SINAMICS drives
SINAMICS DCM DC Converter
12-pulse applications

Application

Edition 09/2015

Answers for industry.
SINAMICS DCM
12-pulse applications

Compact User Manual
Legal information

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**WARNING**
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**NOTICE**
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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.

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WARNING
Observe safety notices in the associated operating instructions
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 support for technical issues here:
Area of application

This application document provides support for SINAMICS DCM converters in 12-pulse applications.

In order to make sense of this application document, it is assumed that the reader has read the contents of the SINAMICS DCM operating instructions.

The following converter topologies are covered:

- **12-pulse parallel operation**
  This mode of operation is especially used at higher power ratings to achieve lower line harmonics. In addition, by using this circuit, a lower DC current ripple is obtained when compared to a 6-pulse connection.

- **12-pulse series operation**
  This mode of operation is ideal when converting from older systems to digital control (using a SINAMICS DC MASTER Control Module) while keeping the existing power unit and consequently the nominal system data.

The following subjects are covered:

- Configuration of the required components
- Commissioning
- Switchover of the power unit topology - option S50

---

**Note**

Based on the engineering and commissioning examples described here, redundant operation is not possible.
12-pulse parallel connection

3.1 Topologies

Topology

The following diagram shows the topology of a 12-pulse parallel connection.

![Diagram of 12-pulse parallel connection](image)

Figure 3-1 12-pulse parallel connection (1), block diagram

The following diagram shows the topology of a 12-pulse parallel connection, where an additional 6-pulse converter is connected in parallel to each of the two 12-pulse converters connected in parallel.
12-pulse parallel connection

3.1 Topologies

Note

If additional converters are connected in parallel to the master converter, then exactly the same number of converters must also be connected in parallel with the slave converter.

Operation of 12-pulse parallel connection and 6-pulse parallel connection

For the converter topologies as shown in Fig. 3-1 and Fig. 3-2, the following mixed operation is permissible:

Master side: 4Q unit(s)
Slave side: 2Q unit(s)

This means, in torque direction 1, 12-pulse operation – and in torque direction 2, 6-pulse operation.

In some special cases, this operating mode is used to address the following requirements:

- Asymmetrical current demand (infeed power is far higher than the regenerative infeed power)
- A high-speed DC breaker should be used in the armature circuit for fast shutdown in regenerative operation. This high-speed breaker only has to be dimensioned for regenerative operation (energy recovery) – and is only necessary for the 4Q units.

Reactor to decouple the partial converters: We recommend that individual reactors are used instead of an interphase transformer.

Reason: In 6-pulse operation, current only flows through the interphase transformer at one
side, and would therefore consequentially go into saturation. The parameterization: the same as for a pure 12-pulse parallel connection.

### 3.2 Configuration

**Not permitted: Operation of several 12-pulse systems on a common 12-pulse transformer**

The operation of several 12-pulse systems on a common 12-pulse transformer (see figure below) is not permitted. This can cause balance currents, which can result in a blown fuse or even damage (e.g., thyristor damage).


![Non-permissible parallel connection](image)

Figure 3-3 Non-permissible parallel connection

However, you can connect devices in parallel according to Figure 3-4 Parallel connection of additional SINAMICS DCM devices in 6-pulse operation (Page 14) or Figure 3-5 Parallel connection of additional SINAMICS DCM units in 12-pulse operation (Page 15).
3.2.1 **Power increase with parallel connection**

In order to increase power, additional SINAMICS DCMs can be connected in parallel.

The options permitted for the parallel connection of SINAMICS DCM devices are described in the chapters "Parallel connection of additional SINAMICS DCM devices in 6-pulse operation (Page 14)" and "Parallel connection of additional SINAMICS DCM units in 12-pulse operation (Page 15)".

3.2.1.1 **Parallel connection of additional SINAMICS DCM devices in 6-pulse operation**

A maximum of 5 additional SINAMICS DCM devices (M1P1 to M1P5 and S1P1 to S1P5) can be connected in parallel to the SINAMICS DCM devices of the 12-pulse unit (master M1 and slave S1) in 6-pulse operation (for details on the 6-pulse parallel connection, see SINAMICS DCM operating instructions, chapter "Connecting devices in parallel and in series").

The following figure shows an example with one device connected in parallel:

![Diagram of parallel connection](image)

1) Transformer
2) Overvoltage protection
3) Insulation monitoring
4) SINAMICS DCM
5) Smoothing reactor
6) DC motor
7) Line reactor
8) Data exchange (12-pulse parallel connection)
9) Data exchange (6-pulse parallel connection)

$U_N =$ rated voltage of the line supply connected at the converter input

$I_d =$ direct current of a partial converter ($\frac{1}{4}$ total direct current)

**Figure 3-4** Parallel connection of additional SINAMICS DCM devices in 6-pulse operation

**Explanation of the abbreviations**

M1 Master, first branch
M1P1 6-pulse slave of M1

12-pulse parallel connection

3.2 Configuration

12-pulse applications

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S1  12-pulse slave of M1; simultaneously 6-pulse master of S1P1
S1P1  6-pulse slave of S1

Advantages and disadvantages of this configuration:
- Advantage: Only one 12-pulse transformer is required.
- Disadvantage: Smoothing reactors are required to avoid a higher current ripple.

3.2.1.2 Parallel connection of additional SINAMICS DCM units in 12-pulse operation

The 12-pulse unit (master M1 and slave S1) can be connected in parallel to a maximum of 2 additional 12-pulse units (M2, S2 and M3, S3) on the DC side, whereby the units connected in parallel follow the setpoints of the first master.

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

The following figure shows an example with a 12-pulse unit connected in parallel:

```
1) Transformer  2) Overvoltage protection  3) Insulation monitoring
4) SINAMICS DCM  5) Smoothing reactor  6) DC motor
7) Current setpoint  8) Data exchange (12-pulse parallel connection)
e.g. peer-to-peer

U_N = rated voltage of the line supply connected at the converter input
I_d = direct current of a partial converter (¼ total direct current)
```

Figure 3-5 Parallel connection of additional SINAMICS DCM units in 12-pulse operation

The transformers and smoothing reactors are dimensioned according to points Dimensioning of the converter transformer (Page 17) and Dimensioning of the smoothing reactors (Page 19).
Advantages and disadvantages of this configuration:

- Advantage: Lower current ripple
- Disadvantage: Each unit requires its own 12-pulse transformer

### 3.2.2 Prerequisites for the device

#### Transformer

12-pulse operation is achieved in the network by an additional winding system, electrically swiveled by 30°, belonging to the supplying transformer. Here at least one of the two converters (master or slave) of the 12-pulse system must be supplied via a galvanically isolated voltage (isolating transformer) (see Figure 3-6 Application with three-winding converter transformer (Page 17) and Figure 3-7 Application with isolation transformer (Page 18)).

It is possible to select which of the two converters should be supplied by the voltage leading or lagging by approx. 30° as required.

#### Converter equipment

Signal connection via parallel interface.

The parallel interface cable between the converters should be as short as possible. The permitted maximum cable length of 15 m should not be used if possible.

The total length of the bus cables for the parallel connector must not exceed 30 m (e.g., maximum 2 x 15 m with a master device with 2 slave devices), whereby the cables must always be as short as possible. If several devices are connected in parallel, the master device must be arranged in the center of the bus connection; the slave devices on either side are distributed as evenly as possible.

Equipotential bonding must be provided and the shield must be connected to ground with a large contact surface on either side.

All SINAMICS DCMs must have the same software version.

#### Smoothing reactor

Since the instantaneous values of device output voltages differ due to the different phase angle of the line infeed, decoupling via smoothing reactors must be provided upstream of the parallel device connection on the DC voltage side.

#### Overvoltage protection

Converter equipment which is connected to the line supply via a separate converter transformer must be protected against overvoltages that can occur as a result of line-side switching operations by means of overvoltage protection.

If the converter input is protected by means of open contact gaps during primary-side transformer switching operations, no protective circuit is required at the converter input.
Insulation monitoring

When using non-grounded low-voltage networks, an insulation monitoring device must be used to monitor the insulation. The insulation resistance is continuously monitored, and if the value falls below an adjustable threshold value, this is signaled.

Note

For 12-pulse applications we recommend that the armature voltage is measured close to the motor. As a consequence, voltage drops across reactors as well as across cable and busbar systems are automatically taken into account when measuring the armature voltage. The voltage actually available at the motor is measured. The external voltage measurement via analog input AI2 at X177.29-30 is activated using parameter p51854 = 1.

p51855 is used to scale the analog value measured via X177.29-30 (AI2). See function diagram 6902 in the SINAMICS DCM List Manual.

3.2.3 Dimensioning of the converter transformer

Application with three-winding converter transformer

Figure 3-6  Application with three-winding converter transformer

Transformer: A separate three-winding converter transformer is used to connect to the network of a higher voltage level.

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

Transformer type rating: \( S_T = U_N \times 1,35 \times 1,05 \times I_d \times 2 \)
Application with isolation transformer

Transformer: When there is a low-voltage rail, an isolation transformer with a voltage transformation ratio of 1:1 is used upstream of a converter for a 30° phase offset.

Suitable vector groups for the transformer: Dy11, Yd11, Dy5, \( u_k = 4\% \) to 6\%

Transformer type rating: \( S_T = U_N \times 1,35 \times 1,05 \times I_d \)

**Note**

If converters are connected in parallel in order to increase the current (parallel connection of additional max. 5 devices per 6-pulse branch is possible), a line reactor must be connected upstream of each converter unit with min. 2\% \( u_k \) in order to decouple each converter. In order to ensure symmetrical current distribution in the parallel converter units, the lowest possible deviation of the impedance values of the individual line reactors is required. In practice, a 3\% difference can be achieved at a reasonable cost. The additional voltage drop in the line reactors must be taken into account during the configuration.

If converters are used which do not have any arm fuses and 4Q operation is possible at the same time, every converter is to be supplied with a fuse on the DC side which has been dimensioned according to its output current.
### 3.2.4 Dimensioning of the smoothing reactors

**WARNING**

The correct dimensioning of smoothing reactors is very important and should be made only by persons with sufficient knowledge of 12-pulse applications.

If the inductance of the smoothing reactors is too low, instead of 60° long current blocks, this may result in 30° long current blocks of twice the size in both partial converters. In this case, even if the semiconductor fuses are correctly dimensioned, the thyristors may not be protected and will quickly be destroyed.

A smoothing reactor is used for each of the two partial converters. The reactor is a 2-value reactor. This means that the inductance of the reactor is defined for two current values. The reactor is thermally dimensioned according to the rms value of the DC reactor current. The following formulas are used for rough estimates of the reactor values.

Calculating the required inductance:

\[
\begin{align*}
L_{D1} &= \text{Inductance of the reactor at } 0.2 \times I_{dn} \\
L_{D2} &= \text{Inductance of the reactor at } 0.33 \times I_{dmax}
\end{align*}
\]

Inductance for 50 Hz line frequency:

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

Inductance for 60 Hz line frequency:

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

\[
\begin{align*}
L &= \text{Inductance in Henry} \\
I_{dn} &= \text{Half rated DC current of the DC motor} \\
I_{dmax} &= \text{Half maximum current of the DC motor} \\
U_{di} &= U_N \times 1.35 \text{ (} U_N = \text{rated voltage of the line supply, } U_{di} = \text{ideal DC voltage)}
\end{align*}
\]

Condition: \(3.5 \times L_{D2} \geq L_{D1}\)

If the condition is not fulfilled, \(L_{D2}\) must be increased accordingly.

The condition is satisfied when \(I_{dmax} < 2 \times I_{dn}\)
3.2.5 Selection for overvoltage protection

The purpose of overvoltage protection is to protect the semiconductor valves of converters against overvoltages between the phases of a three-phase network. The overvoltage protection limit voltage may not exceed the blocking voltage of the valves to be protected.

Figure 3-8 Overvoltage protection

The transformer is connected on the line side, as shown in the above figure. If the transformer is disconnected under load, the magnetization energy across the arc of the primary-side switch is not completely released. In the event of blocked firing pulses, this energy results in an overvoltage on the secondary side of the transformer and must be limited by the overvoltage protection.

When switching to no-load operation, the overvoltage protection must only handle the magnetizing energy of the transformer. The magnetization energy is calculated as follows:

\[ W_M = \frac{S_N}{4 \cdot \pi \cdot f} \cdot \frac{I_0}{I_N} \]

- \( W_M \) = Transformer magnetization energy
- \( S_N \) = Transformer rated power
- \( I_0 \) = Transformer no-load current
- \( I_N \) = Transformer rated current
- \( f \) = Line frequency in Hz

If the transformer is disconnected in the event of a fault, the shunted energy is greater in relation to the load, whereby a distinction must still be made between motor and generator load.

"SICROWBAR 7VV3002 AC overvoltage protection for thyristors and diodes" units are available as overvoltage protection for the connection between the three line phases.

Information on the calculation of energy to be shunted in the various situations and technical data for SICROWBAR 7VV3002 can be found in the SICROWBAR 7VV3002 operating instructions.

Internet link: SICROWBAR overvoltage protection 7VV3002 operating instructions (https://support.industry.siemens.com/cs/ww/en/pd/13450/man)

Dimensioning for 10,000 operating cycles is recommended.
3.2.6 Insulation monitoring

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

Since the network on the DC voltage side is galvanically connected via the parallel connection of the two partial converters, only one insulation monitor can be used to monitor the network and DC voltage side for ground faults.

Table 3-1 Possible devices for insulation monitoring:

<table>
<thead>
<tr>
<th>Rated network voltage</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 with MZ611</td>
<td>AREVA T&amp;D/ALSTOM</td>
</tr>
<tr>
<td></td>
<td>IRDH 275/IRDH375 with 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>

3.3 Commissioning

In principle, all converters should be commissioned as described in the Commissioning chapter of the SINAMICS DCM DC Converter operating instructions.

The settings in chapter Specifying the operating mode (Page 22) and chapter Additional parameter settings (Page 23) should be made before commissioning (chapter Carrying out commissioning (Page 24)).

To make the settings, use

- BOP20 operator panel
- AOP30 operator panel: Parameter list
- STARTER commissioning tool: Expert list.
3.3.1 Specifying the operating mode

Two operating modes are supported:

Operation with firing angle interface (p51799 = 0 or p51799 = 21)

- Master (SINAMICS DCM 1): Closed-loop speed control, armature current closed-loop control and field current closed-loop control
- Slave (SINAMICS DCM 2): Armature current closed-loop control

The master determines the theoretical firing angle and transfers it to its own gating unit and to the gating unit of the slave. Both partial converters synchronize to their own network and form their own firing points. However, both the master and the slave have their own current controller which intervenes to make any corrections.

Operation with current setpoint interface (p51799 = 22)

- Master (SINAMICS DCM 1): Closed-loop speed control, armature current closed-loop control and field current closed-loop control
- Slave (SINAMICS DCM 2): Armature current closed-loop control

The master determines the armature current setpoint and transfers this to its own armature current controller and to the armature current controller of the slave. Both partial converters control their own partial current independently.

n+m mode

For a 12-pulse parallel connection, restricted redundant operation is possible. With the setting p51803 = 1, if a slave fails (devices with setting p51800 = 23 or 24) then, depending on the minimum number of power units (set in p51802), this is tolerated. Master devices (12 pulse - master p51800 = 21, or 12 pulse slave - p51800 = 22) must remain operational. The drive is shut down if one of the two fails. It is not possible to transfer the master – and redundancy of armature and field (setting, p51803 = 2) is not possible. If the electronic supply fails, or devices are removed with active bus terminating resistor, then for the device in front, the bus terminating resistor should be activated using p51801 = 1. When reinstalling the previously removed device, the change must be appropriately undone (p51801 = 0).
### 3.3.2 Additional parameter settings

Table 3-2 Parameter settings on the master converter and on the slave converter:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Master</th>
<th>Slave or parallel devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>p51799</td>
<td>Mode of operation</td>
<td>0, 21 or 22</td>
</tr>
<tr>
<td>p51800</td>
<td>Position in the topology</td>
<td>21 (12-pulse master)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 (12-pulse slave)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 (devices connected in parallel to the master)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 (devices connected in parallel to the slave)</td>
</tr>
<tr>
<td>p51801</td>
<td>Amount of send data</td>
<td>0,4,8,12,16</td>
</tr>
<tr>
<td>p51802</td>
<td>Number of power units 1)</td>
<td>≥ 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 2</td>
</tr>
<tr>
<td>p51803</td>
<td>n+m mode</td>
<td>0 or 1</td>
</tr>
<tr>
<td>p51804[..]</td>
<td>Send data</td>
<td>Application-specific</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the same as for the master</td>
</tr>
<tr>
<td>p51805</td>
<td>Bus terminator</td>
<td>0 or 1 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 or 1 2)</td>
</tr>
<tr>
<td>p51806</td>
<td>Station address</td>
<td>Unique address (1..16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The same as for the master (1..16)</td>
</tr>
<tr>
<td>p51807</td>
<td>Telegram failure time</td>
<td>Recommended, 0.1 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recommended, 0.1 s</td>
</tr>
<tr>
<td>p50082</td>
<td>Field operating mode</td>
<td>≠ 0 (application-specific)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 (no field)</td>
</tr>
<tr>
<td>p50076[..]</td>
<td>Reduction in the rated unit DC cur-</td>
<td>Application-specific</td>
</tr>
<tr>
<td></td>
<td>rent 3)</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50078[..]</td>
<td>Rated value for supply voltage</td>
<td>Application-specific</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50100</td>
<td>Rated motor current</td>
<td>Rated motor current/number of SINAMICS DCMs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50357</td>
<td>Threshold for interrupted tachometer</td>
<td>Application-specific</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100% (tachometer interruption monitoring not active)</td>
</tr>
</tbody>
</table>

1) If the number of power units that are ready to operate for n+m operation is less than the value set in p51802, then fault message F60044 is output, followed by shutdown (OFF2).

2) = 1 at the two outermost units (= at the physical ends of the bus line)
   = 0 on all of the other units

3) Note: In conjunction with r50072[..], ensure that p50076[..] is correctly set, as described in the List Manual under p50076[..].
3.3.3 Carrying out commissioning

Preconditions for commissioning

- the smoothing reactors are available and are dimensioned correctly (see Chapter Dimensioning of the smoothing reactors (Page 19)) and
- the parameter for the rated motor current (p50100) is set correctly at all of the partial converters.

**WARNING**

The thyristors may be destroyed, if the inductance of the smoothing reactor is too low.

Commission the master converter and the slave converter as described in the SINAMICS DCM DC converter operating instructions (commissioning steps 1 up to and including 8):

- When commissioning with the BOP20 operator panel: Perform commissioning steps
- When commissioning with the AOP30 operator panel: Execute "Drive commissioning" menu command
- When using the STARTER commissioning tool for commissioning: Start the project wizard

**Note**

For a 12-pulse parallel connection, we recommend to switch over the method of calculating the EMF calculation for the armature current precontrol to p50162 = 4 (EMF calculated from the speed actual value). Reason: Contrary to the EMF calculation method according to the factory setting p50162 = 1 (measured EMF), this calculation method is not dependent on the parameterized values of the inductances.

3.3.4 Optimization runs

The optimization runs should only be carried out on the master converter. The slave converters must be connected and ready for operation.

When optimizing the armature current control, a distinction has to be made as to whether an interphase transformer is being used as smoothing reactor, or whether 2 individual reactors are being used.
3.3.4.1 Optimization for 2 individual reactors

Perform the optimization run for the armature current control (p50051 = 25).

During this optimization run, the firing angle is shifted in the Alpha-G direction until either 90% of the rated motor current is reached or until the rated device current (r50072[1]) is reached, depending on which case occurs first.

The optimization run for the armature current closed-loop control (p50051 = 25) sets the following parameters on the master converter:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Master</th>
<th>Slave or parallel units</th>
</tr>
</thead>
<tbody>
<tr>
<td>p50110 Armature resistance ( Ra )</td>
<td>Actual armature resistance ( \times ) half the number of SINAMICS DCMs</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p50111 Armature inductance ( La )</td>
<td>Actual armature inductance ( \times ) half the number of SINAMICS DCMs</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51591 La reduction factor</td>
<td>-</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51596 Reactor resistance ( R )</td>
<td>Actual reactor resistance ( \times ) half the number of SINAMICS DCMs</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51594 Smoothing inductance ( L )</td>
<td>Actual reactor inductance ( \times ) half the number of SINAMICS DCMs</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51595 L reduction factor</td>
<td>-</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p50155 Kp armature current controller</td>
<td>-</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p50156 Tn armature current controller</td>
<td>-</td>
<td>The same as at the master</td>
</tr>
</tbody>
</table>

In many cases, the optimization run is missing the criteria for the correct distribution of the total inductance between the armature inductance and the inductance of the smoothing reactors, especially if the two inductances differ considerably. This is why it is recommended that these parameters are always checked and, if necessary, set manually to the correct values.

In cases such as these, frequently fault message F60051 is output with fault value 50111, as well as a negative value in r50047[1].

In this case, proceed as described in Chapter Optimization for an interphase transformer (Page 26).
Optimization for an interphase transformer

When an interphase transformer is being used, in spite of the 12-pulse connection, we recommend that the optimization run is carried out for 6-pulse operation.

To do this, p51800 should be set = 0 at the master before starting the optimization run. The optimization run determines a total inductance from the armature filter inductance and cable inductance. When the filter inductance is known, this can be subtracted from the value determined in p50111.

\[ p50111_{\text{new}} = p50111_{\text{determined}} - L_{\text{filter}} \]

If several devices are connected in parallel, then the determined values must be set corresponding to Table (* half the number of SINAMICS DCM). The current control values must be manually checked.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Master</th>
<th>Slave or parallel units</th>
</tr>
</thead>
<tbody>
<tr>
<td>p50110 Armature resistance Ra</td>
<td>Actual armature resistance × half the number of SINAMICS DCMs</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p50111 Armature inductance La</td>
<td>Actual armature inductance × half the number of SINAMICS DCMs</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51591 La reduction factor</td>
<td>-</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51596 Filter resistance Rs</td>
<td>Actual filter resistance × half the number of SINAMICS DCMs</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51594 Filter inductance Ls</td>
<td>Actual filter inductance × half the number of SINAMICS DCMs</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51595 Ls reduction factor</td>
<td>-</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p50155 Kp armature current controller</td>
<td>-</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p50156 Tn armature current controller</td>
<td>-</td>
<td>The same as at the master</td>
</tr>
</tbody>
</table>

In the table above, the parameter values of the master converter must be manually transferred to the slave converter. The additional optimization runs are then carried out, starting with the optimization run for the speed control at the master converter.
4.1 Topologies

4.1.1 12-pulse series connection of two SINAMICS DCMs

Topology

The following diagram shows the topology of a 12-pulse series connection of two SINAMICS DCM.

![Diagram of 12-pulse series connection](image)

Figure 4-1 12-pulse series connection (1), block diagram

The following diagram shows the topology of a 12-pulse series connection, where an additional converter is connected in parallel to each of the two 12-pulse converters connected in series.
Operating modes

There are two operating modes:

- **Operation with the same firing times ($p51799 = 41$):**
  Both partial converters are fired at precisely the same instant. The master calculates the firing point and this is transferred to the slave via the parallel interface. Synchronization to the line supply is exclusively performed by the master. The slave must be connected to the line supply with the same phase sequence as the master.

- **Operation with sequence control ($p51799 = 42$):**
  Both partial converters synchronize to the line supply and generate their own firing points. The firing angle for the master and the firing angle for the slave are calculated by the master and the firing angle and the torque direction for the slave are transferred to the slave via the parallel interface. The firing angle for the master and slave are generated so that the reactive power load of the line supply is as low as possible. This is the case if one of the two partial converters is at a control limit and the other carries-out the closed-loop control. This type of closed-loop control is only possible for continuous current. Operation with the same firing points is automatically selected in the discontinuous (pulsating) current range.

Remark

The current ripple is significantly higher when the two partial converters operate with sequence control than when they operate with the same firing times. In this case, the current ripple approximately corresponds to that for 6-pulse operation. Especially in older motors, under certain circumstances this ripple can cause problems (for example, during commutation).
Therefore, a conscious decision must be made:

- Low ripple, but no reduction of the reactive power:  
  → operation with the same firing times ($p51799 = 41$)
- Low reactive power, but no reduction of the ripple:  
  → Operation with sequence control ($p51799 = 42$)

**Note**

The power unit of the slave converter must be connected to the 12-pulse transformer so that its phases lag the phases of the line supply at the master by 30°. The phase sequence must be the same.

### 4.1.2 12-pulse series connection: controlled converter + uncontrolled converter

**Topology**

The following diagram shows the topology of a 12-pulse series connection of a SINAMICS DCM 2-quadrant unit and a diode rectifier. (thyristor bridge B6 + diode rectifier)

**Remark:**

The incoming AC voltage of the controlled converter should be 10% to 15% higher than that at the controlled converter, in order that the current can be reliably reduced down to 0.
4.2 Configuration

4.2.1 Power increase with parallel connection

Additional devices can be connected in parallel to the SINAMICS DCM 12-pulse series master device and the 12-pulse series slave device to increase the output current.

The maximum possible configuration is 2 groups in series, each consisting of 3 devices connected in parallel.

Suggested circuit:

![Diagram of 12-pulse series connection](image)

- 1) Transformer
- 2) Overvoltage protection
- 3) Insulation monitoring
- 4) SINAMICS DCM master
- 5) SINAMICS DCM slave
- 6) DC motor
- 7) Line reactor
- 8) Parallel interface
- 9) Symmetry resistor

$U_N = $ rated voltage of the line supply connected at the converter input

$I_d = $ direct current of a partial converter ($\frac{1}{2}$ total direct current)

Figure 4-4 Connection of additional SINAMICS DCM devices in 6-pulse operation
4.2.2 Prerequisites for the device

Transformer

12-pulse operation is achieved in the network by an additional winding system, electrically swiveled by 30°, belonging to the supplying transformer. Here at least one of the two converters (master or slave) of the 12-pulse system must be supplied via a galvanically isolated voltage (isolating transformer) (see Figure 4-5 Converter transformer dimensioning at higher voltage level (Page 33) and Figure 4-6 Converter transformer dimensioning at low voltage (Page 34)).

Note

Both converters must be supplied with a clockwise rotation field.

In addition, it is important to ensure that the three-phase current system on the slave device lags behind that of the master device by 30°. This phase allocation may need to be checked by taking a measurement.

Converter equipment

SINAMICS DCM software version V1.2 or higher.

All SINAMICS DCMs must have the same software version.

Symmetry resistor

With a 12-pulse series connection, symmetry resistors must be connected in parallel to the individual converters connected in series, through which at least one current in the amount of the maximum thyristor reverse current flows. This ensures that, in the range of the small armature current or when armature current = 0, the total armature voltage is distributed symmetrically to both individual devices.

As a result of the activation of the thyristors with long pulses, an increased reverse current may flow. The symmetry resistors must be dimensioned so that at maximum armature voltage, a cross-current of at least 100 mA flows. With the parallel connection of a device, the cross-current at maximum voltage should be at least 200 mA and for two devices at least 300 mA.

Overvoltage protection

Converter equipment which is connected to the network via a separate converter transformer must be protected against overvoltages that can occur as a result of line-side switching operations by means of overvoltage protection.

If the converter input is protected by means of open contact gaps during primary-side transformer switching operations, no protective circuit is required at the converter input.
Insulation monitoring

When using non-grounded low-voltage networks, an insulation monitoring device must be used to monitor the insulation. The insulation resistance is continuously monitored, and if the value falls below an adjustable threshold value, this is signaled.

Using external armature voltage sensing

The motor armature voltage can either be sensed in the devices themselves – or using an external PT directly at the motor terminals.

The following differences should be noted:

- **Internal armature voltage sensing (p51854 = 0)**
  Every SINAMICS DCM senses its own output voltage (C-D), and uses this as armature voltage.

  DC converter
  The output voltage is wired inside the device.

  Control Module:
  The output voltage must be connected at inputs C and D on the voltage sensing module.

  For a series connection, the following applies:
  The motor armature voltage is calculated in the device from the sum of the output voltages of the master and slave.

  For a series connection of a SINAMICS DCM and a diode bridge, the following applies:
  The motor armature voltage is calculated in the device from the sum of the output voltages of the master and diode bridge.
  The diode bridge output voltage is calculated according to the formula "Ud = p51798 *output voltage of the master*.

- **External armature voltage sensing (p51854 = 1)**
  The motor armature voltage is connected via an external voltage transformer at X177.39-30 (AI2). This measured value is used as armature voltage.

  If the external armature voltage sensing is used, then it must be used at the master and at the slave.

**Note**

See also function diagram 6902 in the List Manual
4.2.3 Dimensioning of the converter transformer

Application with three-winding converter transformer

![Diagram of converter transformer dimensioning](image)

1) Transformer  2) Overvoltage protection  3) Insulation monitoring
4) SINAMICS DCM master  5) SINAMICS DCM slave  6) DC motor
8) Parallel interface  9) Symmetry resistor

$U_N =$ rated voltage of the line supply connected at the converter input

$I_d =$ direct current through both SINAMICS DCM devices and motor

Figure 4-5 Converter transformer dimensioning at higher voltage level

Transformer: A separate three-winding converter transformer is used to connect to the network of a higher voltage level.

Preferred vector groups for the transformer: $\text{Dd0Dy11, Dd6Dy5, Yy0Yd11, Yy6Yd5}$, $u_k = 4\%$ to $6\%$

It is important to ensure that the three-phase current system on the slave device lags behind that of the master device by $30^\circ$.

Transformer type rating: $S_T = U_N \times 1,35 \times 1,05 \times I_d \times 2$
4.2 Configuration

Application with isolation transformer

Transformer: When there is a low-voltage rail, an isolation transformer with a voltage transformation ratio of 1:1 is used upstream of the slave converter for a 30° phase offset.

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

Transformer type rating: $S_T = U_N \times 1,35 \times 1,05 \times I_d$

Note

If converters are connected in parallel in order to increase the current (parallel connection of additional max. 2 devices per 6-pulse branch is possible), a line reactor must be connected upstream of each converter unit with min. $2\%$ $u_k$ in order to decouple each converter. In order to ensure symmetrical current distribution in the parallel converter units, the lowest possible deviation of the impedance values of the individual line reactors is required. In practice, a $3\%$ difference can be reached at a reasonable cost. The additional voltage drop in the line reactors must be taken into account during the configuration.

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

4.2.4 Voltage limits

The output voltage of a 12-pulse series system is set by the insulation strength and the semiconductor reverse voltages of the individual devices.

Devices with 690, 830 and 950 VAC have the same control module, i.e. the insulation against ground is dimensioned for 950 VAC for all three devices. However, this voltage cannot be fully utilized because series connection can cause a much higher voltage against ground in the system in the event of a ground fault. In addition, the faulty functioning of the symmetry
resistors or of one of the converters can, for example, result in an impermissible increase in the thyristor reverse voltages.

For this reason, the maximum input voltage depending on the device types (according to the following table) must not be exceeded by any device:

<table>
<thead>
<tr>
<th>MLFB device type</th>
<th>Max. input voltage [V_{rms}]</th>
<th>MLFB device type</th>
<th>Max. input voltage [V_{rms}]</th>
<th>MLFB device type</th>
<th>Max. input voltage [V_{rms}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>6RA8013-6DV62</td>
<td>2 x 300</td>
<td>6RA8078-6FV62</td>
<td>2 x 300</td>
<td>6RA8091-6FS22</td>
<td>2 x 300</td>
</tr>
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<td>6RA8013-6FV62</td>
<td>2 x 300</td>
<td>6RA8081-6DS22</td>
<td>2 x 300</td>
<td>6RA8091-6FV62</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8018-6DV62</td>
<td>2 x 300</td>
<td>6RA8081-6DS22</td>
<td>2 x 300</td>
<td>6RA8093-4DS22</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8018-6FV62</td>
<td>2 x 300</td>
<td>6RA8081-6GS22</td>
<td>2 x 300</td>
<td>6RA8093-4DV62</td>
<td>2 x 300</td>
</tr>
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<td>2 x 300</td>
<td>6RA8081-6GV62</td>
<td>2 x 300</td>
<td>6RA8093-4GS22</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8025-6DV62</td>
<td>2 x 300</td>
<td>6RA8082-6FS22</td>
<td>2 x 300</td>
<td>6RA8093-4GV62</td>
<td>2 x 300</td>
</tr>
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<td>2 x 300</td>
<td>6RA8082-6FV62</td>
<td>2 x 300</td>
<td>6RA8093-4KS22</td>
<td>2 x 300</td>
</tr>
<tr>
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<td>2 x 300</td>
<td>6RA8093-4K6V2</td>
<td>2 x 500</td>
</tr>
<tr>
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<td>2 x 300</td>
<td>6RA8085-6DV62</td>
<td>2 x 300</td>
<td>6RA8093-4LS22</td>
<td>2 x 500</td>
</tr>
<tr>
<td>6RA8025-6GV62</td>
<td>2 x 300</td>
<td>6RA8085-6FS22</td>
<td>2 x 300</td>
<td>6RA8093-4LV62</td>
<td>2 x 500</td>
</tr>
<tr>
<td>6RA8028-6DS22</td>
<td>2 x 300</td>
<td>6RA8085-6FV62</td>
<td>2 x 300</td>
<td>6RA8095-4DS22</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8028-6DV62</td>
<td>2 x 300</td>
<td>6RA8085-6GS22</td>
<td>2 x 300</td>
<td>6RA8095-4DV62</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8028-6FS22</td>
<td>2 x 300</td>
<td>6RA8085-6GV62</td>
<td>2 x 300</td>
<td>6RA8095-4GS22</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8028-6FV62</td>
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</tr>
<tr>
<td>6RA8031-6DS22</td>
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<td>6RA8086-6DV62</td>
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<td>6RA8095-4KS22</td>
<td>2 x 500</td>
</tr>
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<td>6RA8086-6DS22</td>
<td>2 x 300</td>
<td>6RA8095-4KV62</td>
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</tr>
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<td>6RA8031-6FS22</td>
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<td>6RA8087-6DV62</td>
<td>2 x 300</td>
<td>6RA8095-4LS22</td>
<td>2 x 500</td>
</tr>
<tr>
<td>6RA8031-6FV62</td>
<td>2 x 300</td>
<td>6RA8087-6FS22</td>
<td>2 x 300</td>
<td>6RA8095-4LV62</td>
<td>2 x 500</td>
</tr>
<tr>
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<td>6RA8087-6FV62</td>
<td>2 x 300</td>
<td>6RA8096-4GS22</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8031-6GV62</td>
<td>2 x 300</td>
<td>6RA8087-6GS22</td>
<td>2 x 300</td>
<td>6RA8096-4GV62</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8075-6DS22</td>
<td>2 x 300</td>
<td>6RA8087-6GV62</td>
<td>2 x 300</td>
<td>6RA8096-4MS22</td>
<td>2 x 500</td>
</tr>
<tr>
<td>6RA8075-6DV62</td>
<td>2 x 300</td>
<td>6RA8088-6LS22</td>
<td>2 x 500</td>
<td>6RA8096-4MV62</td>
<td>2 x 500</td>
</tr>
<tr>
<td>6RA8075-6FS22</td>
<td>2 x 300</td>
<td>6RA8088-6LV62</td>
<td>2 x 500</td>
<td>6RA8097-4GS22</td>
<td>2 x 300</td>
</tr>
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<td>2 x 300</td>
<td>6RA8090-6GS22</td>
<td>2 x 300</td>
<td>6RA8097-4GV62</td>
<td>2 x 300</td>
</tr>
<tr>
<td>6RA8075-6GS22</td>
<td>2 x 300</td>
<td>6RA8090-6GV62</td>
<td>2 x 300</td>
<td>6RA8097-4KS22</td>
<td>2 x 500</td>
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<td>2 x 500</td>
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<td>2 x 300</td>
<td>6RA8098-4DV62</td>
<td>2 x 300</td>
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<td>6RA8091-6DV62</td>
<td>2 x 300</td>
<td>6RA800-0MV62</td>
<td>2 x 500</td>
</tr>
</tbody>
</table>

If higher input voltages are present, SINAMICS DC MASTER Control Modules should be used in connection with suitable external power units in order to achieve the required proof voltage. The corresponding systems are available on request.
4.2 Configuration

4.2.5 Selection for overvoltage protection

The purpose of overvoltage protection is to protect the semiconductor valves of converters against overvoltages between the phases of a three-phase network. The overvoltage protection limit voltage may not exceed the blocking voltage of the valves to be protected.

![Overvoltage protection](Image)

Figure 4-7 Overvoltage protection

The transformer is connected on the line side, as shown in the above figure. If the transformer is disconnected under load, the magnetization energy across the arc of the primary-side switch is not completely released. In the event of blocked firing pulses, this energy results in an overvoltage on the secondary side of the transformer and must be limited by the overvoltage protection.

When switching to no-load operation, the overvoltage protection must only handle the magnetizing energy of the transformer. The magnetization energy is calculated as follows:

$$W_M = \frac{S_N}{4 \cdot \pi \cdot f} \cdot \frac{I_0}{I_N}$$

- $W_M$ = Transformer magnetization energy
- $S_N$ = Transformer rated power
- $I_0$ = Transformer no-load current
- $I_N$ = Transformer rated current
- $f$ = Line frequency in Hz

If the transformer is disconnected in the event of a fault, the shunted energy is greater in relation to the load, whereby a distinction must still be made between motor and generator load.

"SICROWBAR 7VV3002 AC overvoltage protection for thyristors and diodes" units are available as overvoltage protection for the connection between the three line phases.

Information on the calculation of energy to be shunted in various operations and technical data for SICROWBAR 7VV3002 can be found in the SICROWBAR 7VV3002 operating instructions.

Internet link: SICROWBAR overvoltage protection 7VV3002 operating instructions

Dimensioning for 10,000 operating cycles is recommended.
4.2.6 Insulation monitoring

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

Since the network on the DC voltage side is galvanically connected via the parallel connection of the two partial converters, only one insulation monitor can be used to monitor the network and DC voltage side for ground faults.

Table 4-1 Possible devices for insulation monitoring:

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

4.3 Commissioning

In principle, all converters should be commissioned as described in the Commissioning chapter of the SINAMICS DCM DC Converter operating instructions.

The settings in Chapter Additional parameter settings (Page 37) should be made before commissioning. See Chapter Carrying out commissioning (Page 40)

To make the settings, use

- BOP20 operator panel
- AOP30 operator panel: Parameter list
- STARTER commissioning tool: Expert list.

4.3.1 Additional parameter settings

Parameter settings on the master converter and on the slave converter.

Table 4-2 For 12-pulse series connection of SINAMICS DCM converters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Master</th>
<th>Slave or parallel devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>p51799</td>
<td>Mode of operation</td>
<td>0, 41 or 42</td>
</tr>
<tr>
<td>p51800</td>
<td>Position in the topology</td>
<td>41 (Master)</td>
</tr>
</tbody>
</table>
### 4.3 Commissioning

#### Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Master</th>
<th>Slave or parallel devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>p51801</td>
<td>Amount of send data</td>
<td>0,4,8,12,16</td>
</tr>
<tr>
<td>p51802</td>
<td>Number of power units $^1$</td>
<td>≥ 2</td>
</tr>
<tr>
<td>p51803</td>
<td>n+m mode</td>
<td>0</td>
</tr>
<tr>
<td>p51804[..]</td>
<td>Send data</td>
<td>Application-specific</td>
</tr>
<tr>
<td>p51805</td>
<td>Bus terminator</td>
<td>0 or 1 $^2$</td>
</tr>
<tr>
<td>p51806</td>
<td>Station address</td>
<td>Unique address</td>
</tr>
<tr>
<td>p51807</td>
<td>Telegram failure time</td>
<td>0.1 s</td>
</tr>
<tr>
<td>p50082</td>
<td>Field operating mode</td>
<td>≠ 0</td>
</tr>
<tr>
<td>p50076[..]</td>
<td>Reduction in the rated unit DC current $^3$</td>
<td>Application-specific</td>
</tr>
<tr>
<td>p50078[..]</td>
<td>Rated value for supply voltage</td>
<td>Application-specific</td>
</tr>
<tr>
<td>p50100</td>
<td>Rated motor current</td>
<td>Rated motor current/half the number of SINAMICS DCMs</td>
</tr>
<tr>
<td>p50101</td>
<td>Rated motor voltage</td>
<td>Summed voltage (actual armature voltage)</td>
</tr>
</tbody>
</table>

$^1$ If the number of power units that are ready to operate for n+m operation is less than the value set in p51802, then fault message F60044 is output, followed by shutdown (OFF2).

$^2$ = 1 at the two outermost units (= at the physical ends of the bus line)

$^3$ = 0 on all of the other units

Note: In conjunction with r50072[..], ensure that p50076[..] is correctly set, as described in the List Manual under p50076[..].
For 12-pulse series connection of SINAMICS DCM converters with an uncontrolled rectifier:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Master</th>
<th>Parallel units</th>
</tr>
</thead>
<tbody>
<tr>
<td>p51798 Voltage on the uncontrolled rectifier</td>
<td>Application-specific (50 % - 100 %)</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p51799 Mode of operation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>p51800 Position in the topology</td>
<td>45 (master for diode rectifier)</td>
<td>43</td>
</tr>
<tr>
<td>p51807 Telegram failure time</td>
<td>0.0 s</td>
<td>0.1 s if devices connected in parallel are available</td>
</tr>
<tr>
<td>p51801 Amount of send data</td>
<td>0,4,8,12,16</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51802 Number of power units 1)</td>
<td>≥ 2</td>
<td>≥ 2</td>
</tr>
<tr>
<td>p51803 n+m mode</td>
<td>0 or 1</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51804 Send data</td>
<td>Application-specific</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51805 Bus terminator</td>
<td>0 or 1 2)</td>
<td>0 or 1 2)</td>
</tr>
<tr>
<td>p51806 Station address</td>
<td>Unique address (1..16)</td>
<td>The same as at the master</td>
</tr>
<tr>
<td>p51807 Telegram failure time</td>
<td>Recommended, 0.1 s</td>
<td>Recommended, 0.1 s</td>
</tr>
<tr>
<td>p50082 Field operating mode</td>
<td>≠ 0 (application-specific)</td>
<td>0 (no field)</td>
</tr>
<tr>
<td>p50076 Reduction in the rated unit DC current 3)</td>
<td>Application-specific</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50078 Rated value for supply voltage</td>
<td>Application-specific</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50100 Rated motor current</td>
<td>Rated motor current/number of SINAMICS DCMs</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50165 Enable torque direction change</td>
<td>0 or 1 4)</td>
<td>The same as at the master</td>
</tr>
</tbody>
</table>

1) If the number of power units that are ready to operate for n+m operation is less than the value set in p51802, then fault message F60044 is output, followed by shutdown (OFF2).
2) = 1 at the two outermost units (= at the physical ends of the bus line)  
   = 0 on all of the other units
3) Note: In conjunction with r50072[.], ensure that p50076[.] is correctly set, as described in the List Manual under p50076[.].
4) For 4Q units, it is imperative that the torque direction change is inhibited:  
   0 = M0 or MII; 1 = M0 or MI
4.3 Commissioning

4.3.2 Carrying out commissioning

Commission the master converter and the slave converter as described in the SINAMICS DCM DC converter operating instructions (commissioning steps 1 up to and including 8):

- When commissioning with the BOP20 operator panel:
  Perform commissioning steps

- When commissioning with the AOP30 operator panel:
  Execute "Drive commissioning" menu command

- When using the STARTER commissioning tool for commissioning:
  Start the project wizard

\( n+m \) mode

For a 12-pulse series connection, restricted redundant operation is possible. With the setting \( p51803 = 1 \), if a slave fails (devices with setting \( p51800 = 23 \) or \( 24 \)) then, depending on the minimum number of power units (set in \( p51802 \)), this is tolerated. Master devices (12 pulse - master \( p51800 = 21 \), or 12 pulse slave - \( p51800 = 22 \)) must remain operational. The drive is shut down if one of the two fails. It is not possible to transfer the master – and redundancy of armature and field (setting, \( p51803 = 2 \)) is not possible. If the electronic supply fails, or devices are removed with active bus terminating resistor, then for the device in front, the bus terminating resistor should be activated using \( p51801 = 1 \). When reinstalling the previously removed device, the change must be appropriately undone (\( p51801 = 0 \)).
4.3.3 **Optimization runs**

The optimization runs should only be carried out on the master converter. The slave converters must be connected and ready for operation at this point.

The optimization run for the armature current closed-loop control \((p50051 = 25)\) sets the following parameters on the master converter:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Master</th>
<th>Slave or parallel devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>p50110 Armature resistance (R_a)</td>
<td>Actual armature resistance × half the number of SINAMICS DCMs</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50111 Armature inductance (L_a)</td>
<td>Actual armature inductance × half the number of SINAMICS DCMs</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p51591 La reduction factor</td>
<td>-</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50155 Kp armature current controller</td>
<td>-</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50156 Tn armature current controller</td>
<td>-</td>
<td>The same as on the master</td>
</tr>
</tbody>
</table>

The parameter values from the above table must be transferred manually from the master converter to the slave converter.

The additional optimization runs are then carried out, starting with the optimization run for the speed control at the master converter.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Master</th>
<th>Parallel units</th>
</tr>
</thead>
<tbody>
<tr>
<td>p50110 Armature resistance (R_a)</td>
<td>Actual armature resistance × number of parallel units</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50111 Armature inductance (L_a)</td>
<td>Actual armature inductance × number of converters in parallel</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p51591 La reduction factor</td>
<td>-</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50155 Kp armature current controller</td>
<td>-</td>
<td>The same as on the master</td>
</tr>
<tr>
<td>p50156 Tn armature current controller</td>
<td>-</td>
<td>The same as on the master</td>
</tr>
</tbody>
</table>

The parameter values from the above table must be transferred manually from the master converter to the parallel slave converters.

The additional optimization runs are then carried out, starting with the optimization run for the speed control at the master converter.
Switchover of the power unit topology - option S50

Note
The SINAMICS DCM can only be equipped or retrofitted with option S50 in the factory.

In certain applications, it is necessary to switch between two different power unit topologies (such as between 12-pulse parallel connection and 12-pulse series connection) during operation by means of a command.

SINAMICS DCM converters with option S50 provide the control for this purpose. The actual switch between power unit topologies is performed with external contactors.

The detailed functionality and a recommended interconnection are provided in function block diagram 9360 in the SINAMICS DCM List Manual.

Please contact your local Siemens office or Customer Support for more information.

Prerequisites for the switchover of the power unit topology

- All SINAMICS DCMs involved must be equipped with option S50.
- No "n+m" mode may be used.
- The "parallel/series switching master" function must remain at the same SINAMICS DCM for both power unit topologies.
- SINAMICS DCM software version V1.3 or higher.
- All SINAMICS DCMs must have the same software version.

Parameter assignment

The following parameters must be set separately for the two power unit topologies:

**Power unit topology 1**
- p51799 Mode of operation of the armature converter
- p51800 Position of the power unit in the topology
- p51802 Number of active power units

**Power unit topology 2**
- p51794 Mode of operation of the armature converter
- p51795 Position of the power unit in the topology
- p51802 Number of active power units
Selection of the required power unit topology and function

The required power unit topology can be selected on the parallel switching master with a BICO input (see p51790) and is passed on internally to the parallel switching slaves. The p51790 setting on the parallel switching slaves has no effect.

If the required power unit topology does not match the currently active topology, a switchover is triggered. Switchovers that have been started are carried out in full, and only then is a further switchover possible.

Control of the contactors for the power unit topology

The contactors are controlled via two BICO outputs (see r53312.0 and r53312.1) on the parallel switching master, and these generate the selected power unit topology. The corresponding BICO outputs on the parallel switching slaves must not be used.

The contactors can only be switched in a de-energized state.

During power up of the SINAMICS DCM, both power unit topologies are switched off. After this, the two power unit topologies are mutually locked inside the device so that only one power unit topology can be switched on. For safety reasons, the contactors must also be mutually locked via auxiliary contacts as shown in function block diagram 9360.

Feedback from the active power unit topology

The active power unit topology is queried on the parallel switching master using a BICO input (see p51791). The corresponding BICO input on the parallel switching slave has no effect.

Switchover

The switchover of power unit topology is permitted in every operating state.

In the event of a switchover to the "Operation" state, current reduction, controller disable and firing pulse inhibit are carried out and then the hardware is switched via the contactors. With the feedback from the active power unit topology, the firing pulses and the controller are released again.

During the controller disable and firing pulse inhibit, the SINAMICS DCM is in operating state o1.8.

The duration of the current-free pause during the switchover is influenced primarily by the duration of the hardware switchover by the contactors.

Two times can be set:

- **p51792** Stabilization time for the feedback from the current power unit topology
  A change to the feedback signal is only effective if the signal features the new state continuously for longer than the stabilization time.
  During this time the previous state remains effective.

- **p51793** Maximum duration of switchover
  Once this time has elapsed, the feedback from the active power unit topology must match the one requested.
Controller optimization

The two power unit topologies generally require certain parameters, e.g., p50100 (rated motor current), p50110 (armature circuit resistance), p50111 (armature circuit inductance), controller gains, etc., to be set in accordance with the topology.

To do this, the drive data sets (DDS) must be used:

The BICO output for controlling the contactors (r53312.0) must be used as the DDS selection signal (p50820).

The optimization runs or the manual optimization for both power unit topologies must then be carried out separately and the determined values entered in index 0 or index 1 of the appropriate controller parameters.

Recommended procedure:

1. Carry out the optimization of power unit topology 1 in DDS 0 in full
2. Copy DDS 0 to DDS 1 (see p0819)
3. Carry out the optimization of power unit topology 2 in DDS 1

Note
A change to the selection of power unit topology during an optimization run leads to the cancelation of the optimization run with fault message F60052.

Monitoring functions

The following properties or states are monitored and in the event of an error result in fault message F60044:

- If power unit topology 2 is selected,
  - option S50 must be available
  - the master function must be set on the same SINAMICS DCM as for power unit topology 1
  - no "n+m" mode may be set (i.e., p51803 must = 0)

- The feedback signal must - except during a switchover of the topology - always match the selection signal.

- The maximum duration of the topology switchover may not exceed the assigned time.

Note
If fault message F60044 resulting from a change in the fault reaction (see p02100/p02101) or in the message type (see p02118/p02119) does not lead to the Fault operating state, the SINAMICS DCM remains in operating state o1.8 in the event of a fault.
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