

SIMOREG DC Master

6RA70 Series

Converters with microprocessor from 6kW to 1900kW
for variable-speed DC drives

Application
12-Pulse Applications



NOTE

This application documentation does not purport to handle or take into account all of the equipment details or versions or to cover every conceivable operating situation or application. If you require more detailed information, or if special problems occur, which are not handled in enough detail in this document, please contact your local Siemens office.

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**WARNING**

These converters contain hazardous electrical voltages, hazardous rotating machinery (fans) and control rotating mechanical components (drives). Death, serious bodily injury or substantial damage to property will occur if the instructions in the relevant operating manuals are not observed.

Only qualified personnel who are thoroughly familiar with all safety notices contained in the operating instructions as well as erection, operating and maintenance instructions must be allowed to work on these devices.

Successful and safe operation of this equipment is dependent on careful transportation, proper storage and installation as well as correct operation and maintenance.

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We have checked that the contents of this publication agree with the hardware and software described herein. However, differences can never be ruled out, so that we cannot accept any guarantee for complete agreement. The information given in this publication is reviewed at regular intervals and any corrections that might be necessary are made in the subsequent printings. Suggestions for improvement are welcome at all times.

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1 Applications

SIMOREG converters of the 6RA70 series are equipped with fully digital closed and open loop control and are used for armature and field supply of variable-speed DC drives.

This application documentation provides help with the configuration of the required components and start-up of the SIMOREG 6RA70 devices in 12-pulse operation.

12-pulse operation is chiefly used with higher outputs to achieve lower system perturbation. In addition, this circuit also reduces the ripple of the direct current as compared with a 6-pulse circuit.

2 Configuring 12-Pulse Converter Systems

2.1 Requirements on the device side

- a) Transformer: On the line side, 12-pulse operation is achieved by the addition of a winding system in the feeding transformer which is inclined by 30° . At least one of the two converters must be fed by an isolated voltage (isolating transformer).
- b) Converter units: Two SIMOREG converters with the same power feed the two offset line voltages to a machine, each power section carrying half the total direct current.
The first SIMOREG unit is the master drive for closed-loop speed and current control and for the field current supply. The second SIMOREG unit is the slave drive and is operated with current control. The slave drive receives the current setpoint from the master drive so that both converters are carrying half the motor current.
On 4Q devices, the command stages are also mutually interlocked (the command stage determines the torque direction set in each case), so that both converter sections are carrying current in the same torque direction.
- c) Smoothing reactor: As the momentary values of the output voltages of the devices differ due to the varying phase angle of the network input, the devices must be decoupled on the DC voltage side via smoothing reactors before they are switched in parallel.
- d) Overvoltage protection: Converters that are connected to the network via their own converter transformer, must be protected against the overvoltages resulting from plant-side switching operations at the device input by a surge suppressor.
If the converter input is protected by open breaker gaps during primary-side switching operations of the transformer, no suppressor circuit is required on the converter input.
- e) Insulation monitoring: With ungrounded low-voltage networks, an insulation monitoring device must be used to monitor the state of the insulation. The insulation resistance in the ungrounded low-voltage network is monitored by continuous measurement and a signal is output if the measured value falls below a settable threshold.

2.1.1 Design of the converter transformer

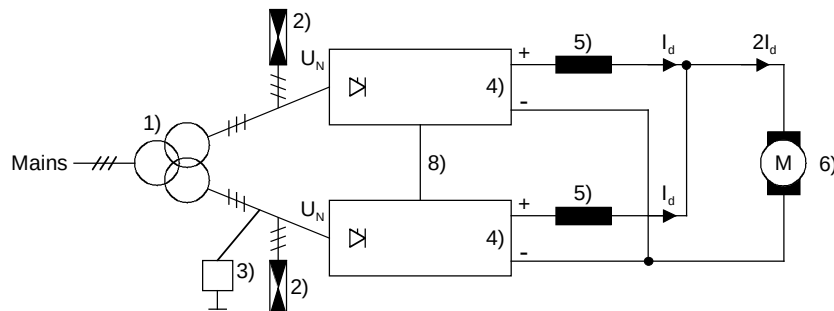


Fig. 1

In Fig. 1:

Transformer: The device has its own three-winding converter transformer for connection of a higher-level voltage level to the network.

Preferred switching groups for the transformer: Dy5Dd0, Yy0Yd11, $u_k = 4$ to 6%

Type rating of transformer: $S_T = U_N * 1.35 * 1.05 * I_d * 2$

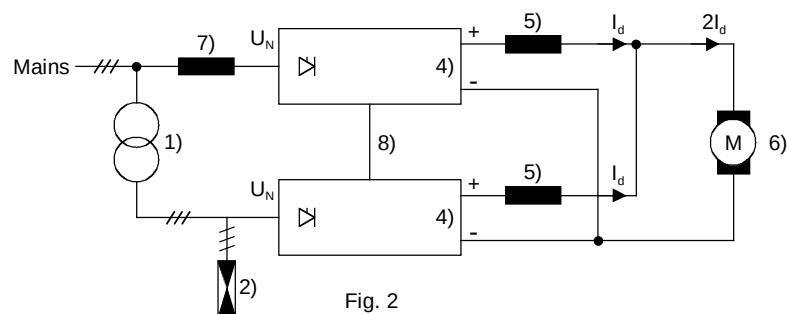


Fig. 2

In Fig. 2:

Transformer: If a low-voltage busbar is present, an isolating transformer with a voltage transformation ratio of 1:1 is connected in front of a converter to achieve a 30° phase offset.

Suitable switching groups for the transformer: Dy11, Yd11, Dy5, $u_k = 4$ to 6%

Type rating of transformer: $S_T = U_N * 1.35 * 1.05 * I_d$

Legend for Fig. 1/2:

- | | | |
|------------------------|---------------------------|--------------------------|
| 1) Transformer | 2) Overvoltage protection | 3) Insulation monitoring |
| 4) SIMOREG - 6RA70 | 5) Smoothing reactor | 6) DC motor |
| 7) Commutating reactor | 8) Current setpoint input | |

U_N = Rated voltage of supplying network at converter input I_d = direct current of a converter section (1/2 of total direct current)

NOTE

If converters are connected in parallel to increase the current, a commutating reactor with u_D approx. 2% must be connected in front of each power section in order to decouple the snubber circuit and to achieve symmetrical division of the current.

2.1.2 SIMOREG DC-MASTER converters of the 6RA70 series

The 6RA70 converters are suitable for implementing 12-pulse circuits for 1Q or 4Q operation, depending on the converter type used.

On the input side of the power section, the devices supply each other with two three-phase voltages of the same level, and a phase angle of 30°.

Each converter subsystem carries half the total direct current. If the rated current for the 6RA70 SIMOREG devices is not sufficient, the direct current can be increased by switching the SIMOREG in parallel.

Please refer to the Chapter Start-up for information about the necessary signal connection between the two SIMOREG units and special aspects of controlling the devices.

2.1.3 Dimensioning the smoothing reactors

One smoothing reactor is used for each of the two converter sections. The reactor is a two-value reactor, which means that the inductance of the reactor is defined for two current values.

The thermal rating of the reactor is based on the rms value of the reactor direct current.

Calculation of the required inductance:

1) Inductance of the reactor at $0.2 * I_{dn}$ (L_{D1})

2) Inductance of the reactor at I_{dmax} (L_{D2})

Inductance for 50 Hz line frequency:

$$L_{D1} = 0,296 * 10^{-3} * \frac{U_{di}}{0,2 * I_{dn}}$$

$$L_{D2} = 0,296 * 10^{-3} * \frac{U_{di}}{0,33 * I_{dmax}}$$

Inductance for 60 Hz line frequency:

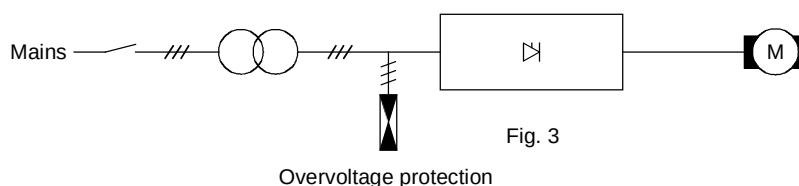
$$L_{D1} = 0,24 * 10^{-3} * \frac{U_{di}}{0,2 * I_{dn}}$$

$$L_{D2} = 0,24 * 10^{-3} * \frac{U_{di}}{0,33 * I_{dmax}}$$

L: Inductance in henry I_{dn} : Half the rated direct current of direct current motor I_{dmax} : Half the maximum current of direct current motor $U_{di} = U_N * 1.35$ (U_N : Rated voltage of supply system)

2.1.4 Selection for overvoltage protection

The overvoltage protection is used to protect the semiconductor rectifiers of converters from overvoltages between the phases of a three-phase system. The limiting voltage of the overvoltage protection must not be any higher than the reverse voltage of the rectifiers to be protected.



The transformer is connected on the line side as shown in Fig. 3. If the transformer is switched off during no-load operation, the magnetizing current of the transformer on the converter side continues to flow, resulting in an overvoltage. In that case, the overvoltage protection must absorb the magnetization energy of the transformer.

The magnetization energy is calculated as follows:

$$W_M = \frac{S_N}{2 * \pi * f} * \frac{I_0}{I_N}$$

W_M = Magnetization energy of transformer
 S_N = Rated power of transformer
 I_0 = No-load current of transformer
 I_N = Rated current of transformer
 f = Line frequency in Hz

A "SITOR overvoltage protection" unit is available for connection between the three line phases to provide overvoltage protection.

Technical data of the SITOR overvoltage protection:

Rated line-side voltage SIMOREG	Order No. Overvoltage protection	U_{AN} V	$W0$ Ws	$W2$ Ws	$W4$ Ws	I_{max} A
400 V	7VV3002-3CD20	1100	600	216	40	400
575 V	7VV3002-3GD20	1700	750	234	50	1000
690 V	7VV3002-3DD20	2100	2640	770	144	700
830 V	7VV3002-3ED20	2400	2600	620	176	500

Data according to Catalog DA 94.2- 1995 (Overvoltage protection modules; Electronic ground-leakage monitors)

U_{AN} : Rated response voltage
 $W0$ = Energy that can be absorbed once
 $W2$ = Energy that can be absorbed 100 times
 $W4$ = Energy that can be absorbed 10,000 times
 I_{max} = Maximum ground leakage

Recommended dimensioning for $W_M < W4$ (10,000 switching cycles)

For more information about the SITOR overvoltage protection please refer to Instruction Manual Order No. 7VV3002-8AA00.

2.1.5 Insulation monitoring

In ungrounded low voltage networks a ground-leakage monitor is used to monitor the insulation resistance. This measures the current that flows across a known series resistor. For this purpose, a measuring voltage is injected into the network against the PE conductor. If the measured value falls below the settable threshold value for the insulation resistance, an alarm is output.

As the network on the DC voltage side is not isolated because of the parallel connection of the two converter sections, only one ground-leakage monitor can be used to monitor the line and DC voltage side for a ground fault.

Possible devices that can be used for insulation monitoring:

Rated voltage network	Type	Manufacturer
up to 690 V	MR627	CEGELEC
	IRDH 265	BENDER
up to 1000 V	MR627 with MZ611	CEGELEC
	IRDH 265 with AGH 150 W	BENDER

3 Start-up the SIMOREG DC Master Series 6RA70

3.1 Signal link between master and slave device

- a) The current setpoint of the master device is picked off directly in front of the current control loop (connector 0120) and fed to the slave device as the current setpoint. The current control loop is active on each of the two converter devices.
- b) On devices for four-quadrant operation, the command levels are mutually blocked on current reversal, ensuring that current reversal takes place on both devices simultaneously. The signal for torque reversal is transferred.
On devices with on-quadrant operation, the command level is not active, so that no blocking is necessary.
- c) The signal link for a) and b) can be implemented with terminals or with a serial interface of the basic unit using the peer-to-peer protocol. Before setting the parameters please refer to Chapter 3.2.

3.1.1 Device coupling via analog and binary inputs and outputs

The analog unassigned output 1 terminals 14/15 (master) defines the current setpoint on analog input 1 terminals 4/5 (slave).

On devices for four-quadrant operation, the signal exchange for blocking the command level is implemented on terminals 36 and 46.

Master			Slave
Analog out	14	4	Analog in
M	15	5	M
Binär out	46	36	Binär in
Binär in	36	46	Binär out
M	47	47	M

Shield cables for analog setpoint, on slave side connect shield to ground with large contact surface.

Parameters for master device	Function
P750 = 120	Selects the current setpoint of the master for analog output to terminal 14.
P771 = 220	Selects binector 0220 "Signal of torque direction" for binary output to terminal 46. Set on 4Q devices only!
P165 = 10	Selects terminal 36 as "Enable for torque direction on torque direction change with parallel operation" Set on 4Q devices only!

Parameters for slave device	Function
P601.03 = 11	Selects analog input terminal 4/5 as source for the current setpoint.
P771 = 220	Selects binector 0220 "Signal of torque direction" for binary output to terminal 46. Set on 4Q devices only!
P165 = 10	Selects terminal 36 as "Enable for torque direction on torque direction change with parallel operation" Set on 4Q devices only!

3.1.2 Device coupling via the serial interface of the basic unit

The master/slave converters communicate using the peer-to-peer protocol via the RS485 terminals of the basic unit. Instead of binary and analog terminals, the data are transmitted between the devices via the serial interface (SST2 or SST3). A high transmission baud rate ensures fast data communication. The signal Enable torque direction is transmitted via a binector/connector converter on 4Q devices. (SW V1.4 and higher).

Connecting cable between the 6RA70 devices:

Peer-to-peer interface 2

Master			Slave		
	Tx+	56	58	Rx+	
		57	59		
	Tx-			Rx-	
		58	56		
	Rx+			Tx+	
		59	57		
		60	60		
	M			M	

Peer-to-peer interface 3

This interface is only available with option K01 (module CUD2).

Master		Slave	
Tx+	61	63	Rx+
	62	64	Rx-
	63	61	Tx+
	64	62	Tx-
	65	65	M
M			

Shield cable, connect the shield to ground with large contact surface on master and slave side.

A combination of both interfaces (e.g. Master SST2; slave SST3) is possible.

Parameters for master device		Function
SST 2	SST 3	
P790 = 5	P800 = 5	Select peer-to-peer protocol 2
P793 = 13	P803 = 13	Selects a baud rate of 187.5 kBd.
P791 = 2	P801 = 2	Transfer 2 values via peer to peer
P797 = 1.0	P807 = 1.0	Telegram time to failure 1 s
P795 = 1	P805 = 1	Bus termination enabled
P794.01 = 120	P804.01 = 120	Transfer current setpoint as 1st word
P794.02 = 6020	P804.02 = 9020	Transfer binector/connector converter as 2nd word Required for 4Q only!
U117.01 = 220	U118.01 = 220	Indication of torque direction to binector/connector converter bit 0. Required for 4Q only!
P165 = 6200	P195 = 9200	Indication of torque direction from 2nd receive word bit 0 Set for 4Q only!

Parameters for slave device		Function
SST 2	SST 3	
P790 = 5	P800 = 5	Select peer-to-peer protocol 2
P793 = 13	P803 = 13	Selects a baud rate of 187.5 kBd.
P791 = 2	P801 = 2	Transfer 2 values via peer to peer
P797 = 1.0	P807 = 1.0	Telegram time to failure 1 s
P795 = 1	P805 = 1	Bus termination enabled
P601.03 = 6001	P601.03 = 9001	The first process data from the master has the effect of a current setpoint in the slave.
P794.02 = 6020	P804.02 = 8020	Transfer binector/connector converter as 2nd word Required for 4Q only!
U117.01 = 220	U118.01 = 220	Indication of torque direction to binector/connector converter bit 0. Required for 4Q only!
P165 = 6200	P165 = 9200	Indication of torque direction from 2nd receive word bit 0 Set for 4Q only!

3.2 Notes on start-up

What to look out for when controlling the devices:

We recommend evaluating the fault indication from the slave drive, and in the event of a fault in the slave, shutting down the master, too (e.g. opening terminal 37 on the master).

The "Shut down" signal (terminal 37 low signal) should not be entered in the slave until the shutdown procedure on the master is complete (e.g. indication "ready for operation" on the master goes to Low)

Start-up of the closed-loop control:

The devices are started up as described in Chapter "Start-up" of the Instruction Manual.

Half the total current is set on both the master drive and the slave for the rated current of the motor (P100).

Special parameter settings on the slave drive:

Parameters for slave device	Function
P83 = 3	"EMF actual value" selected as speed actual value.
P820.xx = 42	42 is entered at the first index "xx" of P820 that has the value "0". Error message (F42) tachometer fault is masked.
P820.xx = 38	38 is entered at the first index "xx" of P820 that has the value "0". Error message (F38) overspeed is masked.
P82 = 0	Internal field is not used

With the exception of the parameterization for signal exchange with the slave and the motor rated current, the master drive is set as if it were a single unit.

The current control loop of each of the drives is started up separately.

The armature circuit resistance (parameter P110) is also determined during the current controller optimization run. As the armature is operated with double the current of the converter section in 12-pulse operation, the effect of the armature resistance is doubled. This can be calculated for precise definition of the armature resistance and entered in P110 of the master and the slave.

$$P110 = R_{\text{reactor}} + R_{\text{line}} + 2 \cdot R_{\text{motor armature}}$$

Once the current control loops have been optimized separately, the parameters for signal exchange between the SIMOREG K devices can be set for 12-pulse operation as described in Sections 2.1.1 or 2.1.2.

The devices already operate in 12-pulse operation for the purpose of optimized closed-loop speed control, i.e. the single currents of the devices, which are equal on average, are added via the output reactors to form the total direct current for the load.

The speed, and if necessary technology closed-loop control, is performed in the master drive.

If the drive is operated with field weakening, operating the master device with torque control is recommended.

If the master is also to be operated with current control, the current setpoint is entered in the master.

Transferring the signal from K120 of the master device to the slave ensures that both current controllers have the same setpoint. The same values must be entered in parameters P157 and P158 of both devices (master and slave).

