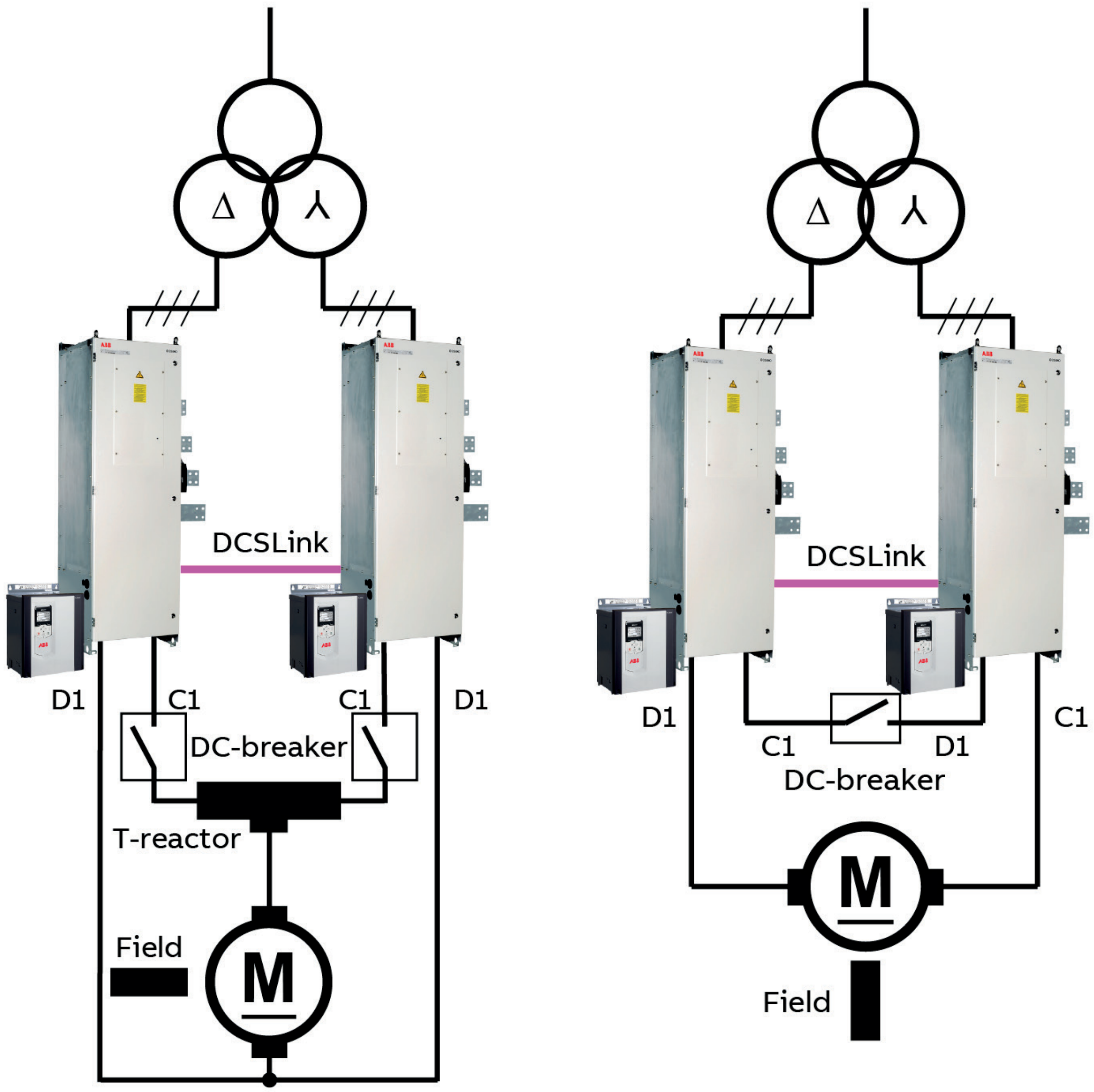
ABB INDUSTRIAL DRIVES

DCS880 drives
12-pulse manual



DCS880 Drive manuals

All the documents available for the drive system DCS880 are listed below:

		Language						
	Publication number	E	D	I	ES	F	CN	RU
General								
DCS880 Quick guide	3ADW000480	x						
Safety instructions all languages	3ADW000481	x	x	x	x	x	x	x
DCS880 Documentation pack	DCS880 CD download	x						
DCS880 Units								
DCS880 Flyer	3ADW000475	x	x			x		
DCS880 Technical catalog	3ADW000465	x						
DCS880 Hardware manual	3ADW000462	x						
DCS880 Firmware manual	3ADW000474	x						
DCS880 Service manual	3ADW000488	x						
DCS880 Hardparallel manual	3ADW000530	x						
DCS880 12-pulse manual	3ADW000533	x						
Instructions for mounting the SDCS-CMA-2	3ADW000396	x						
ACS-AP-x assistant control panels user’s manual	3AUA0000085685	x						
DCS Thyristor power converter – Technical guide	3ADW000163	x						
Functional safety								
Supplement for functional safety	3ADW000452	x						
Functional safety for enclosed converter								
+Q957 Prevention of unexpected Start Up	3ADW000504	x						
+Q951 Emergency stop, category 0 with MC opening	3ADW000505	x						
+Q952 Emergency stop, category 1 with MC opening	3ADW000506	x						
+Q963 Emergency stop, category 0 without MC opening	3ADW000507	x						
+Q964 Emergency stop, category 1 without MC opening	3ADW000508	x						
Enclosed converter								
Installation manual	3ADW000091	x	x					
DCS800-A +S880 Enclosed converters, flyer	3ADW000523	x	x					
Door mounting kits								
DPMP-01 mounting platform for ACS-AP control panel	3AUA0000100140	x						
DPMP-02 mounting platform for ACS-AP control panel	3AUA0000136205	x						
Serial communication								
FCAN-01 CANopen adapter module	3AFE68615500	x	x					
FDNA-01 DeviceNet™ adapter module	3AFE68573360	x						
FECA-01 EtherCAT adapter module	3AUA0000068940	x	x					
FENA-11/-21 Ethernet adapter module	3AUA0000093568	x						
FEPL-02 Ethernet POWERLINK adapter module	3AUA0000123527	x	x					
FPBA-01 PROFIBUS DP adapter module	3AFE68573271	x	x					
FSCA-01 RS-485 adapter module	3AUA0000109533	x						
FDCO-01/02 DDCS communication modules	3AUA0000114058							
Tool and maintenance manuals and guides								
Drive composer PC tool	3AUA0000094606	x						
Drive (IEC61131-3) application programming manual	3AUA0000127808	x						
Adaptive programming, Application guide	3AXD50000028574	x						
NETA-21 remote monitoring tool	3AUA0000096939	x						
NETA-21 remote monitoring tool guide	3AUA0000096881	x						
DDCS branching unit NDBU-95 user’s manual	3BFE64285513	x						
Extension modules								
FIO-11 Analog extension module	3AFE68784930	x						
FIO-01 Digital extension module	3AFE68784921	x						
FAIO-01 Analog extension module	3AUA0000124968	x						
FDIO-01 Digital extension module	3AUA0000124966	x						
FEN-01 TTL encoder interface	3AFE68784603	x						
FEN-31 HTL encoder interface	3AUA0000031044	x						
FEA-03 F series extension adapter	3AUA0000115811	x						
Ethernet tool network for ACS880 drives application guide	3AUA000012563	x						

Status 05.2019 x → existing p → planned DCS880 Manuals list e h.docx

Table of contents

Safety instructions

What this chapter contains

This chapter contains the safety instructions you must follow when installing, operating and servicing the drive.
If ignored, physical injury or death may follow, or damage may occur to the drive, the motor or driven equipment. Read the safety instructions before you work on the unit.

To which products this chapter applies

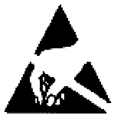
The information is valid for the whole range of the product DCS880, the converter modules DCS880-S0x size H1 … H8, field exciter units DCF80x, etc. like the Rebuild Kit DCS880-R00.

Usage of warnings and notes

There are two types of safety instructions throughout this manual: warnings and notes. Warnings caution you about conditions which can result in serious injury or death and/or damage to the equipment, and advice on how to avoid the danger. Notes draw attention to a particular condition or fact or give information on a subject.
The warning symbols are used as follows:

Dangerous voltage warning warns of high voltage which can cause physical injury or death and/or damage to the equipment.

General danger warning warns about conditions, other than those caused by electricity, which can result in physical injury or death and/or damage to the equipment.



Electrostatic sensitive devices warning warns of electrostatic discharge which can damage the equipment.

Installation and maintenance work

These warnings are intended for all who work on the drive, motor cable or motor. Ignoring the instructions can cause physical injury or death and/or damage to the equipment.

WARNING

- **Only qualified electricians are allowed to install and maintain the drive!**
- Never work on the drive, motor cable or motor when main power is applied.
- Always ensure by measuring with a multimeter (impedance at least 1 MΩ) that:
  - 1. Voltage between drive input phases U1, V1 and W1 and the frame is close to 0 V.
  - 2. Voltage between terminals C+ and D- and the frame is close to 0 V.
- Do not work on the control cables when power is applied to the drive or to the external control circuits. Externally supplied control circuits may cause dangerous voltages inside the drive even when the main power on the drive is switched off.
- Do not make any insulation resistance or voltage withstand tests on the drive or drive modules.
- Isolate the motor cables from the drive when testing the insulation resistance or voltage withstand of the cables or the motor.
- When reconnecting the motor cable, always check that the C+ and D- cables are connected with the proper terminal.

Notes:
- The motor cable terminals on the drive are at a dangerously high voltage when the main power is on, regardless of whether the motor is running or not.
- Depending on the external wiring, dangerous voltages (115 V, 220 V or 230 V) may be present on the relay outputs of the drive system (e.g. XRO1 … XRO3).
- DCS880 with enclosure extension: Before working on the drive, isolate the whole drive system from the supply.

Grounding

These instructions are intended for all who are responsible for the grounding of the drive. Incorrect grounding can cause physical injury, death and/or equipment malfunction and increase electromagnetic interference.

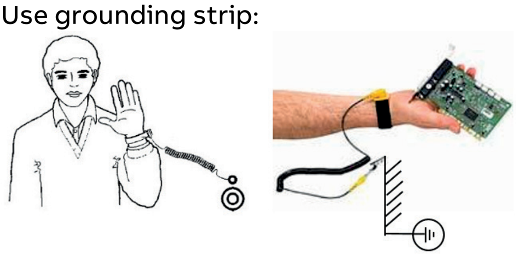
WARNING
- Ground the drive, motor and adjoining equipment to ensure personnel safety in all circumstances, and to reduce electromagnetic emission and pick-up.
- Make sure that grounding conductors are adequately sized and marked as required by safety regulations.
- In a multiple-drive installation, connect each drive separately to protective earth (PE ⏚).
- Minimize EMC emission and make a 360° high frequency grounding (e.g. conductive sleeves) of screened cable entries at the cabinet lead-through plate.
- Do not install a drive equipped with an EMC filter to an ungrounded power system or a high resistance-grounded (> 30 Ω) power system.

Notes:
- Power cable shields are suitable as equipment grounding conductors only when adequately sized to meet safety regulations.
- As the normal leakage current of the drive is higher than 3.5 mA_{AC} or 10 mA_{DC} a fixed protective earth connection is required.
- This product can cause a DC current in the protective earthing conductor. Where a residual current-operated protective (RCD) or monitoring (RCM) device is used for protection in case of direct or indirect contact, only an RCD or RCM of Type B is allowed on the supply side of this product.

Printed circuit boards and fiber optic cables

These instructions are intended for all who handle the circuit boards and fiber optic cables. Ignoring the following instructions can cause damage to the equipment.

WARNING
- The printed circuit boards contain components sensitive to electrostatic discharge. Wear a grounding wrist band when handling the boards. Do not touch the boards unnecessarily.
- Use grounding strip:



- ABB order no.: 3ADV050035P0001

WARNING
- Handle the fiber optic cables with care.
- When unplugging optic cables, always grab the connector, not the cable itself.
- Do not touch the ends of the fibers with bare hands as the fiber is extremely sensitive to dirt.
- The minimum allowed bend radius is 35 mm (1.38 in.).

Mechanical installation

These notes are intended for all who install the drive. Handle the unit carefully to avoid damage and injury.

WARNING
- DCS880 sizes H4 ... H8:
  - The drive is heavy. Lift the drive by lifting lugs only.
  - The drive’s center of gravity is high. Do not tilt the unit. The unit will overturn from a tilt of about 6 degrees. An overturning drive can cause physical injury.
  - Do not lift the unit by the front cover.
  - Place units H4 … H6 only on their back.
- Make sure that dust from drilling does not enter the drive when installing. Electrically conductive dust inside the unit may cause damage or lead to malfunction.
- Ensure sufficient cooling.
- Do not fasten the drive by riveting or welding.

Operation

These warnings are intended for all who plan the operation of the drive or operate the drive. Ignoring the instructions can cause physical injury or death and/or damage to the equipment.

WARNING
- Before adjusting the drive and putting it into service, make sure that the motor and all driven equipment are suitable for operation throughout the speed range provided by the drive. The drive can be adjusted to operate the motor at speeds above and below the base speed.
- Do not control the motor with the disconnecting device (disconnecting mains); instead, use the control panel keys and , or commands via the I/O board of the drive.
- Mains connection:
  You can use a disconnect switch (with fuses) to disconnect the electrical components of the drive from the mains for installation and maintenance work. The type of disconnect switch used must be as per EN 60947-3, Class B, so as to comply with EU regulations, or a circuit-breaker type which switches off the load circuit by means of an auxiliary contact causing the breaker's main contacts to open. The mains disconnect must be locked in its "OPEN" position during any installation and maintenance work.
- EMERGENCY STOP buttons must be installed at each control desk and at all other control panels requiring an emergency stop function. Pressing the STOP button on the control panel of the drive will neither cause an emergency stop of the motor, nor will the drive be disconnected from any dangerous potential.
- To avoid unintentional operating states, or to shut the unit down in case of any imminent danger according to the standards in the safety instructions it is not sufficient to merely shut down the drive via signals "RUN", "drive OFF" or "Emergency Stop" respectively "control panel" or "PC tool".
- Intended use:
- The operating instructions cannot take into consideration every possible case of configuration, operation or maintenance. Thus, they mainly give such advice only,

which is required by qualified personnel for normal operation of the machines and devices in industrial installations.

- If in special cases the electrical machines and devices are intended for use in non-industrial installations - which may require stricter safety regulations (e.g. protection against contact by children or similar) - these additional safety measures for the installation must be provided by the customer during assembly.

Note:

- When the control location is not set to Local (Local not shown in the status row of the display), the stop key on the control panel will not stop the drive. To stop the drive using the control panel, press the Loc/Rem key and then the stop key .

Introduction to this manual

Chapter overview

This chapter describes the purpose, contents and the intended use of this manual.

Before You Start

The purpose of this manual is to provide you with the information necessary to control and program a 12-pulse drive. This includes:

- The different types of 12-pulse configurations and their operation principles.
- The required hardware.
- The required firmware.
- The needed parameters.
- The start-up of a 12-pulse configuration.

Study carefully the Safety instructions at the beginning of this manual before attempting any work on or with a 12-pulse drive. Read through this manual before starting-up a 12-pulse drive. The installation and commissioning instructions given in the DCS880 Hardware manual and DCS880 Quick guide must also be read before proceeding.
This manual describes the **standard** DCS880 firmware.

What this manual contains

The Safety instructions can be found at the beginning of this manual.

Introduction to this manual, the chapter you are currently reading, introduces you to this manual.

12-pulse technology describes:

- 12-pulse technology.
- Types of 12-pulse configurations.
- Types of transformers.
- Needed T-reactors.
- High-speed DC-breakers.
- Galvanic isolation.
- Advanced current measurement.
- DCSLink.
- Drive logic.

12-pulse parallel configurations describes:

- Firmware configuration.
- Hardware configurations.
- 12-pulse parallel with one motor.
- 12-pulse parallel with two motors.

12-pulse serial/Serial sequential configurations describes:

- Firmware configuration,
- Hardware configurations,
- Measuring the DC voltage
- 12-pulse serial/Serial sequential with one motor,
- 12-pulse serial/Serial sequential with two motors and
- 12-pulse serial/Serial sequential in sandwich configuration.

Start-up provides information on how to commission the 12-pulse configurations using DCS880 thyristor converters.

Target group

This manual is designed to help those responsible for planning, installing, starting up and servicing thyristor power converters.
These people should possess:
- Basic knowledge of physics, electrical engineering, electrical wiring principles, components as well as symbols used in electrical engineering.
- Basic experience with DC drives and DC products.

Related documents

A list of related manuals is shown on the inside of the front cover under DCS880 Drive manuals.

Terms and abbreviations

Term/Abbreviation	Definition
AC 800M	Type of programmable controller manufactured by ABB.
ACS-AP-I	Types of control panel used with DCS880 drives.
ACS-AP-W	
AI	Analog input; interface for analog input signals.
AO	Analog output; interface for analog output signals.
D2D	Drive-to-drive; communication link between drives.
DCS800	A product family of ABB drives.
DDCS	Distributed drives communication system; a protocol used in communication between ABB drive equipment.
DI	Digital input; interface for digital input signals.
DIO	Digital input/output; interface that can be used as a digital input or output.
DO	Digital output; interface for digital output signals.
Drive	Converter to control DC motors.
DriveBus	A communication link used by, for example, ABB controllers. DCS880 drives can be connected to the DriveBus link of the controller.
DriveAP	Adaptive Programming of the drive.
Drive composer	PC tool for commissioning and maintenance of ABB drives.
Drive control unit	Contains the electronics of the drive. The power unit is connected to the drive control unit.
EFB	Embedded fieldbus interface.
FAIO-01	Optional analog I/O extension module.
FBA	Fieldbus adapter.
FCAN-01	Optional CANopen adapter.
FCNA-01	Optional ControlNet adapter.
FDCO-0x	Optional DDCS communication module.
FDIO-01	Optional digital I/O extension module.
FDNA-01	Optional DeviceNet adapter.
FEA-03	Optional I/O extension adapter.
FECA-01	Optional EtherCAT® adapter.
FEN-01	Optional TTL encoder interface module.
FEN-11	Optional absolute encoder interface module.

Term/Abbreviation	Definition
FEN-21	Optional resolver interface module.
FEN-31	Optional HTL encoder interface module.
FENA-11	Optional Ethernet/IP, Modbus/TCP and PROFINET IO adapter.
FENA-21	Optional dual-port Ethernet/IP, Modbus/TCP and PROFINET IO adapter.
FEPL-02	Optional POWERLINK adapter.
FIO-01	Optional digital I/O extension module.
FIO-11	Optional analog I/O extension module.
FPBA-01	Optional PROFIBUS DP adapter.
FPTC-01	Optional thermistor protection module.
FPTC-02	Optional ATEX-certified thermistor protection module for potentially explosive atmospheres.
FSCA-01	Optional Modbus/RTU adapter.
FSO-xx	Optional safety functions module.
HTL	High-threshold logic.
I/O	Input/Output.
ModuleBus	A communication link used by, for example, ABB controllers. ACS880 drives can be connected to the optical ModuleBus link of the controller.
Network control	With fieldbus protocols based on the Common Industrial Protocol (CIP™), such as DeviceNet and Ethernet/IP, denotes the control of the drive using the Net Ctrl and Net Ref objects of the ODVA AC/DC Drive Profile. For more information, see www.odva.org, and the following manuals: – FDNA-01 DeviceNet adapter module User's manual (3AFE68573360) – FENA-01/-11 Ethernet adapter module User's manual (3AUA0000093568).
Parameter	User-adjustable operation instruction to the drive.
PID controller	Proportional-integral-derivative controller. The speed control is based on a PID algorithm.
PLC	Programmable logic controller.
Power unit	Contains the power electronics and power connections of the drive. The drive control unit is connected to the power unit.
PTC	Positive temperature coefficient.
PU	See power unit.
RDCO-0x	DDCS communication module.
RFG	Ramp function generator.
RO	Relay output; interface for a digital output signal. Implemented with a relay.
Signal	Value measured or calculated by the drive.
SSI	Synchronous serial interface.
STO	Safe torque off.
TTL	Transistor-transistor logic.
UPS	Uninterruptible power supply; power supply equipment with battery to maintain output voltage during power failure.

Cybersecurity disclaimer

This product is designed to be connected to and to communicate information and data via a network interface.

It is the customer's sole responsibility to provide and continuously ensure a secure connection between the product and the customer network or any other network (as the case may be). The customer shall establish and maintain any appropriate measures (such as but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc.) to protect the product, the network, its system and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. ABB and its affiliates are not liable for damages and/or losses related to such security breaches, any unauthorized access, interference, intrusion, leakage and/or theft of data or information.

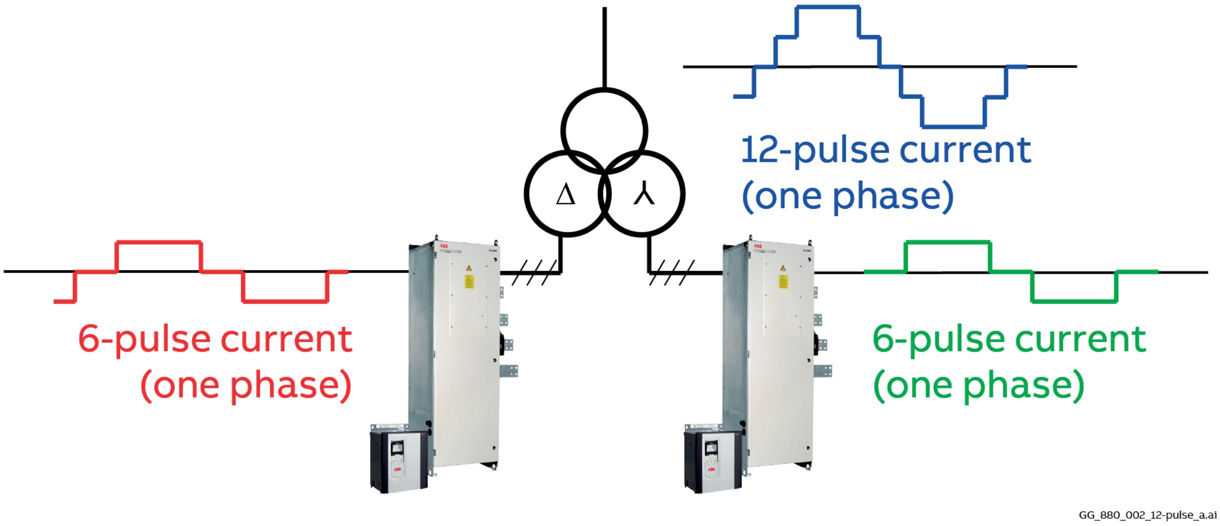
12-pulse technology

Definition of 12-pulse

The characteristic features of 12-pulse are:

– A DC drive consisting of two 6-pulse thyristor converters.
– A dedicated three winding 12-pulse transformer provides the AC power for both converter modules from separate secondary windings.
– The phase shift of the windings differs by 30°.

An example is a Delta/Delta/Star transformer:



Advantages of 12-pulse

The most significant advantages of 12-pulse technology are:

– Reduced level of harmonics on the primary side of the transformer.
– Expansion of the power range by doubling the drives output current (⇒ parallel configuration) or voltage (⇒ serial configuration).
– Possibility of emergency operation with one converter module in case of a breakdown in the other one.
– Improved motor efficiency due to reduced DC current ripple.

12-pulse harmonics

Harmonics on the AC side of a 6-pulse bridge (line current):

	h	5	7	11	13	17	19	23	25
Idealized	I_h / I_1	20 %	14 %	9 %	7 %	6 %	5 %	4 %	4 %
Typical	I_h / I_1	26 %	10 %	9 %	5 %	2 %	1 %	1 %	1 %

⇨ $THD_{Current}$ = 36.1 % (Total Harmonic Distortion of line current).

Harmonics on the AC side of a 12-pulse bridge (line current):

	h	5	7	11	13	17	19	23	25
Idealized	I_h / I_1	0 %	0 %	9 %	7 %	0 %	0 %	4 %	4 %
Typical	I_h / I_1	3 %	2 %	9 %	5 %	1 %	1 %	2 %	1 %

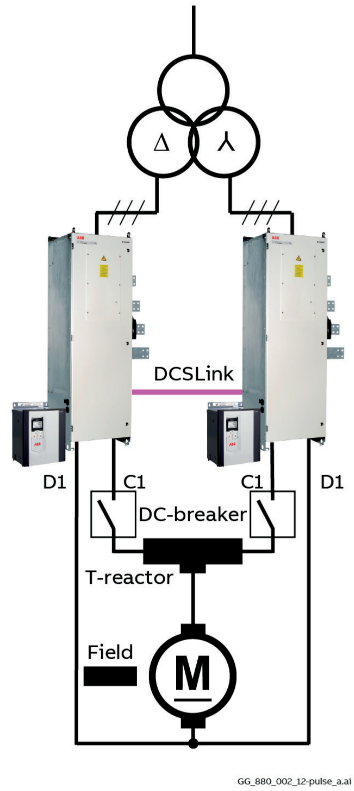
⇨ $THD_{Current}$ = 11.8 % (Total Harmonic Distortion of line current).

Types of 12-pulse configurations

12-pulse parallel configuration

Characteristics of 12-pulse parallel configuration:

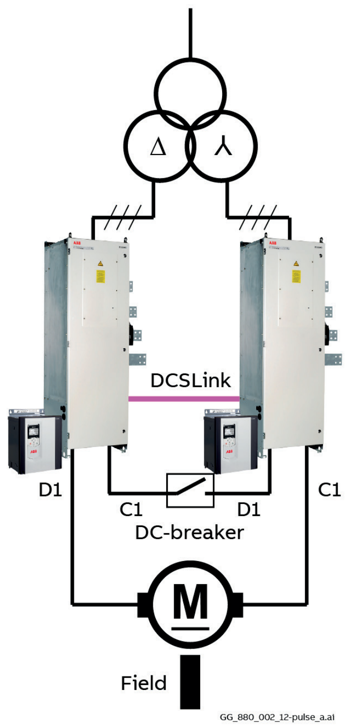
- Extension of power range by doubling the DC current.
- Suppression of line harmonics: 5th, 7th, 17th, 19th, … .
- 75 % less DC current ripple compared to 6-pulse.
- Reduced motor noise level.
- Higher motor efficiency.
- Communication between the converter modules via SDCS-DSL-H1x.
- High-speed DC-breakers are provided by ABB.
- Iron core T-reactors (interphase transformers) are provided by ABB.
- Emergency operation (one converter module only) with full speed at maximum 50 % torque possible.
- Maximum mains voltage is 500 V_{AC} (IEC)/525 V_{AC} (UL) for H1 … H5, 690 V_{AC} for H6, 800 V_{AC} for H7 and 1190 V_{AC} for H8 converter modules.
- The mains voltage for both converters must have the same level (e.g. 690 V_{AC}).



12-pulse serial configuration

Characteristics of 12-pulse serial configuration:

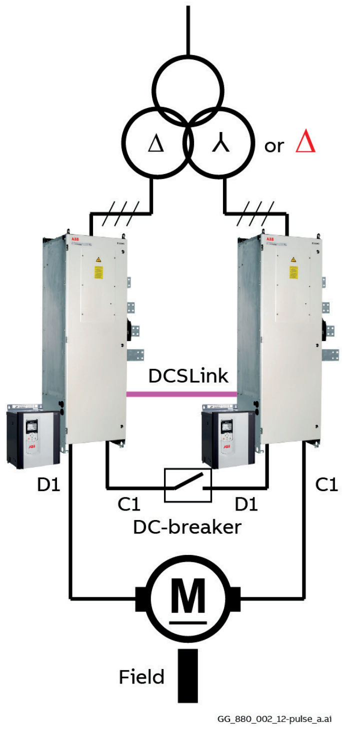
- Extension of power range by doubling the DC voltage.
- Suppression of line harmonics: 5th, 7th, 17th, 19th, … .
- 75 % less DC current ripple compared to 6-pulse.
- Reduced motor noise level.
- Higher motor efficiency.
- Communication between the converter modules via SDCS-DSL-H1x.
- High-speed DC-breaker is provided by ABB.
- Emergency operation (one converter module only) with maximum half speed at 100 % torque possible.
- Maximum mains voltage is 2 • 350 V_{AC} for H6 and 2 • 600 V_{AC} for H7/H8 converter modules (higher voltages for H8 converter modules on request).
- H1 … H5 are not used for 12-pulse serial.



Serial sequential configuration

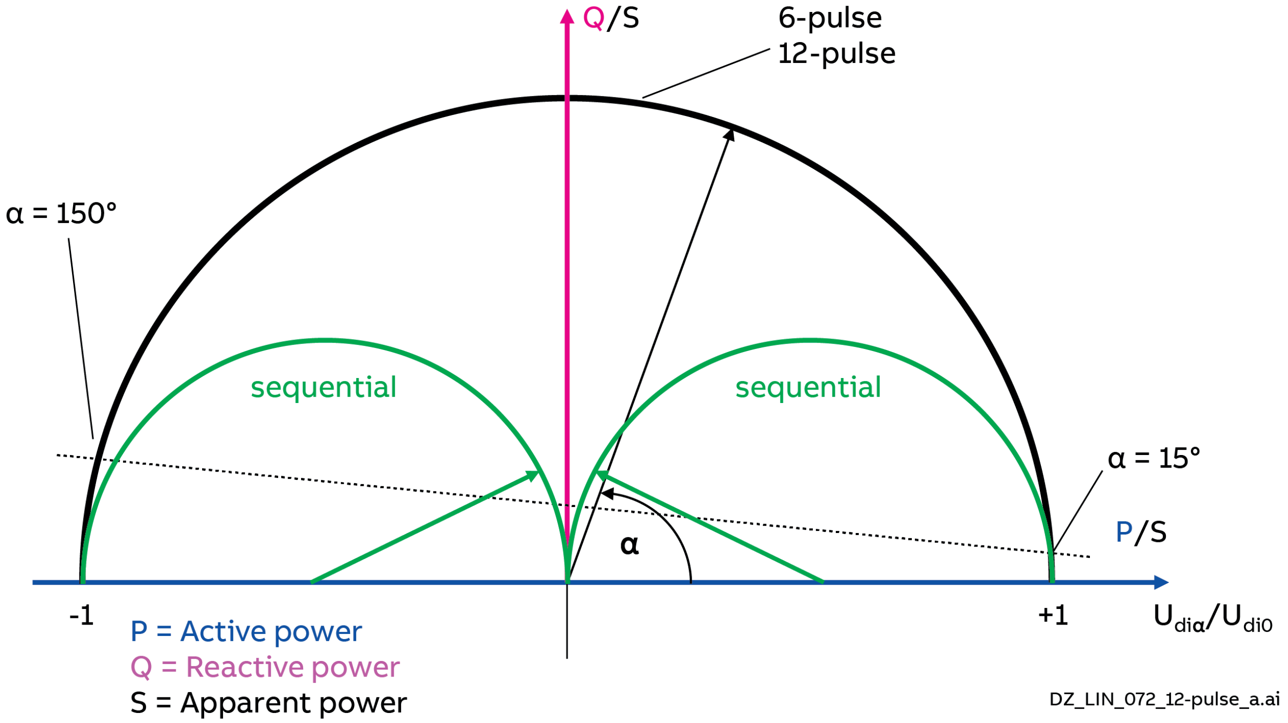
Characteristics of serial sequential configuration:

- Extension of power range by doubling the DC voltage.
- The motor gets the sum of both converters DC voltages but normally they are not equal.
- Reduced consumption of reactive power.
- Motor current is a mix between 12- and 6-pulse when using a transformer with 30° phase shift.
- Communication between the converter modules via SDCS-DSL-H1x.
- High-speed DC-breaker is provided by ABB.
- Emergency operation (one converter module only) with maximum half speed at 100 % torque possible.
- Maximum mains voltage is 2 • 350 V_{AC} for H6 and 2 • 600 V_{AC} for H7/H8 converter modules (higher voltages for H8 converter modules on request).
- H1 … H5 are not used for serial sequential.



The serial sequential configuration is identical with the 12-pulse serial configuration except that the phase shift of the two transformer secondary windings can be the same (e.g. Delta / Delta / Delta). Serial sequential can be set using 99.06 Operation mode.
When using serial sequential the motor current is a mix between 12- and 6-pulse when using a transformer with 30° phase shift. Thus, the motor must cope with a 6-pulse ripple of the armature current and the line current includes 6-pulse harmonics.

Reactive power consumption
Basically, the reactive power consumption is high, when the armature voltage of a converter is low. By controlling two converters in serial sequential, the reactive power consumption can be reduced. In serial sequential control one of the two converters is always operating with full positive or full negative armature voltage (the firing angle has reached the maximum or minimum limit) while the other is being controlled.
This way only one converter at a time will consume reactive power and thus the total reactive power consumption can be reduced.
This application is typically used for operation with full torque at low speeds (e.g. mine hoists, …).



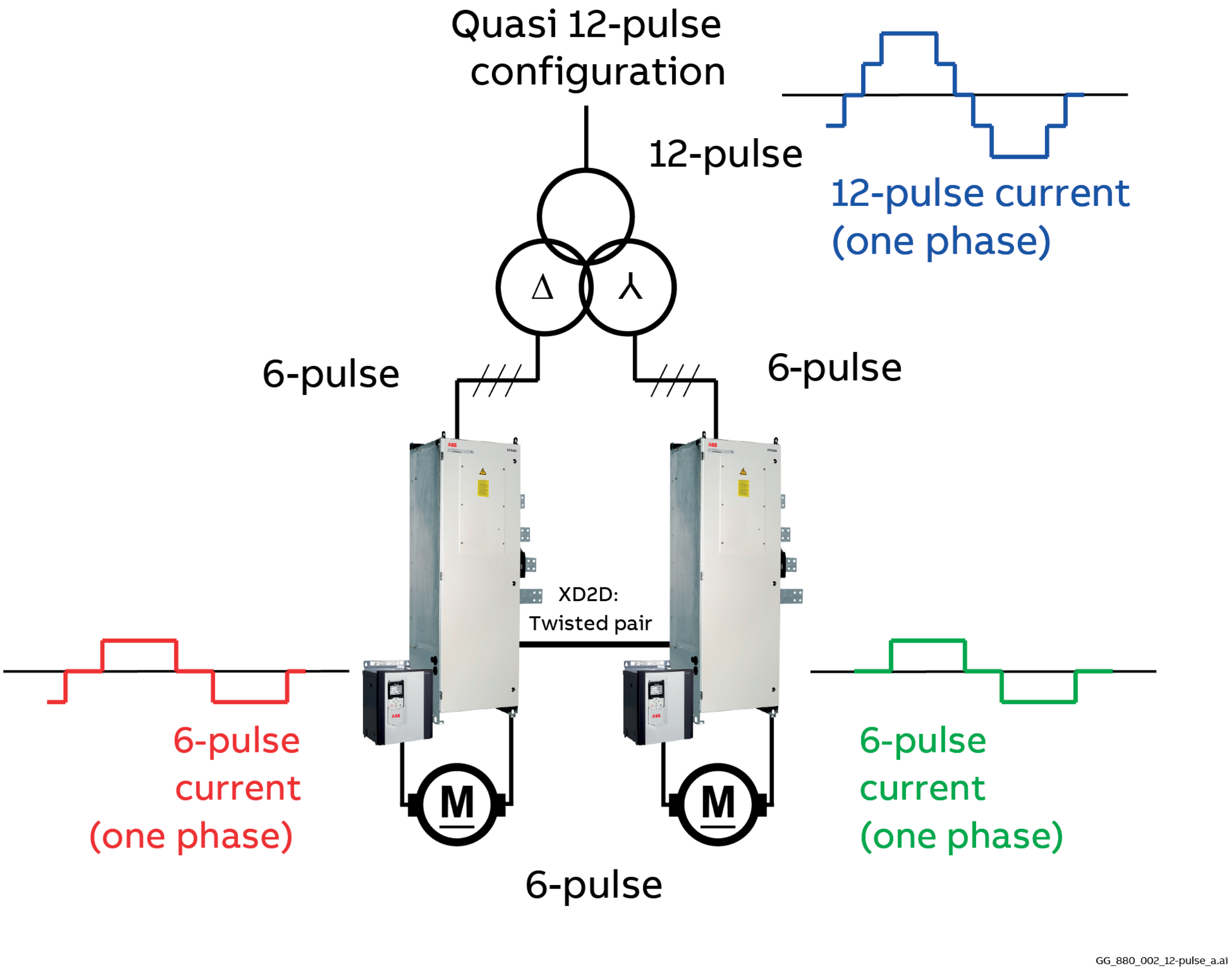
DZ_LIN_072_12-pulse_a.ai

The above figure shows the power consumption as a function of the armature voltage for a serial sequential configuration. As one can see the peak of the reactive power consumption decreases considerably compared to that of a 6-pulse or 12-pulse serial configuration. The difference is obvious at low armature voltages (low speeds). For example, to reach zero armature voltage one drive is supplying maximum positive voltage and the other is supplying maximum negative voltage. Thus, serial sequential configurations are used for drives supplying large currents at low speeds for a lengthy time.

Quasi 12-pulse

Characteristics of quasi 12-pulse configuration:

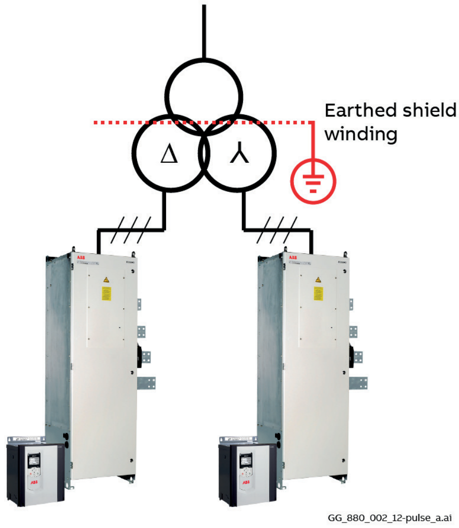
- Suppression of line harmonics: 5th, 7th, 17th, 19th, … on the primary side of the three winding 12-pulse transformer.
- Communication between the converter modules via master-follower.



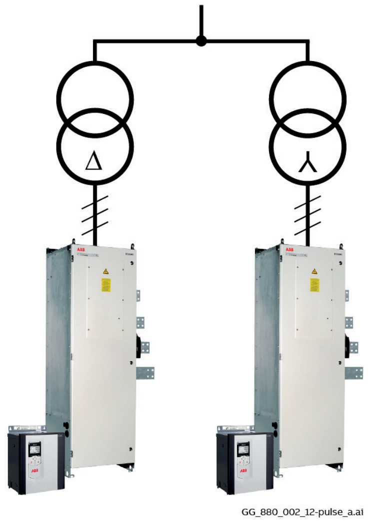
In a master-follower configuration the speed control is usually performed by the master. Current and field control are independently carried out by master and follower. Each motor is supplied with a 6-pulse voltage. But the line current on the primary side of the three winding 12-pulse transformer is a 12-pulse current.

Converter transformers used for 12-pulse configurations

In most 12-pulse systems the modules are connected to a dedicated three winding converter transformer. A three winding converter transformer has one primary winding and two secondary windings. Each of the secondary windings is only supplying one of the two converter modules, thus the name dedicated converter transformer.



It is also possible to use two dedicated converter transformers with 30° phase shift, one for each converter module. The mains voltage for both converters must have the same level (e.g. 690 V_{AC}).



Differences between standard transformers and converter transformers

Converter transformers are specially designed to be used together with converters. They are designed to withstand the higher demands of the converter operation:

- The converter transformer mechanical design achieves high short circuit strength and low forces during a short circuit.
- Reduced u_k (relative voltage drop) compared to standard transformers.
- The converter transformer has a high thermal capacity. Thus, it can resist frequent overloads up to 250 %, which typically happens when used to supply main drives in rolling mills.
- The converter transformer core is laminated, and its windings are designed to reduce circulating currents and thus losses due to current harmonics.
- The converter transformer windings have a better insulation to resist the voltage spikes of commutation notches.
- The converter transformer has an earthed shield winding between the primary and the secondary winding to ensure that overvoltages are kept away from converter modules when the mains voltage is connected to its primary side. This shield is also very useful to suppress capacitive feed through during switching operations on the primary side of the transformer. In addition, the shield also suppresses EMC from the converter to the upstream network.
- The converter transformer must resist DC components in the mains current which cause additional losses and can damage the core. Thus, temperature supervision is mandatory.

Additional details to be taken into consideration

To avoid overvoltages, switch on the components gradually. First connect the mains to the primary side of the converter transformer and then connect the secondary side of the converter transformer to the converter.
Another option is to incorporate RC elements on the secondary side of the converter transformer.

Dimensioning

Dimensioning is determined solely by the electrical conditions involved, like:

- Line frequency.
- Primary side voltage.
- Secondary side voltage.
- Converter module mains voltage.
- Rated current of the converter modules. Converter transformers with a high relative voltage drop - u_k - creating synchronization problems with the mains. Additionally, when regenerating, a high u_k strongly reduces the commutation reserve. Thus, drives with high peak load require transformers with a u_k of 6 % or smaller.
- Nominal current of the motor.
- Detailed duty load cycle of the motor.

To dimension the converter transformer, calculate the converter transformer power using following formula:

$$S = \frac{0.82 * I_{MotN} * \sqrt{3} * U_{Mains}}{1000} [kVA]$$

With: S = apparent power [kVA] of the converter transformer.
0.82 = conversion factor from DC current to AC current.
I_{MotN} = nominal motor current [A].
U_{Mains} = converter module mains voltage [V].

Take the motor overload into account when adapting the converter transformer u_k and its overload according to the relationship between converter transformer u_k, converter transformer overload and β (thyristor recovery time). With firing angle α plus thyristor recovery time β less or equal 180° ($\alpha + \beta = 180°$) and α_{max} = 150° follows the absolute maximum of β = 30°. Below table shows the maximum β at a certain transformer overload depending on its u_k.

Converter transformer u_k	4 %	5 %	6 %	7 %	8 %	9 %
Converter transformer overload	β					
150 %	22.6°	25.2°	27.5°	29.8°	31.9°	33.9°
200 %	26.1°	29.9°	31.9°	34.5°	37.0°	39.4°
250 %	29.3°	32.7°	35.5°	38.7°	41.5°	-
300 %	32.1°	35.9°	39.9°	42.6°	-	-
325 %	33.5°	37.7°	41.0°	-	-	-

Example:
With I_{MotN} = 3800 A_{DC} and U_{Mains} = 750 V_{AC} follows:

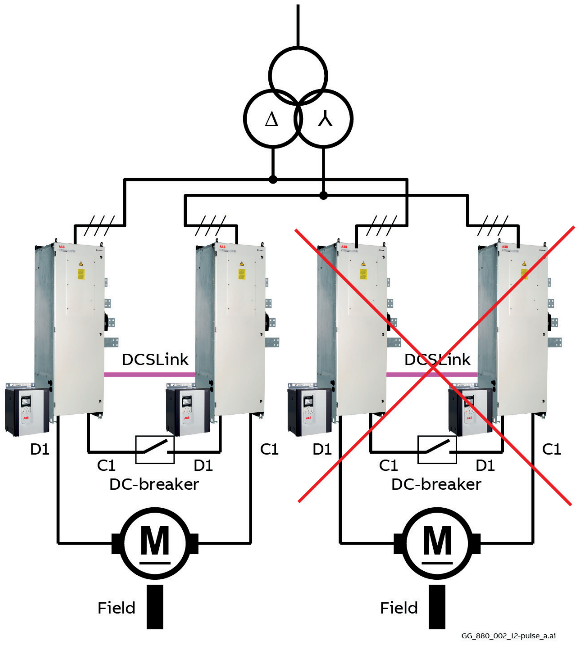
$$S = \frac{0.82 * 3800\,A * \sqrt{3} * 750\,V}{1000} = 4048\,kVA = 4.048\,MVA$$

In case the motor is running with nominal load the converter transformer power is about 4 MVA.
In case the motor is overloaded for a short time the converter transformer can also be overloaded.
Depending on the u_k of the converter transformer the overload capability is different. From the table above follows:

- If the u_k of the converter transformer is 4 % it can be overloaded by 250 %.
- If the u_k of the converter transformer is 5 % it can be overloaded by 200 %.
- If the u_k of the converter transformer is 6 % it can be overloaded by 150 %.

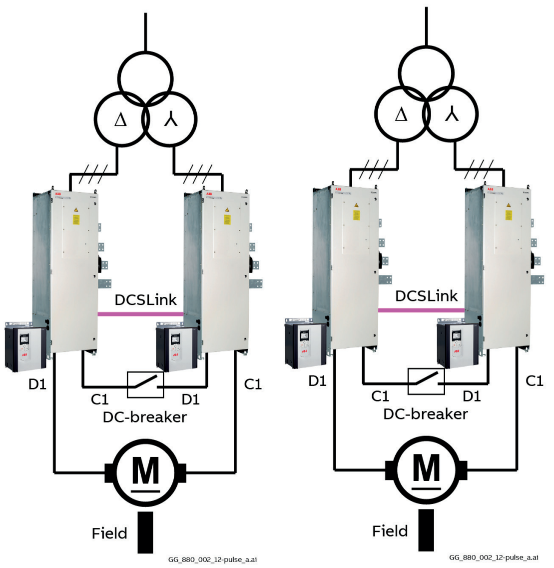
Two 12-pulse systems connected to one transformer

For physical reasons it is not possible to connect two 12-pulse systems at one common transformer. Because the voltage level between the two secondary windings (one in star and the other in delta) is controlled by the switching (control angle) of the first 12-pulse system. Connecting a second 12-pulse system creates circulating currents. Blown fuses or thyristor damages can be the result.

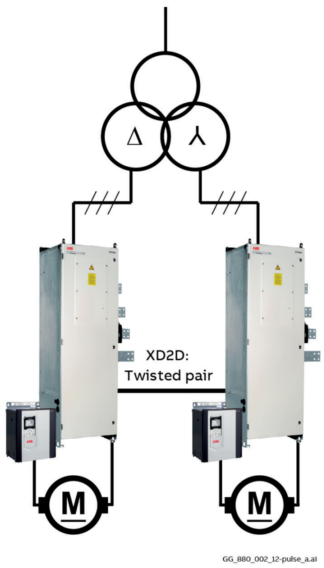


Permitted solutions

The use of two separate transformers, thus having two separate 12-pulse systems.



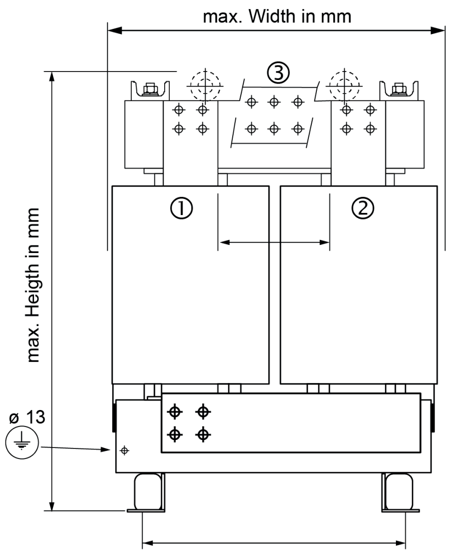
The use of a quasi 12-pulse system.



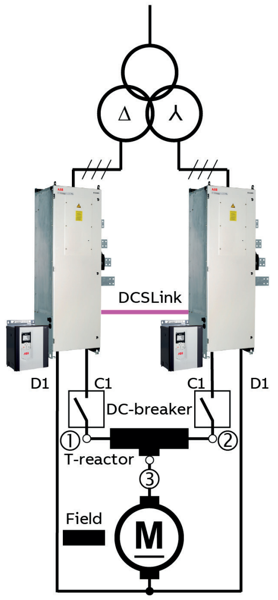
T-reactors (interphase transformers)

Characteristics of iron core T-reactors:

- Providing a maximum decoupling between the converters with a minimum additional inductance for the motor control (in case the inductance of an air core reactor is smaller than the motor inductance the dynamics of the current control is reduced).
- Used in 12-pulse parallel configurations.
- Customized iron core T-reactors (interface transformers) are provided by ABB.
- Have a high overload capability.
- Iron core T-reactors are easy integrated into cabinets.
- Iron core T-reactors are smaller than air-core reactors or 2 individual DC chokes.
- The T-reactor is a current compensating choke operating with different currents between terminals ① and ②.



ME_DRO_009_t-reactor_a.ai



GG_880_002_12-pulse_a.ai

T-reactors, also known as interphase transformers, are only used in 12-pulse parallel configurations. The 30° phase shift between 12-pulse master and 12-pulse slave mains voltages generates an instantaneous voltage difference between the output voltages of both converters. The maximum amount of this difference is 50 % of the peak value of the mains voltage. The T-reactor absorbs this instantaneous voltage difference and provides the typical 12-pulse current to the DC-motor.

T-reactors are provided by ABB. To be able to deliver the correct T-reactor for the drive the following data will be needed, the:

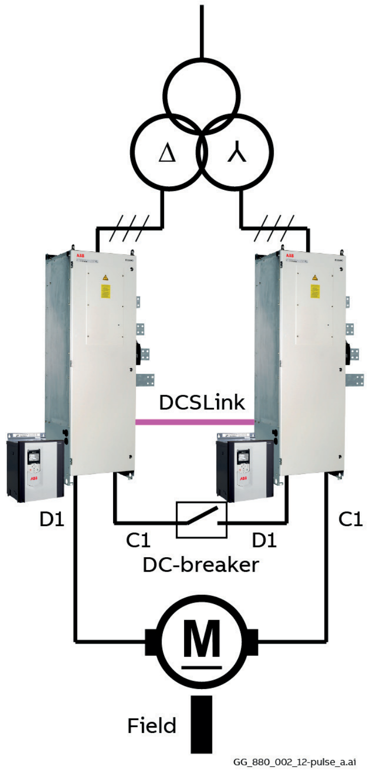
- Mains voltage of both converters (the mains voltage for both converters must have the same level; e.g. 690 V_{AC}).
- Tolerance of the mains voltage (e.g. ± 10 %).
- Nominal current of the motor.
- EMF of the motors normal operating point.
- Line frequency.
- Detailed duty load cycle of the motor.

In case the drive is used for non-motoric applications all details are needed, such as:

- Kind of application.
- Resistance of the load.
- Inductivity of the load.
- Capacity of the load.
- Requested du/dt characteristics of the output voltage etc.

High-speed DC-breakers

Characteristics of high-speed DC-breakers:
- Protect the DC-motors against overcurrent.
- Use fast magnetic trip coils.
- Feature trip relays (On-Off relay) which are controlled by the drives.
- A special, fast trip relay is available.
- Overcurrent trips are resettable, thus higher availability of the drives.
- Strongly recommended for drives without AC breakers.
- High-speed DC-breakers are provided by ABB.
- ABB integrates high-speed DC-breakers into drive cabinets.

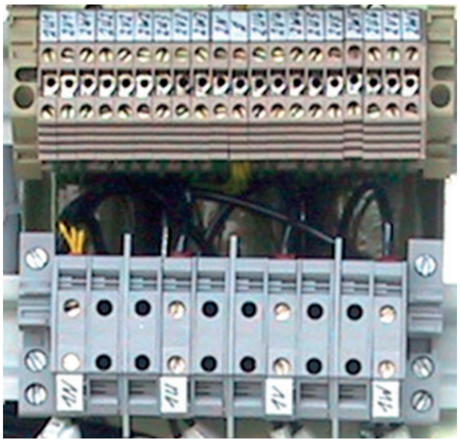


High-speed DC-breakers can extinguish excessive DC currents immediately. Thus, DC motors can be protected against overcurrents causing damages e. g. flash over at the commutator. Usually the high-speed DC-breaker trips itself when an overcurrent occurs. This is done by means of a fast magnetic overcurrent trip coil.
It is also possible to trip the high-speed DC-breaker with a trip command from the drive. This trip signal is generated by motor or drive overcurrent, mains undervoltage and too fast current rise. To reduce the delay time before the high-speed DC-breaker is opened after a trip command from the drive, fast tripping relays are available.
When using high-speed DC-breakers overcurrent trips become resettable, because they switch before other parts in the system, for example fuses, become damaged. Thus, the availability of the whole drive increases.
High-speed DC-breakers are strongly recommended when using drives without AC breakers to ensure, that the DC motors are protected against damage from overcurrent.
ABB is also providing high-speed DC-breakers and integrates them into the drive lineups.

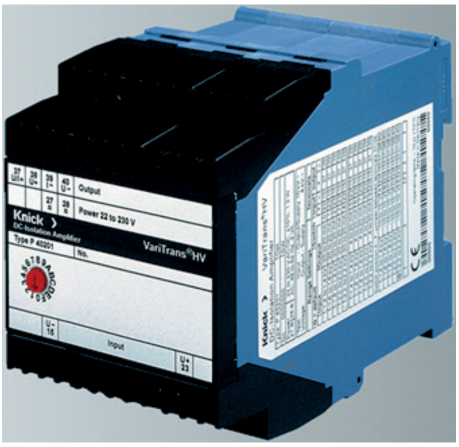
Galvanic isolation

Usually the DC- and AC-voltage is measured via high ohmic resistors with a scaling of 1 MΩ per 100 V.
Galvanic isolation is used to isolate the DC- and AC- high resistance voltage measurement circuits of the converter modules from high DC- and AC-voltages. It is typically used when either the mains voltage or the motor voltage is higher than 690 V.
Only the DC- and AC- high resistance voltage measurement circuits must be galvanically isolated, because the current measurement is already isolated via current transformers (CTs). Galvanic isolation is used in both 6-pulse and 12-pulse systems.
To isolate the AC-voltage measurement a special isolation AC transformer for all three phases is needed. The DC-voltage measurement is isolated by means of a DC transducer. To complete the galvanic isolation of the voltage measurement circuit a standard SDCS-PIN-H51 is needed inside the converter module. Thus, galvanic isolation is only possible for converter sizes H6 … H8.
The transformer, the DC-DC transducer are provided by ABB.

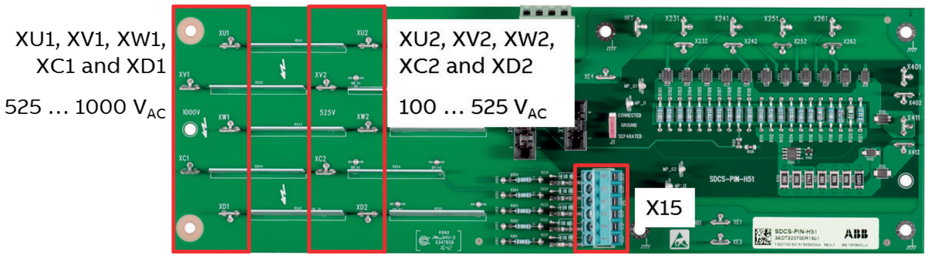
AC transformer T90



DC transducer A92



SDCS-PIN-H51



AC- and DC-voltage measurement:
- For galvanic isolation a standard SDCS-PIN-H51 can be used. AC transformer T90 and DC transducer A92 are connected via X15.
- Standard mains voltage measurements from 100 … 525 V_{AC} using XU2, XV2, XW2, XC2 and XD2.
- Standard mains voltage measurements from 525 … 1000 V_{AC} using XU1, XV1, XW1, XC1 and XD1.

Galvanic isolation (standard)

Settings from 500 V_{AC} to 1190 V_{AC}.

Nominal mains voltage (99.10 Nominal mains voltage)	AC transformer terminals T90 (3ADT745047P1)	DC transducer position A92 (P42000D3-0111, 3ADN260008P1)	Hardware coding (95.28 Set: Drive AC voltage scaling
100 … 525 V_{AC}	2U1-2V1-2W1	0 (675 V)	500 V_{AC}
270 … 600 V_{AC}	2U2-2V2-2W2	1 (810 V)	600 V_{AC}
315 … 690 V_{AC}	2U3-2V3-2W3	2 (945 V)	690 V_{AC}
360 … 800 V_{AC}	**2U4-2V4-2W4**	**3 (1080 V)**	**800 V_{AC}**
450 … 1000 V_{AC}	2U5-2V5-2W5	5 (1350 V)	1000 V_{AC}
540 … 1190 V_{AC}	2U6-2V6-2W6	6 (1620 V)	1190 V_{AC}

Depending on the mains voltage different settings must be chosen. With a mains voltage of 750 V_{AC}:
- Set 99.10 Nominal mains voltage = 750 V.
- The AC transducers terminals 2U4-2V4-2W4 must be used.
- The DC transducer must be set to position (3) with a maximum voltage of 1080 V_{DC}.
- The hardware coding must be set to the maximum value of the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = 800 V.
- For galvanic isolation a standard SDCS-PIN-H51 can be used. AC transformer T90 and DC transducer A92 are connected via X15.

For more information see chapter Galvanic isolation of the DCS880 Hardware manual.

Galvanic isolation (12-pulse serial and serial sequential)

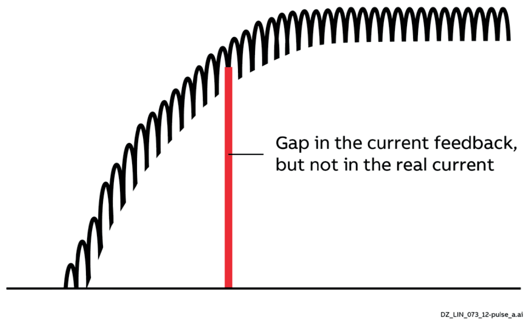
Settings from 1000 V_{AC} to 1500 V_{AC}.

Nominal mains voltage (99.10 Nominal mains voltage)	AC transformer terminals T90 (3ADT745053P1)	DC transducer position A92 (P42001D3, 3ADV050096P7)	Hardware coding (95.28 Set: Drive AC voltage scaling)
2 • 400 … 2 • 500 V_{AC}	2U5-2V5-2W5	A (1400 V)	1000 V_{AC}
2 • 500 … 2 • 600 V_{AC}	2U6-2V6-2W6	B (1600 V)	1200 V_{AC}
2 • 600 … 2 • 725 V_{AC}	2U7-2V7-2W7	E (2200 V)	1500 V_{AC} (H8 only)

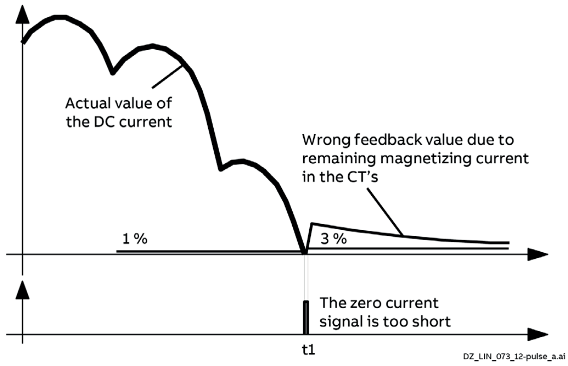
Advanced current measurement

For DC current measurement ABB DC drives are equipped with CTs (current transformers) on the AC side. If such drives are connected at weak mains and the current controller is tuned for fast response an interaction between the networks and the drives can happen. All 12-pulse configurations with converter currents over 1000 A have this impact on the current measurement.
The problem either appears as a current instability or an increase of the bridge reversal time due to remaining magnetizing current in the CTs.

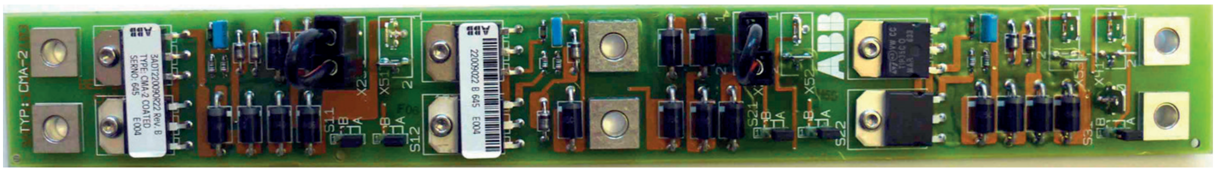
Current instability.



Remaining magnetizing current in the CTs.



To avoid the problems all converters over 1000 A should be equipped with the current measurement aid SDCS-CMA-2.

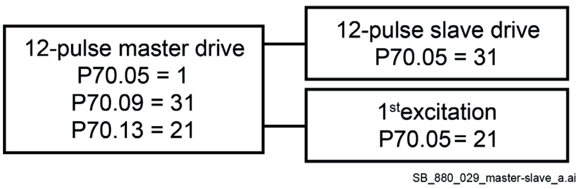


DCSLink

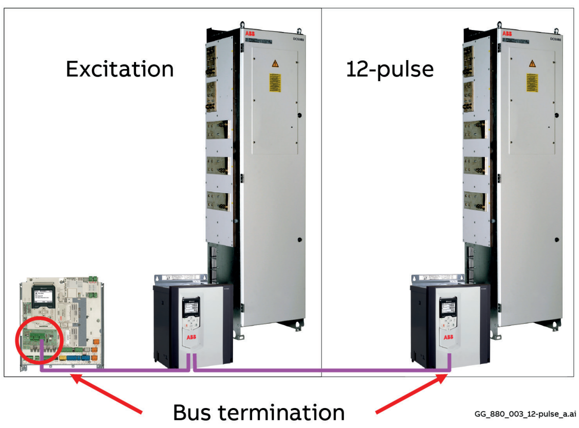
The DCS880 is equipped with the DCSLink to communicate with several different converters via the same hardware:

- Communication from 12-pulse master to external field exciter.
- Communication from 12-pulse master to 12-pulse slave.
- Communication supervision.

The DCSLink can be set up as follows.

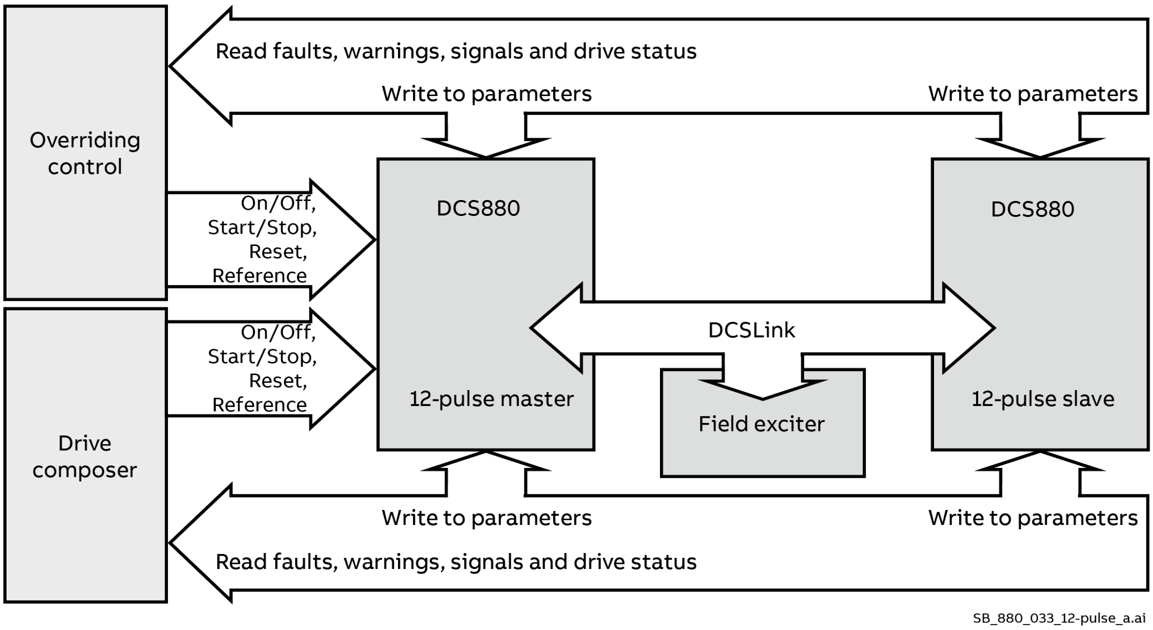


12-pulse and excitation.



Drive Logic

The switch-on/switch-off options for the DCS880 are multifarious, as are the possible switching and operator control locations, like unit terminals, overriding control system, control panel or Drive composer. To not lose this flexibility, we have refrained from changing the 6-pulse standard drive logic. Thus, the DCS880 12-pulse drive logic is based on the standard DCS880 drive logic.
The complete drive (12-pulse master and 12-pulse slave) is controlled by the 12-pulse master. This function is activated in the 12-pulse slave by means of 20.01 Command location = 12-pulse link. Thus, it is enough to connect only the 12-pulse master to the overriding control system.
It is strongly recommended to connect the 12-pulse slave as well to the overriding control system if its detailed status is needed or parameters must be written to.
The same is valid for Drive composer pro.



The overriding control needs to send the signals On/Off, Start/Stop, Reset and the reference only to the 12-pulse master. Then the signals are sent via 29.01 12-pulse master status word and the DCSLink to 06.09 Used main control word of the 12-pulse follower. The 06.01 Main control word of the 12-pulse slave is not valid.
In case parameters like controller gains, motor ratings, operation mode, etc. must be changed it is better to send them directly to the 12-pulse slave.

Emergency operation

An emergency operation can be used in case of a breakdown of one converter:
- The parameters for 6-pulse single operation (emergency operation) can be saved and activated in each converter by means of 96.22 User set save/load.
- It is mandatory that both converters have a connection to the overriding control system.
- The field exciter is already connected to both converters by means of the DCSLink, thus only the addresses must be changed.
- Both converters need to be connected to all acknowledge signal from the auxiliary circuits. Their activation is done via group 20.Start/stop/direction.
- Both converters need to be connected to the emergency stop circuit. The activation is done by means of 20.05 Emergency stop source.
- For 12-pulse serial and serial sequential a special short circuit busbar for emergency operation can be ordered from ABB.
- To perform an emergency operation with only one mains contactor a more detailed investigation is required as the handling of the mains contactor must be switched over from the 12-pulse master to the emergency converter (usually the 12-pulse slave).

Tripping behavior

Tripping of the 12-pulse master:

– The 12-pulse master trips according the faults trip level, see DCS880 Firmware manual. The slave is switched off via the DCSLink.

Tripping of the 12-pulse slave:

– The 12-pulse slave trips according the faults trip level, see DCS880 Firmware manual. The 12-pulse master is tripped with F536 12-pulse slave via the DCSLink.

Reset sequence:

– To reset a 12-pulse drive, the overriding control system must send following commands to the 12-pulse master:
    1. Reset.
    2. Off.
    3. start sequence.
– The drive can be also reset via Drive composer, the control panel or via the hardware reset. See 20.13 Reset fault source.

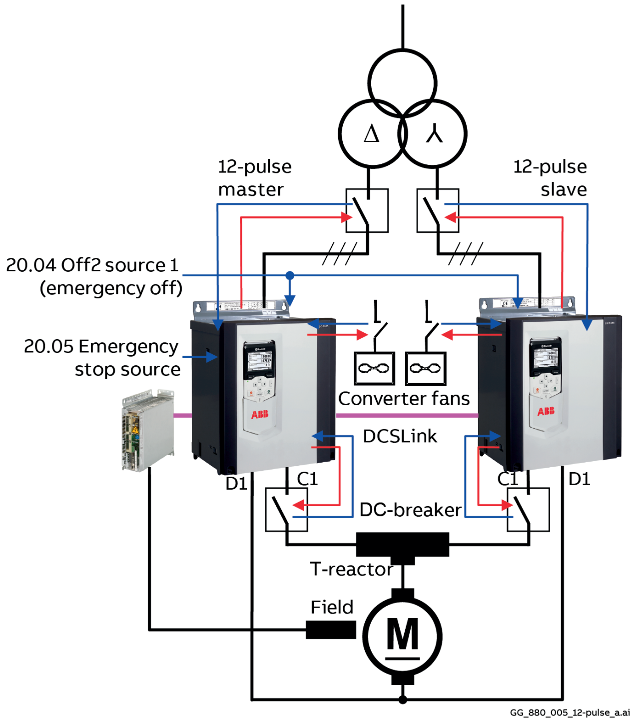
Hardware connections

There are a lot of possibilities to connect the control and acknowledge signals. Following connections are required:

– Each converter should control its own mains contactor, if existing. A single mains contactor or high voltage breaker must be connected to the 12-pulse master.
– Each converter should control its DC-breaker, if existing. A single DC-breaker must be connected to the 12-pulse master.
– Each converter should control its own converter fan.
– Both converters need to be connected to the coast stop circuit by means of 20.04 Off2 source 1 (emergency off).
– The 12-pulse master needs to be connected to the emergency stop circuit by means of 20.05 Emergency stop source.
– n the 12-pulse slave the emergency stop must be deactivated by means of 20.05 Emergency stop source = Off3 inactive.

12-pulse parallel configurations

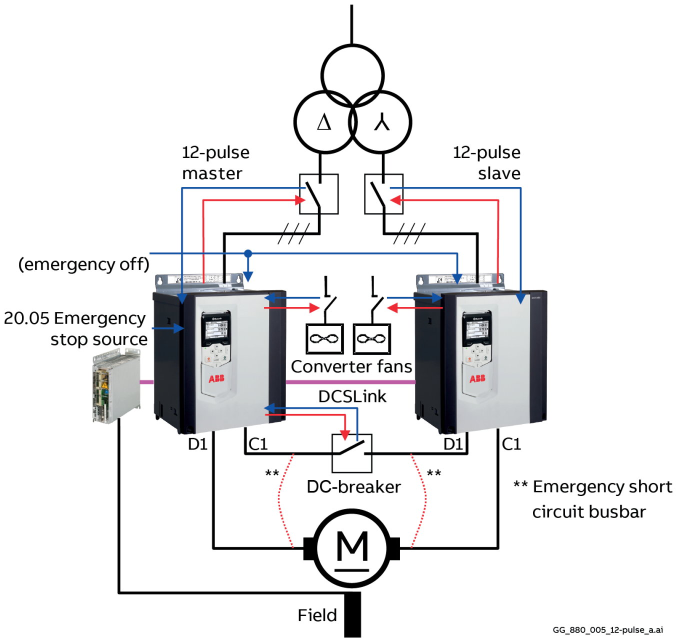
The 12-pulse parallel configuration can be set up as follows.



One DC-breaker per converter is recommended to increases the protection of the motor and to guarantee a proper load sharing between the DC-breakers.

12-pulse serial/Serial sequential configuration

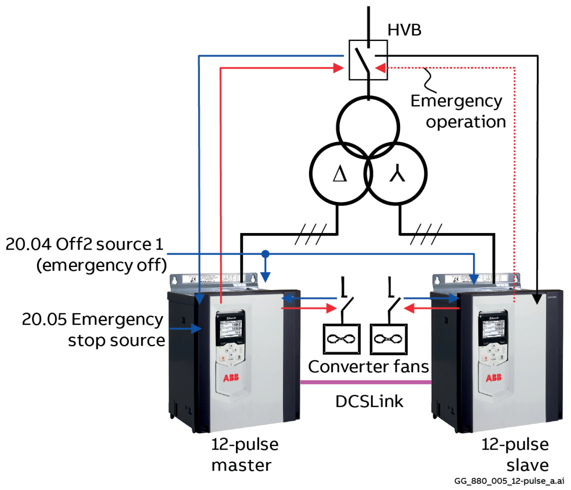
The 12-pulse serial/serial sequential configuration can be set up as follows.



A DC-breaker is recommended to increase the protection of the motor.

12-pulse configuration with a single mains contactor/High Voltage Breaker (HVB)

The 12-pulse configuration with a single mains contactor/high voltage breaker can be set up as follows.

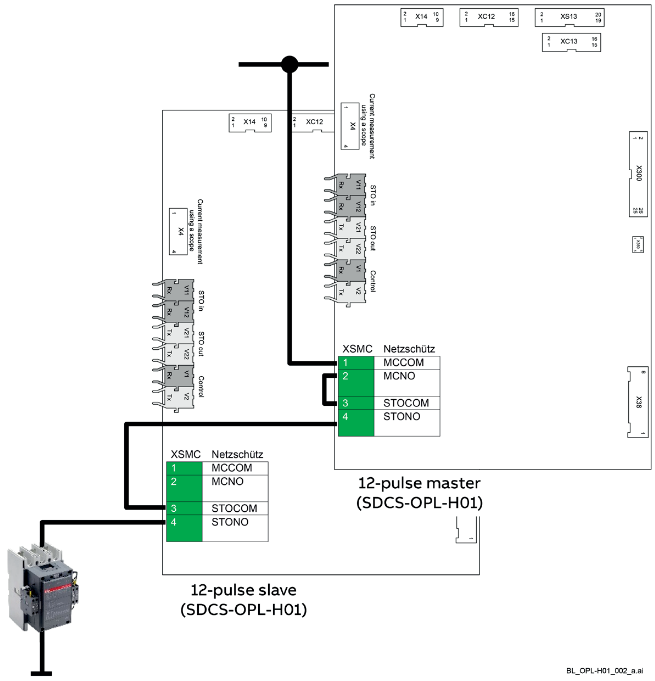


Mains contactors/High voltage breakers should always be switched under no load conditions. Switching mains contactors/high voltage breakers locally under load conditions may damage the drive. For more details please contact Your friendly ABB dealer.

To perform an emergency operation with only one mains contactor/high voltage breaker a more detailed investigation is required as the handling of the mains contactor/high voltage breaker must be switched over from the 12-pulse master to the emergency converter (usually the 12-pulse slave).

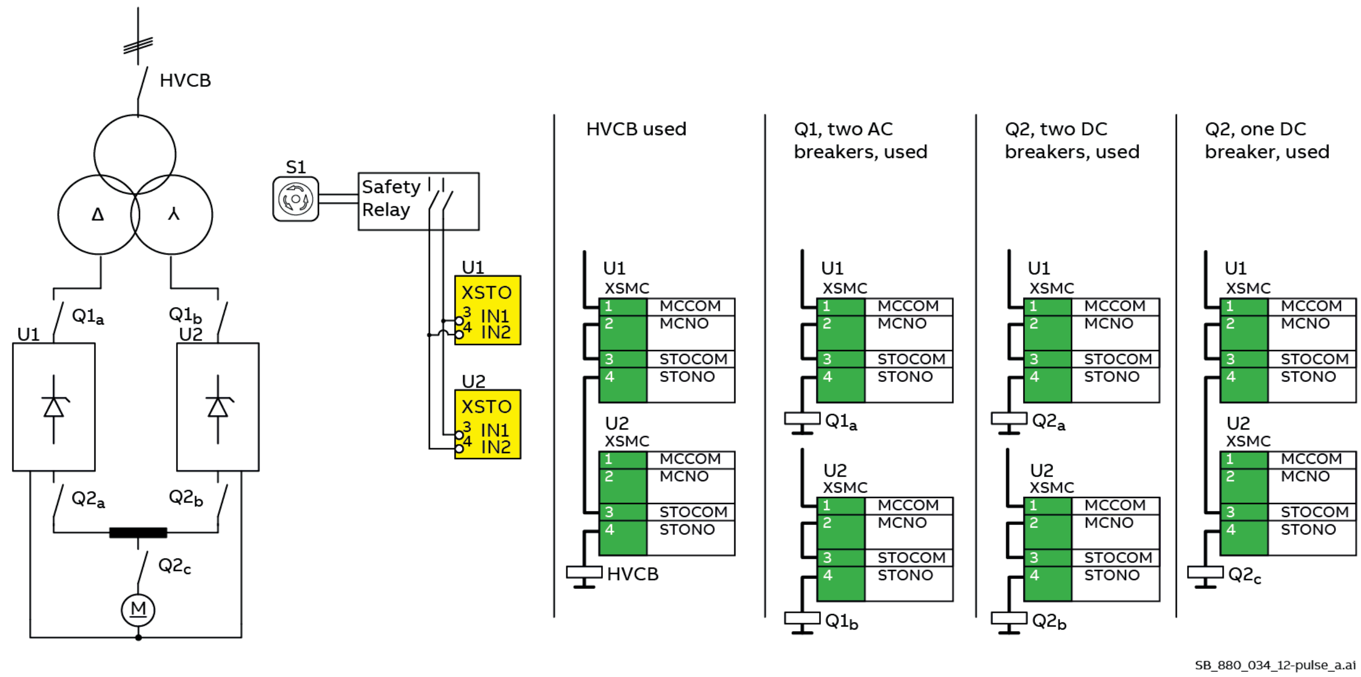
Load switching device

A load switching device, e.g. a mains contactor (MC), an air circuit breaker (ACB), a DC breaker (DCB) or a high-speed DC breaker (HSDCB), is controlled by relay output XSMC:MC on the SDCS-OPL-H01 located inside the 12-pulse master power unit.
For proper function of safe torque off a fault shutdown path is needed. This path includes a load switching device. Both relay outputs XSMC:STO on the SDCS-OPL-H01 inside both 12-pulse power units need to be connected in series with the load switching device.



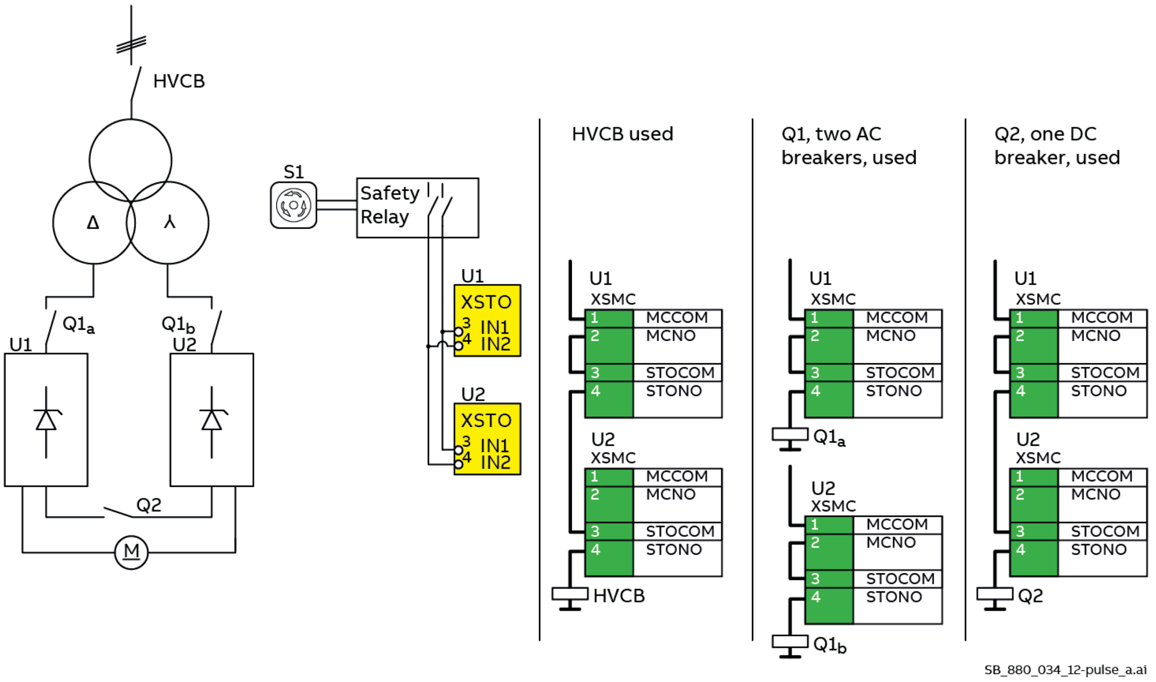
12-pulse parallel

Depending on the used type of load switching devices the configuration varies.



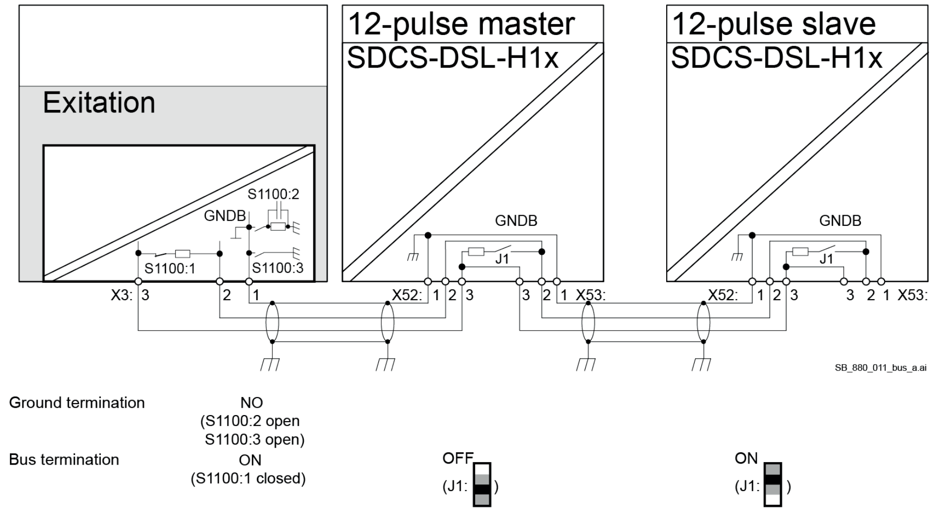
12-pulse serial and serial sequential

Depending on the used type of load switching devices the configuration varies.

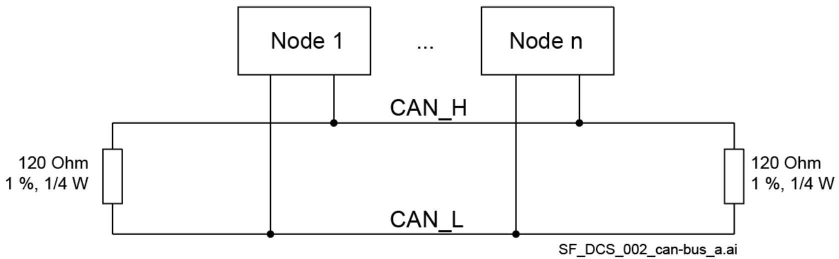


DCSLink configuration

Example for a cable connection.



The DCSLink is a bus system using twisted pair cables. Therefore, bus termination is mandatory at the two physical ends of the bus.

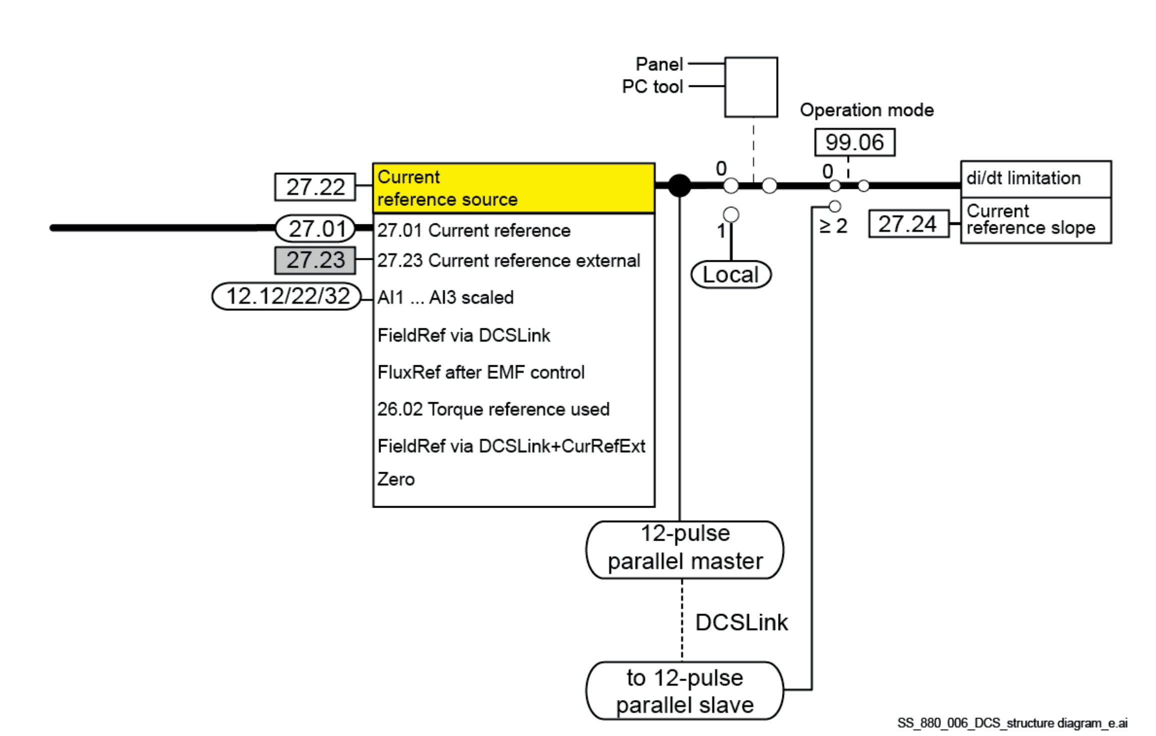


12-pulse parallel configurations

Firmware configuration

DCSLink
The communication via DCSLink is set-up by means of parameters in group 70 DCSLink Communication. Its content is.

12-pulse master		**12-pulse slave**
29.01 12-pulse master status word	⇨	29.01 12-pulse master status word
Armature current reference (12-pulse parallel master).	⇨	Armature current reference (to 12-pulse parallel slave).



29.02 12-pulse slave status word	⇦	29.02 12-pulse slave status word
-	-	01.10 Motor current in A
-	-	01.21 Armature voltage in V

Firmware configuration
In the firmware the converter must be set up either as 12-pulse master or as 12-pulse slave. This is done by means of 99.06 Operation mode.

99.06	**Operation mode**
	Operation mode of the drive. Specifies the operating mode of the drive. 0: **Armature converter**; the drive is used as a 6-pulse single armature converter. 1: **Large field exciter**; the drive is used as a large field exciter. **Attention:** The digital input for the external overvoltage protection is assigned by means of 20.47 Overvoltage protection trigger source. 2: **12-pulse parallel master**; the drive is used as 12-pulse parallel master. Connected to a 3-winding transformer having 30° phase shift between secondary windings.

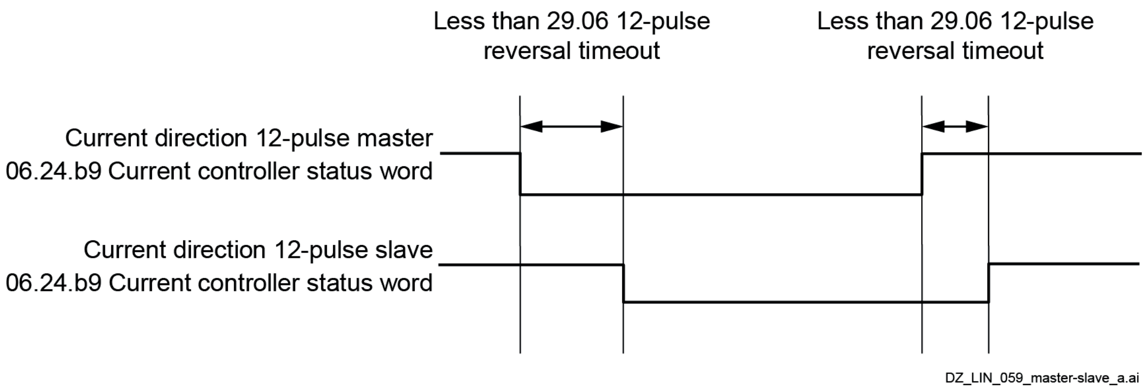
	3: **12-pulse parallel slave**; the drive is used as 12-pulse parallel slave. Connected to a 3-winding transformer having 30° phase shift between secondary windings. 4: **12-pulse serial master**; the drive is used as 12-pulse serial master. Connected to a 3-winding transformer having 30° phase shift between secondary windings. 5: **12-pulse serial slave**; the drive is used as 12-pulse serial slave. Connected to a 3-winding transformer having 30° phase shift between secondary windings. 6: **6-pulse serial master**; the drive is used as 6-pulse serial master. Connected to a 3-winding transformer having no (0°) phase shift between secondary windings. 7: **6-pulse serial slave**; the drive is used as 6-pulse serial slave. Connected to a 3-winding transformer having no (0°) phase shift between secondary windings. 8: **Serial sequential master 30°**; the drive is used as a serial sequential master. Connected to a 3-winding transformer having a 30° phase shift between secondary windings. 9: **Serial sequential slave 30°**; the drive is used as a serial sequential slave. Connected to a 3-winding transformer having a 30° phase shift between secondary windings. 10: **Serial sequential master 0°**; the drive is used as a serial sequential master. Connected to a 3-winding transformer having no (0°) phase shift between secondary windings. 11: **Serial sequential slave 0°**; the drive is used as a serial sequential slave. Connected to a 3-winding transformer having no (0°) phase shift secondary windings.

The 12-pulse specific parameters are mainly inside group 29 12-pulse/Hardparallel.

Monitoring
Following signal is available in the 12-pulse master to supervise the 12-pulse slave:
- 01.61 12-pulse parallel current sum in A is the sum of the actual 12-pulse master and 12-pulse slave armature current in amps.

Both current control status signals, from 12-pulse master and the 12-pulse slave, are available in both converters:
- 29.01 12-pulse master status word is the control status of the 12-pulse master.
- 29.02 12-pulse slave status word is the control status of the 12-pulse slave.

Fault F533 12-pulse reversal timeout
In 12-pulse mode the current direction of both, 12-pulse master and 12-pulse slave, bridges are being monitored. The drive trips with fault F533 12-pulse reversal timeout if the 2 converters have different bridges fired for longer than 29.06 12-pulse reversal timeout.



Notes:
- Fault F533 12-pulse reversal timeout is inactive, if 29.06 12-pulse reversal timeout is set to 1000 ms.
- Valid in the 12-pulse master only.

Fault F534 12-pulse current difference
In 12-pulse parallel mode the 12-pulse master also monitors the current of the 12-pulse slave. The drive trips with fault F534 12-pulse current difference if 29.07 12-pulse parallel current difference level is still exceeded when 29.08 12-pulse parallel current difference delay is elapsed.

Notes:

- Fault F534 12-pulse current difference is inactive, if 29.07 12-pulse parallel current difference level is set to 50 % (maximum).
- Valid in the 12-pulse master only.

Fault F535 12-pulse communication

If the 12-pulse communication timeout set in 70.08 12-pulse timeout has elapsed without receiving a valid message from the 12-pulse slave, the 12-pulse master activates fault F535 12-pulse communication.
Note: Valid in the 12-pulse master only.

Fault F536.12-pulse slave.

Fault F536.12-pulse slave is activated by a fault in the 12-pulse slave and trips the 12-pulse master.
Note: Valid in the 12-pulse master only.

Dynamic response

The dynamic response of the 12-pulse configuration is delayed in comparison to a 6-pulse configuration by:

- 0.5 control cycles (3.3 ms at 50 Hz or 2.77 ms at 60 Hz) due to the 30° offset in the mains supply of the 12-pulse slave.
- 20 ms due to the recommended behavior during the bridge reversal. See 27.38 Reversal delay.

Current controller

In 12-pulse parallel independent current flows through the 12-pulse master and the 12-pulse slave. Thus, the current measurement in the 12-pulse slave must be fully operative.
When the 12-pulse parallel drive is in speed control mode only the speed controller of the 12-pulse master is used and generates the current reference for both units. The speed controller of the 12-pulse slave is not used. The current reference is sent from the 12-pulse master to the 12-pulse slave. Both current controllers the one in the 12-pulse master and the one in the 12-pulse slave are used.
When the 12-pulse parallel drive is in current control mode the current reference is send from the 12-pulse master to the 12-pulse slave. Thus, only the current controllers the one in the 12-pulse master and the one in the 12-pulse slave are used.
Following parameters must have the same value in both units:

- 27.24 Current reference slope.
- 27.27 Current control mode.
- 27.29 M1 current proportional gain.
- 27.30 M1 current integration time.
- 27.31 M1 discontinuous current limit.
- 27.32 M1 armature resistance.
- 27.33 M1 armature inductance.
- 27.38 Reversal delay.
- 27.40 Zero current timeout.
- 27.42 Reversal volt margin.
- 30.34 M1 current limit bridge 2.
- 30.35 M1 current limit bridge 1.
- 30.44 Minimum firing angle.
- 30.45 Maximum firing angle.

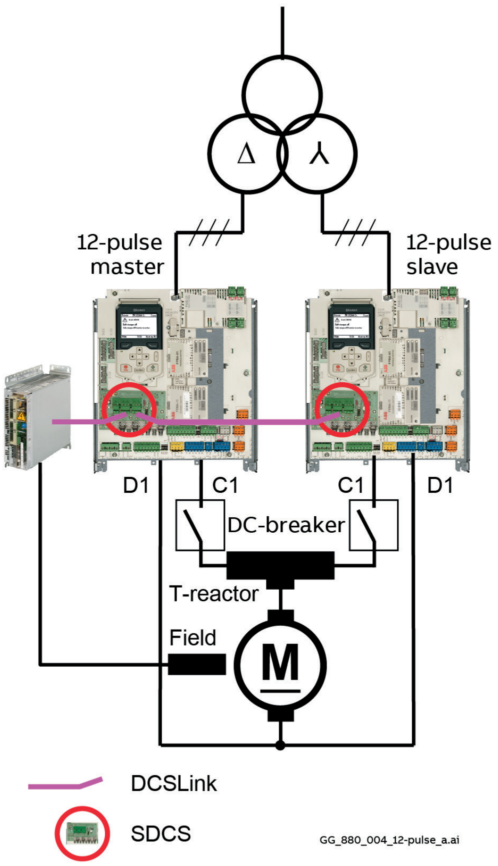
Hardware configurations

12-pulse parallel with master-follower

The following figures show the most significant features of 12-pulse parallel configuration:

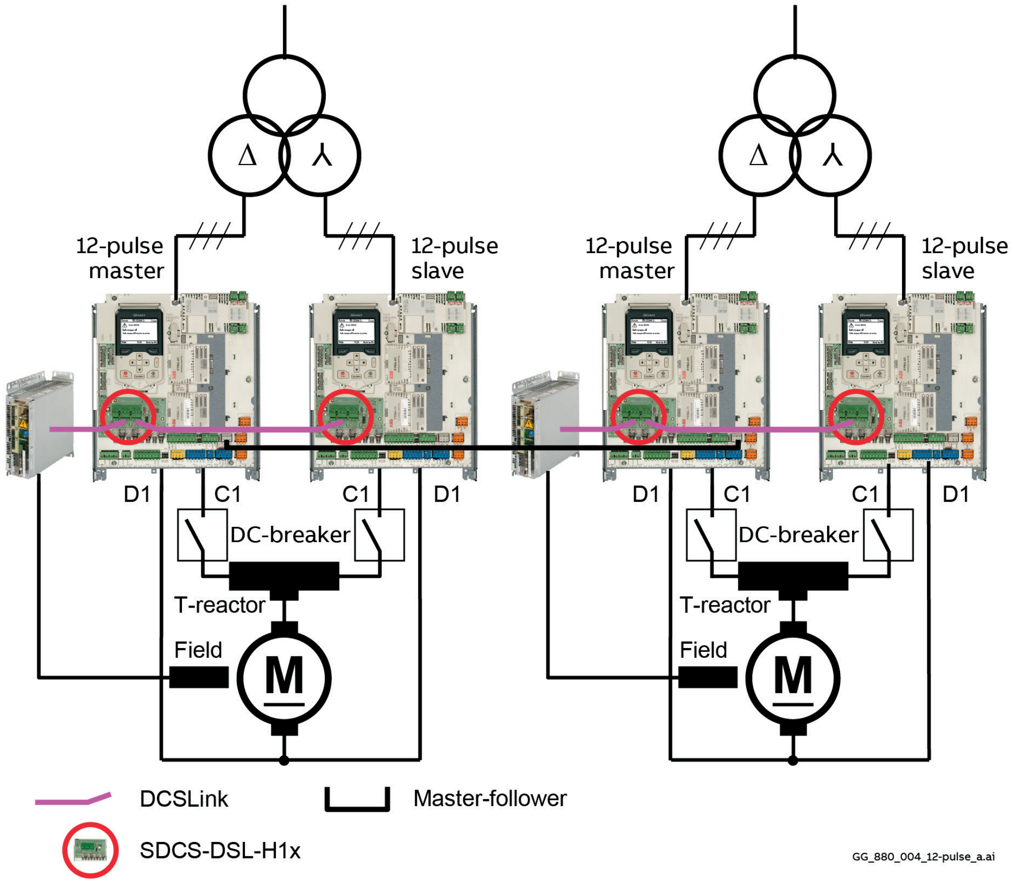
- Connection of two converters in parallel configuration.
- The use of T-reactors.
- Communication from the 12-pulse master to an external field exciter via DCSLink.
- Communication from the 12-pulse master to the 12-pulse slave via DCSLink.
- Master-follower via XD2D or FDCO.

12-pulse parallel



In this combination speed- and EMF/field control is performed by the 12-pulse master, whereas current control is carried out by both the 12-pulse master and the 12-pulse slave.

12-pulse parallel with master-follower

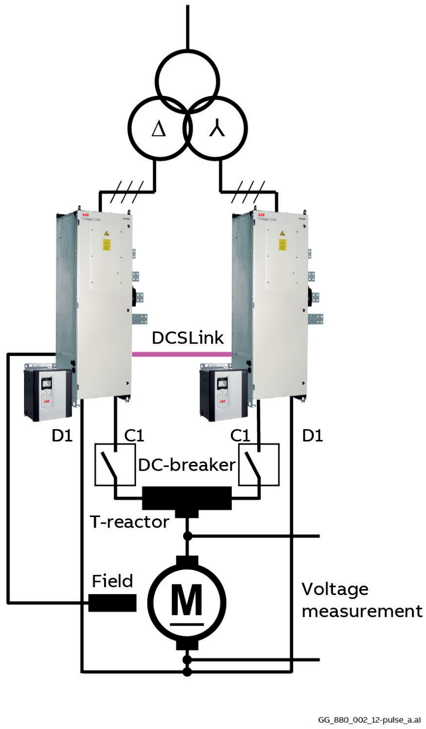


In this configuration the master-follower link transmits e.g. the speed- or torque reference.

12-pulse parallel with one motor

This 12-pulse parallel configuration is supplying one motor. The motor is taking the full armature voltage and the full armature current:

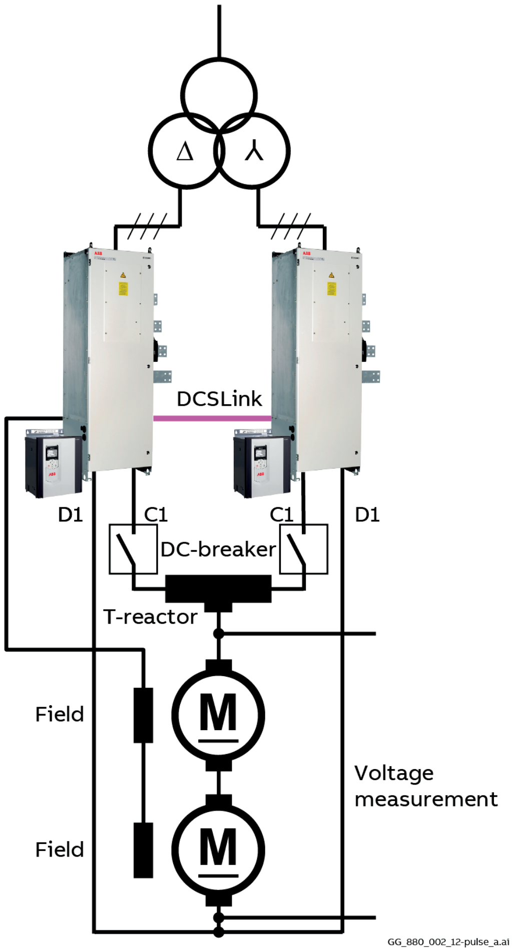
– Both converters measure the full armature voltage. Thus set 95.34 DC voltage measurement adjust = 100 %.
– Each converter supplies half of the armature current. Thus set 99.11 M1 nominal current = ½ rated motor current.
– Both converters supply the full armature voltage. Thus set 99.12 M1 nominal voltage = rated motor voltage.



12-pulse parallel with two motors in series

This 12-pulse parallel configuration is supplying two motors in series. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

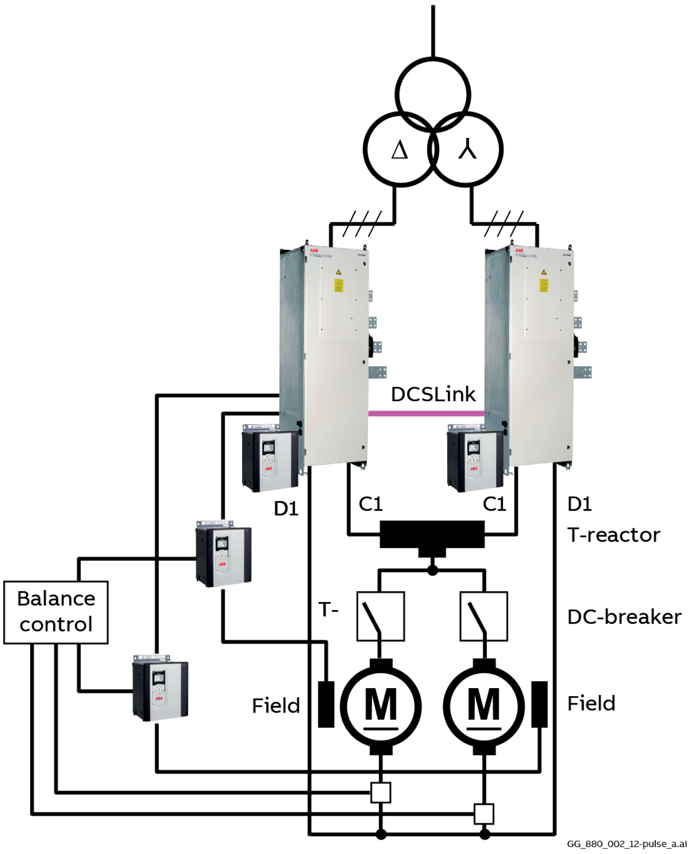
– Both converters measure the full armature voltage. Thus set 95.34 DC voltage measurement adjust = 100 %.
– Each converter supplies half of the armature current. Thus set 99.11 M1 nominal current = ½ rated motor current.
– Both converters supply the full armature voltage. Thus set 99.12 M1 nominal voltage = 2 • rated motor voltage.
– The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and the motor will be damaged.



12-pulse parallel with two motors in parallel

This 12-pulse parallel configuration is supplying two motors in parallel. Both motors are equal (M1 = M2). Each motor is taking the full armature voltage and half of the armature current:

- Both converters measure the full armature voltage. Thus set 95.34 DC voltage measurement adjust = 100 %.
- Each converter supplies half of the armature current. Thus set 99.11 M1 nominal current = rated motor current.
- Both converters supply the full armature voltage. Thus set 99.12 M1 nominal voltage = rated motor voltage.
- The motor currents must be balanced. Thus, a 3rd party balance control is required. This is especially important in field weakening.
  The balance control requires two separate filed exciters and an individual armature current measurement of each motor.



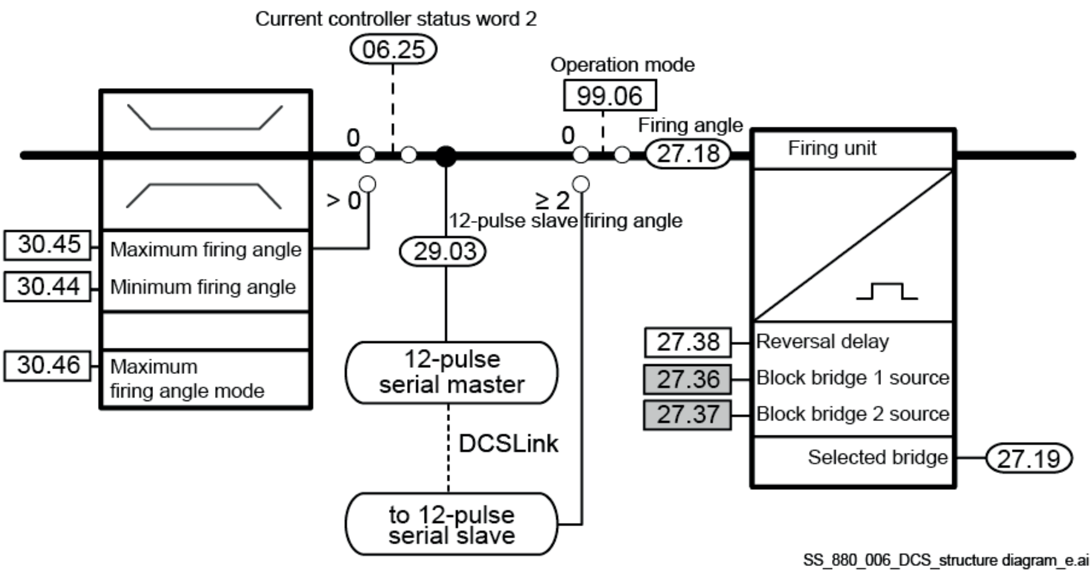
12-pulse serial/Serial sequential configurations

Firmware configuration

DCSLink

The communication via DCSLink is set-up by means of parameters in group 70 DCSLink Communication. Its content is.

12-pulse master		**12-pulse slave**
29.01 12-pulse master status word	⇨	29.01 12-pulse master status word
29.03 12-pulse slave firing angle	⇨	27.18 Firing angle



29.02 12-pulse slave status word	⇦	29.02 12-pulse slave status word
-	-	01.10 Motor current in A
-	-	01.21 Armature voltage in V

Firmware configuration

In the firmware the converter must be set up either as 12-pulse master or as 12-pulse slave. This is done by means of 99.06 Operation mode.

99.06	**Operation mode**
	Operation mode of the drive. Specifies the operating mode of the drive. 0: **Armature converter**; the drive is used as a 6-pulse single armature converter. 1: **Large field exciter**; the drive is used as a large field exciter. **Attention:** The digital input for the external overvoltage protection is assigned by means of 20.47 Overvoltage protection trigger source. 2: **12-pulse parallel master**; the drive is used as 12-pulse parallel master. Connected to a 3-winding transformer having 30° phase shift between secondary windings. 3: **12-pulse parallel slave**; the drive is used as 12-pulse parallel slave. Connected to a 3-winding transformer having 30° phase shift between secondary windings. 4: **12-pulse serial master**; the drive is used as 12-pulse serial master. Connected to a 3-winding transformer having 30° phase shift between secondary windings.

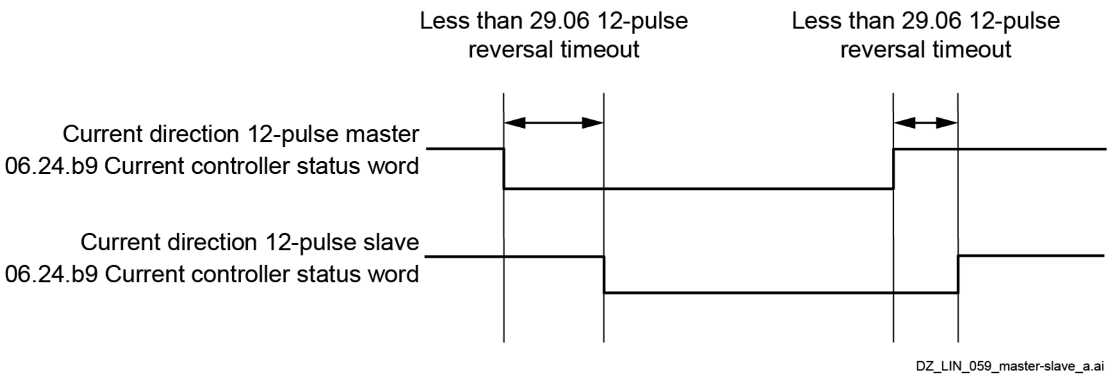
	5: **12-pulse serial slave**; the drive is used as 12-pulse serial slave. Connected to a 3-winding transformer having 30° phase shift between secondary windings. 6: **6-pulse serial master**; the drive is used as 6-pulse serial master. Connected to a 3-winding transformer having no (0°) phase shift between secondary windings. 7: **6-pulse serial slave**; the drive is used as 6-pulse serial slave. Connected to a 3-winding transformer having no (0°) phase shift between secondary windings. 8: **Serial sequential master 30°**; the drive is used as a serial sequential master. Connected to a 3-winding transformer having a 30° phase shift between secondary windings. 9: **Serial sequential slave 30°**; the drive is used as a serial sequential slave. Connected to a 3-winding transformer having a 30° phase shift between secondary windings. 10: **Serial sequential master 0°**; the drive is used as a serial sequential master. Connected to a 3-winding transformer having no (0°) phase shift between secondary windings. 11: **Serial sequential slave 0°**; the drive is used as a serial sequential slave. Connected to a 3-winding transformer having no (0°) phase shift secondary windings.

The 12-pulse specific parameters are mainly inside group 29 12-pulse/Hardparallel.

Monitoring
Following signal is available in the 12-pulse master to supervise the 12-pulse slave:
- 01.60 12-pulse serial armature voltage sum in V is the calculated armature voltage of 12-pulse serial/serial sequential master plus 12-pulse serial/serial sequential slave.
- 29.03 12-pulse slave firing angle is the firing angle reference which is send from the 12-pulse master to the 12-pulse slave.

Both current control status signals, from 12-pulse master and the 12-pulse slave, are available in both converters:
- 29.01 12-pulse master status word is the control status of the 12-pulse master.
- 29.02 12-pulse slave status word is the control status of the 12-pulse slave.

Fault F533 12-pulse reversal timeout
In 12-pulse mode the current direction of both, 12-pulse master and 12-pulse slave, bridges are being monitored. The drive trips with fault F533 12-pulse reversal timeout if the 2 converters have different bridges fired for longer than 29.06 12-pulse reversal timeout.



Notes:
- Fault F533 12-pulse reversal timeout is inactive, if 29.06 12-pulse reversal timeout is set to 1000 ms.
- Valid in the 12-pulse master only.

Fault F535 12-pulse communication
If the 12-pulse communication timeout set in 70.08 12-pulse timeout has elapsed without receiving a valid message from the 12-pulse slave, the 12-pulse master activates fault F535 12-pulse communication.
Note: Valid in the 12-pulse master only.

Fault F536 12-pulse slave
Fault F536 12-pulse slave is activated by a fault in the 12-pulse slave and trips the 12-pulse master.

Note: Valid in the 12-pulse master only.

Dynamic response

The dynamic response of the 12-pulse configuration is delayed in comparison to a 6-pulse configuration by:

- 0.5 control cycles (3.3 ms at 50 Hz or 2.77 ms at 60 Hz) due to the 30° offset in the mains supply of the 12-pulse slave.
- 20 ms due to the recommended behavior during the bridge reversal. See 27.38 Reversal delay.

Current controller

In 12-pulse serial/serial sequential the same current flows through the 12-pulse master and the 12-pulse slave. Usually the current measurement in the 12-pulse slave is fully operative. Thus, the 12-pulse slave uses its own reversal function.

Attention:

In case there is no current measurement available in the 12-pulse slave following parameters must be set properly:

- 27.38 Reversal delay= 0.

Then, the 12-pulse slave uses the reversal command of the 12-pulse master for its own bridge reversal. See 29.01.b12 12-pulse master status word.

In 12-pulse serial/serial sequential only the current controller of the 12-pulse master is used and generates the firing angles for both units. The current controller of the 12-pulse slave is not in use. Thus, following parameters must have the same value in both units:

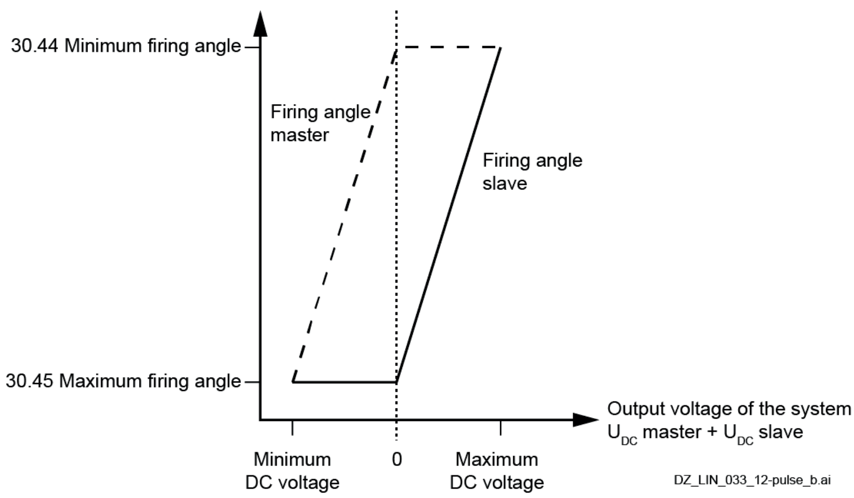
- 30.44 Minimum firing angle.
- 30.45 Maximum firing angle.
- 27.38 Reversal delay.
- 27.40 Zero current timeout.

Serial sequential mode

The serial sequential mode is activated by means of setting 99.06 Operation mode = Serial sequential master 30°; Serial sequential slave 30°; Serial sequential master 0° or Serial sequential slave 0°. The data transmission is equal to the one of the 12-pulse serial mode.

99.06 Operation mode = 12-pulse serial master or 12-pulse serial slave, 12-pulse master and 12-pulse slave are controlled by the same firing angle.

99.06 Operation mode = Serial sequential master 30°; Serial sequential slave 30°; Serial sequential master 0° or Serial sequential slave 0°, sequential control of the firing angles. Only one unit changes its firing angle, while the other unit's firing angle is fixed at the minimum- or maximum firing angle.



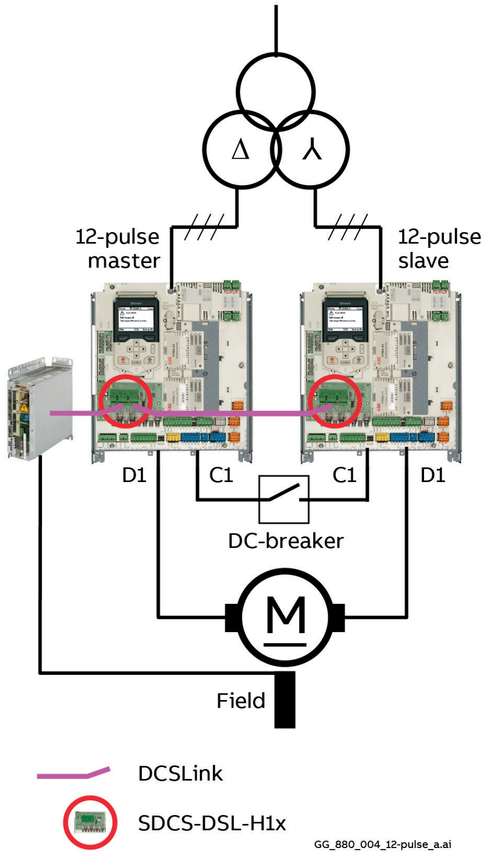
Hardware configurations

12-pulse serial/Serial sequential with master-follower

The following figures show the most significant features of 12-pulse serial/serial sequential configuration (maximum output voltage 1600 V_{DC}):

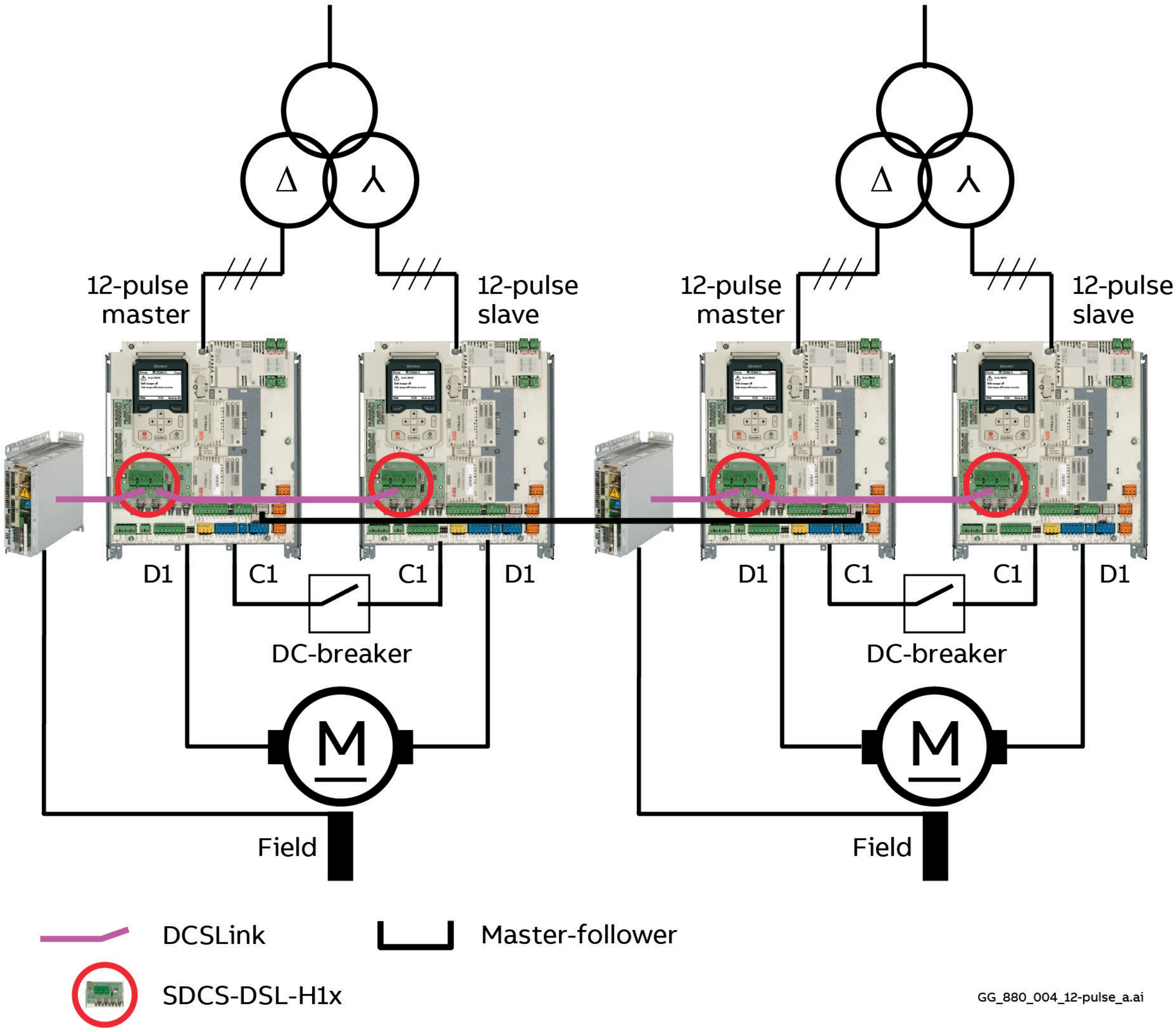
- Connection of two converters in serial/serial sequential configuration.
- Communication from the 12-pulse master to an external field exciter via DCSLink.
- Communication from the 12-pulse master to the 12-pulse slave via DCSLink.
- Master-follower via XD2D or FDCO.

12-pulse serial/Serial sequential



In this combination speed-, current- and field control is performed by the 12-pulse master, the firing angle is sent from the 12-pulse master to the 12-pulse slave.

12-pulse serial/Serial sequential with master-follower



In this configuration the master-follower link transmits e.g. the speed- or torque reference.

Measuring the DC voltage

Normal 12-pulse serial/Serial sequential configuration
In 12-pulse serial/serial sequential configurations the 12-pulse drive must stand the double DC voltage of the original 6-pulse DC voltage. For that reason, only the design of the high resistance voltage measurement circuit on the SDCS-PIN-H51 can be used. The SDCS-PIN-H51 is only available in DCS880 units of sizes H6 … H8.

Size	DC current [A_{DC}]	Mains voltage [V_{AC}]	High resistance voltage measurement	Galvanic isolation
H1 … H5 are not to be used for 12-pulse serial/serial sequential.				
H6	900 … 2000	2 • 200 … 2 • 350	SDCS-PIN-H51 and firmware.	AC transformer and DC transducer.
H7	1900 … 3000	2 • 200 … 2 • 600		
H8	2050 … 4800	2 • 200 … 2 • 600*		
	2050 … 5200	2 • 200 … 2 • 500*		

* Higher voltages up to 2 • 725 V_{AC} for H8 converter modules on request.

Sandwich configuration
An extended voltage range can be applied by means of a special motor configuration called sandwich with a maximum mains voltage of 2 • 1000 V_{AC}.

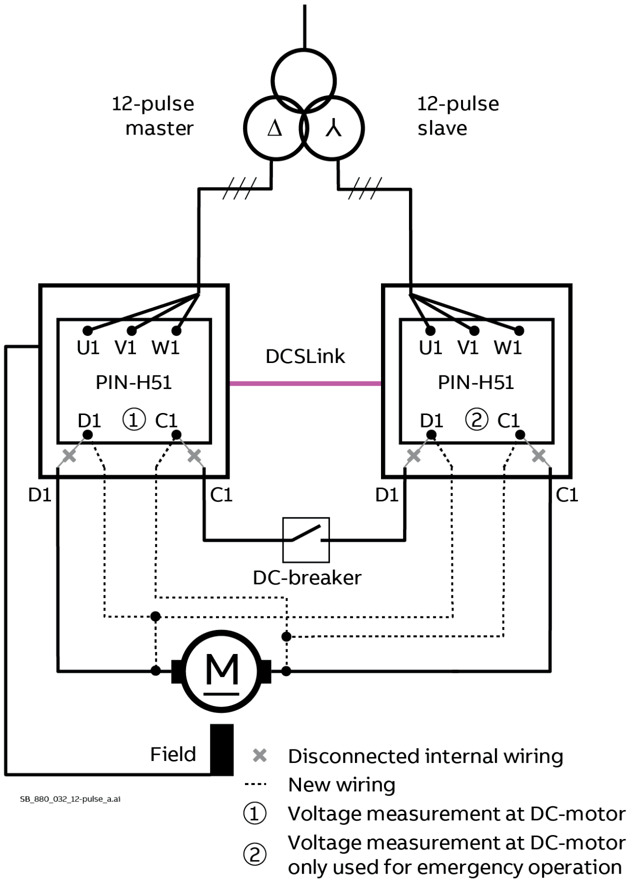
Size	DC current [A_{DC}]	Mains voltage [V_{AC}]	High resistance voltage measurement	Galvanic isolation
H1 … H6 are not to be used for sandwich configuration.				
H7	1900 … 3000	2 • 200 … 2 • 800	SDCS-PIN-H51 and firmware.	AC transformer and DC transducer.
H8	2050 … 5200	2 • 200 … 2 • 500		
	2050 … 4800	2 • 200 … 2 • 800		
	2600 … 4000	2 • 200 … 2 • 1000		

12-pulse serial/Serial sequential with one motor

High resistance voltage measurement with one motor:

This 12-pulse serial configuration is supplying one motor. The motor is taking the full armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 50 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters. Thus, 99.12 M1 nominal voltage = ½ rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	SDCS-PIN-H51 voltage coding	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
04	200 … 250 V_{AC}	XU2 … XD2	500 V_{AC}	500 V_{AC}
04	250 … 300 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
04	300 … 350 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
04	**350 … 400 V_{AC}**	**XU1 … XD1**	**1000 V_{AC}**	**1000 V_{AC}**
05	400 … 500 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
More information see chapter: Measuring the DC voltage.				

Depending on the mains voltage different settings must be chosen. With a mains voltage of **380 V_{AC}**:

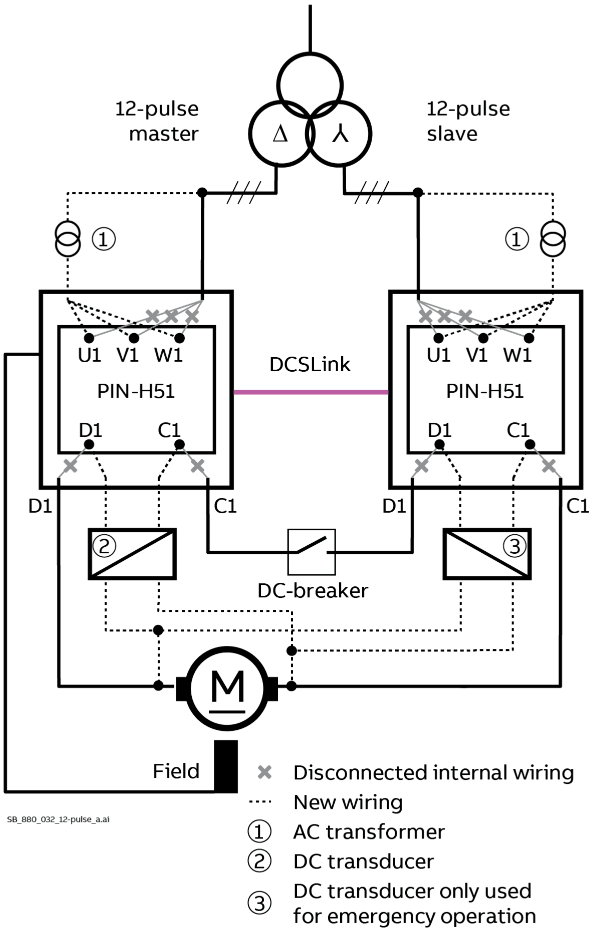
- Set 99.10 Nominal mains voltage = **380 V**.
- The SDCS-PIN-H51 must be able to stand at least twice the mains voltage. In this example the voltage coding must be set to **XU1 … XD1**.
- The hardware coding must be set according to the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **1000 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **1000 V_{AC}**.

For more information see chapter Measuring board SDCS-PIN-H51 of the DCS800 Hardware Manual.

Galvanic isolation with one motor:

This 12-pulse serial configuration is supplying one motor. The motor is taking the full armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 50 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters. Thus, 99.12 M1 nominal voltage = ½ rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	AC transformer terminals T90 (3ADT745047P1)	DC transducer position A92 (P42000D3-0111, 3ADN260008P1)	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
04	200 … 250 V_{AC}	2U1-2V1-2W1	0 (675 V)	500 V_{AC}	500 V_{AC}
04	250 … 300 V_{AC}	2U2-2V2-2W2	1 (810 V)	600 V_{AC}	600 V_{AC}
04	300 … 350 V_{AC}	2U3-2V3-2W3	2 (945 V)	690 V_{AC}	690 V_{AC}
04	350 … 400 V_{AC}	2U4-2V4-2W4	3 (1080 V)	800 V_{AC}	800 V_{AC}
05	400 … 500 V_{AC}	2U5-2V5-2W5	5 (1350 V)	1000 V_{AC}	1000 V_{AC}
06	**500 … 600 V_{AC}**	**2U6-2V6-2W6**	**6 (1620 V)**	**1190 V_{AC}**	**1190 V_{AC}**
More information see chapter: Measuring the DC voltage.					

Depending on the supply voltage different settings must be chosen. With a supply voltage of **550 V_{AC}**:

- Set 99.10 Nominal mains voltage = **550 V**.
- The AC transducers terminals **2U6-2V6-2W6** must be used.
- The DC transducer must be set to **position 6** with a maximum voltage of **1620 V_{DC}**.
- The hardware coding must be set to twice the maximum value of the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **1190 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **1190 V_{AC}**.
- For galvanic isolation a standard SDCS-PIN-H51 can be used. AC transformer T90 and DC transducer A92 are connected via X15.

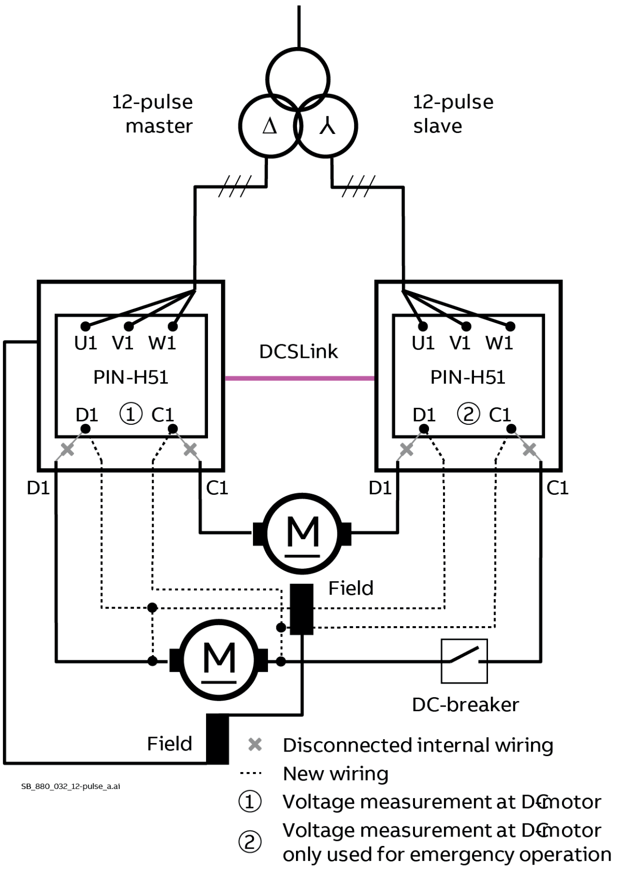
For more information see chapter Galvanic isolation of the DCS800 Hardware Manual.

12-pulse serial/Serial sequential with two motors configuration 1

High resistance voltage measurement with two motors:

This 12-pulse serial configuration is supplying two motors. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 100 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters and taken by 2 motors (M1 = M2). Thus, 99.12 M1 nominal voltage = rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	SDCS-PIN-H51 voltage coding	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
04	**200 … 250 V_{AC}**	**XU2 … XD2**	**500 V_{AC}**	**500 V_{AC}**
04	250 … 300 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
04	300 … 350 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
04	350 … 400 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
05	400 … 500 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
More information see chapter: Measuring the DC voltage.				

Depending on the mains voltage different settings must be chosen. With a mains voltage of **220 V_{AC}**:

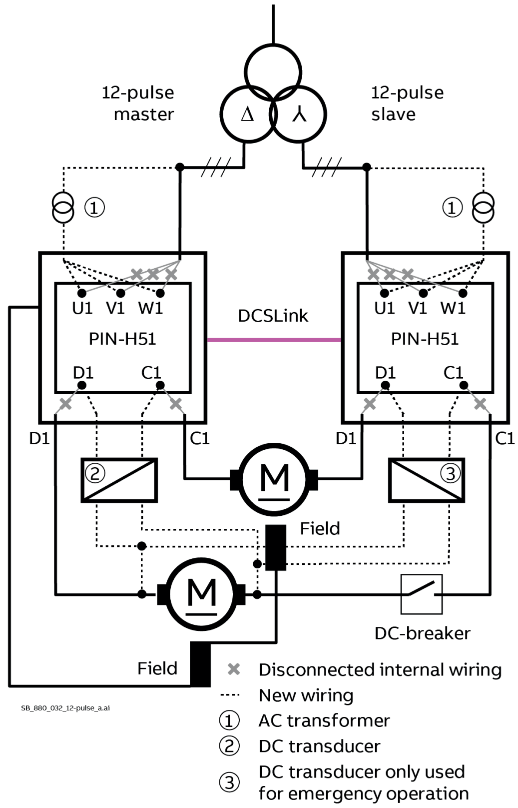
- Set 99.10 Nominal mains voltage = **220 V**.
- The SDCS-PIN-H51 must be able to stand at least twice the mains voltage. In this example the voltage coding must be set to **XU2 … XD2**.
- The hardware coding must be set according to the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **500 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **500 V_{AC}**.
- The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and the motor will be damaged.

For more information see chapter Measuring board SDCS-PIN-H51 of the DCS800 Hardware Manual.

Galvanic isolation with two motors:

This 12-pulse serial configuration is supplying two motors. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 100 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters and taken by 2 motors (M1 = M2). Thus, 99.12 M1 nominal voltage = rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	AC transformer terminals T90 (3ADT745047P1)	DC transducer position A92 (P42000D3-0111, 3ADN260008P1)	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
04	200 … 250 V_{AC}	2U1-2V1-2W1	0 (675 V)	500 V_{AC}	500 V_{AC}
04	250 … 300 V_{AC}	2U2-2V2-2W2	1 (810 V)	600 V_{AC}	600 V_{AC}
04	300 … 350 V_{AC}	2U3-2V3-2W3	2 (945 V)	690 V_{AC}	690 V_{AC}
04	350 … 400 V_{AC}	2U4-2V4-2W4	3 (1080 V)	800 V_{AC}	800 V_{AC}
05	**400 … 500 V_{AC}**	**2U5-2V5-2W5**	**5 (1350 V)**	**1000 V_{AC}**	**1000 V_{AC}**
06	500 … 600 V_{AC}	2U6-2V6-2W6	6 (1620 V)	1190 V_{AC}	1190 V_{AC}
More information see chapter: Measuring the DC voltage.					

Depending on the supply voltage different settings must be chosen. With a supply voltage of **440 V_{AC}**:

- Set 99.10 Nominal mains voltage = **440 V**.
- The AC transducers terminals **2U5-2V5-2W5** must be used.
- The DC transducer must be set to **position 5** with a maximum voltage of **1350 V_{DC}**.
- The hardware coding must be set to twice the maximum value of the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **1000 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **1000 V_{AC}**.
- For galvanic isolation a standard SDCS-PIN-H51 can be used. AC transformer T90 and DC transducer A92 are connected via X15.
- The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and it will be damaged.

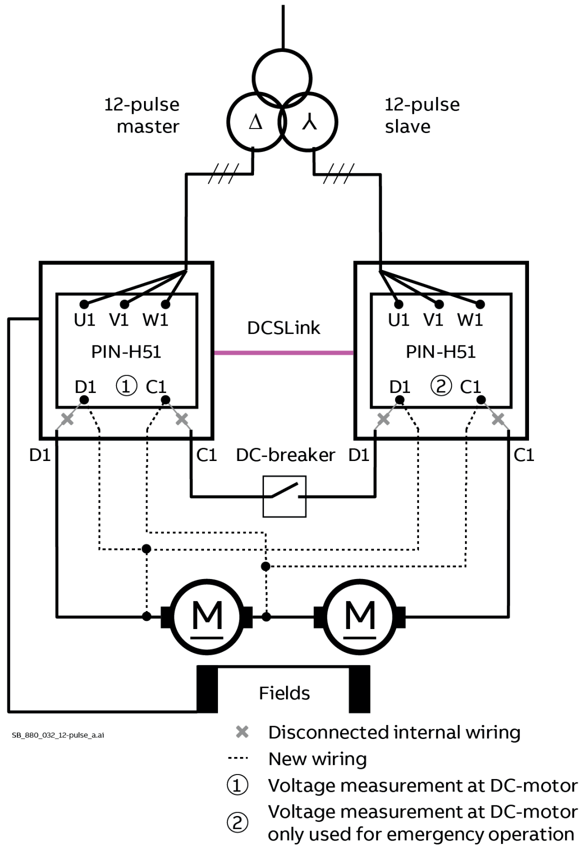
For more information see chapter Galvanic isolation of the DCS800 Hardware Manual.

12-pulse serial/Serial sequential with two motors configuration 2

High resistance voltage measurement with two motors:

This 12-pulse serial configuration is supplying two motors. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 100 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters and taken by 2 motors (M1 = M2). Thus, 99.12 M1 nominal voltage = rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	SDCS-PIN-H51 voltage coding	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
04	**200 … 250 V_{AC}**	**XU2 … XD2**	**500 V_{AC}**	**500 V_{AC}**
04	250 … 300 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
04	300 … 350 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
04	350 … 400 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
05	400 … 500 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
More information see chapter: Measuring the DC voltage.				

Depending on the mains voltage different settings must be chosen. With a mains voltage of **220 V_{AC}**:

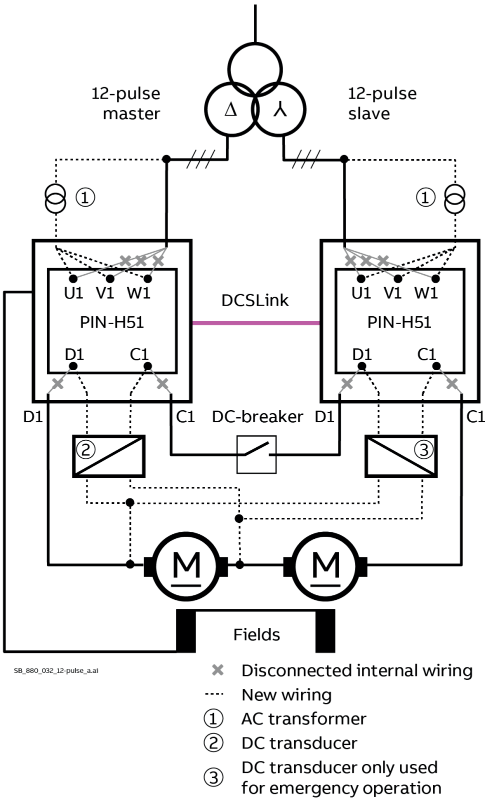
- Set 99.10 Nominal mains voltage = **220 V**.
- The SDCS-PIN-H51 must be able to stand at least twice the mains voltage. In this example the voltage coding must be set to **XU2 … XD2**.
- The hardware coding must be set according to the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **500 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **500 V_{AC}**.
- The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and it will be damaged.

For more information see chapter Measuring board SDCS-PIN-H51 of the DCS800 Hardware Manual.

Galvanic isolation with two motors:

This 12-pulse serial configuration is supplying two motors. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 100 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters and taken by 2 motors (M1 = M2). Thus, 99.12 M1 nominal voltage = rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	AC transformer terminals T90 (3ADT745047P1)	DC transducer position A92 (P42000D3-0111, 3ADN260008P1)	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
04	200 … 250 V_{AC}	2U1-2V1-2W1	0 (675 V)	500 V_{AC}	500 V_{AC}
04	250 … 300 V_{AC}	2U2-2V2-2W2	1 (810 V)	600 V_{AC}	600 V_{AC}
04	300 … 350 V_{AC}	2U3-2V3-2W3	2 (945 V)	690 V_{AC}	690 V_{AC}
04	350 … 400 V_{AC}	2U4-2V4-2W4	3 (1080 V)	800 V_{AC}	800 V_{AC}
05	**400 … 500 V_{AC}**	**2U5-2V5-2W5**	**5 (1350 V)**	**1000 V_{AC}**	**1000 V_{AC}**
06	500 … 600 V_{AC}	2U6-2V6-2W6	6 (1620 V)	1190 V_{AC}	1190 V_{AC}
More information see chapter: Measuring the DC voltage.					

Depending on the supply voltage different settings must be chosen. With a supply voltage of **440 V_{AC}**:

- Set 99.10 Nominal mains voltage = **440 V**.
- The AC transducers terminals **2U5-2V5-2W5** must be used.
- The DC transducer must be set to **position 5** with a maximum voltage of **1350 V_{DC}**.
- The hardware coding must be set to twice the maximum value of the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **1000 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **1000 V_{AC}**.
- For galvanic isolation a standard SDCS-PIN-H51 can be used. AC transformer T90 and DC transducer A92 are connected via X15.
- The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and it will be damaged.

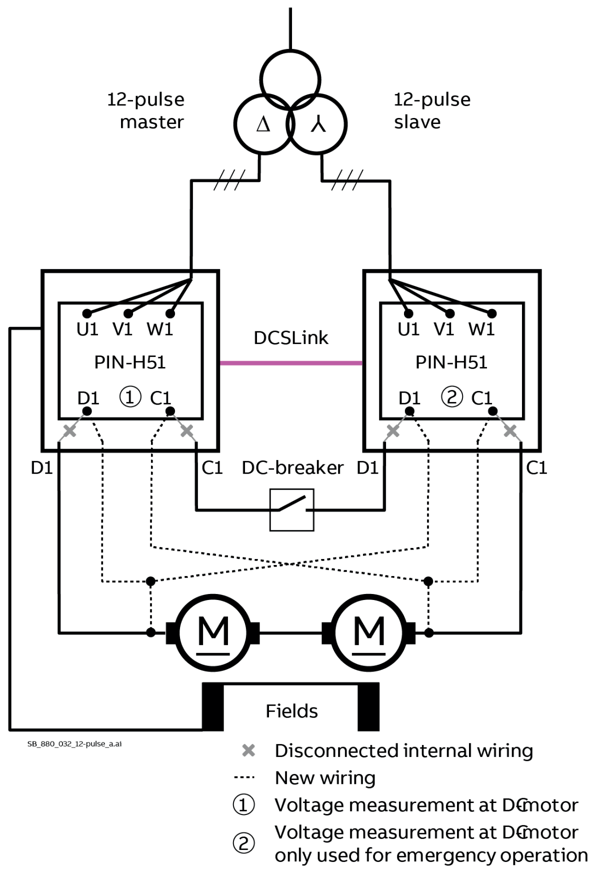
For more information see chapter Galvanic isolation of the DCS800 Hardware Manual.

12-pulse serial/Serial sequential with two motors configuration 3

High resistance voltage measurement with two motors:

This 12-pulse serial configuration is supplying two motors. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 50 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters and taken by 2 motors (M1 = M2). Thus, 99.12 M1 nominal voltage = rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	SDCS-PIN-H51 voltage coding	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
04	**200 … 250 V_{AC}**	**XU2 … XD2**	**500 V_{AC}**	**500 V_{AC}**
04	250 … 300 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
04	300 … 350 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
04	350 … 400 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
05	400 … 500 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
More information see chapter: Measuring the DC voltage.				

Depending on the mains voltage different settings must be chosen. With a mains voltage of **220 V_{AC}**:

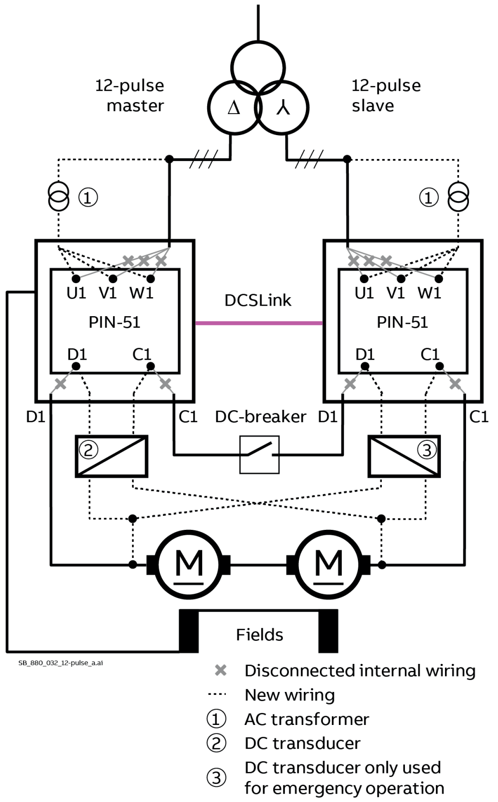
- Set 99.10 Nominal mains voltage = **220 V**.
- The SDCS-PIN-H51 must be able to stand twice the mains voltage. In this example the voltage coding must be set to **XU2 … XD2**.
- The hardware coding must be set according to the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **500 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **500 V_{AC}**.
- The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and it will be damaged.

For more information see chapter Measuring board SDCS-PIN-H51 of the DCS800 Hardware Manual.

Galvanic isolation with two motors:

This 12-pulse serial configuration is supplying two motors. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 50 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters and taken by 2 motors (M1 = M2). Thus, 99.12 M1 nominal voltage = rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	AC transformer terminals T90 (3ADT745047P1)	DC transducer position A92 (P42000D3-0111, 3ADN260008P1)	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
04	200 … 250 V_{AC}	2U1-2V1-2W1	0 (675 V)	500 V_{AC}	500 V_{AC}
04	250 … 300 V_{AC}	2U2-2V2-2W2	1 (810 V)	600 V_{AC}	600 V_{AC}
04	300 … 350 V_{AC}	2U3-2V3-2W3	2 (945 V)	690 V_{AC}	690 V_{AC}
04	350 … 400 V_{AC}	2U4-2V4-2W4	3 (1080 V)	800 V_{AC}	800 V_{AC}
05	**400 … 500 V_{AC}**	**2U5-2V5-2W5**	**5 (1350 V)**	**1000 V_{AC}**	**1000 V_{AC}**
06	500 … 600 V_{AC}	2U6-2V6-2W6	6 (1620 V)	1190 V_{AC}	1190 V_{AC}
More information see chapter: Measuring the DC voltage.					

Depending on the supply voltage different settings must be chosen. With a supply voltage of **440 V_{AC}**:

- Set 99.10 Nominal mains voltage = **440 V**.
- The AC transducers terminals **2U5-2V5-2W5** must be used.
- The DC transducer must be set to **position 5** with a maximum voltage of **1350 V_{DC}**.
- The hardware coding must be set to twice the maximum value of the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **1000 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **1000 V_{AC}**.
- For galvanic isolation a standard SDCS-PIN-H51 can be used. AC transformer T90 and DC transducer A92 are connected via X15.
- The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and it will be damaged.

For more information see chapter Galvanic isolation of the DCS800 Hardware Manual.

12-pulse serial/Serial sequential in sandwich configuration

Extended voltage range up to 2 • 1000 V_{AC}

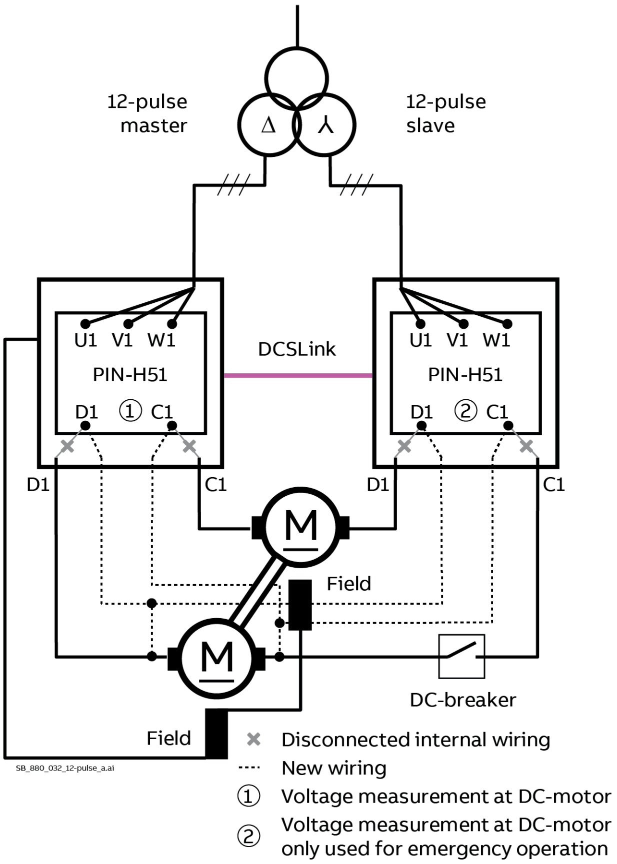
Increasing the mains voltage range is possible by means of the sandwich configuration. The sandwich configuration is possible, if both motors are equal (M1 = M2) and operate under the same conditions (same speed, same armature voltage, same flux, …). Thus, no point of the DC power circuit has the sum of both DC converter voltages (e.g. in case of a ground fault). In consequence the insulation of e.g. the voltage measurement circuits of the SDCS-PIN-H51 board must not stand twice the single converter's DC voltage. The requirements are:

- Both motors must operate under the same condition. E.g. same speed and same armature voltage. This is ensured by a fixed mechanical connection between both motors (e.g. both motors are on one shaft).
- Both motors must have the same flux. This is ensured by connecting both fields in series.
- Both motors must be equal (M1 = M2), which means they must be of the same type with the same motor data and ratings.
- The motors must always be located between the drives. So, the configuration is always drive - motor - drive - motor.

High resistance voltage measurement in sandwich configuration:

This 12-pulse serial configuration is supplying two motors. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 100 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters and taken by 2 motors (M1 = M2). Thus, 99.12 M1 nominal voltage = rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	SDCS-PIN-H51 voltage coding	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
05	200 … 500 V_{AC}	XU2 … XD2	500 V_{AC}	500 V_{AC}
06	500 … 600 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
07	600 … 690 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
08	690 … 800 V_{AC}	XU1 … XD1	1000 V_{AC}	1000 V_{AC}
10	**800 … 1000 V_{AC}**	**XU1 … XD1**	**1000 V_{AC}**	**1000 V_{AC}**
More information see chapter: Measuring the DC voltage.				

Depending on the mains voltage different settings must be chosen. Since this is a sandwich configuration, supply voltages of more than 500 V_{AC} are possible. With a mains voltage of **890 V_{AC}**:

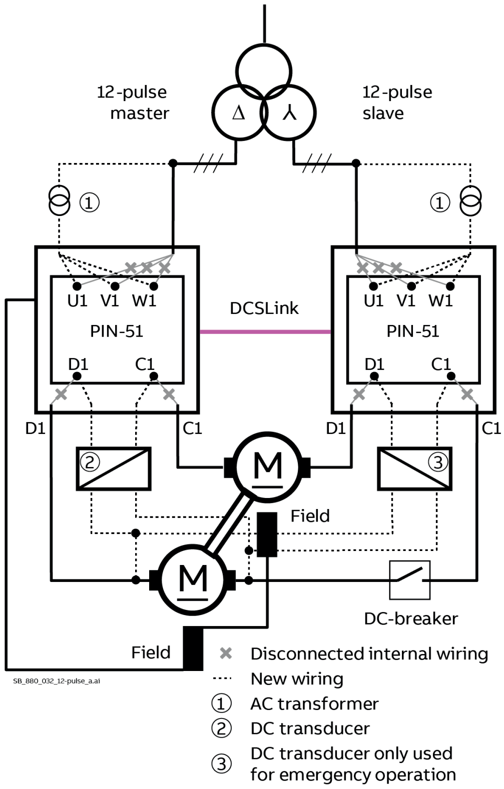
- Set 99.10 Nominal mains voltage = **890 V**.
- The SDCS-PIN-H51 must stand only the supply voltage. In this example the voltage coding must be set to **XU1 … XD1**.
- The hardware coding must be set according to the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **1000 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **1000 V_{AC}**.
- The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and it will be damaged.

For more information see chapter Measuring board SDCS-PIN-H51 of the DCS800 Hardware Manual.

Galvanic isolation with two motors in sandwich configuration:

This 12-pulse serial configuration is supplying two motors. Both motors are equal (M1 = M2). Each motor is taking half of the armature voltage and the full armature current:

- For correct EMF feedback adjust the DC voltage with 95.34 DC voltage measurement adjust = 100 %.
- Both converters have the same current, thus 99.11 M1 nominal current = rated motor current.
- The motor voltage is supplied by 2 converters and taken by 2 motors (M1 = M2). Thus, 99.12 M1 nominal voltage = rated motor voltage.



Voltage class	Nominal mains voltage (99.10 Nominal mains voltage)	AC transformer terminals T90 (3ADT745047P1)	DC transducer position A92 (P42000D3-0111, 3ADN260008P1)	Hardware coding (95.28 Set: Drive AC voltage scaling)	07.64 Drive AC voltage scaling set
05	200 … 500 V_{AC}	2U1-2V1-2W1	0 (675 V)	500 V_{AC}	500 V_{AC}
06	500 … 600 V_{AC}	2U2-2V2-2W2	1 (810 V)	600 V_{AC}	600 V_{AC}
07	600 … 690 V_{AC}	2U3-2V3-2W3	2 (945 V)	690 V_{AC}	690 V_{AC}
08	690 … 800 V_{AC}	2U4-2V4-2W4	3 (1080 V)	800 V_{AC}	800 V_{AC}
10	**800 … 1000 V_{AC}**	**2U5-2V5-2W5**	**5 (1350 V)**	**1000 V_{AC}**	**1000 V_{AC}**
More information see chapter: Measuring the DC voltage.					

Depending on the supply voltage different settings must be chosen. Since this is a sandwich configuration, supply voltages of more than 500 V_{AC} are possible. With a supply voltage of **990 V_{AC}**:

- Set 99.10 Nominal mains voltage = **990 V**.
- The AC transducers terminals **2U5-2V5-2W5** must be used.
- The DC transducer must be set to **position 5** with a maximum voltage of **1350 V_{DC}**.
- The hardware coding must be set to twice the maximum value of the voltage measurement circuit. In this example set 95.28 Set: Drive AC voltage scaling = **1000 V_{AC}**.
- 07.64 Drive AC voltage scaling set shows the set value of the voltage measurement circuit, here **1000 V_{AC}**.
- For galvanic isolation a standard SDCS-PIN-H51 can be used. AC transformer T90 and DC transducer A92 are connected via X15.
- The field windings are connected in serial. In case of a problem with the field exciter both motors lose their armature voltage and will not be damaged. In case of independently supplied fields it might happen that only one field exciter fails. In this case the complete armature voltage of both converters is over the motor with the healthy field exciter and it will be damaged.

For more information see chapter Galvanic isolation of the DCS800 Hardware Manual.

Start-up

General

This chapter describes the commissioning procedure for a 12-pulse drive. This is done based on the procedure used for DCS880-S0x converters. Only the actions and steps, which are different, are listed here.

Safety Instructions

The 12-pulse system is formed by converter modules. Thus, the danger installation and commissioning personal is exposed to during the work is similar, sometimes even higher than for plain converter modules. There is some work, which will only become necessary together with a 12-pulse system.
Because of that the Safety Instructions at the beginning of this manual must be observed with extreme care!
When listing the different steps of the start-up procedure additional warnings will be given. Based on the possible variations caused by the individual projects not all conditions can be covered. Please take this procedure as a general guideline and be prepared to take individual decisions concerning safety and security.

Points to be observed because of the situation

All relevant safety regulations must be observed during installation, commissioning and maintenance work, since it is possible to touch the mains and auxiliary connections and other electrical parts without any protection during installation of the 12-pulse system.
After the mains voltage is disconnected by means of the mains switch, make sure by measuring that no part of the system has either voltage or the system is protected with sufficient touch protection before any work is started.
Be aware of live terminals inside the drive cabinet even after the mains voltage has been disconnected by the mains switch, e.g. incoming busbars before the mains switch itself or external auxiliary power supplies.
Avoid unnecessary voltage withstand tests on any part of the unit.
General Hint:
In addition to the work specifics for the installation of the 12-pulse system attention should be paid to features related to drives in general. There is the engineering and the interface to other components in general, the selection of control cables their routing, grounding, screening and other points which need further considerations. The manual Technical Guide gives some help within the chapter EMC Compliant Installation and Configuration for a Power Drive System. This chapter gives information specific to fulfill the needs necessary for the CE marking. Most often CE marking is not the most important target for a 12-pulse system. Nevertheless, using some of the ideas will make the 12-pulse system safer.

Tools

In addition to the tools needed to maintain electrical parts some special tools are recommended:
- An oscilloscope including memory function with either galvanically isolating transformer or isolating amplifier for safe measurements.
- A clamp on current probe, in case the scaling of the DC load current needs to be checked, a DC clamp on current probe is needed.
- A voltmeter.

Make sure that all equipment in use is suitable for the voltage level applied to the power part!

12-pulse parallel; Parameters

Before starting with the commissioning set all parameters in both armature drives and the excitation drive to default by means of 96.15 Parameter restore = Default. Check with 96.11 Macro active. Should be Default.
Set all parameters listed below accordingly in the 12-pulse master and the 12-pulse slave.

Parameter	Master	Slave	Comments
20.01 Command location	0: Local I/O (def.) 1: Main control word	3: 12-pulse link	
20.04 Off2 source 1 (emergency off)	19: DIL (def.)	19: DIL (def.)	Fast current off.
20.05.Emergency stop source	7: DI5	1: Off3 inactive	Slave = Off3 inactive, otherwise the E Stop works only as coast stop.
29.05 12-pulse mode	0: Normal (def.)	0: Normal (def.)	
31.30 M1 overspeed trip margin	xxx rpm. Typical 20 % of n_{max}.	0 rpm	Slave = 0 rpm, to suppress fault 7310 Overspeed.
31.35 Motor feedback fault	1: Fault (def.)	0: No action	Slave = No action, to suppress fault 7301 Motor speed feedback.
46.01 M1 speed scaling	xxx rpm	xxx rpm	n_{max} = xxx rpm, set to maximum absolute speed.
90.39 External speed source	1: OnBoard encoder 2: Encoder 1 3: Encoder 2 4: Tacho 5: EMF (def.)	6: External	Slave = External, to suppress fault 7310 Overspeed.
92.10 Pulses/revolution	xxx ppr	n.a.	For 90.39 External speed source = Encoder 1 or Encoder 2.
94.23 OnBoard encoder pulses/revolution	xxx ppr	n.a.	90.39 External speed source = OnBoard encoder.
95.34 DC voltage measurement adjust	100.0 % (def.)	100.0 % (def.)	Do not change for 12-pulse parallel.
99.06 Operation mode	2: 12-pulse parallel master	3: 12-pulse parallel slave	
99.07 M1 used field exciter type	xxx	0: None	Choose field exciter for the master. The slave does not have an exciter.
99.10 Nominal mains voltage	xxx V	xxx V	U_{NetN} = xxx V; nominal mains voltage (AC).
99.11 M1 nominal current	xxx A	xxx A	0.5 • I_{MotN} = xxx A* or I_{MotN} = xxx A*.
99.12 M1 nominal voltage	xxx V	xxx V	U_{MotN} = xxx V* or 2 • U_{MotN} = xxx V*. Used for EMF speed feedback.
99.14 M1 nominal (base) speed	xxx rpm	xxx rpm	n_{Base} = xxx rpm. Set to motor base speed.

* Depends on the motor voltage measurement configuration. See chapter 12-pulse parallel configurations.

12-pulse parallel; Matching parameters

Following parameters **must** match in the 12-pulse master and the 12-pulse slave.

Parameter	Master	Slave	Comments
27.24 Current reference slope	10.0 %/ms (def.)	10.0 %/ms (def.)	
27.27 Current control mode	0: Standard (def.)	0: Standard (def.)	
27.29 M1 current proportional gain	xxx	xxx	See 12-pulse parallel armature current autotuning.
27.30 M1 current integration time	xxx ms	xxx ms	
27.31 M1 discontinuous current limit	xxx %	xxx %	
27.32 M1 armature resistance	xxx mΩ	xxx mΩ	
27.33 M1 armature inductance	xxx mH	xxx mH	
27.38 Reversal delay	xxx ms*	xxx ms*	After a command to change current direction the opposite current must be reached before 27.40 Zero current timeout has been elapsed. (29.06) > (27.40) > (27.38).
27.40 Zero current timeout	xxx ms*	xxx ms*	After a command to change current direction the opposite current must be reached before 27.40 Zero current timeout has been elapsed. (29.06) > (27.40) > (27.38).
27.42 Reversal volt margin	6.00 % (def.)	6.00 % (def.)	Do not change, leave at default.
30.34 M1 current limit bridge 2	xxx %	xxx %	
30.35 M1 current limit bridge 1	xxx %	xxx %	
30.44 Minimum firing angle	15.00° (def.)	15.00° (def.)	
30.45 Maximum firing angle	150.00° (def.)	150.00° (def.)	

* 27.38 Reversal delay and 27.40 Zero current timeout depending on the discontinuous current limit.

27.31 M1 discontinuous current limit	27.38 Reversal delay	Delta	27.40 Zero current timeout
≤ 50.00 %	5.0 ms	15 ms	20 ms
≤ 35.00 %	10.0 ms	25 ms	35 ms
≤ 20.00 %	15.0 ms	35 ms	50 ms
≤ 10.00 %	20.0 ms	50 ms	70 ms

12-pulse parallel; Limits

Set the limits in both the 12-pulse master and the 12-pulse slave.

Parameter	Master and slave	Comments
Speed		
21.08 M1 zero speed level	xxx rpm	Typical 1 % of n_{max} (maximum absolute motor speed), when an encoder is used.
30.11 M1 minimum speed	xxx rpm	
30.12 M1 maximum speed	xxx rpm	
Torque		
30.19.Minimum torque 1	xxx %	Parameters must match in the 12-pulse master and the 12-pulse slave.
30.20 Maximum torque 1	xxx %	Parameters must match in the 12-pulse master and the 12-pulse slave.
Current		
27.24 Current reference slope	10.0 %/ms (def.)	Parameters must match in the 12-pulse master and the 12-pulse slave.
30.34 M1 current limit bridge 2	xxx %	Parameters must match in the 12-pulse master and the 12-pulse slave.
30.35 M1 current limit bridge 1	xxx %	Parameters must match in the 12-pulse master and the 12-pulse slave.
Firing angle		
30.44 Minimum firing angle	15.00° (def.)	Parameters must match in the 12-pulse master and the 12-pulse slave.
30.45 Maximum firing angle	150.00° (def.)	Parameters must match in the 12-pulse master and the 12-pulse slave.

12-pulse parallel; Converter protections

Set the converter protections in both the 12-pulse master and the 12-pulse slave.

Parameter	**Master and slave**	**Comments**
Reversal fault		
27.38 Reversal delay	xxx ms*	After a command to change current direction the opposite current must be reached before 27.40 Zero current timeout has been elapsed. (29.06) > (27.40) > (27.38).
27.40 Zero current timeout	xxx ms*	After a command to change current direction the opposite current must be reached before 27.40 Zero current timeout has been elapsed. (29.06) > (27.40) > (27.38).
29.06 12-pulse reversal timeout	100 ms (def.)	Active only in 12-pulse master. (29.06) > (27.40) > (27.38).
Current difference		
29.07 12-pulse parallel current difference level	20 %	Active only in 12-pulse master.
29.08 12-pulse parallel current difference delay	500 ms (def.)	Active only in 12-pulse master.
Armature Overcurrent		
31.44 Armature overcurrent level	xxx %	I_{LIM} = xxx A. Equals 50 % of the permissible motor overcurrent.

* 27.38 Reversal delay and 27.40 Zero current timeout depending on the discontinuous current limit.

27.31 M1 discontinuous current limit	**27.38 Reversal delay**	**Delta**	**27.40 Zero current timeout**
≤ 50.00 %	5.0 ms	15 ms	20 ms
≤ 35.00 %	10.0 ms	25 ms	35 ms
≤ 20.00 %	15.0 ms	35 ms	50 ms
≤ 10.00 %	20.0 ms	50 ms	70 ms

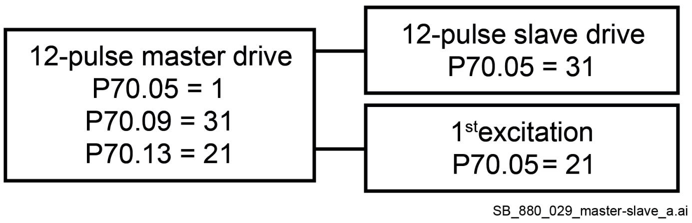
12-pulse parallel; Motor protection

Set the motor protections in both the 12-pulse master and the 12-pulse slave.

Parameter	Master and slave	Comments
Stall protection		
31.24 Stall function		
31.25 Stall torque level		
31.26 Stall speed level		
31.27 Stall time		
Armature overvoltage		
31.50 Armature overvoltage level		
Motor temperature		
35.11 Temperature 1 source		
35.12 Temperature 1 fault level		
35.13 Temperature 1 warning level		
Measured motor temperature		
35.14 Temperature 1 AI source		
35.15 Supervision 1 klixon source		
Motor thermal model		
35.50 Motor ambient temperature 1		
35.51 Motor load curve 1		
35.52 Zero speed load 1		
35.53 Break point 1		
35.54 Motor nominal temperature rise 1		
35.55 Motor thermal time constant 1		

12-pulse parallel; DCSLink

Set up the DCSLink.



Parameter	Master	Slave	Comments
70.05 DCSLink node ID	1	31	
70.08 12-pulse timeout	≥ 15 ms	≥ 15 ms	Generates fault F535 12-pulse communication.
70.09 12-pulse slave node ID	31 (def.)	n.a.	

Parameter	Master	Excitation	Comments
70.05 DCSLink node ID	1	21	
70.12 Field exciter timeout	100 ms (def.)	-	Generates either fault F516 M1 field exciter communication and/or fault F519 M2 field exciter communication.
70.13 M1 field exciter node ID	21 (def.)	n.a.	

12-pulse parallel; Type code settings

The type code settings are usually set by the factory. They can be checked in group 7 System info.

Parameter	Master and slave	Comments
07.02 Power unit set		The value is read from 95.14 Set: Power unit.
07.60 Drive size		Read from 95.25 Set: Type code.
07.61 Drive block bridge 2 set		Read from 95.25 Set: Type code or set with 95.26 Set: Drive block bridge 2.
07.62 Drive DC current scaling set		Read from 95.25 Set: Type code or set with S 95.27 Set: Drive DC current scaling.
07.63 Drive DC overcurrent level		Read from 95.25 Set: Type code or set with S 95.27 Set: Drive DC current scaling.
07.64 Drive AC voltage scaling set		Read from 95.25 Set: Type code or set with 95.28 Set: Drive AC voltage scaling.
7.65 Drive max bridge temperature set		Read from 95.25 Set: Type code or set with 95.29 Set: Drive max bridge temperature
95.14 Set: Power unit		
95.16 Control unit configuration		
95.24 Service mode		
95.25 Set: Type code		Normally set by the factory. To change use 95.24 Service mode = Set: Type code.
95.26 Set: Drive block bridge 2		Automatically taken from type code and thus 0: **Auto**.
95.27 Set: Drive DC current scaling		Automatically taken from type code.
95.28 Set: Drive AC voltage scaling		Automatically taken from type code.
95.29 Set: Drive max bridge temperature		Automatically taken from type code. For H7 and H8 units the air entry temperature can be set to 55°C in hot motor rooms.

12-pulse parallel; Galvanic isolation

Details see chapter Galvanic Isolation.

Parameter	Master and slave	Comments
AC transformer T90		E.g. 2U2, 2V2, 2W2 for mains voltages from 500 … 600 VAC.
DC transducer A92		E.g. 1 ≡ 810 V for mains voltages from 500 … 600 VAC.

12-pulse parallel; Additional settings

Additional setting in case of problems, when using an overriding control and Drive composer.

Parameter	Master and slave	Comments
24.18 Speed error filter time 1	0 ms (def.)	Cyclic bridge changes (bridge reversals) can lead to F533 12-pulse reversal timeout, F534 12-pulse current difference or F557 Reversal time. To prevent the cyclic bridge changes, it is recommended to re-tune the speed controller (making it more stable) and to use the speed error filter times. E.g. set 24.18 Speed error filter time 1= 24.19 Speed error filter time 2 = 10 ms.
24.19 Speed error filter time 2	0 ms (def.)	
27.34 Mains compensation time	10 ms (def.)	Set when the current is distributed differently on the thyristors (fast disturbances in current).
27.50 M1 armature inductance current controller	0.0 mH (def.)	Typically left at default. Set back to default, when the current is instable.
27.51 M1 armature inductance EMF speed feedback	0.0 mH (def.)	Typically left at default. Set back to default, when the current is instable.
30.27 Max torque during regenerating	325.00 % (def.)	The mains voltage is going down due to high load currents. To prevent regeneration operation at the commutation limit use 30.27 Max torque during regenerating.
95.44 PLL deviation level	15.00	Stabilizes the PLL.
95.45 PLL proportional gain	0.50 (def.)	
95.46 PLL filter time	10.0 ms	
95.47 PLL Uk compensation	0.0 % (def.)	Set slowly to higher values (1 by 1), if the sync. voltage is disturbed by commutation notches. To be used only with dedicated mains transformers.

12-pulse parallel; Large field exciters using DCS880-S01/S02 modules

In the 12-pulse master module.

Parameter	Master	Comments
28.17 M1 EMF/field control mode	1: EMF	EMF controller released, field weakening active, depending on the application.
31.57 Minimum field current trip delay	2000 ms (def.)	Delays fault F541 M1 field exciter low current.
31.58 M1 field current low level	xxx %	Sets level for fault F541 M1 field exciter low current.
70.05 DCSLink node ID	1	
70.12 Field exciter timeout	100 ms (def.)	Generates either fault F516 M1 field exciter communication and/or fault F519 M2 field exciter communication.
70.13 M1 field exciter node ID	21 (def.)	Use the same node number as in 70.05 DCSLink node ID of the large field exciter.
99.07 M1 used field exciter type	10: DCS880-S01. 11: DCS880-S02.	
99.13 M1 nominal field current	xxx A	IFN = xxx A, rated field current.

In the large field exciter module (DCS880-S01/S02).

Parameter	Excitation	Comments
20.01 Command location	4: Field exciter link	Control from the 12-pulse master. Source for the control word (On/Off1, Run/Stop and Reset).
20.47 Overvoltage protection trigger source	3: DI1 … 8: DI6 11: DIO1 12: DIO2 19: DIL	Depending on the hardware connection to the DCF506.
27.22 Current reference source	30: FieldRef via DCSLink	Field current reference from the 12-pulse master.
27.31 M1 discontinuous current limit	0.00 %	
27.38 Reversal delay	50.0 ms	
27.40 Zero current timeout	500 ms	To be set longer than 27.38 Reversal delay.
28.17 M1 EMF/field control mode	0: Fix (def.)	
31.50 Armature overvoltage level	1000.0 %	Disables the overvoltage supervision.
70.05 DCSLink node ID	21	Use the same node number as in 70.13 M1 field exciter node ID of the 12-pulse master.
95.44 PLL deviation level	20.00°	To suppress F514 Mains synchronization lost.
99.06 Operation mode	1: Large field exciter	
99.07 M1 used field exciter type	0: None	
99.10 Nominal mains voltage	xxx V	UNetN = xxx V; nominal mains voltage (AC).
99.11 M1 nominal current	xxx A	IFN = xxx A, rated field current.
99.12 M1 nominal voltage	xxx V	UFN = xxx V, rated field voltage.

12-pulse parallel; Field current autotuning

Field current autotuning for large field supplies using DCS880-S01/S02 modules **must** be started **directly** in the large field exciter.

Parameter	Large field exciter	Comments
99.20 Tuning request	1: Field current autotuning	Give the On and Run commands within 20 s.
27.29 M1 current proportional gain	xxx	Is set by the field current autotuning. Typical p-part values are around 4.
27.30 M1 current integration time	xxx	Is set by the field current autotuning.
27.31 M1 discontinuous current limit	0.00 %	Is set to zero by the field current autotuning.

Note:
This autotuning does not work when started from the Drive composer pro DCS880 Assistant.

12-pulse parallel; Armature current autotuning

The 12-pulse parallel master must be tuned in 6-pulse mode. Thus the 12-pulse slave must be completely de-energized, and its contactors must be kept open. Set in the 12-pulse master.

Parameter	Master	Comments
99.06 Operation mode	0: Armature converter	After the autotuning is finished set 99.06 Operation mode back to 12-pulse parallel master.
99.20 Tuning request	2: Armature current autotuning	Give the On and Run command within 20 s.

Do the following after a successful autotuning.

Parameter	Comments
27.29 M1 current proportional gain	Use directly in the 12-pulse master and the 12-pulse slave.
27.30 M1 current integration time	Use directly in the 12-pulse master and the 12-pulse slave.
27.31 M1 discontinuous current limit	Use directly in the 12-pulse master and the 12-pulse slave.
27.32 M1 armature resistance	Multiply by 2 and use in the 12-pulse master and the 12-pulse slave.
27.33 M1 armature inductance	Multiply by 2 and use in the 12-pulse master and the 12-pulse slave.

Attention:
In case an autotuning is not starting or interrupted warning AF90 Autotuning is set. The reason for the warning is shown in its AUX code. See Drive composer Event logger.

12-pulse serial/Serial sequential; Parameters

Before starting with the commissioning set all parameters in both armature drives and the excitation drive to default by means of 96.15 Parameter restore = Default. Check with 96.11 Macro active. Should be Default.
Set all parameters listed below accordingly in the 12-pulse master and the 12-pulse slave.

Parameter	Master	Slave	Comments
20.01 Command location	0: Local I/O (def.) 1: Main control word	3: 12-pulse link	
20.04 Off2 source 1 (emergency off)	19: DIL (def.)	19: DIL (def.)	Fast current off.
20.05.Emergency stop source	7: DI5	1: Off3 inactive	Slave = Off3 inactive, otherwise the E Stop works only as coast stop.
29.05 12-pulse mode	0: Normal (def.)	0: Normal (def.)	
31.30 M1 overspeed trip margin	xxx rpm. Typical 20 % of nmax.	0 rpm	Slave = 0 rpm, to suppress fault 7310 Overspeed.
31.35 Motor feedback fault	1: Fault (def.)	0: No action	Slave = No action, to suppress fault 7301 Motor speed feedback.
46.01 M1 speed scaling	xxx rpm	xxx rpm	nmax = xxx rpm, set to maximum absolute speed.
90.39 External speed source	1: OnBoard encoder 2: Encoder 1 3: Encoder 2 4: Tacho 5: EMF (def.)	6: External	Slave = External, to suppress fault 7310 Overspeed.
92.10 Pulses/revolution	xxx ppr	n.a.	For 90.39 External speed source = Encoder 1 or Encoder 2.
94.23 OnBoard encoder pulses/revolution	xxx ppr	n.a.	90.39 External speed source = OnBoard encoder.
95.34 DC voltage measurement adjust	50.0 % 100.0 % (def.)	50.0 % 100.0 % (def.)	See*.
99.06 Operation mode	4: 12-pulse serial master	5: 12-pulse serial slave	For 12-pulse serial.
	8: Serial sequential master 30°	9: Serial sequential slave 30°	For serial sequential.
	10: Serial sequential master 0°	11: Serial sequential slave 0°	
99.07 M1 used field exciter type	xxx	0: None	Choose field exciter for the master. The slave does not have an exciter.
99.10 Nominal mains voltage	xxx V	xxx V	UNetN = xxx V; nominal mains voltage (AC).
99.11 M1 nominal current	xxx A	xxx A	IMotN = xxx A.
99.12 M1 nominal voltage	xxx V	xxx V	0.5 • UMotN = xxx V* or UMotN = xxx V*. Used for EMF speed feedback.
99.14 M1 nominal (base) speed	xxx rpm	xxx rpm	nBase = xxx rpm. Set to motor base speed.

* Depends on the motor voltage measurement configuration. See chapter 12-pulse serial/Serial sequential configurations.

12-pulse serial/Serial sequential; Matching parameters

Following parameters **must** match in the 12-pulse master and the 12-pulse slave.

Parameter	Master	Slave	Comments
27.38 Reversal delay	xxx ms*	xxx ms*	After a command to change current direction the opposite current must be reached before 27.40 Zero current timeout has been elapsed. (29.06) > (27.40) > (27.38).
27.40 Zero current timeout	xxx ms*	xxx ms*	After a command to change current direction the opposite current must be reached before 27.40 Zero current timeout has been elapsed. (29.06) > (27.40) > (27.38).
27.42 Reversal volt margin	6.00 % (def.)	6.00 % (def.)	Do not change, leave at default.
30.44 Minimum firing angle	15.00° (def.)	15.00° (def.)	
30.45 Maximum firing angle	150.00° (def.)	150.00° (def.)	

* 27.38 Reversal delay and 27.40 Zero current timeout depending on the discontinuous current limit.

27.31 M1 discontinuous current limit	27.38 Reversal delay	Delta	27.40 Zero current timeout
≤ 50.00 %	5.0 ms	15 ms	20 ms
≤ 35.00 %	10.0 ms	25 ms	35 ms
≤ 20.00 %	15.0 ms	35 ms	50 ms
≤ 10.00 %	20.0 ms	50 ms	70 ms

12-pulse serial/Serial sequential; Limits

Set the limits in both the 12-pulse master and the 12-pulse slave.

Parameter	Master and slave	Comments
Speed		
21.08 M1 zero speed level	xxx rpm	Typical 1 % of nmax (maximum absolute motor speed), when an encoder is used.
30.11 M1 minimum speed	xxx rpm	
30.12 M1 maximum speed	xxx rpm	
Torque		
30.19.Minimum torque 1	xxx %	Parameters must match in the 12-pulse master and the 12-pulse slave.
30.20 Maximum torque 1	xxx %	Parameters must match in the 12-pulse master and the 12-pulse slave.
Current		
27.24 Current reference slope	10.0 %/ms (def.)	Parameters must match in the 12-pulse master and the 12-pulse slave.
30.34 M1 current limit bridge 2	xxx %	Parameters must match in the 12-pulse master and the 12-pulse slave.
30.35 M1 current limit bridge 1	xxx %	Parameters must match in the 12-pulse master and the 12-pulse slave.
Firing angle		
30.44 Minimum firing angle	15.00° (def.)	Parameters must match in the 12-pulse master and the 12-pulse slave.
30.45 Maximum firing angle	150.00° (def.)	Parameters must match in the 12-pulse master and the 12-pulse slave.

12-pulse serial/Serial sequential; Converter protections

Set the converter protections in both the 12-pulse master and the 12-pulse slave.

Parameter	**Master and slave**	**Comments**
Reversal fault		
27.38 Reversal delay	xxx ms*	After a command to change current direction the opposite current must be reached before 27.40 Zero current timeout has been elapsed. (29.06) > (27.40) > (27.38).
27.40 Zero current timeout	xxx ms*	After a command to change current direction the opposite current must be reached before 27.40 Zero current timeout has been elapsed. (29.06) > (27.40) > (27.38).
29.06 12-pulse reversal timeout	100 ms (def.)	Active only in 12-pulse master. (29.06) > (27.40) > (27.38).
Current difference		
29.07 12-pulse parallel current difference level	20 %	Active only in 12-pulse master.
29.08 12-pulse parallel current difference delay	500 ms (def.)	Active only in 12-pulse master.
Armature Overcurrent		
31.44 Armature overcurrent level	xxx %	ILIM = xxx A

* 27.38 Reversal delay and 27.40 Zero current timeout depending on the discontinuous current limit.

27.31 M1 discontinuous current limit	**27.38 Reversal delay**	**Delta**	**27.40 Zero current timeout**
≤ 50.00 %	5.0 ms	15 ms	20 ms
≤ 35.00 %	10.0 ms	25 ms	35 ms
≤ 20.00 %	15.0 ms	35 ms	50 ms
≤ 10.00 %	20.0 ms	50 ms	70 ms

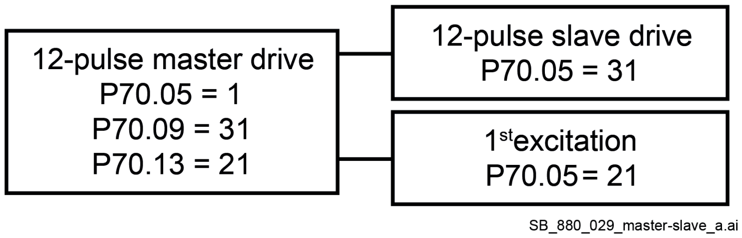
12-pulse serial/Serial sequential; Motor protection

Set the motor protections in both the 12-pulse master and the 12-pulse slave.

Parameter	Master and slave	Comments
Stall protection		
31.24 Stall function		
31.25 Stall torque level		
31.26 Stall speed level		
31.27 Stall time		
Armature overvoltage		
31.50 Armature overvoltage level		
Motor temperature		
35.11 Temperature 1 source		
35.12 Temperature 1 fault level		
35.13 Temperature 1 warning level		
Measured motor temperature		
35.14 Temperature 1 AI source		
35.15 Supervision 1 klixon source		
Motor thermal model		
35.50 Motor ambient temperature 1		
35.51 Motor load curve 1		
35.52 Zero speed load 1		
35.53 Break point 1		
35.54 Motor nominal temperature rise 1		
35.55 Motor thermal time constant 1		

12-pulse serial/Serial sequential; DCSLink

Set up the DCSLink.



Parameter	Master	Slave	Comments
70.05 DCSLink node ID	1	31	
70.08 12-pulse timeout	≥ 15 ms	≥ 15 ms	Generates fault F535 12-pulse communication.
70.09 12-pulse slave node ID	31 (def.)	n.a.	

Parameter	Master	Excitation	Comments
70.05 DCSLink node ID	1	21	
70.12 Field exciter timeout	100 ms (def.)	-	Generates either fault F516 M1 field exciter communication and/or fault F519 M2 field exciter communication.
70.13 M1 field exciter node ID	21 (def.)	n.a.	

12-pulse serial/Serial sequential; Type code settings

The type code settings are usually set by the factory. They can be checked in group 7 System info.

Parameter	Master and slave	Comments
07.02 Power unit set		The value is read from 95.14 Set: Power unit.
07.60 Drive size		Read from 95.25 Set: Type code.
07.61 Drive block bridge 2 set		Read from 95.25 Set: Type code or set with 95.26 Set: Drive block bridge 2.
07.62 Drive DC current scaling set		Read from 95.25 Set: Type code or set with S 95.27 Set: Drive DC current scaling.
07.63 Drive DC overcurrent level		Read from 95.25 Set: Type code or set with S 95.27 Set: Drive DC current scaling.
07.64 Drive AC voltage scaling set		Read from 95.25 Set: Type code or set with 95.28 Set: Drive AC voltage scaling.
7.65 Drive max bridge temperature set		Read from 95.25 Set: Type code or set with 95.29 Set: Drive max bridge temperature
95.14 Set: Power unit		
95.16 Control unit configuration		
95.24 Service mode		
95.25 Set: Type code		Normally set by the factory. To change use 95.24 Service mode = Set: Type code.
95.26 Set: Drive block bridge 2		Automatically taken from type code and thus 0: Auto.
95.27 Set: Drive DC current scaling		Automatically taken from type code.
95.28 Set: Drive AC voltage scaling		Automatically taken from type code.
95.29 Set: Drive max bridge temperature		Automatically taken from type code. For H7 and H8 units the air entry temperature can be set to 55°C in hot motor rooms.

12-pulse serial/Serial sequential; Galvanic isolation

Details see chapter Galvanic Isolation.

Parameter	Master and slave	Comments
AC transformer T90		E.g. 2U2, 2V2, 2W2 for mains voltages from 500 … 600 VAC.
DC transducer A92		E.g. 1 ≡ 810 V for mains voltages from 500 … 600 VAC.

12-pulse serial/Serial sequential; Additional settings

Additional setting in case of problems, when using an overriding control and Drive composer.

Parameter	Master and slave	Comments
24.18 Speed error filter time 1	0 ms (def.)	Cyclic bridge changes (bridge reversals) can lead to F533 12-pulse reversal timeout, F534 12-pulse current difference or F557 Reversal time. To prevent the cyclic bridge changes, it is recommended to re-tune the speed controller (making it more stable) and to use the speed error filter times. E.g. set 24.18 Speed error filter time 1= 24.19 Speed error filter time 2 = 10 ms.
24.19 Speed error filter time 2	0 ms (def.)	
27.34 Mains compensation time	10 ms (def.)	Set when the current is distributed differently on the thyristors (fast disturbances in current).
27.50 M1 armature inductance current controller	0.0 mH (def.)	Typically left at default. Set back to default, when the current is instable.
27.51 M1 armature inductance EMF speed feedback	0.0 mH (def.)	Typically left at default. Set back to default, when the current is instable.
30.27 Max torque during regenerating	325.00 % (def.)	The mains voltage is going down due to high load currents. To prevent regeneration operation at the commutation limit use 30.27 Max torque during regenerating.
95.44 PLL deviation level	15.00	Stabilizes the PLL.
95.45 PLL proportional gain	0.50 (def.)	
95.46 PLL filter time	10.0 ms	
95.47 PLL Uk compensation	0.0 % (def.)	Set slowly to higher values (1 by 1), if the sync. voltage is disturbed by commutation notches. To be used only with dedicated mains transformers.

12-pulse serial/Serial sequential; Large field exciters using DCS880-S01/S02 modules

In the 12-pulse master module.

Parameter	Master	Comments
28.17 M1 EMF/field control mode	1: EMF	EMF controller released, field weakening active, depending on the application.
31.57 Minimum field current trip delay	2000 ms (def.)	Delays fault F541 M1 field exciter low current.
31.58 M1 field current low level	xxx %	Sets level for fault F541 M1 field exciter low current.
70.05 DCSLink node ID	1	
70.12 Field exciter timeout	100 ms (def.)	Generates either fault F516 M1 field exciter communication and/or fault F519 M2 field exciter communication.
70.13 M1 field exciter node ID	21 (def.)	Use the same node number as in 70.05 DCSLink node ID of the large field exciter.
99.07 M1 used field exciter type	10: DCS880-S01. 11: DCS880-S02.	
99.13 M1 nominal field current	xxx A	IFN = xxx A, rated field current.

In the large field exciter module (DCS880-S01/S02).

Parameter	Excitation	Comments
20.01 Command location	4: Field exciter link	Control from the 12-pulse master. Source for the control word (On/Off1, Run/Stop and Reset).
20.47 Overvoltage protection trigger source	3: DI1 … 8: DI6 11: DIO1 12: DIO2 19: DIL	Depending on the hardware connection to the DCF506.
27.22 Current reference source	30: FieldRef via DCSLink	Field current reference from the 12-pulse master.
27.31 M1 discontinuous current limit	0.00 %	
27.38 Reversal delay	50.0 ms	
27.40 Zero current timeout	500 ms	To be set longer than 27.38 Reversal delay.
28.17 M1 EMF/field control mode	0: Fix (def.)	
31.50 Armature overvoltage level	1000.0 %	Disables the overvoltage supervision.
70.05 DCSLink node ID	21	Use the same node number as in 70.13 M1 field exciter node ID of the 12-pulse master.
95.44 PLL deviation level	20.00°	To suppress F514 Mains synchronization lost.
99.06 Operation mode	1: Large field exciter	
99.07 M1 used field exciter type	0: None	
99.10 Nominal mains voltage	xxx V	UNetN = xxx V; nominal mains voltage (AC).
99.11 M1 nominal current	xxx A	IFN = xxx A, rated field current.
99.12 M1 nominal voltage	xxx V	UFN = xxx V, rated field voltage.

12-pulse serial/Serial sequential; Field current autotuning

Field current autotuning for large field supplies using DCS880-S01/S02 modules **must** be started **directly** in the large field exciter.

Parameter	Large field exciter	Comments
99.20 Tuning request	1: Field current autotuning	Give the On and Run commands within 20 s.
27.29 M1 current proportional gain	xxx	Is set by the field current autotuning. Typical p-part values are around 4.
27.30 M1 current integration time	xxx	Is set by the field current autotuning.
27.31 M1 discontinuous current limit	0.00 %	Is set to zero by the field current autotuning.

Note:

This autotuning does not work when started from the Drive composer pro DCS880 Assistant.

12-pulse serial; Armature current autotuning

The 12-pulse serial master drive must be tuned in 12-pulse mode. Thus the 12-pulse slave fires a freewheeling pass and it is not necessary to shorten the DC output of the 12-pulse slave.

Single motor configuration or double motor configuration (the voltage measurement is over both motors)

Parameter	Master	Slave	Comments
99.06 Operation mode	4: 12-pulse serial master	5: 12-pulse serial slave	
95.34 DC voltage measurement adjust	50.0 %	50.0 %	
99.20 Tuning request	2: Armature current autotuning	-	Give the On and Run command within 20 s.

Do the following after a successful autotuning.

Parameter	Comments
27.29 M1 current proportional gain	Multiply by 0.5 and use directly in the 12-pulse master.
27.30 M1 current integration time	Use directly in the 12-pulse master.
27.31 M1 discontinuous current limit	Multiply by 0.5 and use directly in the 12-pulse master.
27.32 M1 armature resistance	Use directly in the 12-pulse master.
27.33 M1 armature inductance	Use directly in the 12-pulse master.

Double motor configuration (the voltage measurement is over one motor only)

Parameter	Master	Slave	Comments
99.06 Operation mode	4: 12-pulse serial master	5: 12-pulse serial slave	
95.34 DC voltage measurement adjust	100.0 %	100.0 %	
99.20 Tuning request	2: Armature current autotuning	-	Give the On and Run command within 20 s.

Do the following after a successful autotuning.

Parameter	Comments
27.29 M1 current proportional gain	Multiply by 0.5 and use directly in the 12-pulse master.
27.30 M1 current integration time	Use directly in the 12-pulse master.
27.31 M1 discontinuous current limit	Multiply by 0.5 and use directly in the 12-pulse master.
27.32 M1 armature resistance	Use directly in the 12-pulse master.
27.33 M1 armature inductance	Use directly in the 12-pulse master.

Attention:
In case an autotuning is not starting or interrupted warning AF90 Autotuning is set. The reason for the warning is shown in its AUX code. See Drive composer Event logger.

Serial sequential; Armature current autotuning

The serial sequential master drive must be tuned in serial sequential mode. Thus, the serial sequential slave fires a freewheeling pass and it is not necessary to shorten the DC output of the serial sequential slave.

Single motor configuration or double motor configuration (the voltage measurement is over both motors)

Parameter	Master	Slave	Comments
99.06 Operation mode	8: Serial sequential master 30°	9: Serial sequential slave 30°	
	10: Serial sequential master 0°	11: Serial sequential slave 0°	
95.34 DC voltage measurement adjust	50.0 %	50.0 %	
99.20 Tuning request	2: Armature current autotuning	-	Give the On and Run command within 20 s.

There is a 30° phase shift in the mains voltage between serial sequential master and serial sequential slave. Do the following after a successful autotuning.

Parameter	Comments
27.29 M1 current proportional gain	Multiply by 0.5 and use directly in the serial sequential master.
27.30 M1 current integration time	Use directly in the serial sequential master.
27.31 M1 discontinuous current limit	Multiply by 0.5 and use directly in the serial sequential master.
27.32 M1 armature resistance	Use directly in the serial sequential master.
27.33 M1 armature inductance	Use directly in the serial sequential master.

There is a 0° phase shift in the mains voltage between serial sequential master and serial sequential slave. Do the following after a successful autotuning.

Parameter	Comments
27.29 M1 current proportional gain	Multiply by 0.5 and use directly in the serial sequential master.
27.30 M1 current integration time	Use directly in the serial sequential master.
27.31 M1 discontinuous current limit	Multiply by 2 and use directly in the serial sequential master.
27.32 M1 armature resistance	Use directly in the serial sequential master.
27.33 M1 armature inductance	Use directly in the serial sequential master.

Attention:
In case an autotuning is not starting or interrupted warning AF90 Autotuning is set. The reason for the warning is shown in its AUX code. See Drive composer Event logger.

Double motor configuration (the voltage measurement is over one motor only)

Parameter	**Master**	**Slave**	**Comments**
99.06 Operation mode	8: Serial sequential master 30°	9: Serial sequential slave 30°	
	10: Serial sequential master 0°	11: Serial sequential slave 0°	
95.34 DC voltage measurement adjust	100.0 %	100.0 %	
99.20 Tuning request	2: Armature current autotuning	-	Give the On and Run command within 20 s.

There is a 30° phase shift in the mains voltage between serial sequential master and serial sequential slave. Do the following after a successful autotuning.

Parameter	**Comments**
27.29 M1 current proportional gain	Multiply by 0.5 and use directly in the serial sequential master.
27.30 M1 current integration time	Use directly in the serial sequential master.
27.31 M1 discontinuous current limit	Multiply by 0.5 and use directly in the serial sequential master.
27.32 M1 armature resistance	Use directly in the serial sequential master.
27.33 M1 armature inductance	Use directly in the serial sequential master.

There is a 0° phase shift in the mains voltage between serial sequential master and serial sequential slave. Do the following after a successful autotuning.

Parameter	**Comments**
27.29 M1 current proportional gain	Multiply by 0.5 and use directly in the serial sequential master.
27.30 M1 current integration time	Use directly in the serial sequential master.
27.31 M1 discontinuous current limit	Multiply by 2 and use directly in the serial sequential master.
27.32 M1 armature resistance	Use directly in the serial sequential master.
27.33 M1 armature inductance	Use directly in the serial sequential master.

Attention:
In case an autotuning is not starting or interrupted warning AF90 Autotuning is set. The reason for the warning is shown in its AUX code. See Drive composer Event logger.

Safe Torque Off (STO)

Contents of this chapter

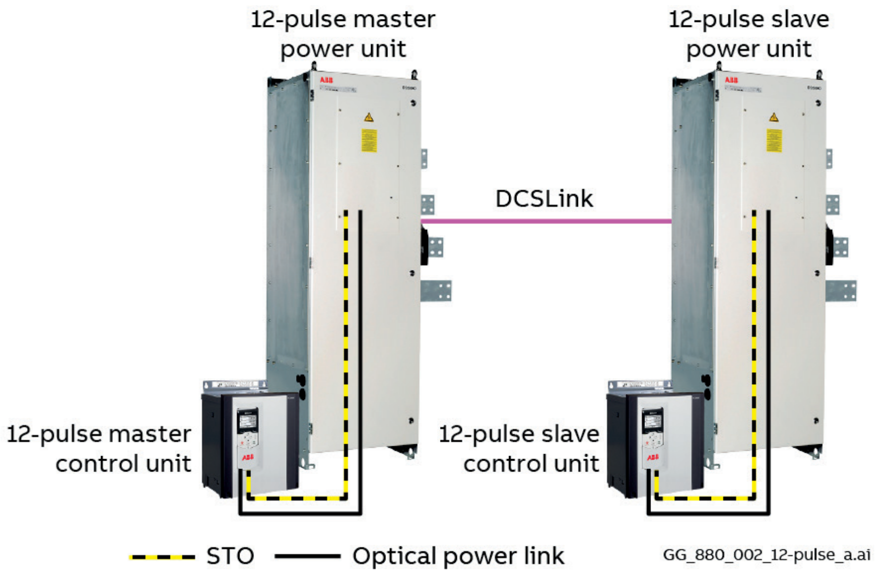
This chapter describes the hardware connections, the acceptance test, the repetitive function test and the STO revalidation test.

Note:

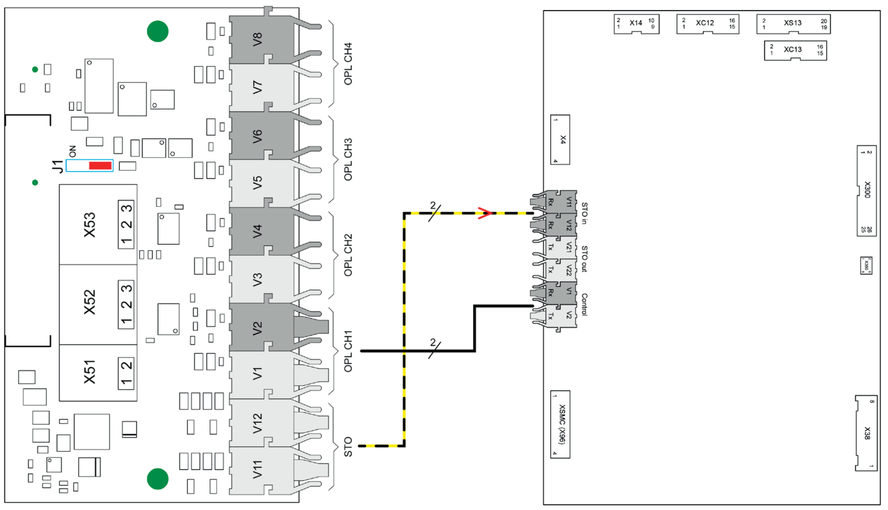
This is not the original operation manual of the STO function for the DCS880.

Hardware Connections

The hardware connections for the safe torque off circuit must be connected in this way.



Detailed overview 12-pulse master:



12-pulse master:
Control unit
(SDCS-DSL-H14)

12-pulse master:
Power unit
(SDCS-OPL-H01)

BL_DSLH1x+OPL_002_STO_a.ai

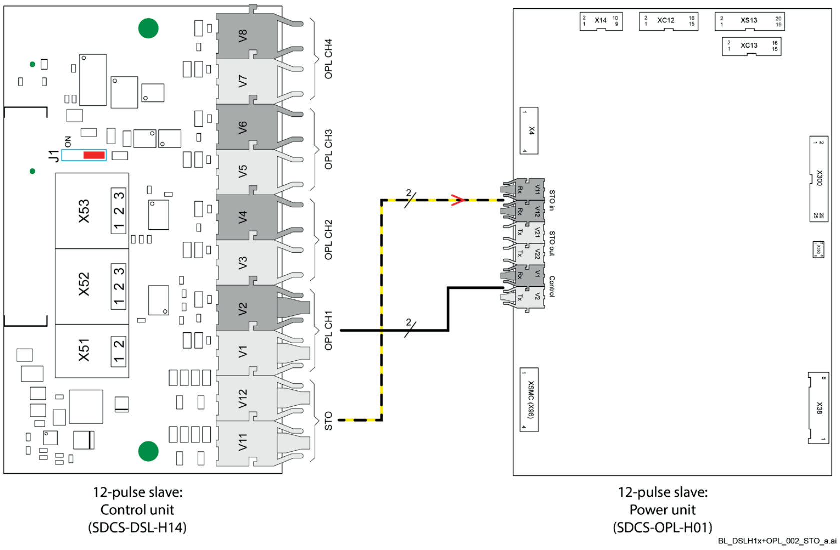
Yellow/Black: Double fiber optic cables for save torque off.

– From 12-pulse master control unit SDCS-DSL-H14 V11, V12 to 12-pulse master power unit SDCS-OPL-H01 V11, V12.

Black: Double fiber optic cables for optical power link.

– From 12-pulse master control unit SDCS-DSL-H14 V1, V2 to 12-pulse master power unit SDCS-OPL-H01 V1, V2.

Detailed overview 12-pulse slave:



Yellow/Black: Double fiber optic cables for save torque off.

– From 12-pulse slave control unit SDCS-DSL-H14 V11, V12 to 12-pulse slave power unit SDCS-OPL-H01 V11, V12.

Black: Double fiber optic cables for optical power link.

– From 12-pulse slave control unit SDCS-DSL-H14 V1, V2 to 12-pulse slave power unit SDCS-OPL-H01 V1, V2.

Description

The STO function can be used, for example, to construct safety or supervision circuits that stop the drive in case of danger (such as an emergency stop circuit). Another possible application is a prevention of unexpected start-up switch that enables short-time maintenance operations like cleaning or work on non-electrical parts of the machinery without switching off the power supply to the drive.

When activated, the STO function disables the control voltage of the power semiconductors of the drive output stage, thus preventing the drive from generating the torque required to rotate the motor. If the motor is running when STO is activated, it coasts to a stop.

The STO function has a redundant architecture, that is, both channels must be used in the safety function implementation.

The STO function of the drive complies with these standards:

Standard	Name
EN 60204-1:2006 + AC:2010	Safety of machinery – Electrical equipment of machines – Part 1: General requirements
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC 61800-5-2:2016 EN 61800-5-2:2017	Adjustable speed electrical power drive systems –Part 5-2: Safety requirements – Functional
IEC 62061:2015 EN 62061:2005 +AC:2010+A1:2013+A2:2015	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
EN ISO 13849-1:2015	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
EN ISO 13849-2:2012	Safety of machinery – Safety-related parts of control systems – Part 2: Validation

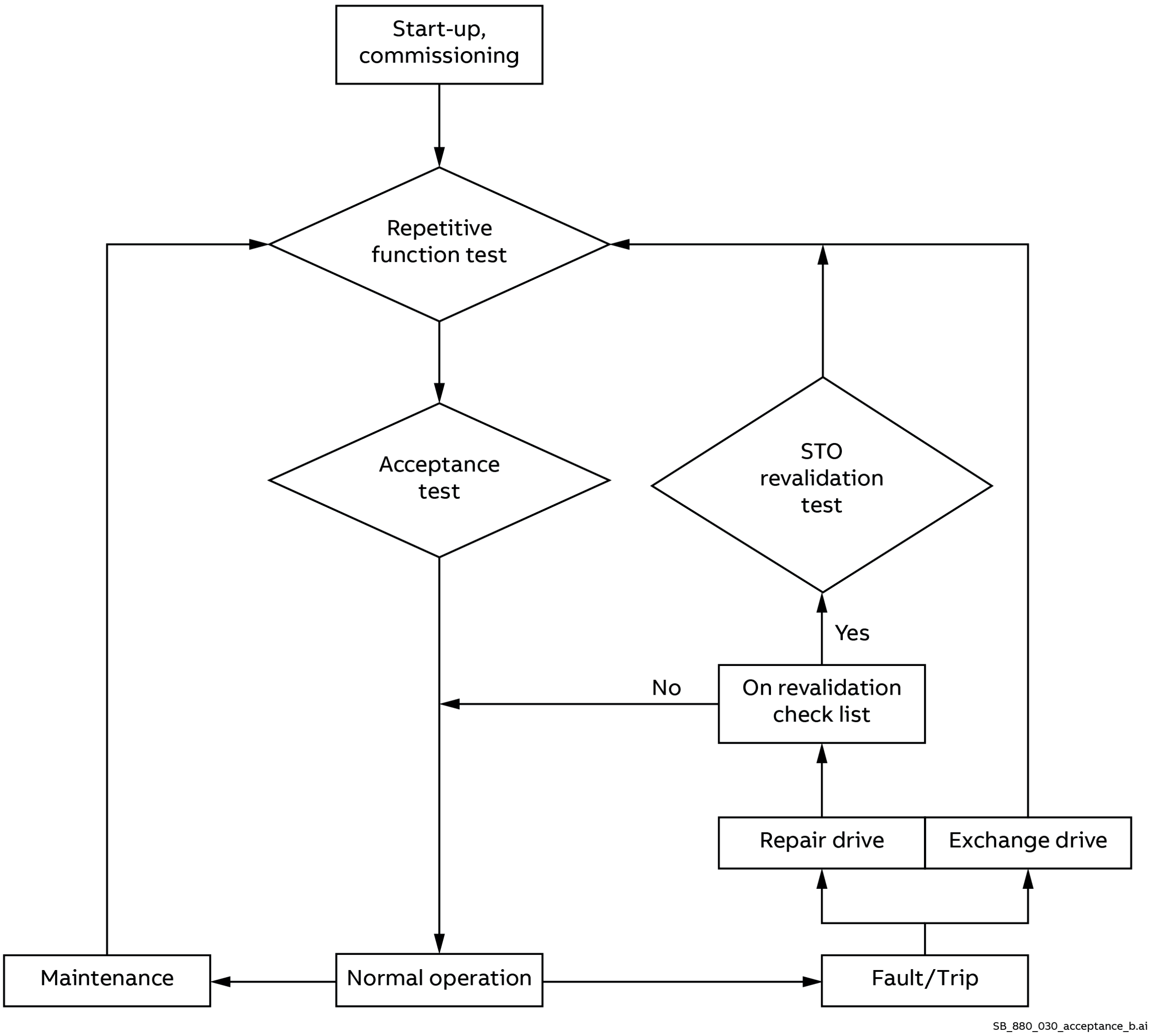
The function also corresponds to Prevention of unexpected start-up as specified by EN 1037:1995 + A1:2008 and Uncontrolled stop (stop category 0) as specified in EN 60204-1:2006 + AC:2010.

Operation principle

1. The STO activates when the activation switch is opened, or safety relay contacts open.
2. The STO inputs on the drive control unit de-energize (low active).
3. The control unit cuts off the firing pulses from the drive thyristors.
4. The control program generates an indication as defined by 31.22 STO indication run/stop (refer to DCS880 Firmware Manual).
5. Motor coasts to a stop (if running). The drive cannot restart while the activation switch or safety relay contacts are open. After the contacts close, a new start command is required to start the drive.

Flow chart

Acceptance test, repetitive function test and STO revalidation test:



Maintenance

The STO function shall be maintained by periodic testing. To perform the maintenance, do the following:

– Repetitive function test.
– Acceptance test.

Fault/Trip

If the drive was repaired and the changed hardware is not in the revalidation check list below, no test is needed.

After a fault/trip the STO function shall be tested depending on the type of repair.

If the complete drive module has been exchanged, do the following:

– Repetitive function test.
– Acceptance test.

If the drive was repaired and the changed hardware is in the revalidation check list below, do the following:

– STO revalidation test.
– Repetitive function test.
– Acceptance test.

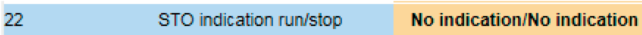
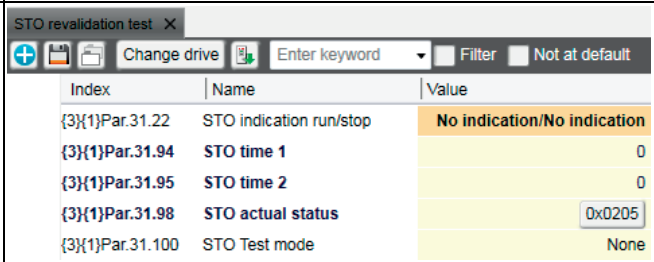
Revalidation check list

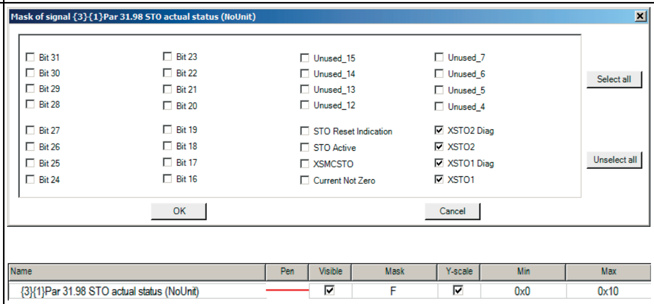
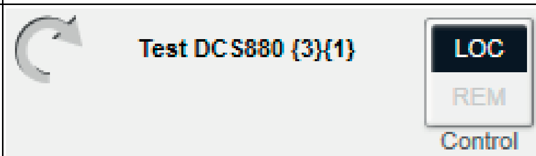
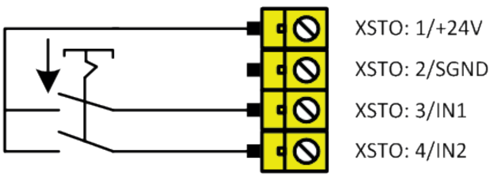
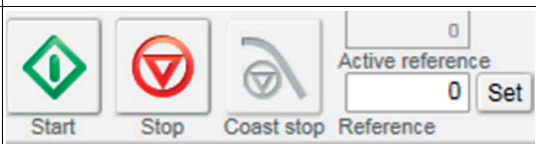
Spare part / Size	H1	H2	H3	H4	H5	H6	H7	H8
Up- or downgrade firmware	X	X	X	X	X	X	X	X
Memory unit	X	X	X	X	X	X	X	X
SDCS-CON-H01	X	X	X	X	X	X	X	X
SDCS-PIN-H01	X	X	X	X	X			
SDCS-POW-H01						X	X	X
SDCS-PIN-H41						X	X	X
SDCS-PIN-H51						X	X	X
SDCS-OPL-H01							X	X
SDCS-DSL-H10								
SDCS-DSL-H12							X	X
SDCS-DSL-H14							X	X
SDCS-SUB-H01	X	X	X	X	X			
SDCS-DPI-H01								
Line fuse								
Branch fuse					X	X	X	X
Thyristor	X	X	X	X	X	X	X	X
Converter fan								
Ribbon cable	X	X	X	X	X	X	X	X
Control panel (ACS-AP-x)								
F-type plug in option (except FSE-31, FSO-21)								
FSO-21, FSE-31	X	X	X	X	X	X	X	X

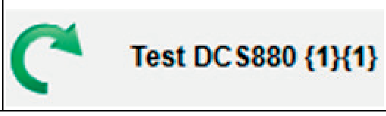
STO revalidation test

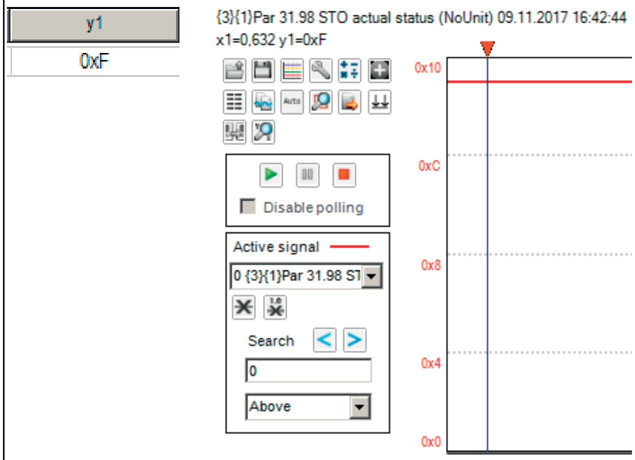
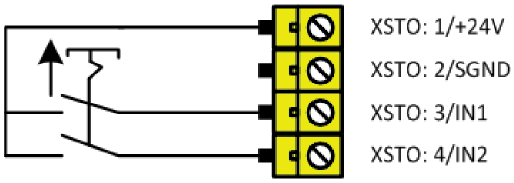
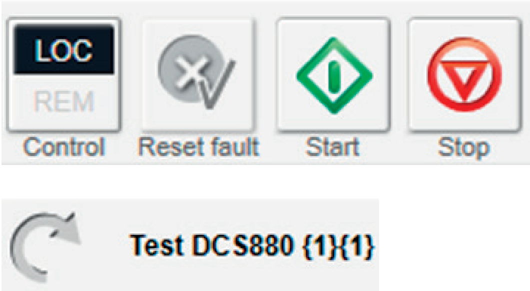
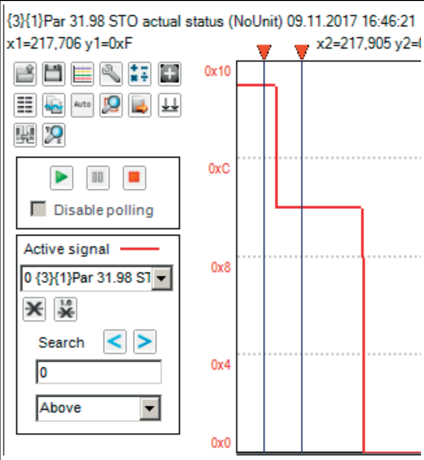
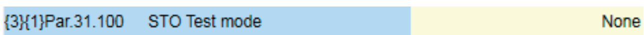
Test procedure

For this test Drive composer pro is needed.
The test must be exercised **twice**. Once for the 12-pulse master and once for the 12-pulse slave.
If one step needs to be done in both, 12-pulse master and 12-puls slave, it is mentioned.

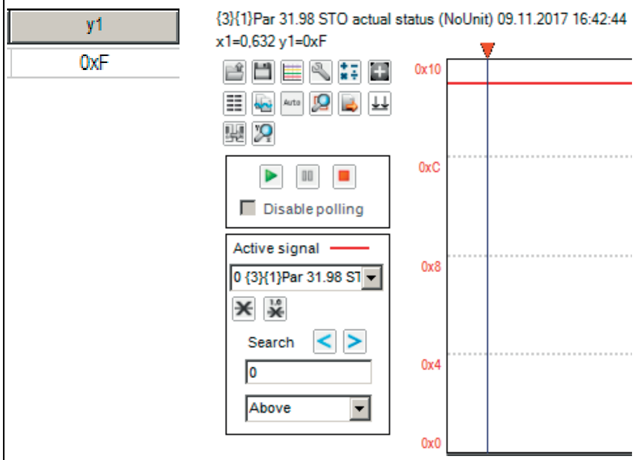
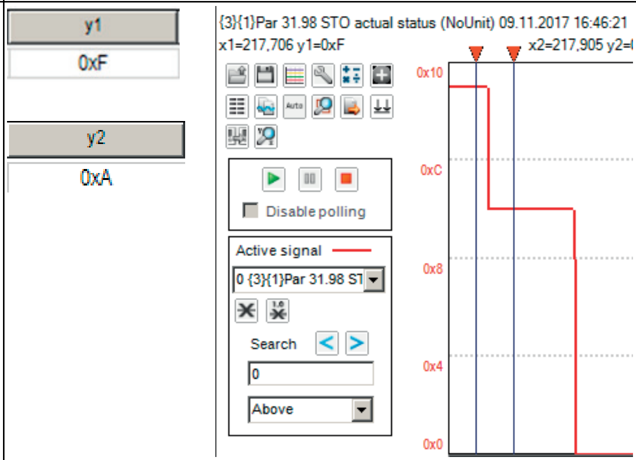
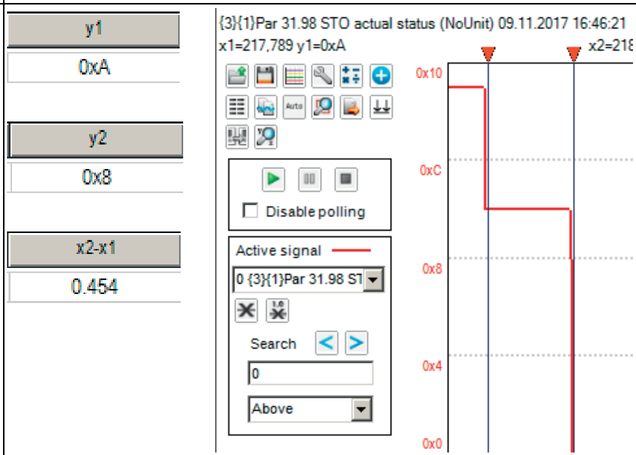
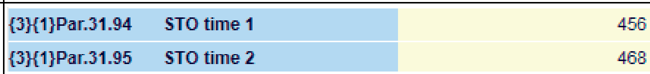
<table>
<tr><th>Step</th><th>Action</th><th>Comment</th></tr>
<tr><td>1</td><td>In both 12-pulse master and 12-pulse slave.
Set 31.22 STO indication run/stop = No indication/No indication.</td><td>
</td></tr>
<tr><td>2</td><td>Write down the values of:
– 31.94 STO time 1 =
– 31.95 STO time 2 =</td><td>
</td></tr>
<tr><td>3</td><td>Create a custom workspace:
– 31.22 STO indication run/stop.
– 31.94 STO time 1.
– 31.95 STO time 2.
– 31.98 STO actual status.
– 31.100 STO Test mode.</td><td>
</td></tr>
<tr><td>4</td><td>Create monitor with 31.98 STO actual status and select following bits:
– XSTO1.
– XSTO1 Diag.
– XSTO2.
– XSTO2 Diag.

– Mask = F.
– Set the Max in the monitor to 0x10.</td><td>
</td></tr>
<tr><td>5</td><td>Set the drive to local.</td><td>
</td></tr>
<tr><td>6</td><td>If open, close the STO terminal circuit.</td><td>
</td></tr>
<tr><td>7</td><td>Give a run (press Start) command and zero speed reference to the drive.
Note:
It is important that there is no current flow during this test.</td><td>


</td></tr>
</table>

Step	Action	Comment
8	Start the monitor value must be 0xF.	
9	In both 12-pulse master and 12-pulse slave. Set 31.100 STO Test mode = No Block.	
10	Open the STO terminal circuit.	
11	Remove the run command (press Stop), if it is still given.	
12	Stop the monitor.	
13	In both 12-pulse master and 12-pulse slave. Set 31.100 STO Test mode = None.	

Evaluation of the graph and observations

Step	Action	Comment
1	At the start of the procedure the monitor value of 31.98 STO actual status must be 0xF.	
2	After opening the STO circuit the value of 31.98 STO actual status must be 0xA.	
3	After about 500 ms the value of 31.98 STO actual status must be 0x0, 0x2 or 0x8. Shortly after the value of 31.98 STO actual status must be 0x0.	
4	Compare the values of 31.94 STO time 1 and 31.95 STO time 2. Their values must be within 20 ms of each other and within ±70 ms of 500 ms.	
5	Document and sign the STO revalidation test which verifies that the safety function is safe and accepted for operation in the machine log book.	

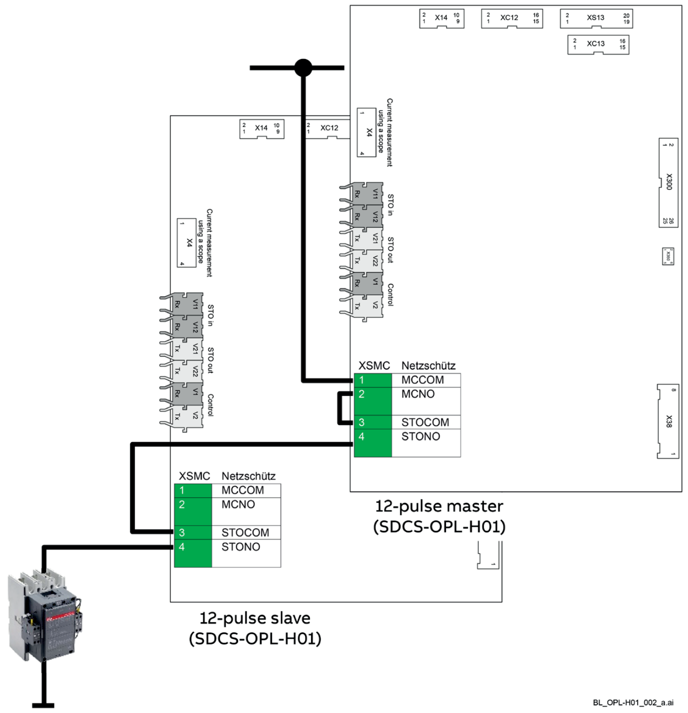
Observation of abnormalities

- Re-try of the validation test is allowed once.
- The root cause could be the Drive composer pro. Close the program and reconnect.
- There could be a current flow through the machine. This is very likely if 31.94 STO time 1 and 31.95 STO time 2 are about 300 ms and fault 5093 Safe off main contactor XSMCSTO is present.
  Re-tune the current controller and make sure, that there is **no** current present during the test.
- If the failure persists exchange the SDCS-CON-H01.
- Then re-do the test.

Repetitive function test (fault shutdown path)

Fault shutdown path

Due to the special nature of STO in DC drives a load switching device, e.g. a mains contactor (MC), an air circuit breaker (ACB), a DC breaker (DCB) or a high-speed DC breaker (HSDCB) must be installed in the power circuit of the system and be opened by any of the relays XSMC:STO on any of the SDCS-OPL-H01 in any of the 12-pulse power units in case of a drive hardware fault.
All relay outputs XSMC:STO on the SDCS-OPL-H01 inside all 12-pulse power units need to be connected in series with the load switching device.

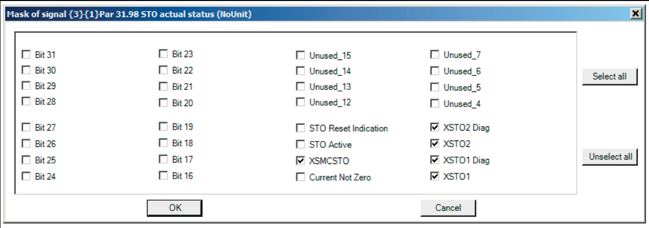


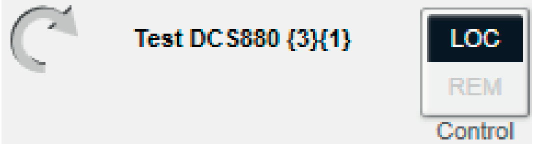
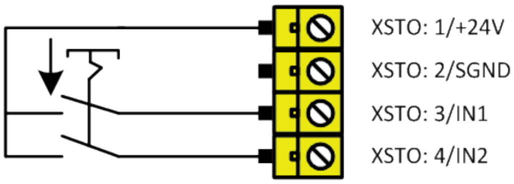
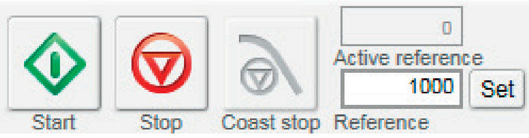
Test procedure

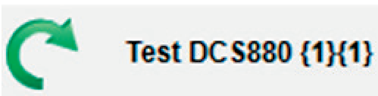
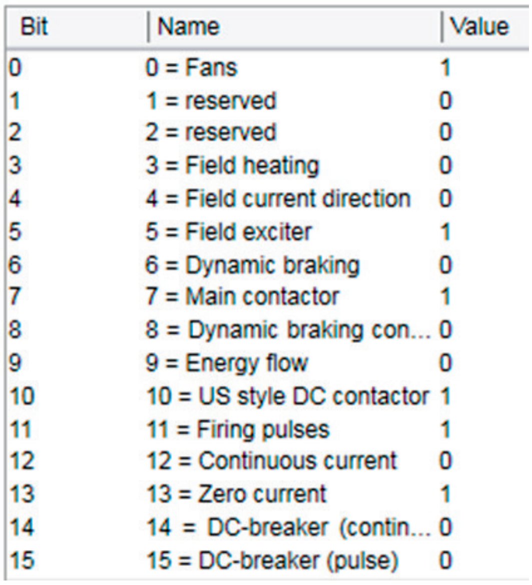
For this test Drive composer pro is needed.
The test must be exercised **twice**. Once for the 12-pulse master and once for the 12-pulse slave.
If one step needs to be done in both, 12-pulse master and 12-puls slave, it is mentioned.

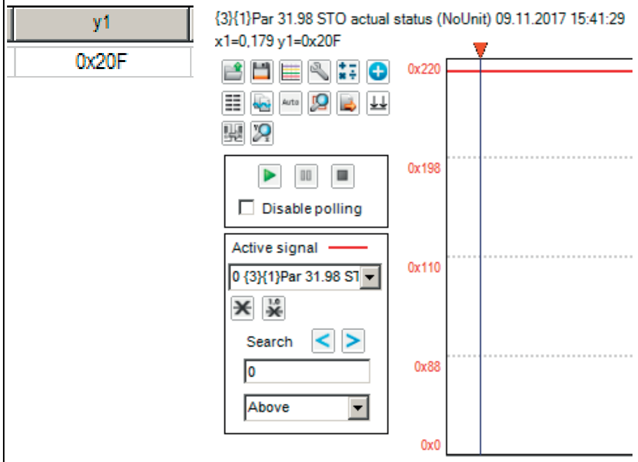
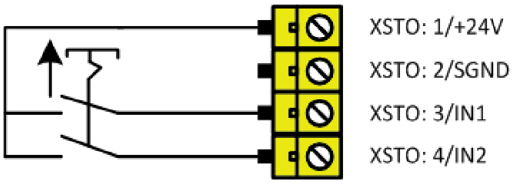
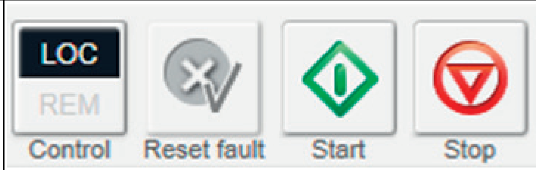
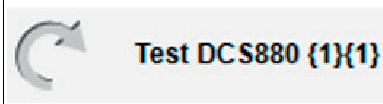
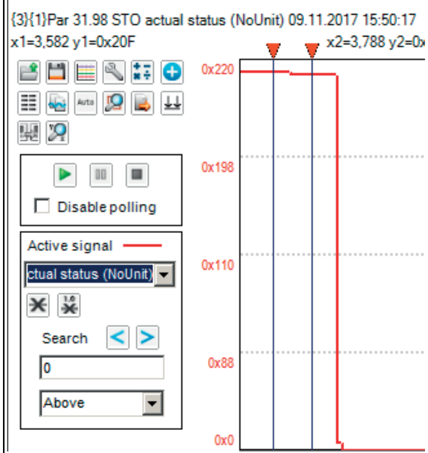
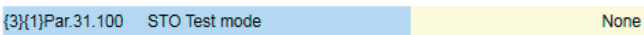
Step	Action	Comment
1	In both 12-pulse master and 12-pulse slave. Set 31.22 STO indication run/stop = No indication/No indication.	22 STO indication run/stop No indication/No indication
2	Write down the values of: – 31.94 STO time 1 = – 31.95 STO time 2 =	94 STO time 1 0 ms 95 STO time 2 0 ms
3	Create a custom workspace: – 31.22 STO indication run/stop. – 31.94 STO time 1. – 31.95 STO time 2. – 31.98 STO actual status. – 31.100 STO Test mode. – 06.24 Current Controller status word 1.	Repetitive function test Change drive Enter keyword Filter Not at default Selec Index Name Value {3}{1}Par.31.22 STO indication run/stop No indication/No indication {3}{1}Par.31.94 STO time 1 0 {3}{1}Par.31.95 STO time 2 0 {3}{1}Par.31.98 STO actual status 0x0205 {3}{1}Par.31.100 STO Test mode None {3}{1}Par.6.24 Current controller status word 1 0x2000

<table>
<tr><th>Step</th><th>Action</th><th>Comment</th></tr>
<tr><td>4</td><td>Create monitor with 31.98 STO actual status and select following bits:
– XSTO1.
– XSTO1 Diag.
– XSTO2.
– XSTO2 Diag.
– XSMCSTO.

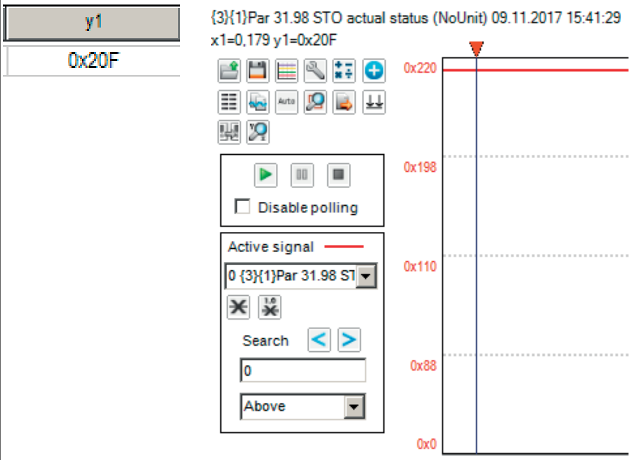
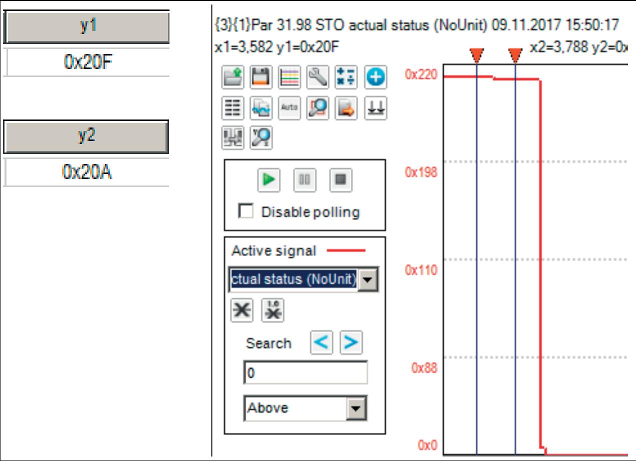
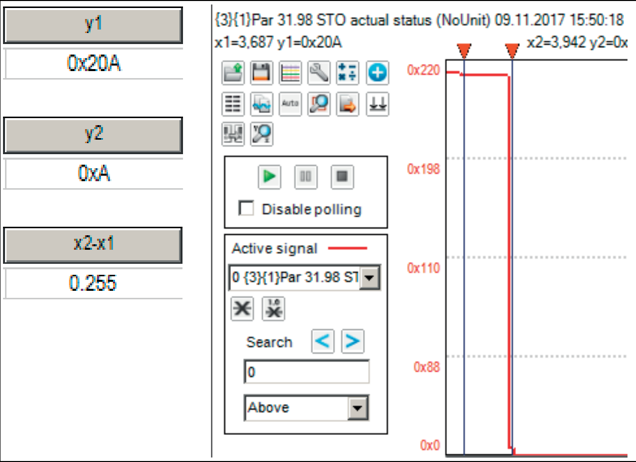
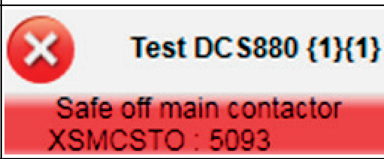
– Mask = 20F.
– Set the Max in the monitor to 0x220.</td><td>

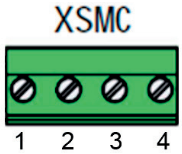

</td></tr>
<tr><td>5</td><td>Set the drive to local.</td><td>
</td></tr>
<tr><td>6</td><td>If open, close the STO terminal circuit.</td><td>
</td></tr>
<tr><td>7</td><td>Give a run (press Start) command and a suitable reference (in this example 1000 rpm have been used) to the drive.
Note:
It is important that there is a current flow during this test. Any current flow is sufficient.</td><td>


</td></tr>
<tr><td>8</td><td>Check following bits in 06.24 Current controller status word 1:
– 06.24.b09 = 0 = Drive is motoring.
– 06.24.b12 = 0 = Discontinuous armature current (recommendation not mandatory).
– 06.24.b13 = 0 = Armature current not zero.</td><td>
<table>
<tr><th>Bit</th><th>Name</th><th>Value</th></tr>
<tr><td>0</td><td>0 = Fans</td><td>1</td></tr>
<tr><td>1</td><td>1 = reserved</td><td>0</td></tr>
<tr><td>2</td><td>2 = reserved</td><td>0</td></tr>
<tr><td>3</td><td>3 = Field heating</td><td>0</td></tr>
<tr><td>4</td><td>4 = Field current direction</td><td>0</td></tr>
<tr><td>5</td><td>5 = Field exciter</td><td>1</td></tr>
<tr><td>6</td><td>6 = Dynamic braking</td><td>0</td></tr>
<tr><td>7</td><td>7 = Main contactor</td><td>1</td></tr>
<tr><td>8</td><td>8 = Dynamic braking con...</td><td>0</td></tr>
<tr><td>9</td><td>9 = Energy flow</td><td>0</td></tr>
<tr><td>10</td><td>10 = US style DC contactor</td><td>1</td></tr>
<tr><td>11</td><td>11 = Firing pulses</td><td>1</td></tr>
<tr><td>12</td><td>12 = Continuous current</td><td>0</td></tr>
<tr><td>13</td><td>13 = Zero current</td><td>1</td></tr>
<tr><td>14</td><td>14 = DC-breaker (contin...</td><td>0</td></tr>
<tr><td>15</td><td>15 = DC-breaker (pulse)</td><td>0</td></tr>
</table></td></tr>
</table>

Step	Action	Comment
9	Start the monitor value must be 0x20F.	
10	In both 12-pulse master and 12-pulse slave. Set 31.100 STO Test mode = No Block.	
11	Open the STO terminal circuit.	
12	Remove the run command (press Stop), if it is still given.	
13	Stop the monitor.	
14	In both 12-pulse master and 12-pulse slave. Set 31.100 STO Test mode back to None.	

Evaluation of the graph and observations

Step	Action	Comment
1	At the start of the procedure the monitor value of 31.98 STO actual status must be 0x20F.	
2	After opening the STO circuit the value of 31.98 STO actual status must be 0x20A.	
3	After about 300 ms the value of 31.98 STO actual status must be 0xA. Shortly after the value of 31.98 STO actual status must be 0x0.	
4	Compare the values of 31.94 STO time 1 and 31.95 STO time 2. Their values must be within ±50 ms of 300 ms.	{3}{1}Par.31.94 STO time 1 286 {3}{1}Par.31.95 STO time 2 286
5	Drive must show fault 5093 Safe off main contactor XSMCSTO. It will also show fault 5092 STO overall fault.	

Step	Action	Comment
	Most likely also fault 3280 Mains low voltage is displayed.	
6	In both 12-pulse master and 12-pulse slave. Relay XSMC:STO (3, 4) on the SDCS-OPL-H01 of both 12-pulse power units must be open. This can be checked by 31.81 Power units XSMC:STO status word = 0. Additionally, it must be verified by means of a meter, that relay XSMC:STO (3, 4) on the SDCS-OPL-H01 of both 12-pulse power units is open.	
7	The load switching element e.g. a mains contactor (MC), an air circuit breaker (ACB), a DC breaker (DCB) or a high-speed DC breaker (HSDCB) connected to XSMC:STO must have been opened.	
8	The SDCS-OPL-H01 in the power unit must be rebooted (cycle auxiliary power) afterwards, as relay XSMC:STO is only closed once during the boot of the board.	

9	Test the function of connector XSMC on the SDCS-OPL-H01 when the motor is stopped.
	– Give a stop command for the drive (if running) and wait until the motor shaft is at a standstill.
	– Ensure that the drive operates as follows:
	  – Unplug connector XSMC on the SDCS- OPL -H01.
	  – Give a start command. The motor should not generate torque. The used load switching device, e.g. a mains contactor (MC), an air circuit breaker (ACB), a DC breaker (DCB) or a high-speed DC breaker (HSDCB) must **not** close.
	  – Re-plug connector XSMC on the SDCS- OPL -H01.
	  – Reset any active faults.
	  – Restart the drive and check that the motor runs normally.	

10	Document and sign the repetitive function test which verifies that the fault shutdown path of the safety function is safe and accepted for operation in the machine log book.	

Acceptance test

The test must be exercised **twice**. Once for the 12-pulse master and once for the 12-pulse slave.

Action	☑
WARNING! Follow the Safety instructions, Ignoring the instructions can cause physical injury or death, or damage to the equipment.	☐
Ensure that the drive can be run and stopped freely during start-up.	☐
Stop the drive (if running), switch off mains- and auxiliary power and isolate the drive from the power lines by disconnectors.	☐
Check the STO circuit connections against the wiring diagram.	☐
Close the disconnectors and switch on mains- and auxiliary power.	☐

Test the operation of the STO function when the motor is stopped.
– Give a stop command for the drive (if running) and wait until the motor shaft is at a standstill.
– Ensure that the drive operates as follows:
    – Open the STO circuit. The drive generates an indication if one is defined for 'stopped' state in 31.22 STO indication run/stop (see DCS880 Firmware Manual).
    – Give a start command to verify that the STO function blocks the drive operation. The motor should not generate torque.
    – Close the STO circuit.
    – Reset any active faults. Restart the drive and check that the motor runs normally.
	☐

Test the operation of the STO function when the motor is running.
– Start the drive and ensure the motor is running.
– Ensure that the drive operates as follows:
    – Open the STO circuit. The motor should stop and should not generate torque. The drive generates an indication if one is defined for 'running' state in 31.22 STO indication run/stop (see DCS880 Firmware Manual).
    – Reset any active faults and try to start the drive.
    – Ensure that the motor stays at standstill and the drive operates as described above in testing the operation when the motor is stopped.
    – Close the STO circuit.
    – Reset any active faults. Restart the drive and check that the motor runs normally.
	☐

Test the control unit: Test the operation of the failure detection of the drive. The motor can be stopped or running. – Open the 1st channel of the STO circuit (wire connected to IN1). If the motor was running, it should coast to a stop. The drive generates fault FA81 Safe torque off 1 loss (see DCS880 Firmware Manual). – Give a start command to verify that the STO function blocks the drive's operation. The motor should not generate torque. – Close the STO circuit. – Reset any active faults. Restart the drive and check that the motor runs normally. – Open the 2nd channel of the STO circuit (wire connected to IN2). If the motor was running, it should coast to a stop. The drive generates fault FA82 Safe torque off 2 loss (see DCS880 Firmware Manual). – Give a start command to verify that the STO function blocks the drive's operation. The motor should not generate torque. – Close the STO circuit. – Reset any active faults. Restart the drive and check that the motor runs normally.	☐
Test the power unit: Test the operation of the failure detection of the drive. The motor can be stopped or running.	☐

Action	☑
– Unplug the 1st optical channel of the STO circuit (optical cable connected to V12 on the SDCS-DSL-H12 or SDCS-DSL-H14). If the motor was running, it should coast to a stop. The drive generates fault 5095 Power units STO stuck at with an AUX code (see DCS880 Firmware Manual). – Give a start command to verify that the STO function blocks the drive's operation. The motor should not generate torque. – Close the STO circuit. – Reset any active faults. Restart the drive and check that the motor runs normally. – Unplug the 2nd optical channel of the STO circuit (optical cable connected to V11 on the SDCS-DSL-H12 or SDCS-DSL-H14). If the motor was running, it should coast to a stop. The drive generates fault 5095 Power units STO stuck at with an AUX code (see DCS880 Firmware Manual). – Give a start command to verify that the STO function blocks the drive's operation. The motor should not generate torque. – Close the STO circuit. – Reset any active faults. Restart the drive and check that the motor runs normally.	
Document and sign the acceptance test which verifies that the safety function is safe and accepted for operation in the machine log book.	☐

DCS Family

DCS550-S modules
The compact drive for machinery application

20 … 1,000 A_{DC}
0 … 610 V_{DC}
230 … 525 V_{AC}
IP00

- Compact
- Robust design
- Adaptive and winder program
- High field exciter current

DCS880 modules
For safe productivity

20 … 5,200 A_{DC}
0 … 1,600 V_{DC}
230 … 1,000 V_{AC}
IP00

- Safe torque off (STO) built in as standard
- Compact and robust
- Single drives, 20 A to 5,200 A, up to 1,600 V_{DC}
- IEC 61131 programmable
- Intuitive control panel and PC tool with USB connection and start up assistant
- Wide range of options to serve any DC motor application

DCS800-A enclosed converters
Complete drive solutions

20 … 20,000 A_{DC}
0 … 1,500 V_{DC}
230 … 1,200 V_{AC}
IP21 – IP54

- Individually adaptable to customer requirements
- User-defined accessories like external PLC or automation systems can be included
- High power solutions in 6- and 12-pulse up to 20,000 A, 1,500 V
- In accordance to usual standards
- Individually factory load tested
- Detailed documentation

DCT880 modules
Thyristor controller

20 … 4,200 A_{AC}
110 … 990 V_{AC}
IP00

- Precise power control in industrial heating applications
- Two or three phase devices
- Power optimizer for peak load reduction
- Built on ABB's all-compatible drives architecture
- Intuitive control panel and PC tool with USB connection and start up assistant
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