22		

Winding data	Symbol	Units	G	H	G	H	G	H	Symbol	Units	G	H	G	H	G	H
Torque constant Δ Δ (line-line)	K_t peak	lb-in./A	5.9	2.9	9.9	5.0	13.8	6.9	K_t peak	Nm/A	.66	.33	1.12	.56	1.56	.78
Voltage constant Δ (line-line)	K_E peak	V/Krpm	70	35	117	59	164	82	K_E peak	V/rad/sec	.66	.33	1.12	.56	1.56	.78
Continuous stall current Δ	I_{CS}	A	13.5	27.0	13.1	26.2	13.8	27.6	I_{CS}	A	13.5	27.0	13.1	26.2	13.8	27.6
Current at peak torque Δ	I_{PK}	A	82	164	82	164	82	164	I_{PK}	A	82	164	82	164	82	164
Resistance (line-line)	R_C cold	Ohms	.93	.23	1.20	.34	1.50	.37	R_C cold	Ohms	.93	.23	1.2	.34	1.5	.37
Resistance (line-line) Δ	R_H hot	Ohms	1.4	.34	1.8	.51	2.3	.55	R_H hot	Ohms	1.4	.34	1.8	.51	2.3	.55
Inductance (line-line)	L	mH	8.9	2.2	13.7	3.4	18.2	4.6	L	mH	8.9	2.2	13.7	3.4	18.2	4.6

Note: All values at 25°C unless otherwise noted.

Δ Windings at 155°C. Motor in 25°C ambient and mounted to a 18" x 18" x 1/2" aluminum sink.

Δ Motor in 25°C ambient and mounted to a 18" x 18" x 1/2" aluminum sink.

Δ Peak value of a sinusoidal waveform. See Section D. Multiply given value by 0.95 to obtain hot values.

Δ For torque linearity, see Section D.

Δ Add holding brake inertia, if applicable.

Δ Caution: For peak torques or peak currents greater than 3x the continuous rating, consult the factory for thermal considerations.

Specifications...optional holding brake

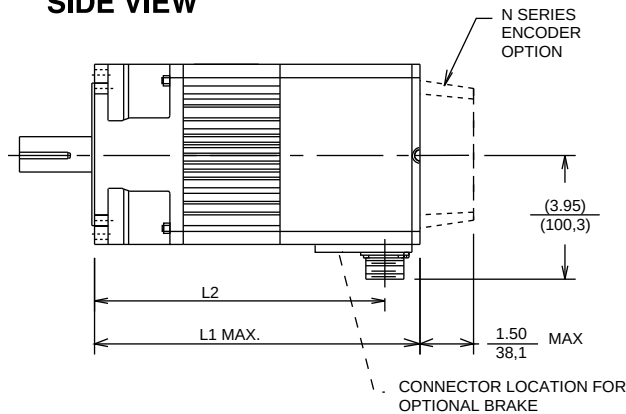
Voltage 100, 24 Vdc
Current 0.262A
Static holding torque (min.) .. 180 lb-in./20.3 Nm
Weight adder 9 lbs./4.2 kg
Inertia 00037 lb-in sec²/.042 kgm² x 10⁻³

Specifications...motor sealing

Motor waterproofing in accordance with NEMA MG1-1.26, part E and IP65 with exception of shaft.
Shaft seal Optional, providing sealing to above specifications. Periodic lubrication required to maintain integrity of seal.

DIMENSIONS. . R60 SERIES

SIDE VIEW



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R63	9.36	(8.12)
R65	11.36	(10.12)
R67	13.36	(12.12)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R63	237.7	(206.2)
R65	288.5	(257.0)
R67	339.3	(307.8)

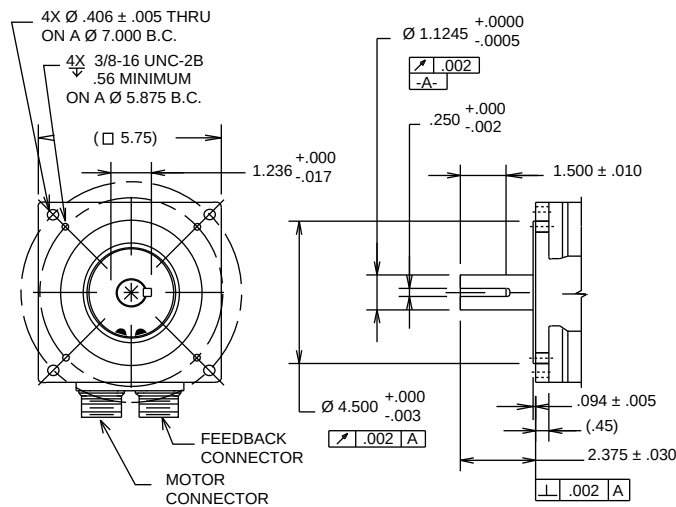
Note: L1 includes primary feedback device.

*Add 2.66 in./67.6 mm for brake option.

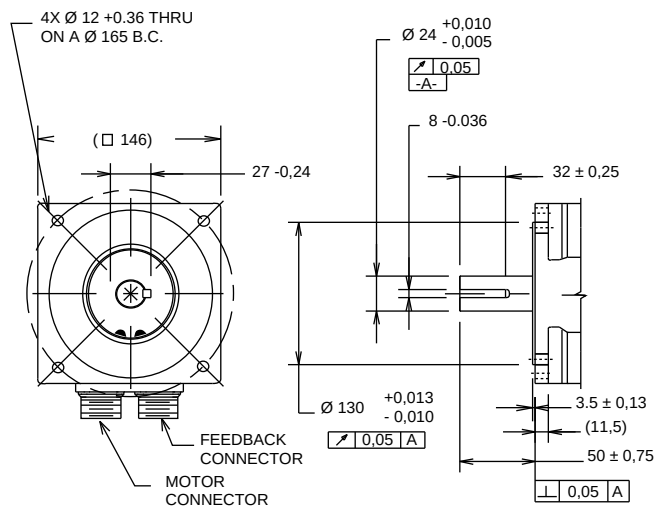
MOUNTING AND SHAFT OPTIONS

FRONT VIEW

ENGLISH (INCHES)



METRIC (MILLIMETERS)



CONNECTORS

R60 SERIES CONNECTORS	
MOTOR	MS3102E20-4P
PRIMARY FEEDBACK	MS3102E20-7P
PRIMARY PLUS SECONDARY FEEDBACK	MS3102E20-29P
BRAKE	MS3102E14S-9P

R80 SERIES

7.5" width/height (square frame)

190 to 451 lb-in. (21 to 50 Nm)
continuous (stall) torque;
710 to 1757 lb-in. (80 to 198 Nm) peak

- Troublefree brushless construction
- Long life bearing system
- Samarium cobalt permanent magnets for maximum torque to inertia
- Low rotor inertia for rapid accel/decel
- Low thermal resistance for maximum power ratings
- High torque over wide speed range
- Anti-cog magnet design for low speed smoothness
- UL recognition

R80 Series brushless servo motors are built for extremely high torque, and power applications. They exhibit excellent torque, speed and/or velocity characteristics.

Samarium cobolt rotors, long life bearings and brushless construction assure maximum performance and service life.



All motors are
UL Recognized
(Files E103510
and E61960)

PERFORMANCE FEATURES

- Selection of primary and secondary feedback devices
- Optional holding brake
- Convenient MS-type connectors
- Rugged TENV, NEMA and IP65 waterproof construction for washdown requirements
- Long life bearings. Outer races won't turn. Front locked (in steel insert) and rear held by O-ring.

TYPICAL APPLICATIONS

- Axis and spindle drives
- Press feeds
- Textile machines
- Robotics
- Machine tools
- Packaging machinery
- Transfer lines

CHARACTERISTICS

Motor parameters and winding data. See system curves beginning on page B-73 for typical torque/speed performance.

English								Metric							
Parameter	Symbol	Units	R84	R86	R88	R8A		Symbol	Units	R84	R86	R88	R8A		
Continuous stall torque [△]	T _{CS}	lb-in.	190	276	357	451		T _{CS}	Nm	21	31	40	50		
Peak torque [△]	T _{PK}	lb-in.	710	1060	1410	1757		T _{PK}	Nm	80	120	159	198		
Inertia (motor only) [△]	J _M	lb-in.-sec ²	.039	.058	.076	.095		J _M	kgm ² x10 ⁻³	4.4	6.6	8.6	10.7		
Static friction (max.)	T _f	lb-in.	2.5	3.7	5.0	6.3		T _f	Nm	.28	.42	.56	.70		
Viscous damping coefficient	K _{DV}	lb-in./Krpm	.96	1.4	1.8	2.2		K _{DV}	Nm/Krpm	.11	.16	.20	.25		
Thermal resistance	R _{TH}	°C/Watt	.30	.25	.23	.21		R _{TH}	°C/Watt	.30	.25	.23	.21		
Thermal time constant [△]	τ _{TH}	min.	40	54	59	63		τ _{TH}	min.	40	54	59	63		
Weight (motor only)	W	lbs	60	77	94	111		M (mass)	kg	27	35	43	49		

Winding data	Symbol	Units	G	H	G	H	G	H	G	H	Symbol	Units	G	H	G	H	G	H
Torque constant [△] [△] (line-line)	K _t peak	lb-in./A	6.7	3.3	8.8	4.4	11.7	5.8	17.7	8.85	K _t peak	Nm/A	.76	.38	.99	.49	1.32	.66
Voltage constant [△] (line-line)	K _e peak	V/Krpm	79	39	104	52	138	69	210	105	K _e peak	V/rad/sec	.76	.38	.99	.49	1.32	.66
Continuous stall current [△]	I _{CS}	A	33	66	37	74	36	73	30	60	I _{CS}	A	33	66	37	74	36	73
Current at peak torque [△]	I _{PK}	A	225	450	255	510	255	510	209	418	I _{PK}	A	255	450	255	510	255	510
Resistance (line-line)	R _c cold	Ohms	.26	.07	.25	.06	.28	.07	.46	.12	R _c cold	Ohms	.26	.07	.25	.06	.28	.07
Resistance (line-line) [△]	R _h hot	Ohms	.39	.10	.37	.09	.42	.10	.69	.17	R _h hot	Ohms	.39	.10	.37	.09	.42	.10
Inductance (line-line)	L	mH	3.2	0.8	3.6	0.9	4.0	1.0	7.4	1.9	L	mH	3.2	0.8	3.6	0.9	4.0	1.0

Note: All values at 25°C unless otherwise noted.

[△] Windings at 155°C. Motor in 25°C ambient and mounted to a 18" x 18" x 1/2" aluminum sink.

[△] Motor in 25°C ambient and mounted to a 18" x 18" x 1/2" aluminum sink.

[△] Peak value of a sinusoidal waveform. See Section D. Multiply given value by 0.95 to obtain hot values.

[△] For torque linearity, see Section D.

[△] Add holding brake inertia, if applicable.

[△] Caution: For peak torques or peak currents greater than 3x the continuous rating, consult the factory for thermal considerations.

Specifications...optional holding brake

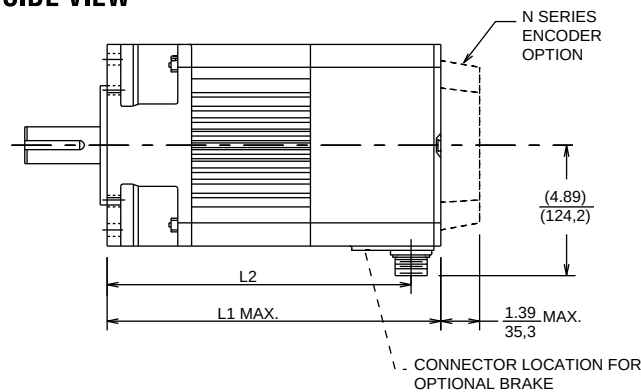
Voltage 100, 24 Vdc
Current 314A
Static holding torque (min.) . . 408 lb-in./46.1 Nm
Weight adder 15 lbs./8.6 kg
Inertia 00149 lb-in sec²/.168 kgm² x 10⁻³

Specifications...motor sealing

Motor waterproofing in accordance with NEMA MG1-1.26, part E and IP65 with exception of shaft.
Shaft seal Optional, providing sealing to above specifications. Periodic lubrication required to maintain integrity of seal.

DIMENSIONS. . R80 Series

SIDE VIEW



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R84	10.93	(9.56)
R86	12.93	(11.56)
R88	14.93	(13.56)
R8A	16.93	(15.56)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R84	277.6	(242.8)
R86	328.4	(293.6)
R88	379.2	(344.4)
R8A	430.0	(395.2)

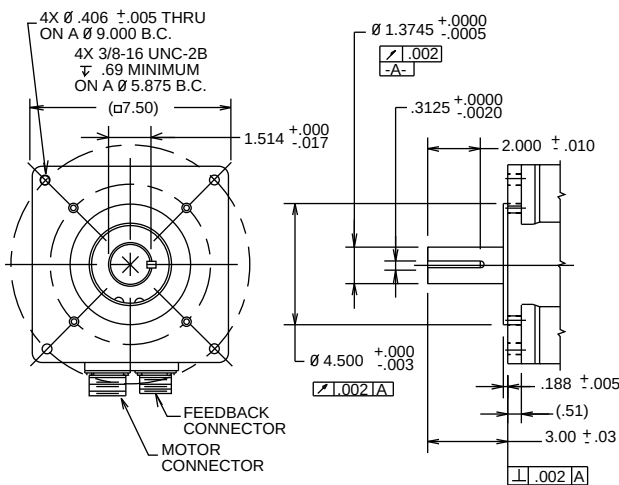
Note: L1 includes primary feedback device.

*Add 2.88 in/73.1 mm for brake option.

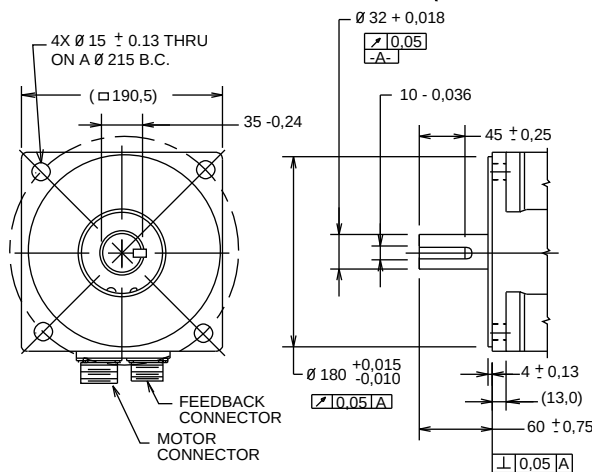
MOUNTING AND SHAFT OPTIONS

FRONT VIEW

ENGLISH (INCHES)



METRIC (MILLIMETERS)



CONNECTORS

R80 SERIES CONNECTORS	
MOTOR	MS3102E24-22P
PRIMARY FEEDBACK	MS3102E20-7P
PRIMARY PLUS SECONDARY FEEDBACK	MS3102E20-29P
BRAKE	MS3102E14S-9P

EXPLOSION-PROOF BRUSHLESS SERVO MOTORS

Pacific Scientific explosion-proof brushless servo motors provide safe operation in many potentially explosive applications. These motors may be used in hazardous locations where vapors or gases mix and form flammable or explosive environments. If an explosion inside the motor should occur, the motor frame will not burst or rupture. Ignition will be confined to the motor cavity and flames or hot gases will not exit to the explosive environment surrounding the motor.

Explosion-proof motors are available in two frame sizes. Both sizes feature a specially designed explosion-proof enclosure and a built-in thermostat. The thermostat must be wired in conjunction with the motor controller to satisfy UL requirements.

RATINGS

These explosion-proof servo motors are capable of delivering the same performance as Pacific Scientific's standard line of brushless servo motors because they have the same magnetic design and internal rotor and stator construction.

Although the explosion-proof motors can deliver the same performance as the standard offerings, the UL ratings are lower to comply with the method UL uses to establish ratings. The key difference is that motor ratings are generally established with the motor mounted to a heat sink—typical of motor installation. The heat sink dissipates heat and allows the motor rating to be higher. UL, however, requires that the motor ratings be established with the motor unmounted (no heat sink). Without a heat sink, the motor rating is reduced accordingly.

FEATURES

However you measure performance, PacSci motors have the muscle. From high torque-to-inertia rare earth magnets to low thermal resistance for maximum power ratings to anti-cog magnet design for smooth, low speed performance.

Like the standard series, once you install these explosion-proof motors, you probably won't have to look at them again. That's because there's more to these motors than meets the eye, like long life bearings, in TENV, NEMA and waterproof housings. All backed by a two year warranty.

Whatever your control scheme, PacSci brushless servo motors can close the loop. From a full selection of primary feedback transducers to an optional encoder for secondary feedback. From mounting options to application-specific windings.

- Troublefree, brushless construction
- From 10.8 to 134 lb-in. continuous torque
- Speeds to 7000 RPM
- UL Listed (File E150845)
- Meet UL requirements of Division 1 locations, Class I (Groups C and D)
- Leads exit through a 1 NPT (1/2 NPT for encoder leads) pipe nipple for convenient connection
- Built-in thermostat to protect motor from overheating under excessive loads
- Rugged TENV, NEMA and waterproof construction for washdown requirements
- Long life bearings. Outer races won't turn. Front locked (in steel insert) and rear held by O-ring
- Optional holding brake
- Rare earth magnetics provide high torque-to-inertia ratios for fast accel/decel
- Low thermal resistance for maximum power rating per frame size
- High torque over wide speed range
- Location flexibility, with no need to provide brush maintenance access
- Reduced EMI through elimination of brushes and brush arcing
- Anti-cog magnet design for smooth low speed performance
- Easily mated with Pacific Scientific digital programmable position or analog torque/velocity servo controllers
- **2 year warranty**

APPLICATIONS

- Automated paint lines
- Pumps—volatile, flammable liquids
- Pumps—air or hydraulic in explosive environments
- Process control in hazardous locations—munitions manufacturing. . . chemical plants

PERFORMANCE

Series	Continuous stall torque—lb-in.(Nm)*	Peak torque—lb-in. (Nm)
R30P Series	up to 27 (3)	75.8 (8,5)
R60P Series	134 (15)	475 (53,2)

*Based on the UL requirement that the continuous duty rating is established with the motor in 40°C ambient and unmounted (without a heatsink).

GENERAL SPECIFICATIONS

Magnet types	samarium cobalt
Housing construction	explosion-proof per division 1, Class I, Groups C and D, temperaure class T3C (160C)
Housing sealing	Although a sealed housing does not fall under the UL explosion-proof requirement, the explosion-proof motor housings are the same construction as the standard series housings. They are TENV and sealed in accordance with NEMA MG1-1.26, part E and IP65 with the exception of the shaft. The shaft seal is optional and provides sealing to the NEMA and IP65 requirements. Periodic lubrication of the seal is required to maintain its integrity.
Terminations	through pipe nipple for connections through explosion-proof conduit
Thermal protection	thermostat—see bottom of pages B-99 and B-101 for specifications
Frame construction	
R30P Series (3.25" width/height)	square
R60P Series (5.75" width/height)	square

PRIMARY FEEDBACK OPTIONS

- (see specifications in Section D)
- Tachsyn® transducer
 - Frameless resolver, transmitter type
 - Hall sensors

SECONDARY FEEDBACK OPTIONS

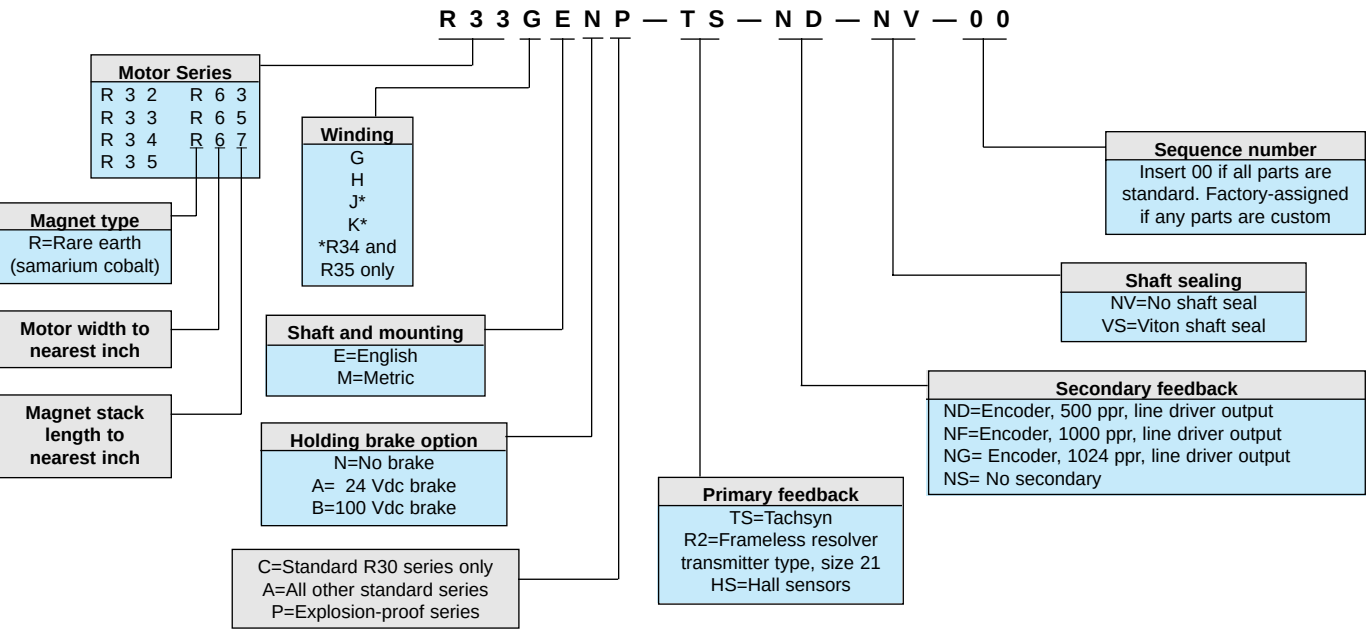
- (see specifications in Section D)
- 500-, 1000-, and 1024-line optical incremental encoders

OTHER OPTIONS

- Holding brake (electrically released)—see specifications—bottom of pages B-99 and B-101)
- English or metric mounting and shaft configurations
- Shaft seals
- High-speed/high-current (low torque constant) or low-speed/low-current (high torque constant) windings

MODEL NUMBER CODE. . .R30P and R60P Series

To construct a motor listing, select the combination of features required and put all the coded information in the proper sequence. Please account for all entries. The model number shown is an example of a properly specified motor.



R30P SERIES

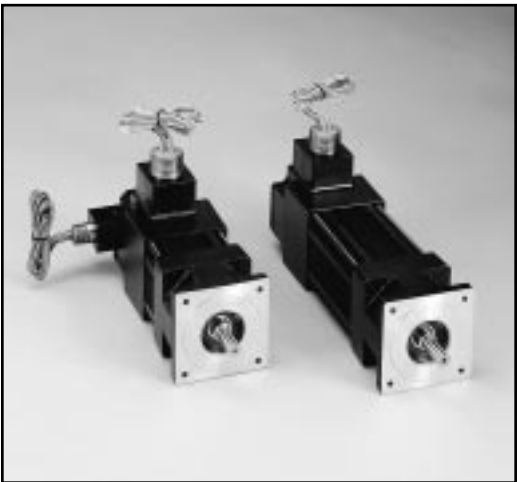
3.25" width/height (square frame)

10.8 to 27 lb-in. (1.2 to 3 Nm)
continuous (stall) torque;
30.3 to 75.8 lb-in. (3.4 to 8.5 Nm) peak

- This compact 3" square frame size is ideal for speed and position control applications requiring maximum performance in minimum space



All motors are UL
Listed (File 150845)



CHARACTERISTICS

Motor parameters and winding data. See system curves beginning on page B-104 for typical torque/speed performance.

English								Metric							
Parameter	Symbol	Units	R32	R33	R34	R35		Symbol	Units	R32	R33	R34	R35		
Continuous Stall Torque [△]	T _{CS}	lb-in.	10.8	16.2	21.6	27		T _{CS}	Nm	1.2	1.8	2.4	3.0		
Peak Torque [△]	T _{PK}	lb-in.	30.3	45.5	60.6	75.8		T _{PK}	Nm	3.4	5.1	6.8	8.5		
Inertia (motor only) [△]	J _M	lb-in. sec ² x10 ⁻³	.45	.64	.82	1.01		J _M	kgm ² x10 ⁻³	.051	.072	.093	.114		
Static friction (max.)	T _f	lb-in.	.23	.31	.39	.47		T _f	Nm	.026	.035	.044	.053		
Viscous damping coefficient	K _{DV}	lb-in./Krpm	.04	.06	.09	.11		K _{DV}	Nm/Krpm	.0045	.0068	.010	.012		
Thermal resistance	R _{TH}	°C/Watt	.93	.84	.76	.70		R _{TH}	°C/Watt	.93	.84	.76	.70		
Thermal time constant [△]	τ _{TH}	min.	20	23	26	29		τ _{TH}	min.	20	23	26	29		
Weight (motor only)	W	lbs	5.5	7.1	8.7	10.2		M (mass)	kg	2.5	3.2	3.9	4.6		

Winding data	Symbol	Units	G	H	G	H	J	K	J	K	Symbol	Units	G	H	G	H	J	K	J	K
Torque constant [△] [△] (line-line)	K _t peak	lb-in./A	4.4	2.2	5.9	3.0	7.9	4.0	9.9	4.9	K _t peak	Nm/A	.49	.24	.67	.33	.89	.44	1.12	.56
Voltage constant [△] (line-line)	K _e peak	V/Krpm	52	26	70	35	93	47	117	58	K _e peak	V/rad/sec	.49	.24	.67	.33	.89	.44	1.12	.56
Continuous stall current [△]	I _{CS}	A	3.0	5.9	3.2	6.4	3.1	6.2	3	6	I _{CS}	A	3.0	5.9	3.2	6.4	3.1	6.2	3	6
Current at peak torque	I _{PK}	A	8.8	17.7	9.6	19.2	9.3	18.6	9	18	I _{PK}	A	8.8	17.7	9.6	19.2	9.3	18.6	9	18
Resistance (line-line)	R _c cold	Ohms	7.3	1.8	6.9	1.7	8.1	2.0	9.2	2.3	R _c cold	Ohms	7.3	1.8	6.9	1.7	8.1	2.0	9.2	2.3
Resistance (line-line) [△]	R _h hot	Ohms	10.9	2.7	10.3	2.5	12.2	3.1	13.9	3.5	R _h hot	Ohms	10.9	2.7	10.3	2.5	12.2	3.1	13.9	3.5
Inductance (line-line)	L	mH	23	5.8	22	5.6	30	7.5	42	10.5	L	mH	23	5.8	22	5.6	30	7.5	42	10.5

Note: All values at 40°C unless otherwise noted.

- [△] Windings at 155°C. Motor in 40°C ambient and unmounted (without heatsink).
- [△] Motor in 40°C ambient and unmounted (without heatsink).
- [△] Peak value of a sinusoidal waveform. See Section D. Multiply given value by 0.95 to obtain hot values.
- [△] For torque linearity, see Section D.
- [△] Add holding brake inertia, if applicable.

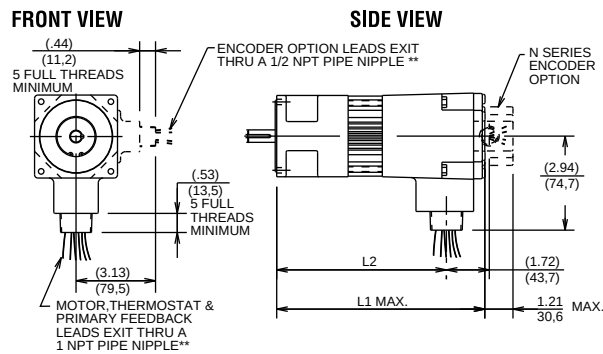
Thermostat (normally closed)

Parameter	Units	Value
Rated voltage	Volts AC	250
Switching current (max)	A	5

Optional Holding Brake (electrically released)

Parameter	Units	Type A	Type B
Static holding torque	lb-in. (min)	32	32
Rated voltage ±10%	Volts DC	24	100
Rated current ±10%	A	.72	.21
Inertia adder	lb-in-sec ² x10 ⁻³	.025	.025
Speed	RPM (max)	5000	5000
Motor weight adder	lbs.	2.8	2.8

DIMENSIONS. . R30P SERIES



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R32	8.45	(6.81)
R33	9.45	(7.81)
R34	10.45	(8.81)
R35	11.45	(9.81)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R32	214,4	(173,5)
R33	239,8	(198,9)
R34	265,7	(224,3)
R35	290,6	(249,7)

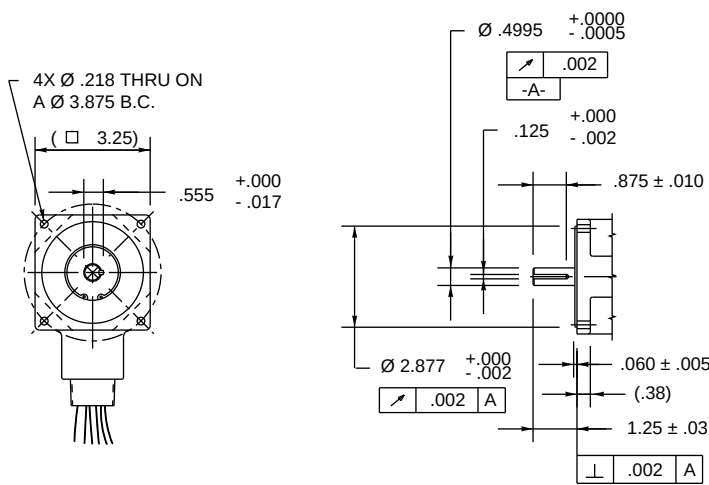
Note: L1 includes primary feedback device.

*Add 2.14 in/54,4 mm for brake option.

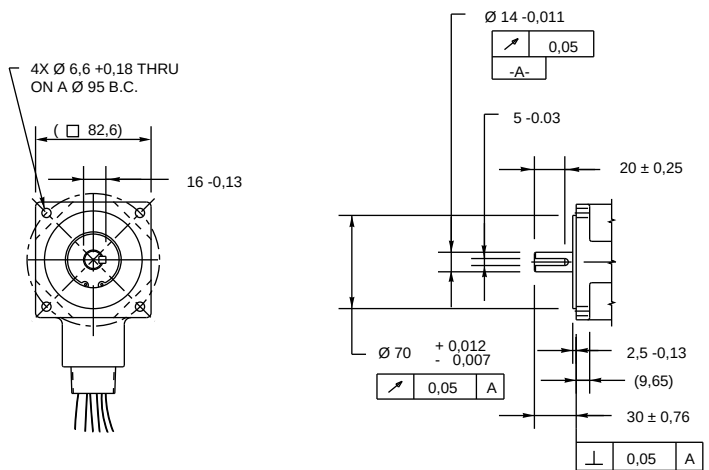
**Standard lead length is 36 in./914,4 mm.

MOUNTING AND SHAFT OPTIONS

ENGLISH (INCHES)



METRIC (MILLIMETERS)



R60P SERIES

5.75" width/height (square frame)

- This motor is built for heavy duty applications and delivers excellent torque and speed control



All motors are UL Listed (File 150845)



57.3 to 134 lb-in. (6.4 to 15 Nm) continuous (stall) torque;
204 to 475 lb-in. (22.8 to 53.2 Nm) peak

CHARACTERISTICS

Motor parameters and winding data. See system curves beginning on page B-105 for typical torque/speed performance.

English						Metric					
Parameter	Symbol	Units	R63	R65	R67	Symbol	Units	R63	R65	R67	
Continuous stall torque ^Δ	T _{CS}	lb-in.	57.3	95.4	134	T _{CS}	Nm	6.4	10.7	15	
Peak torque ^Δ	T _{PK}	lb-in.	204	339	475	T _{PK}	Nm	22.8	40	53.2	
Inertia (motor only) ^Δ	J _M	lb-in.-sec ²	.007	.011	.015	J _M	kgm ² x10 ⁻³	.79	1.24	1.69	
Static friction (max.)	T _f	lb-in.	1.4	2.3	3.2	T _f	Nm	.16	.26	.36	
Viscous damping coefficient	K _{DV}	lb-in./Krpm	.41	.66	.92	K _{DV}	Nm/Krpm	.046	.075	.104	
Thermal resistance	R _{TH}	°C/Watt	.51	.42	.30	R _{TH}	°C/Watt	.51	.42	.30	
Thermal time constant ^Δ	τ _{TH}	min.	19	36	72	τ _{TH}	min.	19	36	72	
Weight (motor only)	W	lbs	29	39	49	M (mass)	kg	13	18	22	

Winding data	Symbol	Units	G	H	G	H	G	H	Symbol	Units	G	H	G	H	G	H
Torque constant ^Δ ^Δ (line-line)	K _t peak	lb-in./A	5.9	2.9	9.9	5.0	13.8	6.9	K _t peak	Nm/A	.66	.33	1.12	.56	1.56	.78
Voltage constant ^Δ (line-line)	K _e peak	V/Krpm	70	35	117	59	164	82	K _e peak	V/rad/sec	.66	.33	1.12	.56	1.56	.78
Continuous stall current ^Δ	I _{CS}	A	11.2	22.3	11.5	21.7	11.4	22.8	I _{CS}	A	11.2	22.3	11.5	21.7	11.4	22.8
Current at peak torque	I _{PK}	A	33.6	66.9	34.6	65	34.2	67.2	I _{PK}	A	33.6	66.9	34.6	65	34.2	67.2
Resistance (line-line)	R _c cold	Ohms	.93	.23	1.20	.34	1.50	.37	R _c cold	Ohms	.93	.23	1.2	.34	1.5	.37
Resistance (line-line) ^Δ	R _h hot	Ohms	1.4	.34	1.8	.51	2.3	.55	R _h hot	Ohms	1.4	.34	1.81	.51	2.3	.55
Inductance (line-line)	L	mH	8.9	2.2	13.7	3.4	18.2	4.6	L	mH	8.9	2.2	13.7	3.4	18.2	4.6

Note: All values at 40°C unless otherwise noted.

- ^Δ Windings at 155°C. Motor in 40°C ambient and unmounted (without heatsink).
- ^Δ Motor in 40°C ambient and unmounted (without heatsink).
- ^Δ Peak value of a sinusoidal waveform. See Section D. Multiply given value by 0.95 to obtain hot values.
- ^Δ For torque linearity, see Section D.
- ^Δ Add holding brake inertia, if applicable.

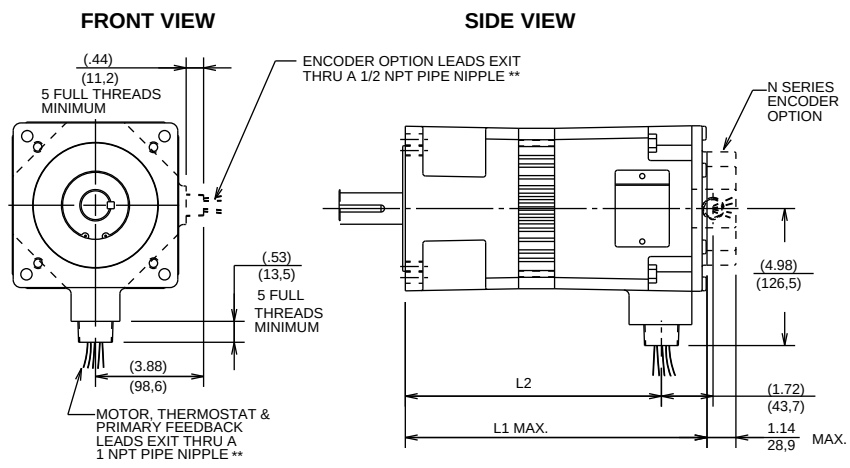
Thermostat (normally closed)

Parameter	Units	Value
Rated voltage	Volts AC	250
Switching current (max)	A	5

Optional Holding Brake (electrically released)

Parameter	Units	Type A	Type B
Static holding torque	lb-in. (min)	180	180
Rated voltage ±10%	Volts DC	24	100
Rated current ±10%	A	.88	.26
Inertia adder	lb-in-sec ² x 10 ⁻³	.33	.33
Speed	RPM (max)	5000	5000
Motor weight adder	lbs.	9	9

DIMENSIONS . . . R60P SERIES



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R63	10.03	(8.33)
R65	12.03	(10.33)
R67	14.03	(12.33)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

MODEL NUMBER	L1 MAX.*	L2 REF.*
R63	254,8	(211,6)
R65	305,6	(262,4)
R67	356,4	(313,2)

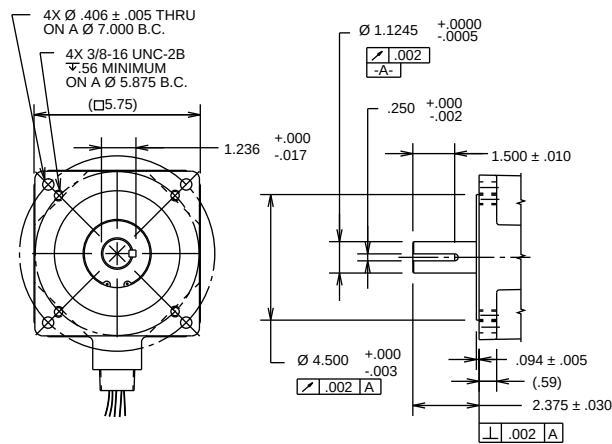
Note: L1 includes primary feedback device.

*Add 3.11 in./79,0 mm for brake option.

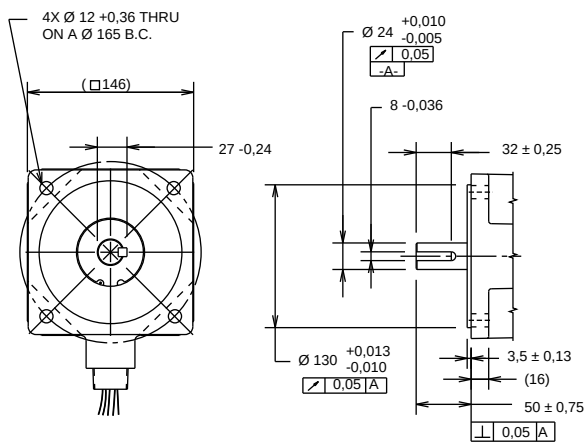
**Standard lead length is 36 in.914,4 mm.

MOUNTING AND SHAFT OPTIONS

ENGLISH (INCHES)



METRIC (MILLIMETERS)



LEADWIRE TERMINATION FOR EXPLOSION-PROOF BRUSHLESS SERVO MOTORS

MOTOR

R30P Series

16 Ga.

Function	Color Code
Phase R	Blue
Phase S	Brown
Phase T	Violet
Ground	Green

R60P Series

12 Ga.

Function	Color Code
Phase R	Blue
Phase S	Brown
Phase T	Violet
Ground	Green

THERMOSTAT

18 Ga.

Function	Color Code
Thermostat	Yellow
Thermostat	Yellow

PRIMARY FEEDBACK

Resolver

18 Ga.

Function	Color Code
S4 (-Cosine)	Orange
S3 (-Sine)	Black/White
S2 (+ Cosine)	White
S1 (+Sine)	Red
R1 (Excitation)	Red/White
R2 (Excitation Return)	Yellow/White

Tachsyn

18 Ga.

Function	Color Code
Excitation	Red
Excitation Return	Black/White
Phase 1	Orange
Phase 2	Red/White
Phase 3	White

Hall Sensors

18 Ga.

Function	Color Code
+4.5 to 24 VDC	Red
Supply Return	Black/White
Sensor 1	Red/White
Sensor 2	Orange
Sensor 3	Yellow

SECONDARY FEEDBACK

Encoder

22 Ga.

Function	Color Code
Channel A	Brown/White
Channel $\bar{A}$	Orange/White
Channel B	Blue/White
Channel $\bar{B}$	Violet/White
Channel Z	Gray
Channel $\bar{Z}$	Gray/White
+5 VDC	Red/Black
Supply Return	Orange/Black

BRAKE

24 Vdc

18 Ga.

Function	Color Code
Brake (+24 VDC)	Black
Brake (Supply Return)	Black

100 Vdc

18 Ga.

Function	Color Code
Brake (+100 VDC)	Black
Brake (Supply Return)	Black

SYSTEMS CURVES. . .SC9x2/SC9x3, SC4x2/SC4x3 and SC7x2/SC7x3 with R30 motors

Up to 23
lb-in. (2.6 Nm)
Cont. rated torque
@ 3000 rpm

3.25 in. "R" Motor

Rating Data

- Caution: the continuous torque performance shown is for the standard series of brushless servo motors. For operation under the UL rating which is based on operation in 40°C ambient and the motor unmounted (without a heatsink) derate the continuous torques by 18%
- Peak torque ratings are for 2 seconds.
- Rated speed is provided for operation on a 230 Vac 3-phase line. Reduce to 70% for 230 Vac 1-phase line operation and to 40% for 115 Vac 1-phase line operation.

Test Conditions

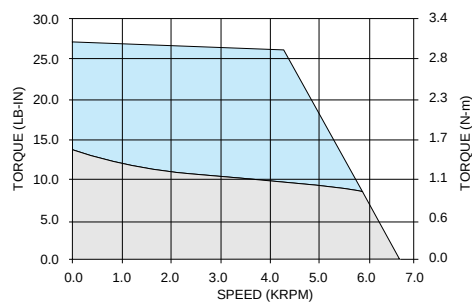
- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" heat sink.
- 25°C ambient.

continuous duty intermittent duty

SC9x2, SC4x2, SC7x2 and these motors

R32G MOTOR

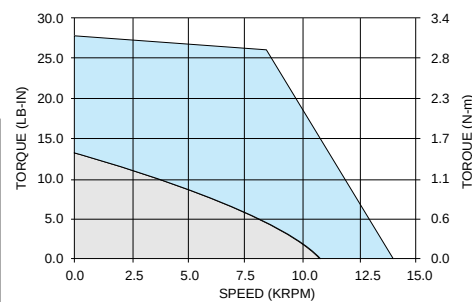
Reference Points	
T_{PS}	27.0
T_{PR}	25.0
T_{CS}	14.0
T_{CR}	10.1
W_R	4,000



SC9x3, SC4x3, SC7x3 and these motors

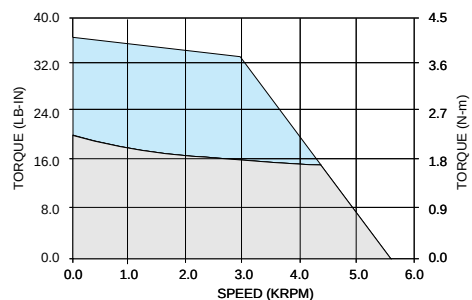
R32H MOTOR

Reference Points	
T_{PS}	27.0
T_{PR}	25.0
T_{CS}	14.0
T_{CR}	6.0
W_R	7,000



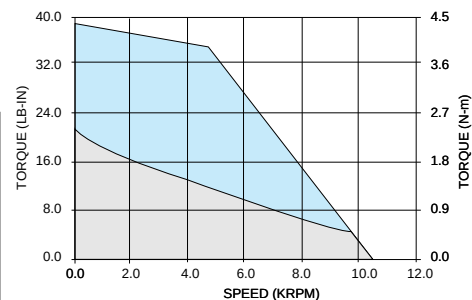
R33G MOTOR

Reference Points	
T_{PS}	36.0
T_{PR}	33.0
T_{CS}	21.0
T_{CR}	16.0
W_R	3,000



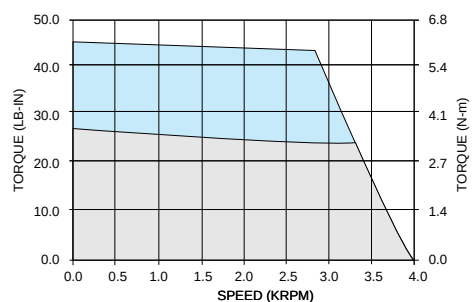
R33H MOTOR

Reference Points	
T_{PS}	39.0
T_{PR}	25.0
T_{CS}	21.0
T_{CR}	10.0
W_R	6,000



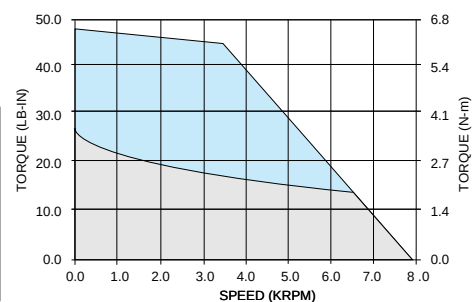
R34J MOTOR

Reference Points	
T_{PS}	45.0
T_{PR}	42.0
T_{CS}	27.0
T_{CR}	24.0
W_R	2,800



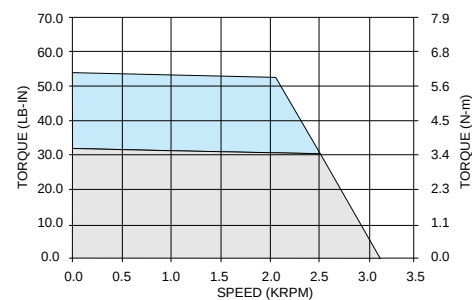
R34K MOTOR

Reference Points	
T_{PS}	48.0
T_{PR}	38.0
T_{CS}	27.0
T_{CR}	16.0
W_R	4,000



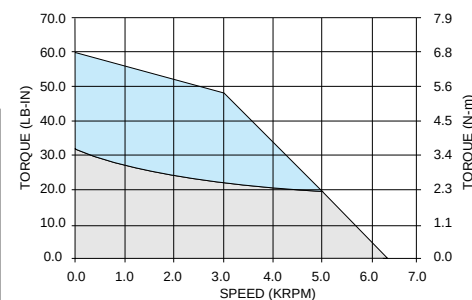
R35J MOTOR

Reference Points	
T_{PS}	54.0
T_{PR}	53.0
T_{CS}	32.0
T_{CR}	30.0
W_R	2,000



R35K MOTOR

Reference Points	
T_{PS}	59.0
T_{PR}	48.0
T_{CS}	32.0
T_{CR}	23.0
W_R	3,000



SYSTEMS CURVES. . .SC7x4/SC7x5
with R60 Series motors

Up to 146
lb-in. (16.5 Nm)
Cont. rated torque
@ 2000 rpm

5.75 in. "R" Motor

Rating Data

- **Caution: the continuous torque performance shown is for the standard series of brushless servo motors. For operation under the UL rating which is based on operation in 40°C ambient and the motor unmounted (without a heatsink) derate the continuous torques by 18%**
- Peak torque ratings are for 5 seconds.
- Rated speed is provided for operation on a 230 Vac 3-phase line.

Test Conditions

- Motor operated at rated winding temperature, mounted to a 18" x 18" x 1/2" heat sink.
- 25°C ambient.

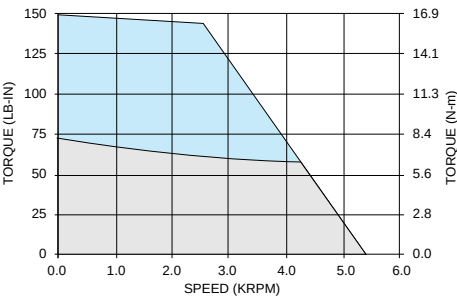
continuous duty intermittent duty

SC7x4 and these motors

SC7x5 and these motors

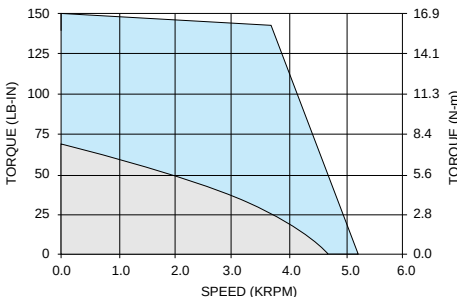
R63G
MOTOR

Reference Points	
T _{PS}	150.0
T _{PR}	125.0
T _{CS}	70.0
T _{CR}	58.0
W _R	3,000



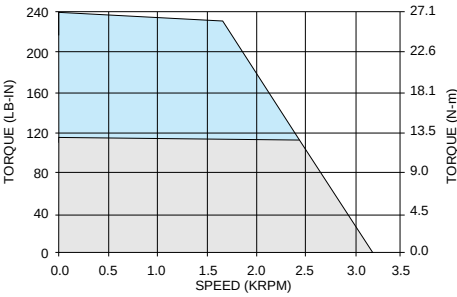
R63H
MOTOR

Reference Points	
T _{PS}	150.0
T _{PR}	142.0
T _{CS}	70.0
T _{CR}	38.0
W _R	6,000



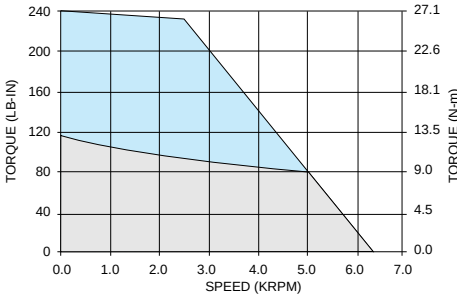
R65G
MOTOR

Reference Points	
T _{PS}	240.0
T _{PR}	230.0
T _{CS}	115.0
T _{CR}	102.0
W _R	1,700



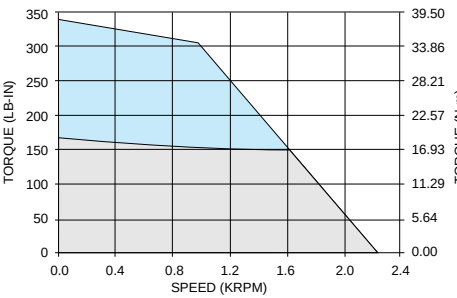
R65H
MOTOR

Reference Points	
T _{PS}	240.0
T _{PR}	200.0
T _{CS}	115.0
T _{CR}	90.0
W _R	3,000



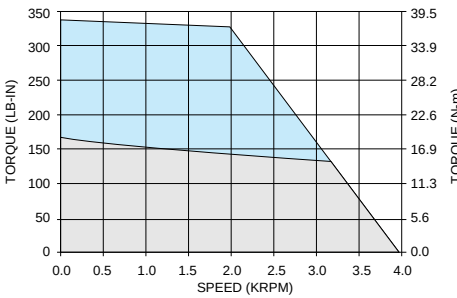
R67G
MOTOR

Reference Points	
T _{PS}	340.0
T _{PR}	305.0
T _{CS}	168.0
T _{CR}	156.0
W _R	1,000



R67H
MOTOR

Reference Points	
T _{PS}	340.0
T _{PR}	330.0
T _{CS}	168.0
T _{CR}	146.0
W _R	2,000





STEPPER SYSTEMS

SELECTION OVERVIEW. . .CONTROLS

HOW TO USE THIS SECTION

Use the system selection overview (right) as a guide to select the level of control you require. Controllers are listed by family/series and functionality.

The table of contents below will help you easily locate the controllers and motors needed to complete your system.

Table of contents	Page
6000 Series Stepper Motor Drives	
Drive modules	C-6
Model 6410 Drive Module	
7.1 A peak, 5.0 A rms	
Single user supply, 24-75 Vdc	
switch selectable microstep and	
current settings	C-7
Model 6415 Oscillator Drive Module	
7.1 A peak, 0.625 to 5.0 A rms	
Single user supply, 24-75 Vdc	
switch selectable microstep and	
current settings	C-16
Model 6420 Indicator Drive Module	
7.1 A peak, 0.625 to 5.0 A rms	
Single user supply, 24-75 Vdc	
switch selectable microstep and	
current settings	C-28
5000 Series Stepper Motor Drives	
Programmable indexer/drivers	C-39
Models 5645/5445/5345	
Stepper BASIC™ programmable	
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Model 5240	
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Models 5630/5430/5330	
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Hybrid Step Motors for System Use	
E & H Series motors	C-82
NEMA 23	C-84
NEMA 34	C-89
NEMA 42	C-97
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M & P Series motors	C-103
NEMA 23	C-107

CONTROLS

Programmable indexer/drive system

Microstep drive system

Board level oscillator/drive

... Step motion control systems

Recommended Step Motors ...E Series, see page C-82

FEATURES		Model	NEMA 42 Frame	NEMA 34 Frame	NEMA 23 Frame	PAGE
			Frame Size (in.)			
			4.2	3.4	2.3	
			Holding Torque Range (oz-in./Nm)			
R DER NAL)	• Programming in PacSci Stepper BASIC™ • Full and microstep operation to 25,000 steps/rev (except 5240) • Encoder interface for closed loop operation • Serial interface, intelligent I/O • Single and multiaxis use • Simple mnemonic instructions (5240 only) • Full and half step operation (5240 only)	5645	1284-4034 oz-in. (9.07-28.49 Nm)	1222 oz-in. (8.63 Nm)		C-40
		5445	1284 oz-in. (9.07 Nm)	319-1222 oz-in. (2.25-8.63 Nm)		C-44
		5345		237-638 oz-in. (1.67-4.51 Nm)	158-225 oz-in. (1.12-1.59 Nm)	C-44
		5240		237-638 oz-in. (1.67-4.51 Nm)	112-225 oz-in. (.79-1.59 Nm)	C-58
	• High efficiency bipolar chopper drives • Pulse & direction input • Idle current reduction • Mid-range instability compensation (except 5230) • Full and microstep operation (except 5230)	5630	1284-4034 oz-in. (9.07-28.49 Nm)	1222 oz-in. (8.63 Nm)		C-66
		5430	1284 oz-in. (9.07 Nm)	319-1222 oz-in. (2.25-8.63 Nm)		C-69
		5330		237-638 oz-in. (1.67-4.51 Nm)	158-225 oz-in. (1.12-1.59 Nm)	C-69
		5230		237-638 oz-in. (1.67-4.51 Nm)	112-225 oz-in. (.79-1.59 Nm)	C-74
	• 4-phase bipolar chopper drive • Single power supply • Switch selectable current • Full and microstep operation • Idle current reduction • Mid-range instability compensation • Modular bipolar chopper drives • Easy to integrate • Microstep operation (except 5210) • PC board mountable (5210) • Modular bipolar chopper indexer/drive	6410	1284 oz-in. (9.07 Nm)	319-1222 oz-in. (2.25-8.63 Nm)		C-7
		6420	1284 oz-in. (9.07 Nm)	319-1222 oz-in. (2.25-8.63 Nm)		C-28
		5210		237-638 oz-in. (1.67-4.51 Nm)	112-225 oz-in. (.79-1.59 Nm)	C-78
	• Board level oscillator/drives • Velocity control from input • Adjustable accel/decel • Full and microstep operation	6415	1284 oz-in. (9.07 Nm)	319-1222 oz-in. (2.25-8.63 Nm)		C-16

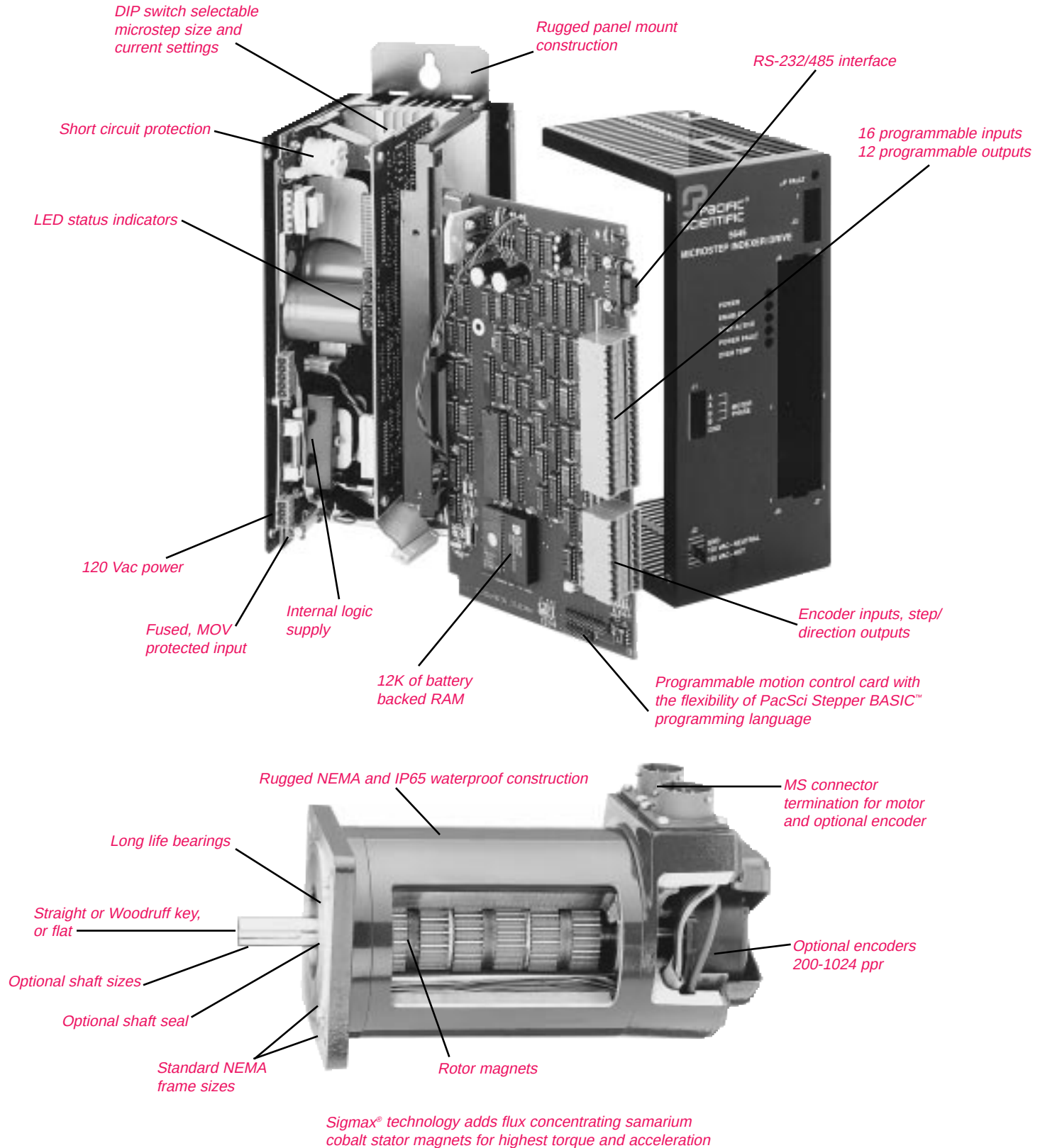
STEP MOTION CONTROL FROM PACSCI

From ready to run intelligent motion systems to economical board level drivers, Pacific Scientific has what you want.

Discover the performance of our patented magnetic and electronic innovations. Find out how easy software control can be with PacSci Stepper BASIC™.

For ultimate reliability, you can count on our integrated approach to design and manufacturing.

For overall value in step motion control, see your local PacSci distributor. You'll receive all the products and technical resources to assure a troublefree startup.



HOW TO ORDER...

MODEL NUMBER CODE:		5	6	45
Drive Type (family) _____				
6 - Stepper Drive (6000) [△]				
5 - Stepper Drive (5000)				
Power Level _____				
6 - 11.3 A peak, 8 A rms, 160 Vdc with integral power supply				
4 - 7.1 A peak, (6000 family only), 5 A rms 65 Vdc with integral power supply				
18 - 75 Vdc with user provided power supply				
3 - 2.5 A rms, 65 Vdc with integral power supply				
18 - 75 Vdc with user provided power supply				
2 - 2.5 A rms, 35 Vdc with integral power supply				
12 - 40 Vdc with user provided power supply				
Functionality & Drive Configuration _____				
45 - Indexer with PacSci Stepper Basic™ programming language				
Integral power supply				
40 - Indexer with mnemonic programming language				
Integral power supply				
30 - Integral power supply				
20 - Indexer with mnemonic programming language				
User provided power supply				
15 - Oscillator board				
User provided power supply				
10 - Driver only				
User provided power supply				

NOTE: Not all configurations are available with all power levels. Refer to Selection Overview on page C-3.

[△] To order options for 6410, see detailed ordering guide on page C-11.





6000 SERIES MICROSTEPPING DRIVES

MODEL 6410

Holding torque range:
158-1284 ox-in.
(1.12 to 9.07 Nm)

Microstepping Drive Module. 0.625 to 5 A rms, 7.1 A peak (microstepping) per phase output. 24 to 75 Vdc

- Single power supply input
- Patented 4-phase Bipolar Chopper Drive for superior current regulation and low ripple current
- Output current adjustable from 0.625 A to 5 A rms with 3 position dipswitch
- Microstepping provides smooth operation and increased resolution
- Patented Digital Electronic Damping™ reduces instability at mid-speed ranges
- Idle current reduction reduces motor heating in many applications
- Selectable step filter rejects noise on step input
- Fault protection:
 - Line-to-line and line-to-neutral shorts
 - Internal power supply under-voltage
 - Bus overvoltage
- Compact size

Model 6410 is an economical, compact stepper drive that converts step and direction inputs into winding currents for two-phase stepper motors. The 6410 can operate with a single power supply ranging from 24 to 75 Vdc. Output voltage is equal to that of the power supply. Output current is adjustable from 0.625 to 5 A rms. The default output current is 5 A rms.

Its compact size of 1.5" W x 5" H x 4.3" deep requires only 7.5 square inches of panel space!

TYPICAL APPLICATIONS

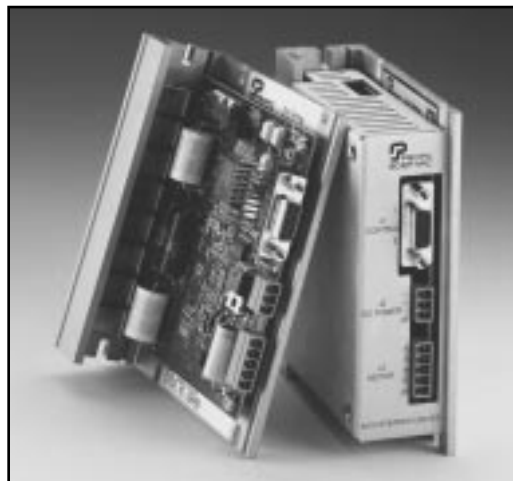
- X-Y tables and slides
- Packaging machinery
- Robotics
- Speciality machinery
- Index feed of materials
- Labeling machines

MICROSTEPPING

Microstepping assures smooth, low speed operation, smoother operation through resonance regions and optimum system resolution. Resolution with 1.8° motors is adjustable to 50,000 steps per revolution with decimal step size selected and to 51,200 with binary step size selected. See the Step Size table on page C-8. The 6410 switches to full step operation above 150 RPM.

FULL TORQUE AT ALL SPEEDS

A patented **Digital Electronic Damping** circuit ensures the availability of full motor torque at all speed ranges. This compensation damps motor oscillations common with stepper systems. Whether in the full step or microstepping mode, full motor torque is achieved throughout the speed range.



HIGH EFFICIENCY BIPOLAR CHOPPING

Patented, 4-phase PWM chopping electronically controls the motor winding currents at 20 KHz frequency. This combines the best of recirculating and nonrecirculating current regulation to provide high back EMF rejection with low ripple current. The benefits include reduced heat dissipation, low electrical noise and improved current control during dynamic braking.

The patented 4 phase control circuit combined with Digital Electronic Damping, provides significantly more motor output power than from other drives.

IDLE CURRENT REDUCTION

This useful function permits an automatic 50% reduction in motor winding current during motor idle conditions to minimize heating during dwell periods. If no step commands have been received for 0.1 second (0.05 and 1.0 seconds can also be selected through DIP switch settings - see page C-10), the current is automatically reduced. Current is restored to full amplitude upon arrival of a step command.

HEAT SINKS

Heat can be removed from the rear of the drive (cold plate mounting) or from the side with an optional side mounted heat sink. See the drawing on page C-10. Providing alternate methods for heat removal allows flexibility for system packaging.

The optional side mounted heat sink adds only 1.0 inch to the width.

FAULT PROTECTION

- Line-to-line and line-to-neutral shorts
- Internal power supply under-voltage
- Bus overvoltage

AGENCY APPROVAL

UL recognized - 508C (Type R) - file # E137798
Meets CSA Standard, C22.2 #142-M1987
Meets IEC vibration standard, #68-2-6

GENERAL. . .Model 6410

Input Power Voltage	.24 Vdc to 75 Vdc																														
Input Power Current	.Motor and load dependent. Usually < motor phase current.																														
Output motor phase current	.See Figure C-4, page C-10 5 A rms max. (5 A peak full step, 7.1 A peak microstepping) Adjustable from 0.625 to 5 A rms in 0.625 amp increments																														
Inputs	.See Figures C-2 and C-3, page C-9																														
Step	.Optically isolated TTL compatible Minimum opto current (opto on): 5.5 ma Maximum opto current (opto on): 10 ma Minimum pulse width: 250 ns (1 μ s when step filter enabled) Maximum frequency: 2.0 MHz (500 KHz when step filter enabled) Motion occurs on low-to-high transition of STEP input (J3 Pin 6)																														
Dir	.Optically isolated TTL compatible For normal motor connections: Current in opto (opto on): Rotation CCW looking at motor shaft Minimum opto current (opto on): 3 ma Maximum opto current (opto on): 4.5 ma Minimum setup time: 50.0 μ s Minimum hold time: zero																														
Enable	.Optically isolated TTL compatible Sense of ENABLE input can be changed using ENBL_SENSE jumper: Jumper In: Current in opto (opto on) enables drive Jumper Out: Current in opto (opto on) disables drive Minimum opto current (opto on): 3 ma Maximum opto current (opto on): 4.5 ma																														
Outputs	.See Figures C-2 and C-3, page C-9																														
Enabled	.Optically isolated open collector, open emitter Drive Enabled: opto transistor on, $V_{sat} = 0.5$ V max. @ 2.0 ma Drive Disabled: opto transistor off, V_{ce} max. = 35 V																														
Step Size	.See Figure C-4, page C-10 Set using 3 positions of DIP switch and decimal jumper Note: Binary values are in Bold .																														
<table><tr><th>Step Size</th><th>Steps per Revolution</th><th>Maximum RPM*</th></tr><tr><td></td><td>(1.8° motor)</td><td></td></tr><tr><td>Full (1/2)</td><td>200 (400)</td><td>12000 (12000)</td></tr><tr><td>1/2 (1/4)</td><td>400 (800)</td><td>12000 (12000)</td></tr><tr><td>1/5 (1/8)</td><td>1000 (1600)</td><td>12000 (12000)</td></tr><tr><td>1/10 (1/16)</td><td>2000 (3200)</td><td>12000 (12000)</td></tr><tr><td>1/25 (1/32)</td><td>5000 (6400)</td><td>12000 (12000)</td></tr><tr><td>1/50 (1/64)</td><td>10000 (12800)</td><td>12000 (9000)</td></tr><tr><td>1/125 (1/128)</td><td>25000 (25600)</td><td>4800 (4600)</td></tr><tr><td>1/250 (1/256)</td><td>50000 (51200)</td><td>2400 (2300)</td></tr></table>		Step Size	Steps per Revolution	Maximum RPM*		(1.8° motor)		Full (1/2)	200 (400)	12000 (12000)	1/2 (1/4)	400 (800)	12000 (12000)	1/5 (1/8)	1000 (1600)	12000 (12000)	1/10 (1/16)	2000 (3200)	12000 (12000)	1/25 (1/32)	5000 (6400)	12000 (12000)	1/50 (1/64)	10000 (12800)	12000 (9000)	1/125 (1/128)	25000 (25600)	4800 (4600)	1/250 (1/256)	50000 (51200)	2400 (2300)
Step Size	Steps per Revolution	Maximum RPM*																													
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Full (1/2)	200 (400)	12000 (12000)																													
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1/125 (1/128)	25000 (25600)	4800 (4600)																													
1/250 (1/256)	50000 (51200)	2400 (2300)																													
*1. Consult factory if operating motor above 3000 RPM. 2. To determine maximum RPM when 500 KHz step filter is enabled multiply $\frac{1}{\text{steps per rev}}$ x 30 million. Note that maximum should not exceed 12000 RPM																															
Idle Current Reduction	.See Figure C-4, page C-10 Enabled or disabled with DIP switch, 50% output current reduction after 0.1 second from last step command (0.05 and 1.0 second timeouts can also be selected using a plug-on jumper. Consult factory for other current reduction options).																														
DIGITAL ELECTRONIC DAMPING	.See Figure C-4, page C-10 Enabled or disabled with DIP switch Max. delay from input step to change in motor excitation: Step frequency < 500 full steps/sec: 500 μ s Step frequency > 500 full steps/sec: 270° of step period																														
Protection	(Any fault disables the drive and must be cleared by cycling input power) Line-to-line short, line to neutral, internal supply under voltage bus over voltage (83 Vdc)																														
Mechanical																															
Dimensions	.5" x 1.5" x 4.3"																														
Weight	.1 lb. nominal																														
Connectors	.See Figure C-2, Page C-9																														
Power Supply	.3 contact plug-in screw terminal																														
Motor	.5 contact plug-in screw terminal																														
Signal	.9 socket D-sub miniature																														

ENVIRONMENTAL . . . Model 6410

Storage Temperature-55°C to +70°C
Operating Temperature Full rated current 0° to 50°C ambient air with or without cover
provide chassis properly mounted so as not to exceed 60°C
Maximum Chassis TEMPERATURE 60°C
Note: For optimal thermal performance, mount the 6410 chassis (back or side) to a cooling plate or heatsink. Use a thermal pad or grease if surface is irregular. A fan or idle current reduction may be employed to keep chassis below 60°C
Convection Cooling(6410 not mounted on cooling plate)
With optional heat sink Full rating (5A) at 25°C Ambient
2.5A max at 45°C Ambient
Without optional heat sink 2.5A max at 25°C Ambient
1.25A max at 45°C Ambient
See Figure C-1 (below) for plot of drive power dissipation vs. output current
Humidity Range 10% to 90%, non-condensing

POWER DISSIPATION VS. OUTPUT CURRENT

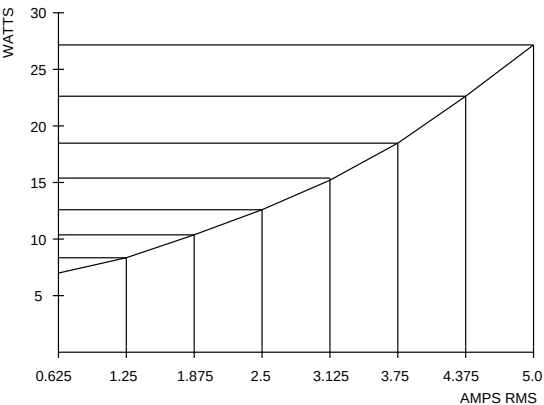


Figure C-1. Power Dissipation vs. Output Current

INTERFACE CIRCUITS

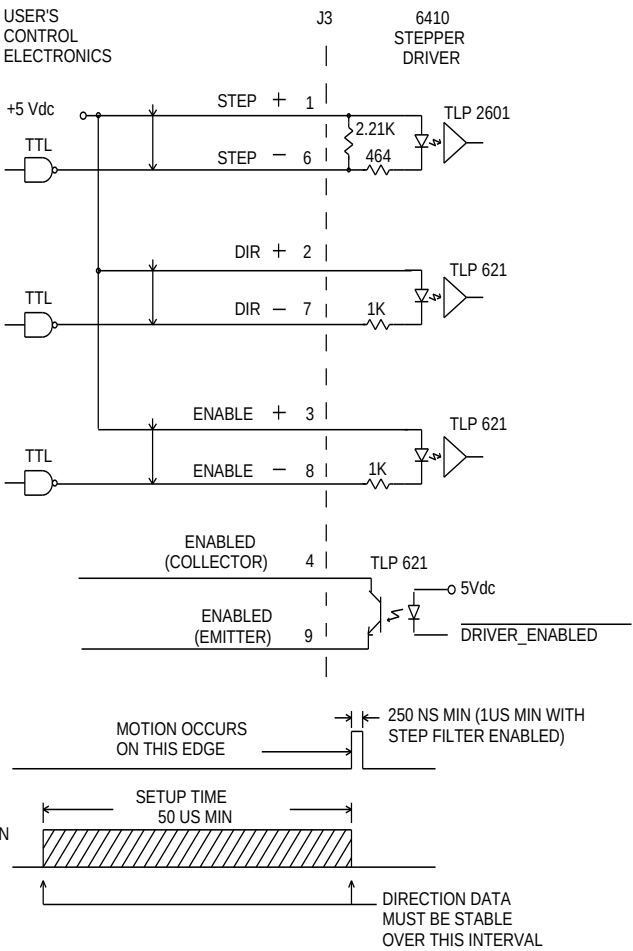


Figure C-3. Interface Circuits

CONNECTION DIAGRAM

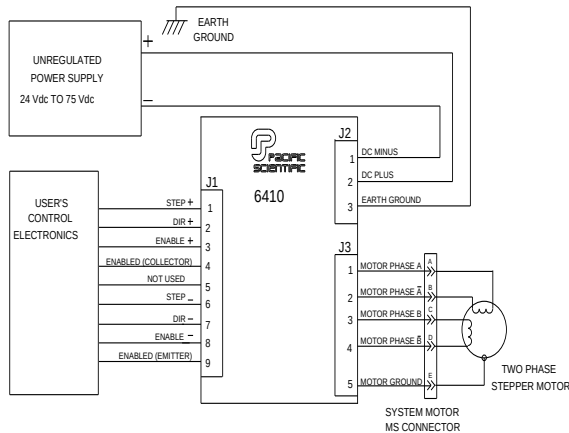


Figure C-2. Connection Diagram

DIP SWITCH (S1) SETTINGS (FIG. 4). . Model 6410

- Output motor phase current
- Step size and rate
- Idle current reduction

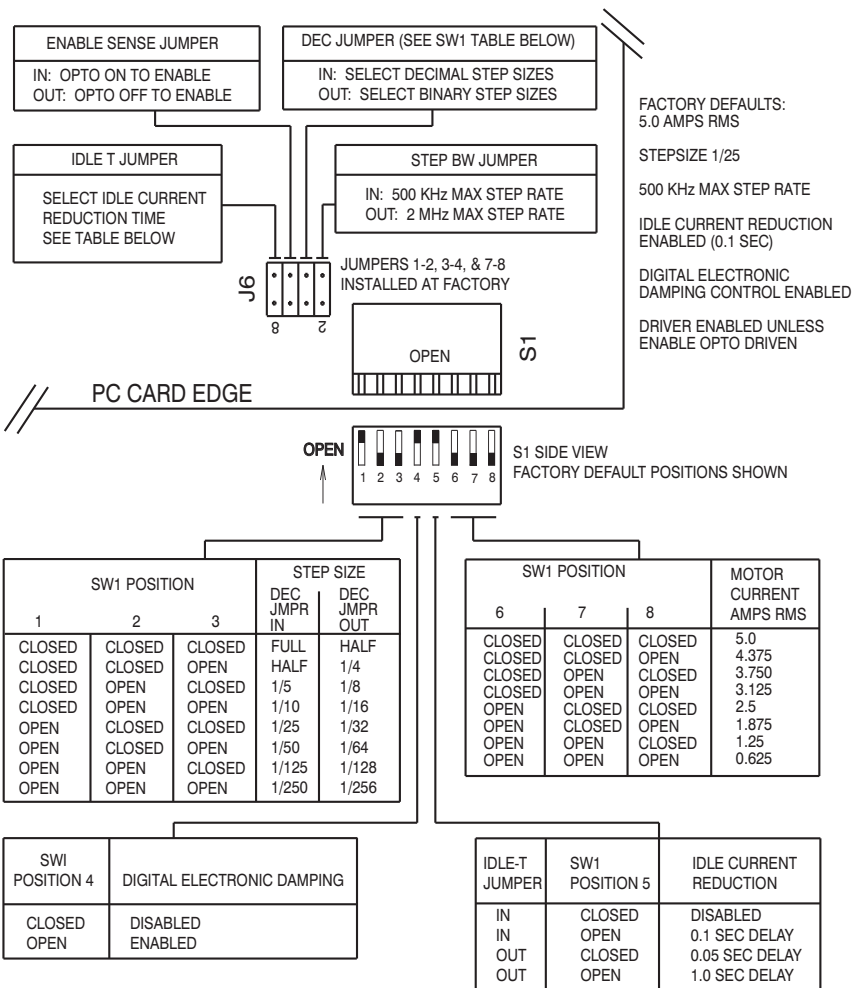
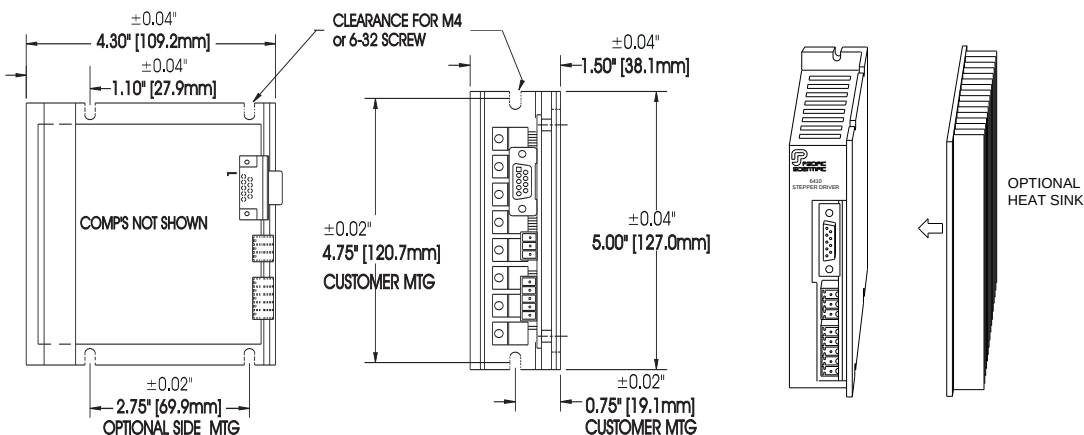


Figure C-4. DIP Switch (S1) Settings

DIMENSIONS. . Model 6410 [mm—dimensions for ref.]



FUNCTIONAL ENHANCEMENT

The 6410 microstepping drive is the core component utilized in a full family of products adding enhanced functionality.

ADDITIONAL PRODUCTS

- 24-75 Vdc Input:
- 6415 Oscillator/Drive ± 0-10 Vdc input or on board potentiometers
 - 6420 Indexer/Drive RS232/RS485 programmable package, mnemonic language, 8 BDIO
- 120/240 VAC 50-60HZ INPUT:
- 6430 Package 6410 drive with AC input
 - 6435 Package 6415 oscillator/drive with AC input
 - 6440 Package 6420 indexer/drive with AC input
 - 6445 Package 6410 drive with Stepper Basic indexer with AC input

HOW TO ORDER. . Model 6410 recommended systems

Order the 6410, accessories and motor as separate model numbers.

CATALOG MODEL NUMBER:

6410-001-N-N-N

Drive Type (family):

Stepper Drive (6000)

Power Level:

7.1 A peak, 5 A rms
24-75 Vdc

Functionality:

Motor Drive Module

Customer Customization Number:

001 indicates standard unit with no customization
All others are factory assigned

Cover Option:

N - No Cover
C - Include Cover

Heat Sink Option:

N - No Heat Sink
H - Include Heat Sink

Connector Kit Option:

N - No Connector Kit
K - Include Connector Kit

NOTE: Standard drive includes Data Sheet. Manual/Design Guide ordered separately.
6410 Accessories: Order in accordance with the following model number codes:

Part No.	Description
CV6410	Cover (includes fastening screws)
HS6410	Heat Sink (includes fastening screws)
CK6410	Connector Kit (includes all mating connectors) 9-pin D-shell and Phoneix Connectors for J3-motor: Phoneix p/n: MC 1.5/5-ST-3.81 and J2-DC input: MC 1.5/3-ST-3.81
MA6410	User Manual / Design Guide
SPC-XXX-6410	With control connector and motor MS connector. Four conductor shielded wire plus ground. In place of XXX, specify length in even one foot increments from 001 to 050 feet. Consult factory for longer lengths.
SPC-CO-XXX	Motor Power Cable Only. Four conductor shielded wire plus ground. In place of XXX, specify length in even one foot increments.

SYSTEM RATINGS AND CHARACTERISTICS

5.0 A,
65V per phase

Model 6410 with recommended E Series motors
See E Series motors . . . NEMA 34 (3.4") and NEMA 42 (4.2") on page C-15.

OD (in)	Motor Model Number Δ	Drive Current/ Phase (amps DC)	Holding Δ Torque (2 phases on) oz-in (Nm) $\pm 10\%$	Detent Torque oz-in (Nm)	Rotor inertia oz-in-S2 (kgm2 x 10 ⁻³)	Weight lbs (kg)	Peak Shaft Power (watts)	Rated Speed at Peak Power (RPM)
Maximum torque at low speed (see plot T in performance curve)								
3.4	E31NX-HTLNN-NS500	5.0	319 (2.25)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	155	1350
3.4	E32NX-HTLNN-NS500	5.0	638 (4.51)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	160	750
3.4	E33NX-HTLNN-NS500	5.0	958 (6.77)	69.3 (0.45)	0.0250 (0.155)	7.6 (3.45)	175	600
3.4	E34HX-HTLNN-NS500	5.0	1222 (8.63)	83.0 (0.59)	0.0350 (0.217)	9.7 (4.41)	175	450
3.4	E41HX-HTLNN-NS500	5.0	1284 (9.07)	58.0 (0.41)	0.0800 (0.496)	14.0 (6.36)	177	450
Maximum torque at HIGH speed (see plot P in performance curve)								
3.4	E32NX-HPLNN-NS500	5.0	474 (3.35)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	240	1650
3.4	E33NX-HPLNN-NS500	5.0	711 (5.02)	69.3 (0.45)	0.0250 (0.155)	7.6 (3.45)	260	1200
3.4	E34HX-HPLNN-NS500	5.0	948 (6.69)	83.0 (0.59)	0.0350 (0.217)	9.7 (4.41)	240	900

2.5 A,
65V per phase

Model 6410 with recommended E Series motors
See E Series motors...NEMA 23 (2.3" and NEMA 34 (3.4") on page C-15.

OD (in)	Motor Model Number Δ	Driver Current/ Phase (amps DC)	Holding Δ Torque (2 phases on) oz-in (Nm) $\pm 10\%$	Detent Torque oz-in (Nm)	Rotor inertia oz-in-S2 (kgm2 x 10 ⁻³)	Weight lbs (kg)	Peak Shaft Power (watts)	Rated Speed at Peak Power (RPM)
Maximum torque at low speed (see plot T in performance curve)								
2.3	E22NX-LTLNN-NS500	2.5	225 (1.59)	9.6 (0.07)	0.0031 (0.019)	2.1 (0.95)	54	1650
3.4	E31NX-LTLNN-NS500	2.5	319 (2.25)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	75	600
3.4	E32NX-LTLNN-NS500	2.5	638 (4.51)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	80	450
Maximum torque at HIGH speed (see plot P in performance curve)								
2.3	E22NX-LPLNN-NS500	2.5	158 (1.12)	9.6 (0.07)	0.0031 (0.019)	2.1 (0.95)	155	2850
3.4	E31NX-LPLNN-NS500	2.5	237 (1.67)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	115	1500
3.4	E32NX-LPLNN-NS500	2.5	474 (3.35)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	120	900

All ratings typical and at 25°C unless otherwise noted.

Δ See page C-15 for motor options. X denotes the construction of the motor, refer to page C-11 for various options. Also refer to Model Number Codes in the system configured hybrid step motor section page C-82.

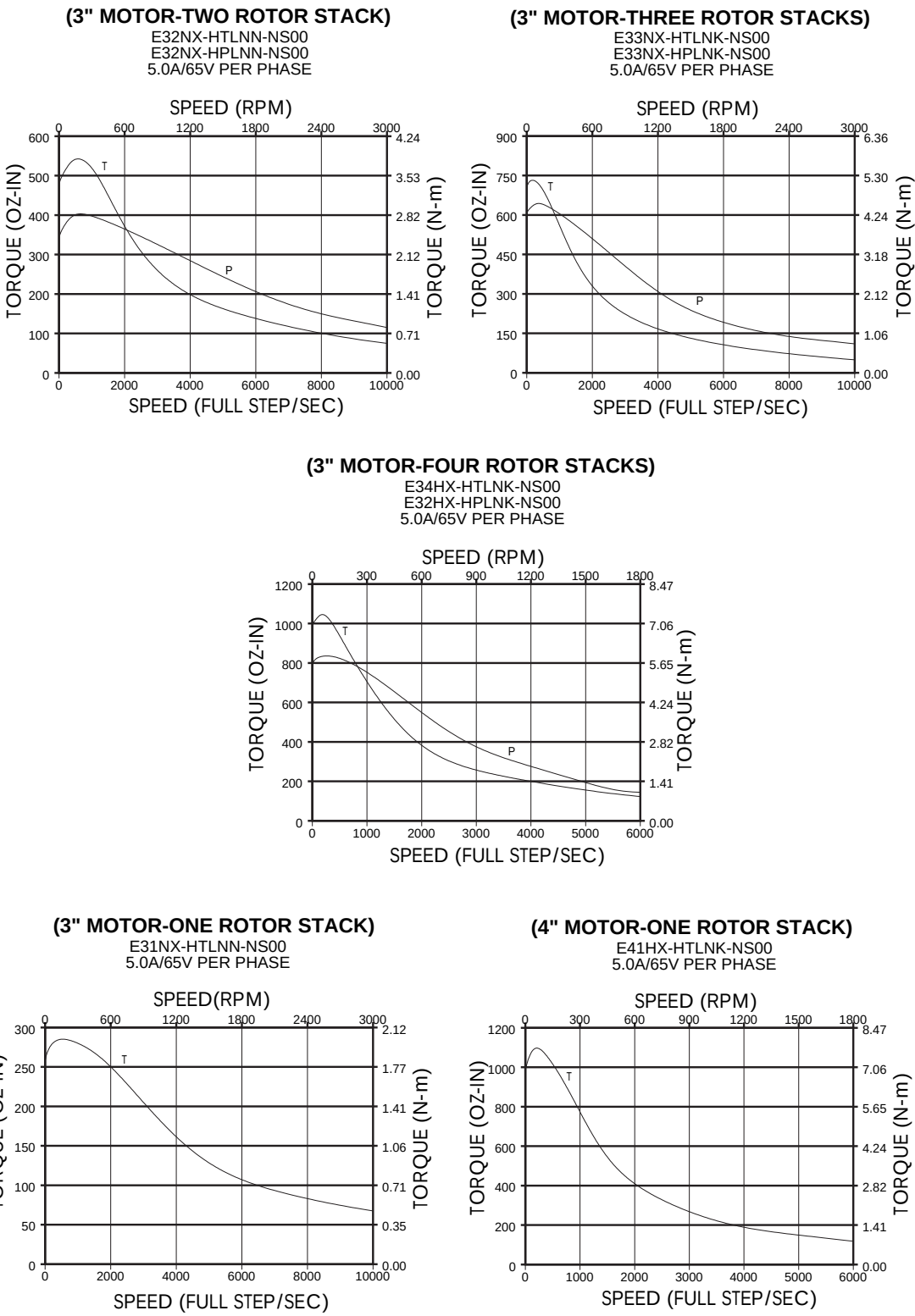
Δ When operated at listed drive current.

Model 6410 torque/speed curves
with recommended motors

5.0 A,
65V per phase

Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points which will vary with motor coupling and systems parameters. In addition to those shown below, Pacific Scientific offers a wide range of other motor windings to meet specific performance requirements. Consult factory.

PERFORMANCE AT 5.0A (RMS)/65V PER PHASE

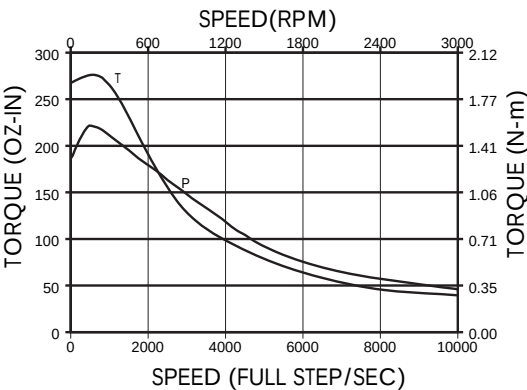


PERFORMANCE AT 2.5A (RMS)/65V PER PHASE

2.5 A,
65V per phase

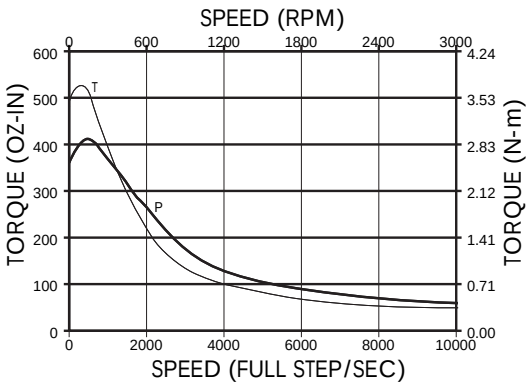
(3" MOTOR-ONE ROTOR STACK)

E31NX-LTLNN-NS00
E31NX-LPLNN-NS00
2.5A/65V PER PHASE



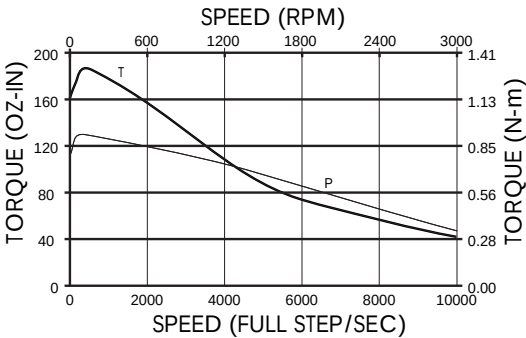
(3" MOTOR-TWO ROTOR STACK)

E32NX-LTLNN-NS00
E32NX-LPLNN-NS00
2.5A/65V PER PHASE



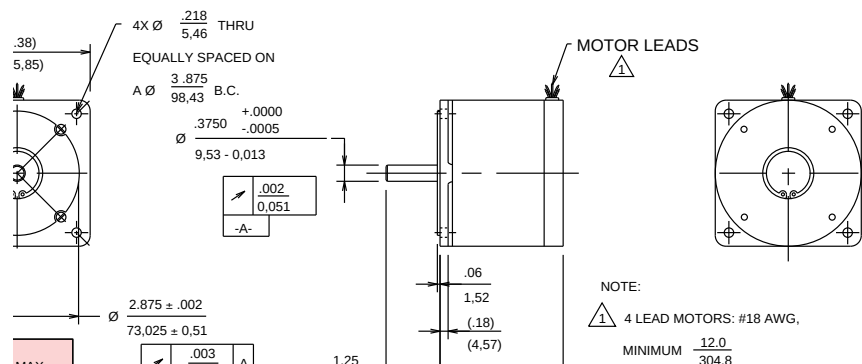
(2" MOTOR-TWO ROTOR STACKS)

E22NX-LTLNN-NS00
E22NX-LPLNN-NS00
2.5A/65V PER PHASE



NEMA 23, 34 AND 42 MECHANICAL CONFIGURATIONS

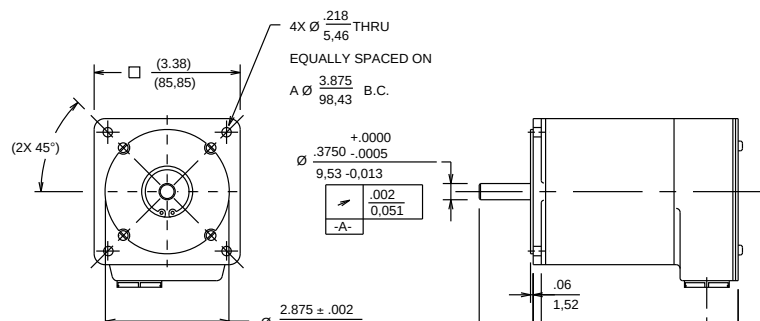
REGULAR CONSTRUCTION/FLYING LEAD HOOK-UP



MODEL NUMBER	2HNX	21NX	22NX	31NX	32NX	33NX	33HX	34HX
A	1.56	2.06	3.06	2.58	3.76	5.06	5.33	6.58
B	0.81	0.81	0.81	1.25	1.25	1.25	1.25	1.25
D	0.25	0.25	0.25	0.375	0.375	0.375	0.5	0.5

Note:
Substitute R for X for flying lead

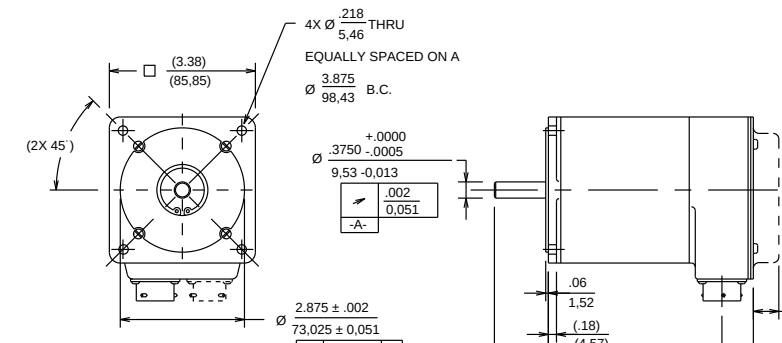
SPLASHPROOF CONSTRUCTION



MODEL NUMBER	31NX	32NX	33NX	33HX	34HX	41HX	42HX	43HX
A	3.62	4.77	6.05	6.73	7.62	5.61	8.04	10.56
B	1.125	1.125	1.125	1.125	1.125	1.75	2.19	2.19
D	0.375	0.375	0.375	0.5	0.5	0.625	0.625	0.75

Note:
Substitute L for X to specify
conduit connection (1/2 NPS Tap)
Substitute M for X to specify
conduit connection (PDG 11 Tap)

SYSTEMS CONSTRUCTION



MODEL NUMBER	31NX	32NX	33NX	33HX	34HX	41HX	42HX	43HX
A	3.62	4.77	6.05	6.73	7.62	5.61	8.04	10.56
B	1.125	1.125	1.125	1.125	1.125	1.75	2.19	2.19
D	0.375	0.375	0.375	0.5	0.5	0.625	0.625	0.75

Note:
Substitute C for X for MS connector
termination

MODEL 6415

Holding torque range:
158-1284 oz-in.
(1.12 to 9.07 Nm)

Module 0.625 to 5 A rms, 7.1 A peak (microstepping) per phase output. 24 to 75 Vdc

- Single power supply input
- Patented 4-phase Bipolar Chopper Drive for superior current regulation and low ripple current
- Output current adjustable from 0.625 A to 5 A rms with 3 position dipswitch
- Microstepping up to 51,200 steps/revolution
- Patented Digital Electronic Damping™ reduces instability at mid-speed ranges
- Idle current reduction reduces motor heating
- Fault protection:
 - Line-to-line and line-to-neutral shorts
 - Internal power supply under-voltage
 - Bus overvoltage
- Compact size, panel or side mountable
- Low / high speed select input
- On-board multi-turn potentiometers
- External customer potentiometer
- Customer supplied ± 10 Vdc analog input
- Optional heat sink

The Pacific Scientific 6415 is an economical, high performance microstepping drive with an integral oscillator. The card is packaged with the highly popular 6410 drive and thus incorporates its many valuable features such as high resolution microstepping (200 to 51,200 steps per revolution) for smooth operation through resonance regions, mid-range **Digital Electronic Damping**, single supply operation, output current adjustment, and idle current reduction.

The 6415 contains a stable, wide range voltage controlled oscillator (VCO) which provides step pulses to the drive card. There are two frequency ranges, customer selectable by a jumper. Its compact size of 1.5" W x 5" H x 4.3" deep requires only 7.5 square inches of panel space!

TYPICAL APPLICATIONS

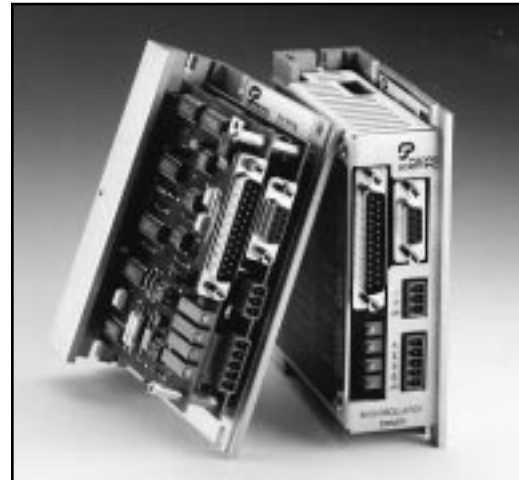
- Clutch Brake Replacement
- Labeling Machines
- Packaging/Specialty Machinery
- Smart Conveyor Systems
- Semiconductor Wafer Polishing
- Constant Speed Applications

MICROSTEPPING

Microstepping assures smooth, low speed operation, smoother operation through resonance regions and optimum system resolution. Resolution with 1.8° motors is adjustable to 50,000 steps per revolution with decimal step size selected and to 51,200 with binary step size selected. See the Step Size table on page C-17. The 6415 switches to full step operation above 150 RPM.

FULL TORQUE AT ALL SPEEDS

A patented **Digital Electronic Damping** circuit ensures the availability of full motor torque at all speed ranges. This compensation damps motor oscillations common with stepper systems. Whether in the full step or microstepping mode, full motor torque is achieved throughout the speed range.



HIGH EFFICIENCY BIPOLAR CHOPPING

Patented, 4-phase PWM chopping electronically controls the motor winding currents at 20 KHz frequency. This combines the best of recirculating and nonrecirculating current regulation to provide high back EMF rejection with low ripple current. The benefits include reduced heat dissipation, low electrical noise and improved current control during dynamic braking.

The patented 4-phase control circuit combined with **Digital Electronic Damping**, provides significantly more motor output power than from other drives.

IDLE CURRENT REDUCTION

This useful function permits an automatic 50% reduction in motor winding current during motor idle conditions to minimize heating during dwell periods. If no step commands have been received for 0.1 second (0.05 and 1.0 seconds can also be selected through DIP switch settings - see page C-22), the current is automatically reduced. Current is restored to full amplitude upon arrival of a step command.

CONTROL FUNCTIONS

The 6415 has four potentiometers on board to control low speed, high speed, exponential accel and linear decel rates. Speed may also be adjusted via an external potentiometer or an analog input. Motion is controlled from a single or two independent Run/Stop inputs. A Min Speed threshold allows no drift at zero speed. The step outputs will drive up to four slaves synchronously.

FAULT PROTECTION

- Line-to-line and line-to-neutral shorts
- Internal power supply under-voltage
- Bus overvoltage

AGENCY APPROVAL

UL recognized - 508C (Type R) - file # E137798
Meets CSA Standard, C22.2 #142-M1987
Meets IEC vibration standard, #68-2-6

GENERAL. . .Model 6415

Input Power Voltage	.24 Vdc to 75 Vdc																														
Input Power Current	.Motor and load dependent. Usually < motor phase current.																														
Output motor phase current	.See Figure C-15, page C-22 5 A rms max. (5 A peak full step, 7.1 A peak microstepping) Adjustable from 0.625 to 5 A rms in 0.625 amp increments																														
Run Speed Control	.Analog input range. See Figures C-10 and C-11, page C-21 Also controllable with internal or external pots ± 10 Vdc																														
Analog Input Impedance	.20 K Ω (differential amp)																														
High Frequency Range	.Run Speed Control: 8 KHZ to 500 KHZ Low Speed Control: 8 KHZ to 370 KHZ																														
Low Frequency Range	.Run Speed Control: 4 KHZ to 250 KHZ Low Speed Control: 4 KHZ to 180 KHZ																														
Run Speed/Low Speed																															
Stability Over Temp./Range	. $\pm 1\%$ of full scale (typical)																														
Accel Ramp	.Exponential Accel Pot Fully CW: 0.4 sec (single time constant) Accel Pot Fully CCW: 0.4 msec (single time constant)																														
Decel Ramp	.Linear Decel Pot Fully CW: 1.4 sec Decel Pot Fully CCW: 6.0 msec																														
Min Speed	.4 KHz maximum (high frequency range) 2 KHz maximum (low frequency range) Steps below this frequency are inhibited to insure no movement at end of decel ramp. This functionality can be disabled by inserting jumper E5 Note: Motor rpm = 0.3 * Freq. (Hz)/step size. For example: If frequency = 500 KHz and step size = 125, rpm = 1200.																														
Inputs	.Optically isolated TTL compatible See Figures C-8 and C-9, page C-20																														
Outputs																															
VCO Input Monitor	.100 K Ω input impedance 8 Vdc full scale																														
+8 V Ref. Out	.50 ma max. @ 25 deg C ambient 25 ma max. @ 50 deg C ambient																														
Step Out	.See Figure C-9, page C-20 100 ma max. @ 25 deg C ambient 50 ma max. @ 50 deg C ambient (max reverse voltage = -50 Vdc)																														
Step Size	.See Figure C-15, page C-22 Set using 3 positions of DIP switch and decimal jumper Note: Binary values are in Bold																														
<table><tr><th>Step Size</th><th>Steps per Revolution</th><th>Maximum RPM*</th></tr><tr><td></td><td>(1.8° motor)</td><td></td></tr><tr><td>Full (1/2)</td><td>200 (400)</td><td>12000 (12000)</td></tr><tr><td>1/2 (1/4)</td><td>400 (800)</td><td>12000 (12000)</td></tr><tr><td>1/5 (1/8)</td><td>1000 (1600)</td><td>12000 (12000)</td></tr><tr><td>1/10 (1/16)</td><td>2000 (3200)</td><td>12000 (12000)</td></tr><tr><td>1/25 (1/32)</td><td>5000 (6400)</td><td>12000 (12000)</td></tr><tr><td>1/50 (1/64)</td><td>10000 (12800)</td><td>12000 (9000)</td></tr><tr><td>1/125 (1/128)</td><td>25000 (25600)</td><td>4800 (4600)</td></tr><tr><td>1/250 (1/256)</td><td>50000 (51200)</td><td>2400 (2300)</td></tr></table>		Step Size	Steps per Revolution	Maximum RPM*		(1.8° motor)		Full (1/2)	200 (400)	12000 (12000)	1/2 (1/4)	400 (800)	12000 (12000)	1/5 (1/8)	1000 (1600)	12000 (12000)	1/10 (1/16)	2000 (3200)	12000 (12000)	1/25 (1/32)	5000 (6400)	12000 (12000)	1/50 (1/64)	10000 (12800)	12000 (9000)	1/125 (1/128)	25000 (25600)	4800 (4600)	1/250 (1/256)	50000 (51200)	2400 (2300)
Step Size	Steps per Revolution	Maximum RPM*																													
	(1.8° motor)																														
Full (1/2)	200 (400)	12000 (12000)																													
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1/5 (1/8)	1000 (1600)	12000 (12000)																													
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1/125 (1/128)	25000 (25600)	4800 (4600)																													
1/250 (1/256)	50000 (51200)	2400 (2300)																													
*1. Consult factory if operating motor above 3000 RPM.																															
Idle Current Reduction	.See Figure C-15, page C-22 Enabled or disabled with DIP switch, 50% output current reduction after 0.1 second from last step command (0.05 and 1.0 second time-outs can also be selected using a plug-on jumper. Consult factory for other current reduction options).																														
DIGITAL ELECTRONIC DAMPING	.See Figure C-15, page C-22 Enabled or disabled with DIP switch Max. delay from input step to change in motor excitation: Step frequency < 500 full steps/sec: 500 μ s Step frequency > 500 full steps/sec: 270° of step period																														
Protection	.(Any fault disables the drive and must be cleared by cycling input power) Line-to-line short, line to neutral, internal supply under voltage bus over voltage (83 Vdc)																														
Mechanical																															
Dimensions	.5" x 1.5" x 4.3"																														
Weight	.1 lb. nominal																														

GENERAL AND ENVIRONMENTAL. . .Model 6415

Connectors	See Figure C-7, page C-19
Power Supply	.3 contact plug-in screw terminal
Motor	.5 contact plug-in screw terminal
Signal	.25 contact plug D sub miniature
Storage Temperature	-55°C to +70°C
Operating Temperature	Full rated current 0° to 50°C ambient air with or without cover provided chassis is properly mounted so as not to exceed 60°C.
Maximum Chassis Temperature	60°C. Note: For optimal thermal performance, mount the 6415 chassis (back or side) to a cooling plate or heatsink. Use a thermal pad or grease if surface is irregular. A fan or idle current reduction may be employed to keep chassis below 60°C
Convection Cooling	(6415 not mounted on cooling plate)
With optional heat sink	Full rating (5A) at 25°C Ambient 2.5A max at 45°C Ambient
Without optional heat sink	2.5A max at 25°C Ambient 1.25A max at 45°C Ambient See chart below for plot of drive power dissipation vs. output current.
Humidity Range	10% to 90%, non-condensing

DIMENSIONS. . .Model 6415

[mm—dimensions for ref. only]

DRIVE POWER DISSIPATION
CHART

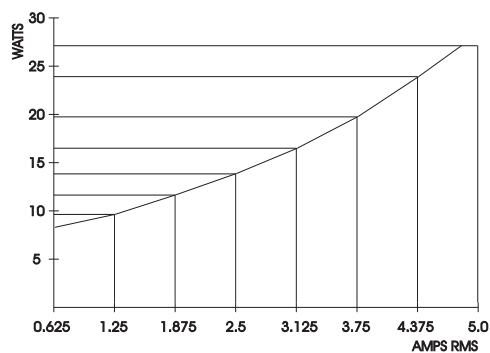
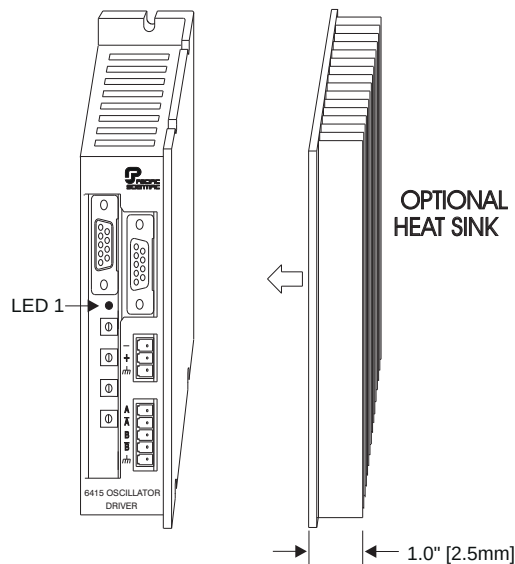


Figure C-5.

DIMENSIONS. . .Model 6415 [mm—dimensions for ref. only]

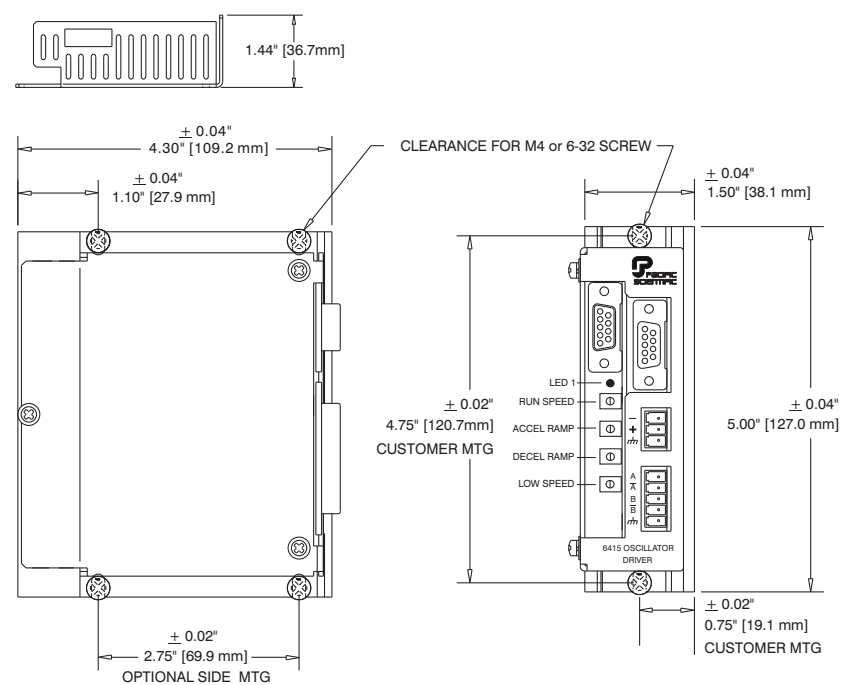


Figure C-6.

CONNECTION DIAGRAM. . .Model 6415

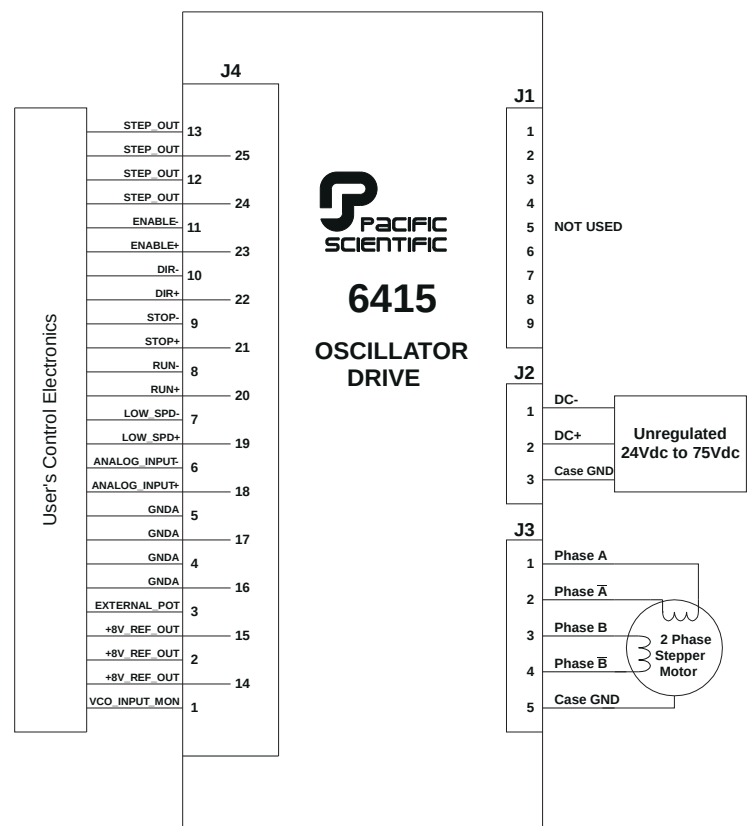


Figure C-7. Connection Diagram

LOW_SPD+/LOW_SPD-

This optically isolated input selects the source of the analog speed command. With the LOW_SPD opto on (J4-7 Low), the analog speed command is derived from the LOW SPEED potentiometer.

With the LOW_SPD opto off (J4-7 High), the analog speed command is derived from one of the following sources depending upon the E1 and E3 jumper configurations:

- Internal RUN SPEED potentiometer (E1 1-2 and E3 1-2 installed - Default)
- External potentiometer (E1 3-4 installed)
- External analog input (E1 5-6 and E3 1-2 installed)
- External analog input scaled (fine tuned) by internal RUN SPEED potentiometer (E1 1-2 and E3 3-4 installed)

The LOW_SPD input can change at any time. The speed (oscillator frequency) will not change instantly, but will ramp to the newly selected speed at a rate controlled by the ACCEL or DECEL potentiometers depending upon whether the speed (magnitude) is increasing or decreasing.

Figure C-12 shows the velocity wave form in a typical application where the high speed is selected when the RUN input is pulsed and latched. Near the end of the motion profile, low speed is selected to insure a short and precise stopping distance when the STOP input is pulsed.

Adjustment Potentiometers

Figures C-12 and C-13 show the typical velocity (pulse frequency) profile in response to a separate RUN/STOP or with a single RUN/STOP and RUN/LOW commands.

Adjustments for RUN SPEED, LOW SPEED, ACCEL RAMP, and DECEL RAMP are made with 4 multi-turn potentiometers.

LOW SPEED is typically set lower than RUN SPEED to allow for accurate stopping. It can also be used as a second RUN SPEED. ACCEL RAMP is typically set to minimize time to reach RUN SPEED without allowing the motor to stall. The DECEL RAMP is linear and stable, allowing a more precise, repeatable stopping position.

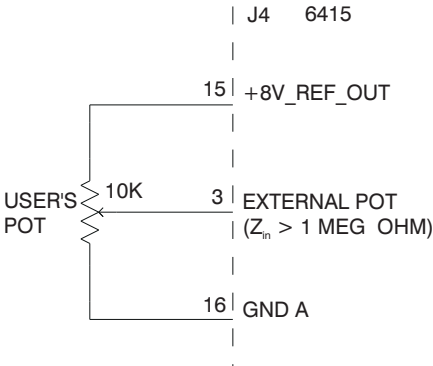


Figure C-10.

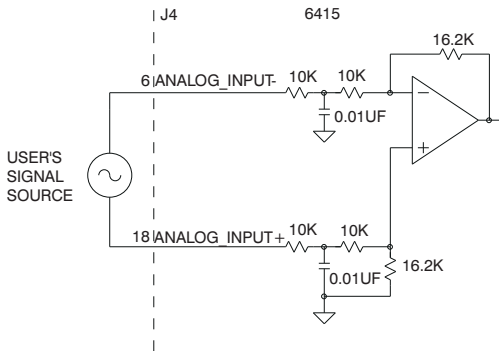


Figure C-11.

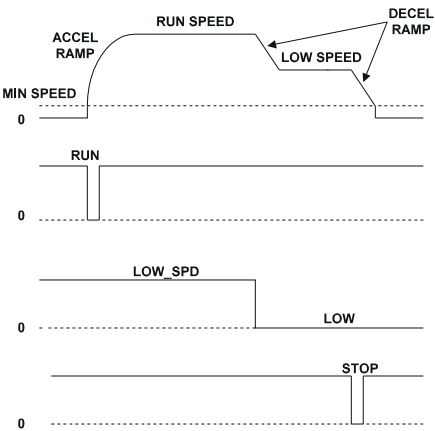


Figure C-12.

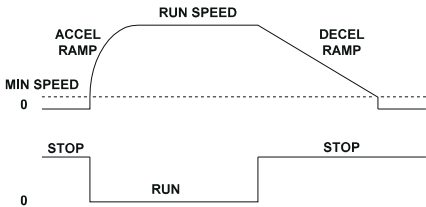


Figure C-13.

DIP SWITCH (S1) SETTINGS. . .Model 6415

OSCILLATOR UPPER BOARD [factory defaults are in bold]

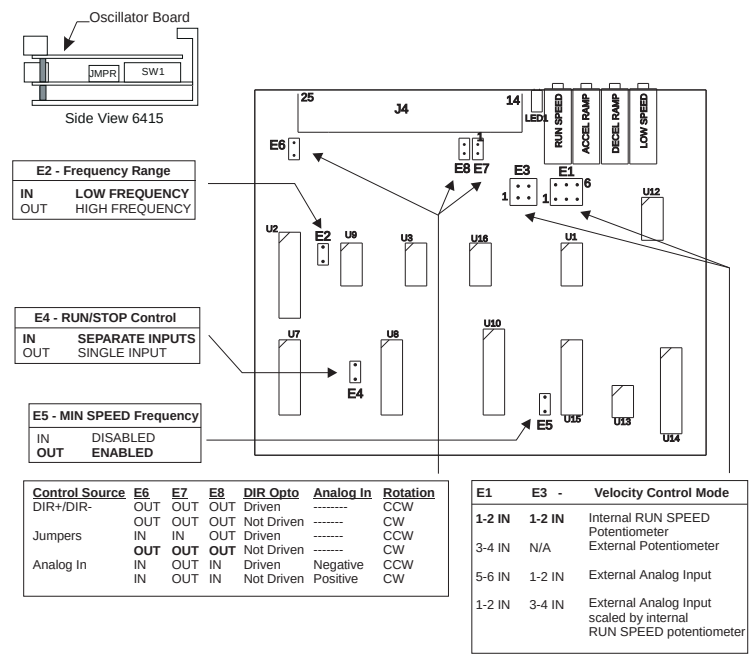


Figure C-14.

OSCILLATOR LOWER BOARD

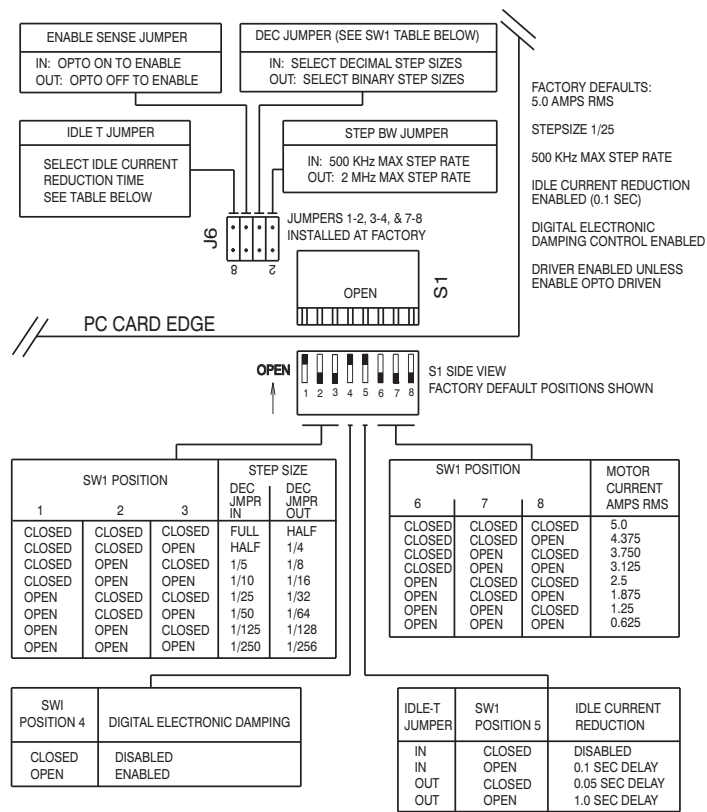


Figure C-15.

FUNCTIONAL ENHANCEMENT

The 6415 microstepping oscillator drive is one of a full family of products adding enhanced functionality.

Additional Products

- 24-75 Vdc Input:
- 6410 Step Motor Drive Step and direction input drive
 - 6420 Indexer/Drive RS232/RS485 programmable package mnemonic language 8 BDIO
- 120/240 Vac 50-60Hz Input:
- 6430 Package 6410 drive with AC input
 - 6435 Package 6415 oscillator/drive with AC input
 - 6440 Package 6420 indexer/drive with AC input
 - 6445 Package 6410 drive with Stepper Basic indexer and AC input functionality.

HOW TO ORDER. . .Model 6415 recommended systems

Order the 6415, accessories and motor as separate model numbers.

CATALOG MODEL NUMBER:

6415-001-N-N-N

Drive Type (family):

Stepper Drive (6000)

Power Level:

7.1 A peak, 5 A rms
24-75 Vdc

Functionality:

Oscillator & Motor Drive

Customer Customization Number:

001 indicates standard unit with no customization
All others are factory assigned

Cover Option:

N - No Cover
C - Include Cover

Heat Sink Option:

N - No Heat Sink
H - Include Heat Sink

Connector Kit Option:

N - No Connector Kit
K - Include Connector Kit

NOTE: Standard drive includes Data Sheet. Manual/Design Guide ordered separately.
6415 Accessories: Order in accordance with the following model number codes:

Part No.	Description
CV6415	Cover (includes fastening screws)
HS6410	Heat Sink (includes fastening screws)
CK6415	Connector Kit (includes all mating connectors) 25-pin D-shell and Phoenix Connectors for J3-motor: Phoenix p/n: MC 1.5/5-ST-3.81 and J2-DC input: MC 1.5/3-ST-3.81
MA6415	User Manual / Design Guide
SPC-XXX-6410	With control connector and motor MS connector. Four conductor shielded wire plus ground. In place of XXX, specify length in even one foot increments from 001 to 050 feet. Consult factory for longer lengths.
SPC-CO-XXX	Motor Power Cable Only. Four conductor shielded wire plus ground. In place of XXX, specify length in even one foot increments.

SYSTEM RATINGS AND CHARACTERISTICS

Model 6415 with recommended E Series motors

See E Series motors. . .NEMA 34 (3.4") and NEMA 42 (4.2") on page C-27.

5.0 A,
65V per phase

OD (in)	Motor Model Number Δ	Drive Current/ Phase (amps DC)	Holding Δ Torque (2 phases on) oz-in (Nm) $\pm 10\%$	Detent Torque oz-in (Nm)	Rotor inertia oz-in-S2 (kgm ² x 10 ⁻³)	Weight lbs (kg)	Peak Shaft Power (watts)	Rated Speed at Peak Power (RPM)
Maximum torque at low speed (see plot T in performance curve)								
3.4	E31NX-HTLNN-NS00	5.0	319 (2.25)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	155	1350
3.4	E32NX-HTLNN-NS00	5.0	638 (4.51)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	160	750
3.4	E33NX-HTLNN-NS00	5.0	958 (6.77)	69.3 (0.45)	0.0250 (0.155)	7.6 (3.45)	175	600
3.4	E34HX-HTLNN-NS00	5.0	1222 (8.63)	83.0 (0.59)	0.0350 (0.217)	9.7 (4.41)	175	450
3.4	E41HX-HTLNN-NS00	5.0	1284 (9.07)	58.0 (0.41)	0.0800 (0.496)	14.0 (6.36)	177	450
Maximum torque at HIGH speed (see plot P in performance curve)								
3.4	E32NX-HPLNN-NS00	5.0	474 (3.35)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	240	1650
3.4	E33NX-HPLNN-NS00	5.0	711 (5.02)	69.3 (0.45)	0.0250 (0.155)	7.6 (3.45)	260	1200
3.4	E34HX-HPLNN-NS00	5.0	948 (6.69)	83.0 (0.59)	0.0350 (0.217)	9.7 (4.41)	240	900

Model 6415 with recommended E Series motors

See E Series motors . . . NEMA 23 (2.3") and NEMA 34 (3.4") on page C-27.

2.5 A,
65V per phase

OD (in)	Motor Model Number Δ	Driver Current/ Phase (amps DC)	Holding Δ Torque (2 phases on) oz-in (Nm) $\pm 10\%$	Detent Torque oz-in (Nm)	Rotor inertia oz-in-S2 (kgm ² x 10 ⁻³)	Weight lbs (kg)	Peak Shaft Power (watts)	Rated Speed at Peak Power (RPM)
Maximum torque at low speed (see plot T in performance curve)								
2.3	E22NX-LTLNN-NS00	2.5	225 (1.59)	9.6 (0.07)	0.0031 (0.019)	2.1 (0.95)	54	1650
3.4	E31NX-LTLNN-NS00	2.5	319 (2.25)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	75	600
3.4	E32NX-LTLNN-NS00	2.5	638 (4.51)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	80	450
Maximum torque at HIGH speed (see plot P in performance curve)								
2.3	E22NX-LPLNN-NS00	2.5	158 (1.12)	9.6 (0.07)	0.0031 (0.019)	2.1 (0.95)	155	2850
3.4	E31NX-LPLNN-NS00	2.5	237 (1.67)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	115	1500
3.4	E32NX-LPLNN-NS00	2.5	474 (3.35)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	120	900

All ratings typical and at 25°C unless otherwise noted.

Δ See page C-27 for motor options. X denotes the construction of the motor, refer to page C-23 for various options. Also refer to Model Number Codes in the system configured hybrid step motor section page C-82.

Δ When operated at listed drive current.

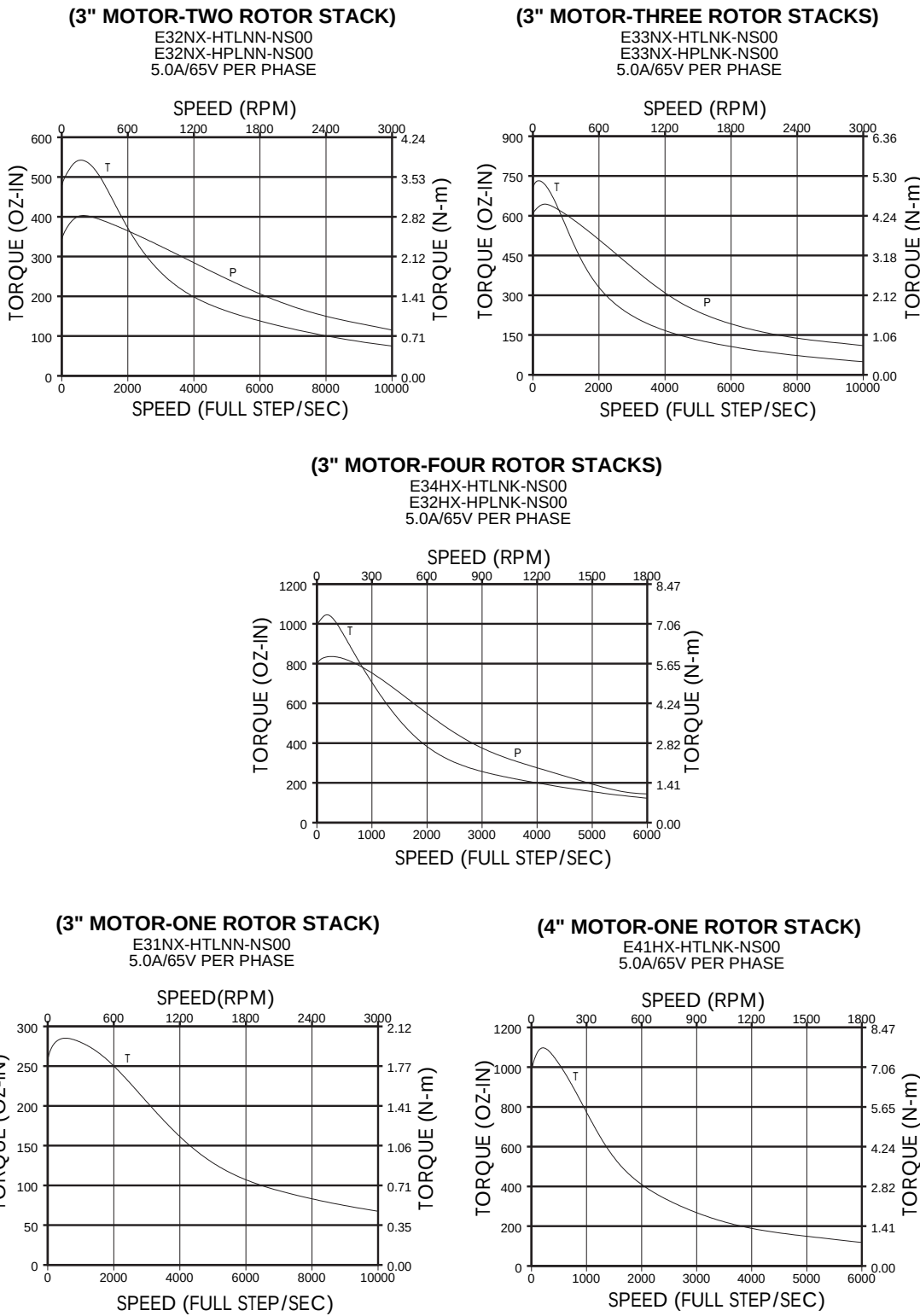
MODEL 6415 TORQUE/SPEED CURVES
with recommended motors

5.0 A,
65V per phase

Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points which will vary with motor coupling and systems parameters.

In addition to those shown below, Pacific Scientific offers a wide range of other motor windings to meet specific performance requirements. Consult factory.

PERFORMANCE AT 5.0A (RMS)/65V PER PHASE

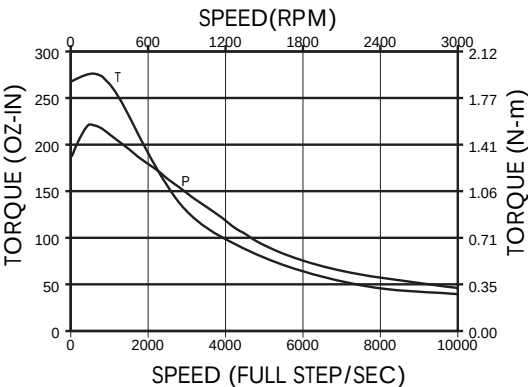


PERFORMANCE AT 2.5A (RMS)/65V PER PHASE

2.5 A,
65V per phase

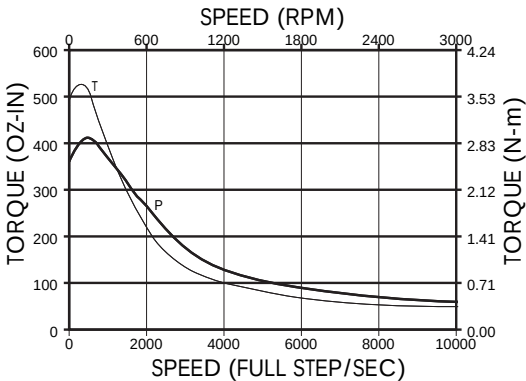
(3" MOTOR-ONE ROTOR STACK)

E31NX-LTLNN-NS00
E31NX-LPLNN-NS00
2.5A/65V PER PHASE



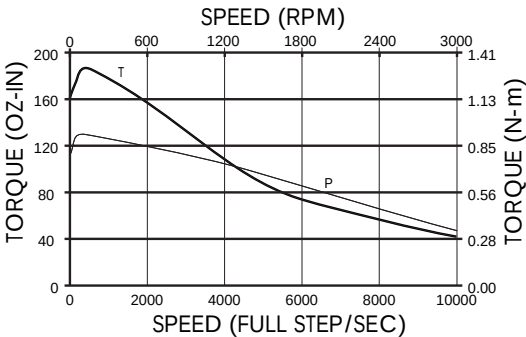
(3" MOTOR-TWO ROTOR STACK)

E32NX-LTLNN-NS00
E32NX-LPLNN-NS00
2.5A/65V PER PHASE



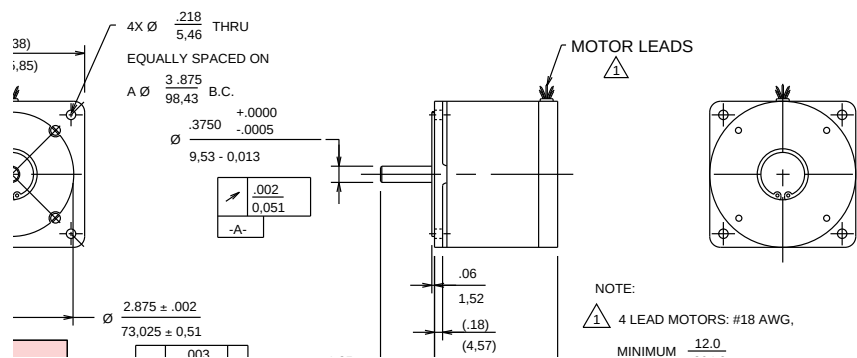
(2" MOTOR-TWO ROTOR STACKS)

E22NX-LTLNN-NS00
E22NX-LPLNN-NS00
2.5A/65V PER PHASE



NEMA 23, 34 AND 42 MECHANICAL CONFIGURATIONS

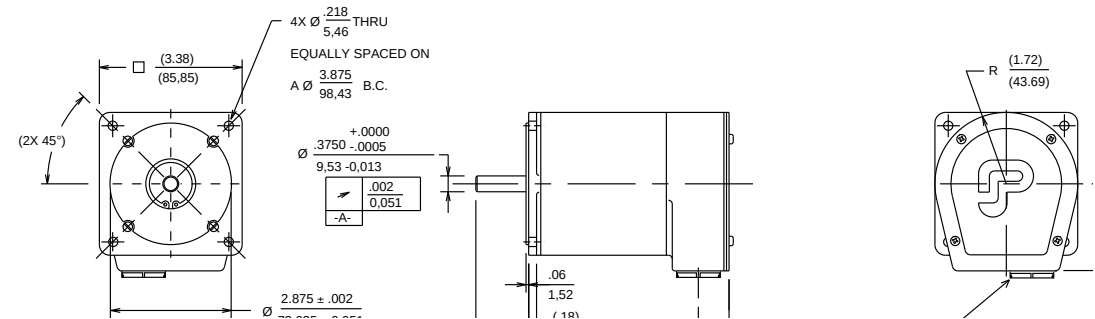
REGULAR CONSTRUCTION/FLYING LEAD HOOK-UP



MODEL NUMBER	2HNX	21NX	22NX	31NX	32NX	33NX	33HX	34HX
A	1.56 39.63	2.06 52.33	3.06 77.73	2.58 65.54	3.76 95.51	5.06 128.53	5.33 135.39	6.58 162.14
B	0.81 20.57	0.81 20.57	0.81 20.57	1.25 31.75	1.25 31.75	1.25 31.75	1.25 31.75	1.25 31.75
D	0.25 6.35	0.25 6.35	0.25 6.35	0.375 9.53	0.375 9.53	0.375 9.53	0.5 12.7	0.5 12.7

Note:
Substitute R for X for flying lead

SPLASHPROOF CONSTRUCTION

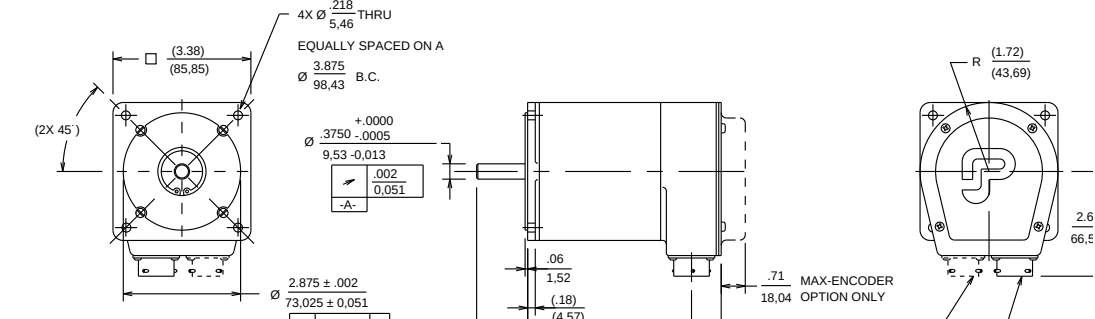


MODEL NUMBER	31NX	32NX	33NX	33HX	34HX	41HX	42HX	43HX
A	3.62 91.95	4.77 121.16	6.05 153.67	6.73 170.94	7.62 193.55	5.61 142.5	8.04 204.22	10.56 268.23
B	1.125 31.75	1.125 31.75	1.125 31.75	1.125 31.75	1.125 31.75	1.75 44.45	2.19 55.63	2.19 55.63
D	0.375 9.53	0.375 9.53	0.375 9.53	0.5 12.7	0.5 12.7	0.625 15.875	0.625 15.875	0.75 19.05

Note:
Substitute L for X to specify
conduit connection (1/2 NPS Tap)

Substitute M for X to specify
conduit connection (PDG 11 Tap)

SYSTEMS CONSTRUCTION



MODEL NUMBER	31NX	32NX	33NX	33HX	34HX	41HX	42HX	43HX
A	3.62 91.95	4.77 121.16	6.05 153.67	6.73 170.94	7.62 193.55	5.61 142.5	8.04 204.22	10.56 268.23
B	1.125 31.75	1.125 31.75	1.125 31.75	1.125 31.75	1.125 31.75	1.75 44.45	2.19 55.63	2.19 55.63
D	0.375 9.53	0.375 9.53	0.375 9.53	0.5 12.7	0.5 12.7	0.625 15.875	0.625 15.875	0.75 19.05

Note:
Substitute C for X for MS connector
termination

MODEL 6420

Holding torque range:
158-1284 oz-in.
(1.12 to 9.07 Nm)

Microstepping Indexer/Drive Module 0.625 to 5 A rms, 7.1 A peak (microstepping) per phase output. 24 to 75 Vdc

- Single power supply input
- Patented 4-phase Bipolar Chopper Drive for superior current regulation and low ripple current
- Output current adjustable from 0.625 A to 5 A rms with 3 position dipswitch
- Microstepping provides smooth operation and increased resolution
- Patented Digital Electronic Damping™ reduces instability at mid-speed ranges
- Idle current reduction reduces motor heating
- Fault protection:
 - Line-to-line and line-to-neutral shorts
 - Internal power supply under-voltage
 - Bus overvoltage
- Compact size, panel or side mountable
- Variable, "on the fly" microstepping for high resolution and high speed operation
- Master, slave two axis control
- Simple programming using a mnemonic code
- Serial communications supporting RS-232, RS-422 and RS-485
- 8 general purpose bi-directional user programmable input/output ports
- 1792 bytes of NVRAM available for user programs.
- 4 bit parallel interface
- Optional heat sink

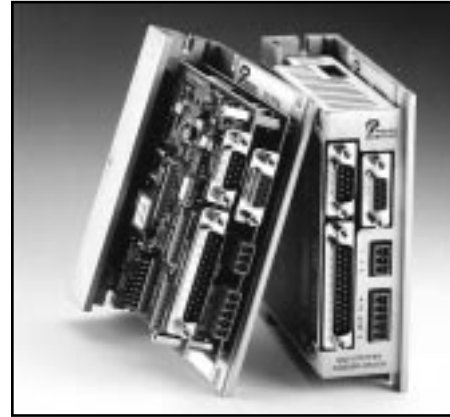
The 6420 communicates using RS232, RS422 or RS485 serial protocols at 9600 baud. A simple single letter mnemonic code is used. Discrete I/O lines provide external start/stop, motor enable, +/- limit +/- jog and home inputs and motor moving, step and direction outputs. The eight bi-directional I/O lines are jumper settable for input or output. Inputs 1 - 4 can be used as a parallel interface to select up to 16 different move profiles. This is ideal for thumbwheel and PLC interfaces.

The 6420 operates in one of two modes, either Fixed or Variable Resolution. In Fixed Resolution the step resolution can be set from 200 step/rev to 51200 steps/rev with either binary or decimal increments (see page C-29). The step pulse rate varies from .08 to 19K pulses/sec, therefore higher step resolution limits top shaft speed. In Variable Resolution the step resolution is fixed to 20K steps/rev, the speed ranges from .02 to 6000 RPM. The 6420 changes step size "on the fly" to provide both high speed and resolution.

The module can be set up for two axis master, slave control. The indexer can provide synchronous or alternating motion for two axes through its step and direction outputs. The motion profile is trapezoidal with independent programmable accel and decel rates. Its compact size 1.5" W x 5" H x 4.3" deep only requires 7.5 square inches of panel space.

TYPICAL APPLICATIONS

- Clutch Brake Replacement
- Labeling Machines
- Packaging/Speciality Machinery
- Smart Conveyor Systems
- Semiconductor Wafer Polishing
- Constant Speed Applications



MICROSTEPPING

Microstepping assures smooth, low speed operation, smoother operation through resonance regions and optimum system resolution. Resolution with 1.8° motors is adjustable to 50,000 steps per revolution with decimal step size selected and to 51,200 with binary step size selected. See the Step Size table on page C-29. The 6420 switches to full step operation above 150 RPM.

FULL TORQUE AT ALL SPEEDS

A patented **Digital Electronic Damping** circuit ensures the availability of full motor torque at all speed ranges. This compensation damps motor oscillations common with stepper systems. Whether in the full step or microstepping mode, full motor torque is achieved throughout the speed range.

HIGH EFFICIENCY BIPOLAR CHOPPING

Patented, 4-phase PWM chopping electronically controls the motor winding currents at 20 KHz frequency. This combines the best of recirculating and nonrecirculating current regulation to provide high back EMF rejection with low ripple current. The benefits include reduced heat dissipation, low electrical noise and improved current control during dynamic braking.

The patented 4-phase control circuit combined with **Digital Electronic Damping**, provides significantly more motor output power than from other drives.

IDLE CURRENT REDUCTION

This useful function permits an automatic 50% reduction in motor winding current during motor idle conditions to minimize heating during dwell periods. If no step commands have been received for 0.1 second (0.05 and 1.0 seconds can also be selected through DIP switch settings - see Figure C-19, page C-31), the current is automatically reduced. Current is restored to full amplitude upon arrival of a step command.

FAULT PROTECTION

- Line-to-line and line-to-neutral shorts
- Internal power supply under-voltage
- Bus overvoltage

AGENCY APPROVAL

See page C-34

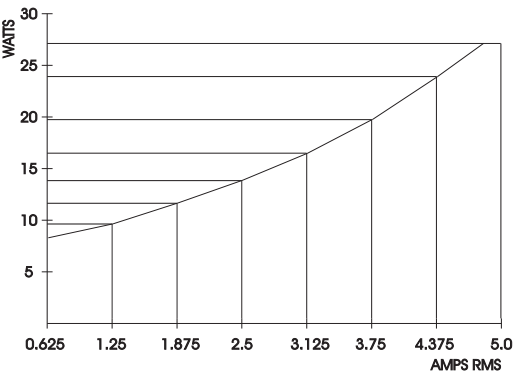
GENERAL. . .Model 6420

Input Power Voltage	.24 Vdc to 75 Vdc			
Input Power Current	.Motor and load dependent. Usually < motor phase current.			
Output motor phase current	See Figure C-20, page C-31			
	5 A rms max. (5 A peak full step, 7.1 A peak micro stepping)			
	Adjustable from 0.625 to 5 A rms in 0.625 amp increments			
Input Power				
Voltage	.24Vdc to 75Vdc			
Current	.Motor and load dependent. Usually motor phase current.			
	A 2000 uf capacitor mounted within three feet of the 6420 is recommended to absorb the motor regen energy			
Output Motor Phase Current	.5 A rms max., 5 A peak full step, 7.1 A peak microstepping			
Discrete Input Voltage	.0 - 30 Vdc max., Vin 0.8V is a logic low and Vin = 3.7V is a logic high			
Discrete Output Voltage	.Open collector 30 Vdc, 70 ma sink, V _{sat} 1.0 Vdc			
Inputs	See Figure C-16, page C-30 for electrical specifications			
Dedicated Inputs	.Start, stop, motor enable, +/- limit, +/- jog and home			
Programmable Inputs	8 available jumper selectable see Figure C-16, page C-30. There are 8 total inputs and outputs			
Outputs	See Figure C-17, page C-30 for electrical specifications			
Opto Supply	.+5.7 Vdc @ 100 ma			
Dedicated Outputs	.Motor moving, fault step and direction out			
Programmable Outputs	8 available jumper selectable see Figure C-17, page C-30. There are 8 total inputs and outputs			
Step Size	<u>Step Size</u>	<u>Min. Speed</u>	<u>Max. Speed</u>	<u>Resolution</u>
		<u>RPM</u>	<u>RPM</u>	<u>Pulses/Rev.</u>
	<i>Fixed Resolution - Binary Steps</i>			
	Full	6 (20)	5700 (19,000)	200
	1/2	3 (10)	3000 (10,000)	400
	1/4	1.5 (5)	1500 (5,000)	800
	1/8	.75 (2.5)	750 (2,500)	1,600
	1/16	.37 (1.25)	375 (1,250)	3,200
	1/32	.19 (.625)	188 (635)	6,400
	1/64	.09 (.312)	46.87 (312)	12,800
	1/128	.05 (.156)	23.43 (156)	25,600
	1/256	.02 (.078)	23.43 (78)	51,200
	<i>Fixed Resolution - Decimal Steps</i>			
	Full	6 (20)	5700 (19,000)	200
	1/2	3 (10)	3000 (10,000)	400
	1/5	1.2 (4)	1200 (4,000)	100
	1/10	.60 (2)	600 (2,000)	2,000
	1/25	.24 (.8)	240 (800)	5,000
	1/50	.12 (.4)	120 (400)	10,000
	1/125	.048 (.16)	48 (160)	25,000
	1/250	.024 (.08)	24 (80)	50,000
	<i>Variable Resolution</i>			
	Full	.02 (.078)	5700 (19000)	20,000
Idle Current Reduction	See Figure C-20, page C-31			
	Enabled or disabled with DIP switch, 50% output current reduction after 0.1 second from last step command (0.05 and 1.0 second time-outs can also be selected using a plug-on jumper. Consult factory for other current reduction options).			
DIGITAL ELECTRONIC DAMPING	See Figure C-20, page C-31			
	Enabled or disabled with DIP switch			
	Max. delay from input step to change in motor excitation:			
	Step frequency < 500 full steps/sec: 500 μ s			
	Step frequency > 500 full steps/sec: 270° of step period			
	5 contact plug-in screw terminal			
Protection	.(Any fault disables the drive and must be cleared by cycling input power)			
	Line-to-line short, line to neutral, internal supply under voltage			
	bus over voltage (83 Vdc)			
Mechanical				
Dimensions	.5" x 1.5" x 4.3"			
Weight	.1 lb. nominal			
Connectors	See Figure C-18, page C-30			
Power Supply	.3 contact plug-in screw terminal			
Motor	.5 contact plug-in screw terminal			
Signal	.25 contact plug D-sub miniature			
Serial	.9 contact plug D-sub miniature			
Storage Temperature	.-55° C to +70° C			
Operating Temperature	.Full rated current 0° to 50°C ambient air with or without cover provided chassis properly mounted so as not to exceed 60°C			

GENERAL AND ENVIRONMENTAL. . .Model 6420

Maximum Chassis Temperature	.60° C.	Note: For optimal thermal performance, mount the 6420 chassis (back or side) to a cooling plate or heatsink. Use a thermal pad or grease if surface is irregular. A fan or idle current reduction may be employed to keep chassis below 60°C
Convection Cooling	(6420 not mounted on cooling plate)	
With optional heat sink	Full rating (5A) at 25°C Ambient	
Without optional heat sink	2.5A max at 45°C Ambient	
	2.5A max at 25°C Ambient	
	1.25A max at 45°C Ambient	
	See chart below for plot of drive power dissipation vs. output current.	
Humidity Range	.10 to 90%, non-condensing	

POWER DISSIPATION CHART



DEDICATED & PROGRAMMABLE INPUT/OUTPUT LINES

The 6420's operation is controlled by several input lines. these lines are active low. Input lines are RC filtered and passed to a 74HC14 Schmidt Trigger. The electrical diagram of input and output lines are shown below.

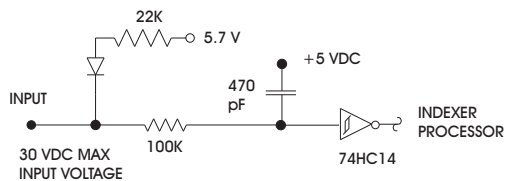


Figure C-16.
Note: Inputs accept 0-30 VDC max, where $V_{in} \leq .8V$ is a logic low and $V_{in} \geq 3.7V$ is a logic high.

CONNECTION DIAGRAM. . .Model 6420

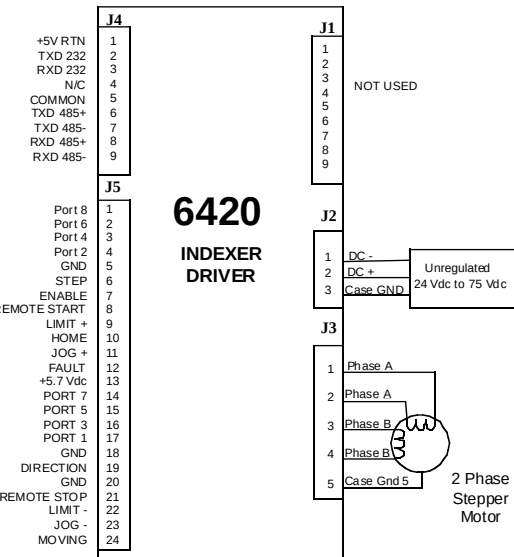


Figure C-18.

The 6420's outputs are open-collector Darlington ULN203 drives. Inductive kick-back protection is provided by the built-in diode and 39 V Zener diode.

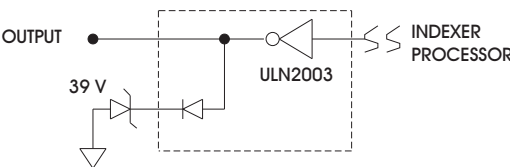


Figure C-17.
Note: All outputs are Open Collector 30 VDC, 70 ma sink, $V_{sat} \leq 1.0V$. All I/O signals are active low.

STEP SIZES AND SPEED RANGES. . .Model 6420

INDEXER DRIVE UPPER BOARD

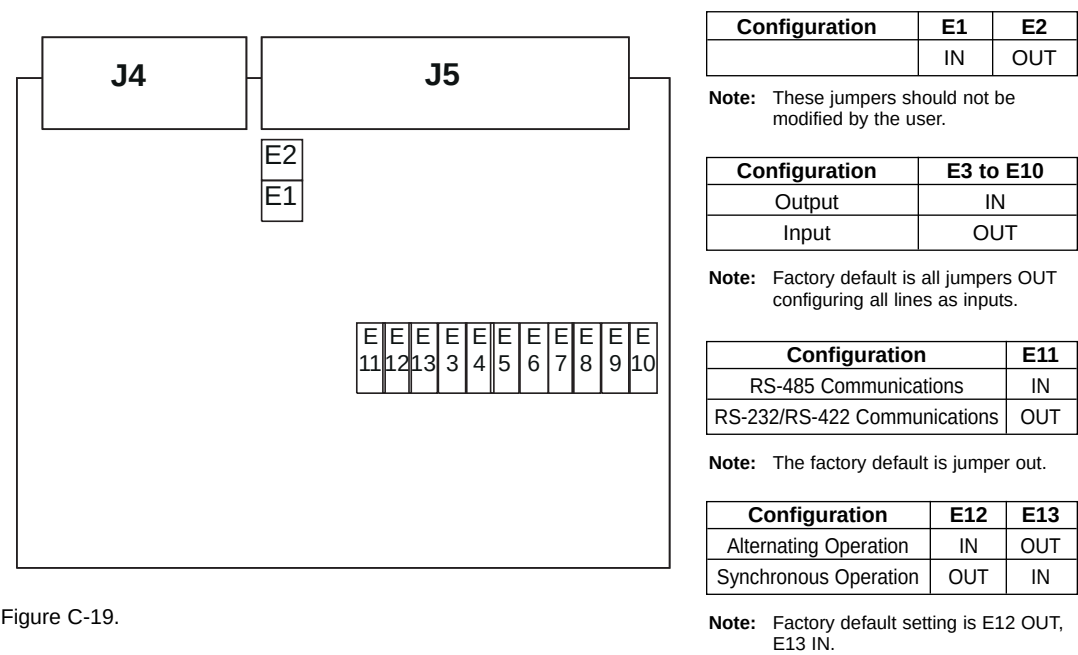


Figure C-19.

INDEXER DRIVE LOWER BOARD

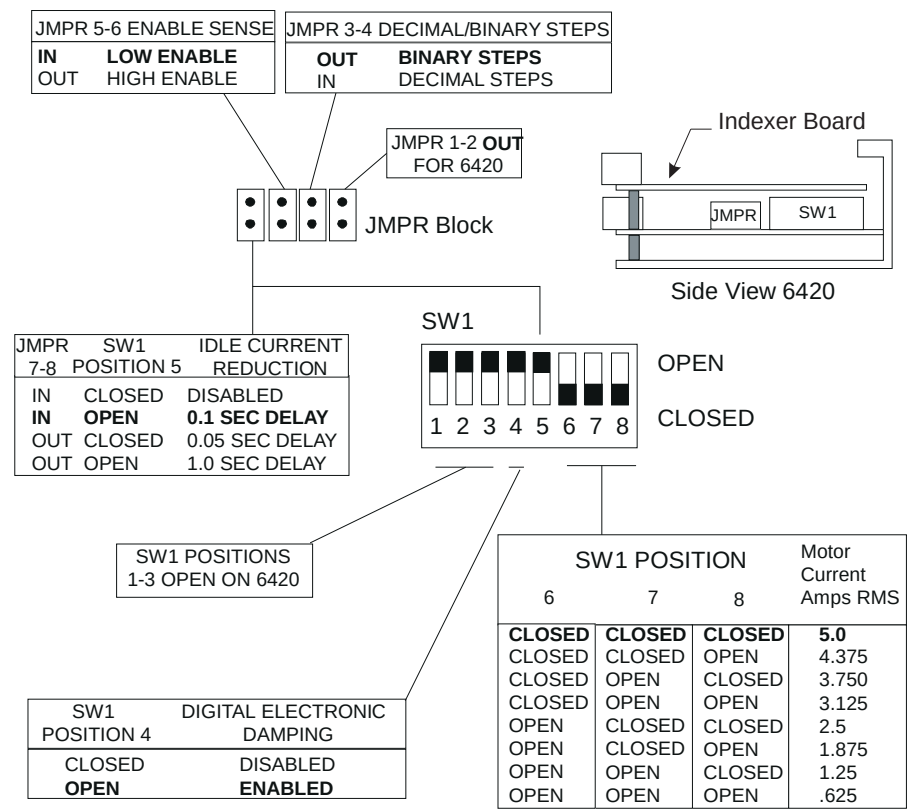
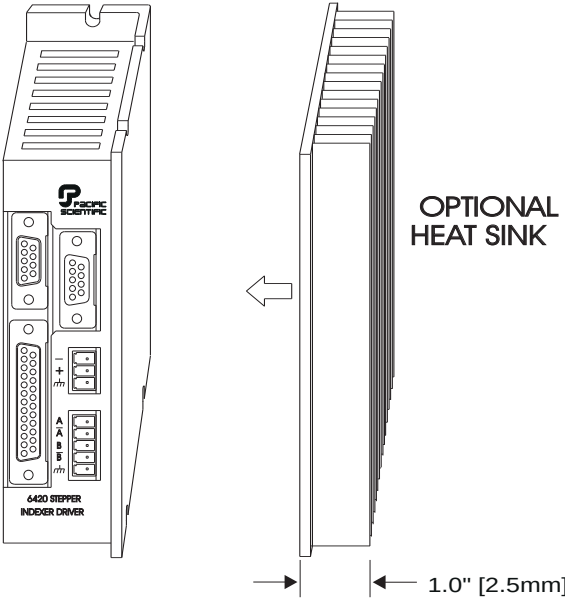
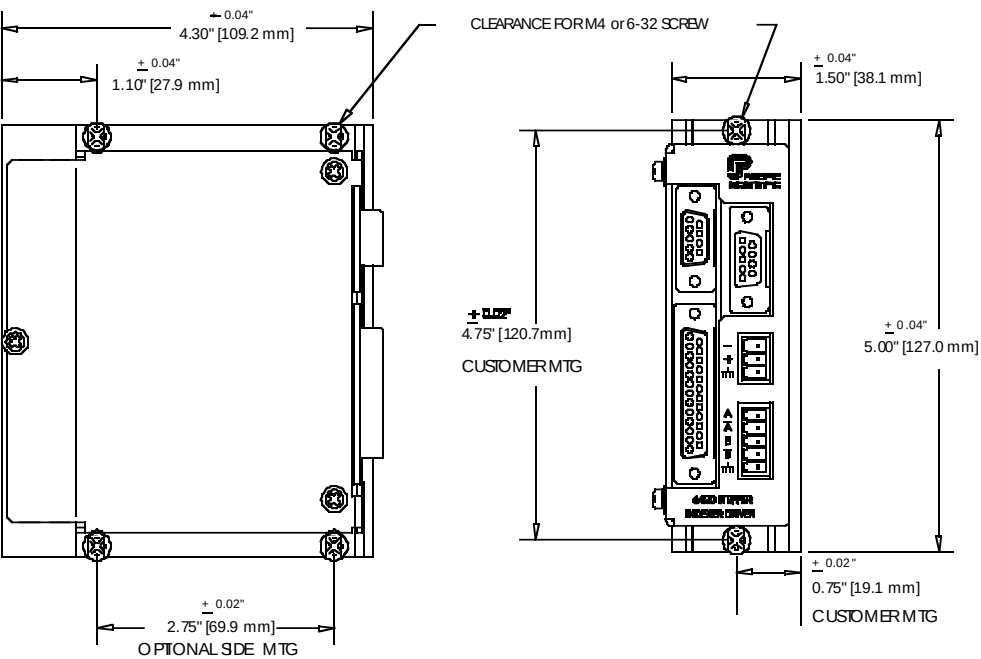


Figure C-20.

DIMENSIONS. . .Model 6420 [MM—DIMENSIONS FOR REF. ONLY]



COMMAND SET

A opcode

A 0 reloads the last saved parameters from NVRAM.
A 8 followed by **A 9** completely initializes NVRAM to default values.

C arg

Reads position counter.
Arg = 1 enables continuous echoing of position via the serial interface only in single-unit mode.

E addr

Edits program at address *addr*.

F vel

Sets the initial velocity to *vel* step pulses/second. $0 \leq vel \leq 20,000$.

G addr [trace]

Go. Where:
• $0 \leq addr \leq 1791$ or 2048 for indexed jump on inputs.
• $0 \leq trace \leq 1$.

H speed dir

Home. Where:
• $20 \leq speed \leq 20,000$ step pulses/second.
• *dir* must be 0 for CW and 1 for CCW motion towards Home position.

I mode

Sets resolution mode. Where:
• *mode* = 0 selects Fixed Resolution Mode.
• *mode* = 1 selects Variable Resolution Mode.

J, B addr cntr

Jump loop nested. Where:
• $0 \leq addr \leq 1791$.
• $0 \leq cntr \leq 255$ for 1 to 256 iterations.

K

Reads input port. Logic "0" input reads back as "1". Bit weightings 1-128 correspond to port 1 to 8. Jumpers E3 to E10 control direction of I/O ports. Jumper OUT for input, IN for output.

L addr

Lists program, returning up to 20 lines at a time. $0 \leq addr \leq 1791$.

M accel decel

Sets accel/decel factor. Where:
• $0 \leq accel \leq 255$.
• $0 \leq decel \leq 255$.

O position vaddr

Sets trip point. Where:
• $-8,388,607 \leq position \leq +8,388,607$.
• $0 \leq vaddr \leq 1791$.

P

This command stores parameters to non-volatile memory.

Q

Displays Initial, Final Velocity, Accel/decel factors, etc.

R vel

Runs at constant velocity. Where $20 \leq vel \leq 20,000$ step pulses/second.

S [arg]

Stop. Embedded in a program, **S 0**, will stop motion but the program will continue.

S 1 terminates the program, placing the indexer into immediate mode.

T enb

Master/Slave control.
Alternating axis operation: E12 IN, E13 OUT, **T 1** enables master, disables slave. **T 0** disables master, enables slave.
Synchronous Operation: E12 OUT, E13 IN, **T 1** enables master and slave. **T 0** disables both master and slave.

U addr cond

Tests a port and jumps if condition is satisfied. $0 \leq addr \leq 1791$.
Port 1 to 8 HIGH 0,2,4,6,8,10,12,14.
Port 1 to 8 LOW 1, 3, 5, 7, 9, 11, 13, 15.

V vel

Sets the final velocity of an absolute (@) or incremental (+ -) move. $0 \leq vel \leq 20,000$ step pulses/second.

W period, Wait

Returns the status of the limit, home and jog switches and the Drive Fault status. The value of *period* specifies whether limit switch or input line information is returned.
 $0 \leq period \leq 65535$, 10ms resolution, with 0 as wait for end of motion.

X arg

X 0 returns 1 for Limit + activ; 2 for Limit - active; 3 for both active. Bit 7 is active high if the drive has faulted.
X 1, returns a binary weighted value corresponding to the level of these signals:
• 1 => Home Input
• 32 => Jog - Input
• 64 => Jog + Input
• 128 => Drive Fault

Y port

Y 0 deactivates all bits producing Logic HIGHS.
Y 255 activates all bits producing Logic LOWs.
 $0 \leq port \leq 255$.

Z

Zeros position counter.

^ speed

Sets jog speed. $0 \leq speed \leq 255$. Actual speed is $30 * speed$ step pulses/second.

@ position

Fixed Resolution: $-8,388,607 \leq position \leq +8,388,607$.
Variable Resolution: $-8,388,607.99 \leq position \leq +8,388,607.99$ with .01 resolution.

+ steps

Fixed Resolution: $0 \leq steps \leq +8,388,607$.
Variable Resolution: $0.00 \leq steps \leq +8,388,607.99$.

- (Negative Incremental Move), steps

Fixed Resolution: $0 \leq steps \leq +8,388,607$.
Variable Resolution: $0.00 \leq steps \leq +8,388,607.99$.

\ arg

Sets the step size in Fixed Resolution Mode, binary and decimal step sizes. In Variable Resolution Mode, scales the step pulse rates. $0 \leq arg \leq 8$.
Fixed Binary & Variable Resolution

Speed:

0 =	Full
1 =	1/2
2 =	1/4
3 =	1/8
4 =	1/16
5 =	1/32
6 =	1/64
7 =	1/128
8 =	1/256

Fixed Decimal:

0 =	Not allowed
1 =	Full
2 =	1/2
3 =	1/5
4 =	1/10
5 =	1/25
6 =	1/50
7 =	1/125
8 =	1/250

^C or ESC

Stops all activity. Indexer will wait for the space bar sign-on or external Remote Start or Jog pulse inputs.

> addr size

Displays a block of memory starting at *addr* in decimal format, returning a total of *size* bytes. Where:
• $0 \leq addr \leq 2047$.
• $0 \leq size \leq 255$ bytes.

< addr data

Writes a data byte to an address specified by *addr* in memory. Where:
• $0 \leq addr \leq 2047$.
• $0 \leq data \leq 255$.

l

Returns a decimal number representing the current move status. Bit weights:
1 => Indexing
2 => Constant
128 => Drive Fault

' nextpos port

Used within a Trip Point Service Routine (TPSR) and provides the capability of setting or clearing user I/O lines as a function of current position. The value port is written to the I/O ports when the previously set position is reached. Next trip point set to position *nextpos*. Where:
• $0 \leq nextpos \leq +8,388,607$.
• $0 \leq port \leq 255$.

= polarity

Sets limit switch polarity. Where:
• 0 = default active LOW limit input.
• 1 = active HIGH limit input

: axis

Aborts operations on a particular axis when configured for RS-485 communications mode.

Power-up Sign-On

Power-up sign-on message returned after entry of 1 or 2 spaces

Special Memory Locations

REMOTE START at Address 0.
Power-up AUTOSTART program at address 1600.
FAST memory 128-191.

Port Configuration

Jumpers E3 to E10 configure Port 1 to 8. Jumper OUT for an INPUT. Jumper IN for an OUTPUT. Ports are active LOW; a 1 will produce a 0 and vice-versa.

AGENCY APPROVAL

UL recognized - 508C (Type R) - file # E137798
Meets CSA Standard, C22.2 #142-M1987
Meets IEC vibration standard, #68-2-6

FUNCTIONAL ENHANCEMENT

The 6420 microstepping indexer/drive module is one of a full family of products adding enhanced functionality.

- Additional Products
- 24-75 Vdc Input:
- 6410 Step Motor Drive Step and direction input drive
 - 6415 Oscillator/Drive± 0-10 Vdc input or on board potentiometers
- 120/240 VAC 50-60HZ INPUT:
- 6430 Package 6410 drive with AC input
 - 6435 Package 6415 oscillator/drive with AC input
 - 6440 Package 6420 indexer/drive with AC input
 - 6445 Package 6410 drive with Stepper Basic indexer and AC input functionality

HOW TO ORDER. . .Model 6420 recommended systems

Order the 6420, accessories and motor as separate model numbers.

CATALOG MODEL NUMBER:

6420-001-N-N

Drive Type (family):

Stepper Drive (6000)

Power Level:

7.1 A peak, 5 A rms
24-75 Vdc

Functionality:

Motor Drive Module with Indexer Board Mnemonic Programming Language

Customer Customization Number:

001 indicates standard unit with no customization
All others are factory assigned

Heat Sink Option:

N - No Heat Sink
H - Include Heat Sink

Connector Kit Option:

N - No Connector Kit
K - Include Connector Kit

NOTE: Standard drive includes Data Sheet. Manual/Design Guide ordered separately.

6420 Accessories: Order in accordance with the following model number codes:

Part No.	Description
HS6410	Heat Sink (includes fastening screws)
CK6420	Connector Kit (includes all mating connectors) 9-pin D-shell and Phoenix Connectors for J3-motor: Phoenix p/n: MC 1.5/5-ST-3.81 and J2-DC input: MC 1.5/3-ST-3.8.
MA6420	User Manual / Design Guide
SPC-XXX-6410	With control connector and motor MS connector. Four conductor shielded wire plus ground. In place of XXX, specify length in even one foot increments from 001 to 050 feet. Consult factory for longer lengths.
SPC-CO-XXX	Motor Power Cable Only. Four conductor shielded wire plus ground. In place of XXX, specify length in even one foot increments.

SYSTEM RATINGS AND CHARACTERISTICS

Model 6420 with recommended E Series motors

See E Series motors. . NEMA 34 (3.4") and NEMA 42 (4.2") on page C-38.

5.0 A,
65V per phase

OD (in)	Motor Model Number Δ	Drive Current/ Phase (amps DC)	Holding Δ Torque (2 phases on) oz-in (Nm) $\pm 10\%$	Detent Torque oz-in (Nm)	Rotor inertia oz-in-S2 (kgm2 x 10 ⁻³)	Weight lbs (kg)	Peak Shaft Power (watts)	Rated Speed at Peak Power (RPM)
Maximum torque at low speed (see plot T in performance curve)								
3.4	E31NX-HTLNN-NS00	5.0	319 (2.25)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	155	1350
3.4	E32NX-HTLNN-NS00	5.0	638 (4.51)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	160	750
3.4	E33NX-HTLNN-NS00	5.0	958 (6.77)	69.3 (0.45)	0.0250 (0.155)	7.6 (3.45)	175	600
3.4	E34HX-HTLNK-NS00	5.0	1222 (8.63)	83.0 (0.59)	0.0350 (0.217)	9.7 (4.41)	175	450
3.4	E41HX-HTLNK-NS00	5.0	1284 (9.07)	58.0 (0.41)	0.0800 (0.496)	14.0 (6.36)	177	450
Maximum torque at HIGH speed (see plot P in performance curve)								
3.4	E32NX-HPLNN-NS00	5.0	474 (3.35)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	240	1650
3.4	E33NX-HPLNN-NS00	5.0	711 (5.02)	69.3 (0.45)	0.0250 (0.155)	7.6 (3.45)	260	1200
3.4	E34HX-HPLNK-NS00	5.0	948 (6.69)	83.0 (0.59)	0.0350 (0.217)	9.7 (4.41)	240	900

Model 6420 with recommended E Series motors

See E Series motors. . NEMA 23 (2.3") and NEMA 34 (3.4") on page C-38.

2.5 A,
65V per phase

OD (in)	Motor Model Number Δ	Driver Current/ Phase (amps DC)	Holding Δ Torque (2 phases on) oz-in (Nm) $\pm 10\%$	Detent Torque oz-in (Nm)	Rotor inertia oz-in-S2 (kgm2 x 10 ⁻³)	Weight lbs (kg)	Peak Shaft Power (watts)	Rated Speed at Peak Power (RPM)
Maximum torque at low speed (see plot T in performance curve)								
2.3	E22NX-LTLNN-NS00	2.5	225 (1.59)	9.6 (0.07)	0.0031 (0.019)	2.1 (0.95)	54	1650
3.4	E31NX-LTLNN-NS00	2.5	319 (2.25)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	75	600
3.4	E32NX-LTLNN-NS00	2.5	638 (4.51)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	80	450
Maximum torque at HIGH speed (see plot P in performance curve)								
2.3	E22NX-LPLNN-NS00	2.5	158 (1.12)	9.6 (0.07)	0.0031 (0.019)	2.1 (0.95)	155	2850
3.4	E31NX-LPLNN-NS00	2.5	237 (1.67)	21.5 (0.15)	0.0083 (0.051)	3.2 (1.45)	115	1500
3.4	E32NX-LPLNN-NS00	2.5	474 (3.35)	41.6 (0.29)	0.0170 (0.102)	5.3 (2.41)	120	900

All ratings typical and at 25°C unless otherwise noted.

- Δ See page C-15 for motor options. X denotes the construction of the motor, refer to page C-11 for various options. Also refer to Model Number Codes in the system configured hybrid step motor section page C-82.
- Δ When operated at listed drive current.

MODEL 6420 TORQUE/SPEED CURVES
with recommended motors

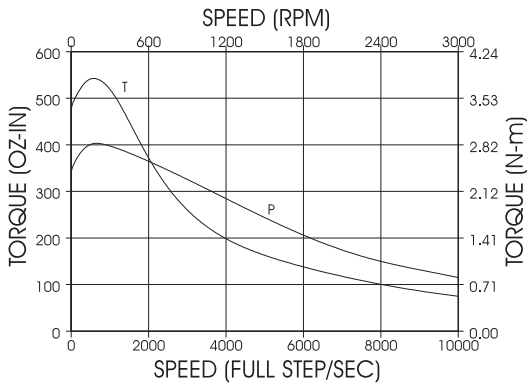
5.0A,
65V per phase

Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points which will vary with motor coupling and systems parameters.

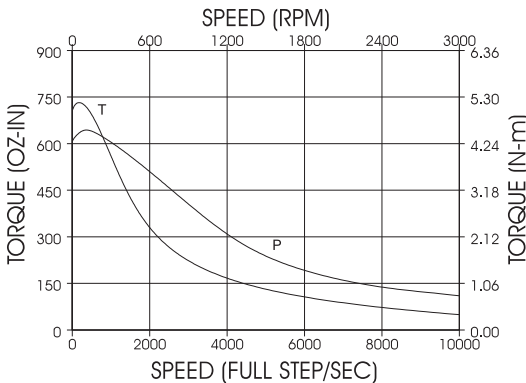
In addition to those shown below, Pacific Scientific offers a wide range of other motor windings to meet specific performance requirements. Consult factory.

PERFORMANCE AT 5.0A (RMS)/65V PER PHASE

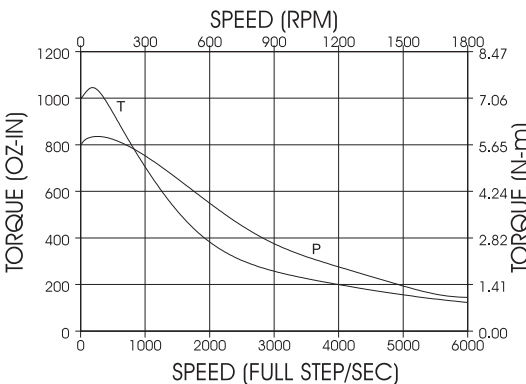
(3" MOTOR-TWO ROTOR STACK)
MTDE32NX-HTLNN-NS50
MTDE32NX-HPLNN-NS50
5.0A/65V PER PHASE



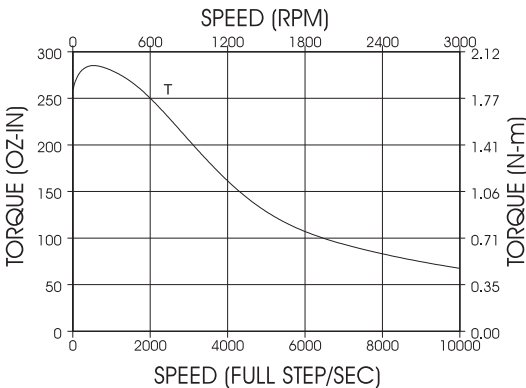
(3" MOTOR-THREE ROTOR STACKS)
MTDE33NX-HTLNK-NS50
MTDE33NX-HPLNK-NS50
5.0A/65V PER PHASE



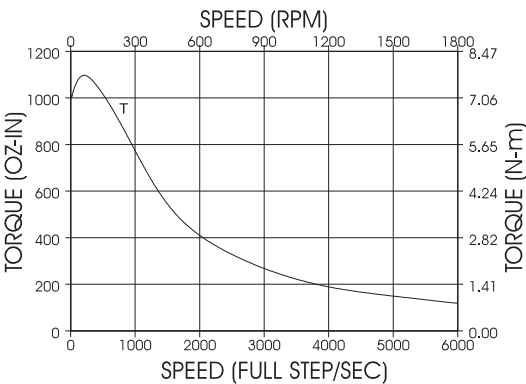
(3" MOTOR-FOUR ROTOR STACKS)
MTDE34HX-HTLNK-NS50
MTDE32HX-HPLNK-NS50
5.0A/65V PER PHASE



(3" MOTOR-ONE ROTOR STACK)
MTDE31NX-HTLNN-NS50
5.0A/65V PER PHASE



(4" MOTOR-ONE ROTOR STACK)
MTDE41HX-HTLNK-NS50
5.0A/65V PER PHASE

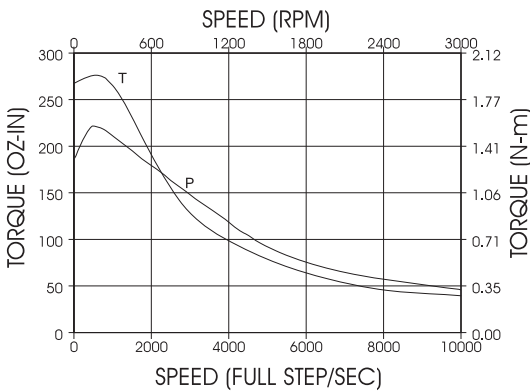


PERFORMANCE AT 2.5A (RMS)/65V PER PHASE

2.5 A,
65V per phase

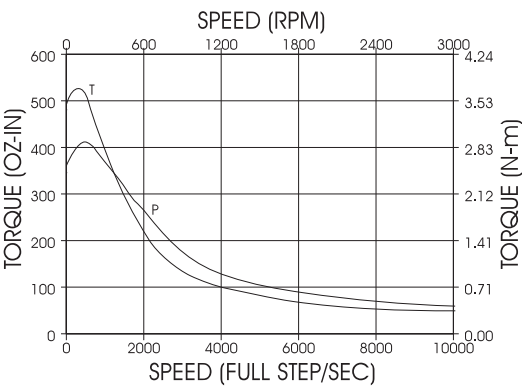
(3" MOTOR-ONE ROTOR STACK)

MTDE31NX-LTLNN-NS50
MTDE31NX-LPLNN-NS50
2.5A/65V PER PHASE



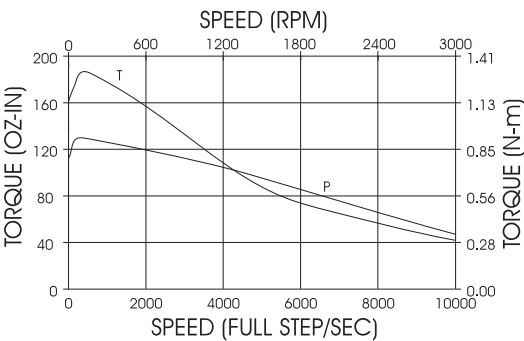
(3" MOTOR-TWO ROTOR STACK)

MTDE32NX-LTLNN-NS50
MTDE32NX-LPLNN-NS50
2.5A/65V PER PHASE



(2" MOTOR-TWO ROTOR STACKS)

MTDE22NX-LTLNN-NS50
MTDE22NX-LPLNN-NS50
2.5A/65V PER PHASE



Technical drawing of a motor lead assembly, showing side and end views with dimensions and tolerances.

Side View Dimensions:

- Top hole: $4X \varnothing \frac{.218}{5.46}$ THRU
- Spacing: EQUALLY SPACED ON
- Inner hole: $A \varnothing \frac{3.875}{98.43}$ B.C.
- Dimension: $\varnothing .3750 \begin{smallmatrix} +.0000 \\ -.0005 \end{smallmatrix}$
- Dimension: $9.53 - 0.013$
- Feature: $\begin{smallmatrix} \nearrow .002 \\ .0051 \end{smallmatrix}$
- Feature: $\begin{smallmatrix} \text{A} \end{smallmatrix}$
- Dimension: $\varnothing \frac{2.875 \pm .002}{73.025 \pm 0.51}$
- Dimension: $\varnothing \frac{.003}{.0273}$
- Feature: $\begin{smallmatrix} \nearrow .003 \\ .0273 \end{smallmatrix}$
- Feature: $\begin{smallmatrix} \text{A} \end{smallmatrix}$
- Dimension: 1.25
- Dimension: $.06$
- Dimension: 1.52
- Dimension: $(.18)$
- Dimension: (4.57)

End View Dimensions:

- Dimension: 1.25
- Dimension: 1.52
- Dimension: $(.18)$
- Dimension: (4.57)

Notes:

- MOTOR LEADS
- NOTE: $\triangle 1$ 4 LEAD MOTORS: #18 AWG, MINIMUM $\frac{12.0}{304.8}$

Technical drawing of a 32NX ball mill. The front view shows a circular mill with a central shaft. Dimensions include a diameter of 218 (tolerance +0.000, -0.0005), a distance of 3.38 (85,85) between mounting points, and a distance of 2.875 ± .002 from the center to the mounting points. The side view shows a cylindrical mill with a diameter of 1.52 (tolerance +.06, -.005) and a length of 1.52 (tolerance +.002, -0.051). The drawing also indicates 4X Ø 218 THRU, EQUALLY SPACED ON, and A Ø 3.875 (98,43) B.C. (Bore Center).

MODEL NUMBER	31NX	32NX	33NX	33HX	34HX	41HX	42HX	43HX
A	3.62 91.95	4.77 121.16	6.05 153.67	6.73 170.94	7.62 193.55	5.61 142.5	8.04 204.22	10.56 268.23
B	1.125 31.75	1.125 31.75	1.125 31.75	1.125 31.75	1.125 31.75	1.75 44.45	2.19 55.63	2.19 55.63
D	0.375 9.53	0.375 9.53	0.375 9.53	0.5 12.7	0.5 12.7	0.625 15.875	0.625 15.875	0.75 19.05

Technical drawing of the 32NX encoder showing front and side views with dimensions and tolerances.

Front View Dimensions:

- Overall width: (3.38) (85,85)
- Mounting holes: 4X Ø $\frac{218}{5,46}$ THRU
- Mounting holes: EQUALLY SPACED ON A
- Mounting holes: Ø $\frac{3,875}{98,43}$ B.C.
- Mounting holes: +.0000 / -.0005
- Mounting holes: 9.53 -0.013
- Mounting holes: .002 / 0.051
- Mounting holes: -A-
- Mounting holes: 2.875 ± .002
- Mounting holes: 73.025 ± 0.051
- Mounting holes: (2X 45°)

Side View Dimensions:

- Encoder body width: .06
- Encoder body width: 1.52
- Encoder body width: (.18) (4.57)
- Encoder body width: .71 MAX-ENCODER / 18,04 OPTION ONLY

MODEL NUMBER	31NX	32NX	33NX	33HX	34HX	41HX	42HX	43HX
A	3.62 91.95	4.77 121.16	6.05 153.67	6.73 170.94	7.62 193.55	5.61 142.5	8.04 204.22	10.56 268.23
B	1.125 31.75	1.125 31.75	1.125 31.75	1.125 31.75	1.125 31.75	1.75 44.45	2.19 55.63	2.19 55.63
D	0.375 9.53	0.375 9.53	0.375 9.53	0.5 12.7	0.5 12.7	0.625 15.875	0.625 15.875	0.75 19.05

Note:
Substitute C for X for termination



5000 SERIES PROGRAMMABLE INDEXER/DRIVES

Start with plug & play simplicity and economy of steppers. Add the functionality of PacSci programmable motion control. Then package step motors and controllers for the harsh realities of the factory floor.

That's what you get from Pacific Scientific's advanced generation of microstepping indexer/drives and E Series systems motors.

Choose open loop control or encoder feedback. Use PacSci Stepper BASIC™ for electronic gearing,

master/follower multi-axis operation, and complex motion profiles based on user defined inputs.

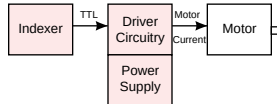
Take control of your application with up to 28 user programmable I/O, 12K battery backed RAM, full floating point math, easy PLC interface and more.

You'll also gain the inherent advantages of PacSci's patented drive electronics to eliminate stepper torque losses at mid-range speeds, utilize higher power motor windings and reduce electrical noise.

MODEL 5645

Microstep indexer/drive package 11.3A peak (microstep)/160V per phase output

Self-contained indexer/driver package for hybrid step motors. Includes communications for programming and/or host controller. Nonvolatile memory provides onboard program storage and standalone operation.



- Easy programming in PacSci Stepper BASIC™
- Single and multiaxis use
- Switch selectable full, 1/2, 1/5, 1/25, 1/125 step operation
- Encoder interface for closed loop operation
- High frequency, inaudible 20 kHz PWM chopping drive
- Direct 120 Vac line operation
- Self-contained, panel mount
- Drives motors over 1 HP
- UL recognized

The Model 5645 Microstep Indexer/Drive Package combines a programmable indexer and high efficiency bipolar chopper MOSFET driver. This self-contained microstep indexer/drive is for medium to high power step motors.

Five switch selectable microstepping ranges deliver smooth low speed operation plus positioning resolution up to 25,000 steps/rev.

The 5645 features four switch selectable output current ranges, from 5.0A rms (7.1A peak microstep) to 8.0A rms (11.3A peak microstep) per phase.

SIMPLIFIED PROGRAMMING

Motion control programming is simplified with PacSci Stepper BASIC™, an easy to learn extension of the familiar BASIC protocol. See page C-50.

Capabilities include complex single or multiaxis motion profiles, electronic gearing and more.

Programming is supported by PacCom™, an IBM PC® compatible software development environment. The 5645 features a full 12K of battery backed RAM user memory for storage of parameters and move profiles.

An RS-232/485 serial communications port is provided for programming and host controllers. Sixteen programmable inputs and twelve programmable outputs are also provided.

ENCODER INTERFACE

The 5645 accepts quadrature encoder inputs to perform position verification and correction, stall detection and electronic gearing functions. An encoder with line drive output is required. Combined with microstepping resolutions up to 25,000 steps/rev, encoder feedback can greatly increase system positioning accuracy. The 5645 accepts typical encoder line counts from 200 to 1024.

FULL TORQUE AT ALL SPEEDS

Patented mid-range instability compensation ensures the availability of full motor torque at speeds up to 10,000 full steps/sec. (3000 RPM). This active control circuit modifies input step timing to damp rotor oscillation caused by the step motor's generated voltage.

In addition, microstepping drives typically drop the motor's torque to 70% of that achieved when in the full step mode. Model 5645, however, continuously supplies RMS current equivalent to the DC rated value of the motor to prevent any torque loss.

HIGH PERFORMANCE CHOPPING

Also patented, 4-phase chopping combines the best of recirculating and nonrecirculating current regulation. The combination produces high back EMF rejection with low chopping ripple current.

Holding torque range:
1222-4034 oz-in. (8.63-28.49 Nm)



When used with high performance step motor windings, benefits include reduced heat dissipation, low electrical noise and improved current control during motor braking. Typically, higher motor shaft power is also delivered to the load.

HIGHER THROUGHPUTS

Idle current reduction permits an automatic 50% reduction in motor winding current during motor idle conditions.

In many applications, idle current reduction can improve machine throughput without exceeding motor or drive thermal ratings.

OPERATING FEATURES

- Two phase, full bridge, bipolar chopper MOSFET drive
- Switch selectable step size:
Full, 1/2, 1/5, 1/25, 1/125
- Switch selectable mid-range instability compensation, active above 500 full steps/sec
- Idle current reduction to 50% current one second after last step pulse

COMMUNICATIONS

- Serial interface:
RS-232, RS-422, RS-485, 9600 baud
- Enable and 16 discrete programmable inputs:
24 Vdc compatible, sourcing input, interface to contact closure or sinking output @1 mA max.
- Fault and 12 discrete programmable outputs:
24 Vdc compatible, sinking output, 0.6 V max. @50 mA sink
- Encoder/step & direction inputs:
Differential, quadrature, encoder interface, also accepts step & direction pulses
- Step & direction outputs:
Differential, TTL line driver for communication with slave drivers

PROTECTION/DIAGNOSTICS

- LED status indicators: Power, enabled, step active, power fault, temperature fault, microprocessor fault
- In-rush current limiting
- Fused, MOV protected input
- Output short circuit protection
- Drive overtemperature shutdown

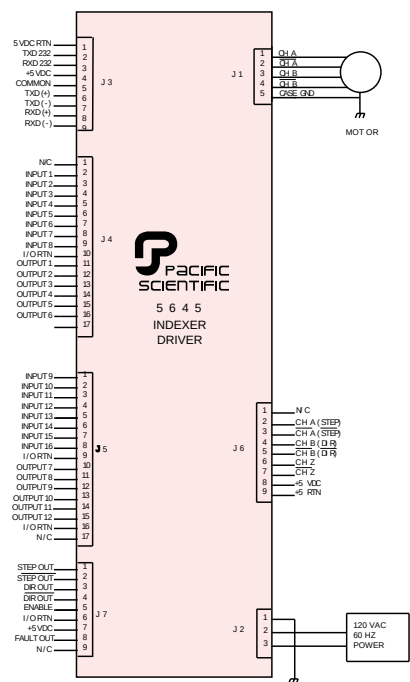
AGENCY APPROVAL

Model 5645 is UL Recognized (File E137798)

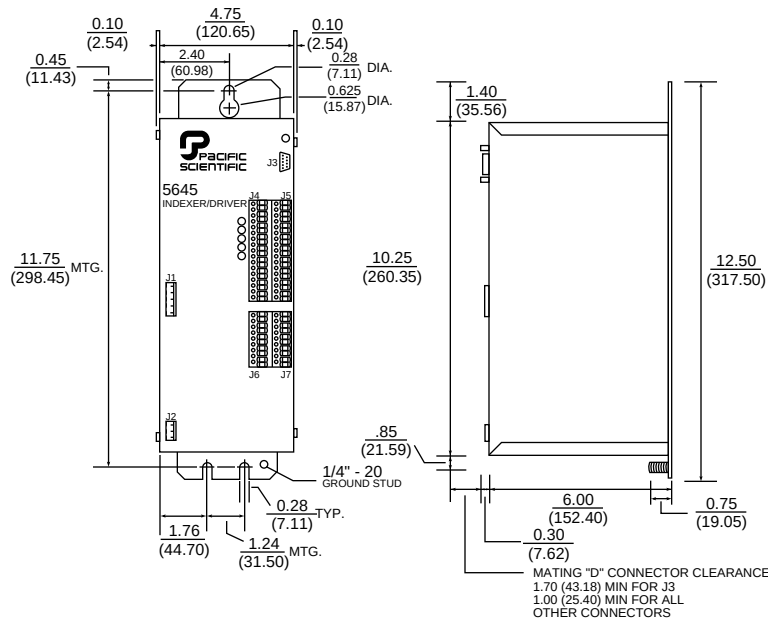
GENERAL . . . Model 5645

Input power	120 Vac (±10%) Single phase, 50/60Hz 13A rms (maximum)
Output current (per phase)	Switch selectable 8.0A rms (11.3A pk microstep) 7.5A rms (10.6A pk microstep) 6.0A rms (8.5A pk microstep) 5.0A rms (7.1A pk microstep)
Output bus voltage	160V nominal (w/ 120 Vac line)
Maximum input pulse rate	40,000 pulses/sec–full step (12,000 RPM) 80,000 pulses/sec–1/2 step (12,000 RPM) 100,000 pulses/sec–1/5 step (6,000 RPM) 500,000 pulses/sec–1/25 step (6,000 RPM) 500,000 pulses/sec–1/125 step (1,200 RPM)
PWM chopping frequency	20 kHz, nominal (inaudible)
Operating temperature	
Full ratings	0° to 50°C ambient
Derated	50°C to 60°C ambient (contact factory for performance)
Storage temperature	-55°C to 70°C
Relative humidity	10% to 90%, noncondensing
User memory	12K battery backed RAM
Programming language	High level, PacSci Stepper BASIC™ (See page C-50 for command summary and page C-54 for programming examples)
Interfacing connectors (furnished)	
Motor	5 position, pluggable, screw terminal Phoenix connector (J1)
Serial port	9 pin D connector (J3)
I/O	Double height, 17 position, pluggable screw terminal Phoenix connector (J4 and J5)
Encoder input, step/direction output	Double height, 9 position, pluggable screw terminal Phoenix connector (J6 and J7)
AC line	3 position, pluggable, screw terminal Phoenix connector (J2)
Weight	11 lbs.
Recommended system motors	E Series, page C-82

CONNECTION DIAGRAM . . . Model 5645



DIMENSIONS $\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)



FRONT VIEW

SIDE VIEW

HOW TO ORDER . . . 5645 Recommended systems

Order motor and indexer/drive as separate model numbers. E Series motors, recommended for systems use, are equipped with MS type power connectors.

Systems motors Page C-82

Cabling and accessories Page D-3

SYSTEM RATINGS AND CHARACTERISTICS

8.0 and 5.0A,
160V per phase

Model 5645 with recommended E Series motors
See E Series motors...NEMA 34 (3.4") on page C-89 and NEMA 42 (4.2") on page C-97.

OD (in)	Motor Model Number [△]	Drive Current/ Phase (amps DC)	Holding [△]		Phase Resistance (ohms) ±10%	Phase [△] inductance (mH) ±20%	Rotor Inertia oz-in-S² (kgm² x 10⁻³)	Weight lbs (kg)	Peak Power (W)	Rated Speed at Peak Power (RPM)
			Torque (2 phases on)	Detent						
			oz-in (Nm) ±10%	Torque oz-in (Nm)						
Maximum torque at low speed (see plot T in performance curve)										
3.4	E34HC-HTLNK-NS50	5.0	1222 (8.63)	83.0 (0.59)	0.70	8.3	0.0350 (0.217)	9.7 (4.41)	430	1050
4.2	E41HC-HTLNK-NS50	5.0	1284 (9.07)	58.0 (0.41)	0.62	9.0	0.0800 (0.496)	14.0 (6.36)	430	1050
4.2	E42HC-HTLNK-NS50	8.0	2589 (18.28)	81.0 (0.57)	0.40	6.4	0.1600 (0.993)	21.0 (9.55)	640	750
4.2	E43HC-HTLNK-NS50	8.0	4034 (28.49)	106.0 (0.75)	0.60	11.2	0.2400 (1.489)	29.0 (13.18)	660	600

All ratings typical and at 25°C unless otherwise noted.

[△] See How to Order and Model Number Codes in System Motor Section, which begins on page C-82.

[△] When operated at listed driver current.

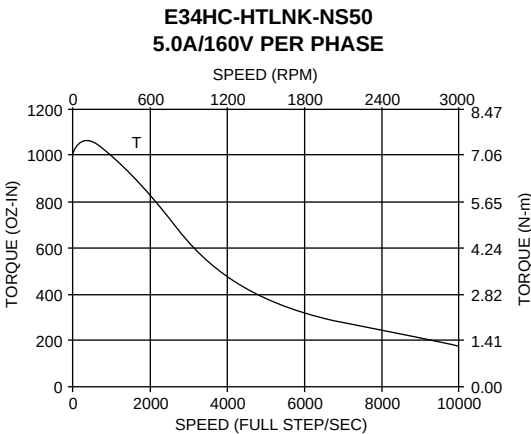
[△] Small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

Torque/Speed curves with recommended motors

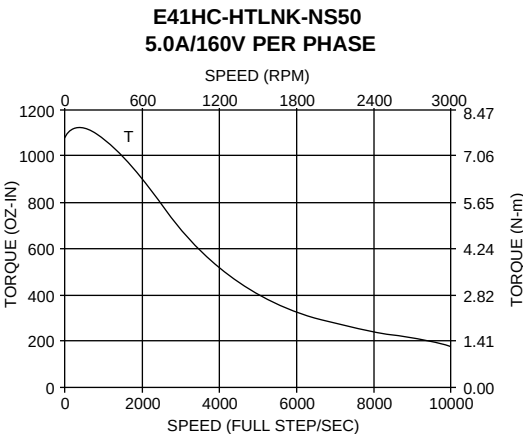
Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated unmounted (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and system parameters.

PERFORMANCE AT 5.0A/160V PER PHASE

(3" MOTOR-FOUR ROTOR STACKS)

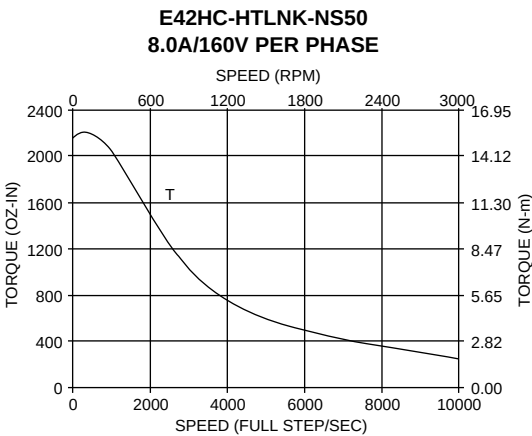


(4" MOTOR-ONE ROTOR STACK)

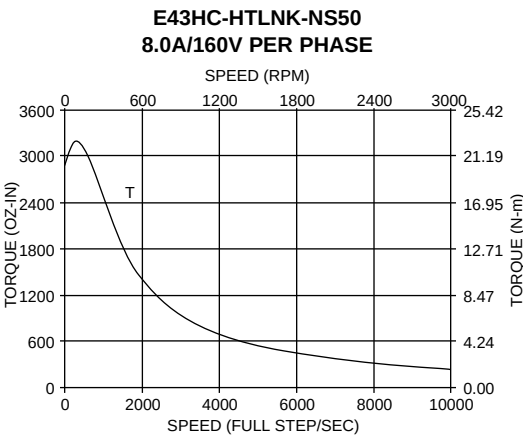


PERFORMANCE AT 8.0A/160V PER PHASE

(4" MOTOR-TWO ROTOR STACKS)



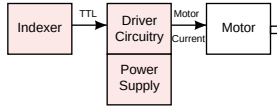
(4" MOTOR-THREE ROTOR STACKS)



MODELS 5445/5345*

Microstep indexer/drive packages 5.0 and 2.5A peak/65V per phase output

Self-contained indexer/driver package for hybrid step motors. Includes communications for programming and/or host controller. Nonvolatile memory provides onboard program storage and standalone operation.



- Easy programming in PacSci Stepper BASIC™
- Single and multi axis use
- Full, 1/2, 1/5, 1/25, 1/125 step operation
- Encoder interface for closed loop operation
- Inaudible, high frequency 20 kHz PWM chopping drive
- Direct 120/240 single phase line operation
- Compact panel mount

The Model 5445 (5.0A) and 5345 (2.5A) Microstep Indexer/Drive Packages combine a programmable indexer and high efficiency bipolar chopper MOSFET drive. These self-contained microstep indexer/drivers are ideal for medium power step motors.

Five switch selectable microstepping ranges deliver smooth low speed operation plus positioning resolution up to 25,000 steps/rev.

SIMPLIFIED PROGRAMMING

Motion control programming is simplified with PacSci Stepper BASIC™, an easy to learn extension of the familiar BASIC protocol. See page C-50.

Capabilities include complex single or multi-axis motion profiles, electronic gearing and more.

Programming is supported by PacCom™, an IBM PC® compatible software development environment. The indexer/drivers feature a full 12K of battery backed RAM user memory for storage of parameters and move profiles.

An RS-232/485 serial communications port is provided for programming and interfacing to host controllers. Sixteen programmable inputs and twelve programmable outputs are also provided.

ENCODER INTERFACE

The 5445 and 5345 accept quadrature encoder inputs to perform position verification and correction, stall detection and electronic gearing functions. An encoder with line drive output is required. Combined with microstepping resolutions up to 25,000 steps/rev, encoder feedback can greatly increase system accuracy. Both models accept typical encoder line counts from 200 to 1024.

FULL TORQUE AT ALL SPEEDS

Patented mid-range instability compensation ensures the availability of full motor torque at speeds up to 20,000 full steps/sec. (6000 RPM). This active control circuit modifies input step timing to damp rotor oscillation generated by the step motor's generated voltage.

In the full step mode, full motor torque is achieved throughout the speed range. In the microstep mode, motor torque is reduced to 70% of its full step level at speeds below 150 RPM.

HIGH PERFORMANCE CHOPPING

Also patented, 4-phase chopping combines the best of recirculating and nonrecirculating current regulation. The combination produces high back EMF rejection with low chopping ripple current.

When used with high performance step motor windings, benefits include reduced heat dissipation, low electrical noise and improved current control during motor braking. Typically, higher motor shaft power is also delivered to the load.

Holding torque range:
5445–319-1284 oz-in. (2.52-9.07 Nm)
5345–158-638 oz-in. (1.12-4.51 Nm)



HIGHER THROUGHPUTS

Idle current reduction permits an automatic 50% reduction in motor winding current during motor idle conditions.

In many applications, idle current reduction can improve machine throughput without exceeding motor or drive thermal ratings.

OPERATING FEATURES

- Two phase, full bridge, bipolar chopper MOSFET drive
- Switch selectable full, 1/2, 1/5, 1/25 and 1/125 step operation
- Switch selectable mid-range instability compensation, active above 500 full steps/sec
- Idle current reduction to 50% current one second after last step pulse

COMMUNICATIONS

- Serial interface:
RS-232, RS-422, RS-485, 9600 baud
- Enable and 16 discrete programmable inputs:
24 Vdc compatible, sourcing input, interface to contact closure or sinking output @1 mA max.
- Fault and 12 discrete programmable outputs:
24 Vdc compatible, sinking output, 0.6 V max. @50 mA sink
- Encoder/step & direction inputs:
Differential, quadrature, encoder interface, also accepts step & direction pulses
- Step & direction outputs:
Differential, TTL line driver for communication with slave drives

PROTECTION/DIAGNOSTICS

- LED status indicators:
Power, disabled, microprocessor fault
- In-rush current limiting
- Fused, MOV protected input
- Output short circuit protection
- Drive overtemperature shutdown

*Consult factory for detailed information on the new 6445 replacement product.

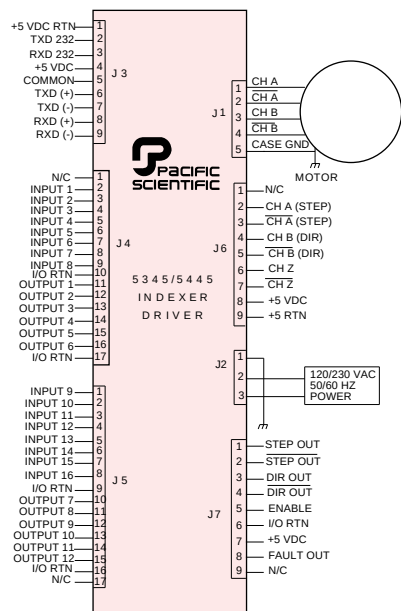
GENERAL. . .Models 5445 and 5345*

Input power	Specify 120 Vac ($\pm 10\%$), 50/60 Hz or 240 Vac ($\pm 10\%$), 1 phase, 50/60 Hz
Model 5445	5.0A rms maximum @ 120 Vac 2.5A rms maximum @ 240 Vac
Model 5345	2.5A rms maximum @ 120 Vac 1.25A rms maximum @ 240 Vac
Output current (per phase)	
Model 5445	5.0A (full step) 3.5A rms (microstep)
Model 5345	2.5A (full step) 1.75A rms (microstep)
Output bus voltage	65V nominal (w/ 120 Vac line)
Maximum input pulse rate	40,000 pulses/sec–full step (12,000 RPM) 80,000 pulses/sec–1/2 step (12,000 RPM) 100,000 pulses/sec–1/5 step (6,000 RPM) 500,000 pulses/sec–1/25 step (6,000 RPM) 500,000 pulses/sec–1/125 step (1,200 RPM)
PWM chopping frequency	20 kHz, nominal (inaudible)
Operating temperature	
Full ratings	0° to 50°C ambient
Derated	50°C to 60°C ambient (contact factory for performance)
Storage temperature	-55°C to 70°C
Relative humidity	10% to 90%, noncondensing
User memory	12K battery backed RAM
Programming language	High level, PacSci Stepper BASIC™ (See page C-50 for command summary and page C-54 for programming examples)
Interfacing connectors (furnished)	
Motor	5 position, pluggable, screw terminal Phoenix connector (J1)
Serial port	9 pin D connector (J3)
I/O	Double height, 17 position, pluggable screw terminal Phoenix connector (J4 and J5)
Encoder input, step/direction output	Double height, 9 position, pluggable screw terminal Phoenix connector (J6 and J7)
AC line	3 position, pluggable, screw terminal Phoenix connector (J2)
Weight	17 lbs.
Recommended system motors	E Series, page C-82

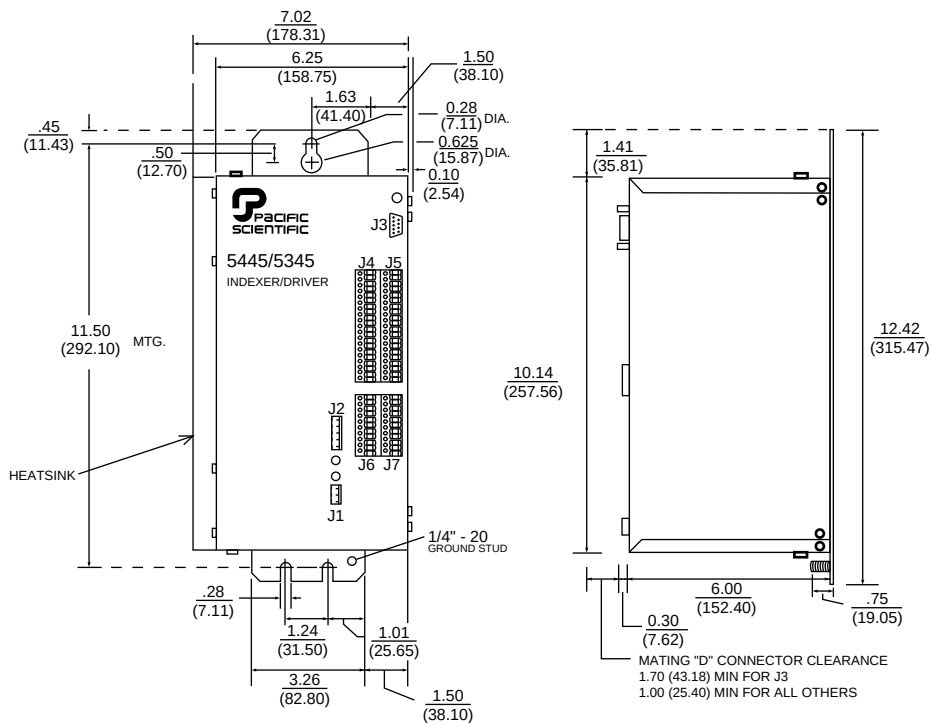
Note: For 240 Vac operation, designate by adding (-240) extension to drive.

**Consult factory for detailed information on the
new 6445 replacement product.*

CONNECTION DIAGRAM. . Models 5445 and 5345*



DIMENSIONS $\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)



HOW TO ORDER. . 5445 and 5345 Recommended systems

Order motor and indexer/drive as separate model numbers. If a 230 Vac input is required for the control, simply add a -230 suffix to the model number (e.g., 5445-230). E Series motors, recommended for systems use, are equipped with MS type power connectors.

Systems motors Page C-82

Cabling and accessories Page D-3

**Consult factory for detailed information on the new 6445 replacement product.*

SYSTEM RATINGS AND CHARACTERISTICS*

5.0A,
65V per phase

Model 5445 with recommended E Series motors
See E Series motors...NEMA 34 (3.4") on page C-89 and NEMA 42 (4.2") on page C-97.

OD (in)	Motor Model Number [△]	Holding [△]								
		Drive	Torque	Detent Torque oz-in (Nm)	Phase	Phase [△]	Rotor Inertia oz-in-S² (kgm² x 10⁻³)	Weight lbs (kg)	Peak Power (W)	Rated Speed at Peak (RPM)
		Current/	(2 phases on)		Resistance	inductance				
		Phase (amps DC)	oz-in (Nm) ±10%		(ohms) ±10%	(mH) ±20%				
Maximum torque at low speed (see plot T in performance curve)										
3.4	E31NC-HTLNN-NS50	5.0	319 (2.25)	21.5 (0.15)	0.30	2.3	0.0083 (0.051)	3.2 (1.45)	130	1200
3.4	E32NC-HTLNN-NS50	5.0	638 (4.51)	41.6 (0.29)	0.45	5.0	0.0170 (0.102)	5.3 (2.41)	130	600
3.4	E33NC-HTLNN-NS50	5.0	958 (6.77)	69.3 (0.45)	0.62	7.5	0.0250 (0.155)	7.6 (3.45)	140	450
3.4	E34HC-HTLNK-NS50	5.0	1222 (8.63)	83.0 (0.59)	0.70	8.3	0.0350 (0.217)	9.7 (4.41)	140	420
4.2	E41HC-HTLNK-NS50	5.0	1284 (9.07)	58.0 (0.41)	0.62	9.0	0.0800 (0.496)	14.0 (6.36)	147	450
Maximum torque at high speed (see plot P in performance curve)										
3.4	E32NC-HPLNN-NS50	5.0	474 (3.35)	41.6 (0.29)	0.20	2.3	0.0170 (0.102)	5.3 (2.41)	190	1200
3.4	E33NC-HPLNN-NS50	5.0	711 (5.02)	69.3 (0.45)	0.27	3.3	0.0250 (0.155)	7.6 (3.45)	215	900
3.4	E34HC-HPLNK-NS50	5.0	948 (6.69)	83.0 (0.59)	0.33	4.2	0.0350 (0.217)	9.7 (4.41)	200	750

2.5A,
65V per phase

Model 5345 with recommended E Series motors
See E Series motors...NEMA 23 (2.3") on page C-84 and NEMA 34 (3.4") on page C-89.

OD (in)	Motor Model Number [△]	Drive Current/ Phase (amps DC)	Holding [△]	Detent Torque oz-in (Nm)	Phase Resistance (ohms) ±10%	Phase [△] inductance (mH) ±20%	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)	Peak Power (W)	Rated Speed at Peak (RPM)
			Torque							
			(2 phases on) oz-in (Nm) ±10%							
Maximum torque at low speed (see plot T in performance curve)										
2.3	E22NC-LTLNN-NS50	2.5	225 (1.59)	9.6 (0.07)	1.24	3.8	0.0031 (0.019)	2.1 (0.95)	95	1500
3.4	E31NC-LTLNN-NS50	2.5	319 (2.25)	21.5 (0.15)	1.20	10.5	0.0083 (0.051)	3.2 (1.45)	66	600
3.4	E32NC-LTLNN-NS50	2.5	638 (4.51)	41.6 (0.29)	1.80	20.5	0.0170 (0.102)	5.3 (2.41)	66	300
Maximum torque at high speed (see plot P in performance curve)										
2.3	E22NC-LPLNN-NS50	2.5	158 (1.12)	9.6 (0.07)	0.71	1.8	0.0031 (0.019)	2.1 (0.95)	130	2550
3.4	E31NC-LPLNN-NS50	2.5	237 (1.67)	21.5 (0.15)	0.53	4.1	0.0083 (0.051)	3.2 (1.45)	100	1350
3.4	E32NC-LPLNN-NS50	2.5	474 (3.35)	41.6 (0.29)	0.80	9.2	0.0170 (0.102)	5.3 (2.41)	95	600

[△] All ratings typical and at 25°C unless otherwise noted.

[△] See How to Order and Model Number Codes in System Motor Section, which begins on page C-82.

[△] When operated at listed drive current.

[△] Small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

*Consult factory for detailed information on the new 6445 replacement product.

Model 5445 Torque/Speed curves
with recommended motors*

5.0A,
65V per phase

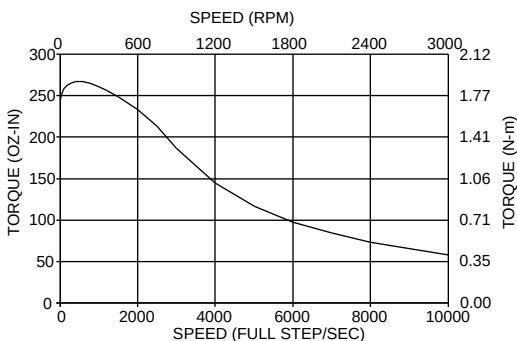
Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and systems parameters.

When driven by the 5445 and *not* microstepping, the motor produces full torque and follows the full step dynamic torque curve. However, when microstepping to achieve smooth operation at low speeds, motor torque is reduced to about 70% of that produced in the full step mode up to about 500 steps/sec. (150 RPM). Beyond 500 steps/sec., where microstepping is no longer required, a transition (transparent to user) occurs back to the full step dynamic torque curve.

PERFORMANCE AT 5.0A/65V PER PHASE

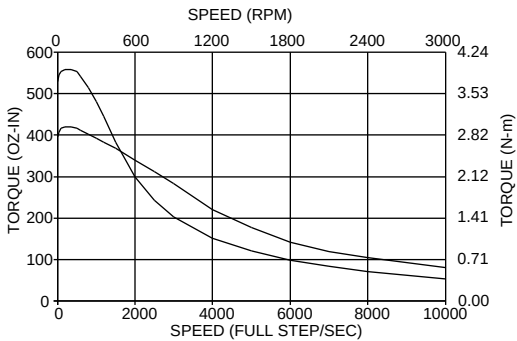
(3" MOTOR-ONE ROTOR STACK)

E31NC-HTLNN-NS50
5.0A/65V PER PHASE



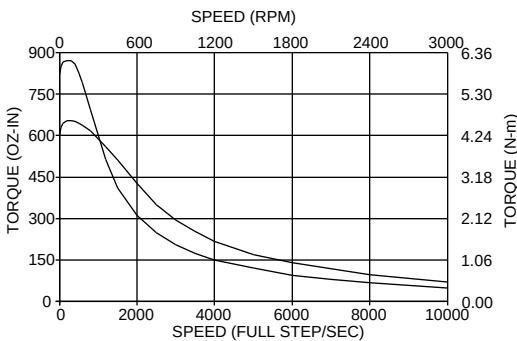
(3" MOTOR-TWO ROTOR STACKS)

E32NC-HTLNN-NS50
E32NC-HPLNN-NS50
5.0A/65V PER PHASE



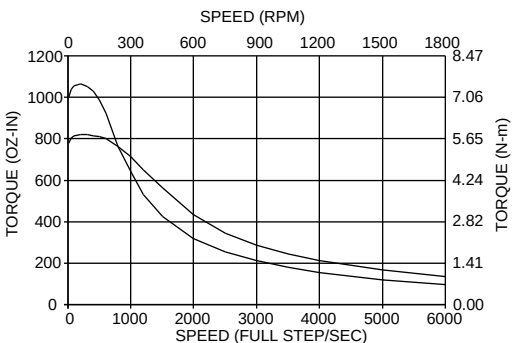
(3" MOTOR-THREE ROTOR STACKS)

E33HC-HTLNK-NS50
E33HC-HPLNK-1550
5.0A/65V PER PHASE



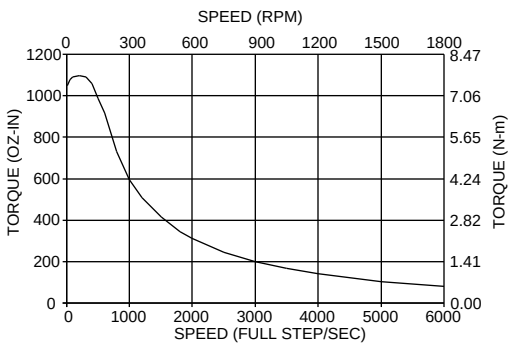
(3" MOTOR-FOUR ROTOR STACKS)

E34HC-HTLNK-NS50
E34HC-HPLNK-NS50
5.0A/65V PER PHASE



(4" MOTOR-ONE ROTOR STACK)

E41HC-HTLNK-NS50
5.0A/65V PER PHASE



*Consult factory for detailed information on the new 6445 replacement product.

Model 5345 Torque/Speed curves
with recommended motors*

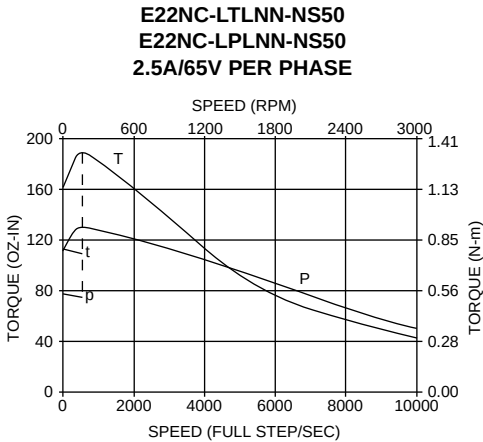
2.5A,
65V per phase

Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and systems parameters.

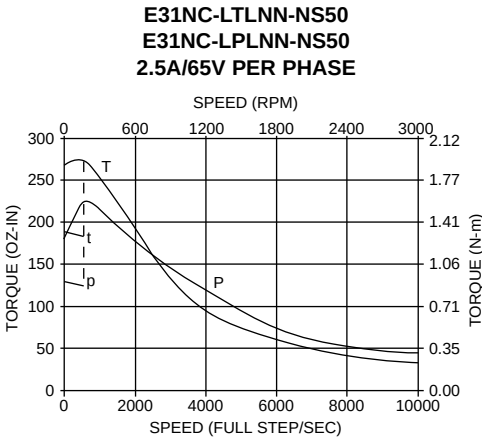
When driven by the 5345 and *not* microstepping, the motor produces full torque and follows the full step dynamic torque curve. However, when microstepping to achieve smooth operation at low speeds, motor torque is reduced to about 70% of that produced in the full step mode up to about 500 steps/sec. (150 RPM). Beyond 500 steps/sec., where microstepping is no longer required, a transition (transparent to user) occurs back to the full step dynamic torque curve.

PERFORMANCE AT 2.5A/65V PER PHASE

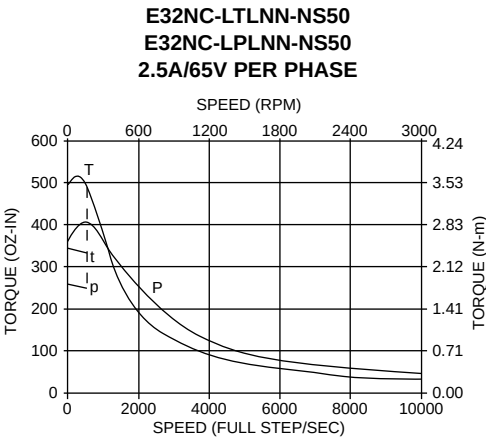
(2" MOTOR-TWO ROTOR STACKS)



(3" MOTOR-ONE ROTOR STACK)



(3" MOTOR-TWO ROTOR STACKS)



*Consult factory for detailed information on the new 6445 replacement product.

PROGRAMMING SOFTWARE. . . PacSci Stepper BASIC™

For programmable indexer/ drives Models 5645, 5445 and 5345

PacSci Stepper BASIC™ is a straightforward extension of the familiar BASIC protocol. Unlike specialized motion control programming languages, PacSci Stepper BASIC lets you concentrate on your application—not on learning a new language. Over 100 motion specific variables enable you to program your specific application requirements. Microprocessor controls provide full floating point math operations and conditional logic.

Full software documentation and programming help is always available.

Best of all, the PacSci Stepper BASIC programming language is similar to PacSci ServoBASIC™ for our brushless servo products. If you use both stepper and servo, you'll find a simple, common programming language.

APPLICATIONS

Use PacSci Stepper BASIC programming for single and multi-axis applications. To control velocity, acceleration and position. To generate incremental or absolute move profiles.

You can synchronize axes, emulate limit switches and trigger actions based on discrete inputs or registration marks.

In multi-axis point-to-point positioning applications, PacSci Stepper BASIC can eliminate the need for substantially more costly motion controllers.

COMMUNICATIONS TOOLKIT

PacCom™, a software development environment supporting PacSci Stepper BASIC, runs on your IBM or IBM compatible microcomputer. PacCom provides you with:

- Program upload/download utilities
- Terminal emulator
- Editor
- Syntax checker
- Serial port initialize function



INSIDE PACSCI STEPPER BASIC™

PacSci Stepper BASIC takes advantage of conventional BASIC's program flow, arithmetic, logic and I/O instructions. A range of motion-specific commands have simply been added.

PacSci's approach reflects research conducted with motion control users, who considered mnemonic programming overly limiting.

Our research identified a need among motion control users for a motion controller that's general purpose, flexible and programmable. Higher level languages—such as BASIC, PASCAL and C—were evaluated.

The majority of users preferred BASIC. Their primary objection to previous BASIC-like motion control languages was inconsistency of instruction sets, even among individual manufacturers' product lines.

PacSci Stepper BASIC has been carefully structured to overcome the limitations of earlier motion programming languages.

Programmable devices raise certain machine safety issues which are a user responsibility.

See page D-44 for an important statement of limited warranty and disclaimer regarding software provided by Pacific Scientific.

PACSCI STEPPER BASIC™ VERSION 3.6 COMMAND SUMMARY

For programmable indexer/drives, Models 5645, 5445 and 5345

ABS(x)

Returns the absolute value of a number.

ACCEL.RATE

= x is the rate the motor accelerates to change speed.

ADDRESS

Indicates the multi-drop address of the controller.

AND

Performs a logical AND operation.

AUTO

Generates program line numbers automatically.

CCW.OT

= x is the counterclockwise software overtravel step limit.

CCW.OT.JUMP

= x is the line number jumped to for counterclockwise overtravel errors.

CCW.OT.ON

= 1 enables counterclockwise overtravel checking.

CHR(x)

Converts an ASCII code to its equivalent character for display on the terminal.

CINT(x)

Converts a value to an integer by rounding off.

CLEAR

Clears FLGn, FLTn, and INTn to zero.

CLR.SCAN1;CLR.SCAN2

Turns Off Scan 1 and Scan 2.

CONT

Causes the program to continue after STOP is encountered.

CONTINUOUS.MOTION

= 1 for continuous motion over multiple moves.

CW.OT

= x is the clockwise overtravel limit.

CW.OT.JUMP

= x is the line number jumped to for clockwise overtravel errors.

CW.OT.ON

= 1 enables clockwise overtravel checking.

DCL.TRACK.ACL

= 1 for deceleration to occur at the same rate as acceleration;
= 0 for separate deceleration.

DECEL.RATE

= x is the rate the motor decelerates to change speed.

DELETE

Deletes one or more lines from a program.

DIR

= 0 for clockwise rotation (viewed from shaft-end); = 1 for counterclockwise rotation.

ENABLE

= 1 allows power flow to the motor.

ENABLED

= 1 is the read-only indicator that the control is enabled.

ENC.FREQ

= x is the display of the encoder frequency in pulses per second.

ENCDR.POS

= x is the display of external encoder position or a user-entered value to redefine encoder position.

ENCODER

= x specifies the line count of the external encoder for use with electronic gearing.

END

Terminates the execution of a program.

FAULTCODE

= 1 is the indicator that a fault has occurred; = 0 indicates no fault or is user entered to clear the code.

FLG1 to FLG8

= x is the user-defined flag (0 or 1) value.

FLT1 to FLT32

= x is the user-defined floating point (decimal) value.

FOR...NEXT

Allows a series of statements to be executed in a loop a given number of times.

FREE

Displays the number of free bytes of program memory.

GEARING

= 1 enables following the motion of a master control source; = 2 follows clockwise master inputs only; = 3 follows counterclockwise master inputs only.

GO.ABS

Commands a motor move to the position specified by TARGET.POS.

GO.FUNC

= x determines the response to Start (Input 7) when RMT.START = 0; = 0 performs GO.VEL; = 1 performs GO.INCR; = 2 performs GO.ABS.

GO.HOME

Commands a motor move to the electrical home position.

GO.INCR

Commands a motor move an incremental index (INDEX.DIST) from the current position.

GOSUB x...RETURN

Branches program execution to a subroutine, executes it, and returns.

GOTO

x causes program execution to jump to line number x.

GO.VEL

Moves the motor at constant speed (RUN.SPEED).

HOME.ACTIVE

= 0 for a physical home switch that opens at home (closed otherwise); = 1 if switch closes at home (open otherwise).

HMPOS.OFFSET

= x is the offset distance from the mechanical home position.

IF...THEN

Controls program execution based on the truth or falsity of an expression.

INDEX.DIST

= x is the distance the motor moves for each incremental index (GO.INCR).

INKEY()

Returns an ASCII code for the first keystroke in the terminal input buffer.

INP1 to INP16

= 1 is the read-only display for each input that is Off.

IN.POSITION

= 1 is the read-only indicator that the motor is at the commanded position.

INPUT variable

Obtains information from the terminal while the program is running.

INPUTS

= x is the BCD read-only display that corresponds to the sum of the Off inputs.

INT1 to INT32

= x is the user-defined integer value.

INT(x)

Converts a number into the largest integer less than or equal to the original number.

JOG.SPEED

= x is the speed the motor moves when jogging.

LIST

Displays the complete or partial program on the terminal screen.

PACSCI STEPPER BASIC™ VERSION 3.6 COMMAND SUMMARY...(Cont.)

LOAD

Copies saved programs stored in NVRAM into RAM.

LOADVAR

Copies stored global variables from NVRAM into RAM.

MAX.DECEL

= x is the rate the motor decelerates in certain conditions.

MIN.SPEED

= x is the minimum start/stop speed for the motor.

MOVING

= 1 is the read-only indicator that the motor is moving.

NEW

Clears the program from RAM and sets the value of FLGn, FLTn, and INTn to zero.

OR

Performs a logical OR operation.

OT.ERROR

= 0 is the read-only indicator for no overtravel error; = 1 indicates clockwise overtravel error; = 2 indicates counterclockwise overtravel error.

OUTPUTS

= x is the BCD value sum for turning On user-defined outputs.

PACK

Speeds up program execution by generating the GOTO table before the program executes.

PAUSE

Pauses a program for a time specified by WAIT.TIME.

POS.CHK1; POS.CHK2; POS.CHK3

= x is the commanded position at which outputs 1, 2, and 3 are turned Off or On.

POS.CHK1.OUT; POS.CHK2.OUT; POS.CHK3.OUT

= x specifies and enables or disables an output when POS.CHKn is exceeded.

POS.COMMAND

= x is the display of the commanded position or a user-entered value to redefine motor position.

POS.VERIFY.CORRECTION

= x is the read-only indicator of the number of steps required to compensate for a motor position verification error.

POS.VERIFY.DEADBAND

= x is the maximum step limit allowed before a Position Verification Error triggers.

POS.VERIFY.ERROR

= 1 is the read-only indicator that a position error has occurred.

POS.VERIFY.JUMP

= x is the line number jumped to upon a Position Verification Error.

POS.VERIFY.TIME

= x is the settling time for the encoder reading.

PREDEF.INP10 to PREDEF.INP15

= 1 enables individual predefined inputs 10 to 15; = 0 for discrete input operation.

PREDEF.INP

= x is the BCD value sum for predefining inputs 10 to 15 as a group.

PREDEF.OUT

= 1 enables predefined Output 12 to indicate motor moving; = 0 for discrete Output 12 operation.

PRINT

Displays program output on the terminal screen while the program is running.

PWR.ON.ENABLE

= 1 automatically enables the drive on power up.

PWR.ON.OUTPUTS

= x is the BCD value sum for enabling user-defined outputs on power up.

QRY

Displays the parameters and current status of the control on the terminal screen.

QRY.PRM

Displays the parameters of the control on the terminal screen.

QRY.STAT

Displays the current status of the control on the terminal screen.

RATIO

= x is the ratio between the motor shaft and the encoder shaft for use with electronic gearing.

REG.DIST

= x is the distance moved when the Registration input triggers.

REG.ENCPOS

= x is the display of the encoder position when the Registration input triggers.

REG.FLAG

= 1 indicates that a Registration input triggered; = 0 indicates no fault or is user-entered to clear the indicator.

REG.FUNC

= 1 enables a REG.DIST move when the Registration input triggers.

REM

Allows you to put comments in a program. These comments do not affect program execution and are removed when the program is downloaded to the drive.

RENUM

Renumbers program lines.

RESET.STACK

Clears the software internal stack of subroutine return addresses.

RETURN

Returns program execution from a subroutine.

RMT.START

= 0 causes a move based on GO.FUNC when Start (Input 7) triggered; = 1 causes a RUN command to execute when Start triggered; = 2 automatically executes a RUN command on power up. **Note:** For RMT.START = 0 or 1, PREDEF.INP7 must equal 1.

RUN

Executes all or part of a program in RAM.

RUN.SPEED

= x is the maximum motor speed.

SAVE

Saves program from RAM to NVRAM memory.

SAVEVAR

Saves INTn, FLTn, or a group of variables from RAM to NVRAM memory.

SEEK.HOME

Moves the motor to the mechanical limit switch.

SET.SCAN1; SET.SCAN2

Activates Scan 1 or Scan 2 to respond to the scan trigger.

SETUP

(lockcode 4800) initializes variables to default values. Must be used after a PROM with new software version is installed.

SK1.ENCPOS

Records the position of the external encoder when the SCAN condition is satisfied.

SK1.ENCPOS; SK2.ENCPOS

= x is the read-only encoder position displayed upon a Scan 1 or Scan 2 trigger.

SK1.JUMP; SK2.JUMP

= x is the line number jumped to upon Scan 1 or Scan 2 trigger.

PACSCI STEPPER BASIC™ VERSION 3.6 COMMAND SUMMARY...(Cont.)

SK1.OUTPUT; SK2.OUTPUT
= x specifies and enables or disables an output when a Scan 1 or Scan 2 is triggered.

SK1.TRIGGER; SK2.TRIGGER
= x defines the input condition that triggers a Scan 1 or Scan 2.

/(Slash)
Allows log on to a specific drive when using RS-422/485 and enables global command issuance.

STALL.DEADBAND
= x is the range allowed for a difference between commanded and measured steps. When exceeded, a stall error triggers.

STALL.ERROR
= 1 is the read-only indicator that a stall has occurred.

STALL.JUMP
= x is the line number jumped to upon a Stall Error.

STALL.STOP
= 1 to stop the motor when a stall occurs.

STEP.DIR.INPUT
= 0 configures encoder input J6 for quadrature encoder signals; = 1 configures encoder input J6 for step/direction signals.

STEPSIZE
= x is the step size in internal software.

STOP
Stops motion and interrupts the program.

STOP.MOTION
Stops motion while allowing continued program execution.

TARGET.POS
= x is the target position for GO.ABS.

TIME
= x is a continually running internal timer.

TRON and TROFF
Enable and disable tracing of executing program lines.

UPD.MOVE
Updates a move in process with new parameters.

VELOCITY
= x is the read-only display of the actual speed of the motor.

VER
Displays the current version of the software.

WAIT.TIME
= x is the wait time used with PAUSE.

WHEN
Executes an action when a condition is satisfied.

WHEN.ENCPOS
= x is the read-only encoder position display at the time the WHEN statement becomes true.

WHENPCMD
= x is the read-only commanded motor position display at the time the WHEN statement becomes true.

WHILE...WEND
Executes a series of statements as long as the expression after the WHILE statement is true.

PROGRAMMING EXAMPLES. . .PacSci Stepper BASIC™

These are actual programs demonstrating the flexibility of PacSci Stepper BASIC™ programming complex motion profiles.

PacSci Stepper BASIC is so inherently flexible that you may never need to tap its full potential. If there's a software solution to your problem, PacSci applications engineers will help you find it.

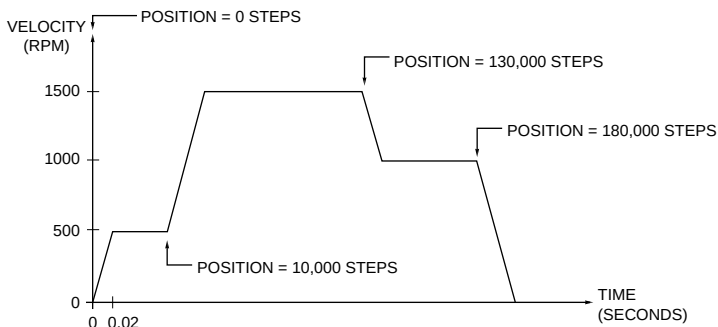
For programmable indexer/drives, Models 5645, 5445 and 5345

PROGRAMMING EXAMPLES

EXAMPLE 1. . .Velocity change on position count

This program produces a multiple level velocity profile. Velocity changes are initiated based upon position events.

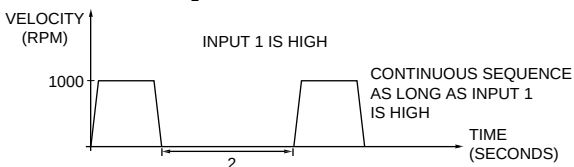
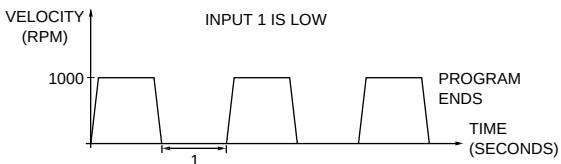
Program line		Comments
10	ACCEL.RATE = 5000	SET ACCEL TO 5,000 RPM/S
20	RUN.SPEED = 500	SET RUN SPEED TO 500 RPM
30	GO.HOME	GO TO THE HOME POSITION
40	IF MOVING THEN 40	LOOP UNTIL HOME
50	GO.VEL	GO TO 500 RPM
60	RUN.SPEED = 1500	SET RUN SPEED TO 1500 RPM
70	IF POS.COMMAND < 10000 THEN 70	LOOP UNTIL 10,000 STEPS
80	GO.VEL	GO TO 1500 RPM
90	RUN.SPEED = 1000	SET RUN SPEED TO 1000 RPM
100	IF POS.COMMAND < 130000 THEN 100	LOOP UNTIL 130,000 STEPS
110	GO.VEL	GO TO 1000 RPM
120	IF POS.COMMAND < 180000 THEN 120	LOOP UNTIL 180,000 STEPS
130	STOP.MOTION	GO TO 0 RPM
140	END	END PROGRAM



EXAMPLE 2. . .Jump on input

Here, the IF . . THEN command is used to test a discrete input and take action depending upon the state of the input. The jumps in the program depend upon the state of Input 1.

Program line		Comments
10	ACCEL.RATE = 5000	SET ACCEL TO 5,000 RPM/S
20	RUN.SPEED = 1000	SET RUN SPEED TO 1,000 RPM
30	CYCLE.COUNT = 1	SET CYCLE COUNTER TO 1
40	INDEX.DIST = 70000	SET INDEX DISTANCE TO 70,000 STEPS
50	IF INP1 = 1 THEN 100	TEST INPUT 1 STATE IF INPUT 1 IS HIGH GO TO 100 IF INPUT 1 IS LOW GO TO 60
60	DWELL.TIME = 1	SET DWELL TIME TO 1 SECOND
70	CYCLE.COUNT = 3	SET CYCLE COUNTER TO 3
80	GO.INCR	INITIATE INCREMENTAL MOVES
90	END	END PROGRAM
100	WAIT.TIME = 2	SET PAUSE TIME TO 2 SECONDS
110	GO.INCR	INITIATE INCREMENTAL MOVE
120	IF MOVING THEN 120	HOLD ON LINE UNTIL PREVIOUS MOVE IS COMPLETE
130	PAUSE	PAUSE FOR 2 SECONDS
140	GOTO 50	GO BACK TO 50



EXAMPLE 3. . Using WHEN for rapid response

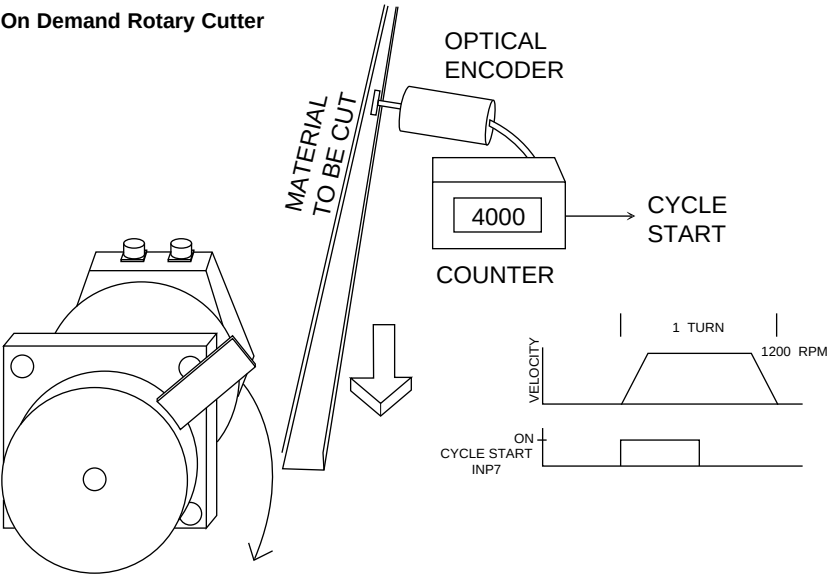
Use the PacSci Stepper BASIC™ instruction WHEN to achieve high speed reponse to inputs.

This program rotates a cutting blade one full revolution on the off-to-on transition of input INP7. WHEN ensures that the incremental move is initiated within one millisecond of the input transition.

Typically the cut command is derived from an encoder and counter, which measure length of material passing the blade.

Program line	Comments
5 STEPSIZE = 25	SET MICROSTEP SIZE TO 25 MICROSTEPS/STEP
10 OUTPUTS = 4095	ALL OUTPUTS TURNED OFF (HIGH)
20 ENABLE = 1	SOFTWARE ENABLE FLAG TURNED ON
30 WAIT.TIME = 0.100000	SET WAIT TIME TO EQUAL .1 SECOND
40 WHILE ENABLED = 0	EXECUTE LINES 50-90 IF NOT ENABLED
50 OUT1 = 0	TURN OUTPUT 1 ON (LOW)
60 PAUSE	WAIT FOR 0.1 SECOND
70 OUT1 = 1	TURN OUTPUT 1 OFF (HIGH)
80 PAUSE	WAIT FOR 0.1 SECOND
90 WEND	LOOP BACK TO WHILE STATEMENT (LINE 40)
100 ACCEL.RATE = 2000	SET ACCELERATION TO 2000 RPM/S
110 RUN.SPEED = 1200	SET RUN SPEED TO 1200 RPM
120 INDEX.DIST = 5000	SET INDEX DISTANCE TO 5000 STEPS
130 CYCLE.COUNT = 1	SET CYCLE COUNT TO 1 (SEE GO.INCR)
140 OUT7 = 0	TURN OUTPUT 7 ON (LOW)
150 IF INP7 = 0 THEN 170	WAIT FOR INPUT 7 TO GO HIGH
160 WHEN INP7 = 0, GO.INCR	INDEX MOTOR WHEN INPUT 7 GOES LOW
170 OUT7 = 1	TURN OUTPUT 7 OFF (HIGH)
180 IF MOVING THEN 180 ELSE 140	HOLD ON LINE UNTIL MOVE COMPLETE

On Demand Rotary Cutter



EXAMPLE 4. . .Sample thumbwheel interface program

This program uses a block of four thumbwheels interfaced to a Model 5645, 5445 or 5345 indexer/drive to perform user selected feed-to-length operation.

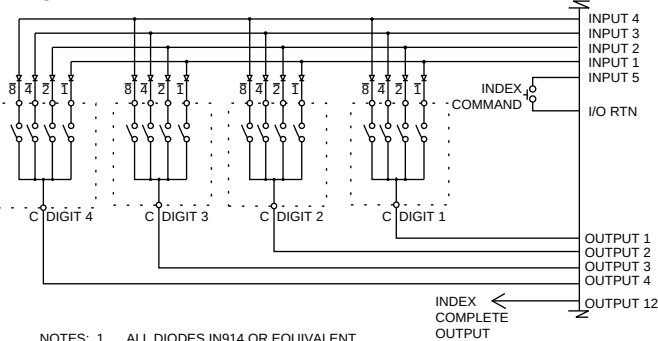
The thumbwheel is configured to have three digits to the left of the decimal point and one to the right. So an example index distance might be 120.2 revolutions. A move is made when Input 5 is tripped.

Program line	Comments
50 ACCEL_RATE=3000	SET ACCEL TO 3000 RPM/S
60 CYCLE_COUNT=1	SET CYCLE COUNTER TO 1
70 RUN_SPEED=1000	SET RUN SPEED TO 1000 RPM
80 WAIT_TIME=.25	SET WAIT TIME TO 0.25 S
90 OUT5=0	SET OUTPUT 5 LOW
120	READ FEED LENGTH FROM THUMBWHEELS
140 OUT1=1: OUT2=1: OUT3=1: OUT4=1: OUT5=1	ALL STROBES OFF(HIGH)
160	STROBE AND READ DIGIT 1
180 OUT1=0	TURN DIGIT 1 STROBE ON(LOW)
190 GOSUB 1000	GO TO READ BCD DIGIT SUBROUTINE
200 INDEX_DIST=0	CLEAR INDEX DISTANCE
210 INDEX_DIST=0.1*INT1	SCALE DIGIT 1 TO 0.1'S & STORE
230	STROBE AND READ DIGIT 2
250 OUT1=1: OUT2=0	DIGIT 1 STROBE OFF, DIGIT 2 STROBE ON
260 GOSUB 1000	GO TO READ BCD DIGIT SUBROUTINE
270 INDEX_DIST=INDEX_DIST+INT1	SCALE DIGIT 2 TO 1'S AND ADD
290	STROBE AND READ DIGIT 3
310 OUT2=1: OUT3=0	DIGIT 2 STROBE OFF, DIGIT 3 STROBE ON
320 GOSUB 1000	GO TO READ BCD DIGIT SUBROUTINE
330 INDEX_DIST=INDEX_DIST+10*INT1	SCALE DIGIT 3 TO 10'S AND ADD
350	STROBE AND READ DIGIT 4
370 OUT3=1: OUT4=0	DIGIT 3 STROBE OFF, DIGIT 4 STROBE ON
380 GOSUB 1000	GO TO READ BCD DIGIT SUBROUTINE
390 INDEX_DIST=INDEX_DIST+100*INT1	SCALE DIGIT 4 TO 100'S & ADD
410	SCALE REVOLUTIONS TO STEPS
430 INDEX_DIST=INDEX_DIST*4096	CONVERT REVOLUTIONS TO STEPS
500	MOVE ROUTINE
520 IF INP5=1 THEN 520	WAIT FOR INDEX SIGNAL ON INPUT 5
530 GO_INCR	DO INDEX MOVE
540 WHILE POSITION<>POS_COMMAND	WAIT FOR INDEX COMPLETE
550 OUT5=1	SET INDEX COMPLETE OUTPUT HIGH
560 PAUSE	WAIT .25 S
570 OUT5=0	SET INDEX COMPLETE LOW
580 GOTO 120	GO TO READ THUMBWHEELS
1000	READ BCD DIGIT SUBROUTINE
1020 INT1=INP1*1+INP2*2+INP3*4+INP4*8	READ BCD DIGIT
1030 RETURN	RETURN FROM SUBROUTINE

NOTES: Δ With PREDEF.OUT = 1 output 12 will be in a state of 1 when the motor is moving. Output 12 is the designated moving output.

Δ In line 1020 reading the inputs can be done in the following way:
INT1 = INPUTS AND15. This just looks at the value of the first 4 inputs and converts to decimal equivalent.

4 Digit Thumbwheel Interface



- NOTES: 1. ALL DIODES IN914 OR EQUIVALENT
2. THUMBWHEELS ARE COMPLEMENTARY BCD
C&K 3 SERIES TYPE 23 OR EQUIVALENT

EXAMPLES 5 & 6. . .Closed loop operation (with encoder feedback)

This program is a method for position correction. Four PacSci Stepper BASIC™ variables are key to operation:

POS.VERIFY.TIME POS.VERIFY.JUMP
POS.VERIFY.DEADBAND POS.VERIFY.CORRECTION

Program line	Comments
10 MIN.SPEED = 10	SETS START/STOP SPEED TO 10 RPM
20 RUN.SPEED = 1000	SETS RUN.SPEED TO 1000 RPM
30 ACCEL.RATE = 5000	SETS ACCELERATION RATE TO 5000 RPM/SEC.
40 ENCODER = 1000	SETS ENCODER TO 1000 PPR.
50 WAIT.TIME = .250	SETS TIME FOR PAUSE
60 POS.VERIFY.TIME = 200	ESTABLISHES A SETTLING TIME OF 200 MS.
70 POS.VERIFY.DEADBAND = 10	SETS ALLOWABLE DIFFERENCE BETWEEN COMMANDED AND MEASURED MICROSTEPS
75 POS.VERIFY.JUMP = 1000	WHEN STALL OCCURS AUTO JUMP TO 1000
80 INPUT "ENTER DISTANCE IN STEPS", INDEX.DIST	USER INPUT DISTANCE
90 POS.COMMAND = 0 ENCDR.POS = 0	RESET COMMAND POSITION AND ENCODER POSITION
100 GO.INCR	EXECUTE INCREMENTAL MOVE
150 IF MOVING THEN 150	SYNCHRONIZE PROGRAM RUNTIME
175 PAUSE	PAUSE FOR 250 MS.
500 GOTO 2000	GO TO END OF PROGRAM
1000 PRINT "MAKING CORRECTION MOVE"	PRINT MESSAGE
1010 INDEX.DIST = POS.VERIFY.CORRECTION	SET NEW INDEX TO CORRECTION ERROR
1020 GO.INCR	EXECUTE CORRECTION MOVE
1030 IF MOVING THEN 1030	SYNCHRONIZE PROGRAM RUN TO MOTION
1035 PAUSE	WAIT 250 MS.
2000 PRINT "FINAL ENCODER POSITION IS" ENCDR.POS	PRINT MESSAGE
2100 END	END OF PROGRAM

This program is a method for stall detection. Three PacSci Stepper BASIC™ variables are key to operation:

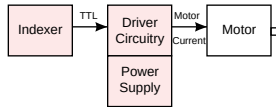
STALL.DEADBAND
STALL.JUMP
STALL.STOP

Program line	Comments
10 MIN.SPEED = 10	SETS START/STOP RATE TO 10 RPM
20 RUN.SPEED = 800	SETS RUN SPEED TO 800 RPM
30 ACCEL.RATE = 1000	SETS ACCELERATION RATE TO 1000 RPM/SEC.
40 MAX.DECEL = 10000	SETS MAXIMUM DECELERATION USED WITH STOP COMMAND
50 INDEX.DIST = 100000	SETS DISTANCE TO MOVE IN STEPS
60 STALL.DEADBAND = 200	SETS ALLOWABLE DIFFERENCE BETWEEN POSITION COMMAND AND ENCODER POSITION
70 STALL.JUMP = 1000	CAUSES JUMP TO LINE 1000 IF STALL OCCURS
80 STALL.STOP = 1	CAUSES STOP MOTION IF STALL OCCURS
90 POS.COMMAND = 0 ENCDR.POS = 0	RESETS POSITION COMMAND AND ENCODER POSITION
100 GO.INCR	EXECUTE INCREMENTAL MOVE
150 IF MOVING THEN 150	SYNCHRONIZE PROGRAM RUN TIME TO MOTION
160 PAUSE	WAIT
170 GOTO 90	REPEAT CYCLE
1000 PRINT "MOTOR STALLED AT "CINT (ENCDR.POS * 1.250000)" STEPS"	MESSAGE PRINTED

MODEL 5240*

Programmable indexer/driver 2.5A/35V per phase driver output

Self-contained indexer/driver package for hybrid step motors. Includes RS-232 communications for programming and/or host controller. Nonvolatile memory provides onboard program storage and standalone operation.



- Economical indexer with simple mnemonic programming
- Full and half step operation
- RS-232 interface
- High frequency, inaudible 17 kHz PWM chopping drive
- Direct 120 Vac line operation
- Self-contained, panel mount

The Model 5240 Indexer/Drive Package combines a programmable indexer and high efficiency bipolar MOSFET drive. This self-contained full and half step indexer/driver provides high performance for low power step motors.

The integrated indexer/driver design offers a convenient, economical alternative to user connection of individual components. The 5240 is ideal for applications without requirements for microstepping or the full software control capabilities of our Model 5645, 5445 and 5345 indexer/drivers.

Consider controlling the Model 5240 with a PLC/ASCII module or a smart user terminal.

SIMPLIFIED PROGRAMMING INSTRUCTIONS

Twenty-five simple mnemonic commands allow you to program a wide range of trapezoidal motion profiles, including incremental and absolute position moves. Programmable parameters include acceleration, maximum velocity parameters and constant velocity.

In immediate mode, instructions are executed upon remote trigger or manually entered command. In program mode, instructions are stored for execution as a program. The Model 5240 features 223 bytes of usable nonvolatile RAM memory.

IDLE CURRENT REDUCTION

This useful function permits an automatic reduction in motor winding current to 1.25A when no motor motion is commanded after 1.0 second. Use idle current reduction to minimize heating during dwell periods.

Holding torque range:
112-638 oz-in. (.79-4.51Nm)



OPERATING FEATURES

- Constant current, full bridge MOSFET bipolar chopper drive
- Switch selectable full and half step operation
- Move distance selectable from 1 to 65,535 steps, with cycle counter
- Run velocity selectable up to 10,000 full steps/sec (3000 RPM)
- Start/stop velocity selectable from 0 to 2550 full steps/sec
- Preset dwell time from 0.001 to 65 sec

COMMUNICATIONS

- RS-232 (300 to 9600 Baud)
- 5 bidirectional user programmable I/O
- Dedicated inputs:
 - Jog, remote stop, go, limit, home switch inputs
- Dedicated outputs:
 - Moving, distance event

PROTECTION

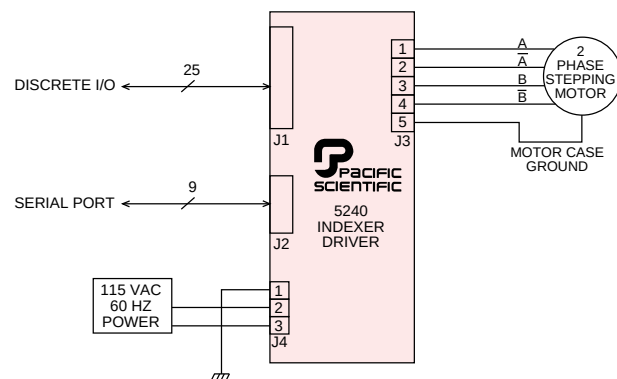
- Full drive short circuit protection
- Optical isolation between indexer and drive
- Drive overtemperature shutdown
- Output protection:
 - Phase-to-phase, phase-to-ground, phase-to-supply

*Consult factory for detailed information on the new 6440 replacement product.

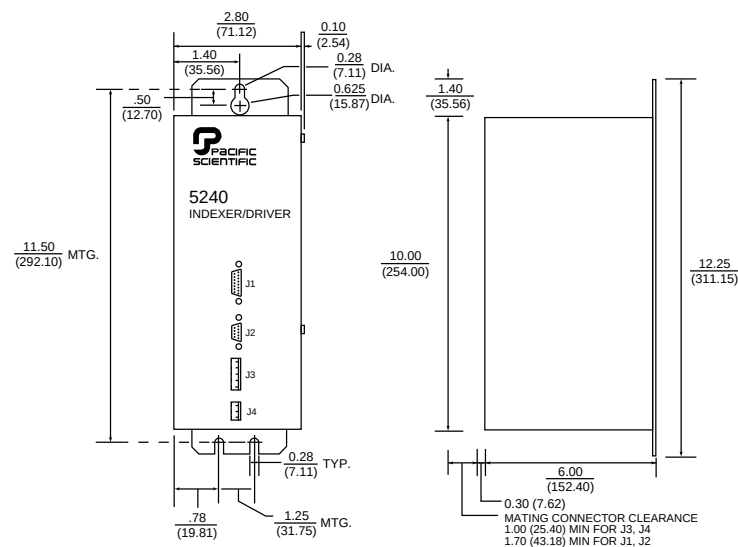
GENERAL. . .Model 5240*

Input power	Specify 120 Vac (±10%), 50/60 Hz or 240 Vac (+5, -10%), 1 phase, 50/60 Hz 1.0 A rms maximum @ 120 Vac 0.5 A rms maximum @ 240 Vac
Output current per phase	2.5A
Output bus voltage	35V nominal
Maximum input pulse rate	20 kHz
PWM chopping frequency	17 kHz nominal (inaudible)
Operating temperature	
Full ratings	0° to 50°C ambient
Derated	50°C to 60°C ambient (contact factory for performance)
Storage temperature	-55°C to 70°C
Relative humidity	10% to 90% (noncondensing)
User memory	223 bytes
Programming language	Mnemonic (see Command Summary, page C-62)
Interfacing connectors (furnished)	
Motor	5 position, pluggable, screw terminal Phoenix connector (J3)
AC line	3 position, pluggable, screw terminal Phoenix connector (J4)
Interfacing connectors (user provides)	
I/O, disable, jog, jog home, overtravel, remote start/stop	25 pin D connector (J1)
Serial Port	9 pin D connector (J2)
Weight	6 lbs.
Recommended system motors	E Series, page C-82

CONNECTION DIAGRAM. . .Model 5240



DIMENSIONS in. (metric dimensions for ref. only)



FRONT VIEW

SIDE VIEW

*Consult factory for detailed information on the new 6440 replacement product.

SYSTEM RATINGS AND CHARACTERISTICS*

2.5A,
35V per phase

Model 5240 with recommended E Series motors
See E Series motors...NEMA 23 (2.3") on page C-84 and NEMA 34 (3.4") on page C-89.

OD (in)	Motor Model Number [△]	Holding [△]								
		Drive	Torque		Phase	Phase [△]				Rated
		Current/	(2 phases on)	Detent	Resistance	inductance	Rotor Inertia		Peak	Speed at
		Phase	oz-in (Nm)	Torque	(ohms)	(mH)	oz-in-S²	Weight	Power	Peak Power
		(amps DC)	±10%	oz-in (Nm)	±10%	±20%	(kgm² x 10 ⁻³)	lbs (kg)	(W)	(RPM)
Maximum torque at low speed (see plot T in performance curve)										
2.3	E21NC-HTLNN-NS50	2.5	112 (0.79)	4.8 (0.03)	0.71	2.1	0.0016 (0.010)	1.2 (0.55)	54	1650
2.3	E22NC-LTLNN-NS50	2.5	225 (1.59)	9.6 (0.07)	1.24	3.8	0.0031 (0.019)	2.1 (0.95)	52	750
3.4	E31NC-LTLNN-NS50	2.5	319 (2.25)	21.5 (0.15)	1.20	10.5	0.0083 (0.051)	3.2 (1.45)	36	300
3.4	E32NC-LTLNN-NS50	2.5	638 (4.51)	41.6 (0.29)	1.80	20.5	0.0170 (0.102)	5.3 (2.41)	35	150
Maximum torque at high speed (see plot P in performance curve)										
2.3	E22NC-LPLNN-NS50	2.5	158 (1.12)	9.6 (0.07)	0.71	1.8	0.0031 (0.019)	2.1 (0.95)	75	1500
3.4	E31NC-LPLNN-NS50	2.5	237 (1.67)	21.5 (0.15)	0.53	4.1	0.0083 (0.051)	3.2 (1.45)	55	750
3.4	E32NC-LPLNN-NS50	2.5	474 (3.35)	41.6 (0.29)	0.80	9.2	0.0170 (0.102)	5.3 (2.41)	55	450

All ratings typical and at 25°C unless otherwise noted.

- [△] See How to Order and Model Number Codes in System Motor Section, which begins on page C-82.
- [△] When operated at listed driver current.
- [△] Small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

*Consult factory for detailed information on the new 6440 replacement product.

Model 5240 Torque/Speed curves with recommended motors*

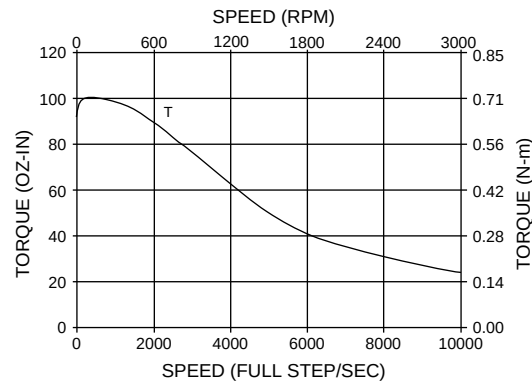
2.5A,
35V per phase

Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated unmounted (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and system parameters.

PERFORMANCE AT 2.5A/35V PER PHASE

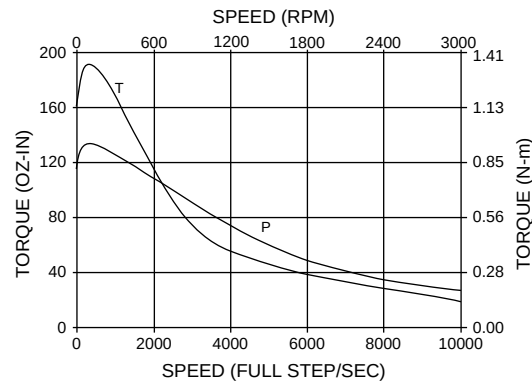
(2" MOTOR-ONE ROTOR STACK)

E21NC-HTLNN-NS50
2.5A/35V PER PHASE



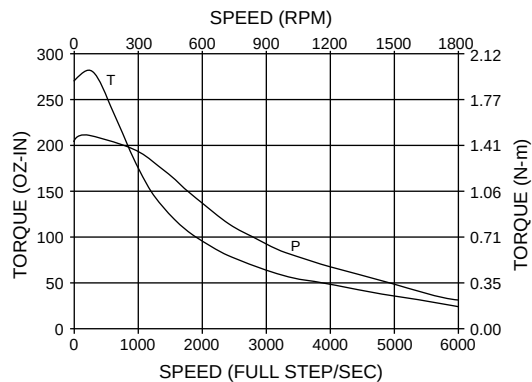
(2" MOTOR-TWO ROTOR STACKS)

E22NC-LTLNN-NS50
E22NC-LPLNN-NS50
2.5A/35V PER PHASE



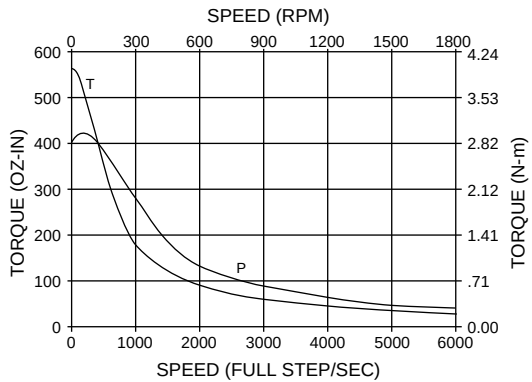
(3" MOTOR-ONE ROTOR STACK)

E31NC-LTLNN-NS50
E31NC-LPLNN-NS50
2.5A/35V PER PHASE



(3" MOTOR-TWO ROTOR STACKS)

E32NC-LTLNN-NS50
E32NC-LPLNN-NS50
2.5A/35V PER PHASE



*Consult factory for detailed information on the new 6440 replacement product.

COMMAND SUMMARY. . .Model 5240*

COMMAND	DESCRIPTION	MODES [△]	NOTES	COMMAND	DESCRIPTION	MODES [△]	NOTES
ESC	Abort/terminate	I,P	△	Q n	Query status	I	
A 1	Clear memory and initialize	I	△	R nn	Set ramp to velocity mode	I,P	
C b	Enable current	I,P	△	S	Stop	I,P	△
E aa	Edit from address aa	I	△	U aa k	Jump to address on input port		
F nn	Start/stop velocity	I,P	△	V nn	Set velocity	I,P	△
G aa b	Go from address aa, trace	I	△	W nn	Set wait time	P	
H nn b	Return to home	I	△	Y n	Set output port	I,P	
J aa n	Jump to address aa, n + 1 times	P		Z p	Set position counter	I,P	
K	Read input port	I,P		+ nn	Incremental move, positive	I,P	△
L aa	List from address aa	I		- nn	Incremental move, negative	I,P	△
M n	Set accel/decel slope	I,P	△	@ p	Absolute move	I,P	△
O p	Distance event	I,P		\ n	Divide	I,P	△
P	Store parameters	I	△				

△ Modes: I = immediate, P = program

△ Command should not be executed with motion in progress

b: Data bit (0 or 1)

aa: Nonvolatile memory address

nn: Data

△ Slope can be changed during Ramp to Velocity moves

△ May be executed at any time

n: Data byte

p: Position data

k: Port level

HOW TO ORDER. . .5420 Recommended systems

Order motor and indexer/drive as separate model numbers. If a 230 Vac input is required for the control, simply add a -230 suffix to the model number (e.g., 5240-230). E Series motors, recommended for systems use, are equipped with MS type power connectors.

- Systems motors Page C-82
- Cabling and accessories Page D-3

*Consult factory for detailed information on the new 6440 replacement product.

PROGRAMMING EXAMPLES. . .Model 5240*

These examples demonstrate the Model 5240's mnemonic programming capabilities. Ask Pacific Scientific for additional program examples and applications engineering assistance.

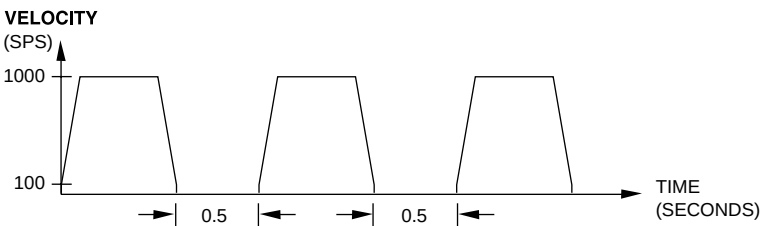
MULTIPLE MOVES

This program illustrates the generation of multiple moves utilizing the jump on counter command.

Program:

0	M5
2	F100
5	V1000
8	+1000
11	W500
14	J8 2
17	E

Result:



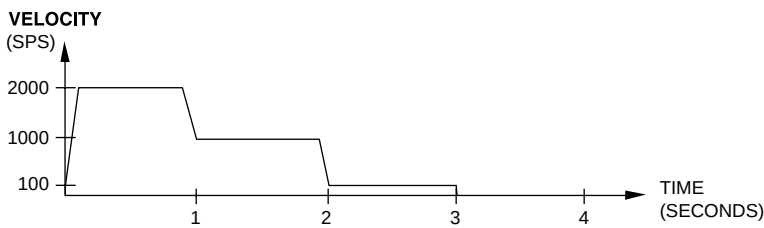
VELOCITY PROFILES

This example uses the ramp to velocity command, which can be used to generate complex velocity profiles.

Program:

0	M5
2	F100
5	R2000
8	W1000
11	R1000
14	W1000
17	R100
20	W1000
23	R0
26	E

Result:



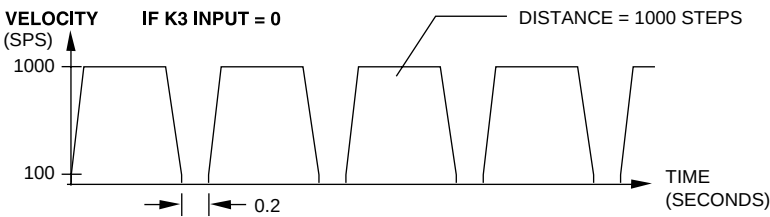
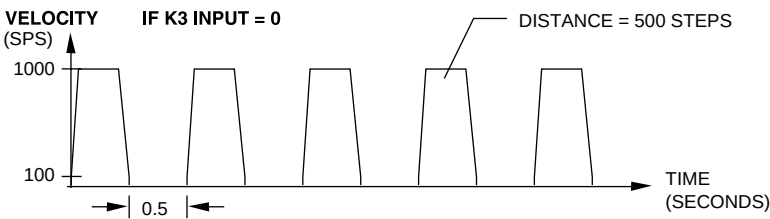
CONDITIONAL JUMPS

This program illustrates the conditional jump on an input state. The K3 input is used to select which profile is

Program:

0	M5
2	F100
5	V1000
8	U19 4
11	+500
14	W500
17	G8
19	+1000
22	W200
25	G8
27	E

Result:



*Consult factory for detailed information on the new 6440 replacement product.



5000 SERIES STEP MOTOR DRIVES

With Pacific Scientific, you are not limited to predefined systems. We offer a broad range of step motor drives to complement your in-house motion control design.

Your choices range from economical board level oscillator/drives to self-contained microstep drives. Whether you're controlling motion with a PLC or a EuroCard mounted microprocessor, we have off-the-shelf solutions.

Combine your indexing hardware with our extensive selection of step motors and drives. We're equally comfortable driving a half stack NEMA 23 motor or integral horsepower motor. Whether you need quiet, rapid cycling for a business machine or precisely controlled metalworking muscle, you'll find the answers in this catalog.

OFF-LINE DRIVE PACKAGES

Ready to run driver packages are available in power ranges up to 11.3A peak—the same as our programmable indexer/drives.

These full featured, bipolar MOSFET chopper drives offer microstepping and patented control circuitry for exceptional performance.

Optically isolated I/O, supplied connectors and panel mount configuration assure fast, troublefree startup. Protective features and LED status indicators help keep your system up and running.



OFF-LINE DRIVE PACKAGES Pages C-66, C-69, C-74

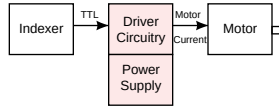


MODEL 5630

Microstep drive package 11.3A peak (microstep) 160V per phase output

- Plug & play package
- Full, 1/2, 1/5, 1/25, 1/125 step operation
- High frequency, inaudible 20 kHz PWM chopping drive
- Optically isolated I/O
- Full short circuit protection
- Direct 120 Vac line operation
- Compact panel mount
- Drives motors over 1 HP
- UL recognized

Includes both bipolar chopper drive circuitry and power supplies for operation from AC power sources.



The Model 5630 Microstep Drive Package is a high efficiency bipolar chopper MOSFET drive for medium to high power step motors. Drive and motor plug together and are ready to run in minutes.

Five switch selectable microstepping ranges deliver smooth low speed operation plus positioning resolution up to 25,000 steps/rev.

The 5630 features four switch selectable output current ranges, from 5.0A rms (7.1A peak microstep) to 8.0A rms (11.3A peak microstep) per phase.

FULL TORQUE AT ALL SPEEDS

Patented mid-range instability compensation ensures the availability of full motor torque at all speeds. This active control circuit modifies input step timing to damp rotor oscillation generated by the step motor's generated voltage.

In addition, microstepping drives typically drop the motor's torque to 70% of that achieved when in the full step mode. Model 5630, however, continuously supplies RMS current equivalent to the DC rated value of the motor to prevent any torque loss.

HIGH PERFORMANCE CHOPPING

Also patented, 4-phase chopping combines the best of recirculating and nonrecirculating current regulation. The combination produces high back EMF rejection with low chopping ripple current.

When used with high performance step motor windings, benefits include reduced heat dissipation, low electrical noise and improved current control during motor braking. Typically, higher motor shaft power is also delivered to the load.

IDLE CURRENT REDUCTION

This DIP switch selectable function permits an automatic 50% reduction in motor winding current during motor idle conditions. Use idle current reduction to minimize heating during dwell periods.

Holding torque range:
1222-4034 oz-in. (8.63-28.49 Nm)



OPERATING FEATURES

- Two phase, full bridge, bipolar chopper MOSFET drive
- Switch selectable step size:
Full, 1/2, 1/5, 1/25, 1/125
- Switch selectable mid-range instability compensation, active above 150 RPM (500 full steps/sec)
- Switch selectable idle current reduction to 50% current one second after last step pulse

COMMUNICATIONS

- Optically isolated inputs:
Enable, step, direction, reset
- Optically isolated fault output

PROTECTION/DIAGNOSTICS

- LED status indicators:
Power, enabled, step active, power fault, temperature fault
- In-rush current limiting
- Fused, MOV protected input
- Output short circuit protection
- Drive overtemperature shutdown

AGENCY APPROVAL

Model 5630 is UL Recognized (File E137798)

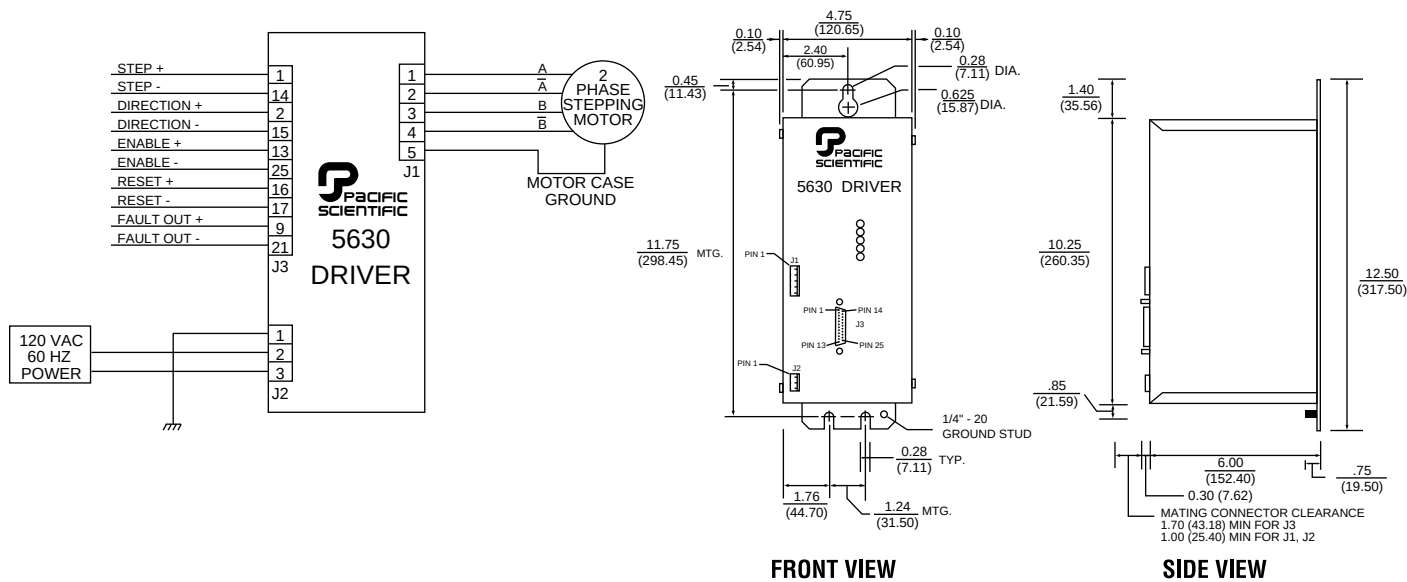
GENERAL. . .Model 5630

Input power	120 Vac (±10%) Single phase, 50/60 Hz 13A rms maximum
Output current (per phase)	Switch selectable 8.0A rms (11.3A pk microstep) 7.5A rms (10.6A pk microstep) 6.0A rms (8.5A pk microstep) 5.0A rms (7.1A pk microstep)
Output voltage	160V nominal (w/ 120 Vac line)
Maximum input pulse rate	40,000 pulses/sec–full step (12,000 RPM) 80,000 pulses/sec–1/2 step (12,000 RPM) 200,000 pulses/sec–1/5 step (12,000 RPM) 500,000 pulses/sec–1/25 step (6,000 RPM) 500,000 pulses/sec–1/125 step (1,200 RPM)
Minimum input pulse width	750nS
PWM chopping frequency	20 kHz, nominal (inaudible)
Operating temperature	
Full ratings	0° to 50°C ambient
Derated	50°C to 60°C ambient (contact factory for performance)
Storage temperature	-55°C to 70°C
Relative humidity	10% to 90%, noncondensing
Interfacing connectors (furnished)	
Motor	5 position, pluggable, screw terminal Phoenix connector (J1)
User command	25 pin D connector (J3)
AC line	3 position, pluggable, screw terminal Phoenix connector (J2)
Weight	9 lbs.
Recommended system motors	E Series, page C-82

CONNECTION DIAGRAM. . .Model 5630

DIMENSIONS

$\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)



HOW TO ORDER. . .5630 Recommended systems

Order motor and drive as separate model numbers. E Series motors, recommended for systems use, are equipped with MS type power connectors.

Systems motors Page C-82

Cabling and accessories Page D-3

SYSTEM RATINGS AND CHARACTERISTICS

8.0 and 5.0A,
160V per phase

Model 5630 with recommended E Series motors
See E Series motors...NEMA 34 (3.4") on page C-89 and NEMA 42 (4.2") on page C-97.

OD (in)	Motor Model Number [△]	Holding [△]								
		Drive	Torque		Phase	Phase [△]				Rated
		Current/	(2 phases on)	Detent	Resistance	inductance	Rotor Inertia		Peak	Speed at
		Phase	oz-in (Nm)	Torque	(ohms)	(mH)	oz-in-S ²	Weight	Power	Peak Power
		(amps DC)	±10%	oz-in (Nm)	±10%	±20%	(kgm ² x 10 ⁻³)	lbs (kg)	(W)	(RPM)
Maximum torque at low speed (see plot T in performance curve)										
3.4	E34HC-HTLNK-NS00	5.0	1222 (8.63)	83.0 (0.59)	0.70	8.3	0.0350 (0.217)	9.7 (4.41)	430	1050
4.2	E41HC-HTLNK-NS00	5.0	1284 (9.07)	58.0 (0.41)	0.62	9.0	0.0800 (0.496)	14.0 (6.36)	430	1050
4.2	E42HC-HTLNK-NS00	8.0	2589 (18.28)	81.0 (0.57)	0.40	6.4	0.1600 (0.993)	21.0 (9.55)	640	750
4.2	E43HC-HTLNK-NS00	8.0	4034 (28.49)	106.0 (0.75)	0.60	11.2	0.2400 (1.489)	29.0 (13.18)	660	600

All ratings typical and at 25°C unless otherwise noted.

△ See How to Order and Model Number Codes in System Motor Section, which begins on page C-82.

△ When operated at listed driver current.

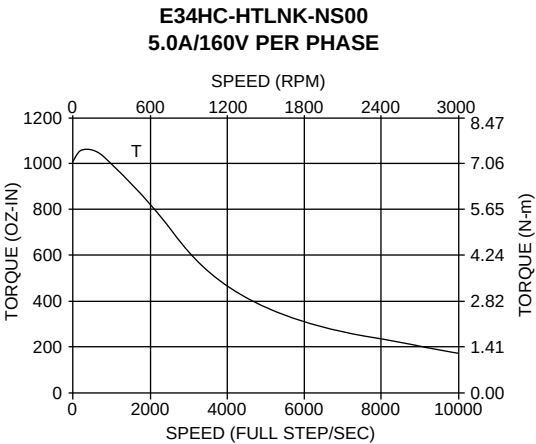
△ Small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

Torque/Speed curves with recommended motors

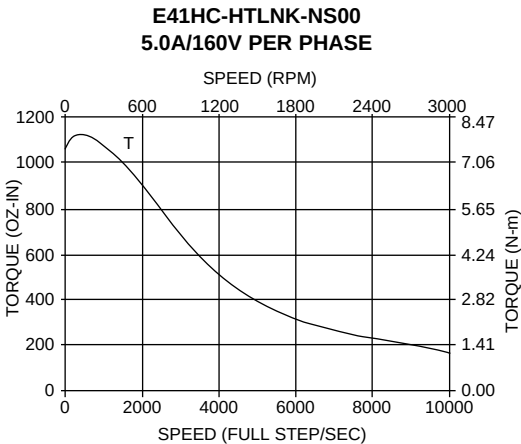
Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated unmounted (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and system parameters.

PERFORMANCE AT 5.0A/160V PER PHASE

(3" MOTOR-FOUR ROTOR STACKS)

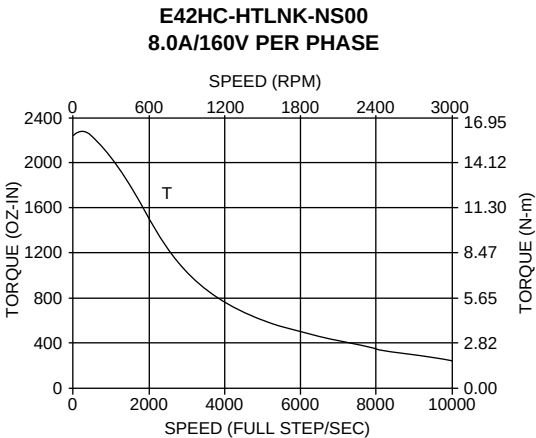


(4" MOTOR-ONE ROTOR STACK)

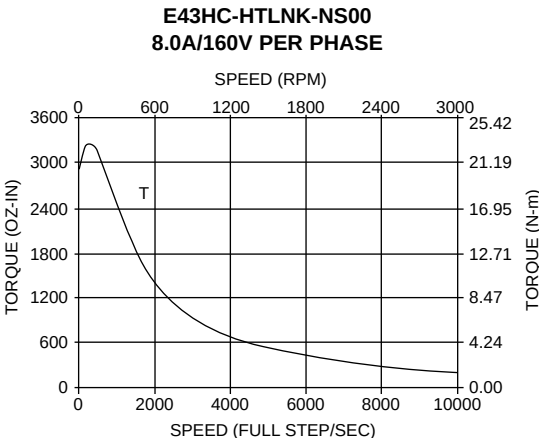


PERFORMANCE AT 8.0A/160V PER PHASE

(4" MOTOR-TWO ROTOR STACKS)



(4" MOTOR-THREE ROTOR STACKS)



MODELS 5430/5330*

Microstep drive packages 5.0 and 2.5A/65V per phase output

- Economical, high efficiency 20 kHz bipolar chopper drive
- Full, 1/2, 1/5, 1/25, 1/125 step operation
- Optically isolated TTL/CMOS compatible inputs
- Full short circuit protection
- Direct 120 Vac line operation with regulated logic supply
- Compact panel mount

The Model 5430 (5.0A) and 5330 (2.5A) Microstep Drive Packages are high efficiency bipolar chopper drives with five switch selectable microstepping ranges. These economical drives convert step and direction inputs into motor winding currents for two phase bipolar step motors.

MICROSTEPPING

Microstepping provides smooth, low speed operation and optimum system resolution. Both models switch to full step above 150 RPM effectively boosting current 30% above the microstepping level.

FULL TORQUE AT ALL SPEEDS

Patented mid-range instability compensation ensures the availability of full motor torque at all speeds. This active control circuit modifies input step timing to damp rotor oscillation generated by the step motor's generated voltage.

In the full step mode, full motor torque is achieved throughout the speed range. In the microstep mode, motor torque is reduced to 70% of its full step level at speeds below 150 RPM.

HIGH EFFICIENCY BIPOLAR CHOPPING

Also patented, 4-phase PWM chopping electronically controls the motor winding currents at 20 kHz frequency.

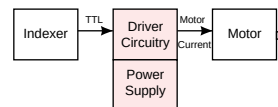
This combines the best of recirculating and nonrecirculating current regulation, producing high back EMF rejection with low chopping ripple current.

When used with high performance step motor windings, benefits include reduced heat dissipation, low electrical noise and improved current control during motor braking. Typically, higher motor shaft power is also delivered to the load.

Holding torque range:
5430–319-1284 oz-in. (2.25-9.07 Nm)
5330–158-638 oz-in. (1.12-4.51 Nm)



Includes both bipolar chopper drive circuitry and power supplies for operation from AC power sources.



IDLE CURRENT REDUCTION

This useful function permits an automatic 50% reduction in motor winding current during motor idle conditions. Use idle current reduction to minimize heating during dwell periods.

OPERATING FEATURES

- Constant current, full bridge, bipolar chopper MOSFET drive
- Switch selectable step size:
Full, 1/2, 1/5, 1/25, 1/125
- Jumper selectable mid-range instability compensation, active above 500 full steps/sec (150 RPM)
- Switch selectable 50% current reduction one second after last step pulse

COMMUNICATIONS

- Optically isolated, TTL or open collector compatible inputs:
Step and direction
- Motor current disable input:
Logic 0 produces zero current level

PROTECTION

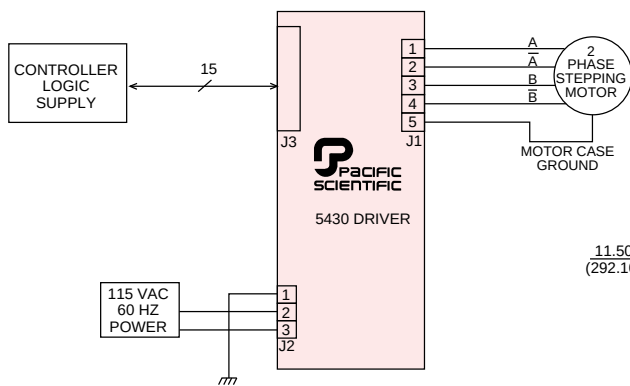
- Transformer isolated input
- Fused, MOV protected input
- Output short circuit protection
- Overtemperature shutdown

*Consult factory for detailed information on the 6430 replacement product.

GENERAL. . .Models 5430 and 5330*

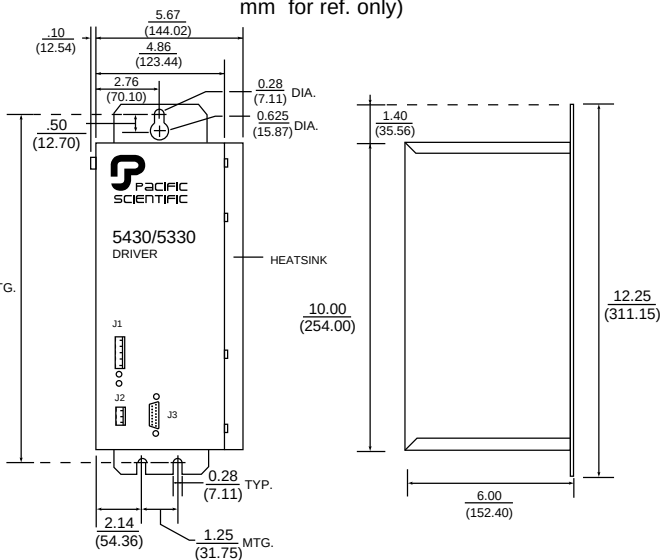
Input power	Specify 120 Vac (±10%), 60 Hz or 230 Vac (±10%), 1 phase, 50 Hz
Model 5430	5A rms
Model 5330	2.5A rms
Output current (per phase)	
Model 5430	5.0A rms (full step mode) 3.5A rms (microstep mode)
Model 5330	2.5A rms (full step mode) 1.75A rms (microstep mode)
Output bus voltage	65V nominal (w/ 120 Vac line)
Maximum input pulse rate	40,000 pulses/sec–full step (12,000 RPM) 80,000 pulses/sec–1/2 step (12,000 RPM) 200,000 pulses/sec–1/5 step (12,000 RPM) 500,000 pulses/sec–1/25 step (6,000 RPM) 500,000 pulses/sec–1/125 step (1,200 RPM)
Minimum input pulse width	1 microsecond
PWM chopping frequency	20 kHz, nominal (inaudible)
Operating temperature	
Full ratings	0° to 50°C ambient
Derated	50°C to 60°C ambient (contact factory for performance)
Storage temperature	-55°C to 70°C
Relative humidity	10% to 90%, noncondensing
Interfacing connectors (furnished)	
Motor	5 position, pluggable, screw terminal Phoenix connector (J1)
User command	15 pin D connector (J3)
AC line	3 position, pluggable, screw terminal Phoenix connector (J2)
Weight	13 lbs.
Recommended system motors	E Series, page C-82

CONNECTION DIAGRAM. . .
Models 5430 and 5330



DIMENSIONS

in. (metric dimensions
mm for ref. only)



FRONT VIEW

SIDE VIEW

HOW TO ORDER. . .5430 and 5330 Recommended systems

Order motor and driver as separate model numbers. If a 230 Vac input is required for the control, simply add a -230 suffix to the model number (e.g., 5430-230). E Series motors, recommended for systems use, are equipped with MS type power connectors.

Systems motors	Page C-82
Cabling and accessories	Page D-3

*Consult factory for detailed information on the 6430 replacement product.

SYSTEM RATINGS AND CHARACTERISTICS*

5.0A,
65V per phase

Model 5430 with recommended E Series motors
See E Series motors...NEMA 34 (3.4") on page C-89 and NEMA 42 (4.2") on page C-97.

OD (in)	Motor Model Number [△]	Holding [△]									
		Drive	Torque		Phase	Phase [△]				Rated	
		Current/	(2 phases on)	Detent	Resistance	inductance	Rotor Inertia		Peak	Speed at	
		Phase	oz-in (Nm)	Torque	(ohms)	(mH)	oz-in-S ²	Weight	Power	Peak Power	
		(amps DC)	±10%	oz-in (Nm)	±10%	±20%	(kgm² x 10 ⁻³)	lbs (kg)	(W)	(RPM)	
Maximum torque at low speed (see plot T in performance curve)											
3.4	E31NC-HTLNN-NS00	5.0		319 (2.25)	21.5 (0.15)	0.30	2.3	0.0083 (0.051)	3.2 (1.45)	130	1200
3.4	E32NC-HTLNN-NS00	5.0		638 (4.51)	41.6 (0.29)	0.45	5.0	0.0170 (0.102)	5.3 (2.41)	130	600
3.4	E33NC-HTLNN-NS00	5.0		958 (6.77)	69.3 (0.45)	0.62	7.5	0.0250 (0.155)	7.6 (3.45)	140	450
3.4	E34HC-HTLNN-NS00	5.0		1222 (8.63)	83.0 (0.59)	0.70	8.3	0.0350 (0.217)	9.7 (4.41)	140	420
4.2	E41HC-HTLNN-NS00	5.0		1284 (9.07)	58.0 (0.41)	0.62	9.0	0.0800 (0.496)	14.0 (6.36)	147	450
Maximum torque at high speed (see plot P in performance curve)											
3.4	E32NC-HPLNN-NS00	5.0		474 (3.35)	41.6 (0.29)	0.20	2.3	0.0170 (0.102)	5.3 (2.41)	190	1200
3.4	E33NC-HPLNN-NS00	5.0		711 (5.02)	69.3 (0.45)	0.27	3.3	0.0250 (0.155)	7.6 (3.45)	215	900
3.4	E34HC-HPLNN-NS00	5.0		948 (6.69)	83.0 (0.59)	0.33	4.2	0.0350 (0.217)	9.7 (4.41)	200	750

2.5A,
65V per phase

Model 5330 with recommended E Series motors
See E Series motors...NEMA 23 (2.3") on page C-84 and NEMA 34 (3.4") on page C-89.

OD (in)	Motor Model Number [△]	Holding [△]									
		Drive	Torque		Phase	Phase [△]				Rated	
		Current/	(2 phases on)	Detent	Resistance	inductance	Rotor Inertia		Peak	Speed at	
		Phase	oz-in (Nm)	Torque	(ohms)	(mH)	oz-in-S ²	Weight	Power	Peak Power	
		(amps DC)	±10%	oz-in (Nm)	±10%	±20%	(kgm ² x 10 ⁻³)	lbs (kg)	(W)	(RPM)	
Maximum torque at low speed (see plot T in performance curve)											
2.3	E22NC-LTLNN-NS00	2.5		225 (1.59)	9.6 (0.07)	1.24	3.8	0.0031 (0.019)	2.1 (0.95)	95	1500
3.4	E31NC-LTLNN-NS00	2.5		319 (2.25)	21.5 (0.15)	1.20	10.5	0.0083 (0.051)	3.2 (1.45)	66	600
3.4	E32NC-LTLNN-NS00	2.5		638 (4.51)	41.6 (0.29)	1.80	20.5	0.0170 (0.102)	5.3 (2.41)	66	300
Maximum torque at high speed (see plot P in performance curve)											
2.3	E22NC-LPLNN-NS00	2.5		158 (1.12)	9.6 (0.07)	0.71	1.8	0.0031 (0.019)	2.1 (0.95)	130	2550
3.4	E31NC-LPLNN-NS00	2.5		237 (1.67)	21.5 (0.15)	0.53	4.1	0.0083 (0.051)	3.2 (1.45)	100	1350
3.4	E32NC-LPLNN-NS00	2.5		474 (3.35)	41.6 (0.29)	0.80	9.2	0.0170 (0.102)	5.3 (2.41)	95	600

△ See How to Order and Model Number Codes in System Motor Section, which begins on page C-82.

△ All ratings typical and at 25°C unless otherwise noted.

△ When operated at listed driver current.

△ Small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

*Consult factory for detailed information on the 6430 replacement product.

Model 5430 Torque/Speed curves
with recommended motors*

5.0A,
65V per phase

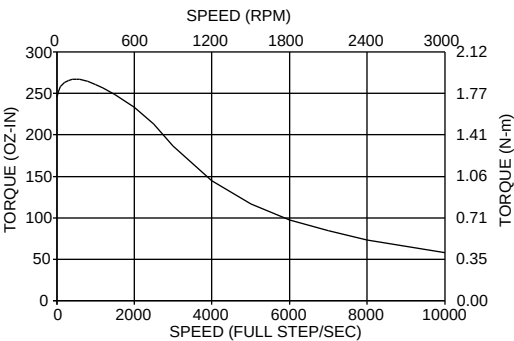
Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and systems parameters.

When driven by the 5430 and *not* microstepping, the motor produces full torque and follows the full step dynamic torque curve. However, when microstepping to achieve smooth operation at low speeds, motor torque is reduced to about 70% of that produced in the full step mode up to about 500 steps/sec. (150 RPM). Beyond 500 steps/sec., where microstepping is no longer required, a transition (transparent to user) occurs back to the full step dynamic torque curve.

PERFORMANCE AT 5.0A/65V PER PHASE

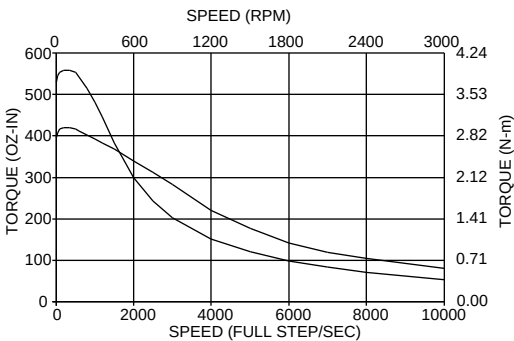
(3" MOTOR-ONE ROTOR STACK)

E31NC-HTLNN-NS00
5.0A/65V PER PHASE



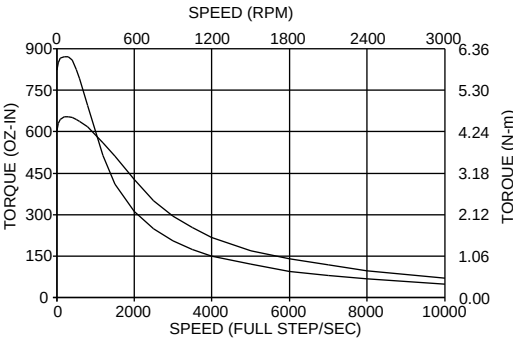
(3" MOTOR-TWO ROTOR STACKS)

E32NC-HTLNN-NS00
E32NC-HPLNN-NS00
5.0A/65V PER PHASE



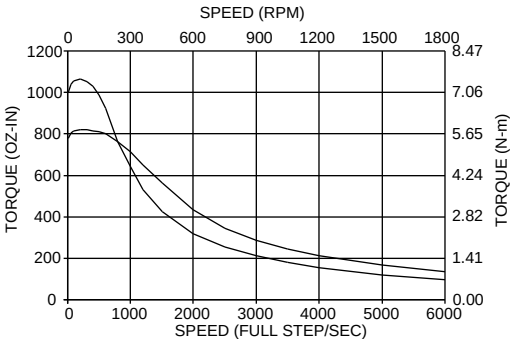
(3" MOTOR-THREE ROTOR STACKS)

E33HC-HTLNK-NS00
E33HC-HPLNK-NS00
5.0A/65V PER PHASE



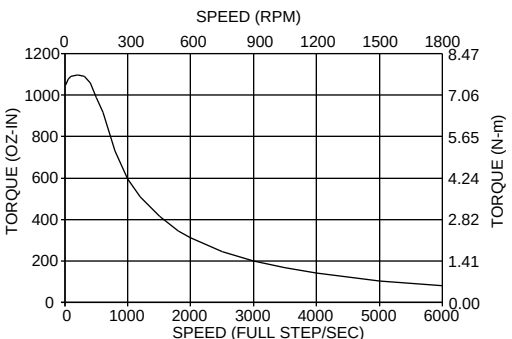
(3" MOTOR-FOUR ROTOR STACKS)

E34HC-HTLNK-NS00
E34HC-HPLNK-NS00
5.0A/65V PER PHASE



(4" MOTOR-ONE ROTOR STACK)

E41HC-HTLNK-NS00
5.0A/65V PER PHASE



*Consult factory for detailed information on the 6430 replacement product.

Model 5330 Torque/Speed curves
with recommended motors*

2.5A,
65V per phase

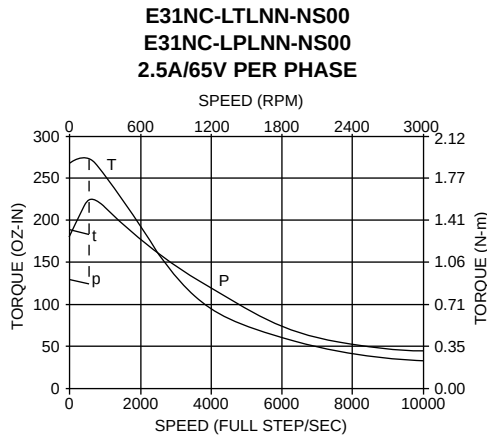
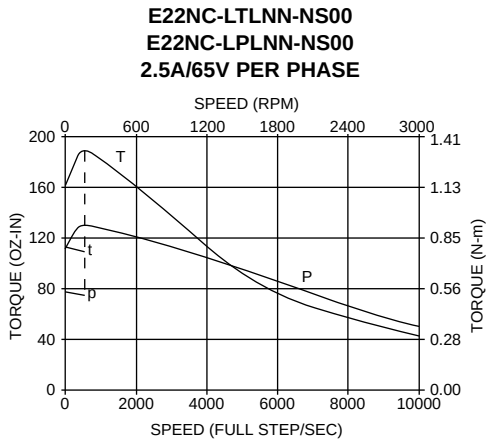
Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and systems parameters.

When driven by the 5330 and *not* microstepping, the motor produces full torque and follows the full step dynamic torque curve. However, when microstepping to achieve smooth operation at low speeds, motor torque is reduced to about 70% of that produced in the full step mode up to about 500 steps/sec. (150 RPM). Beyond 500 steps/sec., where microstepping is no longer required, a transition (transparent to user) occurs back to the full step dynamic torque curve.

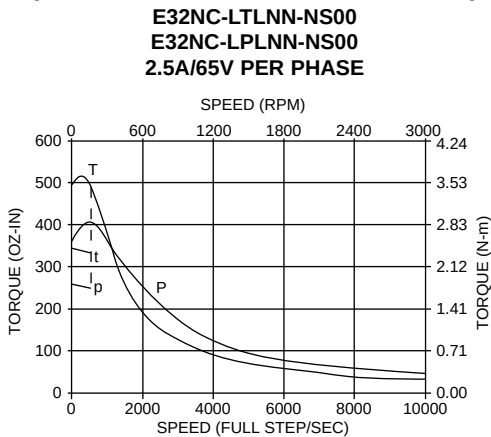
PERFORMANCE AT 2.5A/65V PER PHASE

(2" MOTOR-TWO ROTOR STACKS)

(3" MOTOR-ONE ROTOR STACK)



(3" MOTOR-TWO ROTOR STACKS)



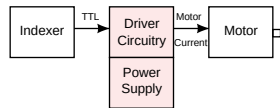
*Consult factory for detailed information on the
6430 replacement product.

MODEL 5230*

Full/half step drive package 2.5A/35V per phase output

- Economical, easy to use drive
- Full/half step operation
- Overtemperature and short circuit protection
- 120 Vac line operation
- Compact, panel mount

Includes both bipolar chopper drive circuitry and power supplies for operation from AC power sources.



The economical Model 5230 Drive Package is a bipolar chopper drive with built in power supply for operation directly from a 120 Vac line.

OPERATING FEATURES

- Constant current, full bridge, bipolar chopper MOSFET drive
- Jumper selectable full/half step operation
- Idle current reduction to 1.25A when no motor motion is commanded for 0.1 sec

COMMUNICATIONS

- Optically isolated TTL/CMOS compatible inputs: Step and direction

PROTECTION

- Transformer isolated input
- Fused, MOV protected input
- Output short circuit protection
- Overtemperature shutdown

Holding torque range:
112-638 oz-in. (.79-4.51 Nm)

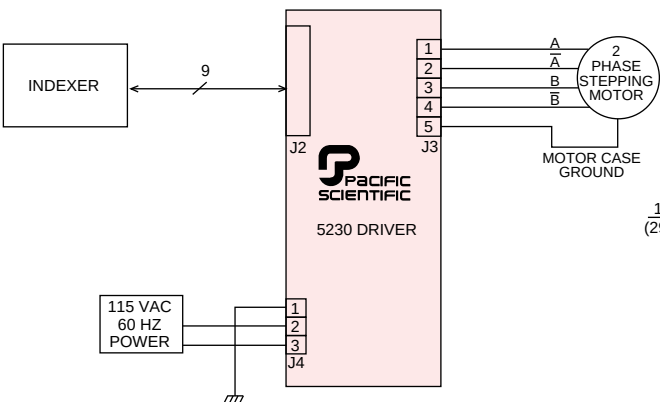


**Consult factory for detailed information on the 6430 replacement product.*

GENERAL. . .Model 5230*

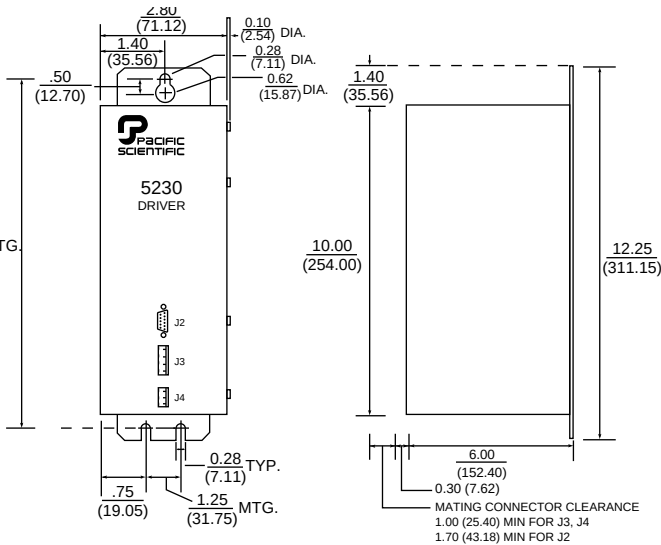
Input power	Specify 120 Vac (+5,-15%), 60 Hz or 240 Vac (+5,-15%), single phase 50/60 Hz
Output current per phase	2.5A
Output bus voltage	.35V nominal
Input format	
(step and direction)	Optically isolated TTL/CMOS compatible inputs
Maximum input pulse rate	20,000 pulses/sec–full step (6,000 RPM) 20,000 pulses/sec–1/2 step (3,000 RPM)
Minimum input pulse width	.5 microseconds
Motor current disable input	Logic 0 shuts down the output
PWM chopping frequency	.17 kHz nominal (inaudible)
Operating temperature	
Full ratings	.0° to 50°C ambient
Derated	.50°C to 60°C ambient (contact factory for performance)
Storage temperature	–55°C to 70°C
Relative humidity	10% to 90% (noncondensing)
Interfacing connectors (furnished)	
Motor	.5 position, pluggable, screw terminal Phoenix connector (J3)
AC line	.3 position, pluggable, screw terminal Phoenix connector (J4)
Interfacing connectors (user provides)	
Serial port	.9 pin D connector (J2)
Weight	.6 lbs.
Recommended system motors	.E Series, page C-82

CONNECTION DIAGRAM. . .Model 5230



DIMENSIONS

$\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)



FRONT VIEW

SIDE VIEW

HOW TO ORDER. . .5230 Recommended systems

Order motor and drive as separate model numbers. If a 230 Vac input is required for the control, simply add a -230 suffix to the model number (e.g., 5230-230). E Series motors, recommended for systems use, are equipped with MS type power connectors.

Systems motors Page C-82

Cabling and accessories Page D-3

*Consult factory for detailed information on the 6430 replacement product.

SYSTEM RATINGS AND CHARACTERISTICS*

2.5A,
35V per phase

Model 5230 with recommended E Series motors
See E Series motors...NEMA 23 (2.3") on page C-84 and NEMA 34 (3.4") on page C-89.

OD (in)	Motor Model Number [△]	Holding [△]								
		Drive	Torque		Phase	Phase [△]				Rated
		Current/	(2 phases on)	Detent	Resistance	inductance	Rotor Inertia		Peak	Speed at
		Phase	oz-in (Nm)	Torque	(ohms)	(mH)	oz-in-S ²	Weight	Power	Peak Power
		(amps DC)	±10%	oz-in (Nm)	±10%	±20%	(kgm ² x 10 ⁻³)	lbs (kg)	(W)	(RPM)
Maximum torque at low speed (see plot T in performance curve)										
2.3	E21NC-HTLNN-NS00	2.5	112 (0.79)	4.8 (0.03)	0.71	2.1	0.0016 (0.010)	1.2 (0.55)	54	1650
2.3	E22NC-LTLNN-NS00	2.5	225 (1.59)	9.6 (0.07)	1.24	3.8	0.0031 (0.019)	2.1 (0.95)	52	750
3.4	E31NC-LTLNN-NS00	2.5	319 (2.25)	21.5 (0.15)	1.20	10.5	0.0083 (0.051)	3.2 (1.45)	36	300
3.4	E32NC-LTLNN-NS00	2.5	638 (4.51)	41.6 (0.29)	1.80	20.5	0.0170 (0.102)	5.3 (2.41)	35	150
Maximum torque at high speed (see plot P in performance curve)										
2.3	E22NC-LPLNN-NS00	2.5	158 (1.12)	9.6 (0.07)	0.71	1.8	0.0031 (0.019)	2.1 (0.95)	75	1500
3.4	E31NC-LPLNN-NS00	2.5	237 (1.67)	21.5 (0.15)	0.53	4.1	0.0083 (0.051)	3.2 (1.45)	55	750
3.4	E32NC-LPLNN-NS00	2.5	474 (3.35)	41.6 (0.29)	0.80	9.2	0.0170 (0.102)	5.3 (2.41)	55	450

All ratings typical and at 25°C unless otherwise noted.

[△] See How to Order and Model Number Codes in System Motor Section, which begins on page C-82.

[△] When operated at listed drive current.

[△] Small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

*Consult factory for detailed information on the 6430 replacement product.

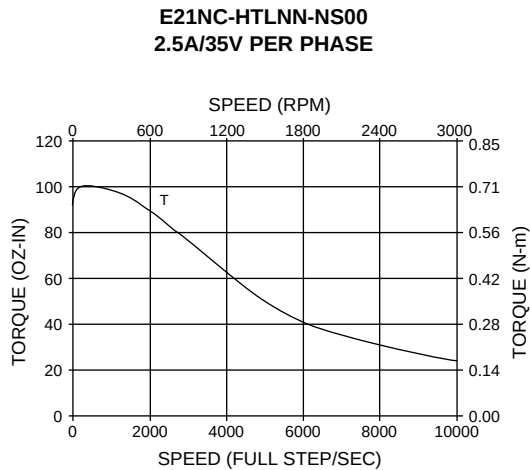
Model 5230 Torque/Speed curves with recommended motors*

2.5A,
35V per phase

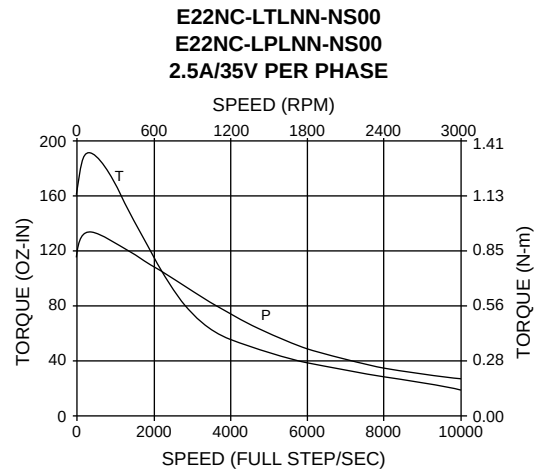
Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated unmounted (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and system parameters.

PERFORMANCE AT 2.5A/35V PER PHASE

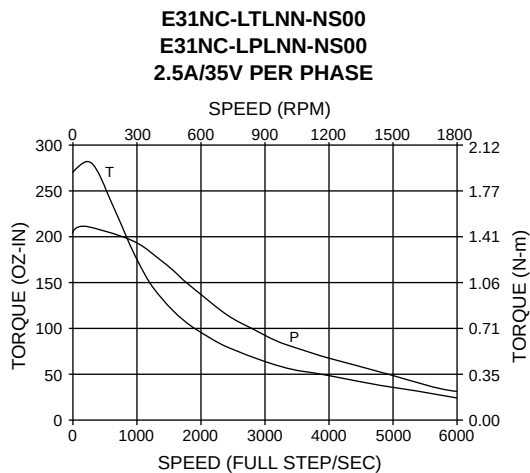
(2" MOTOR-ONE ROTOR STACK)



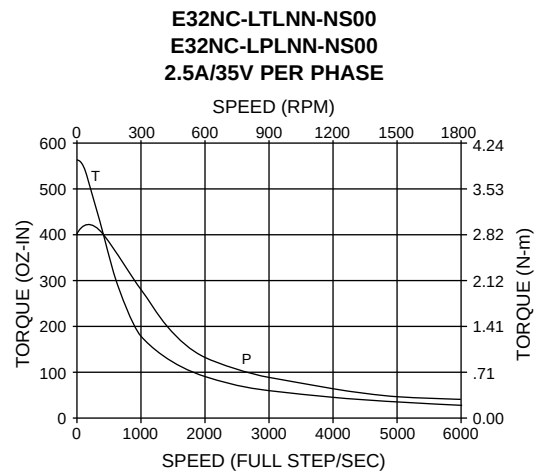
(2" MOTOR-TWO ROTOR STACKS)



(3" MOTOR-ONE ROTOR STACK)



(3" MOTOR-TWO ROTOR STACKS)



*Consult factory for detailed information on the 6430 replacement product.

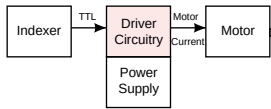
MODEL 5210

Holding torque range:
112-638 oz-in. (.79-4.51 Nm)

PC board mountable drive module 2.5A/12-40V per phase

- Economical, PC board mountable
- Full/half step operation
- Adjustable motor current (2.5A/phase maximum)
- Overtemperature and short circuit protection
- Compact (0.85" x 2.65" x 3.40")

PC board mountable module includes bipolar chopper driver circuitry. Operates from DC power sources.



The economical Model 5210 is a board level, constant current, full bridge, bipolar chopper MOSFET drive. Ideal for use with low to medium power step motors, this compact drive module is readily interfaced to a microprocessor.

This bipolar drive delivers the full torque available from a motor—up to 30% more torque than a unipolar drive, which utilizes only half the motor winding.

The Model 5210 produces output voltage equal to that of a user supplied 12-40 Vdc unregulated power source. A 5 Vdc logic supply is also required.



OPERATING FEATURES

- Constant current, full bridge, bipolar chopper MOSFET drive
- Jumper (leadwire) selectable full/half step operation

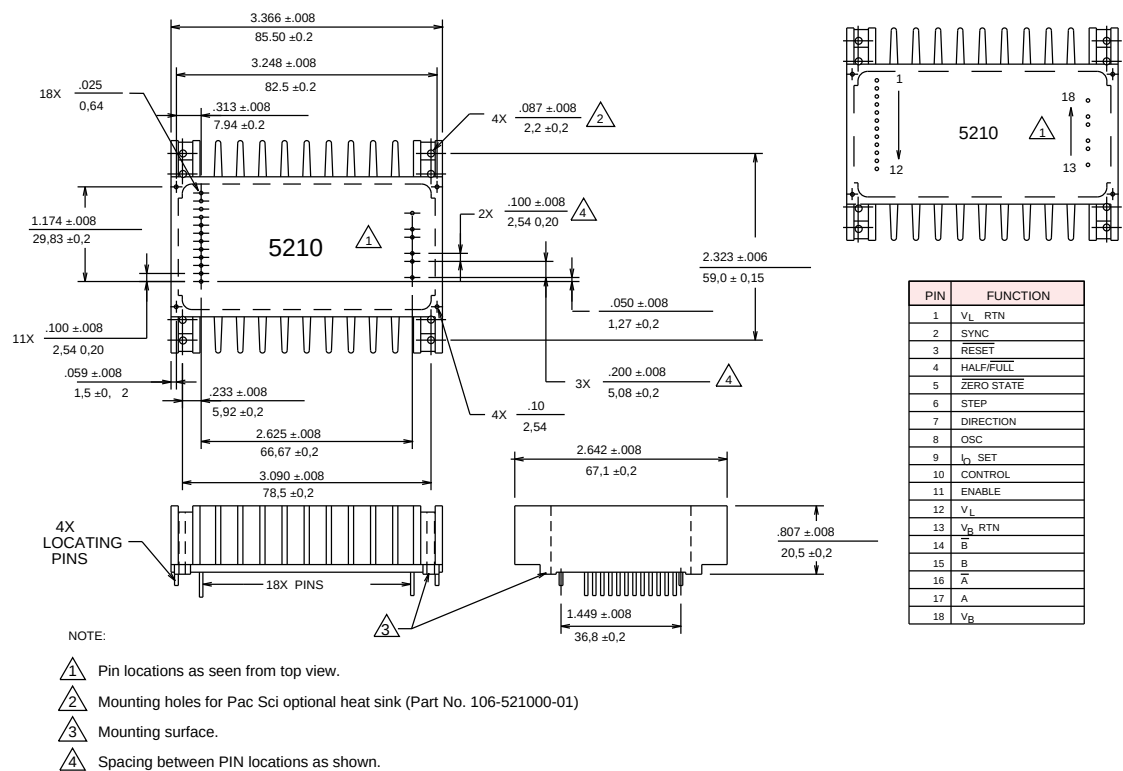
PROTECTION

- Output short circuit protection:
 - Phase-to-phase, phase-to-ground, phase-to-supply
- Overtemperature shutdown

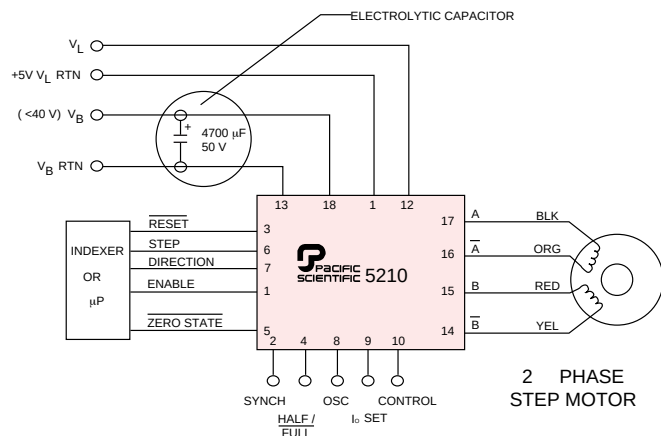
GENERAL. . .Model 5210

Input power	.12-40 Vdc, 5 Vdc logic
Output current per phase	.25A with addition of external resistor between pins 9 and 12. See installation manual.
Output voltage	.12-40V
Input format (step and direction)	TTL/CMOS compatible
Maximum input pulse rate	20,000 pulses/sec–full step (6,000 RPM) 20,000 pulses/sec–1/2 step (3,000 RPM)
Minimum input pulse width	.500 nS
Motor current disable input	Logic 0 shuts down the output
PWM chopping frequency	.17 kHz (inaudible)
Operating temperature	.0° to 50°C ambient (Heat sink required for operation above 35°C)
Storage temperature	–55°C to 70°C
Relative humidity	.10% to 90% (noncondensing)
Weight	.6.7 oz.
Recommended system motors	.E and H Series, page C-82

DIMENSIONS $\frac{\text{in}}{\text{mm}}$ (metric dimensions for ref. only)



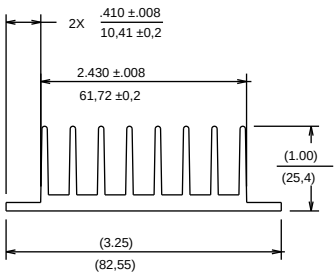
TYPICAL CONNECTION DIAGRAM



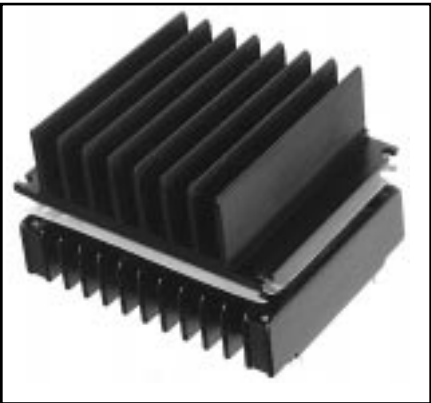
HEAT SINK

To operate the 5210 at its full rated current of 2.5A in ambient temperatures above 30°C, a heat sink is required. The heat sink mounts on top of the 5210. Four self-tapping screws are provided for easy installation. A flexible conductive membrane is also furnished and is positioned between the 5210 and heat sink. See the exploded view.

Order the heat sink separately, part number 172-521150-001.



HEAT SINK



HOW TO ORDER. . .5210
Recommended systems

Order motor and drive as separate model numbers.
Systems motors E & H Series, page C-82

SYSTEM RATINGS AND CHARACTERISTICS

2.5A,
35V per phase

Model 5210 with recommended motors
See E Series motors...NEMA 23 (2.3") on page C-84 and NEMA 34 (3.4") on page C-89.

OD (in)	Motor Model Number [△]	Drive Current/ Phase (amps DC)	Holding [△] Torque (2 phases on)		Detent Torque oz-in (Nm)	Phase Resistance (ohms) ±10%	Phase [△] inductance (mH) ±20%	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)	Peak Power (W)	Rated Speed at Peak Power (RPM)
			oz-in (Nm)								
			±10%								
Maximum torque at low speed (see plot T in performance curve)											
2.3	E21NC-HTLNN-NS00	2.5	112 (0.79)	4.8 (0.03)	0.71	2.1	0.0016 (0.010)	1.2 (0.55)	63	1800	
2.3	E22NC-LTLNN-NS00	2.5	225 (1.59)	9.6 (0.07)	1.24	3.8	0.0031 (0.019)	2.1 (0.95)	62	900	
3.4	E31NC-LTLNN-NS00	2.5	319 (2.25)	21.5 (0.15)	1.20	10.5	0.0083 (0.051)	3.2 (1.45)	43	450	
3.4	E32NC-LTLNN-NS00	2.5	638 (4.51)	41.6 (0.29)	1.80	20.5	0.0170 (0.102)	5.3 (2.41)	43	300	
Maximum torque at high speed (see plot P in performance curve)											
2.3	E22NC-LPLNN-NS00	2.5	158 (1.12)	9.6 (0.07)	0.71	1.8	0.0031 (0.019)	2.1 (0.95)	89	1800	
3.4	E31NC-LPLNN-NS00	2.5	237 (1.67)	21.5 (0.15)	0.53	4.1	0.0083 (0.051)	3.2 (1.45)	64	900	
3.4	E32NC-LPLNN-NS00	2.5	474 (3.35)	41.6 (0.29)	0.80	9.2	0.0170 (0.102)	5.3 (2.41)	65	450	

All ratings typical and at 25°C unless otherwise noted.

[△] When operated at listed drive current.

[△] See How to Order and Model Number Codes in System Motor Section, which begins on page C-82.

[△] Small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

Model 5210 Torque/Speed curves
with recommended motors

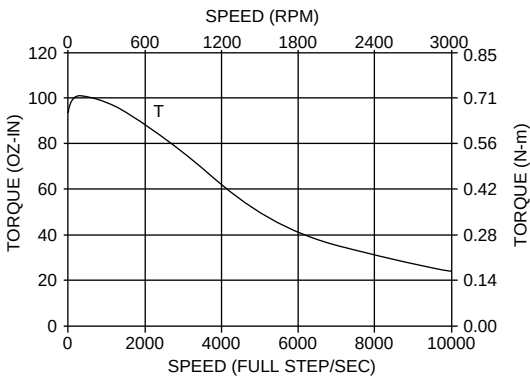
2.5A,
35V per phase

Motors will perform continuously as shown without the winding temperature rise exceeding 90°C when the motor is operated unmounted (without heat sink) in an ambient temperature of up to 40°C. The curves do not reflect systems resonance points, which will vary with motor coupling and system parameters.

PERFORMANCE AT 2.5A/35V PER PHASE

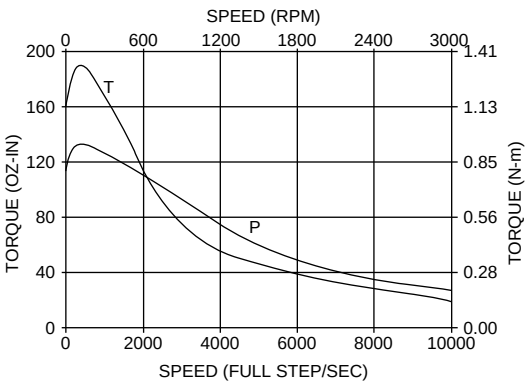
(2" MOTOR-ONE ROTOR STACK)

E21NC-HTLNN-NS00
2.5A/35V PER PHASE



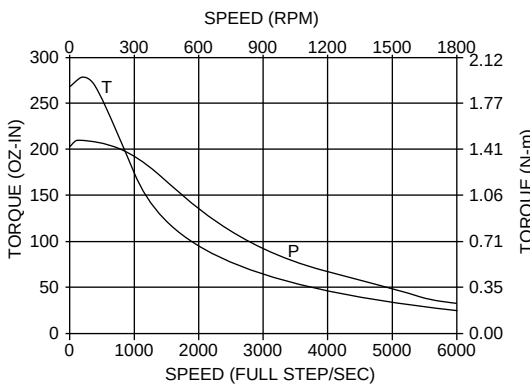
(2" MOTOR-TWO ROTOR STACKS)

E22NC-LTLNN-NS00
E22NC-LPLNN-NS00
2.5A/35V PER PHASE



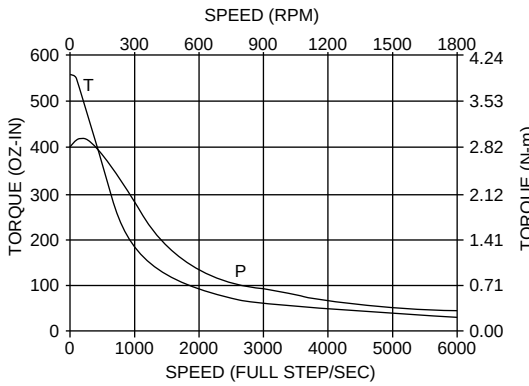
(3" MOTOR-ONE ROTOR STACK)

E31NC-LTLNN-NS00
E31NC-LPLNN-NS00
2.5A/35V PER PHASE



(3" MOTOR-TWO ROTOR STACKS)

E32NC-LTLNN-NS00
E32NC-LPLNN-NS00
2.5A/35V PER PHASE





HYBRID STEP MOTORS FOR SYSTEMS USE

Recent advances in software and electronic design make it all too easy to take step motors for granted. In fact, the right step motor can significantly increase your MTBF, produce higher torque in the same envelope size, and run cooler.

Unlike many systems suppliers, we've always engineered and manufactured our own motors. Most recently, we've applied PacSci's combined experience in step motors and servo motors to give you a new option.

THE E SERIES

The E Series motor family, manufactured by Pacific Scientific, was specifically developed to complement all PacSci 5000 and 6000 Series step motor controls. These Sigmax™ enhanced hybrid step motors are recommended for all controls and are listed in the ratings and characteristics table for each control.

E motors feature:

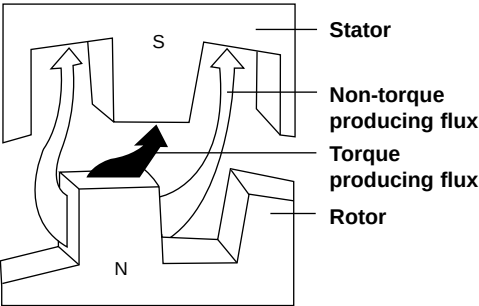
- Long life bearings
- Locked outer bearing races
- Convenient MS connectors for power and encoder feedback provide reliable connections and fast hookup
- Sealed construction on most models
- Patented Sigmax™ enhanced-performance technology

EXTRA PERFORMANCE. . . THAT'S SIGMAX®

Does your application require that extra measure of performance? With their patented Sigmax® technology, E Series motors will deliver that extra torque and acceleration when you need it.

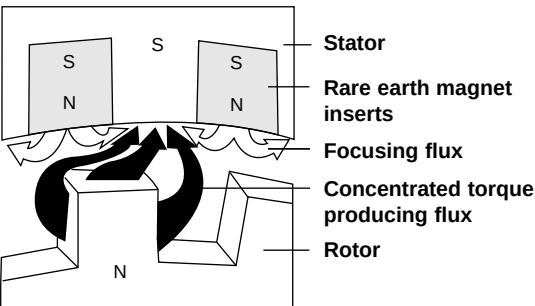
Here's how Sigmax works. Stator mounted samarium cobalt magnets in E Series motors concentrate magnetic flux at desired points between the rotor and stator. This flux focusing action optimizes flux paths, increasing torque production and current utilization compared to conventional hybrid designs.

H SERIES STANDARD HYBRID



Typical paths of flux transfer in an energized conventional hybrid step motor. Some flux leakage occurs in normal operation.

E SERIES SIGMAX® TECHNOLOGY



Patented Sigmax® technology* redirects magnetic flux to inhibit leakage and optimize torque production.

* Sigmax® technology is covered by U.S. patents 4,712,028, 4,713,470, 4,763,034 and 4,827,164.

YOUR BEST VALUE IN MOTION CONTROL

Yet, all these advantages don't make PacSci systems cost more than other popular makes of intelligent motion control. That's PacSci value.

When you call a PacSci applications engineer, you're talking to someone who understands both the mechanical and electrical aspects of your motor—in addition to control hardware and software capabilities. That, too, is PacSci value.

E SERIES HYBRID STEP MOTORS

Holding torque range:
112-225 oz-in. (.79-1.59 Nm)

NEMA 23 FRAME SIZE Systems configuration

- High torque-to-inertia
- High acceleration
- MS connector equipped
- Long life bearings
- Locked outer bearing races

To simplify specification, these 2" hybrid step motors are preconfigured for the most common low power application parameters. Each is ideally suited for use with various Pacific Scientific 5300 and 5200 series drivers and indexer/drives.

MS connector termination is standard, assuring reliability and fast startup.

The 2" systems motors are intended for operation in applications where waterproofing is not an issue.



RECOMMENDED SYSTEMS MOTORS. . ratings and characteristics

We suggest you use E Series enhanced hybrid step motors to achieve the highest overall performance from your system. See page C-83 for the specific advantages of the Sigmax® technology.

While Sigmax offers the highest output performance, your selection is not limited to these systems motors. Pacific Scientific is a full line step motor manufacturer with configurations to meet a broad spectrum of applications.

Model Number [△]	Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Drive Current/ Phase (amps DC)	Detent Torque oz-in (Nm)	Phase Resistance (ohms) ±10%	Phase [△] Inductance (mH) ±20%	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)
E21NC-HTLNN-NS00	112 (0.79)	2.5	4.8 (0.03)	0.71	2.1	0.0016 (0.010)	1.2 (0.55)
E22NC-LPLNN-NS00	158 (1.12)	2.5	9.6 (0.07)	0.71	1.8	0.0031 (0.019)	2.1 (0.95)
E22NC-LTLNN-NS00	225 (1.59)	2.5	9.6 (0.07)	1.24	3.8	0.0031 (0.019)	2.1 (0.95)

All ratings typical and at 25°C unless otherwise noted.

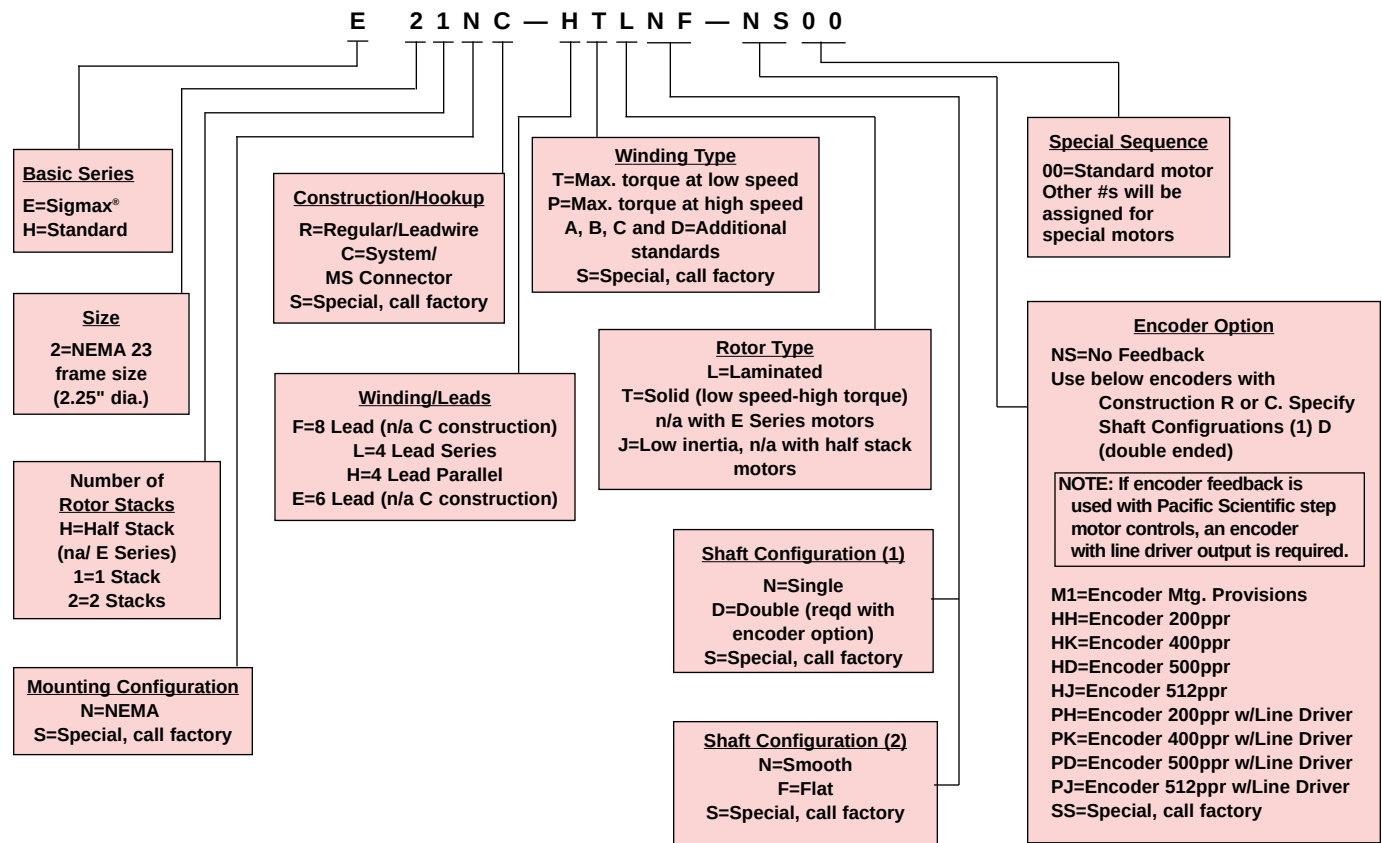
[△] See How to Order and Model Number Code on page C-85.

[△] When operated at listed drive current.

[△] Typical small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

GENERAL PURPOSE—CONVENTIONAL HYBRIDS
NEMA 23 FRAME (2.3" Dia.)

MODEL NUMBER CODE



The example above indicates an E series (Sigmax®) NEMA 23 frame motor with one rotor stack. This motor is equipped with an MS connector on the end of a 12 inch cable for power, a bipolar parallel connection, a maximum torque winding and a single ended shaft with a flat.

HOW TO ORDER

Order motors and controls as separate part numbers. Review the Motor Model Number code to assure that all options are designated. Connections, encoders and phasing diagrams start on page D-17. Motor dimensions are on page C-88.

GENERAL PURPOSE—CONVENTIONAL HYBRIDS

NEMA 23 FRAME (2.3" Dia.)—Ratings and Characteristics

Review the Model Number Code, page C-85, to assure that all options are designated. Connections, encoders and phasing diagrams start on page D-17. Motor dimensions are on page C-88. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated currents are in descending order	Motor Model Number [△]	Connection [△]			Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)
		Parallel	Series	Unipolar								
Torque range: 36-51 oz-in. .25-.36 Nm	H2HNX-HALXX-XX00	•			51 (0.36)	4.9	0.22	0.5	↑	↑	↑	↑
	H2HNX-LALXX-XX00		•		51 (0.36)	2.4	0.79	2.0	↑	↑	↑	↑
	H2HNX-EALXX-XX00			•	36 (0.26)	3.5	0.41	0.5	↑	↑	↑	↑
STANDARD H2H Series 1/2 rotor stack	H2HNX-HTLXX-XX00	•			50 (0.36)	2.5	0.75	1.8	↑	↑	↑	↑
	H2HNX-LTLXX-XX00		•		50 (0.36)	1.26	2.89	7.3	1.6 (0.011)	7.1	0.0010 (0.007)	0.9 (0.41)
	H2HNX-ETLXX-XX00			•	36 (0.25)	1.78	1.46	1.8	↓	↓	↓	↓
	H2HNX-HBLXX-XX00	•			51 (0.36)	2.4	0.79	2.0	↓	↓	↓	↓
	H2HNX-LBLXX-XX00		•		51 (0.36)	1.22	3.05	8.1	↓	↓	↓	↓
	H2HNX-EBLXX-XX00			•	36 (0.26)	1.73	1.54	2.0	↓	↓	↓	↓
SIGMAX® E21 Series 1 rotor stack	E21NX-HCLXX-XX00	•			120 (0.85)	5.8	0.19	0.5	↑	↑	↑	↑
	E21NX-LCLXX-XX00		•		120 (0.85)	2.9	0.67	1.9	↑	↑	↑	↑
	E21NX-ECLXX-XX00			•	85 (0.60)	4.1	0.35	0.5	↑	↑	↑	↑
	E21NX-HALXX-XX00	•			126 (0.89)	5.4	0.20	0.6	↑	↑	↑	↑
	E21NX-LALXX-XX00		•		126 (0.89)	2.7	0.76	2.5	↑	↑	↑	↑
	E21NX-RALXX-XX00			•	89 (0.63)	3.8	0.40	0.6	4.8 (0.034)	6.0	0.0015 (0.011)	1.2 (0.55)
	E21NX-HTLXX-XX00	•			123 (0.87)	2.8	0.72	2.2	↓	↓	↓	↓
	E21NX-LTLXX-XX00		•		123 (0.87)	1.39	2.8	8.7	↓	↓	↓	↓
	E21NX-ETLXX-XX00			•	87 (0.61)	1.97	1.42	2.2	↓	↓	↓	↓
	E21NX-HBLXX-XX00	•			123 (0.87)	1.41	2.73	8.5	↓	↓	↓	↓
	E21NX-LBLXX-XX00		•		123 (0.87)	0.71	10.8	33.9	↓	↓	↓	↓
	E21NX-EBLXX-XX00			•	87 (0.61)	1.0	5.42	8.5	↓	↓	↓	↓
STANDARD E21 Series 1 rotor stack	H21NX-HCLXX-XX00	•			83 (0.58)	5.8	0.19	0.6	↑	↑	↑	↑
	H21NX-LCLXX-XX00		•		83 (0.58)	2.9	0.67	2.2	↑	↑	↑	↑
	H21NX-ECLXX-XX00			•	59 (0.41)	4.1	0.35	0.6	↑	↑	↑	↑
	H21NX-HALXX-XX00	•			87 (0.61)	5.4	0.21	0.7	↑	↑	↑	↑
	H21NX-LALXX-XX00		•		87 (0.61)	2.7	0.76	2.9	↑	↑	↑	↑
	H21NX-EALXX-XX00			•	61 (0.43)	3.8	0.40	0.7	2.8 (0.02)	6.0	0.0015 (0.011)	1.2 (0.55)
	H21NX-HTLXX-XX00	•			85 (0.60)	2.8	0.72	2.5	↓	↓	↓	↓
	H21NX-LTLXX-XX00		•		85 (0.60)	1.39	2.8	10.2	↓	↓	↓	↓
	H21NX-ETLXX-XX00			•	60 (0.42)	1.97	1.42	1.42	↓	↓	↓	↓
	H21NX-HBLXX-XX00	•			84 (0.60)	1.41	2.73	9.9	↓	↓	↓	↓
	H21NX-LBLXX-XX00		•		84 (0.60)	0.71	10.8	39.5	↓	↓	↓	↓
	H21NX-EBLXX-XX00			•	60 (0.42)	1.0	5.42	9.9	↓	↓	↓	↓

All ratings typical and at 25°C unless otherwise noted.

△ An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See How to Order and Model Number Code on page C-85.

△ Motor connections are determined by the Windings/Leads designation in the Model Number Code on page C-85. Note that the F designation, although not shown in the above tables, is an 8-lead option...see Terminations, page D-17. In addition to the lead wire termination, terminal board and MS connector hookup for parallel, series or unipolar operation is also available.

△ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).

△ Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory.

△ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

△ Thermal resistance measured with motor hanging in still air (unmounted).

GENERAL PURPOSE—CONVENTIONAL HYBRIDS

NEMA 23 FRAME (2.3" Dia.)—Ratings and Characteristics

Review the Model Number Code, page C-85, to assure that all options are designated. Connections, encoders and phasing diagrams start on page D-17. Motor dimensions are on page C-88. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated currents are in descending order	Motor Model Number [△]	Connection [△]			Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S² (kgm² x 10 ⁻³)	Weight lbs (kg)								
		Parallel	Series	Unipolar																
Torque range: 148-225 oz-in. 1.05-1.59 Nm	E22NX-HPLXX-XX00	•			210 (1.48)	6.7	0.19	0.5	↑	↑	↑	↑								
	E22NX-LPLXX-XX00		•		210 (1.48)	3.4	0.68	2.1												
	E22NX-EPLXX-XX00			•	148 (1.05)	4.7	0.35	0.5												
SIGMAX® E22 Series 2 rotor stacks	E22NX-HCLXX-XX00	•			218 (1.54)	6.4	0.21	0.6					9.6 (0.068)	4.4	0.0031 (0.022)	2.1 (0.95)				
	E22NX-LCLXX-XX00		•		218 (1.54)	3.2	0.73	2.5												
	E22NX-ECLXX-XX00			•	154 (1.09)	4.5	0.38	0.6												
	E22NX-HTLXX-XX00	•			223 (1.58)	5.0	0.33	1.1									↓	↓	↓	↓
	E22NX-LTLXX-XX00		•		223 (1.58)	2.5	1.2	4.5												
	E22NX-ETLXX-XX00			•	158 (1.12)	3.5	0.62	1.1												
	E22NX-HBLXX-XX00	•			225 (1.59)	3.1	0.79	2.9												
	E22NX-LBLXX-XX00		•		225 (1.59)	1.6	3.07	11.8												
	E22NX-EBLXX-XX00			•	159 (1.12)	2.2	1.55	2.9												
	E22NX-HDLXX-XX00	•			225 (1.59)	2.4	1.25	4.7					↓	↓	↓	↓				
	E22NX-LDLXX-XX00		•		225 (1.59)	1.22	4.91	19.0												
	E22NX-EDLXX-XX00			•	159 (1.12)	1.72	2.47	4.7												
Torque range: 103-156 oz-in. .73-1.10 Nm	H22NX-HPLXX-XX00	•			146 (1.03)	6.7	0.19	0.6									↑	↑	↑	↑
	H22NX-LPLXX-XX00		•		146 (1.03)	3.4	0.68	2.4												
	H22NX-EPLXX-XX00			•	103 (0.73)	4.7	0.35	0.6												
STANDARD H22 Series 2 rotor stacks	H22NX-HCLXX-XX00	•			151 (1.07)	6.4	0.21	0.7	4.6 (0.032)	4.4	0.0031 (0.022)	2.1 (0.95)								
	H22NX-LCLXX-XX00		•		151 (1.07)	3.2	0.73	2.9												
	H22NX-ECLXX-XX00			•	107 (0.75)	4.5	0.38	0.7												
	H22NX-HTLXX-XX00	•			155 (1.09)	5.0	0.33	1.3					↓	↓	↓	↓				
	H22NX-LTLXX-XX00		•		155 (1.09)	2.5	1.2	5.1												
	H22NX-ETLXX-XX00			•	109 (0.77)	3.5	0.62	1.3												
	H22NX-HBLXX-XX00	•			156 (1.10)	3.1	0.79	3.4												
	H22NX-LBLXX-XX00		•		156 (1.10)	1.54	3.07	13.5												
	H22NX-EBLXX-XX00			•	110 (0.78)	2.2	1.55	3.4												
	H22NX-HDLXX-XX00	•			156 (1.10)	2.4	1.25	5.5	↓	↓	↓	↓								
	H22NX-LDLXX-XX00		•		156 (1.10)	1.22	4.91	21.8												
	H22NX-EDLXX-XX00			•	110 (0.78)	1.72	2.47	5.5												

All ratings typical and at 25°C unless otherwise noted.

⚠ An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See How to Order and Model Number Code on page C-85.

Motor connections are determined by the Windings/Leads designation in the Model Number Code on page C-85. Note that the F designation, although not shown in the above tables, is an 8-lead option...see Terminations, page D-17. In addition to the lead wire termination, terminal board and MS connector hookup for parallel, series or unipolar operation is also available.

³ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).

⚠ Windings at 130°C and motor in still air at 40°C (without heat sink).
Operation of these motors above rated current may cause demagnetization. Contact factory.

⁵ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

⁶ Thermal resistance measured with motor hanging in still air (unmounted).

$\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)

(See Section D for Technical Data)

Technical drawing of a motor lead assembly, showing front, side, and top views with dimensions and tolerances.

Front View:

- Overall width: 2.25 ± 0.15 (57,15)
- Overall height: 1.500 ± 0.002 (38,1 ± 0,51)
- Four mounting holes: $4 \times \varnothing .200$ (5,08) THRU, EQUALLY SPACED ON 2.625 (66,68) B.C.
- Central hole: $\varnothing .2500$ (+.0000 / -.0005) (6,35 -0,013)
- Surface finish: $.002$ (0,051) A-

Side View:

- Lead length: $L \text{ MAX.}$
- Lead diameter: $.81$ (20,57)
- Lead thickness: $.06$ (1,52)
- Lead width: $(.18)$ (4,57)
- Surface finish: $.003$ (0,077) A

Top View:

- Motor leads: $\triangle$

MODEL NUMBER	L MAX.
2HNR	$\frac{1.56}{39,63}$
21NR	$\frac{2.06}{52,33}$
22NR	$\frac{3.06}{77,73}$

NOTE:

△ 1 MOTOR LEADS: #22 AWG, 12.0 MINIMUM.
304.8

The image contains three technical drawings of a rear shaft assembly, labeled A, B, and C.

- FLAT CONFIGURATION = F (Drawing A):** A side view of the shaft. Dimensions include a total length of .50 (12,7 FULL DEPTH), a distance of .219 (5,56) from the left end to the start of the shaft, and a distance of .81 (20,57) from the left end to the center of the shaft.
- REAR SHAFT CONFIGURATION = D (Drawing B):** A side view of the shaft with a plant symbol at the left end. Dimensions include a distance of .75 ± .04 (19,05 ± 1,02) from the left end to the center of the shaft. A feature control frame points to a hole with the following specifications:

Ø	$\frac{+.0000}{-.0005}$
	$\frac{6,35}{-0,013}$

 A second feature control frame points to a surface with the following specifications:

↗	$\frac{.002}{0,051}$
---	----------------------
- SYSTEM CONSTRUCTION = C (Drawing C):** A side view showing the shaft connected to a component labeled "MS CONNECTOR". A dimension of 12.0 (304,8) MINIMUM is shown between the top of the connector and the top of the shaft.

Technical drawing of the Hewlett-Packard Encoder. The drawing includes a side view on the left and a front view on the right. The side view shows a cylindrical component with a flange. The front view shows a square flange with four mounting holes. Dimensions are provided for the side view: a distance of .72 (18.29) from the center of the shaft to the center of the mounting holes. The front view shows a square flange with a central circular feature and four mounting holes. The overall width of the flange is dimensioned as Ø (1.812) (46.02).

HEWLETT
PACKARD
ENCODER

.72
18.29

Ø (1.812)
(46.02)

E SERIES HYBRID STEP MOTORS

Holding torque range:
237-1222 oz-in. (1.67-8.63 Nm)

NEMA 34 FRAME SIZE Systems configuration

- High torque-to-inertia
- High acceleration
- Standard encoder option
- MS connector equipped
- Long life bearings
- Locked outer bearing races
- NEMA and IEC IP65 sealed

Three inch OD hybrid step motors meet a broad range of motion control application requirements. Each of these models is ideally suited for use with various Pacific Scientific 6000, 5600, 5400, 5300 and 5200 series drives and indexer/drives.

An MS connector termination is standard, assuring reliability and fast startup. Splashproof construction and long life bearings are also standard. Motor splashproofing is in accordance with NEMA MG1-1.26, part E and IEC IP65 with exception of the shaft. Longer stack lengths are provided with a heavy duty NEMA front end bell for extra mounting rigidity.

A shaft seal providing sealing to the motor specifications, and an integral optical encoder with MS connector termination are both optional.



RECOMMENDED SYSTEMS MOTORS. . ratings and characteristics

We suggest you use E Series enhanced hybrid step motors to achieve the highest overall performance from your system. See page C-83 for the specific advantages of the Sigmax® technology.

While Sigmax offers the highest output performance, your selection is not limited to these systems motors. Pacific Scientific is a full line step motor manufacturer with configurations to meet a broad spectrum of applications.

Model Number [△]	Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Drive Current/ Phase (amps DC)	Detent Torque oz-in (Nm)	Phase Resistance (ohms) ±10%	Phase [△] Inductance (mH) ±20%	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)
E31NC-LTLNN-NS00	319 (2.25)	2.5	21.5 (0.15)	1.20	10.5	0.0083 (0.051)	3.2 (1.45)
E31NC-LPLNN-NS00	237 (1.67)	2.5	21.5 (0.15)	0.53	4.1	0.0083 (0.051)	3.2 (1.45)
E31NC-HTLNN-NS00	319 (2.25)	5.0	21.5 (0.15)	0.30	2.3	0.0083 (0.051)	3.2 (1.45)
E32NC-LTLNN-NS00	638 (4.51)	2.5	41.6 (0.29)	1.80	20.5	0.0170 (0.102)	5.3 (2.41)
E32NC-LPLNN-NS00	474 (3.35)	2.5	41.6 (0.29)	0.80	9.2	0.0170 (0.102)	5.3 (2.41)
E32NC-HTLNN-NS00	638 (4.51)	5.0	41.6 (0.29)	0.45	5.0	0.0170 (0.102)	5.3 (2.41)
E32NC-HPLNN-NS00	474 (3.35)	5.0	41.6 (0.29)	0.20	2.3	0.0170 (0.102)	5.3 (2.41)
E33NC-HTLNN-NS00	958 (6.77)	5.0	69.3 (0.45)	0.62	7.5	0.0250 (0.155)	7.6 (3.45)
E33NC-HPLNN-NS00	711 (5.02)	5.0	69.3 (0.45)	0.27	3.3	0.0250 (0.155)	7.6 (3.45)
E34HC-HTLNN-NS00	1222 (8.63)	5.0	83.0 (0.59)	0.70	8.3	0.0350 (0.217)	9.7 (4.41)
E34HC-HPLNN-NS00	948 (6.69)	5.0	83.0 (0.59)	0.33	4.2	0.0350 (0.217)	9.7 (4.41)

All ratings typical and at 25°C unless otherwise noted.

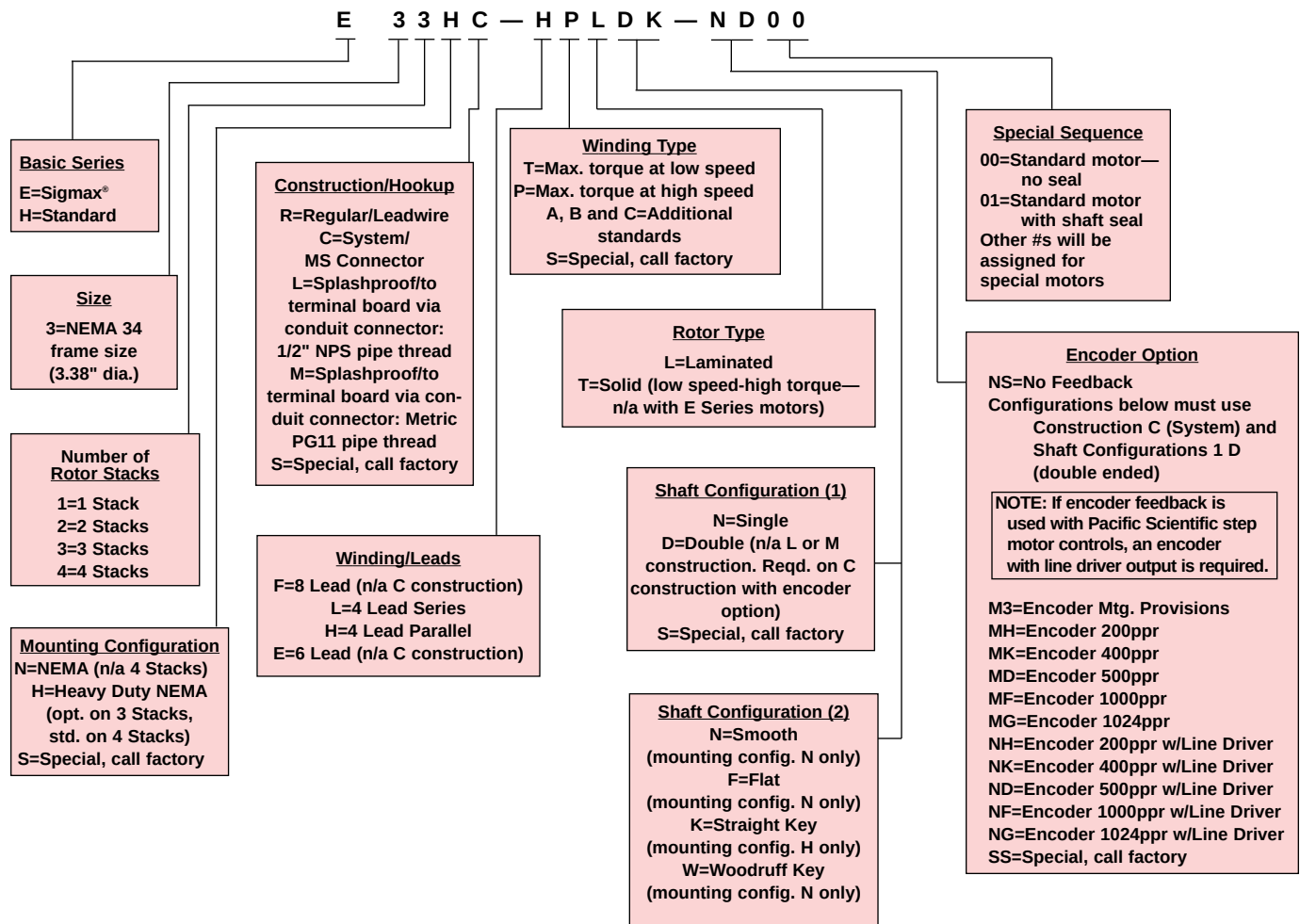
[△] See How to Order and Model Number Code on page C-90.

[△] When operated at listed drive current.

[△] Typical small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

GENERAL PURPOSE—CONVENTIONAL HYBRIDS
NEMA 34 FRAME (3.4" Dia.)

MODEL NUMBER CODE



The example above indicates an E series (Sigmax®) NEMA 34 frame motor with three rotor stacks. This motor is equipped with heavy duty front end bell and shaft and sealed, system rear end bell with MS connectors. It also has a bipolar parallel connection, a maximum power at high speed winding, a straight keyway and a shaft seal. The encoder specified is 500ppr with line drive output.

HOW TO ORDER

Order motors and controls as separate part numbers. Review the Motor Model Number Code to assure that all options are designated. Connections, encoders and phasing diagrams start in Section D. Motor dimensions start on page C-94.

GENERAL PURPOSE—CONVENTIONAL HYBRIDS
NEMA 34 FRAME (3.4" Dia.)—Ratings and Characteristics

Review the Model Number Code, page C-90, to assure that all options are designated. Connections, encoders and phasing diagrams start in Section D. Motor dimensions start on page C-94. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated currents are in descending order	Motor Model Number [△]	Connection [△]		Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S² (kgm² x 10⁻³)	Weight lbs (kg)																				
		Parallel	Series Unipolar																												
Torque range: 223-349 oz-in. 1.58-1.90 Nm	E31NX-H ^{PL} XX-XX00	•		344 (2.43)	8.4	0.13	1.1	↑	↑	↑	↑																				
	E31NX-L ^{PL} XX-XX00		•	344 (2.43)	4.2	0.52	4.4																								
	E31NX-E ^{PL} XX-XX00			•	243 (1.72)	5.9	0.27					1.1																			
SIGMAX® E31 Series 1 rotor stack	E31NX-H ^{AL} XX-XX00	•		349 (2.47)	8.2	0.14	1.2					22 (0.16)	3.9	0.0083 (0.059)	3.2 (1.45)																
	E31NX-L ^{AL} XX-XX00		•	349 (2.47)	4.1	0.55	4.9																								
	E31NX-E ^{AL} XX-XX00			•	247 (1.74)	5.8	0.28									1.2															
E31NX-H ^{BL} XX-XX00	•		316 (2.23)	5.9	0.24	1.7	↓									↓	↓	↓													
E31NX-L ^{BL} XX-XX00		•	316 (2.23)	3.0	0.94	6.9																									
E31NX-E ^{BL} XX-XX00			•	224 (1.58)	4.2	0.50													1.7												
E31NX-H ^{TL} XX-XX00	•		337 (2.38)	5.4	0.29	2.5													↓	↓	↓	↓									
E31NX-L ^{TL} XX-XX00		•	337 (2.38)	2.7	1.12	10.0																									
E31NX-E ^{TL} XX-XX00			•	238 (1.68)	3.8	0.59																	2.5								
E31NX-H ^{CL} XX-XX00	•		316 (2.23)	3.0	0.94	6.9																	↓	↓	↓	↓					
E31NX-L ^{CL} XX-XX00		•	316 (2.23)	1.48	3.73	27.6																									
E31NX-E ^{CL} XX-XX00			•	223 (1.58)	2.1	1.89																					6.9				
Torque range: 158-186 oz-in. 1.12-1.71 Nm	H31NX-H ^{PL} XX-XX00	•		239 (1.69)	8.4	0.13																					1.0	↑	↑	↑	↑
	H31NX-L ^{PL} XX-XX00		•	239 (1.69)	4.2	0.52																					4.0				
	H31NX-E ^{PL} XX-XX00			•	169 (1.20)	5.9																					0.27				
STANDARD H31 Series 1 rotor stack	H31NX-H ^{AL} XX-XX00	•		242 (1.71)	8.2	0.14																					1.1				
	H31NX-L ^{AL} XX-XX00		•	242 (1.71)	4.1	0.50		4.5																							
	H31NX-E ^{AL} XX-XX00			•	171 (1.21)	5.8		0.28	1.1																						
H31NX-H ^{BL} XX-XX00	•		224 (1.58)	5.9	0.24	1.6		↓	↓	↓	↓																				
H31NX-L ^{BL} XX-XX00		•	224 (1.58)	3.0	0.94	6.4																									
H31NX-E ^{BL} XX-XX00			•	158 (1.12)	4.2	0.50						1.6																			
H31NX-H ^{TL} XX-XX00	•		236 (1.66)	5.4	0.29	2.3						↓	↓	↓	↓																
H31NX-L ^{TL} XX-XX00		•	236 (1.66)	2.7	1.12	9.3																									
H31NX-E ^{TL} XX-XX00			•	167 (1.18)	3.8	0.59	2.3																								
H31NX-H ^{CL} XX-XX00	•		224 (1.58)	3.0	0.94	6.4	↓									↓	↓	↓													
H31NX-L ^{CL} XX-XX00		•	224 (1.58)	1.48	3.73	25.8																									
H31NX-E ^{CL} XX-XX00			•	158 (1.12)	2.1	1.89													6.4												

- △ All ratings typical and at 25°C unless otherwise noted.
- △ An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See How to Order and Model Number Code on page C-90.
- △ Motor connections are determined by the Windings/Leads designation in the Model Number Code on page C-90. Note that the F designation, although not shown in the above tables, is an 8-lead option...see Terminations, on page D-17. In addition to the lead wire termination, terminal board and MS connector hookup for parallel, series or unipolar operation is also available.

- △ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).
- △ Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory.
- △ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.
- △ Thermal resistance measured with motor hanging in still air (unmounted).

GENERAL PURPOSE—CONVENTIONAL HYBRIDS
NEMA 34 FRAME (3.4" Dia.)—Ratings and Characteristics (Con't)

Review the Model Number Code, page C-90, to assure that all options are designated. Connections, encoders and phasing diagrams start in Section D. Motor dimensions start on page C-94. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated currents are in descending order	Motor Model Number [△]	Connection [△]		Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S² (kgm² x 10⁻³)	Weight lbs (kg)
		Parallel	Series Unipolar								
Torque range: 443-673 oz-in. 3.13-4.75 Nm	E32NX-HPLXX-XX00	•		673 (4.75)	8.1	0.19	2.2	↑	↑	↑	↑
	E32NX-LPLXX-XX00		•	673 (4.75)	4.1	0.74	8.9	↑	↑	↑	↑
	E32NX-EPLXX-XX00		•	476 (3.36)	5.7	0.39	2.2	↑	↑	↑	↑
	E32NX-HALXX-XX00	•		627 (4.43)	5.6	0.39	3.7	42 (0.3)	2.7	0.0170 (0.120)	5.3 (2.41)
	E32NX-LALXX-XX00		•	627 (4.43)	2.8	1.51	15.0	↑	↑	↑	↑
	E32NX-EALXX-XX00		•	443 (3.13)	4.0	0.78	3.7	↑	↑	↑	↑
	E32NX-HTLXX-XX00	•		659 (4.66)	5.2	0.44	5.0	↓	↓	↓	↓
	E32NX-LTLXX-XX00		•	659 (4.66)	2.6	1.74	19.9	↓	↓	↓	↓
	E32NX-ETLXX-XX00		•	466 (3.29)	3.7	0.89	5.0	↓	↓	↓	↓
Torque range: 314-471 oz-in. 2.22-3.32 Nm	H32NX-HPLXX-XX00	•		471 (3.32)	8.1	0.19	2.4	↑	↑	↑	↑
	H32NX-LPLXX-XX00		•	471 (3.32)	4.1	0.74	9.6	↑	↑	↑	↑
	H32NX-EPLXX-XX00		•	333 (2.35)	5.7	0.39	2.4	↑	↑	↑	↑
	H32NX-HALXX-XX00	•		445 (3.14)	5.6	0.39	4.1	18 (0.3)	2.7	0.0170 (0.120)	5.3 (2.41)
	H32NX-LALXX-XX00		•	445 (3.14)	2.8	1.51	16.2	↑	↑	↑	↑
	H32NX-EALXX-XX00		•	314 (2.22)	4.0	0.78	4.1	↑	↑	↑	↑
	H32NX-HTLXX-XX00	•		463 (3.27)	5.2	0.44	5.4	↓	↓	↓	↓
	H32NX-LTLXX-XX00		•	463 (3.27)	2.6	1.74	21.6	↓	↓	↓	↓
	H32NX-ETLXX-XX00		•	328 (2.31)	3.7	0.89	5.4	↓	↓	↓	↓
Torque range: 656-995 oz-in. 4.63-5.40 Nm	E33NX-HCLXX-XX00	•		927 (6.55)	11.1	0.15	1.3	↑	↑	↑	↑
	E33NX-LCLXX-XX00		•	927 (6.55)	5.5	0.59	5.3	↑	↑	↑	↑
	E33NX-ECLXX-XX00		•	656 (4.63)	7.8	0.29	1.3	↑	↑	↑	↑
	E33NX-HALXX-XX00	•		940 (6.64)	8.6	0.23	2.3	↑	↑	↑	↑
	E33NX-LALXX-XX00		•	940 (6.64)	4.3	0.87	9.1	↑	↑	↑	↑
	E33NX-EALXX-XX00		•	664 (4.69)	6.1	0.46	2.3	↑	↑	↑	↑
	E33NX-HPLXX-XX00	•		995 (7.02)	7.9	0.26	3.1	64 (0.45)	2.0	.0250 (0.176)	7.6 (3.45)
	E33NX-LPLXX-XX00		•	995 (7.02)	4.0	1.02	12.6	↑	↑	↑	↑
	E33NX-EPLXX-XX00		•	703 (4.97)	5.6	0.54	3.1	↑	↑	↑	↑
	E33NX-HBLXX-XX00	•		939 (6.63)	5.4	0.55	5.7	↓	↓	↓	↓
	E33NX-LBLXX-XX00		•	939 (6.63)	2.7	2.17	22.9	↓	↓	↓	↓
	E33NX-EBLXX-XX00		•	664 (4.69)	3.8	1.11	5.7	↓	↓	↓	↓
	E33NX-HTLXX-XX00	•		975 (6.88)	5.1	0.61	7.1	↓	↓	↓	↓
	E33NX-LTLXX-XX00		•	975 (6.88)	2.6	2.41	28.2	↓	↓	↓	↓
	E33NX-ETLXX-XX00		•	689 (4.87)	3.6	1.23	7.1	↓	↓	↓	↓

All ratings typical and at 25°C unless otherwise noted.

- △ An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See How to Order and Model Number Code on page C-90.
- △ Motor connections are determined by the Windings/Leads designation in the Model Number Code on page C-90. Note that the F designation, although not shown in the above tables, is an 8-lead option...see Terminations, on page D-17. In addition to the lead wire termination, terminal board and MS connector hookup for parallel, series or unipolar operation is also available.

- △ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).
- △ Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory.
- △ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.
- △ Thermal resistance measured with motor hanging in still air (unmounted).

NEMA 34 FRAME (3.4" Dia.)—Ratings and Characteristics (Con't.)

Review the Model Number Code, page C-90, to assure that all options are designated. Connections, encoders and phasing diagrams start in Section D. Motor dimensions start on page C-94. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated currents are in descending order	Motor Model Number⚠	Connection ⚠			Holding Torque ⚠ (2 phases on) oz-in (Nm) ±10%	Rated Current/Phase ⚠ (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance ⚠ (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance ⚠ (°C/watt)	Rotor Inertia oz-in-S² (kgm² x 10 ⁻³)	Weight lbs (kg)					
		Parallel	Series	Unipolar													
Torque range: 466-698 oz-in. 3.29-4.93 Nm	H33XX-HCLXX-XX00	•			659 (4.65)	11.1	0.15	1.6	↑	↑	↑	↑					
	H33XX-LCLXX-XX00		•		659 (4.65)	5.5	0.59	6.3									
	H33XX-ECLXX-XX00			•	466 (3.29)	7.8	0.29	1.6									
STANDARD H33 Series 3 rotor stacks	H33XX-HALXX-XX00	•			666 (4.70)	8.6	0.23	2.7	27 (19)	2.0	.0250 (0.176)	7.6 (3.45)					
	H33XX-LALXX-XX00		•		666 (4.70)	4.3	0.87	10.8									
	H33XX-EALXX-XX00			•	471 (3.33)	6.1	0.46	2.7									
	H33XX-HBLXX-XX00	•			666 (4.70)	5.4	0.55	6.8									
	H33XX-LBLXX-XX00		•		666 (4.70)	2.7	2.17	27.2									
	H33XX-EBLXX-XX00			•	471 (3.33)	3.8	1.11	6.8									
	H33XX-HTLXX-XX00	•			687 (4.85)	5.1	0.61	8.4									
	H33XX-LTLXX-XX00		•		687 (4.85)	2.6	2.41	33.6									
	H33XX-ETLXX-XX00			•	468 (3.43)	3.6	1.23	8.4									
	H33XX-HPLXX-XX00	•			698 (4.93)	1.9	0.26	3.7									
	H33XX-LPLXX-XX00		•		698 (4.93)	4.0	1.02	14.9									
	H33XX-EPLXX-XX00			•	494 (3.49)	5.6	0.54	3.7									
	Torque range: 879-1300 oz-in. 6.21-9.18 Nm	E34HX-HALXX-XX00	•			1253 (8.85)	8.1	0.29					3.6	↑	↑	↑	↑
		E34HX-LALXX-XX00		•		1253 (8.85)	4.1	1.14					13.7				
		E34HX-EALXX-XX00			•	886 (6.26)	5.7	0.60					3.6				
SIGMAX® E34 Series 4 rotor stacks	E34HX-HPLXX-XX00	•			1300 (9.18)	7.7	0.33	4.4	83 (0.59)	1.7	0.0350 (0.247)	9.7 (4.41)					
	E34HX-LPLXX-XX00		•		1300 (9.18)	3.9	1.27	17.8									
	E34HX-EPLXX-XX00			•	920 (6.49)	5.5	0.66	4.4									
	E34HX-HTLXX-XX00	•			1243 (8.78)	5.2	0.71	8.7									
	E34HX-LTLXX-XX00		•		1243 (8.78)	2.6	2.8	34.8									
	E34HX-ETLXX-XX00			•	879 (6.21)	3.7	1.43	8.7									
Torque range: 624-916 oz-in. 4.41-6.47 Nm	H34HX-HALXX-XX00	•			888 (6.27)	8.1	0.29	3.8	↑	↑	↑	↑					
	H34HX-LALXX-XX00		•		888 (6.27)	4.1	1.14	15.1									
	H34HX-EALXX-XX00			•	628 (4.44)	5.7	0.60	3.8									
STANDARD H34 Series 4 rotor stacks	H34HX-HPLXX-XX00	•			916 (6.47)	7.7	0.33	4.7	35 (0.25)	1.7	0.0350 (0.247)	9.7 (4.41)					
	H34HX-LPLXX-XX00		•		916 (6.47)	3.9	1.27	18.6									
	H34HX-EPLXX-XX00			•	648 (4.57)	5.5	0.66	4.7									
	H34HX-HTLXX-XX00	•			882 (6.23)	5.2	0.71	9.1									
	H34HX-LTLXX-XX00		•		882 (6.23)	2.6	2.8	36.5									
	H34HX-ETLXX-XX00			•	624 (4.41)	3.7	1.43	9.1									

All ratings typical and at 25°C unless otherwise noted.

 An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See How to Order and Model Number Code on page C-90.

⚠ Motor connections are determined by the Windings/Leads designation in the Model Number Code on page C-90. Note that the F designation, although not shown in the above tables, is an 8-lead option...see Terminations, on page D-17. In addition to the lead wire termination, terminal board and MS connector hookup for parallel, series or unipolar operation is also available.

³ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).

⚠ Windings at 130°C and motor in still air at 40°C (without heat sink).
Operation of these motors above rated current may cause demagnetization. Contact factory.

⁵ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

⁶ Thermal resistance measured with motor hanging in still air (unmounted).

$\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)

(See Section D for Technical Data)

STANDARD NEMA FRONT END BELL=N



REAR SHAFT CONFIGURATION = D

DIMENSIONS . . . GENERAL PURPOSE—CONVENTIONAL HYBRIDS

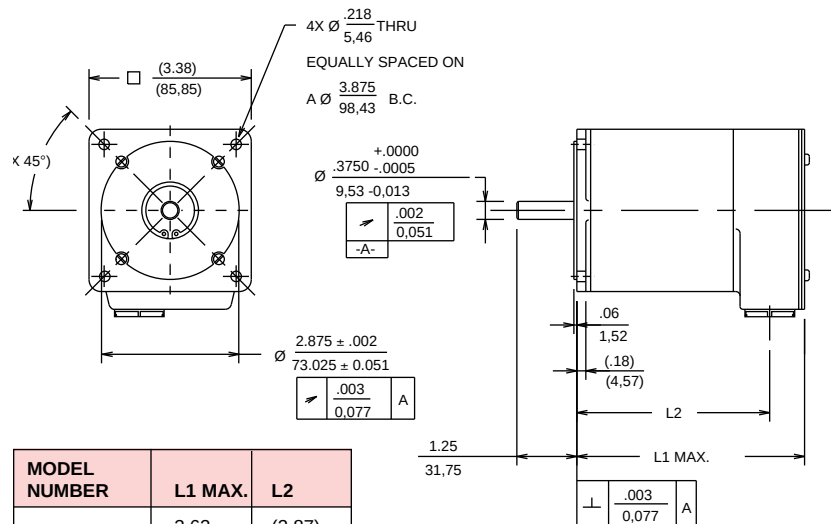
$\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)

NEMA 34 FRAME (Con't.)

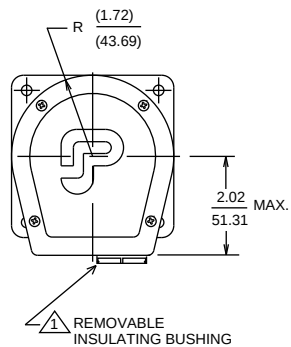
(See Section D for Technical Data)

SPLASHPROOF CONSTRUCTION/TERMINAL BOARD CONNECTIONS=L or M

STANDARD NEMA FRONT END BELL=N

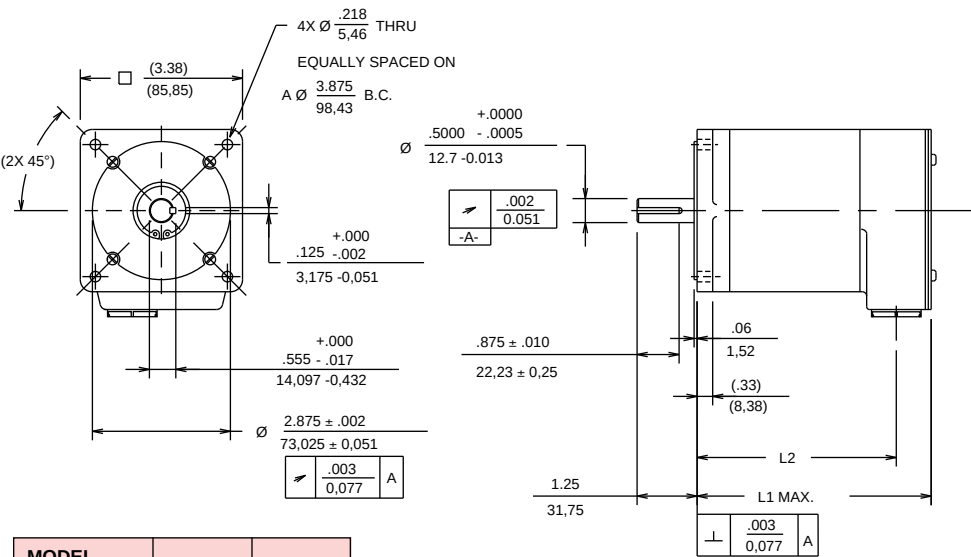


MODEL NUMBER	L1 MAX.	L2
31N(L OR M)	$\frac{3.62}{91,95}$	$\frac{(2.87)}{(72,9)}$
32N(L OR M)	$\frac{4.77}{121,16}$	$\frac{(4.02)}{(102,11)}$
33N(L OR M)	$\frac{6.05}{153,67}$	$\frac{(5.30)}{(134,62)}$

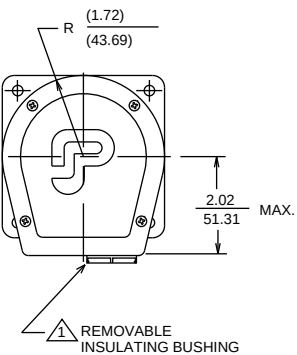


NOTE:
 Δ L Construction = Conduit connection (1/2 NPS TAP) with $\frac{.56}{14,2}$ I.D. removable insulating bushing
M Construction = Conduit connection (PG 11 TAP). (No insulating bushing supplied)
2 Standard front shaft configuration options, refer to page C-94.

HEAVY DUTY NEMA FRONT END BELL=H



MODEL NUMBER	L1 MAX.	L2
33H(L OR M)	$\frac{6.73}{170,94}$	$\frac{(5.61)}{(142,49)}$
34H(L OR M)	$\frac{7.62}{193,55}$	$\frac{(6.86)}{(174,24)}$



NOTE:
 Δ L Construction = Conduit connection (1/2 NPS TAP) with $\frac{.56}{14,2}$ I.D. removable insulating bushing
M Construction = Conduit connection (PG 11 TAP). (No insulating bushing supplied)

DIMENSIONS . . . GENERAL PURPOSE—CONVENTIONAL HYBRIDS

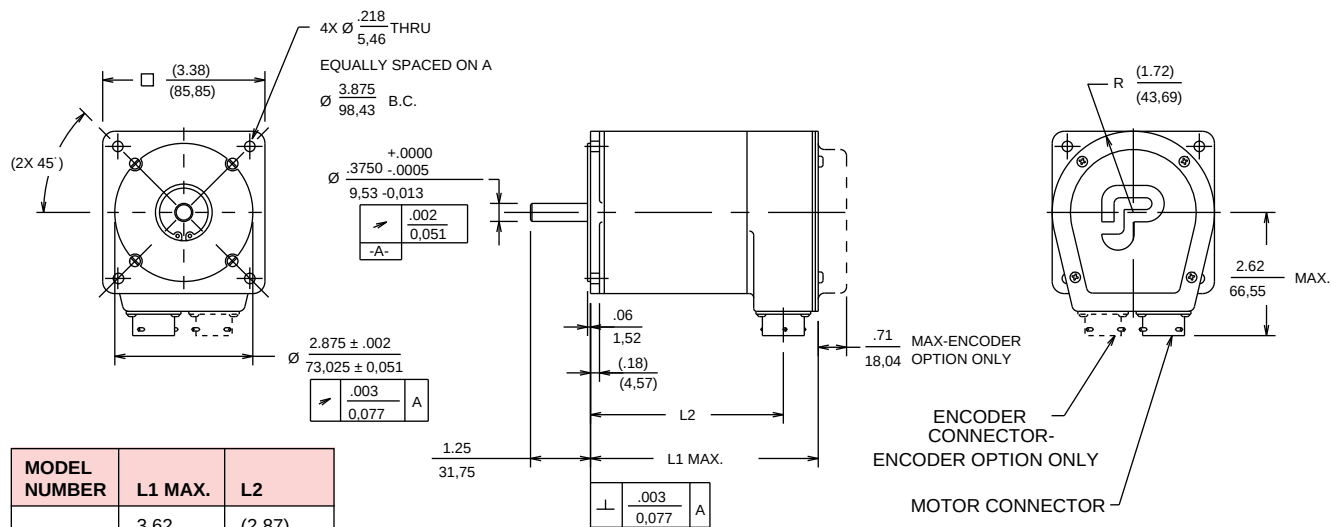
$\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)

NEMA 34 FRAME (Con't.)

(See page Section D for Technical Data)

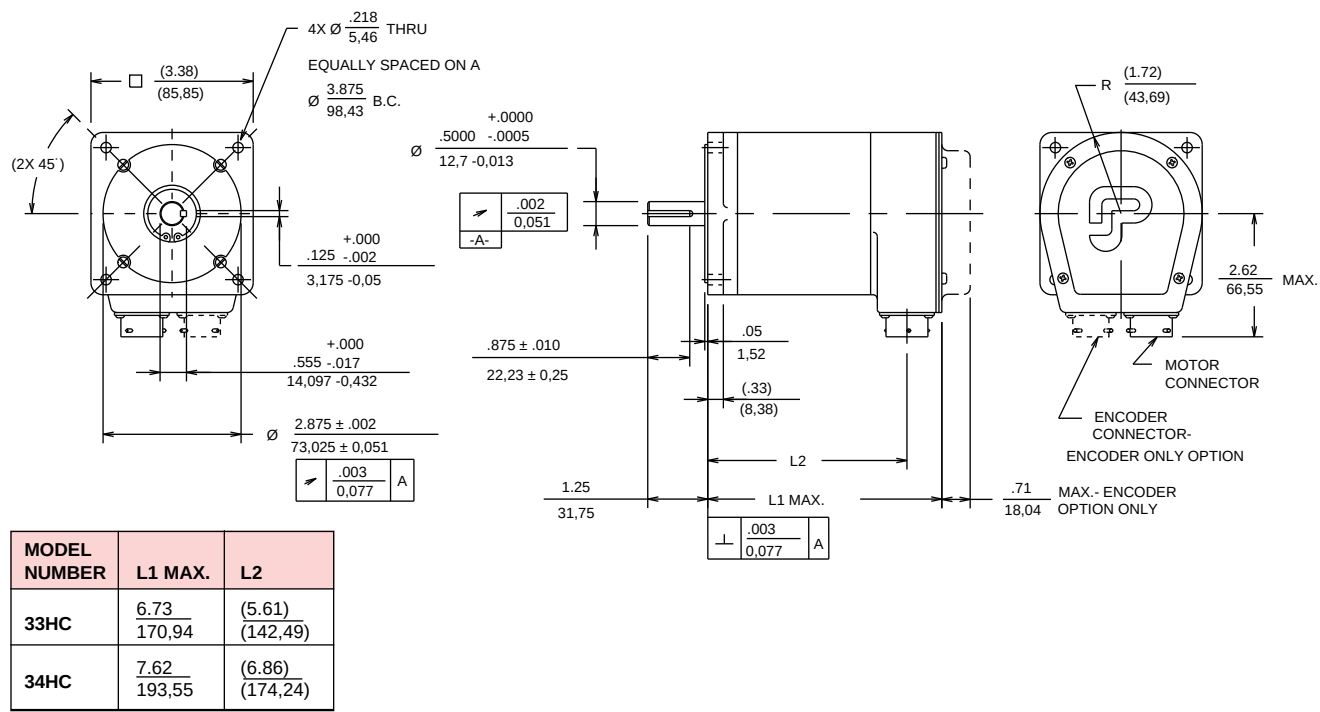
SYSTEM CONSTRUCTION/MS CONNECTOR=C
ENCODER OPTION

STANDARD NEMA FRONT END BELL=N



NOTE: Standard front shaft configuration options, refer to page C-94.

HEAVY DUTY NEMA FRONT END BELL=H



E SERIES HYBRID STEP MOTORS

Holding torque range:
1284-4034 oz-in. (9.07-28.49 Nm)

NEMA 42 FRAME SIZE Systems configuration

- High torque-to-inertia
- High acceleration
- Standard encoder option
- MS connector equipped
- Long life bearings
- Locked outer bearing races
- NEMA and IEC IP65 sealed

These hybrid step motors are designed using Sigmax® technology for the highest torque and power applications. Four inch motors are ideal for use with Pacific Scientific 5600 and 5400 series drives and indexer/drives.

Heavy duty shafts, heavy duty NEMA front end bell, long life bearings, splashproof construction and MS connector terminations are standard. Motor splashproofing is in accordance with NEMA MG1-1.26, part E and IEC IP65 with exception of the shaft.

Options include shaft seal providing sealing to the motor specifications, round mounting configuration and an integral optical encoder with MS connector termination.



RECOMMENDED SYSTEMS MOTORS. . . ratings and characteristics

We suggest you use E Series enhanced hybrid step motors to achieve the highest overall performance from your system. See page C-83 for the specific advantages of the Sigmax® technology.

While Sigmax offers the highest output performance, your selection is not limited to these systems motors. Pacific Scientific is a full line step motor manufacturer with configurations to meet a broad spectrum of applications.

Model Number [△]	Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Drive Current/ Phase (amps DC)	Detent Torque oz-in (Nm)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Rotor Inertia oz-in-S² (kgm² x 10⁻³)	Weight lbs (kg)
E41HX-HTLNK-NS00	1284 (9.07)	5.0	58.0 (0.41)	0.62	9.0	0.0800 (0.496)	14.0 (6.36)
E42HX-HTLNK-NS00	2589 (18.28)	8.0	81.0 (0.57)	0.40	6.4	0.1600 (0.993)	21.0 (9.55)
E43HX-HTLNK-NS00	4034 (28.49)	8.0	106.0 (0.75)	0.60	11.2	0.2400 (1.489)	29.0 (13.18)

All ratings typical and at 25°C unless otherwise noted.

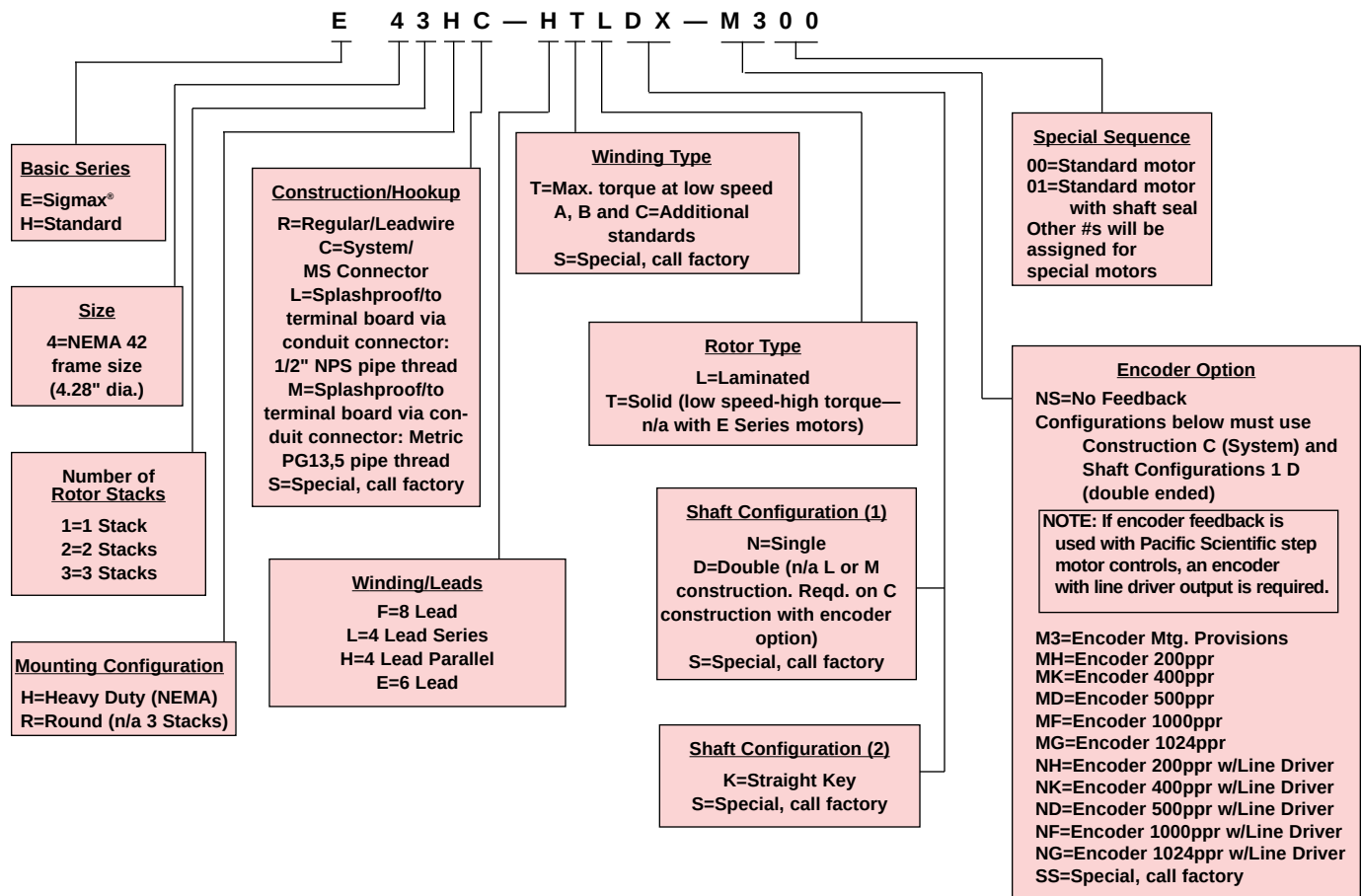
[△] See How to Order and Model Number Code on page C-98.

[△] When operated at listed drive current.

[△] Typical small signal inductance as measured with impedance bridge at 1 kHz, 1 amp.

GENERAL PURPOSE—CONVENTIONAL HYBRIDS
NEMA 42 FRAME (4.2" Dia.)

MODEL NUMBER CODE



The example above indicates a standard NEMA 42 frame motor with three rotor stacks. This motor is equipped with the standard heavy duty NEMA front end bell and shaft and a sealed, system rear end bell with MS connectors. It also has a bipolar parallel connection, a maximum torque at low speed winding, shaft seal, straight keyway and encoder mounting provisions.

HOW TO ORDER

Order motors and controls as separate part numbers. Review the Motor Model Number Code to assure that all options are designated. Connections, encoders and phasing diagrams start in Section D. Motor dimensions are on page C-102.

GENERAL PURPOSE—CONVENTIONAL HYBRIDS

NEMA 42 FRAME (4.2" Dia.)—Ratings and Characteristics

Review the Model Number Code, page C-98, to assure that all options are designated. Connections, encoders and phasing diagrams start in Section D. Motor dimensions are on page C-102. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated currents are in descending order	Motor Model Number [△]	Connection [△]			Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)	
		Parallel	Series	Unipolar									
Torque range: 957-1378 oz-in. 6.76-9.73 Nm	E41HX-HALXX-XX00	•			1378 (9.73)	10.6	0.16	2.5	↑	↑	↑	↑	
	E41HX-LALXX-XX00		•		1378 (9.73)	5.3	0.64	10.0					
	E41HX-EALXX-XX00			•	974 (6.88)	7.5	0.32	2.5					
SIGMAX® E41 Series 1 rotor stack	E41HX-HTLXX-XX00	•			1353 (9.55)	5.4	0.61	9.0	58 (0.41)	1.8	0.0800 (0.565)	14 (6.36)	
	E41HX-LTLXX-XX00		•		1353 (9.55)	2.7	2.41	36.1					
	E41HX-ETLXX-XX00			•	957 (6.76)	3.8	1.21	9.0					
	E41HX-HBLXX-XX00	•			1377 (9.72)	5.3	0.64	10.0	↓	↓	↓	↓	
	E41HX-LBLXX-XX00		•		1377 (9.72)	2.7	2.54	40.0					
	E41HX-EBLXX-XX00			•	974 (6.88)	3.7	1.27	10.0					
	Torque range: 585-839 oz-in. 4.13-5.93 Nm	H41HX-HALXX-XX00	•			839 (5.93)	10.6	0.16	3.1	↑	↑	↑	↑
		H41HX-LALXX-XX00		•		839 (5.93)	5.3	0.64	12.4				
		H41HX-EALXX-XX00			•	593 (4.19)	7.5	0.32	3.1				
STANDARD H41 Series 1 rotor stack	H41HX-HTLXX-XX00	•			828 (5.84)	5.4	0.61	11.2	31 (0.22)	1.8	0.0800 (0.565)	14 (6.36)	
	H41HX-LTLXX-XX00		•		828 (5.84)	2.7	2.41	44.6					
	H41HX-ETLXX-XX00			•	585 (4.13)	3.8	1.21	11.2					
	H41HX-HBLXX-XX00	•			839 (5.92)	5.3	0.64	12.4	↓	↓	↓	↓	
	H41HX-LBLXX-XX00		•		839 (5.92)	2.7	2.54	49.4					
	H41HX-EBLXX-XX00			•	593 (4.19)	3.7	1.27	12.4					

GENERAL PURPOSE—CONVENTIONAL HYBRIDS
NEMA 42 FRAME (4.2" Dia.)—Ratings and Characteristics (Con't.)

Review the Model Number Code, page C-98, to assure that all options are designated. Connections, encoders and phasing diagrams start in Section D. Motor dimensions are on page C-102. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated currents are in descending order	Motor Model Number [△]	Connection [△]			Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)
		Parallel	Series	Unipolar								
Torque range: 1805-2698 oz-in. 12.75-19.06 Nm	E42HX-HCLXX-XX00	•			2698 (19.06)	14.7	0.12	2.7	↑	↑	↑	↑
	E42HX-LCLXX-XX00		•		2698 (19.06)	7.4	0.47	10.6	↑	↑	↑	↑
	E42HX-ECLXX-XX00			•	1908 (13.48)	10.4	0.24	2.7	↑	↑	↑	↑
SIGMAX® E42 Series 2 rotor stacks	E42HX-HBLXX-XX00	•			2598 (18.34)	9.8	0.27	5.4	↑	↑	↑	↑
	E42HX-LBLXX-XX00		•		2598 (18.34)	4.9	1.07	21.7	↑	↑	↑	↑
	E42HX-EBLXX-XX00			•	1837 (12.97)	6.9	0.54	5.4	81 (0.57)	1.3	0.1600 (1.129)	21 (9.55)
	E42HX-HTLXX-XX00	•			2552 (18.02)	7.9	0.41	7.8	↓	↓	↓	↓
	E42HX-LTLXX-XX00		•		2552 (18.02)	4.0	1.62	31.3	↓	↓	↓	↓
	E42HX-ETLXX-XX00			•	1805 (12.75)	5.6	0.81	7.8	↓	↓	↓	↓
	E42HX-HALXX-XX00	•			2693 (19.02)	5.9	0.74	16.6	↓	↓	↓	↓
	E42HX-LALXX-XX00		•		2693 (19.02)	2.9	2.96	66.5	↓	↓	↓	↓
	E42HX-EALXX-XX00			•	1904 (13.45)	4.1	1.48	16.6	↓	↓	↓	↓
	H42HX-HCLXX-XX00	•			1652 (11.66)	14.7	0.12	3.3	↑	↑	↑	↑
	H42HX-LCLXX-XX00		•		1652 (11.66)	7.4	0.47	13.3	↑	↑	↑	↑
	H42HX-ECLXX-XX00			•	1168 (8.25)	10.4	0.24	3.3	↑	↑	↑	↑
STANDARD H42 Series 2 rotor stacks	H42HX-HBLXX-XX00	•			1604 (11.32)	9.8	0.27	6.8	↑	↑	↑	↑
	H42HX-LBLXX-XX00		•		1604 (11.32)	4.9	1.07	27.2	↑	↑	↑	↑
	H42HX-EBLXX-XX00			•	1134 (8.01)	6.9	0.54	6.8	50 (0.35)	1.3	0.1600 (1.129)	21 (9.55)
	H42HX-HTLXX-XX00	•			1581 (11.17)	7.9	0.41	9.8	↓	↓	↓	↓
	H42HX-LTLXX-XX00		•		1581 (11.17)	4.0	1.62	39.2	↓	↓	↓	↓
	H42HX-ETLXX-XX00			•	1118 (7.90)	5.6	0.81	9.8	↓	↓	↓	↓
	H42HX-HALXX-XX00	•			1649 (11.65)	5.9	0.74	20.8	↓	↓	↓	↓
	H42HX-LALXX-XX00		•		1649 (11.65)	2.9	2.96	83.4	↓	↓	↓	↓
	H42HX-EALXX-XX00			•	1166 (8.24)	4.1	1.48	20.8	↓	↓	↓	↓

- All ratings typical and at 25°C unless otherwise noted.

[△] An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See How to Order and Model Number Code on page C-98.

[△] Motor connections are determined by the Windings/Leads designation in the Model Number Code on page C-98. Note that the F designation, although not shown in the above tables, is an 8-lead option...see Terminations, on page D-17. In addition to the lead wire termination, terminal board and MS connector hookup for parallel, series or unipolar operation is also available.
- [△] With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).

[△] Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory.

[△] Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

[△] Thermal resistance measured with motor hanging in still air (unmounted).

GENERAL PURPOSE—CONVENTIONAL HYBRIDS
NEMA 42 FRAME (4.2" Dia.)—Ratings and Characteristics (Con't.)

Review the Model Number Code, page C-98, to assure that all options are designated. Connections, encoders and phasing diagrams start in Section D. Motor dimensions are on page C-102. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated currents are in descending order	Motor Model Number [△]	Connection [△]			Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)
		Parallel	Series	Unipolar								
SIGMAX® E43 Series 3 rotor stacks	E43HX-HCLXX-XX00	•			3722 (26.64)	13.3	0.21	3.7	↑ 106 (0.75) ↓	↑ 0.9 ↓	↑ 0.2400 (1.694) ↓	↑ 29 (13.18) ↓
	E43HX-LCLXX-XX00		•		3722 (26.64)	6.7	0.84	14.7				
	E43HX-ECLXX-XX00			•	2667 (18.84)	9.4	0.42	3.7				
	E43HX-HBLXX-XX00	•			3958 (27.95)	12.5	0.24	4.8				
	E43HX-LBLXX-XX00		•		3958 (27.95)	6.2	0.96	19.3				
	E43HX-EBLXX-XX00			•	2799 (19.77)	8.8	0.48	4.8				
	E43HX-HTLXX-XX00	•			3931 (27.76)	7.9	0.60	11.8				
	E43HX-LTLXX-XX00		•		3931 (27.76)	4.0	2.38	47.0				
	E43HX-ETLXX-XX00			•	2780 (19.63)	5.6	1.19	11.8				
	E43HX-HALXX-XX00	•			4276 (30.20)	5.6	1.2	30.1				
	E43HX-LALXX-XX00		•		4276 (30.20)	2.8	4.77	120.0				
	E43HX-EALXX-XX00			•	3024 (21.35)	3.9	2.39	30.1				
STANDARD H43 Series 3 rotor stacks	H43HX-HCLXX-XX00	•			2163 (15.27)	13.3	0.21	1.3	↑ 70 (0.49) ↓	↑ 0.9 ↓	↑ 0.2400 (1.694) ↓	↑ 29 (13.18) ↓
	H43HX-LCLXX-XX00		•		2163 (15.27)	6.7	0.84	5.4				
	H43HX-ECLXX-XX00			•	1529 (10.80)	9.4	0.42	1.3				
	H43HX-HBLXX-XX00	•			2256 (15.93)	12.5	0.24	1.8				
	H43HX-LBLXX-XX00		•		2256 (15.93)	6.2	0.96	7.0				
	H43HX-EBLXX-XX00			•	1595 (11.26)	8.8	0.48	1.8				
	H43HX-HTLXX-XX00	•			2651 (18.72)	7.9	0.60	16.8				
	H43HX-LTLXX-XX00		•		2651 (18.72)	4.0	2.38	67.1				
	H43HX-ETLXX-XX00			•	1874 (13.24)	5.6	1.19	16.8				
	H43HX-HALXX-XX00	•			2833 (20.00)	5.6	1.2	42.9				
	H43HX-LALXX-XX00		•		2833 (20.00)	2.8	4.77	172.0				
	H43HX-EALXX-XX00			•	2003 (14.15)	3.9	2.39	42.9				

- △ All ratings typical and at 25°C unless otherwise noted.
- △ An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See How to Order and Model Number Code on page C-98.
- △ Motor connections are determined by the Windings/Leads designation in the Model Number Code on page C-98. Note that the F designation, although not shown in the above tables, is an 8-lead option...see Terminations, on page D-17. In addition to the lead wire termination, terminal board and MS connector hookup for parallel, series or unipolar operation is also available.

- △ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).
- △ Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory.
- △ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.
- △ Thermal resistance measured with motor hanging in still air (unmounted).

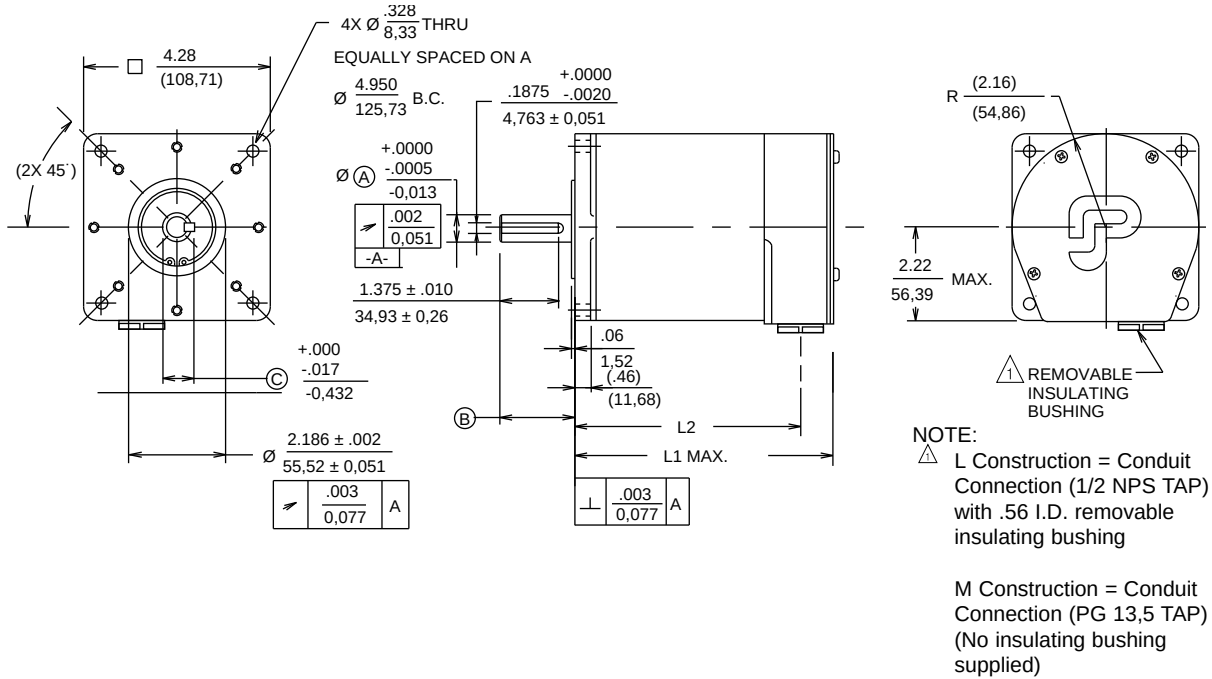
DIMENSIONS . . . GENERAL PURPOSE—CONVENTIONAL HYBRIDS

$\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)

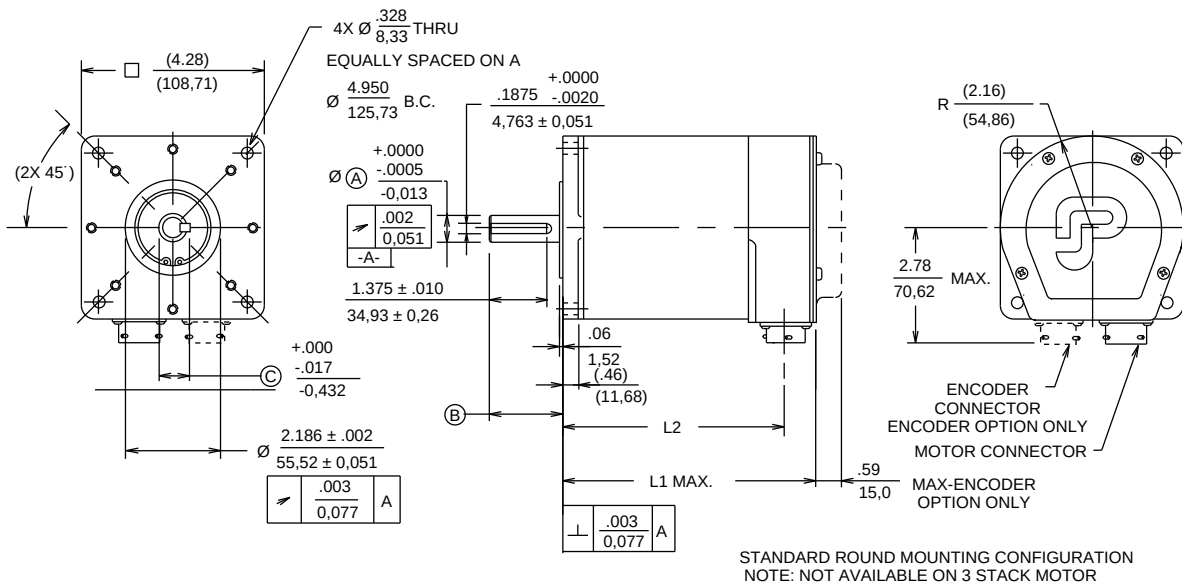
NEMA 42 FRAME

(See Section D for Technical Data)

SPLASHPROOF CONSTRUCTION/TERMINAL BOARD CONNECTIONS=L or M

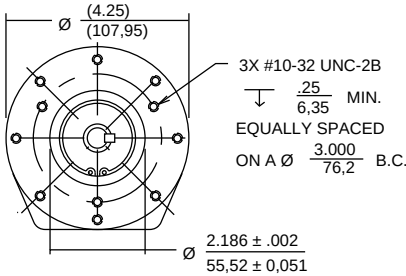


SYSTEM CONSTRUCTION/MS CONNECTOR=C and ENCODER OPTION



STANDARD ROUND MOUNTING CONFIGURATION
NOTE: NOT AVAILABLE ON 3 STACK MOTOR

MODEL NUMBER	L1 MAX.	L2	A	B	C
41H(C, L, OR M)	5.61 142, 5	(4.85) (123,19)	.6250 15,875	1.75 44,45	.705 17,91
42H(C, L, OR M)	8.04 204,22	(7.29) (185,17)	.6250 15,875	2.19 55,63	.705 17,91
43H(C, L, OR M)	10.56 268,23	(9.81) (249,18)	.7500 19,05	2.19 55,63	.830 21,09



ROUND MOUNTING CONFIGURATION = R

POWERMAX™. . THE NEW STANDARD IN NEMA 23 HYBRID STEP MOTORS

Powermax™ sets the world performance standard for NEMA 23 step motors. At up to 253 oz-in. holding torque, you won't find a more powerful two inch stepper.

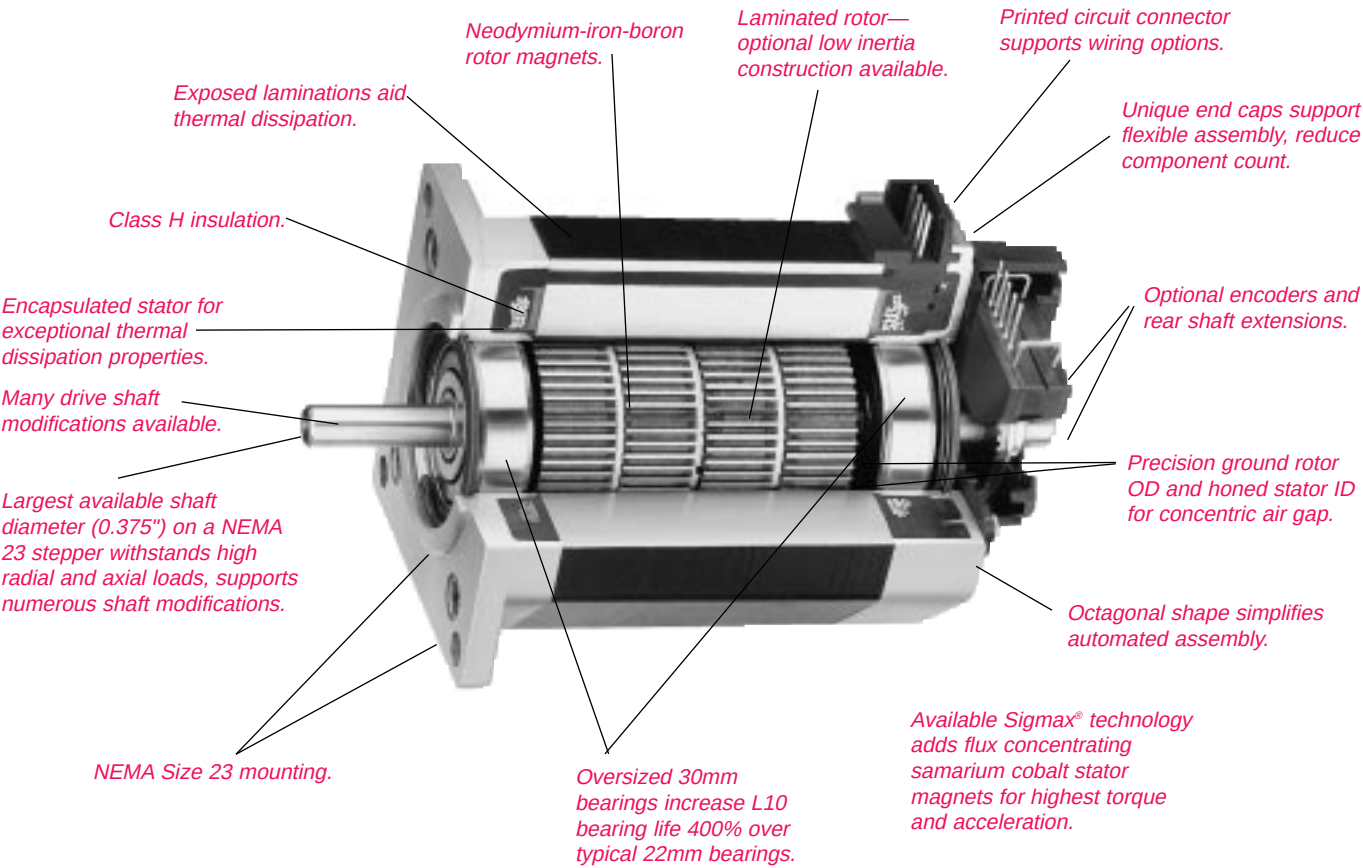
With Powermax, you also gain the cost advantages of design for manufacturability (DFM) and North America's most advanced step motor manufacturing line.

That makes Powermax economical without sacrificing features—such as long life bearings, high temperature insulation and quality magnet materials.

Plus, DFM means we can build Powermax to your specifications, in the volumes you need, according to your JIT or other delivery schedule. To see what we mean, just turn this page.



Visit the Powermax™ flexible manufacturing line in Rockford, Illinois. See how we make Powermax performance, quality and modifications economical.



POWERMAX™ GIVES YOU OPTIONS

Powermax™ proves that an economical step motor doesn't have to limit your options. It's just the opposite, thanks to flexible manufacturing.

Whether you require a simple drive shaft flat or an integral lead screw, Powermax motors are made to your order.

To give us your specifications, just use the guide in Section D of this catalog. Then call or fax today for a free quotation.



Standard Motors

Clockwise from right: Powermax motors come in half, single and double rotor stacks in holding torques from 42 to 253 oz-in.

Typical modifications

Large diameter drive shaft



Powermax offers the largest diameter (0.375") drive shaft available in a NEMA 23 step motor.



Large diameter drive shaft with special flat.



Two flats on drive shaft permit use of dual setscrews for increased locking force.



Large diameter drive shaft with flat withstands high radial and axial loads, supports numerous shaft modifications.



Extended length drive shaft with flat.



Flat extending full length of long drive shaft for secure engagement.

Drive shaft modifications



Threaded, gun-drilled bore in drive shaft. Flat. Threaded mounting inserts in front end cap.



Cross-drilled shaft accepts hardened roll pin to attach sleeves, pulleys and gears.



Slotted drive shaft permits screwdriver adjustment for applications requiring manual shaft positioning. Flat on shaft.



Extended, stepped down shaft machined as two mating parts for minimum runout tolerances.

Drive shaft add-ons



Hardened steel gear extension press-fitted to drive shaft.



Acme lead screw fixed to drive shaft. Rear shaft extension.



Helical gear press-fitted to drive shaft.



Plastic gear with brass bushing attached by hardened roll pin through cross-drilled hole in shaft.

Encoder options



Encoder-ready rear shaft extension and mounting provision (1.812" Bolt circle) accepts popular encoders.



HP HEDS 5600 encoder (without line driver outputs) mounted on rear shaft extension and end cap.

HP HEDS 5600 encoder with line driver outputs and preterminated ribbon cable.



POWERMAX® MOTOR TECHNOLOGY

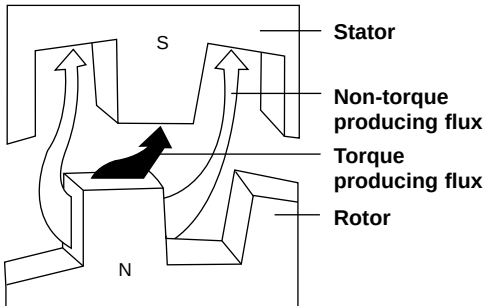
Pacific Scientific developed Powermax to be the best cost/performance value available in hybrid step motors. Just what you users and OEMs are looking for.

That's why you'll find so many standard Powermax models in the universal NEMA 23 frame size. With Powermax, you can tailor motor torque, acceleration and inertia to every axis on your design. Economically, using a single mounting configuration and the driver of your choice.

Does your application require that extra measure of performance? Then consider the Powermax M Series, featuring the patented Sigmax® technology.*

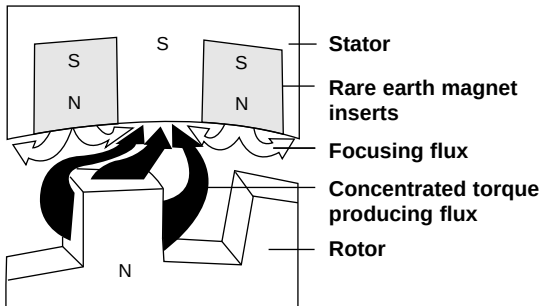
Samarium cobalt magnets in M Series motors concentrate magnetic flux at desired points between the rotor and stator. Sigmax technology optimizes flux paths to increase torque production and current utilization over conventional hybrid designs.

P SERIES STANDARD HYBRID



Typical paths of flux transfer in an energized conventional hybrid step motor. Some flux leakage occurs in normal operation.

M SERIES ENHANCED HYBRID SIGMAX® TECHNOLOGY



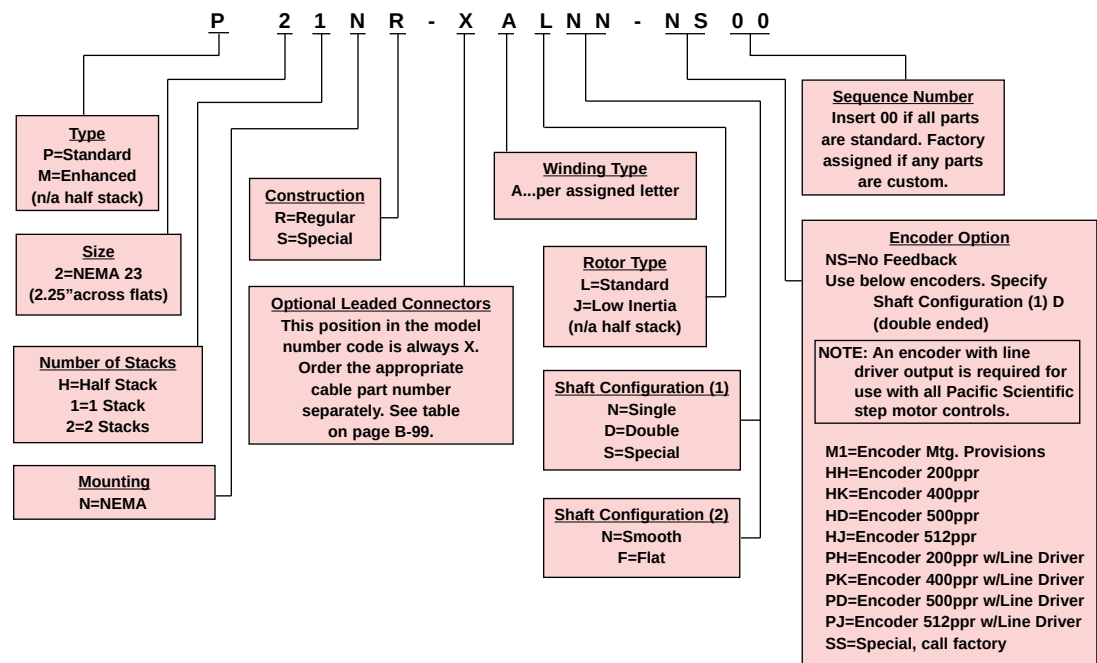
Patented Sigmax® technology* redirects magnetic flux to inhibit leakage and optimize torque production.

* Sigmax® technology is covered by U.S. patents 4,712,028, 4,713,470, 4,763,034 and 4,827,164.

TECHNICAL OVERVIEW

Types	
POWERMAX M Series	Hybrid step motors with rare earth magnets in the stator teeth
POWERMAX P Series	Hybrid step motors
Rotor construction	
POWERMAX M and P Series; with "L" rotor designates	Laminated (high speed efficiency)
POWERMAX M and P Series; with "J" rotor designates	Low mass/low inertia (fast start/stop, high acceleration)
Windings	
A, B, C, D, E, F, G	Standard winding to match any application
Phases	2
Full steps per revolution	200
Full step angle	1.8°
Angular accuracy	
POWERMAX M and M "J"	±1.5% of one step, no load, non-cumulative
POWERMAX P and P "J"	±3% of one step, no load, non-cumulative
Operating temperature	-20 to 40°C
Insulation	NEMA Class B, 130°C
Insulation resistance	100 Megohms @500 Vdc and 25°C
Shaft load ratings	
Max. radial load (at center of std. shaft extention)	20 lb.
Max. axial load (on front shaft extension toward motor)	13 lb.
Bearing life	
Since large bearings (30 mm) are used, L-10 life is typically about 4 times that of 22 mm or smaller bearings used on other NEMA Size 23 motors. Powermax L-10 bearing life exceeds 10,000 hours at any rotational speed up to 10,000 full steps/second if operated within the max. radial and axial loads specified above.	
Encoder options	See page C-113.

MODEL NUMBER CODE . . . POWERMAX Motors



HOW TO ORDER

Review the Motor Model Number Code to assure that all options are designated. Dimensions, connections, phasing diagrams are on page C-111. Encoder options are on page C-113.

POWERMAX HYBRIDS NEMA 23 FRAME (2.3")

Ratings and Characteristics

Review the Model Number Code above to assure that all options are designated. Dimensions, connections and phasing diagrams are on page C-111. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated Currents are in descending order	Motor Model Number [△]	Connection [△]			Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)
		Parallel	Series	Unipolar								
Torque range: 42-64 oz-in. .29-.45 Nm	P2HNX-XALXX-XX00	•			64 (0.45)	5.9	0.19	0.5				
	P2HNX-XALXX-XX00		•		64 (0.45)	3.0	0.76	2.0				
	P2HNX-XALXX-XX00			•	45 (0.32)	4.2	0.38	0.5				
STANDARD P2H Series 1/2 rotor stack	P2HNX-XBLXX-XX00	•			59 (0.42)	2.6	0.76	1.9				
	P2HNX-XBLXX-XX00		•		59 (0.42)	1.3	3.04	7.6				
	P2HNX-XBLXX-XX00			•	42 (0.29)	1.84	1.52	1.9				
	P2HNX-XCLXX-XX00	•			61 (0.43)	2.5	0.84	2.3				
	P2HNX-XCLXX-XX00		•		61 (0.43)	1.25	3.36	9.2				
	P2HNX-XCLXX-XX00			•	43 (0.30)	1.77	1.68	2.3	2.5 (0.018)	6.6	0.0010 (0.007)	1.0 (0.45)
	P2HNX-XFLXX-XX00	•			60 (0.42)	1.61	1.92	5.1				
	P2HNX-XFLXX-XX00		•		60 (0.42)	0.80	7.68	20.4				
	P2HNX-XFLXX-XX00			•	42 (0.30)	1.10	3.84	5.1				
	P2HNX-XGLXX-XX00	•			61 (0.43)	0.72	11.1	27.4				
	P2HNX-XGLXX-XX00		•		61 (0.43)	0.36	44.4	109.6				
	P2HNX-XGLXX-XX00			•	43 (0.30)	0.51	22.2	27.4				

- All ratings typical and at 25°C unless otherwise noted.
- [△] An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See Model Number Code above.
- [△] See Model Number Code above, optional leaded connectors on page C-112 and connection information on page C-112.
- [△] With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).
- [△] Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory.
- [△] Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.
- [△] Thermal resistance measured with motor hanging in still air (unmounted).

POWERMAX HYBRIDS
NEMA 23 FRAME (2.3")—Ratings and Characteristics (Con't.)

Review the Model Number Code, page C-107, to assure that all options are designated. Dimensions, connections and phasing diagrams are on page C-111. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated Currents are in descending order	Motor Model Number [△]	Connection [△]			Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)
		Parallel	Series	Unipolar								
Torque range: 89-144 oz-in. .63-1.02 Nm	M21NX-XALXX-XX00	•			142 (1.00)	5.6	0.23	0.7	↑	↑	↑	↑
	M21NX-XALXX-XX00		•		142 (1.00)	2.8	0.92	2.8				
	M21NX-XALXX-XX00			•	100 (0.71)	4.0	0.46	0.7				
SIGMAX® M21 Series 1 rotor stack	M21NX-XBLXX-XX00	•			137 (0.97)	4.6	0.32	1.0	↑	↑	↑	↑
	M21NX-XBLXX-XX00		•		137 (0.97)	2.3	1.28	4.0				
	M21NX-XBLXX-XX00			•	97 (0.68)	3.3	0.64	1.0				
	M21NX-XCLXX-XX00	•			144 (1.02)	3.5	0.53	2.0				
	M21NX-XCLXX-XX00		•		144 (1.02)	1.75	2.12	8.0				
	M21NX-XCLXX-XX00			•	102 (0.72)	2.5	1.06	2.0				
	M21NX-XDLXX-XX00	•			135 (0.95)	1.51	2.61	8.7				
	M21NX-XDLXX-XX00		•		135 (0.95)	0.76	10.4	34.8				
	M21NX-XDLXX-XX00			•	95 (0.67)	1.07	5.22	8.7				
	M21NX-XELXX-XX00	•			140 (0.99)	1.43	2.89	10.7				
	M21NX-XELXX-XX00		•		140 (0.99)	0.72	11.6	42.8				
	M21NX-XELXX-XX00			•	99 (0.70)	1.01	5.78	10.7				
	M21NX-XFLXX-XX00	•			126 (0.89)	0.65	14.0	39.8				
	M21NX-XFLXX-XX00		•		126 (0.89)	0.33	56.0	159.0				
	M21NX-XFLXX-XX00			•	89 (0.63)	0.46	28.0	39.8				
	P21NX-XALXX-NX-00	•			114 (0.81)	5.6	0.23	0.8				
	P21NX-XALXX-NX-00		•		114 (0.81)	2.8	0.92	3.2				
	P21NX-XALXX-NX-00			•	81 (0.57)	4.0	0.46	0.8				
STANDARD P21 Series 1 rotor stack	P21NX-XBLXX-XX00	•			111 (0.79)	4.6	0.32	1.1	↑	↑	↑	↑
	P21NX-XBLXX-XX00		•		111 (0.79)	2.3	1.28	4.4				
	P21NX-XBLXX-XX00			•	79 (0.55)	3.3	0.64	1.1				
	P21NX-XCLXX-XX00	•			116 (0.82)	3.5	0.53	2.3				
	P21NX-XCLXX-XX00		•		116 (0.82)	1.75	2.12	9.2				
	P21NX-XCLXX-XX00			•	82 (0.58)	2.5	1.06	2.3				
	P21NX-XDLXX-XX00	•			109 (0.77)	1.51	2.61	10.3				
	P21NX-XDLXX-XX00		•		109 (0.77)	0.76	10.4	41.2				
	P21NX-XDLXX-XX00			•	77 (0.54)	1.07	5.22	10.3				
	P21NX-XELXX-XX00	•			113 (0.80)	1.43	2.89	12.7				
	P21NX-XELXX-XX00		•		113 (0.80)	0.72	11.6	50.8				
	P21NX-XELXX-XX00			•	80 (0.56)	1.01	5.78	12.7				
	P21NX-XFLXX-XX00	•			103 (0.73)	0.65	14.0	47.3				
	P21NX-XFLXX-XX00		•		103 (0.73)	0.33	56.0	189.0				
	P21NX-XFLXX-XX00			•	73 (0.51)	0.46	28.0	47.3				

- △ An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See Model Number Code on page C-107.

△ See Model Number Code on page C-107, optional leaded connectors on page C-112 and connection information on page C-112.

△ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).
- △ Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory.

△ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

△ Thermal resistance measured with motor hanging in still air (unmounted).

POWERMAX HYBRIDS

NEMA 23 FRAME (2.3")—Ratings and Characteristics (Con't.)

Review the Model Number Code, page C-107, to assure that all options are designated. Dimensions, connections and phasing diagrams are on page C-111. In addition to those below, motors with characteristics for specific performance requirements are offered. Call us.

Rated Currents are in descending order	Motor Model Number [△]	Connection [△]			Holding Torque [△] (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase [△] (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance [△] (mH) ±20%	Detent Torque oz-in (Nm)	Thermal Resistance [△] (°C/watt)	Rotor Inertia oz-in-S ² (kgm ² x 10 ⁻³)	Weight lbs (kg)
		Parallel	Series	Unipolar								
Torque range: 161-253 oz-in. 1.13-1.79 Nm	M22NX-XALXX-XX00	•			230 (1.62)	6.5	0.21	0.7	↑ 17 (0.12) ↓	↑ 4.5 ↓	↑ 0.0036 (0.025) ↓	↑ 2.5 (1.13) ↓
	M22NX-XALXX-XX00		•		230 (1.62)	3.3	0.84	2.8				
	M22NX-XALXX-XX00			•	163 (1.15)	4.6	0.42	0.7				
SIGMAX® M22 Series 2 rotor stack	M22NX-XBLXX-XX00	•			253 (1.79)	4.6	0.38	1.7				
	M22NX-XBLXX-XX00		•		253 (1.79)	2.3	1.52	6.8				
	M22NX-XBLXX-XX00			•	179 (1.26)	3.3	0.76	1.7				
	M22NX-XCLXX-XX00	•			238 (1.68)	3.1	0.78	3.1				
	M22NX-XCLXX-XX00		•		238 (1.68)	1.55	3.12	12.4				
	M22NX-XCLXX-XX00			•	168 (1.19)	2.2	1.56	3.1				
	M22NX-XDLXX-XX00	•			238 (1.68)	2.5	1.22	5.0				
	M22NX-XDLXX-XX00		•		238 (1.68)	1.25	4.88	20.0				
	M22NX-XDLXX-XX00			•	168 (1.19)	1.77	2.44	5.0				
	M22NX-XELXX-XX00	•			227 (1.60)	1.64	2.71	10.1				
	M22NX-XELXX-XX00		•		227 (1.60)	0.82	10.8	40.4				
	M22NX-XELXX-XX00			•	161 (1.13)	1.16	5.42	10.1				
Torque range: 138-214 oz-in. .97-1.51 Nm	M22NX-XGLXX-XX00	•			235 (1.66)	0.99	7.35	36.3				
	M22NX-XGLXX-XX00		•		235 (1.66)	0.50	29.4	145.0				
	M22NX-XGLXX-XX00			•	166 (1.17)	0.75	14.7	36.3				
	P22NX-XALXX-XX00	•			197 (1.39)	6.5	0.21	0.8				
	P22NX-XALXX-XX00		•		197 (1.39)	3.3	0.84	3.2				
	P22NX-XALXX-XX00			•	139 (0.98)	4.6	0.42	0.8				
	P22NX-XBLXX-XX00	•			214 (1.51)	4.6	0.38	2.1				
	P22NX-XBLXX-XX00		•		214 (1.51)	2.3	1.52	8.4				
	P22NX-XBLXX-XX00			•	151 (1.07)	3.3	0.76	2.1				
	P22NX-XCLXX-XX00	•			203 (1.43)	3.1	0.78	3.9				
	P22NX-XCLXX-XX00		•		203 (1.43)	1.55	3.12	15.6				
	P22NX-XCLXX-XX00			•	144 (1.01)	2.2	1.56	3.9				
	P22NX-XDLXX-XX00	•			203 (1.43)	2.5	1.22	6.2				
	P22NX-XDLXX-XX00		•		203 (1.43)	1.25	4.88	24.8				
	P22NX-XDLXX-XX00			•	144 (1.01)	1.77	2.44	6.2				
	P22NX-XELXX-XX00	•			195 (1.38)	1.64	2.7	12.6				
	P22NX-XELXX-XX00		•		195 (1.38)	0.82	10.8	50.4				
	P22NX-XELXX-XX00			•	138 (0.97)	1.16	5.4	12.6				
STANDARD P22 Series 2 rotor stack	P22NX-XGLXX-XX00	•			200 (1.42)	0.99	7.35	37.4	↑ 7 (0.049) ↓	↑ 4.5 ↓	↑ 0.0036 (0.025) ↓	↑ 2.5 (1.13) ↓
	P22NX-XGLXX-XX00		•		200 (1.42)	0.50	29.4	149.6				
	P22NX-XGLXX-XX00			•	142 (1.00)	0.75	14.7	37.4				

- △ All ratings typical and at 25°C unless otherwise noted.

△ An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See Model Number Code on page C-107.

△ See Model Number Code on page C-107, optional leaded connectors on page C-112 and connection information on page C-112.

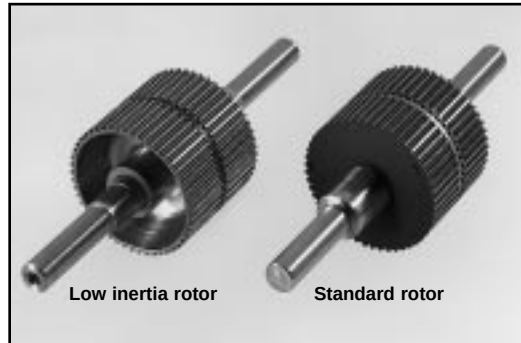
△ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).
- △ Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory.

△ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

△ Thermal resistance measured with motor hanging in still air (unmounted).

ROTOR INERTIA CHARACTERISTICS . . . Powermax motors

Single and double stack Powermax motors are available with both standard and low inertia rotors. Choose low inertia to produce the highest acceleration rates possible.



ACCELERATION COMPARISON

	Model	Rotor Type	Δ Inertia oz-in-S ² x 10 ⁻³ / kgm ² x 10 ⁻³	Theoretical Normalized Acceleration ^{Δ}
Single Stack	P21NR-XXL	Standard	1.68/0.010	1
	P21NR-XXJ	Low inertia	1.30/0.008	1.27
	M21NR-XXL	Standard	1.68/0.010	1.23
	M21NR-XXJ	Low inertia	1.30/0.008	1.59
Double Stack	P22NR-XXL	Standard	3.57/0.022	1
	P22NR-XXJ	Low inertia	2.59/0.016	1.30
	M22NR-XXL	Standard	3.57/0.022	1.18
	M22NR-XXJ	Low inertia	2.59/0.016	1.63

Δ Low inertia rotors not offered for half stack models

Δ Comparative values for normalized acceleration of unloaded motors. Base value is standard hybrid motor with standard rotor, indicated for single and double stack lengths.

Actual acceleration capability depends on load, velocity profile and driver power. Comparisons made with 90°C temperature rise using bipolar drive.

NEMA 23 FRAME (2.3")—Ratings and Characteristics

Review the Model Number Code, page C-107, to assure that all options are designated. Dimensions, connections and phasing diagrams are on page C-111. ***In addition to those windings below, all windings offered for the standard motors on the previous pages are available with the low inertia rotors. Call us!***

Motor Model Number ^Δ	Connection ^Δ			Holding Torque ^Δ (2 phases on) oz-in (Nm) ±10%	Rated Current/ Phase ^Δ (amps DC)	Phase Resistance (ohms) ±10%	Phase Inductance ^Δ		Detent Torque oz-in (Nm)	Thermal Resistance ^Δ (°C/watt)	Rotor Inertia oz-in-S² (kgm² x 10 ⁻³)	Weight lbs (kg)
	Parallel	Series	Unipolar				(mH) ±20%					
Torque range: 99-140 oz-in. .70-.99 Nm	M21NX-XAJXX-XX00	•		140 (0.99)	5.6	0.23	0.7			↑	↑	↑
	M21NX-XAJXX-XX00		•	140 (0.99)	2.8	0.92	2.8		9.4			
SIGMAX® M21 Series 1 rotor stack	M21NX-XAJXX-XX00		•	99 (0.70)	4.0	0.46	0.7	(0.066)				
Torque range: 79-111 oz-in. .55-.78 Nm	P21NX-XAJXX-XX00	•		111 (0.78)	5.6	0.23	0.9			↓	↓	↓
	P21NX-XAJXX-XX00		•	111 (0.78)	2.8	0.92	3.6		4			
STANDARD P21Series 1 rotor stack	P21NX-XAJXX-XX00		•	79 (0.55)	4.0	0.46	0.9	(0.028)				
Torque range: 178-252 oz-in. 1.26-1.78 Nm	M22NX-XBJXX-XX00	•		252 (1.78)	4.6	0.38	1.5			↑	↑	↑
	M22NX-XBJXX-XX00		•	252 (1.78)	2.3	1.52	6.0		17			
SIGMAX® M22 Series 2 rotor stack	M22NX-XBJXX-XX00		•	178 (1.26)	3.3	0.76	1.5	(0.12)				
Torque range: 142-201 oz-in. 1.00-1.42 Nm	P22NX-XBJXX-XX00	•		201 (1.42)	4.6	0.38	1.8			↓	↓	↓
	P22NX-XBJXX-XX00		•	201 (1.42)	2.3	1.52	7.2		7			
STANDARD P22 Series 2 rotor stack	P22NX-XBJXX-XX00		•	142 (1.00)	3.3	0.76	1.8	(0.49)				

All ratings typical and at 25°C unless otherwise noted.

Δ An "X" in the Model Number Code indicates an undefined option. Colored letter indicates winding. See Model Number Code on page C-107.

Δ See Model Number Code on page C-107, optional leaded connectors on page C-112 and connection information on page C-112.

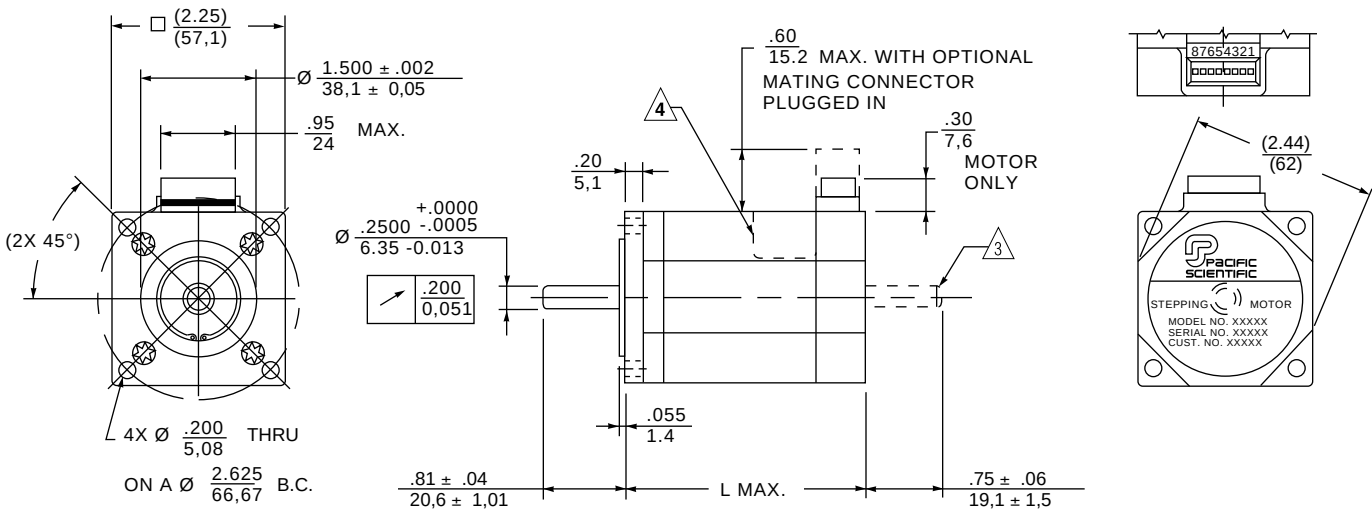
Δ With rated current applied. Windings at 130°C and motor unmounted and in still air at 40°C (without heat sink).

Δ Windings at 130°C and motor in still air at 40°C (without heat sink). Operation of these motors above rated current may cause demagnetization. Contact factory

Δ Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

Δ Thermal resistance measured with motor hanging in still air (unmounted).

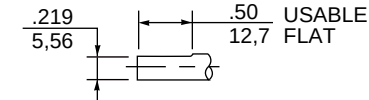
DIMENSIONS . . . (POWERMAX HYBRIDS) $\frac{\text{in.}}{\text{mm}}$ (metric dimensions for ref. only)



Motor Model	L Max.
P2H	$\frac{1.60}{40.7}$
P or M21	$\frac{2.06}{52.4}$
P or M22	$\frac{3.10}{78.8}$

STANDARD SHAFT OPTIONS

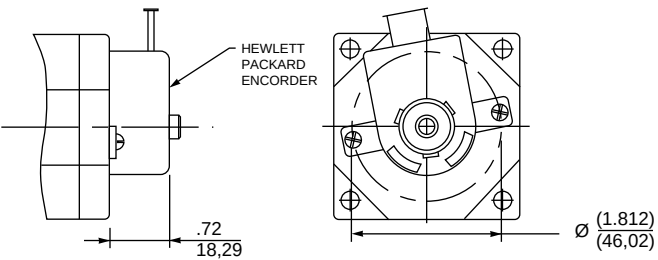
1. Shaft modifications also available.
2. Optional flat available on front shaft as shown.



- Optional rear shaft extension available as shown. Same diameter as front shaft extension.
- Alternate label location when rear shaft extensions provided.

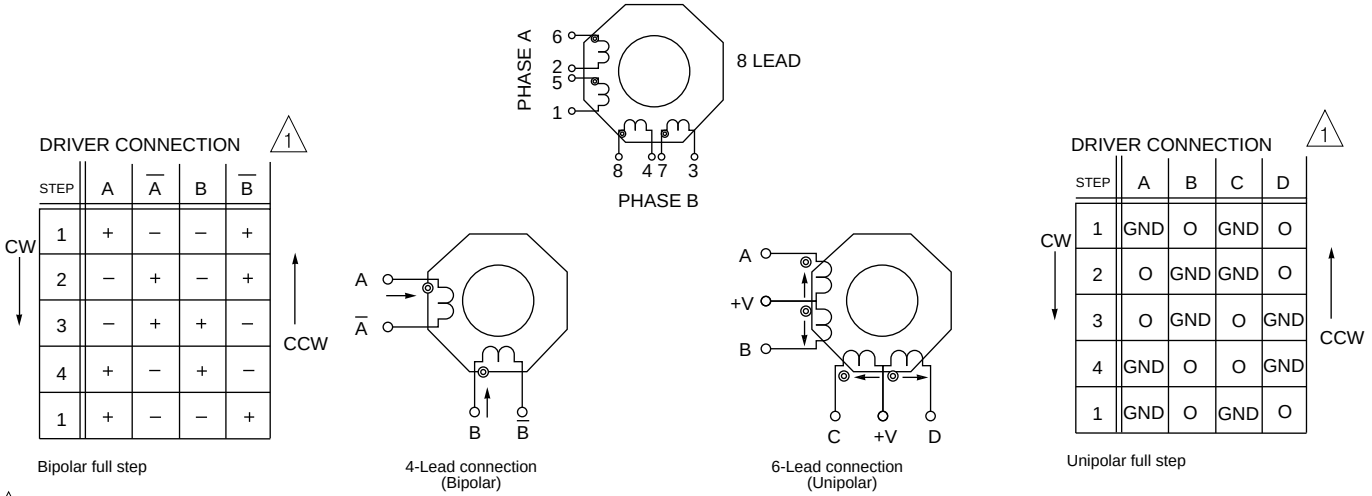
ENCODER OPTION

See page C-113 for encoder/mounting specifications.



CONNECTION INFORMATION . . . Terminations and phase sequencing

NOTE: Phase sequencing direction of rotation as viewed from mounting end of motor.



- Notes:
- 0 = off or open
 - +
 -
 - GND = ground

POWERMAX HYBRIDS

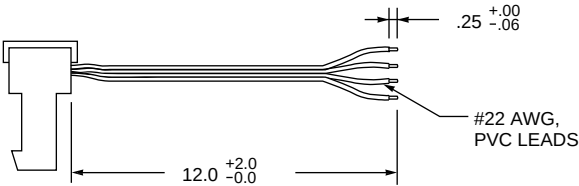
CONNECTION INFORMATION . . . Optional leaded connectors

Four different leaded connectors are available from Pacific Scientific. Order the "GW" part number as a separate item.

Part Number	Phase Connection	Pin No.	Connector/Leadwire Assembly Lead Colors	Driver Connection
GW0000F (8 Lead)	bipolar series	6 1 8 3 2 & 5 4 & 7	Black Orange Red Yellow Wht/Blk & Wht/Org Wht/Red & Wht/Yel	A A B B none none
	bipolar parallel	6 & 5 1 & 2 8 & 7 3 & 4	Blk & Wht/Org Org & Wht/Blk Red & Wht/Yel Yel & Wht/Red	A A B B
	unipolar	6 1 8 3 2 & 5 4 & 7	Black Orange Red Yellow Wht/Blk & Wht/Org Wht/Red & Wht/Yel	A B C D + V + V
GW0000E (6 Lead)	unipolar	6 1 8 3 2 & 5 4 & 7	Black Orange Red Yellow Wht/Blk & Org Wht/Red & Yel	A B C D + V + V
GW0000H (4 Lead)	bipolar parallel	6 & 5 1 & 2 8 & 7 3 & 4	Black Orange Red Yellow	A A B B
GW0000L (4 Lead)	bipolar series	6 1 8 3	Black Orange Red Yellow	A A B B

Typical leaded connector

(4-lead shown)



. . . Optional mating connector only

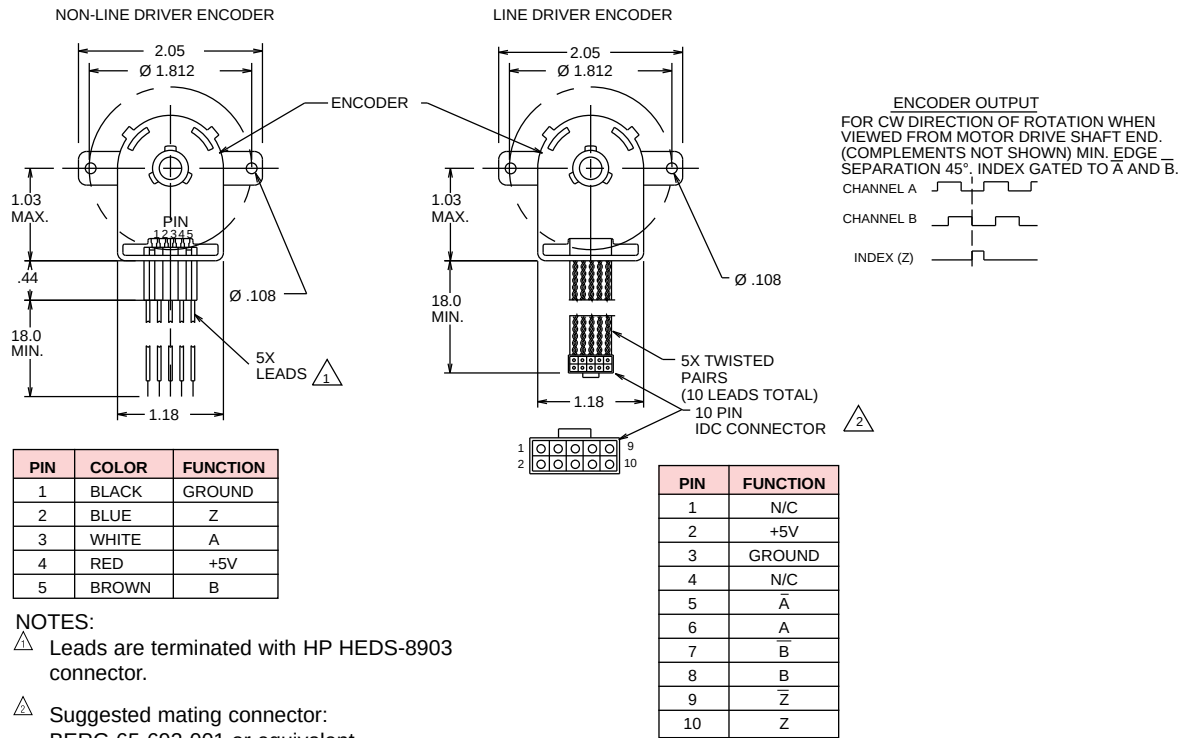
A separate mating connector housing and strain relief cover are available from Pacific Scientific or AMP. The user attaches leads to the connector.

ITEM	PACIFIC SCIENTIFIC	AMP
STANDARD HOUSING	GP00012	641653-8
STANDARD COVER	GP00013	643077-8

ENCODER OPTIONS

NEMA 23 ENCODER OPTION

The standard encoder offered on the NEMA 23 motor is the Hewlett-Packard HEDS 5600 series.



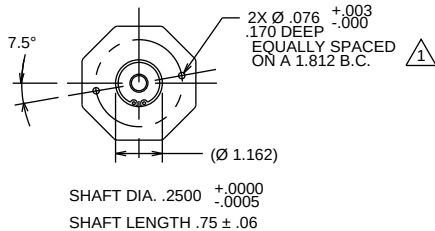
PARAMETERS		NON-LINE DRIVER				LINE DRIVER			
TYPE		INCREMENTAL				INCREMENTAL			
ENCODER OPTION		HH	HK	HD	HJ	PH	PK	PD	PJ
PULSES PER REVOLUTION		200	400	500	512	200	400	500	512
SUPPLY VOLTAGE		+5V ± 10% @ 85 mA MAX.				+5V ± 10% @ 85 mA MAX.			
OUTPUT FORMAT		DUAL CHANNEL QUADRATURE AND INDEX				DUAL CHANNEL QUADRATURE W/ COMPLEMENTS INDEX W/ COMPLEMENTS			
OUTPUT TYPE		SQUARE WAVE TTL COMPATIBLE				RS-422A COMPATIBLE			
FREQUENCY RESPONSE:									
DATA		100 kHz				100 kHz			
INDEX		100 kHz				100 kHz			
ROTOR INERTIA		5 x 10 ⁻⁷ lb-in-S ²				5 x 10 ⁻⁷ lb-in-S ²			
WEIGHT		0.08 lb.				0.08 lb.			

- NOTES:
- TYPICAL @ 25° C.

Pacific Scientific indexer/drives require encoders with line drive output (PH, PK, PD, PJ).

ENCODER MOUNTING PROVISION ONLY = M1

FOR HEWLETT PACKARD HEDS 5600 SERIES OR SIMILAR.



- NOTES:
- For #2 self tapping screw.

Encoder mounts directly to motor endbell (without thermal isolation).

GENERAL INFORMATION



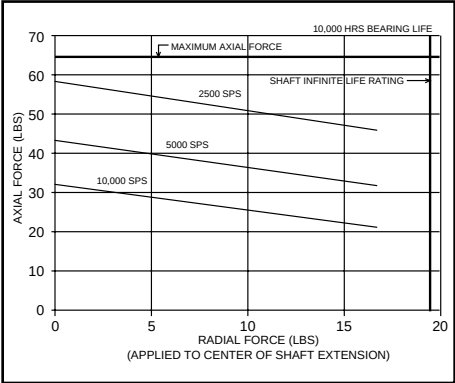
SECTION OVERVIEW . . . GENERAL INFORMATION

HOW TO USE THIS SECTION

This section contains a variety of technical data and general reference information. Use it to help you in selecting a system and choosing accessories to enhance your system. You will find data on brushless servo and step motors, as well as definitions of feedback devices.

The table of contents below will help you locate the exact information that you require.

Table of contents	Page
Accessories and Cabling	D-3
Servo system cabling	D-4
Stepper system cabling	D-8
Wiring, grounding, and shielding techniques . . .	D-10
Brushless servo motor technical data	D-13
Motor connections	
Phase sequencing tables	
Bearing life	
Stepper motor technical data	D-17
Motor power connections	
Phase sequencing tables	
Encoder options	
Overview of feedback devices	D-21
Feedback device technical data	
System sizing and selection	D-28
Glossary	D-39
Conversion tables	D-43



ACCESSORIES AND CABLING

Order these accessories to simplify installation, startup and programming of your PacSci step motor and servo motor controls.

RS-232 CABLES

Use to connect programmable indexer/drivers to personal computers.

FOR MODELS 5645, 5445 AND 5345

Six foot RS-232 cable connects indexer/drivers to 25 pin serial port on PC. Also includes 25 pin to 9 pin adapter for PCs with 25 pin serial port. Available in standard 6 foot length only.

HOW TO ORDER. . .

RS-232 cable

Model number

CS-232-5600



RS-232 cable CS-232-5600

FOR MODEL 5240

Six foot RS-232 cable connects indexer/driver's J2 to 9 pin serial port on PC. Also includes 9 pin to 25 pin adapter for PCs with 25 pin serial port. Available in standard 6 foot length only.

HOW TO ORDER. . .

RS-232 cable

Model number

CS-232-5200



RS-232 cable CS-232-5200, CS-232-750

FOR MODEL SC750

Use to connect SC750 servo controllers to personal computers. The 6 foot RS-232 cable connects 9 pin SC750 connector (J58 port) to PC's 9 pin serial port. Includes 9 to 25 pin adaptor for PCs with 25 pin serial port.

HOW TO ORDER. . .

RS-232 cable

Model number

CS-232-750

OPERATOR INPUT PANEL

Use as a handheld or panel mount operator input panel for the SC750 servo controller.

The compact 4" x 7" x 1" module features a full numeric keypad, six function keys and a 16 character LCD display.

HOW TO ORDER. . .

Operator input panel

Panel with 6 foot cable

Model number

T10

T10C



Operator Input Panel

I/O EMULATION BOARD

Contains switches and LEDs to exercise SC750 I/O. Includes 3 foot cable. Use this emulation board to simplify system startup and troubleshooting.

HOW TO ORDER. . .

I/O emulation board

Model number

IOEM-750



I/O Emulation Board

SERVO SYSTEM CABLING

All PacSci brushless servo controllers are equipped with the appropriate connectors.

All PacSci brushless servo motors are equipped with MS type connectors for power and feedback.

Use one power cable and one feedback cable to connect the brushless servo controller and motor.

THE ADVANTAGES OF FACTORY CABLING

The most common—and easily preventable—cause of startup problems is cabling.

That's why we offer factory tested, fully terminated connecting cables for PacSci brushless servo systems. Factory cabling saves you time as well as troubleshooting.

Power Cables

Power cables feature four conductor, shielded wire with standard color coding to simplify connection to controllers. Jacket is black polyurethane.

Specifications

R20, R30, F40 and R40 Series motors

18 AWG (19/30 stranded)*
Type B insulation
600V, 105°C, MIL 16878/1

*For R40 and F40 motors used with 30A peak drives, 12 AWG wire used.

R60 Series motors 12 AWG (65/30 stranded)
Type C insulation
600V, 105°C, MIL 16878/1

R80 Series motors 10 AWG (105/30 stranded)
Type C insulation
600V, 105°C, MIL 16878/1

Feedback Cables

Feedback cables are available for both primary feedback only and primary plus secondary feedback. Jacket is black polyurethane.

Specifications

All motors 22 AWG (7/30 stranded)
300V, 105°C, MIL 16878/1
Type B insulation

PacLAN Data Cable

Twinaxial transmission cable. Use with SC750 to interconnect LAN nodes for digital communications up to 500 feet. Jacket is blue PVC.

Specifications

Use with SC750 25 AWG (7/33 stranded)
124 Ohm characteristic impedance
60°C, UL Style 2092
Passes VW-1 vertical wire flame test



Power Cable



Primary Feedback Cable



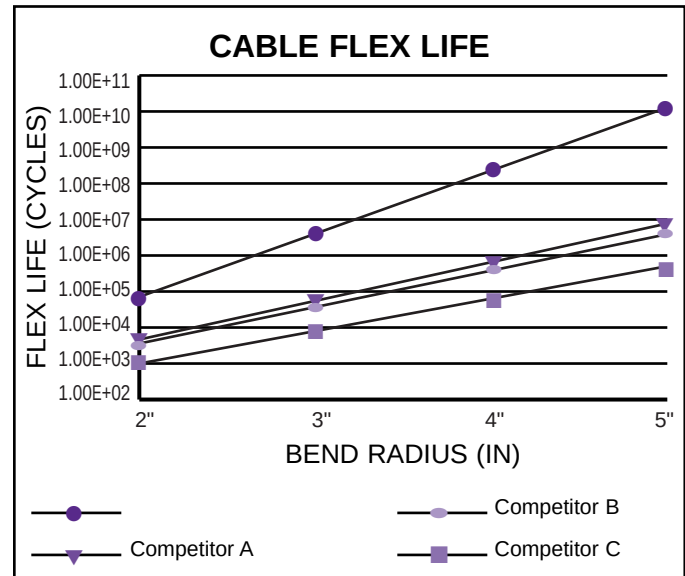
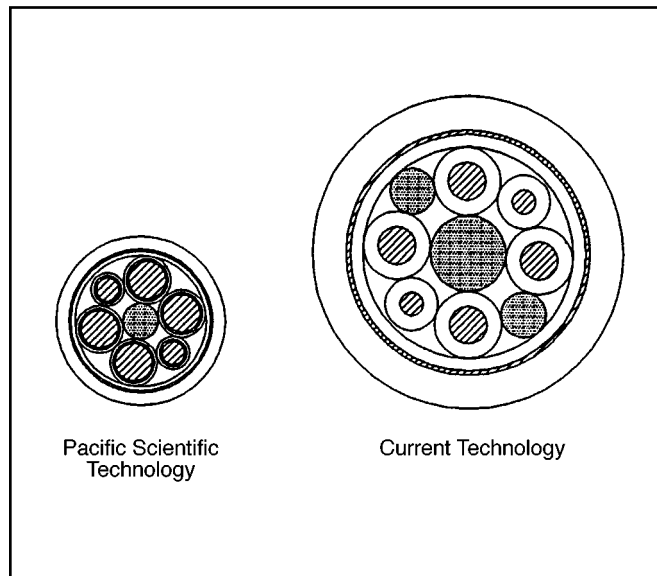
Primary Plus Secondary Feedback Cable



PacLAN Data Cable

INDUSTRIAL ELECTRONICS... HIGH FLEX LIFE JACKETS, MODELING and TESTING

Small Outer Diameter...and...Increased Flex Life



Engineer's Summary

- High conductor stranding, advanced load sharing techniques, proprietary insulation materials, unique cabling and tough jacketing techniques allow flex life performance to be 100x better than current technology.
- Round cable diameters are typically 1/2 the O.D. of the current technology while offering the same conductor size, the same current carrying capacity and the same voltage ratings as the current technology.
- Resistant to solvents, fuels, oils and coolants.
- Cost-effective standard products as well as custom designs available.
- U.L. approved
- CSA approved

RELIABILITY PREDICTION AND CHARACTERIZATION

Computer Modeling of Cable Flex Life

- Computer model allows prediction of cable flex life at any bend radius
- Predicts flex life for customer specific applications
- Allows reduced bend radius while meeting reliability requirements
- Reduces cost in redesign and retest

Testing and Characterization of Cable Flex Performance

- Tested to standardized rolling flex methods
- Characterized to three (3) different bend radii
- Documented performance through actual flex testing

PACIFIC SCIENTIFIC J-380

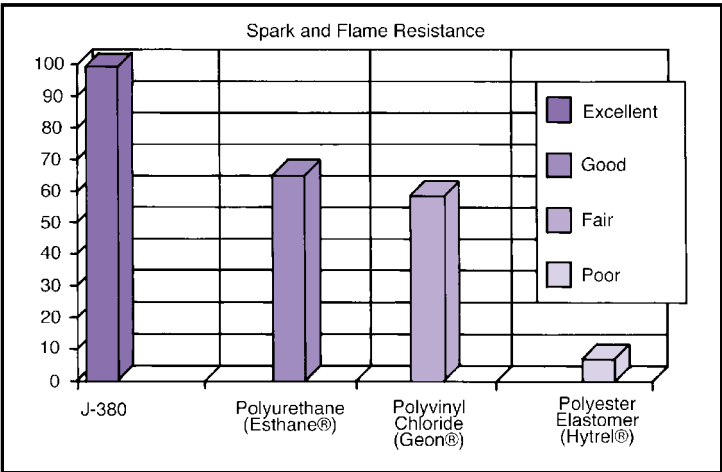
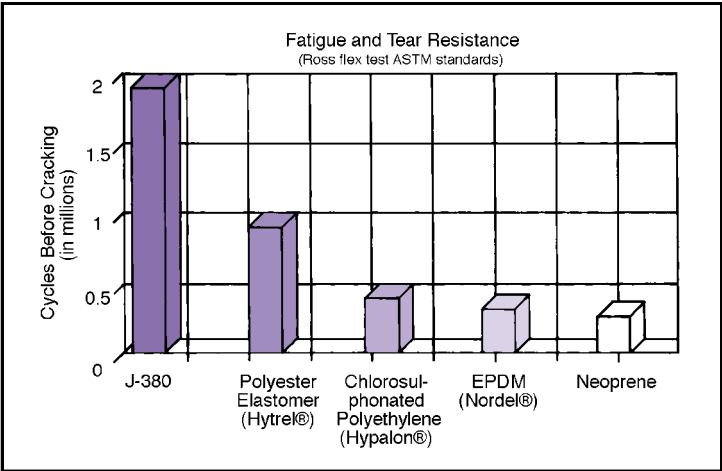
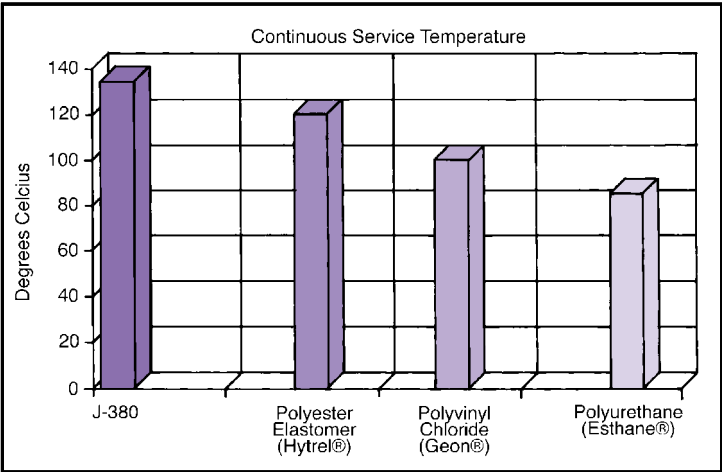
Wire and Cable Jacketing Material

J-380 is the material of choice for jacketing many of Pacific Scientific's factory automation cable products. Not only are the electrical properties of the jacket superior to many plastics and elastomers, but mechanical performance characteristics make J-380 ideally suited for most factory automation applications. Some of the outstanding performance characteristics are charted to the right.

Excellent Chemical Resistance

J-380 is inherently resistant to the following industrial chemicals:

- Hydraulic Fluids
- Machine Cutting Fluids
- Lubricating Oils
- Greases
- Acids and Bases
- Aqueous Solutions
- Petroleum Oils and Fuels (room temp.)
- Organic Solvents (non-halogenated)
- Alcohols
- Ketones
- Glycols
- Esters



HOW TO ORDER SERVO SYSTEM CABLING

Power Cable with motor connector and optional control connector

Model Number

CP-XX-XXX-XXX F

Cable designator

Motor Connector Type

Specify designator:
R2 (for R20 Series) R4 (for R40 and F40 Series) R8 (for R80 or R8A Series)
R3 (for R30 Series) R6 (for R60 Series)

Cable Length

Specify length in whole foot increments; 001 to 150 feet

Control Connector Type

Specify control model, i.e. if for use with SC722, insert 722
402 722 724 726 753 755 902 942 933 904 944 935
403 723 725 752 754 756 932 903 943 934 905 945
Leave blank for no connector

Cable Option

F = Flexible cable
E = Environmental connectors
R = Right angle connectors
Leave blank for standard cable.
Consult factory for special requirements.

Primary Feedback Cable or Primary Plus Secondary Feedback Cable With motor connector and optional control connector (thermistor wires included)

Model Number

CF-XX-XXX-XXX F

Cable designator

Feedback Type

For primary only
HO=Hall Sensors only
TO=Tachsyn only
RO=Resolver only
For primary plus secondary only
HE= Hall Sensors/encoder HR=Hall Sensors/resolver
TE=Tachsyn® /encoder TR=Tachsyn® /resolver
RE=Resolver/encoder RR=Resolver/resolver

Cable Length

Specify length in whole foot increments; 001 to 150 feet

Control Connector Type

Specify control series
400 720 750
Leave blank for no connector

Cable Option

F = Flexible cable (Not available with HE, TE, RE, TR & RR Feedback types)
E = Environmental connectors
R = Right angle connectors
Leave blank for standard cable.
Consult factory for special requirements.

PacLAN Data Cable

Model Number

CL-CO-XXX

Cable designator

Cable Length

Specify length in whole foot increments

Brake Cable

Model Number

CB-XXX

Cable designator

Cable Length

Specify length in whole foot increments

STEPPER SYSTEM CABLING

All PacSci stepper controls are equipped with the appropriate connectors.
All PacSci step motors are available with MS type connectors for power and encoder option.

THE ADVANTAGES OF FACTORY CABLING

The most common—and easily preventable—cause of startup problems is cabling.
That's why we offer factory tested, fully terminated connection cables for your motion control system. Factory cabling saves you time as well as trouble-shooting. Use for all controls except 5216, 5215 and 5210.

MOTOR POWER CABLES

Motor power cables feature four conductor shielded wire plus ground, with standard color coding to simplify connection to controls. Jacket is black polyurethane.

SPECIFICATIONS

All motors 5 conductor, 16 AWG, 2 twisted. Foil shielded with drain wires plus one unshielded. Black polyurethane jacket.

HOW TO ORDER. . .

Motor power cables

With motor connector and control connector. Available in whole foot increments up to 50 feet.



Motor power cable



Encoder feedback cable. . .
NEMA 34 and 42 motors



Encoder feedback cable. . .NEMA 23 motors

STEPPER MOTOR POWER CABLE		Model number
Cable designator _____ (Stepper Power Cable for 6410, 5410 and 5310)		SPC - XXX - 6410
Cable length _____ Specify length in whole foot increments, from 001 to 50 feet.		
Drive Designator _____ Specify for 6410, 5410 or 5310 only. Specify CO for cable only. For all other drives, leave blank.		

ENCODER FEEDBACK CABLES. . .For control Models 5645, 5445 and 5345 only.
SPECIFICATIONS. . .All motors 22 AWG, 7/30 stranded,

300V, 105°C,
MIL 16878/1,
Type B insulation

HOW TO ORDER. . .

Encoder feedback cable

With motor connector and control connector.
Available in whole foot increments up to 150 feet.

CAUTION: Only encoders with line driver output may be
used with Pacific Scientific indexer/drivers.

ENCODER FEEDBACK CABLE	Model number
Note: for NEMA 23 motors, add-E20 to the model number.	
Cable designator _____ (Stepper Encoder Cable)	SEC - XXX
Cable length _____ Specify length in whole foot increments, from 001 to 150 feet.	

MATING POWER CONNECTORS

Use to build up your own cabling to power motor.
Clamp finished.

FOR SIZE 34 AND 42 MOTORS
HOW TO ORDER. . .

	Model number
4 lead mating connector	SZ00007
6 or 8 lead mating connector	SZ00009

FOR SIZE 23 MOTOR
HOW TO ORDER. . .

	Model number
4 lead mating connector	SZ00007

MATING ENCODER CONNECTORS

Use to build up your own cabling to interface
encoder.

FOR SIZE 34 AND 42 MOTORS
HOW TO ORDER. . .

	Model number
Mating connector with clamp	SZ00008

FOR SIZE 23 MOTOR
HOW TO ORDER. . .

	Model number
Mating connector for line driver type	DuPont BergCon® 65043-032 Mini-Latch housing

WIRING, GROUNDING, AND SHIELDING TECHNIQUES

Proper wiring, grounding, and shielding techniques are important in obtaining proper servo operation and performance. Incorrect wiring, grounding, or shielding can cause erratic servo performance or even a complete lack of operation. This note summarizes the proper techniques and is intended as a supplement to the information contained in the controller instruction manuals.

MOTOR POWER WIRING

Pacific Scientific motors are three phase and hence have three terminals. These three motor terminals are labeled R, S, and T. It is imperative that the R, S, and T motor terminals be connected to the respective R, S, and T outputs of the controller. Improper phasing of these terminals will result in erratic motor operation including “deadspots,” runaway, or stall.

Another important aspect of motor wiring is grounding of the motor. There is capacitive coupling between the motor’s three phase winding and the motor’s case. When PWM voltages are applied to the motor terminals, the motor case tends to follow these voltages because of the coupling capacitance. If the motor is not grounded, Fig. D-1a, a shock hazard is present because of capacitively coupled voltage on the motor case. Therefore, motor wiring should be viewed as a four wire connection rather than a three wire connection with the fourth wire being motor ground as shown in D-1b. The motor must be properly grounded to insure proper operation and to prevent shock hazard.

When the motor is grounded, pulses of current flow in the ground wire due to the motor’s winding-case capacitance. These pulses are short in duration and occur at the PWM frequency. Electrical noise due to these pulses can be radiated if proper techniques are not used. To prevent radiated noise, the motor ground wire should be tightly bundled or twisted with the three wires connected to the motor terminals as shown in D-1c. This will typically reduce radiated noise to an acceptable level.

If desired or required, two other techniques can be applied to attenuate noise further. Both techniques are shown in D-1d. The first is shielding the four motor wires. The shield should be connected at the controller end only. As a general rule a shield should only be connected at one end to prevent ground loops. The second technique is the insertion of a common mode choke in the three wires connecting the motor terminals to the controller. This common mode choke is simply 10 turns of each motor terminal wire on a Ferroxcube 510-00003-00 ferrite toroidal core. This choke acts to reduce the amplitude of the current pulses flowing in the motor ground wire.

As a general rule, the motor wiring should be kept as far away as possible from the feedback transducer wiring and any other signal level wiring. In addition, all signal level wiring should be done using shielded cable to reduce the risk of noise problems.

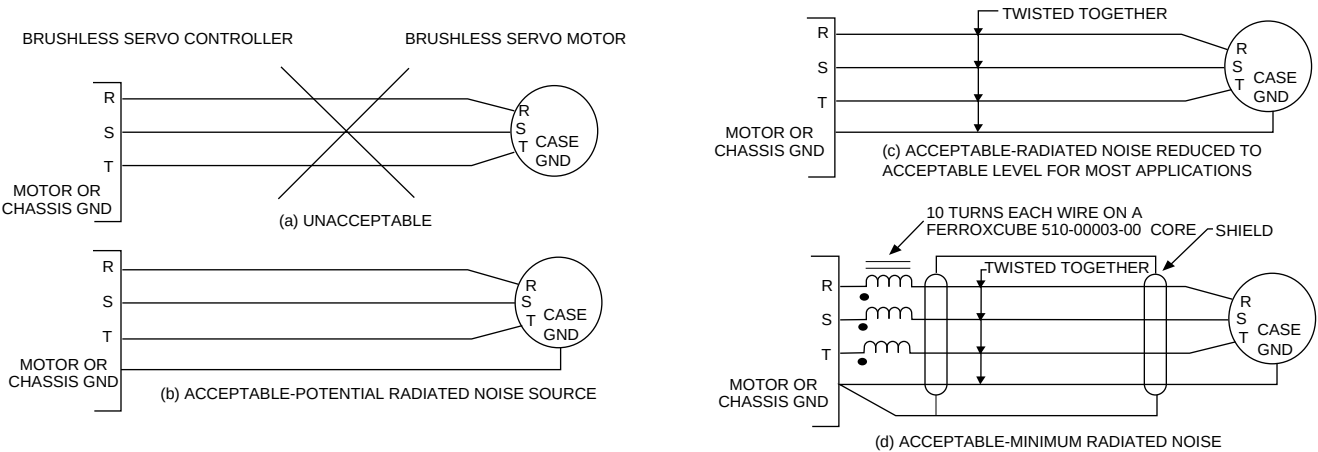


Figure D-1. Motor Wiring

WIRING, GROUNDING, AND SHIELDING TECHNIQUES (Cont.)

FEEDBACK TRANSDUCER WIRING

Pacific Scientific brushless servo systems use three standard feedback devices. For a torque only control system, Hall-effect devices are used. These devices provide motor commutation information to the brushless servo controller. For analog velocity control systems, a Tachsyn® is used. This device provides motor commutation information and motor velocity information. Finally, for position control systems and some velocity control systems a resolver is used. This device provides motor commutation information, motor velocity information, and motor position information.

Each of the feedback devices described above must be properly wired to insure proper operation of the servo system. The wiring practices for each device are described below.

HALL-EFFECT DEVICES

Three Hall-effect devices are required to provide commutation information for Pacific Scientific three-phase brushless servo motors. The Hall-effect outputs are open collector transistors. These outputs drive the brushless servo controller sensor inputs which have resistor pull-ups.

Wiring for the Hall-effect devices consists of one wire for each of the three sensor signals and two wires which provide power to the Hall-effect devices. The three sensor signal wires should be twisted together and the two power wires should be twisted together as shown in D-2a.

For improved noise immunity, the five wires can be placed in a shield which is connected to the 12V RTN at the controller as shown in D-2b. This is especially important if the motor wiring is run near (within 12 inches) of the sensor wiring. The shield should only be connected at the controller end.

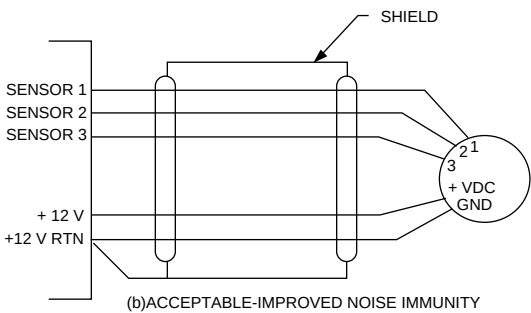
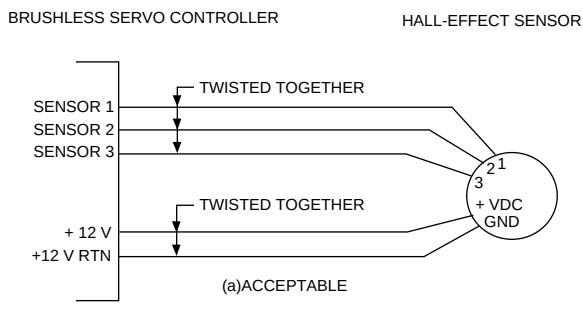


Figure D-2. Hall-Effect Sensor Wiring

TACHSYN® WIRING

The Tachsyn® is a five wire device that operates similar to a resolver. Two of the Tachsyn® wires are a high frequency excitation signal. The remaining three wires are outputs which supply commutation and velocity information to the controller. **Both sets of wires must be shielded and the two excitation wires must be**

in separate shield from the output wires. If they are not placed in separate shields, the motor will not operate or will operate erratically.

The Tachsyn® must always be wired as shown in Figure D-3b. Any other wiring scheme will result in improper motor operation.

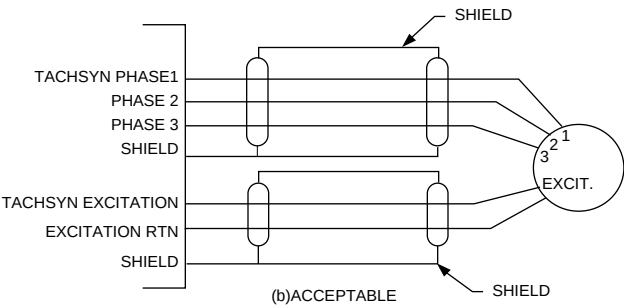
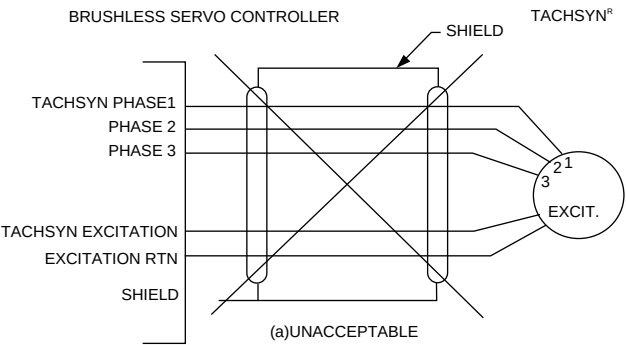


Figure D-3. Tachsyn® Wiring

WIRING, GROUNDING, AND SHIELDING TECHNIQUES (Cont.)

RESOLVER WIRING

The resolver is a six wire device. As with the Tachsyn®, two of the wires are a high frequency excitation signal. The remaining four wires are outputs which supply commutation, velocity, and position information to the controller. These four wires are separated into two distinct pairs: sine (S1 and S3) and cosine (S2 and S4). Hence

the six wires are segregated into three pairs. Each pair must be run in a separate shield to insure proper motor operation.

The resolver must always be wired as shown in Figure D-4b. Any other wiring scheme may result in improper motor operation.

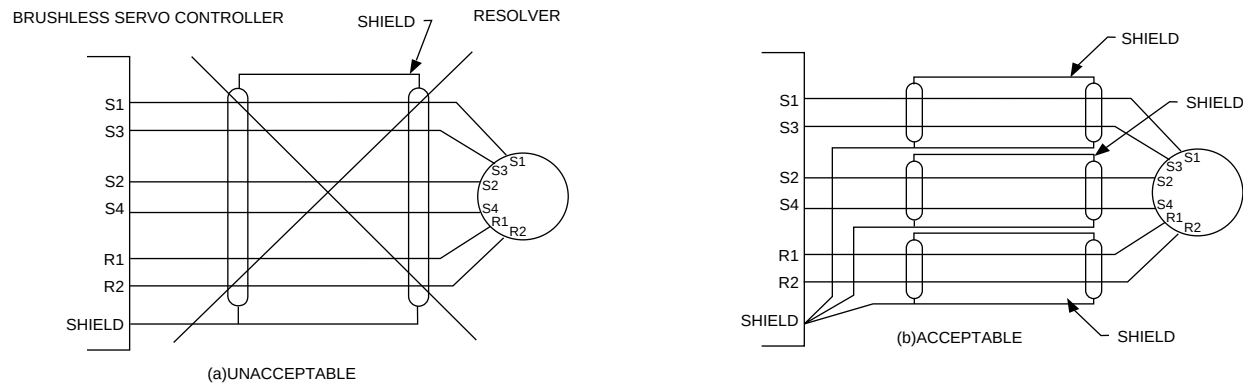


Figure D-4. Resolver Wiring

GROUNDING

The grounding procedures listed in the controller instructions should be followed. In general, the following rules should be observed.

All component chassis ground points and signal ground or common points should be tied together at a single point (star connection). This point should then be tied with a single conductor to an earth ground point. This form of grounding prevents ground loops and insures that all components are properly grounded against shock hazard.

SHIELDING

In general, it is good practice to shield all wires carrying low level signals. This is especially important if the signal level wires are run near power level wiring such as motor wires or relay wires.

When shielding wires, connect only one end of the shield, preferably the source end. Connecting both ends of a shield will result in ground loops. It is recommended that the unconnected end of the shield be insulated to prevent accidental connection.

BRUSHLESS SERVO MOTOR TECHNICAL DATA

This section contains technical information on brushless servo motors. The topics discussed are:

- Connector descriptions
- Torque linearity
- Bearing life curves

Refer to Section B for more information on brushless servo motors.

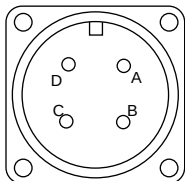
CONNECTOR DESCRIPTIONS. . R20, R30, R40, F40, R60, R80 Series Motors

Described here are pinouts of standard Pacific Scientific R20, R30, R40, F40, R60 and R80 motors. The pinout of the motor-power connector does not vary among motors with varying feedback configurations.

The pinout of feedback connectors varies with the devices employed and with primary-only or primary-and-secondary configurations.

MOTOR CONNECTORS

All Series Except R20



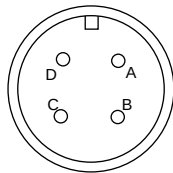
STANDARD PINOUTS– All Series

Connector Pin	Function
A	Phase R
B	Phase S
C	Phase T
D	Ground (Frame)

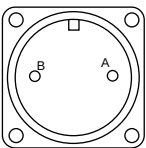
SUGGESTED MATING CONNECTOR AND CLAMP

SERIES	CONNECTOR	CLAMP
R20, R30 F40, R40 R60	MS3106A20-4S PACIFIC SCIENTIFIC P/N CZ00007	MS3057-12A-1 PACIFIC SCIENTIFIC P/N CE00003
R80	MS3106A24-22S PACIFIC SCIENTIFIC P/N CZ00010	MS3057-16A-1 PACIFIC SCIENTIFIC P/N CE00004

R20 Series Only



BRAKE CONNECTOR



STANDARD PINOUTS

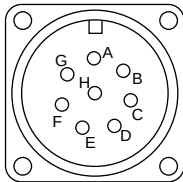
Connector Pin	Function
A	+Vdc
B	Vdc RTN

SUGGESTED MATING CONNECTOR AND CLAMP

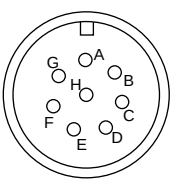
CONNECTOR	CLAMP
MS3106A14S-9S PACIFIC SCIENTIFIC P/N CZ00011	MS3057-6A-1 PACIFIC SCIENTIFIC P/N CE00005

PRIMARY-FEEDBACK-ONLY CONNECTORS

All Series
Except R20



R20 Series
Only



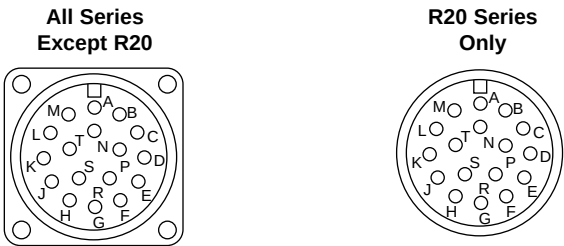
STANDARD PINOUTS–All Series

Connector Pin	Tachsyn	Resolver	Hall Sensors
A	Excitation	S4 (-cosine)	+Vdc
B	Excitation RTN	S3 (-sine)	Vdc RTN
C	Phase 1	S2 (+ cosine)	Sensor 1
D	Phase 2	S1 (+sine)	Sensor 2
E	Phase 3	R1 (Excitation)	Sensor 3
F	N/C	R2 (Excitation RTN)	N/C
G	Thermistor	Thermistor	Thermistor
H	Thermistor	Thermistor	Thermistor

SUGGESTED MATING CONNECTOR AND CLAMP

CONNECTOR	CLAMP
MS3106A20-7S PACIFIC SCIENTIFIC P/N CZ00008	MS3057-12A-1 PACIFIC SCIENTIFIC CE00003

PRIMARY & SECONDARY
FEEDBACK CONNECTOR



STANDARD PINOUTS–All Series

Primary Feedback				Secondary Feedback
Connector Pin	Tachsyn	Resolver	Hall Sensors	Encoder
A	Excitation	S4 (-cosine)	+Vdc	
B	Excitation RTN	S3 (-sine)	Vdc RTN	
C	Phase 1	S2 (+cosine)	Sensor 1	
D	Phase 2	S1 (+sine)	Sensor 2	
E	Phase 3	R1 (excitation)	Sensor 3	
F	Thermistor	Thermistor	Thermistor	
G				Encoder A
H				Encoder A̅
J				Encoder B
K				Encoder B̅
L				Encoder Z
M				Encoder Z̅
N				
P		R2 (excitation RTN)		
R	Thermistor	Thermistor	Thermistor	
S				Encoder +Vdc
T				Encoder Vdc RTN

SUGGESTED MATING CONNECTOR AND CLAMP

CONNECTOR	CLAMP
MS3106A20-29S	MS3057-12A-1
PACIFIC SCIENTIFIC	PACIFIC SCIENTIFIC
P/N CZ00009	CE00003

DEFINITIONS

Voltage (K_E) and Torque (K_T) Constants

All Pacific Scientific motors are 3-phase WYE connected. The phase-to-phase (line-line) back EMF approximates a sinusoidal waveform. The back-EMF constant, or voltage constant, is measured while driving the motor as a generator at 1000 rpm and is expressed as a peak value. The motor's torque constant may then be calculated from the voltage constant measurement.

Two types of controls are typically used to drive the motor; either 6-step (DC or trapezoidal) or sinusoidal (AC or continuous commutation). The relationship of the motor's peak voltage constant and peak torque constant to their effective values depends on which type of drive is used.

A 6-step control puts current in 2 phases at a time, commutating every 60 electrical degrees. The amplifier current is usually specified as the DC portion of the square wave output, and the motor's effective K_T and K_E are the average values through the 60° commutation zone, or .95 x the peak values.

A sinusoidal control puts a sinusoidally varying current in all three phases. The amplifier current is usually specified as either a peak value or as an RMS value.

For a peak current specification, the motor's effective K_T is .86 x K_T peak.

For an RMS current specification, the motor's effective K_T is 1.22 x K_T peak.

The motor's K_E expressed in V_{RMS}/Krpm is .707 x K_E peak.

The same conversion methods apply to metric values.

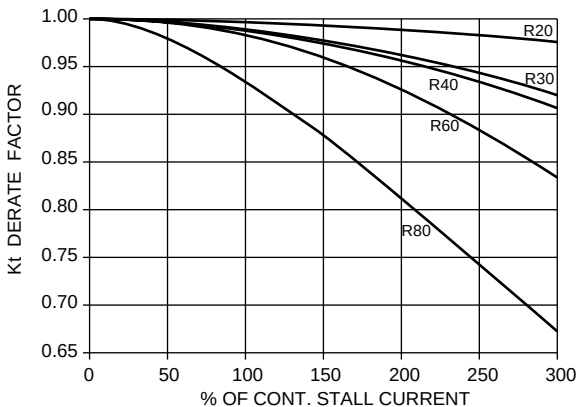
Maximum linear torque (10% loss in K_T)

The torque/current relationship of any permanent-magnet motor changes as more current is applied. This change is the result of the degree of saturation of the motor's magnetic circuit.

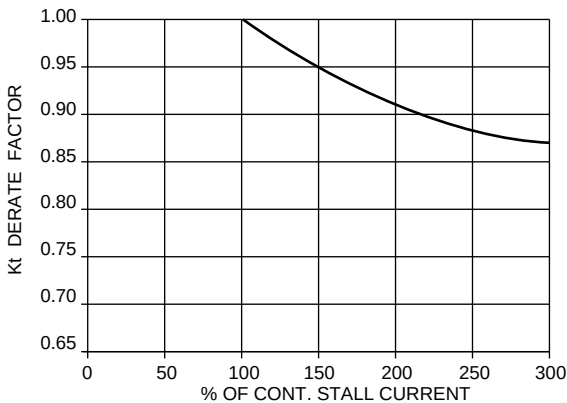
At low current levels, the torque/current relationship is quite linear. As more current is applied, torque will tend to increase more non linearly with respect to current. The maximum linear torque value is expressed at that point where torque has dropped 10% from a theoretical linear relationship. Note that additional torque can be produced beyond this point but a disproportionate amount of current must be applied.

TORQUE LINEARITY

All R-Series Motors



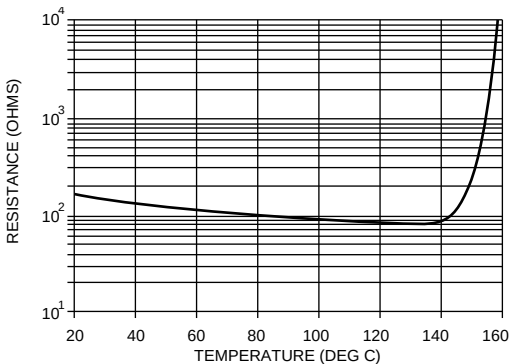
F40 Series Motors



TYPICAL THERMISTOR CHARACTERISTICS, ALL MOTORS

The protective, positive-temperature-coefficient (PTC) thermistors in all motors operate with the characteristics shown here.

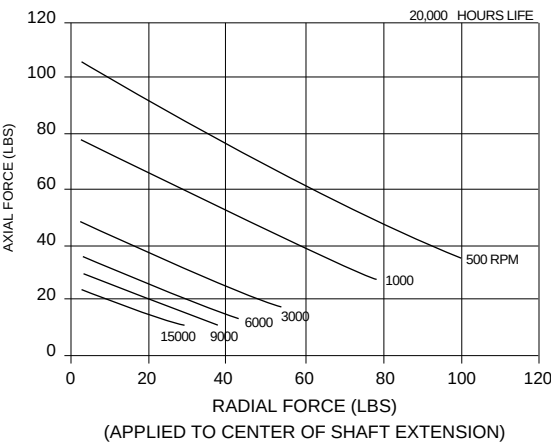
Caution: For peak currents or peak torques greater than 3 times continuous motor rating, consult factory for thermal considerations.



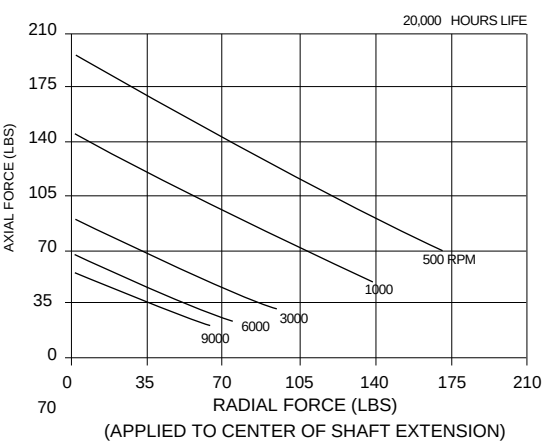
L-10 BEARING LIFE

The curves shown here depict worse-case bearing life for each Pacific Scientific brushless servo motor series.

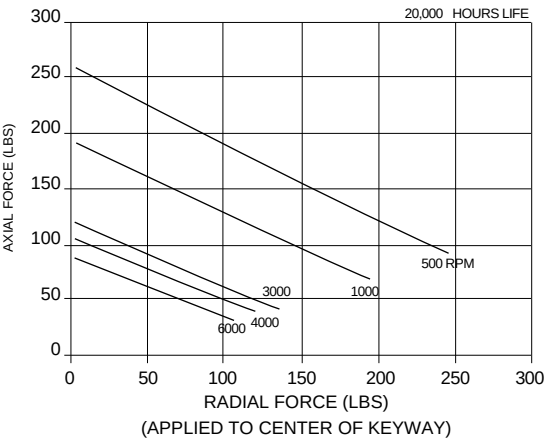
R20 SERIES



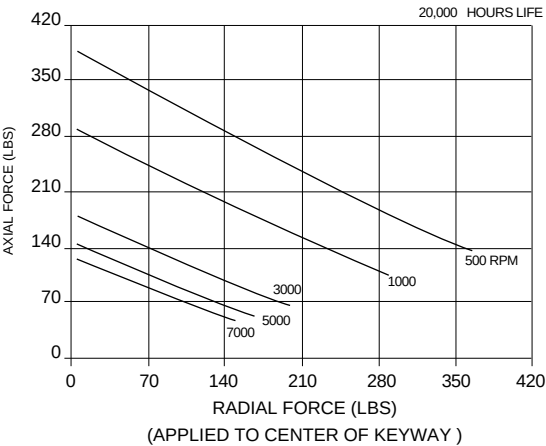
R30 SERIES AND R30P SERIES



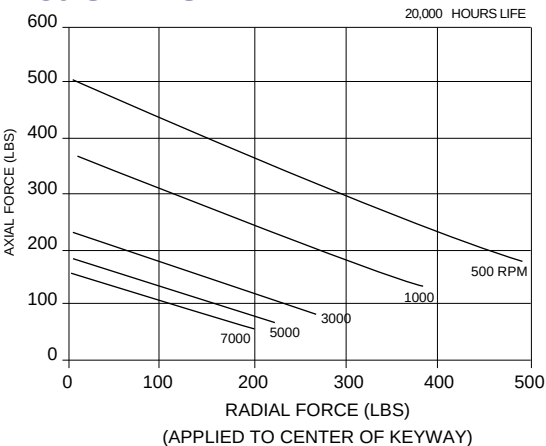
R40 SERIES and F40 SERIES



R60 SERIES AND R60P SERIES



R80 SERIES



STEPPER MOTOR TECHNICAL DATA

This section contains technical information on stepper motors. The topics discussed are:

- Hybrid motor power connections
- Phase sequencing tables
- Encoder options

Refer to Section C for more information on stepper motors.

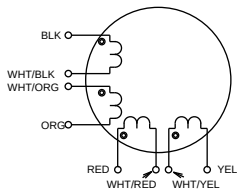
HYBRID MOTOR POWER CONNECTIONS

FLYING LEADS, TERMINAL BOARD OR MS CONNECTOR

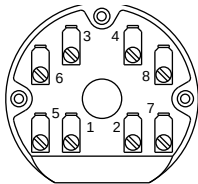
Four winding designs; F, E, L or H may be specified in the Model Number Code. For all motor terminations, refer to the step motor controller connection diagram to assure that proper connections are made. Consult our application engineers for assistance if necessary.

DESIGNATION F . . . 8 flying leads, 8 terminals or MS connector

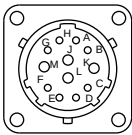
The 8 lead motor is the most versatile configuration. It may be connected by the user in choice of 8 lead, 4 lead (series or parallel) or 6 lead configuration.



8-Lead Configuration



Terminal Board
NEMA 34 and 42



MS Connector
NEMA 34 and 42

CONNECTION	DRIVER CONNECTION	LEAD COLOR	TERMINAL #	MS PIN OUT
4-LEAD BIPOLAR	A	BLACK (BLK)	1	A
SERIES	$\bar{A}$	ORANGE (ORG)	3	B
	B	RED	2	C
	$\bar{B}$	YELLOW (YEL)	4	D
	NONE	WHT/BLK & WHT/ORG	6 & 5	E & F
	NONE	WHT/RED & WHT/YEL	7 & 8	G & H
4-LEAD BIPOLAR	A	BLK & WHT/ORG	1 & 5	A & F
PARALLEL	$\bar{A}$	ORG & WHT/BLK	3 & 6	B & E
	B	RED & WHT/YEL	2 & 7	C & H
	$\bar{B}$	YEL & WHT/RED	4 & 8	D & G
6-LEAD UNIPOLAR	A	BLACK (BLK)	1	A
	B	ORANGE (ORG)	3	B
	C	RED	2	C
	D	YELLOW (YEL)	4	D
	+V	WHT/BLK & WHT/ORG	6 & 5	E & F
	+V	WHT/RED & WHT/YEL	7 & 8	G & H

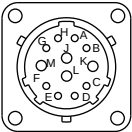
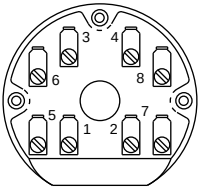
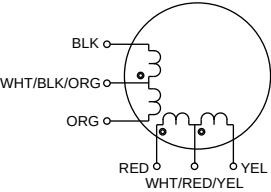
MOTOR POWER CONNECTOR
MS3122E14-12P

SUGGESTED MATING CONNECTOR	
PAC SCI P.N.	MS P.N.
SZ00009	MS3116F14-12S

- NOTE:
1. MS Pins J, K, L not used. Pin M is ground.
 2. See phase sequencing tables, page D-19.

DESIGNATION E . . . 6 flying leads, 6 terminals or MS connector

The 6 lead motor is normally used with unipolar drives. In some cases, the 6 lead motor can be used in a 4 lead series configuration for use with bipolar drives.



6-Lead Configuration

Terminal Board
NEMA 34 and 42

MS Connector
NEMA 34 and 42

CONNECTION	DRIVER CONNECTION	LEAD COLOR	TERMINAL #	MS PIN OUT
6-LEAD UNIPOLAR	A	BLACK (BLK)	1	A
	B	ORANGE (ORG)	3	B
	C	RED	2	C
	D	YELLOW (YEL)	4	D
	+V	WHT/BLK/ORG	5	J
	+V	WHT/RED/YEL	6	L
4-LEAD BIPOLAR SERIES	A	BLACK (BLK)	1	A
	A	ORANGE (ORG)	3	B
	B	RED	2	C
	B	YELLOW (YEL)	4	D
	NONE	WHT/BLK/ORG	5	J
	NONE	WHT/RED/YEL	6	L

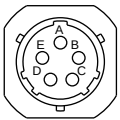
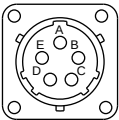
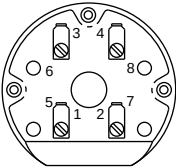
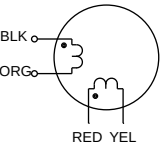
MOTOR POWER CONNECTOR
MS3122E14-12P

SUGGESTED MATING CONNECTOR	
PAC SCI P.N.	MS P.N.
SZ00009	MS3116F14-12S

- NOTE:
- 1. Terminals 7 and 8 are not used.
 - 2. MS Pins E, F, G, H, K not used. MS Pin M is ground.
 - 3. See phase sequencing tables, page D-19.

DESIGNATION L or H . . . 4 flying leads, 4 terminals or MS connector

The 4 lead motor is for use with bipolar drives.



4-Lead Configuration

Terminal Board

MS Connector
NEMA 34 and 42

MS Connector
NEMA 23

CONNECTION	DRIVER CONNECTION	LEAD COLOR	TERMINAL #	MS PIN OUT
4-LEAD BIPOLAR	A	BLACK (BLK)	1	A
	A	ORANGE (ORG)	3	B
	B	RED	2	C
	B	YELLOW (YEL)	4	D

MOTOR POWER CONNECTOR	
NEMA 34 & 42	NEMA 23
MS3122E14-5P	MS3121F14-5P

SUGGESTED MATING CONNECTOR NEMA 23, 34 & 42	
PAC SCI P.N.	MS P.N.
SZ00007	MS3116F14-5S

- NOTE:
- 1. Terminals 5, 6, 7 and 8 are not used. MS Pin E is ground.
 - 2. See phase sequencing tables, page D-19.

PHASE SEQUENCING TABLES

NOTE: Direction of rotation as viewed from mounting end of motor.

DRIVER CONNECTION					DRIVER CONNECTION					DRIVER CONNECTION				
STEP	A	$\overline{A}$	B	$\overline{B}$	STEP	A	$\overline{A}$	B	$\overline{B}$	STEP	A	B	C	D
1	+	-	0	0	1	+	-	-	+	1	GND	0	GND	0
2	+	-	+	-	2	-	+	-	+	2	0	GND	GND	0
3	0	0	+	-	3	-	+	+	-	3	0	GND	0	GND
4	-	+	+	-	4	+	-	+	-	4	GND	0	0	GND
5	-	+	0	0	1	+	-	-	+	1	GND	0	GND	0
6	-	+	-	+	BIPOLAR FULL STEP PHASE SEQUENCING					UNIPOLAR FULL STEP PHASE SEQUENCING				
7	0	0	-	+										
8	+	-	-	+										
BIPOLAR HALF STEP PHASE SEQUENCING					NOTES:									
					1 0 = OFF OR OPEN.									
					2 + = POSITIVE CURRENT FLOW.									
					3 - = NEGATIVE CURRENT FLOW.									

SHAFT LOAD AND L-10 BEARING LIFE

Bearings are the only wearing component of a step motor. PacSci uses heavy duty, long life bearings to assure you the maximum useful life from every step motor you purchase.

The N-mount is a standard NEMA front end bell, for all NEMA 23 and many NEMA 34 frame size motors.

The H-mount is a heavy duty NEMA configuration, provided as standard on certain stack lengths in NEMA 34 and all NEMA 42 frame sizes. H-mount is an option on 3-stack NEMA 34 motors. Consult motor Model Number Codes for more information.

SHAFT LOADING

Motor	Max. Radial Force (Lb.) [△]	Max. Axial Force (Lb.)
2" N-Mount	19	65
3" N-Mount	35	180
3" H-Mount	96	180
4" H & R-Mount	140	400
Powermax [△]	20	13

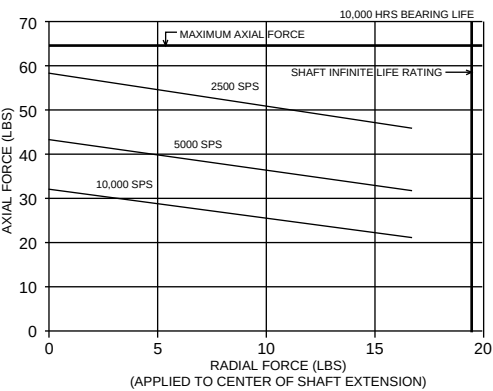
[△] The max. radial forces shown reflect the following assumptions:

- a. Radial forces are slowly applied in a reversed manner.
- b. Motors are operated at 1 * E-series torque.
- c. Infinite fatigue life with 99% reliability.
- d. Safety factor = 2.

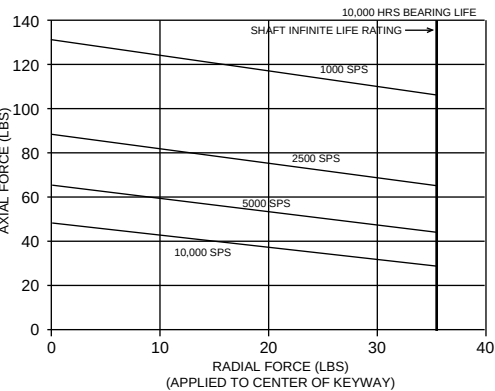
[△] These designs do not have a locked front bearing. They may be operated up to the maximum radial and axial loads and achieve an L-10 life of 10,000 hours at speeds up to 10,000 steps per second. Without a locked front bearing, loads in excess of those shown will overcome the bearing preload. Designs with a locked front bearing withstand much higher inward axial loads.

L-10 BEARING LIFE

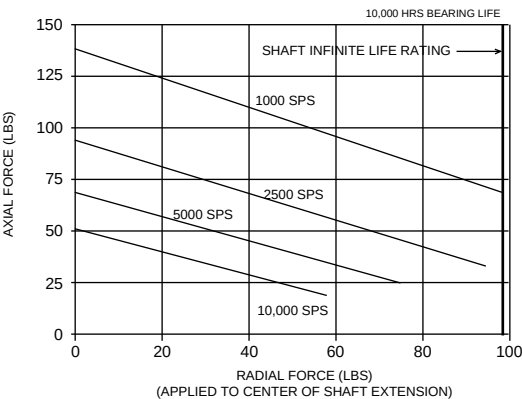
2" N-MOUNT (round motor)



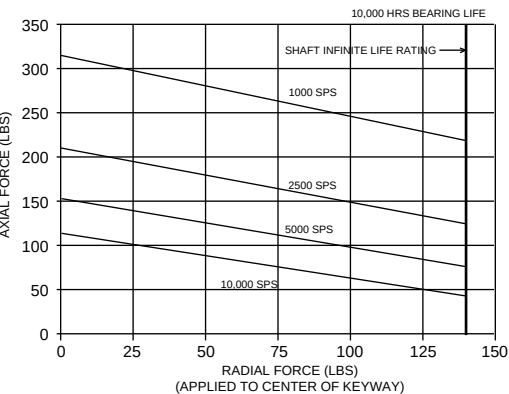
3" N-MOUNT



3" H-MOUNT



4" H & R-MOUNT



OVERVIEW OF FEEDBACK DEVICES

A wide variety of feedback devices are used in DC servo systems and brushless servo systems. This note outlines the devices, their uses, and their merits in a brushless servo system. The tables on page D-22 summarize the information.

HALL-EFFECT SENSORS

Hall-effect devices are used to sense magnetic fields. They are used in some brushless servo systems to provide commutation information to the brushless servo controller.

For three phase brushless servo motors, three Hall-effect devices are used to provide commutation signals. In some motors, a magnetized wheel is attached to the rear of the motor shaft. In other motors, the actual rotor magnets are used in lieu of a magnetized wheel. The three Hall-effect devices sense the magnet field of the wheel or the rotor magnets as the motor shaft rotates and produce three square wave signals phased 120° apart. These three signals are used by the brushless controller to generate currents in the proper motor phases for optimum torque production.

The Hall-effect device itself is an electronic component and has a temperature rating of 155°C.

DC TACHOMETER (brush-type)

The DC tachometer is used to sense motor velocity. It generates an analog DC voltage that is proportional to shaft velocity. The polarity of the output voltage is determined by the direction of rotation. The tachometer can be viewed as a DC servo motor operated as a DC generator. Brushes and a commutator couple the output voltage from the rotating winding to the stationary terminal connections.

The DC tachometer is an electromagnetic device and contains no electronics.

BRUSHLESS TACHOMETER

Like the DC tachometer, this device is used to sense motor velocity. It provides an analog DC voltage proportional to speed with its polarity determined by the direction of rotation. However, unlike the DC tachometer, the brushless tachometer does not have brushes or a commutator. Commutation is done electronically which eliminates brushes and their potential problems.

The commutation electronics are typically located in the tachometer package mounted on the rear of the motor. The brushless tachometer was developed specifically for use with brushless motors.

RESOLVER

The resolver is an electromagnetic device that is excited with a high frequency carrier signal. The resolver output is a two phase, amplitude modulated signal. These signals are processed by a resolver-to-digital converter (RDC) located in the controller. There are no electronics located in the resolver package mounted on the motor.

The RDC produces an analog velocity signal and a digital position word. The digital position word is used for motor commutation and can also be used for motor positioning. The resolver is functionally equivalent to Hall-effect sensors plus brushless tachometer plus absolute encoder.

SYNCHRO

The synchro is essentially a three phase version of the resolver. Synchro signals can be processed by an RDC by first running the three phase synchro signals through a Scott-T transformer. This transformer converts the three phase signals to two phase signals which can be used by the RDC.

In industrial servo applications, the resolver is far more prevalent than the synchro. This is due primarily to the lower cost of the resolver and its ability to directly interface to the RDC electronics. Synchros require the Scott-T transformer to interface to the RDC which adds cost and complexity.

TACHSYN®

The Tachsyn® is a modification of a synchro or resolver. It is an electromagnetic device which provides rotor position information as well as velocity information. The rotor position information is in the same form as that produced by Hall-effect sensors. The velocity information is an analog DC voltage proportional to speed. The Tachsyn® functionally replaces Hall-effect sensors plus a brushless tachometer.

The Tachsyn® signals must be processed to produce the analog tachometer signal and the commutation signals. The processor electronics are located in the controller rather than in the Tachsyn® package mounted on the motor.

ENCODER

An encoder is an electro-optical position sensor. It is available in absolute or incremental versions with the incremental version more commonly used.

An incremental encoder consists of a glass, mylar, or metal disk with alternating opaque and transparent stripes. Light from an LED or lamp is passed through the disk onto a photosensor which detects the alternating opaque and transparent stripes. Encoder outputs are typically two phase digital signals in quadrature (90° out of phase). Rotational direction information is obtained by sensing which output phase is leading. Absolute encoders operate on similar principles but have multiple tracks to generate absolute position information.

The processing electronics used to convert the optical signals to digital signals are contained in the encoder package mounted on the motor.

SUMMARY

In general, it is good design practice to keep electronics and optics out of the motor since motors are designed to operate at high winding temperatures, i.e., 155°C. When the motor is operated at its rated continuous torque, the temperature around the feedback device mounted on the motor can reach 110°C or more. This temperature is well beyond the operating range of commercial and industrial grade electronic components. To solve the temperature sensitivity problem, more expensive military grade components must be used or the motor must be derated to reduce the winding temperature to an acceptable level. Either solution introduces added cost to the system.

The Tachsyn® and resolver offer a solution to the temperature problem since both devices are rated to a 155°C operating temperature and their processing electronics are located in the controller rather than on the motor.

The inherent ruggedness of the Tachsyn® and resolver is important when considering other environmental issues such as shock, vibration, and contamination. Optical encoders can be especially susceptible to these environmental hazards.

FEEDBACK DEVICES

Device	Technology	Parameter(s) Measured	Function
Hall-Effect	Electronic-magnetic	Coarse rotor position	Brushless motor commutation, limited velocity feedback.
DC Tachometer	Electromagnetic	Motor velocity	Analog velocity feedback.
Brushless Tachometer	Electromagnetic	Motor velocity	Analog velocity feedback.
Tachsyn®	Electromagnetic	Coarse rotor position, Motor velocity	Brushless motor commutation, Analog velocity feedback.
Resolver	Electromagnetic	Coarse rotor position, Motor velocity, Fine rotor position	Brushless motor commutation, Analog velocity feedback, Digital position feedback.
Synchro	Electromagnetic	Coarse rotor position, Motor velocity, Fine rotor position	Brushless motor commutation, Analog velocity feedback, Digital position feedback.
Encoder	Electro-optical	Fine rotor position	Digital position feedback, limited velocity feedback.

STANDARD PACIFIC SCIENTIFIC SERVO SYSTEM CONFIGURATIONS

Configuration	Standard Feedback Device	Example System	Comments
Torque Control, analog command	Hall-Effect Sensors	SC402 Controller & R32 Motor w/ Hall-Effect Sensors	Sensors provide motor commutation information to controller.
Velocity Control, analog command	Tachsyn®	SC402 Controller & R32 Motor w/Tachsyn®	Tachsyn® provides motor commutation and velocity information to the controller.
Position Control, digital command	Resolver	SC752 Controller & R32 Motor w/ Resolver	Resolver provides motor commutation, digital position, and analog velocity information to the controller.

BRUSHLESS SERVO MOTOR FEEDBACK COMBINATIONS

Primary Feedback Devices

- Tachsyn®
- Commutation signals
 - Analog velocity information
 - Is used in combination with a Tachsyn processor board for signal conditioning, installed on the servo controller.
- Resolver, transmitter type
- Commutation signals
 - Analog position information
 - Velocity data
- Hall sensors
- Commutation signals

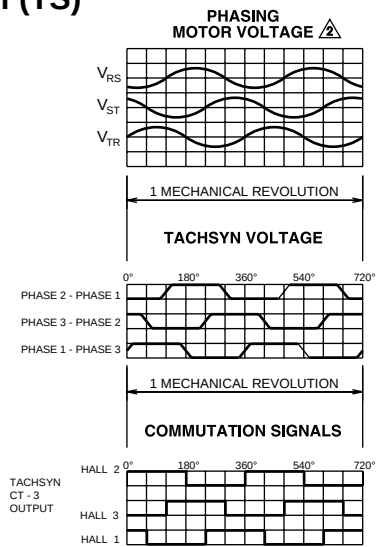
Secondary Feedback Devices

- Digital Optical Encoders
- Digital position
 - Velocity data

A wide selection of feedback configurations are available for Pacific Scientific brushless servo motors. Options include motors equipped with primary-only, primary/secondary, and, (rarely utilized) secondary-only feedback. Described below are the feedback options available, and the purposes for which they are employed. Any one of the three primary feedback devices may be factory-installed by Pacific Scientific on the brushless servo motor of your choice. Any one of the secondary-feedback types can be factory-installed on the same motor. Motors are available equipped with the mounting provisions only for certain feedback devices (see model number code).

PRIMARY FEEDBACK DEVICES. . . TECHNICAL DATA

Tachsyn (TS)



Typical output @ 25°C with CT-3 processing board[△]

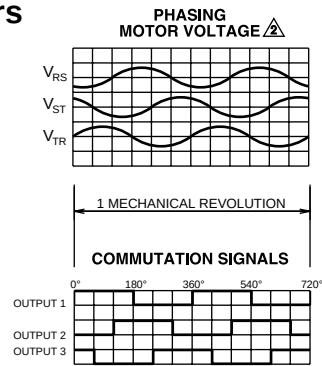
Parameter	Units	Value
Commutation outputs:		See phasing diagram
No. of poles		4
No. of phases		3
Output volts, max.	volts	DC Supply
Output impedance	ohms	1000 max.
Tachometer outputs:		
V/Krpm		See note [△]
Ripple volts	±%	3.0
Max. output volts (Sat.)	volts	DC Supply -1
Min. load resistance	ohms 10K	
Bandwidth to 45° shift	Hz	1000
Offset volts	mV	2 max
Temp. coefficient	%/deg C	-.05
Rotor inertia	lb-in-sec ² x 10 ⁻³	.006
Weight	lb	.23

[△] The Tachsyn transducer (installed in the motor) is used in combination with a Tachsyn CT-3 signal conditioning processor board (installed in the servo controller). The CT-3 processor board is not provided with Pacific Scientific brushless servo motors. Rather, it is a standard option for Pacific Scientific brushless servo controllers.

Available Volts/Krpm outputs are listed in this catalog's servo controller ordering guides. The CT-3 processor board is also available separately, from Servo-Tek®, Hawthorne, N.J.

[△] For clockwise motor rotation.

Hall Sensors (HS)



Typical performance @ 25°C

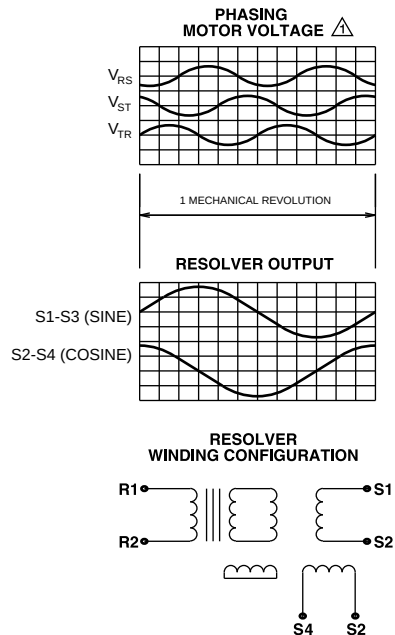
Units	Value	Parameter
Commutations outputs:		See phasing diagram
No. of poles		4
No. of phases		3
Output volts, max.	volts	DC Supply
Power supply required	volts mA	+ 4.5 to 24 VDC 20 mA max
Rotor inertia	lb-in-sec ² x 10 ⁻³	.016-R20 series .049-All other series
Weight	lb	.03-R20 series .08-All other series

[△] For clockwise motor rotation.

PRIMARY FEEDBACK DEVICES. . .TECHNICAL DATA (Cont.)

Frameless resolvers (R1, R2)

Typical performance



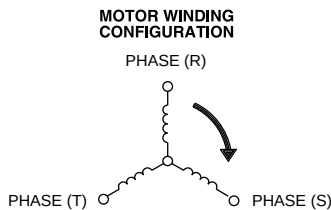
Parameter	Units	R1	R2
Frame size		15	21
Type		Transmitter	Transmitter
Primary		Rotor	Rotor
Speed		1	1
Input current, max.	mA	25	25
Input power, nom	mW	42	30
Transformation ratio		0.5	0.5
Phase shift	DEG	+2	-1
Impedances:			
ZRO	ohms	95 + j190	120 + j220
ZRS	ohms	85 + j145	105 + j200
ZSO @ E-Z	ohms	140 + j190	210 + j470
ZSS @ E-Z	ohms	115 + j140	200 + j420
DC resistances:			
Stator	ohms	75	85
Rotor	ohms	23	31
Null voltage	% of input	0.5	0.6
Max. electrical error	Minutes	±15	±20
Rotor inertia	lb-in-sec ² x 10 ⁻³	.02	.175
Weight	lb	.28	.69

Test conditions: 25°C, Input Voltage 4Vrms, Input Frequency 5 kHz

△ For clockwise rotation.

Phasing diagram, all motors

Shown here is the phasing diagram for CW rotation as viewed from the drive-shaft end of the motor.



Motor-weight adder for secondary-feedback configurations△

Series	lbs
R20	.20
R30	.46
R40	2.0
F40	2.0
R60	2.2
R80	2.3

△ Does not include weight of feedback device.

SECONDARY FEEDBACK DEVICES. . . TECHNICAL DATA

Optical encoders (LA, LB, LC, ND, NF, NG)

Typical performance @ 25° C

Parameter	LA	LB	LC
Pulses per revolution	500	1000	1024
Type	Incremental		
Supply voltage	+5 Vdc ±5% @160 mA typical		
Output format	Dual-channel quadrature and index with complements		
Output type	26LS31 TTL Differential Line Driver (RS422A)–short-circuit protected		
Output voltage	–		
Sink current -	–		
Frequency response-data	125 kHz		
Frequency response-index	125 kHz		
Rotor inertia	1.6 x 10 ⁻⁵ lb-in-sec ²		

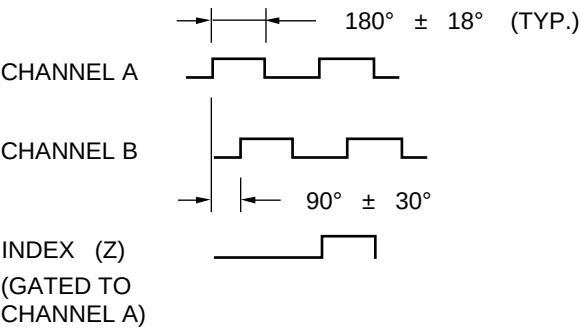
Note: For R2 motors only.

Parameter	ND	NF	NG
Pulses per revolution	500	1000	1024
Type	Incremental		
Supply voltage	+5 Vdc ±5% @160 mA typical		
Output format	Dual-channel quadrature and index with complements		
Output type	26LS31 TTL Differential Line Driver (RS422A)–short-circuit protected		
Output voltage	–		
Sink current	–		
Frequency response-data	125 kHz		
Frequency response-index	125 kHz		
Rotor inertia	1.2 x 10 ⁻⁵ lb-in-sec ²		

ENCODER OUTPUT

L and N Types

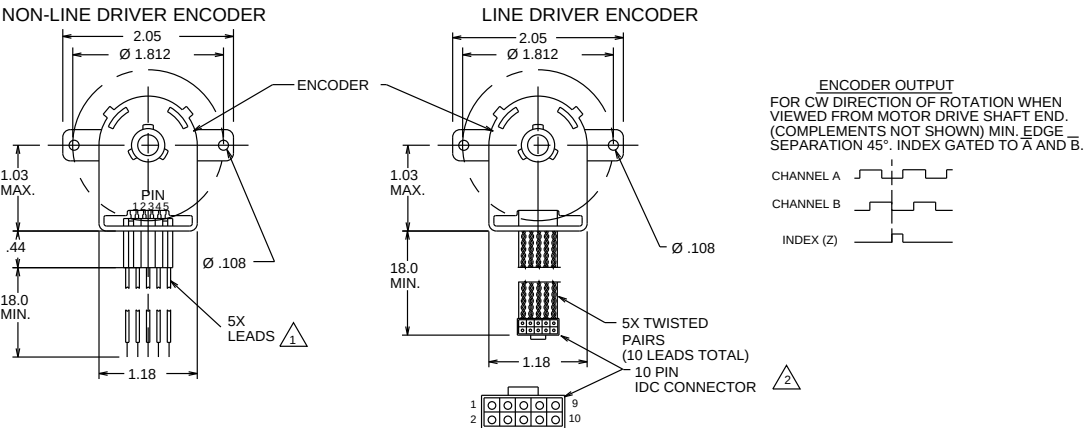
FOR CW DIRECTION OF ROTATION WHEN
VIEWED FROM DRIVE SHAFT END
(COMPLEMENTS NOT SHOWN)



STEPPER MOTOR FEEDBACK ENCODER OPTIONS

NEMA 23 ENCODER OPTION

The standard encoder offered on the NEMA 23 motor is the Hewlett-Packard HEDS 5600 series.



PIN	COLOR	FUNCTION
1	BLACK	GROUND
2	BLUE	Z
3	WHITE	A
4	RED	+5V
5	BROWN	B

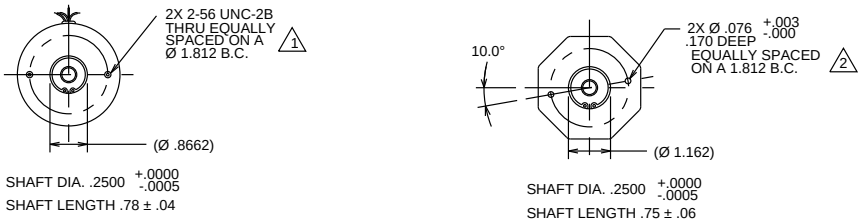
PIN	FUNCTION
1	N/C
2	+5V
3	GROUND
4	N/C
5	$\bar{A}$
6	A
7	$\bar{B}$
8	B
9	$\bar{Z}$
10	Z

- NOTES:
- 1 Leads are terminated with HP HEDS-8903 connector.
- 2 Suggested mating connector: BERG 65-692-001 or equivalent.

PARAMETERS	NON-LINE DRIVER				LINE DRIVER			
	INCREMENTAL				INCREMENTAL			
ENCODER OPTION	HH	HK	HD	HJ	PH	PK	PD	PJ
PULSES PER REVOLUTION	200	400	500	512	200	400	500	512
SUPPLY VOLTAGE	+5V $\pm$ 10% @ 85 mA MAX.				+5V $\pm$ 10% @ 85 mA MAX.			
OUTPUT FORMAT								
OUTPUT TYPE	DUAL CHANNEL QUADRATURE AND INDEX				DUAL CHANNEL QUADRATURE W/ COMPLEMENTS INDEX W/ COMPLEMENTS			
FREQUENCY RESPONSE:	SQUARE WAVE TTL COMPATIBLE				RS-422A COMPATIBLE			
DATA	100 kHz				100 kHz			
INDEX	100 kHz				100 kHz			
ROTOR INERTIA	5×10^{-7} lb-in-S ²				5×10^{-7} lb-in-S ²			
WEIGHT	0.08 lb.				0.08 lb.			

- NOTES:
- 1 TYPICAL @ 25° C.
- 2 ONLY ENCODERS WITH LINE DRIVER OUTPUT (PH, PK, PD, PJ) MAY BE USED WITH PACIFIC SCIENTIFIC INDEXER/DRIVERS.

ENCODER MOUNTING PROVISION ONLY = M1
FOR HEWLETT PACKARD HEDS 5600 SERIES OR SIMILAR.



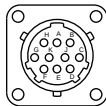
- NOTES:
- 1 Max. thread engagement of mounting screw not to exceed .200.
- 2 For #2 self tapping screw.
3. Encoder mounts directly to motor endbell (without thermal isolation).

STEPPER MOTOR FEEDBACK ENCODER OPTIONS (Cont.)

NEMA 34, NEMA 42 ENCODER OPTIONS

ENCODER MS CONNECTOR

ALL NEMA 34 AND NEMA 42 MOTORS WITH SYSTEM CONSTRUCTION MAY BE SPECIFIED WITH AN INTEGRAL OPTICAL ENCODER.



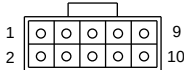
ENCODER CONNECTOR ^Δ

PIN	FUNCTION
A	CHANNEL A
B	CHANNEL $\bar{A}$
C	CHANNEL B
D	CHANNEL $\bar{B}$
E	CHANNEL Z
F	CHANNEL $\bar{Z}$
G	+ 5 VDC
H	5 VDC RTN
K	N/C
J	N/C

MOTOR FEEDBACK CONNECTOR
MS3122E12-10P

SUGGESTED MATING CONNECTOR	
PAC SCI P.N.	MS P.N.
SZ00008	MS3116F12-10S

PARAMETER ^Δ



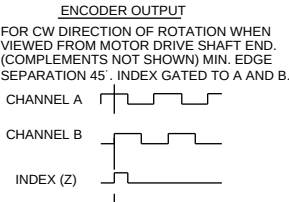
ENCODER CONNECTOR ^Δ

PIN	FUNCTION
1	N/C
2	+5V
3	GROUND
4	N/C
5	$\bar{A}$
6	A
7	$\bar{B}$
8	B
9	$\bar{Z}$
10	Z

MODELS MX21

MATING CONNECTOR NOT OFFERED
SUGGESTED MFR. PART NUMBERS
BEI P/N C94003
BERG P/N 65863-165
MOLEX P/N 10-56-3103

ENCODER OUTPUT
FOR M AND N TYPES



NOTE:

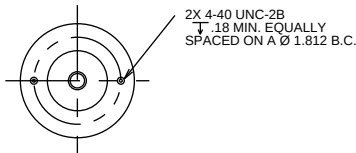
NEMA ^Δ34, NEMA 42
SYSTEM CONSTRUCTION

NEMA ^Δ34, REGULAR
CONSTRUCTION ONLY.

TYPE	NON-LINE DRIVER (M)					LINE DRIVER (N)				
ENCODER OPTION	MH	MK	MD	MF	MG	NH	NK	ND	NF	NG
PULSES PER REVOLUTION	200	400	500	1000	1024	200	400	500	1000	1024
SUPPLY VOLTAGE	+5V ± 10% @ 60 mA MAX.					+5V ± 10% @ 60 mA MAX.				
OUTPUT FORMAT	DUAL CHANNEL QUADRATURE AND INDEX WITH COMPLEMENTS					DUAL CHANNEL QUADRATURE AND INDEX W/ COMPLEMENTS				
OUTPUT TYPE	SQUARE WAVE TTL COMPATIBLE CMOS, SHORT CIRCUIT PROTECTED					26LS31 TTL DIFFERENTIAL LINE DRIVER, SHORT CIRCUIT PROTECTED				
SINK CURRENT	10mA					—				
FREQUENCY RESPONSE:										
DATA	100 kHz					100 kHz				
INDEX	100 kHz					100 kHz				
ROTOR INERTIA	1.6 x 10 ⁻⁶ lb-in-S ²					1.6 x 10 ⁻⁶ lb-in-S ²				
WEIGHT	0.13 lb.					0.13 lb.				

- NOTES:
- ^Δ TYPICAL @ 25° C
- 2 ONLY ENCODERS WITH LINE DRIVER OUTPUT (NH, NK, ND, NF, NG) MAY BE USED WITH PACIFIC SCIENTIFIC INDEXER/DRIVERS.

ENCODER MOUNTING PROVISION ONLY = M3
FOR BEI MX21 SERIES MODULAR ENCODER OR SIMILAR



	CONSTRUCTION (3" & 4")	R CONSTRUCTION (3" ONLY)
SHAFT DIA.	Ø .3748 ^{+.0000} _{-.0005}	Ø .3748 ^{+.0000} _{-.0005}
SHAFT LENGTH	.56 TO .65	.965 ± .04

NOTE: ENCODER MOUNTS TO MOTOR ENDBELL (THERMAL ISOLATOR PROVIDED).



SYSTEM SIZING AND SELECTION

If you're looking for assistance in selecting a motor and drive, we can help. On the next several pages you will find application notes that will walk you through the sizing and selection process. For additional assistance, contact one of our experienced application engineers and ask about our latest sizing software – PacSizit™ for Windows.

This IBM compatible, icon-driven software program will greatly simplify the selection process.

For your copy of PacSizit™ for Windows or application assistance, please call or fax our application engineers.

MOTION CONTROL MECHANICS

The mechanical drive systems used in servo motion control applications can be divided into 4 basic categories: direct drive, gear drive, leadscrew drive, and tangential drive. This application note describes each of these drive categories and outlines the relevant formulas for calculating the various load parameters. In all instances, the formulas reflect all parameters back to the motor shaft. This means that all load parameters are transformed to the equivalent load parameters “seen” by the motor. Reflecting all parameters back to the motor shaft eases the calculations necessary for sizing the motor and controller.

The first section of this note reviews the formulas for calculating the inertia of a cylinder. These formulas are important since inertia is a key load parameter and the inertia of many mechanical components (e.g. leadscrews, gears, shafts, drive rollers, etc.) can be calculated using this formula.

CALCULATING THE INERTIA OF A CYLINDER

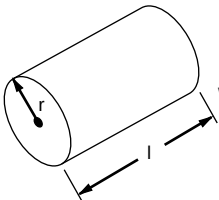
Inertia is the resistance of an object to be accelerated or decelerated. In motion control applications, inertia is an important parameter since it defines the torque required to accelerate and decelerate the load.

SOLID CYLINDER

The inertia of a solid cylinder can be calculated if either its weight and radius or its density, radius, and length are known.

For known weight and radius: $J_L = \frac{1}{2} \frac{W}{g} r^2 = (0.0013) W r^2$

For known density, radius, and length:



$$J_L = \frac{1}{2} \frac{\pi l p r^4}{g} = (0.0041) l p r^4$$

where: J_L = inertia (lb-in-s²)
 W = weight (lb)
 r = radius (in)
 l = length (in)
 p = density of material (lb/in³)
 g = gravitational constant (386 in/s²)

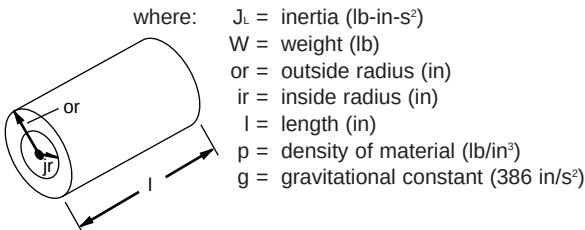
HOLLOW CYLINDER

The inertia of a hollow cylinder can be calculated if its weight, inside radius, and outside radius are known or if its density, inside radius, outside radius, and length are known.

The densities of some commonly used materials are given in the table at the top in the next column.

For known weight and radii: $J_L = \frac{1}{2} \frac{W}{g} (or^2 - ir^2)$
 $= (0.0013) (or^2 - ir^2) W$

For known density, radii, and length: $J_L = \frac{\pi l p}{2 g} (or^4 - ir^4)$
 $= (0.0041) (or^4 - ir^4) l p$



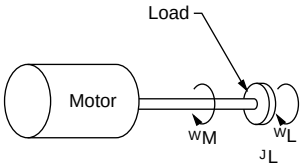
where: J_L = inertia (lb-in-s²)
 W = weight (lb)
 or = outside radius (in)
 ir = inside radius (in)
 l = length (in)
 p = density of material (lb/in³)
 g = gravitational constant (386 in/s²)

MATERIAL DENSITIES

Material	lb/in ³
Aluminum	0.096
Brass	0.300
Bronze	0.295
Copper	0.322
Steel (cold rolled)	0.280
Plastic	0.040
Hard Wood	0.029
Soft Wood	0.018

DIRECT DRIVE LOAD

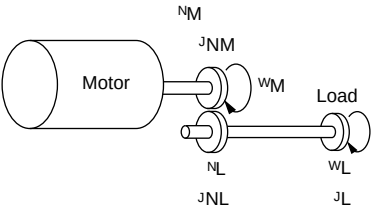
For direct drive loads, the load parameters do not have to be reflected back to the shaft since there are no mechanical linkages involved.



Speed: $W_M = W_L$
Torque: $T_L = T'$
Inertia: $J_T = J_L + J_M$
where: W_M = motor speed (rpm)
 W_L = load speed (rpm)
 J_T = total system inertia (lb-in-s²)
 J_L = load inertia (lb-in-s²)
 J_M = motor inertia (lb-in-s²)
 T_L = load torque at motor shaft (lb-in)
 T' = load torque (lb-in)

GEAR DRIVEN LOAD

Load parameters in a gear driven system have to be reflected back to the motor shaft by the gear ratio or the gear ratio squared. The inertia of the gears has to be included in the calculations. The gear inertias can be calculated using the formulas for the inertia of a cylinder.



Speed: $W_M = W_L (N_L / N_M)$
Torque: $T_L = T' (N_M / N_L)$
Inertia: $J_T = (N_M / N_L)^2 (J_L + J_{NL}) + J_M + J_{NM}$
where: W_M = motor speed (rpm)
 W_L = load speed (rpm)
 N_M = number of motor gear teeth
 N_L = number of load gear teeth
 T_L = load torque reflected to motor shaft (lb-in)
 T' = load torque (lb-in)—not reflected
 J_T = total system inertia (lb-in-s²)
 J_L = load inertia (lb-in-s²)
 J_M = motor inertia (lb-in-s²)
 J_{NM} = motor gear inertia (lb-in-s²)
 J_{NL} = load gear inertia (lb-in-s²)

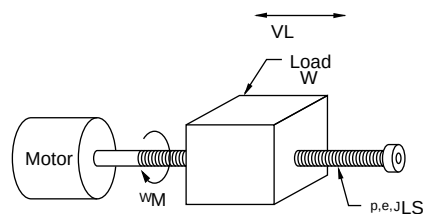
MOTION CONTROL MECHANICS (Cont.)

LEADSCREW DRIVEN LOAD

For this type of drive system, the load parameters have to be reflected back to the motor shaft. The inertia of the leadscrew has to be included and can be calculated using the formulas for inertia of a cylinder. For precision positioning applications, the leadscrew is sometimes preloaded to eliminate or reduce backlash. If preloading is used, the preload torque must be included since it can be a significant term. The leadscrew's efficiency must also be considered in the calculations. Efficiencies of various types of leadscrews are shown here.

TYPICAL LEADSCREW EFFICIENCIES

Type	Efficiency
Ball-nut	0.90
Acme with plastic nut	0.65
Acme with metal nut	0.40



Speed: $w_M = v_L p$

Torque: $T_L^{\Delta} = \frac{1}{2\pi} \frac{F_L}{pe} + \frac{1}{2\pi} \frac{F_{PL}}{p} \times 0.2$
 $= (0.159)F_L/pe + (0.032)F_{PL}/p$

Inertia: $J_T = \frac{W}{g} \left(\frac{1}{2\pi p} \right)^2 \frac{1}{e} + J_{LS} + J_M$
 $= (6.56 \times 10^{-5})W/ep^2 + J_{LS} + J_M$

Friction: $F_F = uW$

$T_F = \frac{1}{2\pi} \frac{F_F}{pe} = (0.159)F_F/pe$

where:

- w_M = motor speed (rpm)
- v_L = linear load speed (in/min)
- p = lead screw pitch (revs/in)
- e = lead screw efficiency
- T_L = load torque reflected to motor shaft (lb-in)
- T_F = friction torque (lb-in)
- F_L = load force (lb)
- F_{PL} = preload force (lb)
- J_T = total system inertia (lb-in-s²)
- J_M = motor inertia (lb-in-s²)
- J_{LS} = lead screw inertia (lb-in-s²)
- W = load weight (lb)
- F_F = frictional force (lb)
- u = coefficient of friction
- g = gravitational constant (386 in/s²)

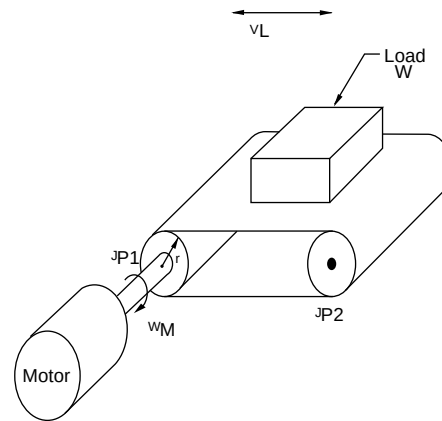
COEFFICIENTS OF FRICTION

Steel on steel	0.580
Steel on steel (lubricated)	0.150
Teflon on steel	0.040
Ball bushing	0.003

Δ For certain applications, the frictional drag torque due to preloading should also be considered as part of the total torque requirements. Since optimum preloading is one-third of operating load, it is common practice to use 0.2 as the preload torque coefficient for the ball screw to obtain a maximum figure for preload frictional drag torque. At higher than optimum preloading, the preload frictional drag will add to the torque requirements, since it is a constant.

TANGENTIALLY DRIVEN LOAD

For this type of drive system, the load parameters have to be reflected back to the motor shaft. A tangential drive can be a rack and pinion, timing belt and pulley, or chain and sprocket. The inertia of the pulleys, sprockets, or pinion gears must be included in the calculations.



Speed: $w_M = \frac{1}{2\pi} \frac{v_L}{r} = (0.159)v_L/r$

Torque: $T_L = F_L r$

Inertia: $J_T = \frac{W}{g} r^2 + J_{P1} + J_{P2} + J_M$
 $= (0.0026)Wr^2 + J_{P1} + J_{P2} + J_M$

Friction: $T_F = F_F r$

where:

- w_M = motor speed (rpm)
- v_L = linear load speed (in/min)
- r = pulley radius (in)
- T_L = load torque reflected to motor shaft (lb-in)
- T_F = friction torque (lb-in)
- F_L = load force (lb)
- J_T = total system inertia (lb-in-s²)
- J_M = motor inertia (lb-in-s²)
- J_P = pulley inertia(s) (lb-in-s²)
- W = load weight including belt (lb)
- F_F = frictional force (lb)
- g = gravitational constant (386 in/s²)

SIZING A SERVO SYSTEM

Many applications require the precise, controlled movement of an object or load. This motion control can be provided by a servo system. To obtain the desired performance from a servo system, the load must be characterized and its motion profile must be defined. If the servo system is incorrectly specified, it can lead to degraded performance, motor overheating, or excessive system cost. This application note describes the process for specifying the correct servo system for your applications.

UNITS OF MEASURE

In motion control applications, many different units of measures are used. Everyone has their favorite units with which they feel comfortable. This application note will use the following units:

Angular acceleration:	radians/second ²	(r/s ²)
Angular velocity:	radians/second	(r/s)
Angular position:	radians	(r)
Torque:	pound-inch	(lb-in)
Inertia:	pound-inch-second ²	(lb-in-s ²)

PERFORMANCE CURVES

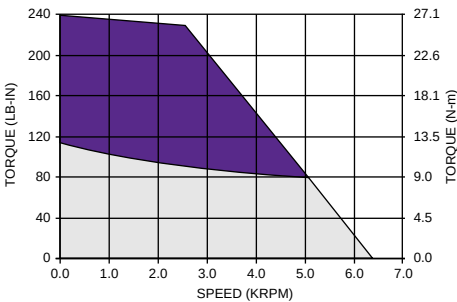
A servo system consists of two main components, a servo amplifier or controller and a servo motor. The servo amplifier provides electrical energy to the servo motor which converts the electrical energy to mechanical energy in the form of torque and speed. Each servo motor has a specific torque-speed operating envelope that is determined by thermal and mechanical considerations. Likewise each servo amplifier has a specific current-voltage operating envelope that is determined by thermal and electrical considerations.

For more information on performance curves, see page B-56. These curves define the torque-speed operating envelope for a specific motor/controller combination.

Figure D-5 shows the performance curves for two standard Pacific Scientific motor/controller combinations. Note that the curves are broken down into two zones, intermittent duty and continuous duty.

R65H MOTOR

Reference Points	
T _{PS}	240.0
T _{PR}	200.0
T _{CS}	115.0
T _{CR}	90.0
W _R	3,000



R84G MOTOR

Reference Points	
T _{PS}	300.0
T _{PR}	280.0
T _{CS}	190.0
T _{CR}	125.0
W _R	3,800

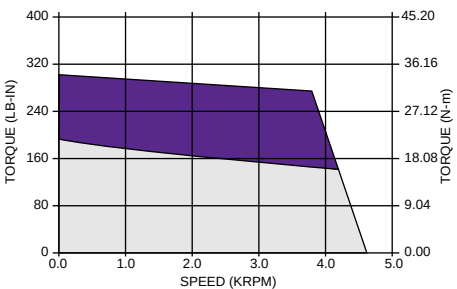


Figure D-5. Performance Curves

The continuous duty zone is bordered by the rated system speed line and the continuous torque line. This continuous duty zone assumes a 25°C ambient motor temperature and it also assumes that the motor is bolted to a 1/2" x 18" x 18" aluminum plate. This plate and rating method is standard in the servo industry. The system can operate on a continuous basis anywhere in this zone. The RMS (root-mean-square) torque is used as the basis for determining continuous torque.

The intermittent duty zone is bordered by the rated system speed line and the peak torque line. The peak torque in these motor/controller combinations can be sustained for up to 5 seconds as shown in the figure. The time allowable at peak torque can vary and depends mainly upon the controller ratings. The motor/controller combination can operate anywhere within this zone on an intermittent basis. The actual operating time allowed in the intermittent duty zone is governed by the torque profile which must have an RMS value which falls within the continuous duty zone.

For example, assume that the load requires 175 lb-in of peak torque at a 50% duty cycle. The RMS value for this torque profile is 124 lb-in. Referring to Figure D-5, it can be seen that the SC725/R65 system can provide the 175 lb-in of peak torque but the 124 lb-in of RMS torque exceeds the 115 lb-in continuous capability of the system. Therefore for this requirement, it would be necessary to go to the next larger system which is the SC725/R84. This system can easily meet the torque requirements.

SYSTEM DERATING

As stated previously, the continuous duty zone of the performance curves is defined assuming that the motor is in a 25°C ambient and that it is bolted to a standard aluminum plate. The motor windings are rated at 155°C. If the ambient temperature is not 25°C, the continuous duty zone of the performance curve must be derated using the following formula:

$$T(t) = T(25^{\circ}\text{C}) \sqrt{[155-t]/130}$$

where $T(t)$ = torque at temperature t
 $T(25^{\circ}\text{C})$ = torque at 25°C ambient temperature
 t = ambient temperature, °C

Note that this derating only has to be applied to the continuous duty zone. The peak torque line does not have to be derated.

Typically the servo motor will not be attached to a standard aluminum plate. However, the mounting used will usually provide some reasonable amount of heatsinking. Many times the mounting will provide heatsinking superior to that provided by the standard aluminum plate. The only way of determining the level of heatsinking provided by the mounting structure is to make thermal measurements when the system is operating.

LOAD PARAMETERS

There are four load parameters which have to be determined as the first step in selecting a servo system. These parameters must be defined at the motor shaft. If there is a mechanical linkage between the load and motor shaft, e.g. gears, belts and pulleys, or a leadscrew, the effect of these mechanics must be taken into account. See page D-29 for details on the effects of various mechanical linkages. The four load parameters are defined below.

1. Friction Torque, T_F (lb-in)
This is the torque required to overcome the contact between mechanical components that resists motion of these components relative to each other. This friction torque is independent of speed. It can be calculated but is usually characterized by measurement. T_F can be easily measured using a torque wrench placed at the drive shaft point.
2. Viscous Torque, T_V (lb-in/KRPM)
Viscous torque is the torque required to move an object through a fluid. A good example of this would be the torque required to turn gears submersed in an oil bath. T_V is proportional to speed and therefore becomes more significant at higher speeds. In most applications, this torque is negligible.

SIZING A SERVO SYSTEM (Cont.)

LOAD PARAMETERS (Cont.)

3. Inertia, J (lb-in-s²)
Inertia is the resistance of an object to change in velocity, i.e. the resistance to accelerate or decelerate. Inertia can be calculated or measured but is typically the most difficult parameter to define.
4. Load Torque, T_L (lb-in)
This is any torque required by the load other than those previously described. For example, holding an object up against the force of gravity requires torque which would be defined under the load torque term. It could also be any externally generated force or torque applied to the motor shaft.

MOTION PROFILE PARAMETERS

The velocity versus time profile of the load must be defined, along with the four parameters described above, to fully characterize the load and allow proper selection of the servo system. As with the load parameters, this profile must be defined at the motor shaft and hence the effect of any mechanical linkages must be taken into account.

Figure D-6 shows two velocity profiles that are typical in position control applications. These profiles are termed triangular and trapezoidal due to their respective shapes. In either case, the acceleration rate, run speed, and deceleration rate are well defined. The distance traveled is equal to the area under the curve.

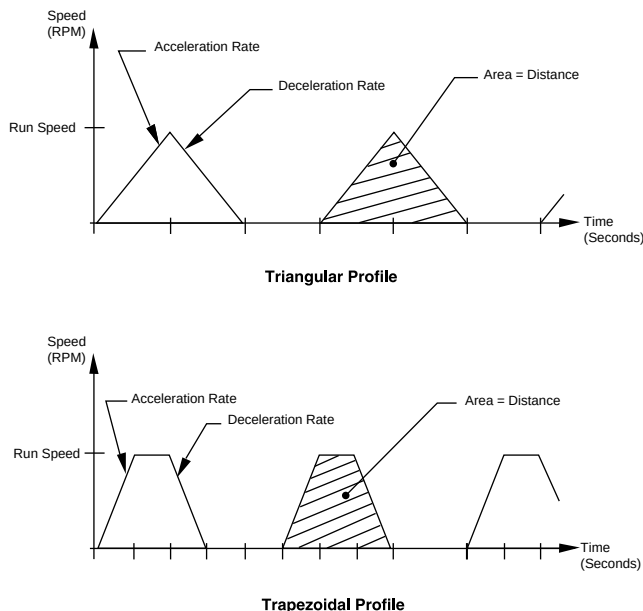


Figure D-6. Velocity Profiles

Using the velocity profile and the load parameter data, a torque versus time profile can be generated. This torque profile, in conjunction with the velocity profile, describes the torque-speed operating envelope required to drive the load. Selection of the proper servo system is accomplished by comparing the torque-speed requirements of the load to the performance curves of the various motor/controller combinations.

CALCULATING PEAK TORQUE REQUIREMENTS

The torque required to drive the load is defined by the equation:

$$T = T_F + T_V + T_L + T_J \quad (1)$$

where	T	= required torque
	T_F	= friction torque
	T_V	= viscous torque
	T_L	= load torque
	T_J	= torque to accelerate/decelerate inertia

Friction, viscous, and load torque have been previously defined. T_J , the torque required to accelerate or decelerate the load inertia, is defined by the formula:

$$\text{for accel: } T_{JA} = Ja \quad (2)$$

$$\text{for accel: } T_{JD} = -Jd$$

where	T_{JA}	= acceleration torque
	T_{JD}	= deceleration torque
	J	= inertia
	a	= acceleration rate
	$-d$	= deceleration rate

Note that the deceleration rate is negative.

Viscous torque, T_V , is proportional to speed and can be defined by the formula:

$$T_V = K_D W \quad (3)$$

where	T_V	= viscous torque
	K_D	= damping constant
	W	= speed

Substituting equations (2) and (3) into (1) results in:

$$\text{for accel: } T_A = T_F + T_L + K_D W + Ja \quad (4a)$$

$$\text{for decel: } T_D = T_F + T_L + K_D W - Jd \quad (4b)$$

By plugging the maximum acceleration/deceleration rate and the maximum speed into equation (4), the peak torque requirements can be calculated:

$$\text{for accel: } T_{APEAK} = T_F + T_L + K_D W_{MAX} + Ja_{MAX} \quad (5a)$$

$$\text{for decel: } T_{DPEAK} = T_F + T_L + K_D W_{MAX} - Jd_{MAX} \quad (5b)$$

Note that for these formulas the inertia is the total system inertia i.e. motor inertia plus the total load inertia. In many applications, T_L and T_V are negligible and can be ignored hence reducing the formulas to:

$$\text{for accel: } T_{APEAK} = T_F + Ja_{MAX} \quad (6a)$$

$$\text{for decel: } T_{DPEAK} = T_F - Jd_{MAX} \quad (6b)$$

Plugging the known load and motion profile parameters into equations (5) or (6), the peak torque requirement can be calculated. The peak torque should be calculated for both acceleration and deceleration and then the larger torque used as the peak torque requirement for selecting the correctly sized servo system.

The calculated peak torque must fall within the intermittent duty zone on the performance curve of the system selected. A safety margin should be included to allow for increases in friction torque, viscous torque, load torque, or inertia. The size of the safety margin should be based upon the magnitude of the parameter variations expected.

SIZING A SERVO SYSTEM (Cont.)

DETERMINATION OF CONTINUOUS TORQUE REQUIREMENTS

Figure D-7 shows a typical trapezoidal velocity profile and its associated torque profile. This figure assumes that the load torque and viscous torque are zero. It also assumes that the deceleration rate is equal to the acceleration rate.

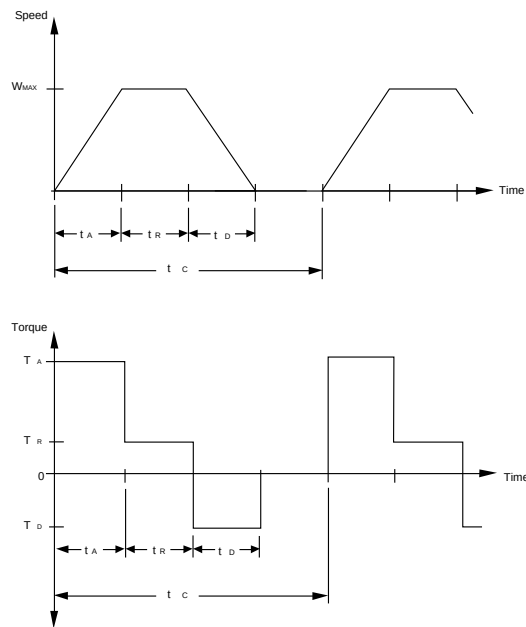


Figure D-7. Velocity and Torque Profiles

During time t_a , the load is accelerated from zero to velocity w_{MAX} . The torque required to accomplish this acceleration is calculated from equation (6a).

Upon reaching velocity w_{MAX} , the load is run at constant velocity for time t_r . Since there is no acceleration or deceleration of the load during this interval, the only torque required is that necessary to overcome friction.

During time t_d , the load is decelerated from w_{MAX} to zero. The torque required to accomplish this deceleration is calculated from equation (6b). Note that the magnitude of the decelerating torque, T_D , is smaller than that of the accelerating torque T_A . This is due to the fact that the friction torque, T_F , assists in decelerating the load and hinders accelerating the load.

The remainder of the cycle time, T_c , is spent at zero velocity and hence requires no torque.

The entire torque profile is shown in Figure D-7. The continuous torque requirements are defined by the RMS torque calculated from this profile. The following formula is used to calculate RMS torque:

$$T_{RMS} = \sqrt{\frac{[T_A^2 t_A + T_R^2 t_R + T_D^2 t_D]}{t_c}} \quad (7)$$

The RMS torque value calculated using this formula must fall within the continuous duty zone of the performance curve. Remember to derate the continuous duty zone if the motor ambient temperature is not 25°C. Also remember to include any required safety margins in the calculations.

SELECTOR FLOWCHART

The process for selecting the properly sized servo system for an application is shown in flowchart form in Figure D-8. This flowchart outlines the procedure for sizing a servo system in a simple, concise form and acts as a handy reference tool. Note from the flowchart that the selection process is sometimes iterative.

EXAMPLE APPLICATION

To help in understanding the process of sizing a servo system, the following application example will go through the procedure step-by-step.

The application is for a rotary table which must be indexed through 8 positions per revolution at a rate of 8 positions per second. All indexes are 1/8 revolution in length and in a clockwise direction. The motor shaft is direct coupled to the rotary table and the ambient temperature can reach 40°C.

An index is done every 125 mS to obtain the 8 indexes per second rate. A process step done at each index position requires 75 mS. This leaves only 50 mS for the 1/8 revolution index to be completed.

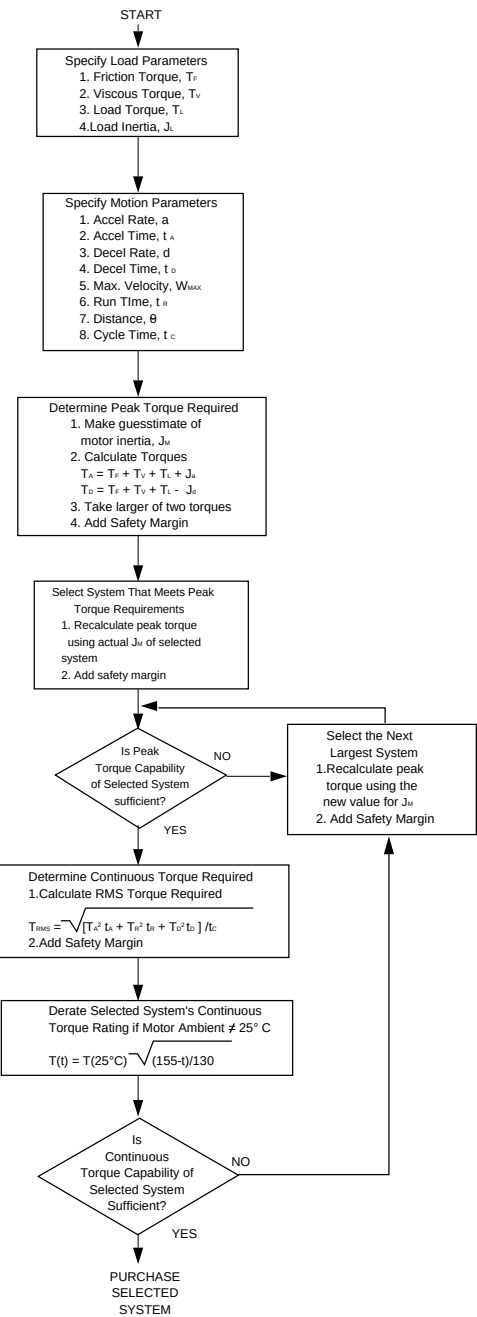


Figure D-8. Flowchart for Selecting Servo System

SIZING A SERVO SYSTEM (Cont.)

EXAMPLE APPLICATION (Cont.)

The product to be used in this application will be the SC750 series Brushless Servo Controller. The Brushless Servo Motor and SC750 model to be used will depend upon the results of the sizing process.

From the flowchart, the first step is to define the four load parameters. Since the load is direct coupled and the rotary table is riding on simple ball bearings, the viscous torque is zero. There are no externally applied torques or forces so the load torque is also zero. A friction torque of 50 lb-in is measured using a torque wrench attached to the table's drive shaft.

Inertia is the fourth load parameter to be defined. The rotary table is a solid cylinder of aluminum 12 inches in diameter and 0.25 inches thick. The inertia can be calculated if the weight of the table or the density of aluminum is known. The following formulas can be used to calculate inertia:

$$\begin{aligned} J_L &= Wr^2/2g && \text{for a known weight} && (8) \\ \text{or } J_L &= \pi \rho r^4/2g && \text{for known material density} && (9) \end{aligned}$$

where J_L = load inertia
 r = radius of the cylinder
 l = thickness (length) of the cylinder
 ρ = density of the material
 W = weight of the cylinder
 g = gravitational constant (386 in/s²)

The density of aluminum is 0.096 lb/in³ therefore using equation (9) the inertia of the table is calculated to be:

$$J_L = .127 \text{ lb-in-s}^2 \quad (10)$$

This inertia value is for the rotary table itself. Objects placed on the table will add to the inertia. For this example, assume that the inertia added by objects on the table is negligible and can be ignored.

Referring to the flowchart, the next step is to define the motion profile. The SC750 Brushless Servo Controller can be programmed to provide trapezoidal or triangular velocity profiles. In this case since the index is short and fast, a triangular profile will be used. The acceleration rate will be set equal to the deceleration rate, $t_A = t_D$. Since the profile is triangular, run time, t_R , is equal to zero. Hence,

$$\begin{aligned} t_A + t_D &= 50 \text{ ms} \\ \text{and } t_A &= t_D = 25 \text{ ms} \end{aligned} \quad (11)$$

The area under the triangular profile is equal to the index distance which is 1/8 revolution or 0.785 radians. From simple geometry,

$$(1/2)(t_A + t_D)(W_{MAX}) = \Theta \quad (12)$$

Substituting the known values into equation (12) and solving for W_{MAX} gives:

$$\begin{aligned} (0.025)W_{MAX} &= 0.785 \\ W_{MAX} &= 31.4 \text{ r/s (or 300 rpm)} \end{aligned}$$

Since the acceleration rate and deceleration rate are constant, they can be calculated from:

$$a = W_{MAX}/t_A \text{ and } d = W_{MAX}/t_D \quad (13)$$

Inserting the known values gives:

$$a = 1256 \text{ r/s}^2 \text{ and } d = 1256 \text{ r/s}^2$$

The final motion profile parameter to be specified is cycle time, t_C , which is 125 ms.

Summarizing the load parameters and motion profile parameters:

Friction Torque:	$T_F = 50 \text{ lb-in}$
Viscous Torque:	$T_V = 0 \text{ lb-in}$
Load Torque:	$T_L = 0 \text{ lb-in}$
Inertia (load):	$J_L = .127 \text{ lb-in-s}^2$
Accel Rate:	$a = 1256 \text{ r/s}^2$
Accel Time:	$t_A = 0.025 \text{ s}$
Decel Rate:	$d = 1256 \text{ r/s}^2$
Decel Time:	$t_D = 0.025 \text{ s}$
Max Velocity:	$W_{MAX} = 31.4 \text{ r/s}$
Run Time:	$t_R = 0 \text{ s}$
Distance:	$\Theta = 0.785 \text{ r}$
Cycle Time:	$t_C = 0.125 \text{ s}$

Using these parameter values in equation (5), the peak torque requirements can be calculated. Note however that the inertia specified is load inertia only and does not include the motor inertia. Since the servo system to be used has not yet been selected, the motor inertia cannot be specified.

As a first iteration, look at the inertia range of the systems available. For the SC750 family of performance curves, the inertia ranges from 0.001 to 0.076 lb-in-s². Since the load inertia is .127 lb-in-s², assume the motor inertia is negligible for the first iteration.

From the flowchart, the peak torque should be calculated for acceleration and deceleration using the guesstimate for the motor inertia which in this case is zero. For consistency in units, the inertia must be in lb-in-s². These units of inertia when multiplied by acceleration or deceleration rates in r/s² will give torque in lb-in.

$$\begin{aligned} \text{for accel: } T_{APEAK} &= 50 + 0 + 0 + (0.127)(1256) = 209 \text{ lb-in} \\ \text{for decel: } T_{DPEAK} &= 50 + 0 + 0 - (0.127)(1256) = 109 \text{ lb-in} \end{aligned}$$

From this, it can be seen that the torque required to accelerate the load is much larger than that required to decelerate the load and hence T_A should be used as the peak torque requirement.

Looking at Figure D-5, the SC755/R65 system is capable of providing 240 lb-in peak at stall and 230 lb-in peak at 3000 rpm. Linearly interpolating to 300 rpm, which is the maximum velocity in this application, the peak torque capability is 239 lb-in. This is sufficient to meet the application requirements. Add the motor inertia of this system to the load inertia and recalculate T_A .

$$\begin{aligned} \text{for accel: } T_{APEAK} &= 50 + (0.127 + 0.011)(1256) = 223 \text{ lb-in} \\ \text{for decel: } T_{DPEAK} &= 50 - (0.127 + 0.011)(1256) = 123 \text{ lb-in} \end{aligned}$$

This is still within the peak torque capabilities of the SC755/R65 system. The continuous torque requirements must now be assessed. Figure D-9 shows the torque profile. Using equation (7) the RMS torque required is calculated:

$$T_{RMS} = \sqrt{[(223)^2(0.025) + (123)^2(0.025)]/0.125} = 114 \text{ lb-in}$$

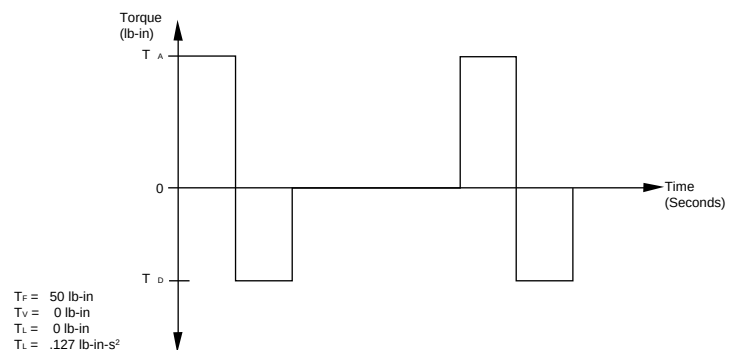
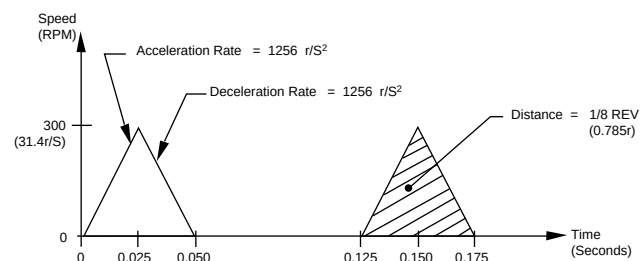


Figure D-9. Application Example

SIZING A SERVO SYSTEM (Cont.)

EXAMPLE APPLICATION (Cont.)

If friction and inertias increase, or if ambient is higher than 25°C (as it is in this application) then the 115 lb-in continuous torque capability of the SC755/R65 system would be exceeded; hence the next larger system must be evaluated.

Figure D-5 also shows a larger system which is the SC755/R84. This system has a motor inertia of 0.039 lb-in-s². Recalculating the acceleration and deceleration torques with this new inertia:

for accel: $T_{\text{APEAK}} = 50 + (0.127 + 0.039)(1256) = 258 \text{ lb-in}$
for decel: $T_{\text{DPEAK}} = 50 - (0.127 + 0.039)(1256) = 158 \text{ lb-in}$

These values are well within the 300 to 320 lb-in peak torque capability of the SC755/R84 system. Recalculating the RMS torque:

$$T_{\text{RMS}} = \sqrt{[(258)^2(0.025) + (158)^2(0.025)]/0.125} = 135 \text{ lb-in}$$

The SC755/R84 system has a continuous stall torque capability of 190 lb-in and 125 lb-in capability at 3000 rpm. Linearly interpolating to 300 rpm gives 184 lb-in. This torque is well above the 135 lb-in requirement. However, the performance curve data is for a 25°C motor ambient temperature. In this example, the motor ambient temperature is 40°C therefore the derating formula must be used. Derating the 184 lb-in at 300 rpm to a 40°C ambient:

$$T(40^\circ\text{C}) = (184) \sqrt{[155-40]/130} = 173 \text{ lb-in}$$

This is still well above the 135 lb-in requirement. Hence the SC755/R84 system will meet the requirements for this application and will provide a safety margin of 19% for peak torque and a 22% margin for continuous torque.

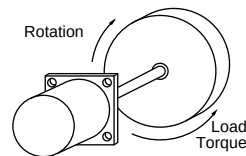
SUMMARY

Load parameters and motion profile parameters must be specified to allow sizing of a servo system for an application. Using these parameters, peak torque, continuous torque, and maximum speed requirements can be calculated. These requirements are compared to the available system performance curves and an appropriate system is selected. Figure D-8 is a flowchart to aid in the sizing process.

SIZING A STEPPER SYSTEM

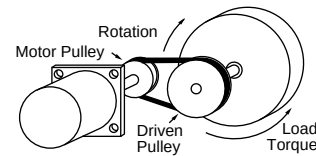
For a comprehensive analysis of your requirements, just complete and FAX us the STEP MOTOR AND CONTROL APPLICATION DATA form on pages D-37 and D-38. An application engineer will contact you promptly.

ROTARY MOTION— DIRECT DRIVE



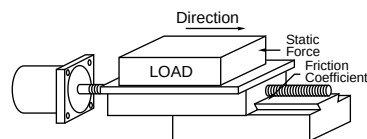
Enhanced hybrid motor torque production, utilizing Sigmoid[®] technology, is ideal for direct drive applications. Benefits include elimination of mechanical gear reduction. Be sure to use a flexible coupling.

ROTARY MOTION— BELT DRIVE



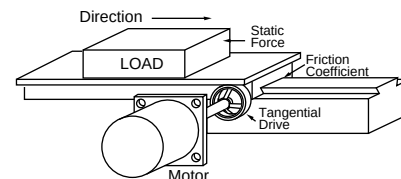
Timing belt or band driven rotary motion is simple to control, efficient and relatively free from backlash.

LINEAR MOTION— LEADSCREW DRIVE



Step motors are well suited to table drives because load remains constant. Leadscrew, rack and pinion, or tangential systems can achieve the desired linear motion and accuracy needed for many applications.

TANGENTIAL MOTION— DIRECT DRIVE



Tangential drives make use of the step motors high torque-to-inertia ratios. In high speed tape and print-head drives, enhanced hybrid motors provide rapid bidirectional accel/decel and critical position control.

STEP MOTOR AND CONTROL APPLICATION DATA

Pacific Scientific
Application Engineering Dept.

Company _____ Date _____

Address _____

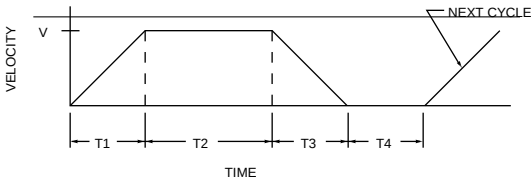
City _____ State _____ Zip _____

Name _____ Title _____ Phone _____

Product Description _____

GENERAL

- **APPLICATION DIAGRAM** Draw below or fax separately. Indicate key power transmission details, e.g., pulley and gear ratios, lead screw pitch, efficiencies, nut preload, etc.,. . .all this to size motor and/or control properly.
- **TYPICAL LOAD VELOCITY PROFILE** Using the diagram below as a guide, complete the values for V through T₄. Show worst case for proper sizing.
- **PACIFIC SCIENTIFIC, PLEASE PROPOSE**
Circle one (motor only) (control only) (motor and control) (fully programmable motion system)
- **PRODUCTS CURRENTLY USED** List manufacturer and model number _____



V = Velocity = _____

T₁ = Accel = _____

T₂ = Run = _____

T₃ = Decel = _____

T₄ = Dwell = _____

CONTROL

Circle or specify

- **INTERFACE REQUIREMENTS TO MACHINE AND/OR MOTION CONTROLLER**
(PLC) (PC) (Multiple axis controller)
(other _____)
- **DRIVE POWER AVAILABLE**
Voltage _____ Current _____
- **DRIVE OUTPUT POWER REQUIRED**
Voltage _____ Current _____
- **DRIVE TYPE** (Unipolar) (Bipolar)
- **CURRENT LIMIT** (R/L: series resistor _____ Ω)
or (chopper)
- **STEP SIZE** (full) (1/2) (micro step size _____)
- **COMMENTS** _____

STEP MOTOR AND CONTROL APPLICATION DATA (Cont.)

Company _____ Date _____

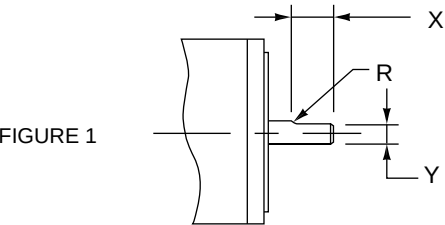
MOTOR

Circle or specify
Note: All motors are 1.8°, 2 or 4 phase or synchronous.

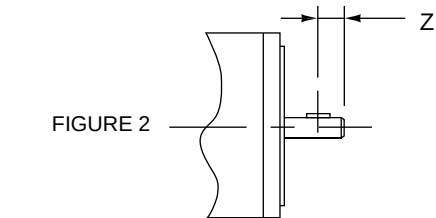
- **INPUT POWER AVAILABLE**
Bus voltage _____ Phase current _____
- **MOTION REQUIREMENTS**
Running speed _____
(RPM) (SPS) (1/2 SPS) (Micro SPS)
- **ACCELERATION RATE** is (Linear) (Non-linear)
- **SMOOTHNESS AT LOW SPEEDS REQUIRED?** Y N
- **PULSE TRAIN GENERATED** by
(Indexer) (Microprocessor)
- **DAMPING REQUIRED?** Y N
- **STATIC REQUIREMENTS** Accuracy _____
Repeatability _____ Resolution _____
Required holding torque _____ oz-in
- **SYSTEM LOADING** Friction loading _____ oz-in
Total load inertia—include coupling and all power
transmission inertias _____ oz-in-sec²
- **COUPLING** (solid) (flex) (bellows)
- **ELECTRICAL CHARACTERISTICS/FEEDBACK**
Inductance _____ mH No. of leads _____
Resistance phase _____ Ω
Encoder line count _____ ppr
Encoder line drivers Y N
Encoder function is (verify/correct) (stall/detection)
(electronic gearing) (other _____)
(_____)
- **SYNCHRONOUS MOTOR** Voltage _____
AC Frequency _____ hz
Pull-out torque _____ oz-in
Starting torque _____ oz-in
- **ENVIRONMENT** Ambient temp _____ °C
Splashproof Y N
Axial load _____ lb Inward _____ lb
Outward _____ lb Radial load _____ lb
- **STANDARD AND SPECIAL FEATURES**
Motor model number from catalog _____

Circle whether you want standard or special features. If
special, indicate details. Note that special features may
result in increased price or leadtime.
- **FRONT SHAFT** (standard) (special)
shaft length _____ ± _____ (±.015)*
shaft dia. _____ ± _____ (+.0000/-.0005)*
run out ^Δ _____ (.002 std. ext.)*

- **Flat** See Fig. 1 (standard option) (special)
Min. usable length X _____
Dim. over flat Y _____ ± _____ (±.005)*
Corner radius R allowed _____ (±.060)*
Other _____



- **Woodruff Key** See Fig. 2
(standard option) (special)
ANSI std. key no. _____ (Example 303)
Key location Z _____ ± _____ (±.020)*
Other _____



- **Straight Key** per electric motor standards
(standard option) (special)
Key: width _____ height _____
length _____ Other _____

- **REAR END BELL** (standard) (special)
mtg. hole B.C. _____ ± _____ (±.010)*
mtg. holes _____
hole pattern _____
other _____
- **REAR SHAFT** (standard) (special)
shaft length _____ ± _____ (±.040)*
shaft dia. _____ ± _____ (+.0000/-.0005)*
run out ^Δ _____ (.002)*
other _____
- **LEADS** (standard) (special)
lead length _____ ± _____
connector p/n _____
color _____

^Δ NEMA standard for shaft run out is .002" plus .001" for each
additional inch of extension past the standard length.

* Indicates the Pacific Scientific standard for reference.

GLOSSARY

Acceleration

The change in velocity as a function of time. Acceleration usually refers to increasing velocity, and deceleration to decreasing velocity.

Accuracy

A measure of the difference between expected position and actual position of a motor or mechanical system. Motor accuracy is usually specified as an angle representing the maximum deviation from expected position.

Ambient temperature

The temperature of the cooling medium, usually air, immediately surrounding the motor or another device.

Amplifier

Electronics which convert low level command signals to high power voltages and currents to operate a servo or stepper motor.

Angular accuracy

The measure of shaft positioning accuracy on a servo or stepping motor.

Back EMF

The voltage generated when a permanent magnet motor is rotated. This voltage is proportional to motor speed and is present regardless of whether the motor winding(s) are energized or unenergized.

Bandwidth

The range of frequencies over which a system can faithfully respond to commands.

Baud rate

The number of binary bits transmitted per second on a serial communications link such as RS-232.

BCD

Binary Coded Decimal is a binary numbering system in which the decimal digits from 0 to 9 are represented by a four bit binary number. Each digit in a decimal number is assigned a four bit binary code. Example: 156 = 0001 0101 0110.

Bipolar chopper driver

A class of step motor driver which uses a switch mode (chopper) technique to control motor current and polarity. Bipolar indicates the capability of providing motor phase current of either polarity (+ or -).

Brushless servo motor

A class of servo motors which operates using electronic commutation of phase currents rather than electromechanical (brushes) commutation. Commutation is a function of rotor position. These motors typically have a permanent magnet rotor and wound stator.

Class B insulation

A NEMA insulation specification. Class B insulation is rated to an operating temperature of 130°C.

Class H insulation

A NEMA insulation specification. Class H insulation is rated to an operating temperature of 180°C.

Closed loop

A broadly applied term, relating to any system in which the output is measured and compared to the input. The output is then adjusted to reach the desired condition. In motion control, the term typically describes a system utilizing a velocity and/or position transducer to generate correction signals in relation to desired parameters.

Cogging

A term used to describe non-uniform angular velocity. Cogging appears as a jerkiness especially at low speeds.

Commutation

A term which refers to the action of steering currents or voltages to the proper motor phases so as to produce optimum motor torque. In brush type motors, commutation is done electromechanically via the brushes and commutator. In brushless motors, commutation is done by the switching electronics using rotor position information obtained by Hall sensors, a tachsyn, or resolver.

Compensation

The adjustment of gain and frequency parameters in a closed-loop system to achieve the desired dynamic response and also to insure a stable (non-oscillating) condition.

Controller

A device that generates motion commands, typically position commands. It may have the ability of controlling several axes of motion at once or it may be part of a stand-alone unit coupled with a motor driver.

Daisy chain

Describes the linking of several RS-232C devices in sequence, such that a single data stream flows through one device and on to the next. Daisy chained devices are usually distinguished by device addresses which indicate the desired destination for data in the stream.

Demag current

The current level at which the motor magnets will be demagnetized. This is an irreversible effect which will alter the motor characteristics and degrade performance.

Detent torque

The maximum torque that can be applied to an unenergized step motor without causing continuous rotating motion.

Driver

Electronics which convert a digital or analog command to high power currents and voltages to drive a step motor.

Duty cycle

A measure of a motor's "on" time or operating time relative to "off" time or rest time. Typically expressed as a percentage of "on" time to total cycle time.

Dynamic braking

A passive technique for stopping permanent magnet brush or brushless motors by dissipating the motor's rotational kinetic energy in the motor winding resistance and/or an external resistance connected to the motor. With electronic drives, the power stage shorts the motor terminals when the motor current is within the drive's current rating and alternates between the short and off when the current nears the drive's rating to insure maximum safe deceleration.

Efficiency

The ratio of power output to power input.

Encoder

A feedback device which converts mechanical motion into electronic signals. The most commonly used, rotary encoders, output digital pulses corresponding to incremental angular motion. For example, a 1000 line encoder produces 1000 pulses every mechanical revolution. The encoder consists of a glass or metal wheel with alternating transparent and opaque stripes, detected by optical sensors to produce the digital outputs.

GLOSSARY (Cont.)

Feedback

A signal which is transferred from the output back to the input for use in a closed loop system.

Four quadrant

Refers to a motion system which can operate in all four quadrants i.e. velocity in either direction and torque in either direction. This means that the motor can accelerate, run, and decelerate in either direction.

Friction

A resistance to motion caused by contacting surfaces. Friction can be constant with varying speed (Coulomb friction) or proportional to speed (viscous friction).

Hall sensors

A feedback device which is used in a brushless servo system to provide information for the amplifier to electronically commutate the motor. The device uses a magnetized wheel and hall-effect sensors to generate the commutation signals.

Holding torque

Sometimes called static torque, holding torque specifies the maximum external torque that can be applied to a stopped, energized motor without causing the rotor to rotate continuously. Generally used as a figure of merit when comparing motors.

Hybrid step motor

A motor designed to move in discrete increments or steps. The motor has a permanent magnet rotor and a wound stator. Such motors are brushless. Phase currents are commutated as a function of time to produce motion.

Idle current reduction

A step motor driver feature that reduces the phase current to the motor when no motor motion is commanded (idle condition). Idle current reduction reduces motor heating and allows high machine throughputs from a given motor.

Indexer

Electronics which convert high level motion commands from a host computer, PLC or operator panel into step and direction pulse streams for use by the step motor driver. Indexers can be broadly divided into two classes. A present indexer typically accepts distance, velocity and ramp time inputs only. The more sophisticated programmable indexer is capable of complex motion control and includes program memory.

Inductance (mutual)

Mutual inductance is the property that exists between two current carrying conductors or coils when magnetic lines of force from one link with those of the other.

Inductance (self)

The self-inductance of a coil is the constant by which the time rate of change of the current in the coil must be multiplied to give the self induced counter EMF.

Inertia

A measure of an object's resistance to a change in velocity. The larger an object's inertia, the larger the torque required to accelerate or decelerate it. Inertia is a function of an object's mass and shape.

Inertial match

The ratio of the reflected inertia of the load is equal to the rotor inertia of the motor.

Inrush current

The current surge generated when a piece of equipment such as a servo amplifier is connected to an AC line. This surge is typically due to the impulse charging of a large capacitor located in the equipment.

Microstepping

An electronic technique for increasing a step motor's position resolution and velocity smoothness by appropriately scaling the phase currents.

Mid-range instability

A phenomenon in which a step motor can fall out of synchronism due to a loss of torque at mid-range speeds. The torque loss is due to the interaction of the motor's electrical characteristics and the driver's electronics. Some drivers have circuitry to eliminate or reduce the effects of mid-range instability.

MOV

Metal Oxide Varistor. This device is used to suppress voltage transients that occurs on an AC line.

NEMA

National Electrical Manufacturer's Association. Acronym for an organization which sets standards for motors and other industrial electrical equipment.

Non-volatile memory

A memory system in which the stored data or program is retained even when power is removed.

Open-loop

A system in which there is no feedback. Stepping motor systems are an example of open-loop control. Motor motion is expected to faithfully follow the input command.

Overshoot

The amount that the parameter being controlled exceeds the desired value.

PID

Proportional-Integral-Derivative. An acronym that describes the compensation structure used in a closed-loop system. Compensation can be done using P, PI, or PID.

PLC

Programmable Logic Controller. Also known as a programmable controller, these devices are used for machine control and sequencing.

Power

The rate at which work is done. In motion control, power is equal to torque multiplied by speed.

Pull-out torque

The maximum torque that can be applied to a step motor running at constant speed without causing a loss of synchronism.

Pulse rate

The frequency of the step pulses applied to a step motor driver. The pulse rate, multiplied by the resolution of the motor/driver combination (in steps per revolution), yields the rotational speed in revolutions per second.

PWM

Pulse Width Modulation. An acronym which describes a switch-mode control technique used in amplifiers and drivers to control motor voltage and current. This control technique is in contrast to linear control and offers the advantages of greatly improved efficiency.

GLOSSARY (Cont.)

RDC

Resolver-to-Digital Converter. An acronym which describes an electronic component which converts the analog signals from a resolver (transmitter type) into a digital word representing angular position.

Regeneration

The action during motor braking, in which the motor acts as a generator and takes kinetic energy from the load, converts it to electrical energy, and returns it to the amplifier.

Repeatability

The degree to which a parameter such as position or velocity can be duplicated.

Resolution

The smallest increment into which a parameter can be broken down. For example, a 1000 line encoder has a resolution of $1/1000$ of a revolution.

Resonance

Oscillatory behavior occurring in a mechanical system.

Resolver

An electromagnetic feedback device which converts angular shaft position into analog signals. These signals can be processed in various ways such as with an RDC to produce digital position information. There are two basic types of resolvers; transmitter and receiver. A transmitter-type is designed for rotor primary excitation and stator secondary outputs. Position is determined by the ratio of the sine output amplitude to cosine output amplitude. A receiver-type is designed for stator primary excitations and rotor secondary output. Position is determined by the phase shift between the rotor output signal and one of the primary excitation signals.

Ringings

Oscillation of a system following a sudden change in state.

RMS Current

Root Mean Square Current. In an intermittent duty cycle application, the RMS Current is equal to the value of steady state current which would produce the equivalent resistive heating over a period of time.

RMS Torque

Root Mean Square Torque. In an intermittent duty cycle application, the RMS Torque is equal to the value of steady state torque which would produce the equivalent motor heating over a period of time.

RS-232

A serial data communications hardware standard. This single ended hardware configuration is used extensively in office computer equipment.

RS-422/485

A serial data communications hardware standard similar to RS-232. However, this is a differential hardware configuration providing improved noise immunity for use in harsh industrial environments. RS-422/485 also permits longer communications distances and several devices to be placed on a single serial link in a multi-drop configuration. A simple converter is available to connect RS-232 devices with RS-422/485 devices.

Samarium cobalt

A type of rare-earth permanent magnet material.

Settling time

The time required for a parameter to stop oscillating or ringing and reach its final value.

Shunt regulator

A device located in a servo amplifier for controlling regenerative energy generated when braking a motor. This device dissipates or “dumps” the kinetic energy as heat.

Slew

In motion control, the portion of a move made at a constant non-zero velocity.

Speed

Describes the linear or rotational velocity of a motor or other object in motion.

Stall torque

The torque available from a motor at stall or 0 rpm.

Step angle

The angular distance the shaft rotates upon receipt of a single step command.

Stiffness

The ability to resist movement induced by an applied torque. Stiffness is often specified as a torque displacement curve, indicating the amount a motor shaft will rotate upon application of a known external force when stopped.

Synchronism

A motor rotating at a speed corresponding correctly to the applied step pulse frequency is said to be in synchronism. Load torques in excess of the motor's capacity (rated torque) will cause a loss of synchronism. This condition is not damaging to a step motor.

Tachometer

An electromagnetic feedback transducer which produces an analog voltage signal proportional to rotational velocity. Tachometers can be either brush or brushless.

Tachsyn®

A brushless, electromagnetic feedback transducer which produces an analog velocity feedback signal and commutation signals for a brushless servo motor. The tachsyn is functionally equivalent to Hall Sensors and a tachometer.

TENV

Totally Enclosed Non-Ventilated. Acronym describing a type of motor physical configuration.

Thermal resistance

Resistance to the flow of heat between two surfaces of the same body or different bodies. Thermal resistance is the reciprocal of thermal conductivity. It is useful in providing a means of evaluating the winding temperature as a function of outside temperature under steady state conditions. It is equal to the winding temperature divided by the watts dissipated in the winding.

Torque

A measure of angular force which produces rotational motion. This force is defined by a linear force multiplied by a radius e.g. lb-in or oz-in. Torque is an important parameter of any motion control system.

Torque constant

A number representing the relationship between motor input current and motor output torque. Typically expressed as lb-in/A or oz-in/A.

Torque-to-inertia ratio

Defined as the motor's holding torque divided by the inertia of its rotor. The higher the ratio, the higher a motor's maximum acceleration capability will be.

GLOSSARY (Cont.)

Unipolar driver

A step motor driver configuration that uses a unipolar power supply and is capable of driving phase current in only one direction. The motor phase winding must be center tapped (6 or 8 lead) to operate with a unipolar driver. The center tap is used instead of providing the current reversal of a bipolar driver.

Velocity

The change in position as a function of time. Velocity has both a magnitude and sign.

Voltage constant (or Back EMF constant)

A number representing the relationship between Back EMF voltage and angular velocity. Typically expressed as V/Krpm.

CONVERSION TABLES

ROTARY INERTIA CONVERSION TABLE

(To convert from A to B, multiply by entry in table)

B A	gm-cm ²	oz-in ²	gm-cm-s ²	Kg-cm ²	lb-in ²	oz-in-s ²	lb-ft ²	Kg-cm-s ²	lb-in-s ²	lb-ft-s ² or slug-ft ²
gm-cm ²	1	5.46 x 10 ⁻³	1.01 x 10 ⁻³	10 ⁻³	3.417 x 10 ⁻⁴	1.41 x 10 ⁻⁵	2.37 x 10 ⁻⁶	1.01 x 10 ⁻⁶	8.85 x 10 ⁻⁷	7.37 x 10 ⁻⁸
oz-in ²	182.9	1	.186	.182	.0625	2.59 x 10 ⁻³	4.34 x 10 ⁻⁴	1.86 x 10 ⁻⁴	1.61 x 10 ⁻⁴	1.34 x 10 ⁻⁵
gm-cm-s ²	980.6	5.36	1	.9806	.335	1.38 x 10 ⁻²	2.32 x 10 ⁻³	10 ⁻³	8.67 x 10 ⁻⁴	7.23 x 10 ⁻⁵
Kg-cm ²	1000	5.46	1.019	1	.3417	1.41 x 10 ⁻²	2.37 x 10 ⁻³	1.019 x 10 ⁻³	8.85 x 10 ⁻⁴	7.37 x 10 ⁻⁵
lb-in ²	2.92 x 10 ³	16	2.984	2.926	1	4.14 x 10 ⁻²	6.94 x 10 ⁻³	2.98 x 10 ⁻³	2.59 x 10 ⁻³	2.15 x 10 ⁻⁴
oz-in-s ²	7.06 x 10 ⁴	386.08	72.0	70.615	24.13	1	.1675	7.20 x 10 ⁻²	6.25 x 10 ⁻²	5.20 x 10 ⁻³
lb-ft ²	4.21 x 10 ⁵	2304	429.71	421.40	144	5.967	1	.4297	.3729	3.10 x 10 ⁻²
Kg-cm-s ²	9.8 x 10 ⁵	5.36 x 10 ³	1000	980.66	335.1	13.887	2.327	1	.8679	7.23 x 10 ⁻²
lb-in-s ²	1.129 x 10 ⁶	6.177 x 10 ³	1.152 x 10 ³	1.129 x 10 ³	386.08	16	2.681	1.152	1	8.33 x 10 ⁻²
lb-ft-s ² or slug-ft ²	1.355 x 10 ⁷	7.41 x 10 ⁴	1.38 x 10 ⁴	1.35 x 10 ⁴	4.63 x 10 ³	192	32.17	13.825	12	1

TORQUE CONVERSION TABLE

(To convert from A to B, multiply by entry in table)

B A	dyne-cm	gm-cm	oz-in.	Kg-cm	lb-in.	N-m	lb-ft	Kg-m
dyne-cm	1	1.019 x 10 ⁻³	1.416 x 10 ⁻⁵	1.0197 x 10 ⁻⁵	8.850 x 10 ⁻⁷	10 ⁻⁷	7.375 x 10 ⁻⁸	1.019 x 10 ⁻⁸
gm-cm	980.665	1	1.388 x 10 ⁻²	10 ⁻³	8.679 x 10 ⁻⁴	9.806 x 10 ⁻⁵	7.233 x 10 ⁻⁵	10 ⁻⁵
oz-in.	7.061 x 10 ⁴	72.007	1	7.200 x 10 ⁻²	6.25 x 10 ⁻²	7.061 x 10 ⁻³	5.208 x 10 ⁻³	7.200 x 10 ⁻⁴
Kg-cm	9.806 x 10 ⁵	1000	13.877	1	.8679	9.806 x 10 ⁻²	7.233 x 10 ⁻²	10 ⁻²
lb-in.	1.129 x 10 ⁶	1.152 x 10 ³	16	1.152	1	.112	8.333 x 10 ⁻²	1.152 x 10 ⁻²
N-m	10 ⁷	1.019 x 10 ⁴	141.612	10.197	8.850	1	.737	.101
lb-ft	1.355 x 10 ⁷	1.382 x 10 ⁴	192	13.825	12	1.355	1	.138
Kg-m	9.806 x 10 ⁷	10 ⁵	1.388 x 10 ³	100	86.796	9.806	7.233	1

CONVERSION FACTORS

TO OBTAIN	MULTIPLY NUMBER OF	BY
-----------	-----------------------	----

LENGTH

cm	inches	2.540
cm	feet	30.48
inches	cm	.3937
inches	feet	12.
feet	cm	3.281 x 10 ⁻²
feet	inches	8.333 x 10 ⁻²

MASS

gm	oz	28.35
gm	lb	453.6
gm	slug	1.459 x 10 ⁻⁴
oz	gm	3.527 x 10 ⁻²
oz	lb	16.
oz	slug	514.7
lb	gm	2.205 x 10 ⁻³
lb	oz	6.250 x 10 ⁻²
lb	slug	32.17
slug*	gm	6.853 x 10 ⁵
slug	oz	1.943 x 10 ³
slug	lb	3.108 x 10 ²

*1 slug mass goes at 1 ft/sec² when acted upon by 1 lb force.

POWER

H.P.	(oz-in.) (deg./sec)	1.653 x 10 ⁻⁷
H.P.	(oz-in.) (RPM)	9.917 x 10 ⁻⁷
H.P.	(#ft) (deg./sec)	3.173 x 10 ⁻⁵
H.P.	(#ft) (RPM)	1.904 x 10 ⁻⁴
H.P.	watts	1.341 x 10 ⁻³
Watts	(oz-in.) (deg./sec)	1.232 x 10 ⁻⁴
Watts	(oz-in.) (RPM)	7.395 x 10 ⁻⁴
Watts	(#ft) (deg./sec)	2.366 x 10 ⁻²
Watts	(#ft) (RPM)	.1420
Watts	H.P.	745.7

TORQUE TO INERTIA RATIO

rad/sec ²	oz-in./gm-cm ²	7.062 x 10 ⁴
rad/sec ²	oz-in./oz-in ²	386.1

TORQUE GRADIENT

#ft/rad	oz-in./degree	0.2984
dyne-cm/rad	oz-in./degree	4.046 x 10 ⁶

TO OBTAIN	MULTIPLY NUMBER OF	BY
-----------	-----------------------	----

FORCE

dyne	gm*	980.7
dyne	oz	2.780 x 10 ⁴
dyne	lb	4.448 x 10 ⁵
gm*	dyne	1.020 x 10 ⁻³
oz	dyne	3.597 x 10 ⁻⁵
lb	dyne	2.248 x 10 ⁻⁶

* used as force units

ROTATION

degrees/sec.	RPM	6.
degrees/sec.	rad/sec.	57.30
RPM	degrees/sec.	.1667
RPM	rad/sec.	9.549
rad/sec.	degrees/sec.	1.745 x 10 ⁻²
rad/sec.	RPM	.1047

MECHANISM EFFICIENCIES

Acme-screw w/brass Nut	~0.35-0.65
Acme-screw w/plastic Nut	~0.50-0.85
Ball-screw	~0.85-0.95
Preloaded Ball-screw	~0.75-0.85
Spur or Bevel gears	~0.90
Timing Belts	~0.96-0.98
Chain & Sprocket	~0.95-0.98
Worm gears	~0.45-0.85

MATERIAL DENSITIES

MATERIAL	lb/in ³	gm/cm ³
Aluminum	0.096	2.66
Brass	0.300	8.30
Bronze	0.295	8.17
Copper	0.322	8.91
Plastic	0.040	1.11
Steel	0.280	7.75
Hard Wood	0.029	0.80

FRICTION COEFFICIENTS F_{fr}=μW_L

MATERIALS	μ	MECHANISM	μ
Steel on Steel	~0.58	Ball Bushings	<0.001
Steel on Steel (greased)	~0.15	Linear Bearings	<0.001
Aluminum on Steel	~0.45	Dove-tail Slides	~0.2++
Copper on Steel	~0.30	Gibb Ways	~0.5++
Brass on Steel	~0.35		
Plastic on Steel	~0.15-0.25		

WARRANTY AND LIMITATION OF LIABILITY

Includes software provided by Pacific Scientific

Pacific Scientific warrants its motors and controllers ("Product(s)") to the original purchaser (the "Customer"), and in the case of original equipment manufacturers or distributors to their original consumer (the "Customer") to be free from defects in material and workmanship and to be made in accordance with Customer's specifications which have been accepted in writing by Pacific Scientific. In no event, however, shall Pacific Scientific be liable or have any responsibility under such warranty if the Products have been improperly stored, installed, used or maintained, or if customer has permitted any unauthorized modifications, adjustments and/or repairs to such Products. Pacific Scientific's obligation hereunder is limited solely to repairing or replacing (at its option), at its factory any Products, or parts thereof, which prove to Pacific Scientific's satisfaction to be defective as a result of defective materials or workmanship, in accordance with Pacific Scientific's stated warranty, provided, however, that written notice of claimed defects shall have been given to Pacific Scientific within two (2) years after the date of the product date code that is affixed to the Product, and within thirty (30) days from the date any such defect is first discovered. The products or parts claimed to be defective must be returned to Pacific Scientific, transportation prepaid by Customer, with written specifications of the claimed defect. Evidence acceptable to Pacific Scientific must be furnished that the claimed defects were not caused by misuse, abuse, or neglect by anyone other than Pacific Scientific.

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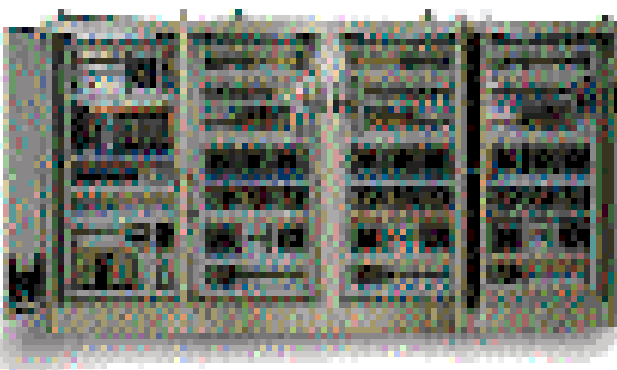


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