SIMOREG DC-MASTER

6RA70 Series

Microprocessor-Based Converters from 6 kW to 2500 kW for Variable-Speed DC Drives
Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol. Notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

**DANGER**
indicates that death or severe personal injury will result if proper precautions are not taken.

**WARNING**
indicates that death or severe personal injury may result if proper precautions are not taken.

**CAUTION**
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

**CAUTION**
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

**NOTICE**
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by personnel qualified for the specific task in accordance with the relevant documentation for the specific task, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

**WARNING**
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.
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1 Instructions

Note
This application document does not claim to contain all details and versions of units, or to take into account all conceivable operational cases and applications.

The standard applications do not represent specific customer solutions, but are only intended to provide support in the implementation of typical applications. The operator is responsible for the correct operation of the products described.

Should you require further information or encounter specific problems which have not been handled in enough detail, please contact your local Siemens office.

The contents of this application document are not part of an earlier or existing contract, agreement or legal relationship, nor do they change such contracts, agreements or legal relationships. The contract of sale in each case outlines all the obligations of the I DT Drive Technologies Division of Siemens AG. The warranty conditions specified in the contract between the parties are the only warranty conditions accepted by the I DT Drive Technologies Division. Any statements contained herein neither create new warranties nor modify the existing warranty.

WARNING
The units listed here contain dangerous electric voltages, dangerous rotating machine parts (fans) and control rotating mechanical parts (drives). Failure to follow the relevant Operating Instructions may result in death, serious injury or extensive material damage.

Technical Support
You can also find help for technical issues through our Technical Support:
www.siemens.de/automation/support-request (German)
www.siemens.com/automation/support-request (English)
2 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 DC-MASTER devices in 12-pulse parallel 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.

Parameterization with respect to 12-pulse operation is identical for SIMOREG DC-MASTER and SIMOREG DC-MASTER Control Module, except for the specific parameters of the CM for norming the external power part.
3 12-Pulse Converter Systems

3.1 Configuring

3.1.1 Requirements on the device side

♦ 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, see figures 3.1.2a and 3.1.2b). Operation of several 12-pulse systems on a common current converter transformer is not permitted, because this can result in impermissible balance currents with a tripped fuse or thyristor damage (see FAQ for 6RA70, SIMOREG DC-MASTER and SIMOREG DC-MASTER Control Module "Several 12-pulse systems on a common converter transformer" at the Internet page of Customer Support: http://support.automation.siemens.com/WW/view/en/26041969). It does not matter which of the two current converters is supplied by the approx. 30° leading or lagging voltage.

♦ 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. The direct current can be increased via parallel switching of additional SIMOREG devices in the same number to master and slave.

♦ 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.

♦ 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.

♦ Isolation 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.
3.1.2 Design of the converter transformer

In figure 3.1.2a:

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, \( u_k = 4 \text{ bis } 6\% \)

Type rating of transformer: \( S_T = U_N \times 1.35 \times 1.05 \times I_{d} \times 2 \)

In figure 3.1.2b:

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, \( u_k = 4 \text{ bis } 6\% \)

Type rating of transformer: \( S_T = U_N \times 1.35 \times 1.05 \times I_{d} \)

Legend for figures 3.1.2a and 3.1.2b:

1) Transformer 2) Overvoltage protection 3) Isolation 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)
CAUTION

If converters are connected in parallel to increase the current (parallel switching of additionally max. 5 devices per 6-pulse branch is possible), then a commutating reactor with minimum 2 % \( u_D \) must be inserted upstream of each converter for mutual decoupling of the surge suppression circuits in the paralleled converters. To ensure symmetrical current distribution between the paralleled converters, the deviation between the impedance values of the individual commutating reactors must be as low as possible. It is generally practicable to limit the deviation to 3%. The additional voltage drop across the commutating reactors must be taken into account at the planning stage.

If current converters are used, which do not have any branch fuses and 4Q operation is possible at the same time, every current convertor is to be supplied with a fuse on the DC side dimensioned corresponding to its output current.

3.1.3 Dimensioning of 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.

The following formulas serve for rough estimates of the reactor values. Final dimensioning should be done by someone with sufficient knowledge of 12-pulse applications.

Calculation of the required inductance:
1) Inductance of the reactor at \( 0.2 \times I_{dn} \) (\( L_{D1} \))
2) Inductance of the reactor at \( I_{dmax} \) (\( L_{D2} \))

Inductance for 50 Hz line frequency:
\[
\begin{align*}
L_{D1} &= 0.296 \times 10^{-3} \times \frac{U_{di}}{0.2 \cdot I_{dn}} \\
L_{D2} &= 0.296 \times 10^{-3} \times \frac{U_{di}}{0.33 \cdot I_{dmax}}
\end{align*}
\]

Inductance for 60 Hz line frequency:
\[
\begin{align*}
L_{D1} &= 0.24 \times 10^{-3} \times \frac{U_{di}}{0.2 \cdot I_{dn}} \\
L_{D2} &= 0.24 \times 10^{-3} \times \frac{U_{di}}{0.33 \cdot I_{dmax}}
\end{align*}
\]

\( L \): Inductance in Henry
\( I_{dn} \): half the rated direct current of direct current motor
\( I_{dmax} \): half the maximum current of direct current motor
\( U_{di} = U_N \times 1.35 \) (\( U_N \): Rated voltage of supply system)

\[ 3.5 \times L_{D2} \geq L_{D1} \] !!! Increase the value of \( L_{D2} \) if this condition is not fulfilled.
3.1.4 Selection of 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.

![Diagram of overvoltage protection](image)

Figure 3.1.4

The transformer is connected on the line side as shown in Fig. 3.1.4. If the transformer is switched off during load operation, the arc of the primary-side switch does not completely relieve the magnetizing energy of the transformer. When firing pulses are prohibited this energy causes overvoltage at the secondary side of the transformer. In that case, an overvoltage protection must absorb the magnetization energy of the transformer and limit the voltage.

At switching off under no-load condition, the overvoltage protection must only handle the magnetizing energy of the transformer. The magnetization energy is calculated as follows:

\[
W_M = \frac{S_N}{4 \cdot \pi \cdot f} \cdot \frac{I_O}{I_N}
\]

- \(W_M\) = Magnetization energy of transformer
- \(S_N\) = Rated power of transformer
- \(I_O\) = No-load current of transformer
- \(I_N\) = Rated current of transformer
- \(f\) = Line frequency in Hz

At shut-down in the case of a malfunction, the shunted energy is greater corresponding to the load, wherein motor and generator load must be distinguished.

A "SICROWBAR 7VV3002 AC overvoltage protection unit for thyristors and diodes" is available for connection between the three line phases to provide overvoltage protection.

Information about calculating the energy to be shunted in the various operation cases and specifications for SICROWBAR 7VV3002 is available in

- Betriebsanleitung/Operating Instructions 3/2008
- SICROWBAR 7VV3002
- C98130-A7200-A1-5-7419

Link to the operating instruction


Recommended dimensioning for 10000 switching cycles.
3.1.5 Isolation 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:

<table>
<thead>
<tr>
<th>Rated voltage network</th>
<th>Type</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 690 V</td>
<td>MR627</td>
<td>AREVA T&amp;D / ALSTOM</td>
</tr>
<tr>
<td></td>
<td>IRDH 275 / IRDH375</td>
<td>BENDER</td>
</tr>
<tr>
<td>up to 1000 V</td>
<td>MR627 mit MZ611</td>
<td>AREVA T&amp;D / ALSTOM</td>
</tr>
<tr>
<td></td>
<td>IRDH 275 / IRDH375 mit AGH 150W-4</td>
<td>BENDER</td>
</tr>
<tr>
<td>up to 1300 V</td>
<td>IRDH 275 / IRDH375 with AGH 204S-4</td>
<td>BENDER</td>
</tr>
</tbody>
</table>

Due to characteristics of the system the power section of the converter is connected to ground with high-resistance (measurement of ac and dc voltage by high-resistant differential amplifiers for synchronization, monitoring, measurement of armature voltage and EMF). This leakage resistance has to be considered when setting the warning and cut-out levels of the isolation monitor. The following table shows the leakage resistance against rated supply voltage per device. The total resistance for a parallel configuration has to be calculated in consideration of the parallel connection of each individual leakage resistance.

### Measurement of armature circuit

<table>
<thead>
<tr>
<th>Rated supply voltage</th>
<th>Leakage resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low voltage device (85 V)</td>
<td>134 kΩ</td>
</tr>
<tr>
<td>up to 575 V (400 V, 460 V, 575 V)</td>
<td>908 kΩ</td>
</tr>
<tr>
<td>up to 830 V (690 V, 830 V)</td>
<td>1308 kΩ</td>
</tr>
<tr>
<td>up to 1000 V (950 V)</td>
<td>1576 kΩ</td>
</tr>
</tbody>
</table>

### Measurement of field circuit

| Low voltage device (130 V)            | 510 kΩ             |
| all other devices                     | 1815 kΩ            |
3.2 Start-up the SIMOREG DC-MASTER
Series 6RA70 with parallel operation

3.2.1 Start-up of control of both individual devices

The setup of the master unit is done as if it were a single unit, except for the parametrization of the communication with the slave and the rated motor current.

- Start-up of the current control loop of each of the two parts of the 12-pulse unit is separate. For this, perform the start-up steps for master and slave separately according to Chapter 7.5 of the operating instructions until point 7.3 (ramp-function generator settings).

- Only half of the total current is set each on the master and slave devices for the rating current of the motor (P100).

At performance of the current controller optimization run by P051=25, the armature circuit resistance and the armature circuit inductance (parameters P110 and P111) are determined (Chapter 7.5 of the operating instructions; item 8.2).

These values only apply for operation of master and slave. In 12-pulse parallel operation, you would have to distinguish between conditions of intermittent and non-intermittent total current to be precise. When there is intermittent total current, only those current parts act both for master and slave, which each partial unit makes alone during a 30° cycle. With increasing current, there is an overlapping of the current parts of master and slave with non-intermittent total current. As a result, the conditions change, and each partial unit sees a greater armature resistance and a greater armature inductance caused by the current part of the other. A description of how the values of P110 and P111 can be corrected to achieve better current control is provided under Additional Adaptations, Chapter 3.2.4.

After the separate optimization of the current control loops, the parameters are set for the signal link between the partial units according to Chapter 0, 3.2.2.2 or 3.2.2.3 for 12-pulse parallel operation.

3.2.2 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 K0125) and fed to the slave device as the current setpoint with P601.05*. The current control loop is active on each of the two converter devices.

*...As a result, the current limitation and a possible ramping of the setpoint of the master also applies to the slave and need not be set two times. Current limitation and ramping must always be the same at any rate.

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.

In devices for four-quadrant operation, there is a mutual locking of the command levels at reversal of current, which ensures that the reversal of current is at the same time in both devices. The report of the torque direction is also transferred.

The auto-reversing stage is not active for devices for one-quadrant operation, and consequently no locking is required.

c) The signal link for a) and b) can be implemented with terminals or with a serial interface of the basic unit. Before setting the parameters please refer to chapter 3.2 of the Operating Instructions.

d) Use of EMF value K0180 (calculated by speed and flux) (V3.22 and higher, also see chapter 3.2.4.7 of this application).

e) The master evaluates the fault message of the slave to shut down the master too in the case of a slave malfunction.
3.2.2.1 Device coupling via analog and binary inputs and outputs

The analog unassigned output 1 terminals X175:14/15 (master) define the current setpoint on analog input 1 terminals X174:4/5 (slave).

The analog unassigned output 2 terminals X175:16/17 (master) define the EMF setpoint on analog input 1 terminals X174:6/7 (slave).

In devices for four-quadrant operation, the signal link for locking the command level is via the terminals X171:36 and X171:46.

Provide equipotential bonding, shield cable, connect the shield to ground with large contact surface on master and slave sides.

Example for parameterizing master and slave:

<table>
<thead>
<tr>
<th>Parameters for Master device</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P750 = 125</td>
<td>Selects the current setpoint of the master for analog output to terminal 14.</td>
</tr>
<tr>
<td>P755 = 180</td>
<td>Selects the EMF value of the Master calculated by speed and flux for analog output to terminal 16 (V3.22 and higher)</td>
</tr>
<tr>
<td>P771 = 220</td>
<td>Selects binector B0220 &quot;Signal of torque direction&quot; for binary output to terminal 46. Set on 4Q devices only!</td>
</tr>
<tr>
<td>P165 = 10</td>
<td>Selects terminal 36 as &quot;Enable for torque direction on torque direction change with parallel operation&quot; Set on 4Q devices only!</td>
</tr>
<tr>
<td>P162.F = 4</td>
<td>Use EMF value K0180 calculated by speed and flux (V3.22 and higher). Prerequisite for using K0180 is a recorded field characteristic curve (including a related value pair P118, P119). The presence of a compensated direct current machine is of advantage if you use this setting.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameters for Slave device</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P601.05 = 11</td>
<td>Selects analog input terminal 4/5 as source for the current setpoint.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>P193 = 15</td>
<td>Selects analog input terminal 6/7 as source for the EMF value.</td>
</tr>
<tr>
<td>P162 = 3</td>
<td>Selects binector B0220 &quot;Signal of torque direction&quot; for binary output to terminal 46. Set on 4Q devices only!</td>
</tr>
<tr>
<td>P771 = 220</td>
<td>Selects binector B0220 &quot;Signal of torque direction&quot; for binary output to terminal 46. Set on 4Q devices only!</td>
</tr>
<tr>
<td>P165 = 10</td>
<td>Selects terminal 36 as &quot;Enable for torque direction on torque direction change with parallel operation&quot; Set on 4Q devices only!</td>
</tr>
</tbody>
</table>

For additional settings, refer to Chapter 3.2.2.4.

### 3.2.2.2 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

#### Peer-to-peer interface 3

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

A combination of both interfaces (e.g. Master SST2; slave SST3) is possible. Provide equipotential bonding, shield cable, connect the shield to ground with large contact surface on master and slave side.
### Example for parameterizing master and slave:

<table>
<thead>
<tr>
<th>Parameters for Master device</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SST 2</strong></td>
<td></td>
</tr>
<tr>
<td>P790 = 5</td>
<td>Select peer-to-peer protocol 2</td>
</tr>
<tr>
<td>P793 = 13</td>
<td>Selects a baud rate of 187.5 kBD. ¹</td>
</tr>
<tr>
<td>P791 = 3 (2)</td>
<td>Transfer 3 values via Peer to Peer (up to V3.21: 2 values only)</td>
</tr>
<tr>
<td>P797 = 1,000</td>
<td>Telegram time to failure 1s</td>
</tr>
<tr>
<td>P795 = 1</td>
<td>Bus termination enabled</td>
</tr>
<tr>
<td>P794.01 = 6020</td>
<td>Transfer binector/connector converter as 1st word</td>
</tr>
<tr>
<td>P794.02 = 125</td>
<td>Transfer current setpoint of master as 2nd word</td>
</tr>
<tr>
<td>P794.03 = 180</td>
<td>Transfer EMF value K0180 calculated by speed and flux (V3.22 and higher) as 3rd word</td>
</tr>
<tr>
<td>U117.01 = 220</td>
<td>Indication of torque direction to binector/connector converter bit 0. Required for 4Q only!</td>
</tr>
<tr>
<td>U117.02 = 179</td>
<td>Acknowledgement of control word or P key of PMU</td>
</tr>
<tr>
<td>P165.B = 6100</td>
<td>Indication of torque direction from 1st received word bit 0 Set for 4Q only!</td>
</tr>
<tr>
<td>P162.F = 4</td>
<td>Use EMF value K0180 calculated by speed and flux (V3.22 and higher). Prerequisite for using K0180 is a recorded field characteristic curve (including a related value pair P118, P119). The presence of a compensated direct current machine is of advantage if you use this setting.</td>
</tr>
<tr>
<td>P675.B = 6101</td>
<td>Source for external fault 1 from receive data word 1, bit 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameters for Slave device</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SST 2</strong></td>
<td></td>
</tr>
<tr>
<td>P790 = 5</td>
<td>Select peer-to-peer protocol 2</td>
</tr>
<tr>
<td>P793 = 13</td>
<td>Selects a baud rate of 187.5 kBD. ¹</td>
</tr>
<tr>
<td>P791 = 3 (2)</td>
<td>Transfer 3 values via Peer to Peer (up to V3.21: 2 values only)</td>
</tr>
<tr>
<td>P797 = 1,000</td>
<td>Telegram time to failure 1s</td>
</tr>
<tr>
<td>P795 = 1</td>
<td>Bus termination enabled</td>
</tr>
<tr>
<td>P601.05 = 6002</td>
<td>Selects 2nd process data word from Master as source for the current setpoint.</td>
</tr>
<tr>
<td>P794.01 = 6020</td>
<td>Transfer binector/connector converter as 1st word</td>
</tr>
<tr>
<td>U117.01 = 220</td>
<td>Indication of torque direction to binector/connector converter bit 0. Required for 4Q only!</td>
</tr>
<tr>
<td>U117.02 = 107</td>
<td>Indication of „No active fault“ to binector/connector converter bit 1.</td>
</tr>
<tr>
<td>P165.B = 6100</td>
<td>Indication of torque direction from 1st received word bit 0 Set for 4Q only!</td>
</tr>
</tbody>
</table>
P162.F = 3
P193 = 6003
P665.B = 6101

Use EMF value from Master.

1st source for control word 1 bit 7 (acknowledge of fault)
from 1st received word bit 1

1) With regard to smallest possible lag time the transfer rate should only be reduced (93750bps minimum) when this is necessary due
to receive errors. Also transmit minimal necessary number of data words only.

For additional settings, refer to Chapter 3.2.2.4.

Following see an example for a possible interconnection between master and slave:
3.2.2.3 Device coupling via paralleling interface of basic unit

The master/slave current converter devices communicate via the paralleling interface of the basic device (board CUD2 required). The data is transferred between the devices in that the paralleling interface is only used for data transfer (with SW V3.23 and above). The slave device does not take over the firing pulses of the master device, but instead works as an independent slave with its own current control. The firing pulses of the master device cannot be used (only possible with 6-pulse parallel operation) because the slave device lags behind the master device by 30° electrically due to the 12-pulse transformer. A high baud rate of transfer ensures fast data exchange.

With 4Q devices, the signal enable torque direction is transferred via a binector connector converter.

Connection cable between 6RA70 devices:
- Patch cable with 4x twisted pairs (CAT5e), as short as possible; only use maximum permitted cable length of 15 m in an emergency!
- Provide equipotential bonding, connect the shield to ground with large contact surface on master and slave sides.

Example for parameterizing master and slave:

<table>
<thead>
<tr>
<th>Parameter Mastergerät</th>
<th>Funktion</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST 2</td>
<td></td>
</tr>
<tr>
<td>U800 = 1</td>
<td>Select paralleling interface</td>
</tr>
<tr>
<td>U803 = 0</td>
<td>Select standard mode</td>
</tr>
<tr>
<td>U804.01 = 6020</td>
<td>Transfer output of binector/connector converter of G-SST2 as 1st word</td>
</tr>
<tr>
<td>U804.02 = 125</td>
<td>Transfer armature current setpoint of master as 2nd word</td>
</tr>
<tr>
<td>U804.03 = 180</td>
<td>Transfer EMF value K0180 calculated by speed and flux (V3.22 and higher) as 3rd word</td>
</tr>
<tr>
<td>U805 = 1</td>
<td>Bus termination enabled</td>
</tr>
<tr>
<td>U806.01 = 12</td>
<td>Master device for 1 slave device with address 2</td>
</tr>
<tr>
<td>U806.02 = 12</td>
<td></td>
</tr>
<tr>
<td>U117.01 = 220</td>
<td>Indication of torque direction to binector/connector converter bit 0. Required for 4Q only!</td>
</tr>
<tr>
<td>U117.01 = 179</td>
<td>Acknowledgement of control word or P key of PMU</td>
</tr>
<tr>
<td>P165.B = 6220</td>
<td>Indication of torque direction from 1st received word bit 0 Set for 4Q only!</td>
</tr>
<tr>
<td>P675.B = 6221</td>
<td>Indication of external fault from 1st received word bit 1</td>
</tr>
<tr>
<td>P162.F = 4</td>
<td>Use EMF value K0180 calculated by speed and flux (V3.22 and higher). Prerequisite for using K0180 is a recorded field characteristic curve (including a related value pair P118, P119). The presence of a compensated direct current machine is of advantage if you use this setting.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter Slavegerät</th>
<th>Funktion</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST 2</td>
<td></td>
</tr>
<tr>
<td>U800 = 1</td>
<td>Select paralleling interface</td>
</tr>
<tr>
<td>U803 = 0</td>
<td>Select standard mode</td>
</tr>
<tr>
<td>U804.01 = 6020</td>
<td>Transfer output of binector/connector converter of G-SST2</td>
</tr>
</tbody>
</table>
For additional settings, refer to Chapter 3.2.2.4.

3.2.2.4 Notes on start-up

Special features for controlling the devices:

ON command and enable operation for slave: In the most simple case (commands via binary inputs), the terminals 37 and 38 from master and slave can be connected. As a result, the slave follows the operating state of the master.

Alternatively, the corresponding bit of the master can be used as ON command of the slave if this is also transferred (e.g. via a binary output/input or transfer of the control word 1).

We recommend evaluating the fault indication from the slave drive, and in the event of a fault in the slave, shutting down the master. For example, this can be done by opening terminal 37 on the master or by using the fault bit of the slave (status word1.Bit3, inverted) as OFF2 command of the master.

When devices are operated in parallel, it makes sense to set additional alpha-W pulses (P161, P179) or a torque-free pause (P160) depending on the value of the effective inductances, because current can still flow in spite of the I=0 message to 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). This is invalid if the armature current setpoint on the slave is fed in via P601.05 (see the example parameterization above).
Special parameter settings on the slave drive:

<table>
<thead>
<tr>
<th>Parameters for slave device</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P082 = 0</td>
<td>Internal field is not used</td>
</tr>
<tr>
<td>P083 = 3</td>
<td>&quot;EMF actual value&quot; selected as speed actual value.</td>
</tr>
<tr>
<td>P084 = 2</td>
<td>Operation under closed-loop current / torque control</td>
</tr>
<tr>
<td>P820.xx = 42</td>
<td>42 is entered at the first index &quot;xx&quot; of P820 that has the value &quot;0&quot;. Error message (F42) tacho fault is masked.</td>
</tr>
<tr>
<td>P820.xx = 38</td>
<td>38 is entered at the first index &quot;xx&quot; of P820 that has the value &quot;0&quot;. Error message (F38) overspeed is masked.</td>
</tr>
</tbody>
</table>

3.2.3 Additional Optimizations

The devices already work in 12-pulse operation for further optimization of the speed control, i.e., the two on the average equally high individual currents of the devices add up to achieve the total DC current for the load via the output reactors.

The speed and – if necessary – technology control is done in the master drive. As a result, optimization need only be performed on the master device.

If the drive is operated with field weakening, we recommend operating the master device in torque-controlled mode (P170 = 1).

If the master device is also to be operated in current-controlled mode, the current setpoint is entered in the master. Transfer of the signal from K0125 of the master device to the slave ensures that both current controllers receive the same setpoint.

3.2.4 Additional Adaptations

Improved adaptation of the precontrol and calculation of the EMF can be performed using the new parameters P185 to P187 with firmware V3.22 and above. The parameters P111, P186 and P187 are set using an iterative procedure intended to find the best combination of these values.

The following adaptations only take effect at \( P185 = 1 \) (12-pulse parallel operation).

According to the start-up of the 12-pulse parallel operation described above, the following applies

\[
P110 = R_{Dr} + R_A
\]
\[
P111 = L_{Dr} + L_A
\]

\( L_{Dr} \) is the inductance of the smoothing reactor; \( R_{Dr} \) is the ohmic resistance of the smoothing reactor.
3.2.4.1 Adaptation of parameter P186

Prerequisite for improved adaptation is the selection of the 12-pulse parallel operation by parameter \( P_{185} = 1 \) (default setting is \( P_{185}=0 \), i.e., 6-pulse operation).

No commuting inductance \( (L_K) \) is contained in P111. \( L_K \) can approximately be determined as follows:

\[
L_K \ (in \ mH) = \frac{u_k \ (in \ %) \cdot U_{eff, mains} \ (in \ V) \cdot 50}{I_{rated} \ (in \ A) \cdot 27.2 \cdot f_{ mains} \ (in \ Hz)}
\]

\( u_k \) is the total-\( u_k \) value of the feeding grid including commuting reactors in relation to device current \( I_{rated} \) (value of P100).

The following values can be determined approximately with known value of \( L_{Dr} \) with the value of P111, which was set at current control optimization, and with the value calculated above for \( L_K \) (with two value reactors according to chapter 3.1.3, we recommend using \( L_{D2} \) as value for \( L_{Dr} \)):

\[
L_A = P_{111} - L_{Dr}
\]

\[
L_1 = L_{Dr} + L_K
\]

With that, the parameter P186 can be set as

\[
P_{186} = \frac{L_1}{L_A}
\]

3.2.4.2 Correction of the crossover point from discontinuous to continuous current of the precontrol characteristic curve

The following parameters are first only corrected on the master and are not copied to the slave before they have been optimally adapted.

A current ramp in current-controlled operation is recorded with the trace function of the DriveMonitors for determining the correction (see figure 3.2.4.2 below as example). This is best done with switched-off field and idle motor (locked braking of the motor might be required). The graph interval and the rise of the current ramp are to be selected in such a way for the graph that the complete ramp fits in the trace graph filling the format as much as possible.

The current setpoint ramp can be generated via oscillation setpoint (function diagram G128) and ramp-function generator.
The following connectors are shown (a few are hidden in Figure 3.2.4.2):

- **K0119** Current controller setpoint (armature) 1
- **K0109** Internal actual current (averaged)
- **K0287** EMF actual value 3
- **K0122** EMF which is applied as an input value for the armature precontrol
- **K0103** Factor of duration of current flow 5
- **K0100** Firing angle (armature) 6
- **K0111** Current controller output, P component (armature)
- **K0112** Current controller output, I component (armature)
- **K0121** Precontrol output (armature) 9
- **K0110** Current controller output (armature)

Figure 3.2.4.2

1/L1 functions for the crossover point from discontinuous to continuous current of the precontrol characteristic curve.

The correction is intended to achieve the best possible setting for precontrol of the armature current, so that the current control need not interfere much. This is the case with the best possible synchronization of the curves of the connectors K0100 and K0121.

To achieve this, search for the break points of the curves of K0100 and K0121 in the trace graph. These indicate the crossover points from discontinuous to continuous current LGK0100 and LGK0121. The crossover point from discontinuous to continuous current LGK0100 indicates the actual crossover point. This is that point where the current flow connector K0103 reaches the value 100%.

Because you have a linear rise in armature current during the recording and only the ratio of the currents $I_{L_K0121}$ and $I_{L_K0100}$ is decisive for the correction, you can also use the LGK0121 and LGK0100 lines shown in red in Figure 3.2.4.2. You can measure these lines between trigger time point (= start of the current...
setpoint ramp) and the respective break point using a cursor. The measured value is shown in "ms" at the top edge of the trace window (marked in red in Figure 3.2.4.2).

As a result, the corrected value of $P111$ is as follows:

$$P111_{corr} = P111_{old} \cdot \frac{I_{LGK0121}}{I_{LGK0100}}$$

The value $L_1$ actually effective for the crossover point from discontinuous to continuous current is consequently

$$L_1 = P111_{corr} \cdot \frac{P186}{1 + P186}$$

### 3.2.4.3 Correction of the ohmic voltage drop

Because the motor is idle, an EMF (K0287) of 0 should result for the total current range. If the curve from connector K0287 (measured EMF) rises with increasing current, the value of P110 is to be increased to such an extent (and vice versa) that there is a horizontal curve to the greatest possible degree.

![Figure 3.2.4.3](image)
3.2.4.4 Adaptation of the curvature of the precontrol in the area of the crossover point from discontinuous to continuous current

If the curve of K0121 is too linear compared to K0100 (i.e., too little curvature), parameter P186 is to be enlarged. This requires correction of P111:

\[ P_{111_{\text{corr}}} = L \cdot \frac{1 + P_{186_{\text{corr}}}}{P_{186_{\text{corr}}}} \]

The steps 3.2.4.2 to 3.2.4.4 are to be repeated for the best possible adaptation if required.

3.2.4.5 Adaptation of the inductive voltage drop by P187

The value of P111 is used for calculating the inductive voltage drop. Since, however, the armature circuit inductance is dependent on the current (magnetic saturation) there can be adaptation to this non-linearity.

A large change in the armature circuit inductance can be the cause of disproportional, antiphase oscillation of both current converter flows (which if added up, produce the armature current of the motor). In this case, it can be necessary to adapt the inductive voltage drop to the actual curve.

For weakening purposes, a factor for evaluating the armature circuit inductance can be included in the calculation of the inductive voltage drop via parameterization of P187.

For example, a fixed setpoint can be used. But the output of a characteristic block (option S00, see function diagram B0160: characteristic blocks) can also be used to consider the relation between the inductance and the current.

3.2.4.6 Adaptation of the current controller P gain

In the area of intermittent armature current, the gain P155 can be adapted via P175. This can be achieved via a characteristic block and K0103 as input value (note: set the value as at 0% when the value is 100%; K0103 can jump to 0% at 100%).

3.2.4.7 EMF calculation for 12-pulse operation

With 12-pulse operation, fast current changes have shown that the previously used EMF can deviate from the actual curve at times. With Firmware V3.22 and above, there is therefore a new EMF value K0180 which can be used as input signal for precontrol at master and slave via parameter P162=4. The presence of a compensated direct current machine is of advantage if you use this setting.

Prerequisite for using connector K0180 is a correctly recorded field characteristic curve and correctly set parameters P078, P118 and P119!

In firmware versions older than V3.22, the calculation of the EMF can be performed with 2 multipliers of option S00 (free function blocks, function diagram B130), for example. You should make certain that the used multipliers are calculated in the fastest time slice (see U950 to U952, setting the corresponding parameter to the value "1"). The calculated EMF value is used in that it is selected as input signal for precontrol via parameter P193 and is wired further via parameter P162=3.

The following applies in general to EMF:

\[ EMF = k \cdot \text{Magnetic Flux} \cdot \text{Speed} = k \cdot \phi \cdot n \]

The following applies with the connectors used with SIMOREG:

\[ EMF = k \cdot K0290 \cdot K0179 \]
where $K_{0290} = \text{machine flow}$ and $K_{0179} = \text{actual speed value, filtered}$.
The following applies with the parameters for SIMOREG DC-MASTER (under consideration of the scalings):

$$k = \frac{P_{118}}{P_{119} \cdot P_{078.01} \cdot 100 \cdot \pi}{3 \cdot \sqrt{2}}$$

**CAUTION**: The value of the $k$ factor must be recalculated when the data for device, motor or speed recording changes (e.g., P078, P102, P741).
3.2.5 Power increase with parallel connection

Additional SIMOREG units can be connected to increase power. Operation of several 12-pulse systems on one 12-pulse transformer (see figure 3.2.5) is not permitted. This can cause balance currents, which can result in a tripped fuse or even damages (e.g., thyristor damage).

![Figure 3.2.5](image)

However, you can connect devices in parallel according to Figure 3.2.5.1 or Figure 3.2.5.2.
3.2.5.1 Parallel connection of additional SIMOREG devices in 6-pulse operation

The SIMOREG devices of the 12-pulse unit (Master M1 and Slave S1) can each be connected in parallel to a maximum of 5 additional SIMOREG devices (M1P1, M1P2 and S1P1, S1P2) in 6-pulse operation (for details of 6-pulse parallel operation, see SIMOREG DC-Master Operating Instructions, section 6.3).

Example with one device connected in parallel each:

Figure 3.2.5.1

Legend for figure 3.2.5.1:

1) Transformer  
2) Overvoltage protection  
3) Isolation monitoring  
4) SIMOREG - 6RA70  
5) Smoothing reactor  
6) DC motor  
7) Commutating reactor  
8) Data exchange (12-pulse paralleling interface)  
9) Data exchange (6-pulse paralleling interface)

\[ U_N = \text{Rated voltage of supplying network at converter input} \]
\[ I_d = \text{direct current of a converter section (1/4 of total direct current)} \]

Advantage of this configuration: only one 12-pulse transformer is required.
Disadvantage of this configuration: smoothing reactors are required to prevent a higher ripple of the current.
3.2.5.2 Parallel connection of additional SIMOREG units in 12-pulse operation

The 12-pulse unit (Master M1 und Slave S1) can be connected in parallel to a maximum of 2 additional 12-pulse units (M2, S2 and M3, S3) in 12-pulse operation on the DC side, wherein the units connected in parallel adhere to the setpoints of the 1st Master.

You must absolutely ensure that each unit is supplied by a separate transformer. If this is not the case, uncontrolled balance currents can arise between the units.

Example with one 12-pulse unit connected in parallel:

Example with one 12-pulse unit connected in parallel:

Legend for figure 3.2.5.2:

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

$U_N =$ Rated voltage of supplying network at converter input

$I_d =$ direct current of a converter section (1/4 of total direct current)

For dimensioning transformers and smoothing reactors, the same calculation documents apply as in points 3.1.2 and 3.1.3.

Advantage of this configuration: less current ripple.

Disadvantage of this configuration: more 12-pulse transformers required.
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