ABB WIND TURBINE CONVERTERS

ACS880-77LC/-87LC/-87CC wind turbine converters

System description



List of related documents

Manuals
ACS880-77LC/-87LC/-87CC wind turbine converters system description
Safety instructions for the wind turbine converter
Start-up guide for the wind turbine converter
Hardware manual for the wind turbine converter
Firmware manual for the wind turbine converter
Drive composer Start-up and maintenance PC tool User’s manual
Manuals for I/O extension modules, fieldbus adapters, etc.

Other documents
Circuit diagrams set
Fieldbus interface description
Firmware release note with the download instructions

For manuals, contact your local ABB representative.

System description

ACS880-77LC/-87LC/-87CC wind turbine converters

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3AXD50000022022 Rev C
EN
EFFECTIVE: 2020-04-27

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1

Introduction to the manual

Contents of this chapter

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

Safety instructions

Obey all safety instructions delivered with the converter. Read the complete safety instructions before you install, commission, or use the converter. The complete safety instructions are part of the hardware manual or there is a separate manual.

Target audience

This manual is intended for people who plan the installation, install, commission, use and service the converter. Read the manual before working on the converter. The reader is expected to know the fundamentals of electricity, wiring, electrical components and electrical schematic symbols.

Purpose of the manual

This manual describes the operation of the whole wind turbine system. The manual is mainly an introduction in getting to know the wind turbine system.

Contents of this manual

This manual contains these chapters:

- *Introduction to the manual*
- *Operation principle*
- *Control modes*
- *Grid fault ride-through*
- *Wind turbine applications (WTA)*

Other related documents

See *List of related documents* on the inside of the front cover.

Product and service inquiries

Address any inquiries about the product to your local ABB representative. For more information, see *Product and service inquiries* on the inside of the back cover.

When you contact ABB, quote the type code and serial number of the converter. In fault situations, the problem solving is faster if you send us the

- fault logger data
- data logger data
- parameter files from the grid-side and generator-side control programs.

Terms and abbreviations

Term/abbreviation	Explanation
AC	Alternating current
BAMU	Auxiliary measurement unit
BCON	Type of control board
BCU	Type of control unit, a BCON board in a metal housing. See *BCON.*
DC	Direct current
DC chopper	Protects the converter by cutting down a peak overvoltage in the converter DC link: conducts the surplus energy from the intermediate circuit of the wind turbine converter to the DC resistor when necessary. The chopper operates when the DC link voltage exceeds a maximum limit. A sudden disturbance in turbine operation or grid can cause the DC voltage rise.
DC resistor	Dissipates the surplus energy conducted by the DC chopper to heat. Essential part of the chopper circuit. See *DC chopper*.
Control board	Circuit board in which the control program runs. See *BCON*.
Control unit	Control board built in a rail-mountable housing. See *BCU*.
Converter	Converts direct current and voltage to alternating current and voltage, or vice versa.
Converter module	Grid-side converter or generator-side converter module
Cut-in speed	The minimum wind speed at which power generation is reasonable.
Cut-out speed	The maximum speed at which the turbine can be operated safely.
DC link	DC circuit between grid-side converter and generator-side converter
DC link capacitors	Energy storage which stabilizes the intermediate circuit DC voltage.
DDCS	Distributed drives communication system; a protocol used in optical fiber communication
DTC	Direct torque control; a generator control method by ABB.
FENA	Optional Ethernet adapter module for EtherNet/IP™, Modbus TCP® and PROFINET IO® protocols
FRT	Fault ride-through
Generator-side converter	The converter part that is connected to the generator stator and controls the generator operation. It converts the AC power from the generator to the converter DC bus.
GFRT	Grid fault ride-through
Grid-side converter	A converter that is connected to the grid and is capable of transferring energy from the converter DC link to the grid and vice versa.
HVRT	High voltage ride-through
I/O	Input/Output
IGBT	Insulated gate bipolar transistor; a voltage-controlled semiconductor type widely used in various converters because of their easy controllability and high switching frequency.
InterBus-S	INTERBUS®, the open sensor/actuator bus from Phoenix Contact
Intermediate circuit	See *DC link*.

Term/abbreviation	Explanation
LC	Liquid-cooled
LCL filter	Inductor-capacitor-inductor filter at AC side of the grid-side converter. Attenuates harmonics.
LVRT	Low voltage ride-through
Main circuit breaker (MCB)	Electrically-controlled main switching and protecting device. A withdrawable breaker can also be used as the main disconnector.
MFRT	Multiple fault ride-through
NETA	Remote monitoring tool for maintenance and supervision
Parameter	User-adjustable operation instruction to the converter, or signal measured or calculated by the converter.
PLC	Programmable logic controller. See *WTC*.
PM	Permanent magnet
RDCO	DDCS communication option module
THD	Total harmonic distortion
UPS	Uninterruptible power supply
Wind turbine converter	A converter for controlling AC generators in wind turbine applications.
Wind turbine system	Wind turbine system consists of the wind turbine, wind turbine converter, generator etc.
WTA	Wind turbine applications. An additional configuration and control function of the wind turbine converter which is used to control wind turbine systems with parallel-connected converters. See chapter *Wind turbine applications (WTA)*.
WTC	Wind turbine controller. The device, typically a PLC, which controls operation of the wind turbine. Located outside the ABB wind turbine converter.
ZMU	Memory unit attached to the BCU control unit connector X205 MEMORY UNIT.

2

Operation principle

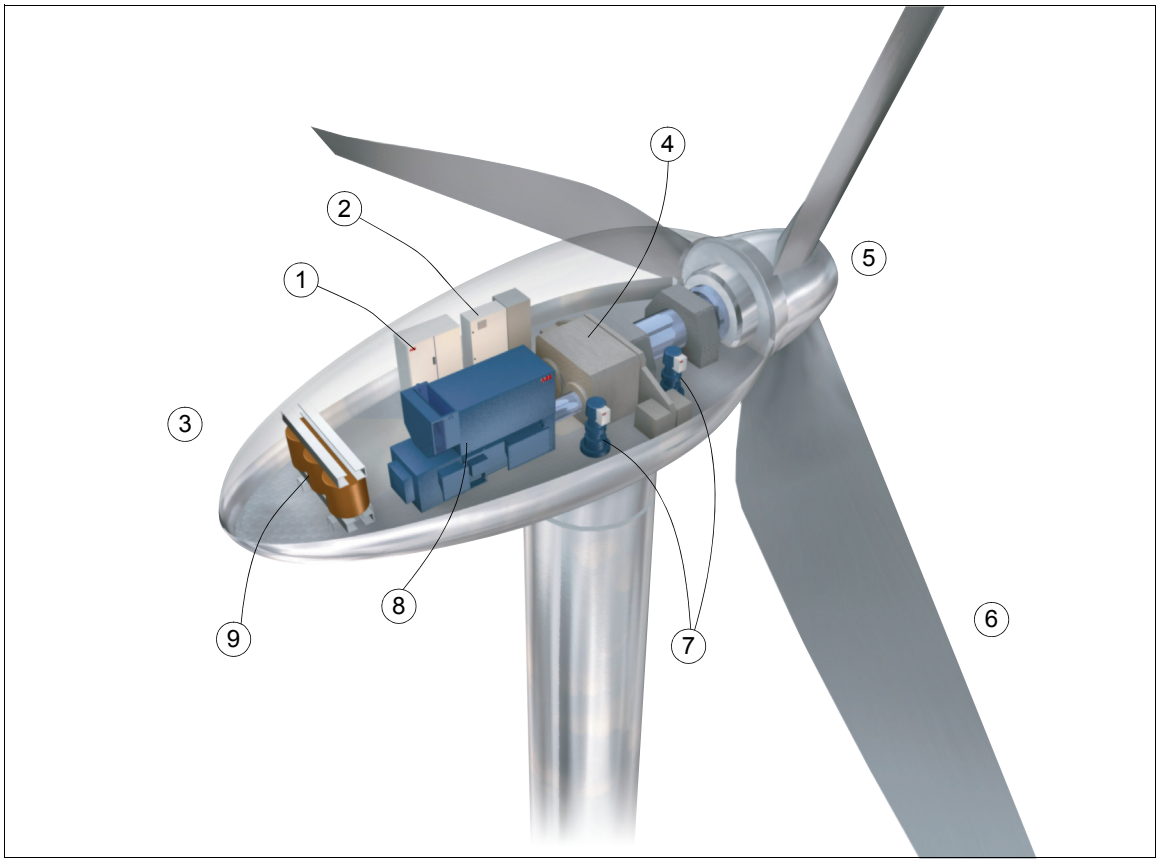
Contents of this chapter

This chapter describes the operation of the ACS880-77LC, ACS880-87LC and ACS880-87CC wind turbine converters and the wind turbine system in short.

General

Components of a wind turbine system

This figure shows the components of a wind turbine system.



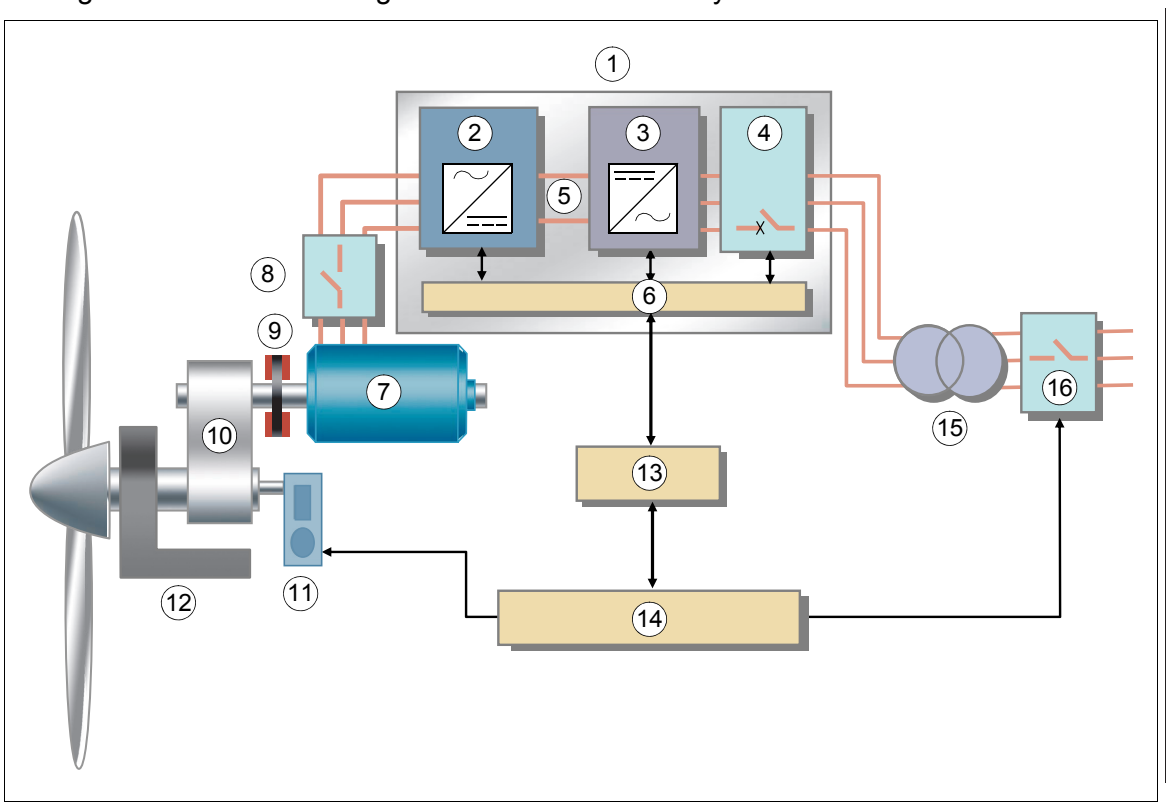
No.	Description
1.	Wind turbine converter
2.	User control cabinet
3.	Nacelle
4.	Gear box
5.	Rotor
6.	Blade
7.	Yaw motors
8.	Generator
9.	Transformer

ACS880-77LC, ACS880-87LC and ACS880-87CC

ACS880-77LC and ACS880-87LC are liquid-cooled AC converters for wind turbine applications. ACS880-87CC is combined-cooled: it contains both liquid-cooled and air-cooled cubicles. You can use the converters with permanent magnet generators and induction generators. One wind turbine converter consists of one grid-side converter connected to the transformer via an LCL filter and one generator-side converter connected to the generator. The converter can be located up in the nacelle or down on the ground level.

The converter is connected between the generator and grid. Full generator power flows through the converter (see section *Full-converter system* on page *14*). The system is typically equipped with a gearbox between the generator and wind turbine rotor to adapt the generator speed to the turbine rotor speed. The converter adapts to the varying generator speed and makes sure that the frequency and phasing of the current fed to the grid match the grid frequency and phase.

This figure shows a block diagram of the wind turbine system.

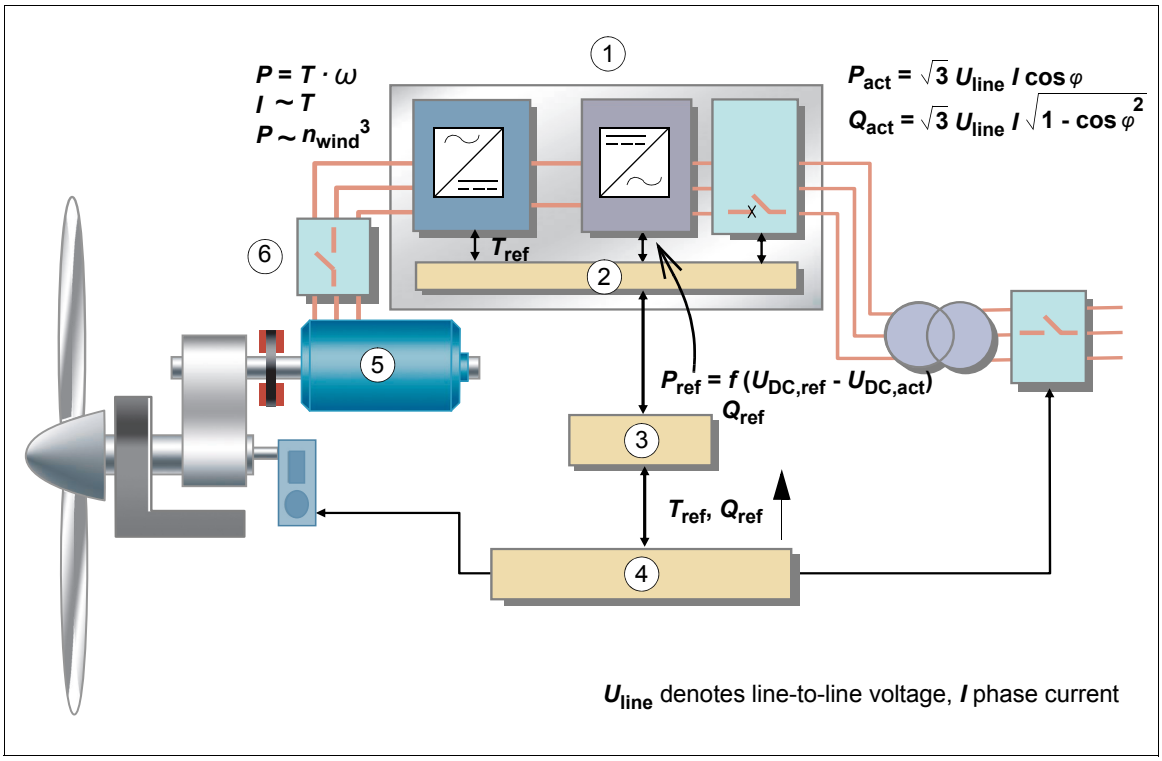


No.	Description	No.	Description
1.	Wind turbine converter	9.	Brake
2.	Generator-side converter	10.	Gearbox
3.	Grid-side converter and LCL filter	11.	Pitch converter
4.	Main circuit breaker	12.	Rotor bearing
5.	Intermediate DC circuit	13.	Fieldbus
6.	Converter control	14.	Wind turbine controller (WTC)
7.	Generator	15.	Line coupling transformer
8.	Stator switch in case of permanent magnet generator. To be acquired separately by the customer.	16.	Medium voltage switch gear (10…24 kV, 50/60 Hz)

Full-converter system

In a wind turbine, the turbine rotor transforms kinetic wind power into rotational shaft power. The generator transfers the mechanical power on its shaft to electric AC current. The wind turbine converter converts the AC current from the generator to DC current and back to AC current which it feeds to the grid (electrical power network). The system enables speed and torque control of the generator shaft and independent active and reactive current control at the grid side.

This figure shows the control principle of the full-converter system.



No.	Description
1.	Wind turbine converter
2.	Converter control
3.	Fieldbus
4.	Wind turbine controller (WTC)
5.	Generator
6.	Stator switch in case of permanent magnet generator. To be acquired separately by the customer.

Control of generator power

The generator power can be controlled by adjusting torque or speed:

$$P = T \cdot \omega = T \cdot \frac{2\ \pi\ \cdot n}{60}$$

where

P ≙ generator power (W)

T ≙ generator torque (N·m)

ω ≙ angular speed of the generator

n ≙ generator speed (rpm).

Wind power increases cubically as wind speed increases:

$$P_w = \rho \cdot \frac{c_p(\lambda, \delta)}{2} \cdot A_r \cdot v_w^3$$

where

P_w ≙ wind power

ρ ≙ air density

c_p ≙ performance coefficient, λ tip speed ratio, δ pitch angle

A_r ≙ rotor surface

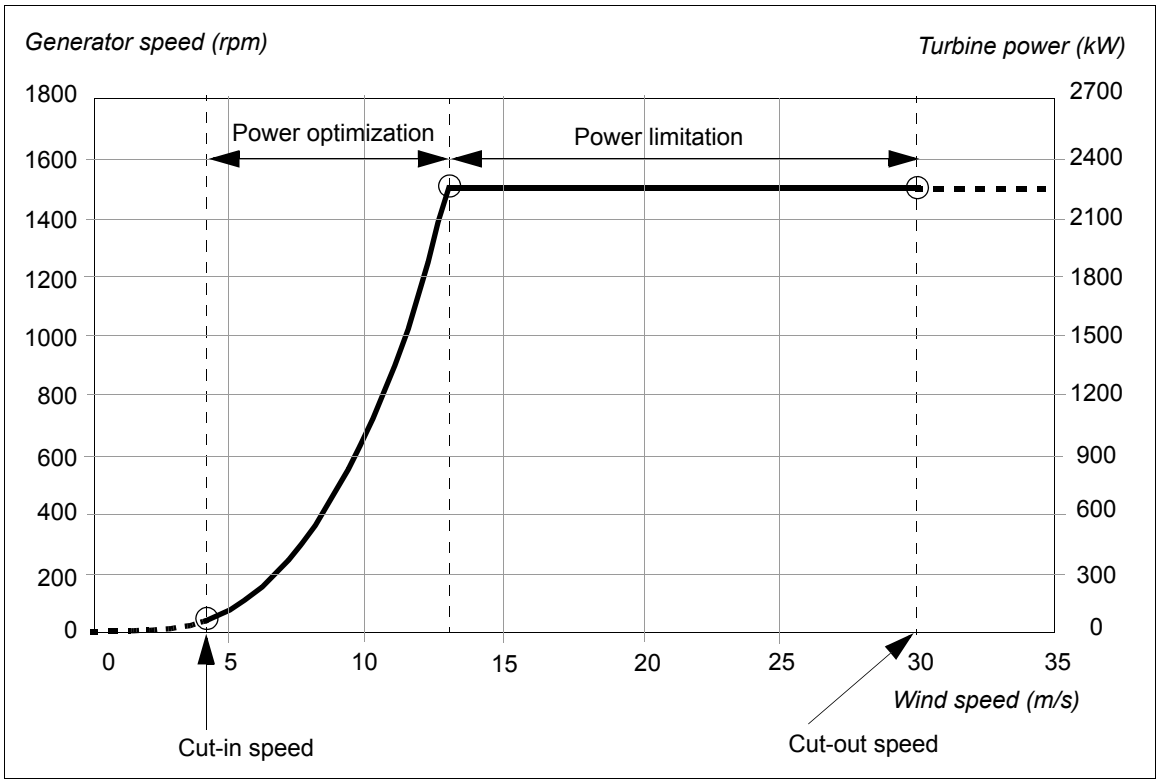
v_w ≙ wind speed.

In normal operation, the wind turbine converter controls the generator torque. The wind turbine controller (WTC) gives a torque reference to the converter which generates a specific torque on the generator shaft. Simultaneously, wind rotates the turbine and generates an opposite torque on the generator shaft. The WTC defines the rotation speed to which the converter adapts. The WTC defines the needed torque reference as a function of wind speed and turbine characteristics.

Operational speed range of a typical wind turbine

There is a minimum wind speed at which power generation is reasonable (cut-in speed) and a maximum speed at which the turbine can be operated safely (cut-off speed). At a certain wind speed, the WTC must limit the rotor speed by changing the pitch angle.

This figure shows an example power-speed curve. It illustrates the operational speed range of the turbine between the cut-in and cut-out speeds.

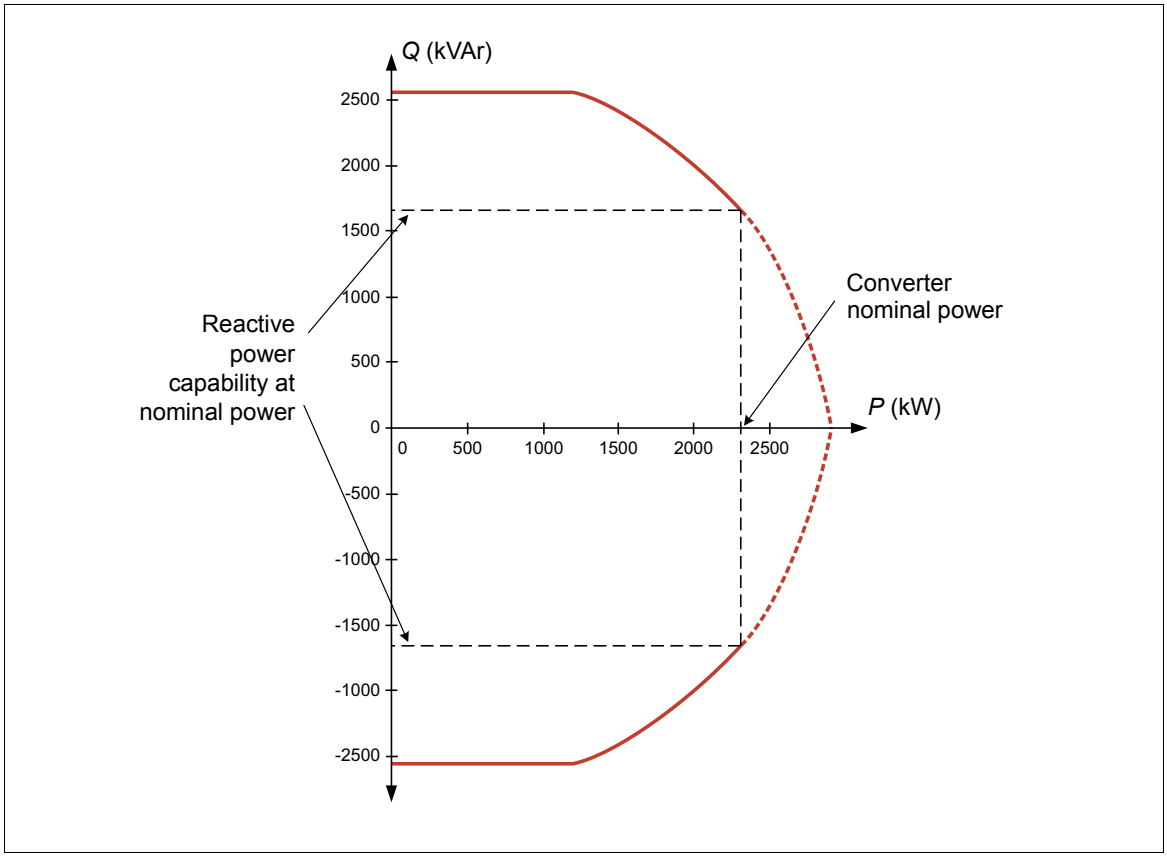


A speed reference is needed, for example, to run the rotor to a certain position for maintenance. This control method is not suitable for continuous power generation. The converter speed control reaches the desired speed by giving an internal torque reference that matches the desired shaft speed.

Control of reactive power

The grid-side converter can control reactive power independently of speed and active power. The maximum reactive current capacity is approximately 80 percent of the active current capacity and depends on the rating of the grid-side converter and on the electrical power system voltage.

This figure shows an example curve of reactive power capability as a function of active power. This is a theoretical example and the actual reactive power capability depends on the converter type and dimensioning corresponding to the generator type and dimensioning, as well as grid conditions and requirements.



Key operational differences between generator types

Induction generator

An induction generator needs a magnetizing current to generate the magnetic flux inside the generator. The generator-side converter feeds this magnetizing current to the generator. When the converter stops modulating, the flux gradually disappears and the voltage at the generator terminals decreases close to zero.

Permanent magnet generator

A permanent magnet (PM) generator does not need a magnetizing current because its magnetic flux is all the time created by magnets.

Back-electromotoric force E_0 is the voltage which can be measured from the generator stator terminals when the generator rotates at nominal speed but no current is taken out. That is, the generator is not loaded and the generator-side converter is not actively controlling the voltage. The value of E_0 is marked on the generator nameplate. For permanent magnet generators, the stator voltage is typically less than the generator no-load voltage E_0.

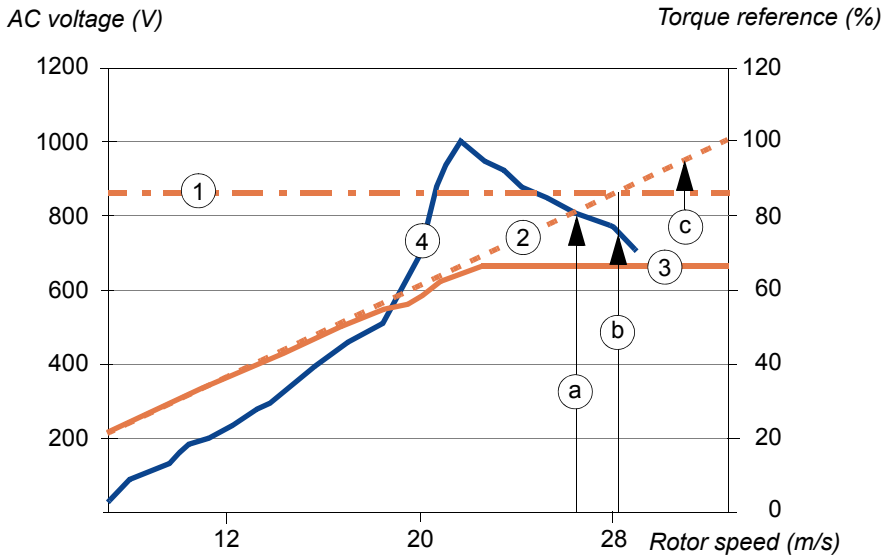
As the generator stator voltage increases linearly as speed increases, the wind turbine converter must be protected against overvoltage. The generator stator circuit must be equipped with switches which have to be acquired separately by the customer. To avoid damage, the converter controls the torque and current to zero before opening the switches.

In addition, a DC chopper connected to the converter intermediate DC circuit and external resistors can be needed for cutting down a DC voltage peak due to certain operation disturbances. See section *DC chopper (option +D150)* on page *21*.

Take these into account when you use a permanent magnet generator:

- Supply the stator switch(es) from a UPS. The converter can be installed at bottom of the tower while the switches are located in the nacelle. This leads to a long cabling distance between them. In this case, we recommend that you install an additional UPS unit in the nacelle to supply the generator stator switches. The converter provides simply a potential-free control for the switches (relay outputs).
- If the UPS power is routed to the switches via the converter, you need to overdimension the UPS to ensure the correct operation of the switch control. The long cables and inductive load lead to a significant voltage drop.
- Check the condition of the stator switch contacts after the converter trips on a short-circuit fault. If you open the switch(es) under load, this can damage the contacts.

The appropriate selection of shutdown speeds is essential for the safety of a permanent magnet generator. This diagram shows the stator voltage control as a function of the generator shaft speed.



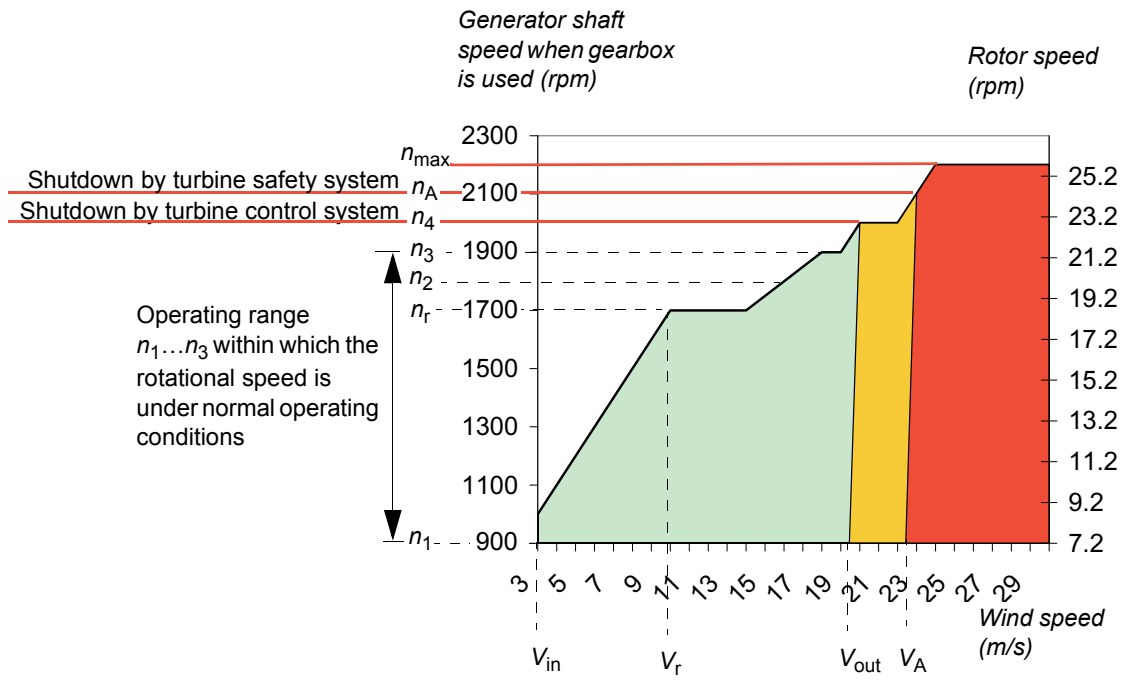
1. Voltage safety limit
2. No-load voltage
3. Generator terminal voltage under load
4. Torque reference

a. Shutdown by turbine control system, wind turbine converter operates. At this speed, the pitch control changes the pitch angle to bring the generator speed back to the operating range.

b. Shutdown by independent turbine safety system. The generator-side converter stops modulating at this speed.

c. Voltage rush at the generator terminals in case of control loss.
Note: Operation above the speed at which the no-load voltage equals the voltage safety limit requires a DC chopper and resistor for protection.

This example shows the generator speed values and limits in different wind speed ranges.



Generator rotational speeds:

n_{max} ≙ maximum overspeed which may never be exceeded, not even momentarily

n_1 ≙ minimum operating speed

n_r ≙ rated speed, that is the rotational speed at rated wind speed V_r

n_2 ≙ set value of the speed used above rated wind speed V_r. The rotational speed deviates upwards or downwards from n_2 only by the standard tolerance.

n_3 ≙ maximum operating speed

n_4 ≙ cut-out speed, that is the speed at which the turbine control system must immediately shut down the wind turbine. The maximum speed of the wind turbine converter is set by parameter *30.12 Maximum speed* of the generator-side converter control program. Above it, the converter trips on overspeed, that is, the torque is controlled to zero and the stator switch(es) open. See the start-up guide.

n_A ≙ activation speed, that is the rotational speed at which the turbine safety system must be triggered immediately.

V_A ≙ safety cut-out wind speed

V_{in} ≙ cut-in wind speed

V_{out} ≙ cut-out wind speed

V_r ≙ rated wind speed.

DC chopper (option +D150)

DC choppers and related DC resistor are optional devices. Typically, the customer needs to dimension and acquire the external DC resistor (also available from ABB with the option +D151) and cabling separately. You must connect each DC chopper to a separate DC resistor.

Operation principle

The DC chopper monitors the intermediate circuit voltage and controls the IGBT switches. When the intermediate circuit voltage (U_{DC}) exceeds a certain limit, the IGBT switch connects the DC resistor to the intermediate circuit. The extra energy is dissipated in the DC resistor and the voltage drops. When the voltage reaches a safe level, the DC resistor is disconnected.

Parameter settings and fault tracing

See the firmware manual.

Converter-driven soft stop

Converter-driven soft stop is used for fast and controlled shutdown of the converter.

Operation principle

The activation request can come from a push-button or from the fieldbus. It can also be activated in fault situations.

After the activation request, the generator-side converter waits for a defined delay time to keep the torque reference as it was. After the delay, generator-side converter ramps the torque reference to zero. The ramp time is defined with a parameter.

When the torque reference is zero, the converter opens the main circuit breaker and generator contactor.

For more information, see the hardware and firmware manuals and the circuit diagrams delivered with the converter.

Wiring

If necessary, wire the converter-driven soft stop function activation and reset buttons to connectors of the converter cabinet. See the circuit diagram delivered with the converter.

Parameter settings and fault tracing

See the firmware manual.

Start-up

See the start-up guide.

3

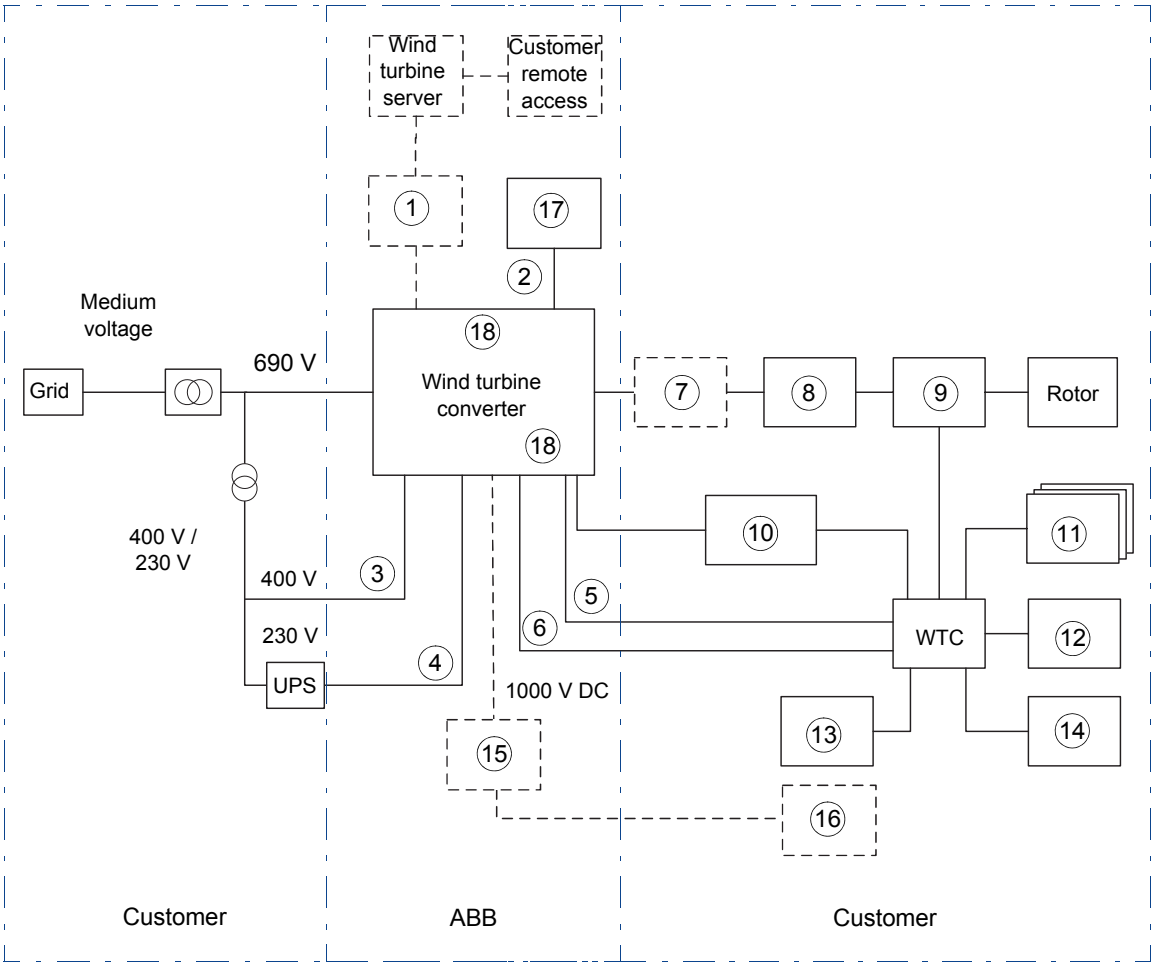
Control modes

Contents of this chapter

This chapter describes the control principles of the ACS880-77LC, ACS880-87LC and ACS880-87CC wind turbine converters.

Overview of the converter power and control interfaces

This figure shows an overview of the converter interfaces.



No.	Description
1.	NETA-21 remote monitoring tool (optional)
2.	Ethernet
3.	Auxiliary supply
4.	Auxiliary supply (UPS)
5.	I/O
6.	Fieldbus
7.	Generator disconnector (optional)
8.	Generator
9.	Gearbox
10.	Emergency stop
11.	Other systems
12.	Pitch control
13.	Cooling system
14.	Yaw control
15.	DC chopper (option +D150)
16.	DC resistor (option +D151)
17.	PC with Drive composer PC tool
18.	Connectors on the BCU control unit of the generator-side converter

The ACS880-77LC/-87LC/-87CC contains two converters:

- generator-side converter: converts the generator-produced AC power to DC
- grid-side converter: feeds the power in the DC link into the power grid.

The converter operation is controlled by two control programs:

- generator control program and
- grid-side control program.

The wind turbine controller (WTC) controls the whole wind turbine system. The WTC controls the converter using the main control word and reads the status from the status words and actual signals selected by parameters. For more information, see the firmware manual.

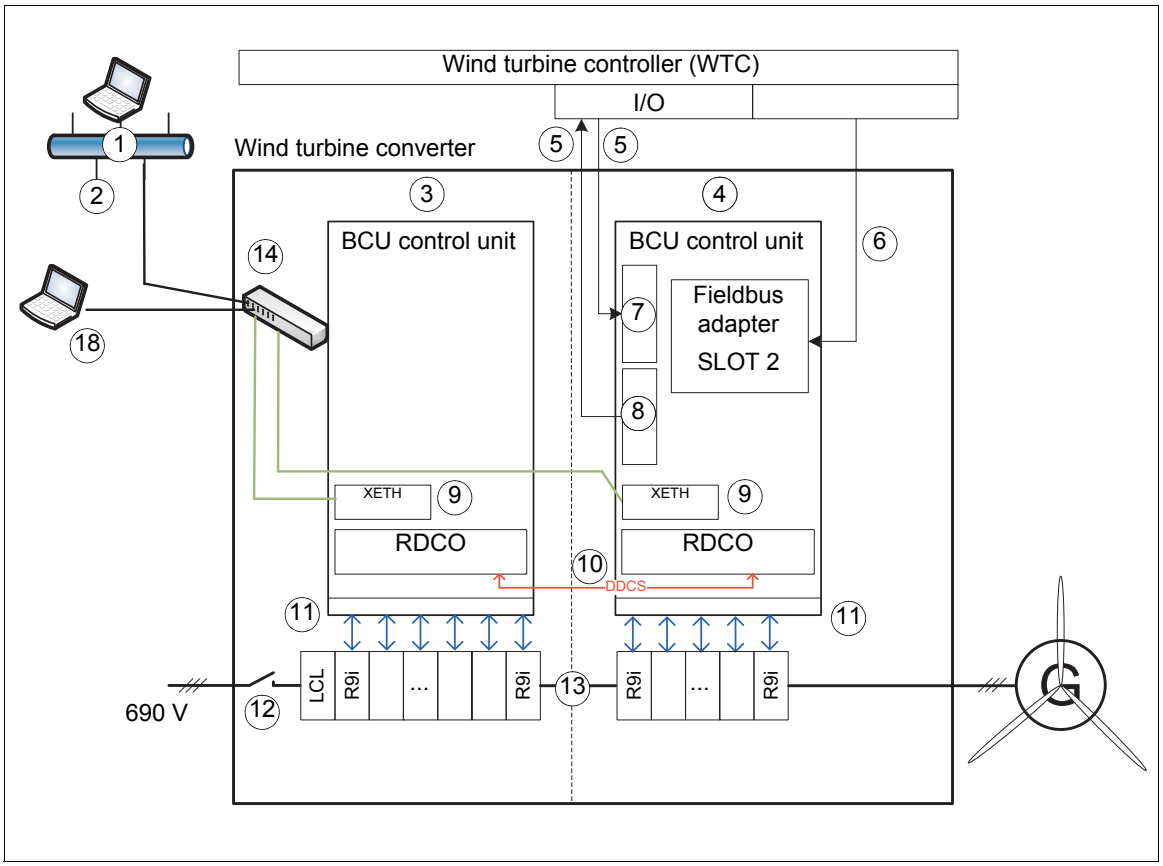
With an optional NETA-21 remote monitoring tool, you can remotely monitor the converter fault diagnostic data loggers and change the control program parameters. For more information, see *NETA-21 remote monitoring tool user's manual* (3AUA0000096939 [English]).

For more information on I/O connections, see the hardware manual.

Converter control interfaces

Overview diagram of the control interfaces

This figure shows an overview control diagram of the wind turbine converter.



No.	Description
1.	Park LAN Ethernet
2.	PC with Drive composer PC tool and Drive loader 2 firmware update tool
3.	Grid-side converter
4.	Generator-side converter
5.	Hardware signals
6.	Fieldbus
7.	Digital input XDI (DI1, DI2)
8.	Relay output XRO3
9.	Embedded Ethernet
10.	DDCS communication between the generator-side converter grid-side converters
11.	Optical power stage link
12.	Main circuit breaker
13.	Intermediate DC circuit
14.	Ethernet switch

Fieldbus connections

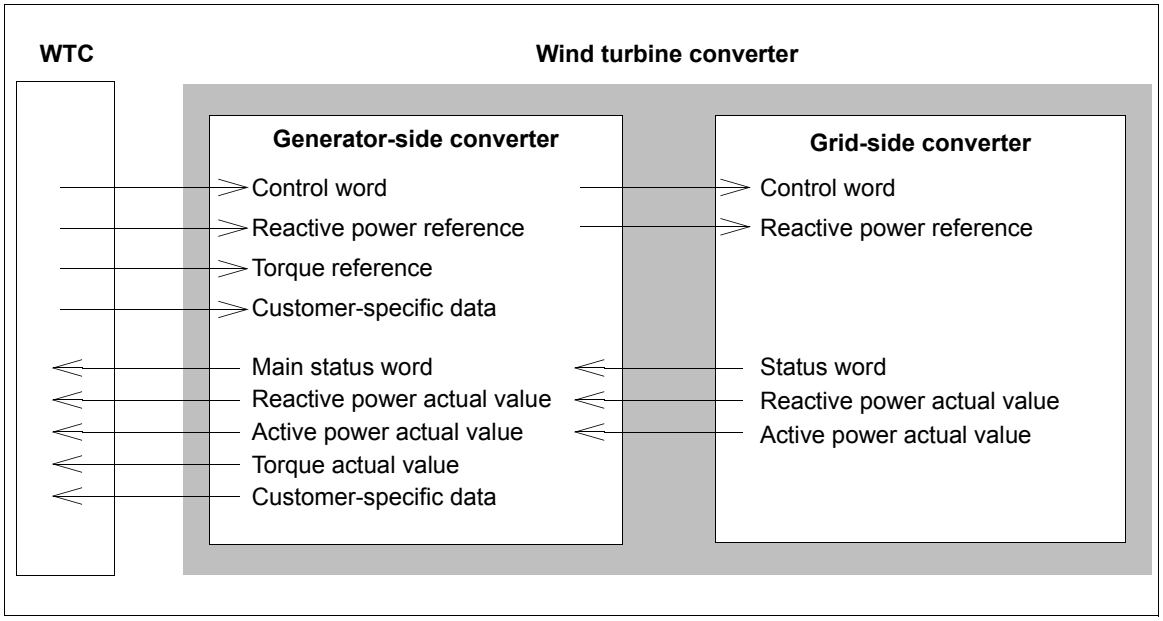
The WTC operates as the overriding controller of the converter. It is connected to the control unit of the generator-side converter via fieldbus. The generator-side control program controls the generator according to the references and commands sent by the WTC.

The control unit of the generator-side converter communicates with the control unit of the grid-side converter and its grid-side control program.

If there are parallel-connected converters which are controlled with the Wind turbine applications (WTA) control function, see chapter *Wind turbine applications (WTA)*.

Fieldbus signals

This diagram shows the exchange of reference and actual signals between the WTC and the two converters inside the wind turbine converter.



4

Grid fault ride-through

Contents of this chapter

This chapter describes grid codes and the grid fault ride-through function. See also the firmware manual of the converter.

Grid codes

Grid codes specify the static and dynamic requirements which the wind power installation must fulfill. The static requirements determine mainly the voltage and power control during normal operation. Most of the grid codes include also power quality requirements such as harmonics distortion limits, flicker and so on. The dynamic requirements define the dynamic behavior of a wind turbine or wind farm under grid disturbance. One of the most important dynamic requirements is the grid fault ride-through (GFRT) capability of the wind power generator. For more information, see section *Grid fault ride-through function (+F276, +D150+F276)* on page *33*.

The optimal solution when balancing between the connection requirements and installation costs depends on the selection of the critical components of the wind turbine system such as the pitch system, generator, converter and transformer. The selection has effect on the capability of an individual turbine to comply with the grid code requirements. Although the converter has an important role in fulfilling the grid code requirements, functioning of the other components and the whole wind turbine system is very important.

For the compliance of the ACS880 with the grid codes, see the hardware manual.

Examples of fault ride-through (FRT) curves

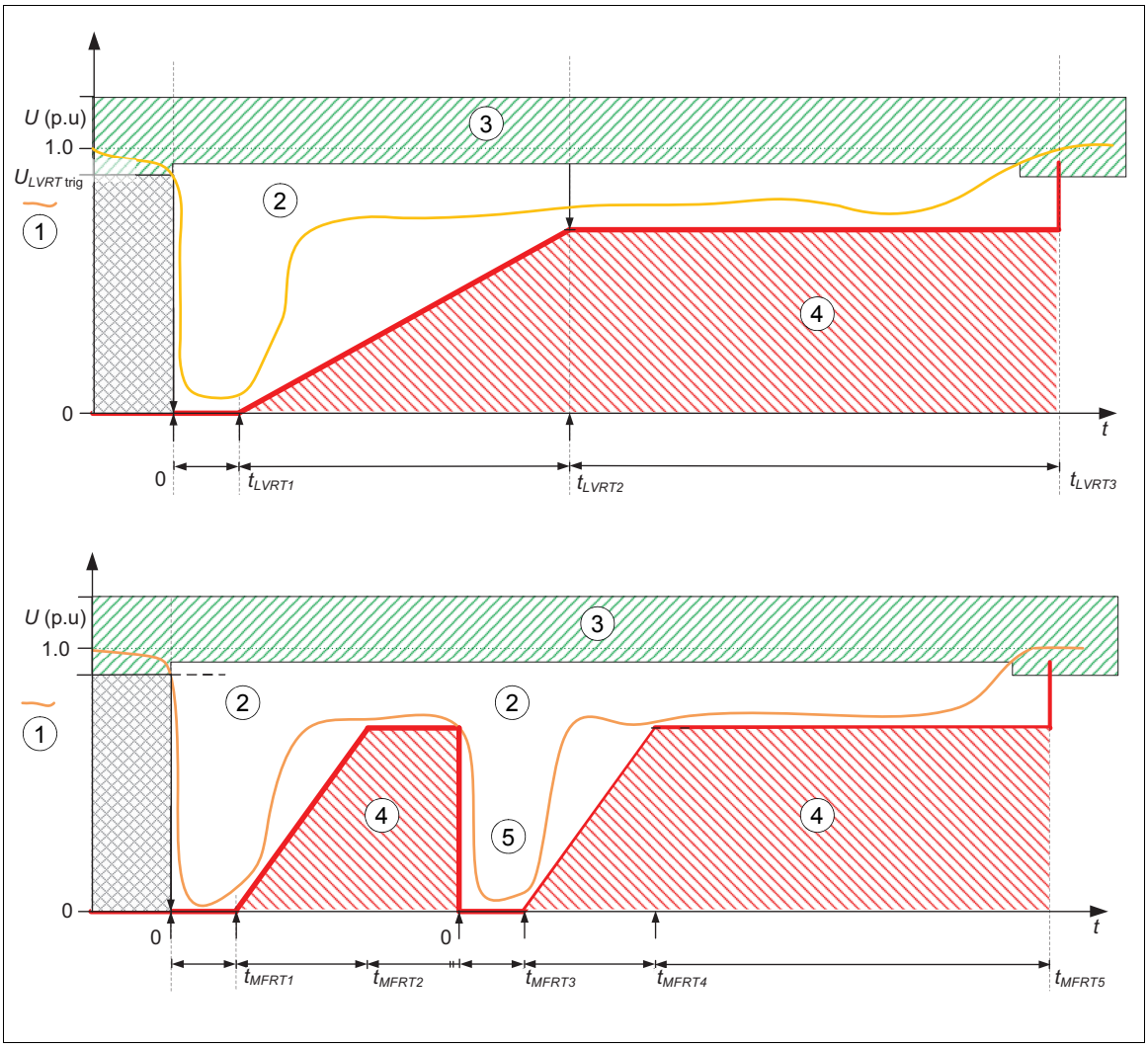
Grid code requirements define the maximum length of grid faults that the wind turbine must withstand. The converter provides tripping curves to define the depth and length of grid failures when the converter trips.

The diagrams below show examples of the grid code requirements: they specify the limits for the symmetrical and asymmetrical grid voltage dips (LVRT, low voltage ride-through), multiple grid voltage dips (MFRT, multiple fault ride-through) and grid voltage swells (HVRT, high voltage ride-through) that the wind turbine must be able to handle.

See the firmware manual for more details on the LVRT and HVRT settings, such as voltage levels and time periods.

Low voltage ride-through (LVRT) and multiple fault ride-through (MFRT)

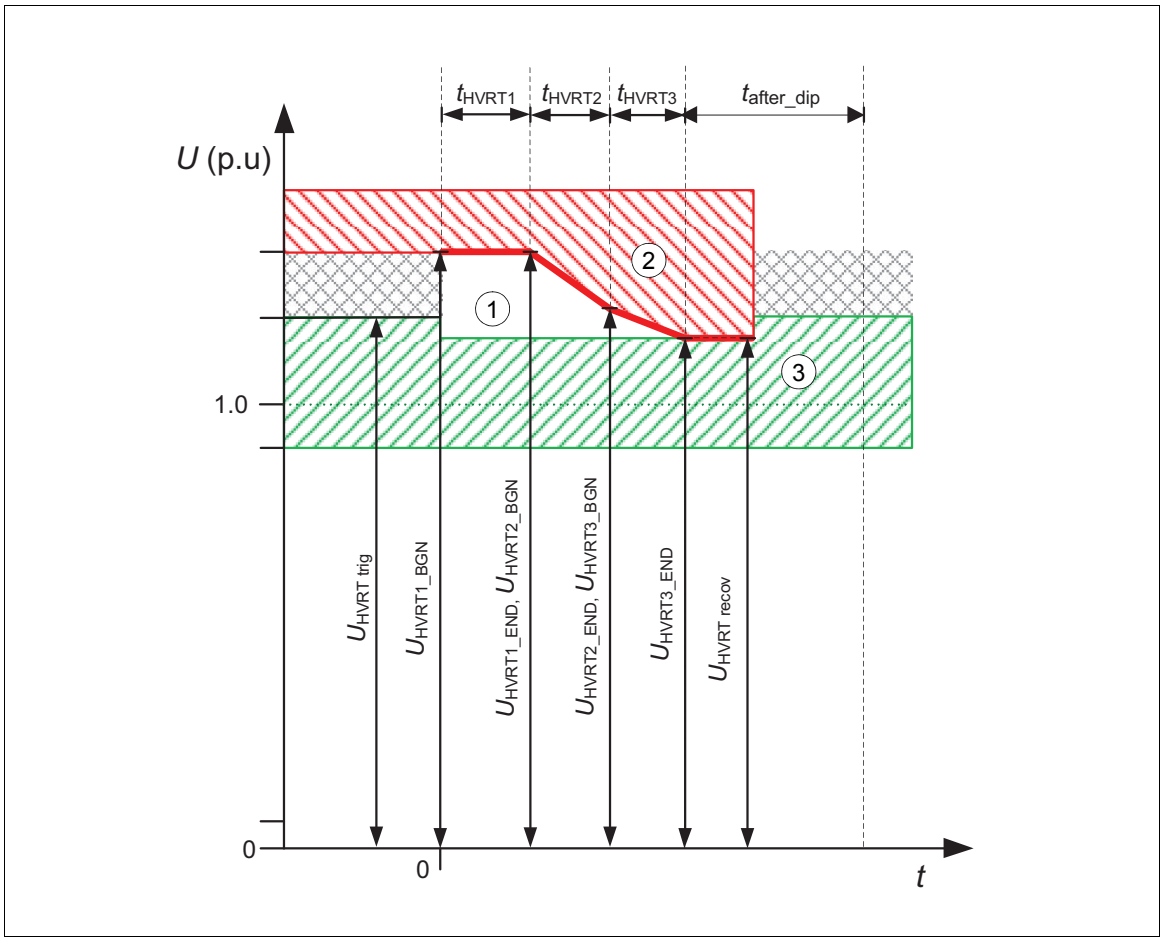
When the grid voltage dip does not exceed the converter trip area, the converter does not trip.



No.	Description
1	Selected grid voltage signal in p.u. of nominal or pre-fault voltage
2	LVRT area
3	Normal operation area
4	Converter trip area
5	Second / multiple dip

High voltage ride-through (HVRT)

The voltage swell may not cause a trip when the grid voltage does not exceed the converter trip area.



No.	Description
1	HVRT area
2	Converter trip area
3	Normal operation area

Grid fault ride-through function (+F276, +D150+F276)

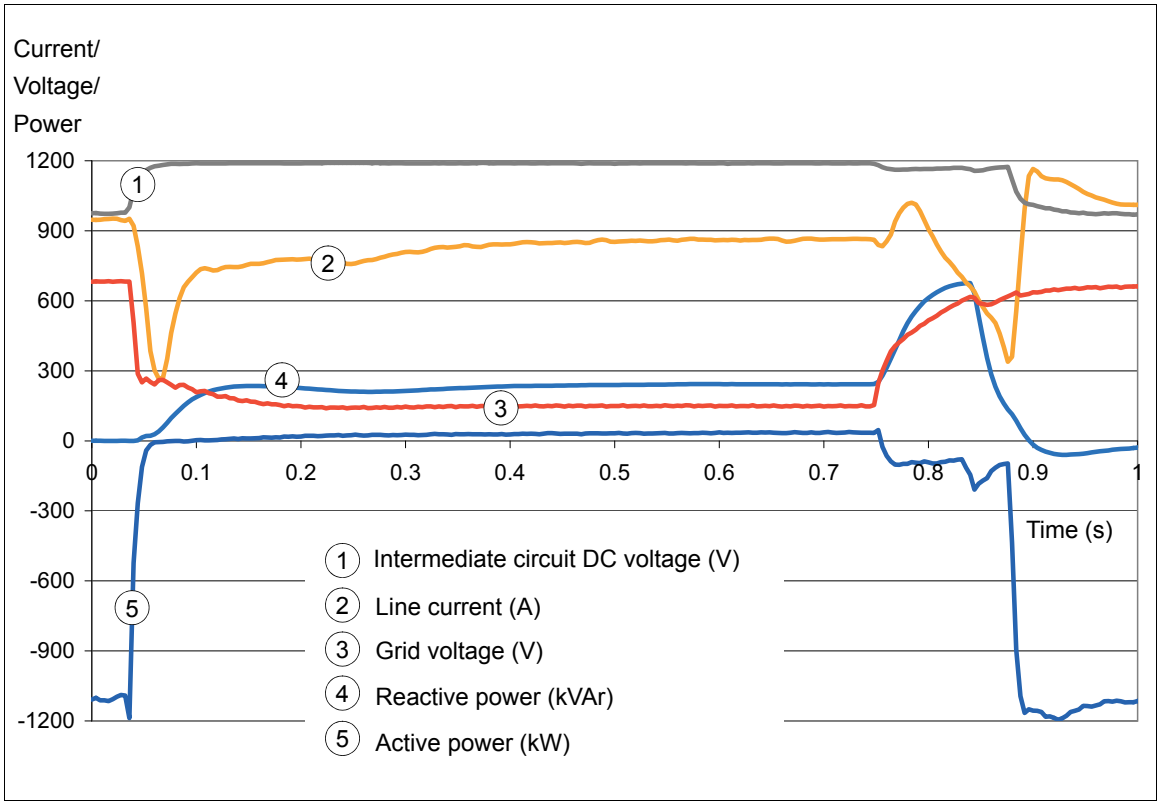
Grid fault ride-through means that instead of disconnection, wind power plants have to stay connected to the network during a pre-defined period. The grid fault ride-through requirements define:

- how long a dip can last
- how to behave with a balanced (symmetrical) dip
- how to behave with an unbalanced (unsymmetrical) dip.

Power plants have requirements concerning the wind turbine performance during voltage dips (sags) in the power system. The requirements vary depending on the country. The wind turbine

- has to stay connected to the power system for a certain time
- must not take power from the power system
- must produce capacitive reactive current as much as required.

This figure shows a typical performance of the converter in a symmetrical voltage dip.



The wind turbine converter has two alternatives for implementing the grid fault ride-through function:

- sole grid fault ride-through function (option +F276)
- grid fault ride-through function and a DC chopper (+D150+F276).

When the converter is equipped with a DC chopper, you must also have a resistor connected to it. Then the chopper can cut down the voltage peaks in the converter DC link by conducting any surplus energy to the resistor which dissipates it (as heat). You can order the resistor as factory-installed in the ABB converter delivery (option +D151), or you can acquire and install the resistor yourself.

Both options include the BAMU auxiliary measuring unit for power system voltage measurements. These measurement signals are further processed by the grid-side converter and used for its internal control.

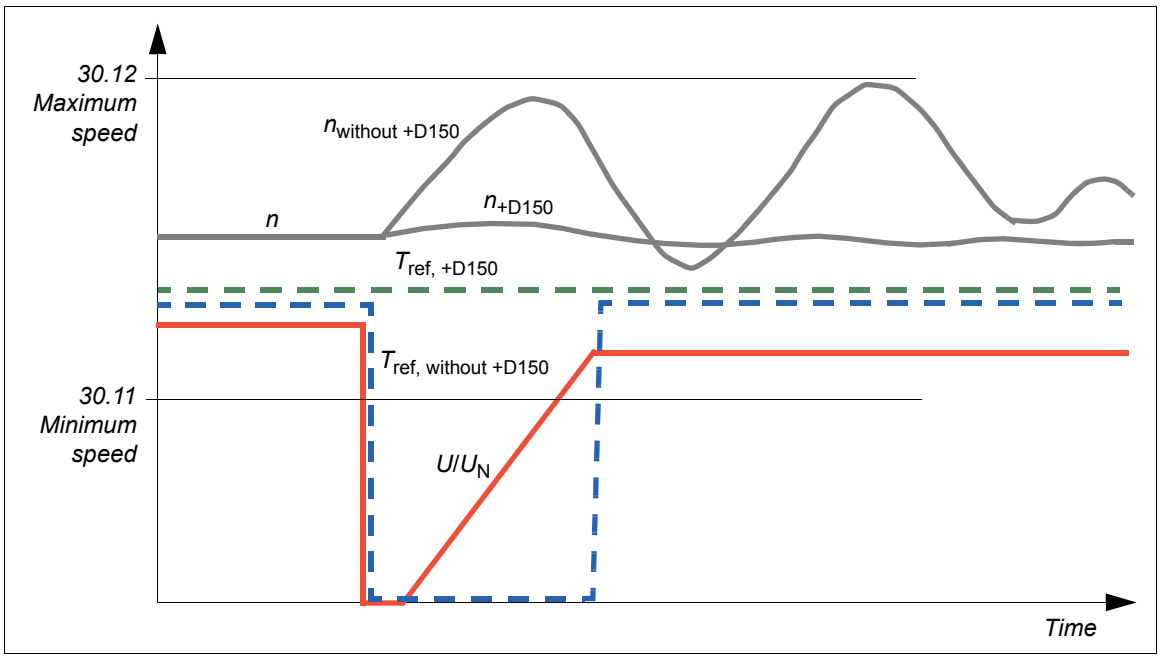
The need of a DC chopper depends on the pitch control dynamics in limiting the increase of the turbine rotor speed to a safe range during the grid fault.

- When the converter is equipped with a DC chopper and resistor, it is not necessary to remove the opposite torque on the generator shaft by the pitch control and, thus, the needed pitch reaction is negligible. The DC chopper keeps the intermediate circuit DC voltage below the overvoltage limit by connecting DC power to the external resistors typically for one second at a time. In the converters a DC chopper, the converter follows the torque reference given by the turbine controller during the voltage dip. This keeps the turbine rotor speed stable.
- When the converter does not have a DC chopper and resistor, the converter cannot follow the torque reference given by the WTC during the grid fault ride-through. Instead, it tries to reduce the reference torque or sets it to zero depending on the severity of the fault. When the torque reference is zero, the turbine rotor speed may rise and the pitch control must keep the generator speed in the allowed range defined by parameters *30.11 Minimum speed* and *30.12 Maximum speed* of the generator-side converter control program. Otherwise, the converter trips.

Under the most severe grid fault events, such as a zero-voltage ride-through condition, the shaft torque of the generator is limited to zero in order to avoid a DC link overvoltage trip.

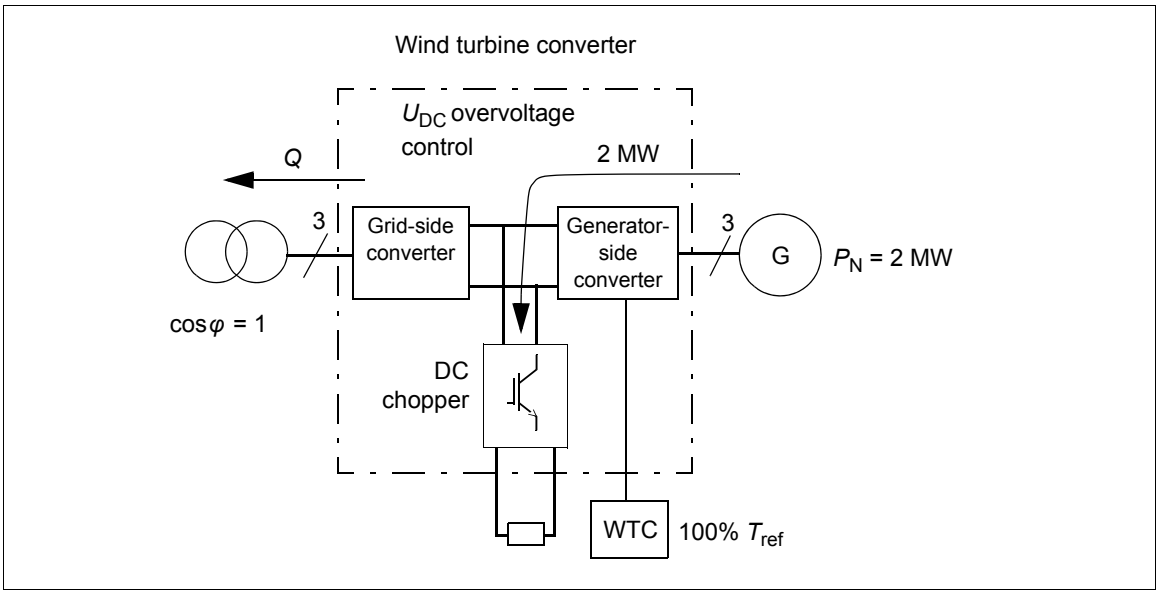
This diagram shows the turbine and converter performance during a grid voltage dip. In the figure:

- n denotes the turbine rotor speed,
- $n_{\text{without +D150}}$ the speed when the converter is not equipped with a DC chopper,
- $n_{\text{+D150}}$ the speed when the converter is equipped with a DC chopper.
- U/U_N is the grid voltage divided by the converter nominal voltage,
- $T_{\text{ref, +D150}}$ is the torque reference which the converter follows when it is equipped with a DC chopper,
- $T_{\text{ref, without +D150}}$ is the torque reference which the converter follows when it is not equipped with a DC chopper.



Example power flow (converter with a DC chopper)

This diagram shows an example how power flows from the generator to the grid.



Converter operation during grid fault ride-through

When the grid fault ride-through function and the BAMU auxiliary measuring unit are enabled, the measured instantaneous phase voltages are processed to determine the instantaneous positive or negative sequence rms voltage, which is used to control the grid-side converter. This internal voltage reference signal is shown in the WTC as the main voltage signal. In addition, the grid-side converter has a logic that is synchronized to the actual voltage measurement. The logic is used to control the grid-side converter during the grid fault ride-through event.

The converter has ride-through-specific levels that define the voltage levels when the converter is allowed to disconnect from the grid. The voltage levels are defined with parameters. ABB has defined default voltage levels based on the country code.

- If the grid voltage goes outside the defined voltage envelope area, the converter trips immediately.
- If the grid voltage stays inside the defined area and crosses the ride-through activation level, the ride-through control mode is activated in the converter. While the converter operates under the ride-through control mode, it uses its internal logic as a reference voltage instead of measured grid voltage.
- When the ride-through control mode is active, the main status word indicates it to the WTC by setting a bit to one. For more information, see the firmware manual.

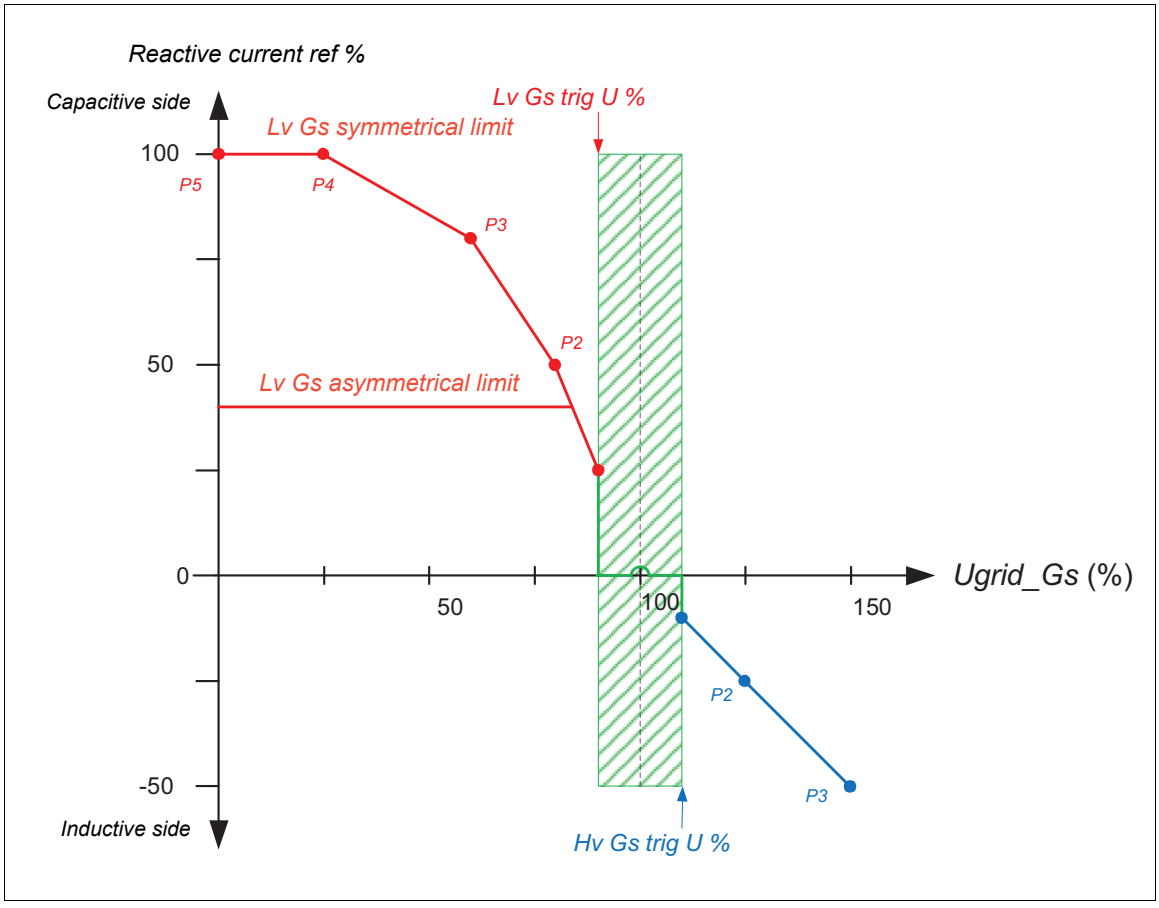
The converter also has a ride-through-specific grid support function that defines the grid support levels in respect to the grid support voltage levels. These levels determine how the grid support is utilized while the ride-through event is active. These levels are independent from the ride-through-specific voltage protection levels. The levels are defined with parameters. ABB has defined default voltage levels based on the country code.

- If the voltage goes outside the defined voltage levels, the converter reactive current is cleared, and the converter follows the WTC reference values.
- If the grid voltage stays inside the defined area and crosses the grid support activation level, the grid support control mode is activated in the converter.
- The user can select the reference of voltage or current for the reactive current support, nominal or pre-fault.
- Pre-fault operation has 60 s default period for determining the required grid support reference.

Grid support curve (Gs)

The diagram below shows an example of the grid support levels.

See the firmware manual for more details of the grid support curve settings, such as voltage levels and time periods.



Typical converter operation during a grid fault event

- In a grid fault event, the grid voltage goes below the voltage protection level, and the converter ride-through operation is active. The grid-side converter is modulating through the transient condition and the ride-through function of the grid-side converter is activated immediately and operates according to the user-defined parameter settings.
- The grid-side converter has limited capability to deliver active power to the grid because of reduced grid voltage. Thus the DC link voltage starts to increase and may reach the activation level of the overvoltage controller. If this limit is reached, the generator-side converter starts to limit the actual torque of the generator to keep the DC link voltage within acceptable level.

Typical converter operation during grid fault period

If the converter grid support mode is activated, the grid-side converter executes grid support according to the user-defined parameter settings. The reactive power reference value sent from the WTC is in lower priority and thus neglected.

Torque reference value sent from the WTC to the generator-side converter is used as a reference. However, the actual generator shaft torque can still be limited by the generator-side converter control to avoid a converter overvoltage trip.

Typical converter operation during grid fault clearance period

When the grid voltage goes above the voltage protection level, the converter operation restores to normal operation. The ride-through control mode indicated to WTC is restored back to zero.

Typical converter operation after grid fault period

Grid fault ride-through function is not active anymore and the converter follows the reference values sent by the WTC.

Parameter settings and fault tracing

The firmware of the converter contains the ready-made parameter settings for the following grid codes:

- REE P.O.12.3: RED ELÉCTRICA DE ESPAÑA P.O.12.3 Operation requirements in front of voltage deeps in wind power installations
- transpower stromübertragungs gmbh: Grid Connection Code for high and extra high voltage, 1st April 2009
- © Verband der Netzbetreiber - VDN: TransmissionCode 2007 Netz- und Systemregeln der deutschen Übertragungsnetzbetreiber, Version 1.1, August 2007
- Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit: Ordinance on System Services by Wind Energy Plants (System Service Ordinance - SDLWindV)
- The grid code: National Grid Electricity Transmission plc, UK
- Indian Wind Grid Code: Centre for Wind Energy Technology, India
- VDE-AR-N 4120 - Technical Connection Rules for High-Voltage: VDE FNN, Germany
- Tennet: Requirements for Offshore Grid Connections in the Grid of TenneT TSO GmbH, Germany
- GB/T 19963-2011, China

In addition, if needed, the user can define when the converter must stay connected to the grid (that is, the depth and length of the grid voltage transient). The user can also define how much the converter supports the grid by feeding reactive current to the grid when the grid voltage stays below a defined area. For more details, see the firmware manual. Grid operators often require also simulation models.

5

Wind turbine applications (WTA)

Contents of this chapter

This chapter describes the principles of the wind turbine applications (WTA) control function.

Overview

The Wind turbine applications (WTA) function is an additional configuration and control function of the generator-side converter. It is used to control wind turbine systems with parallel-connected converters to enhance the usability and availability of the wind turbine converters.

The WTA function makes it possible:

- to run the wind turbine system with a reduced number of converters if one of them is out of order or not needed (for example, at low wind speeds).
- to control the whole wind turbine system as a single converter by the wind turbine controller (WTC).

If there are repeated faults which cannot be reset in one parallel-connected converter, the faulty converter can be disconnected from the system, and the operation can continue with decreased capacity until the faults have been corrected.

You need the WTA function always when the converter hardware is separated into two or three cabinets.

Operation principle

Control connections

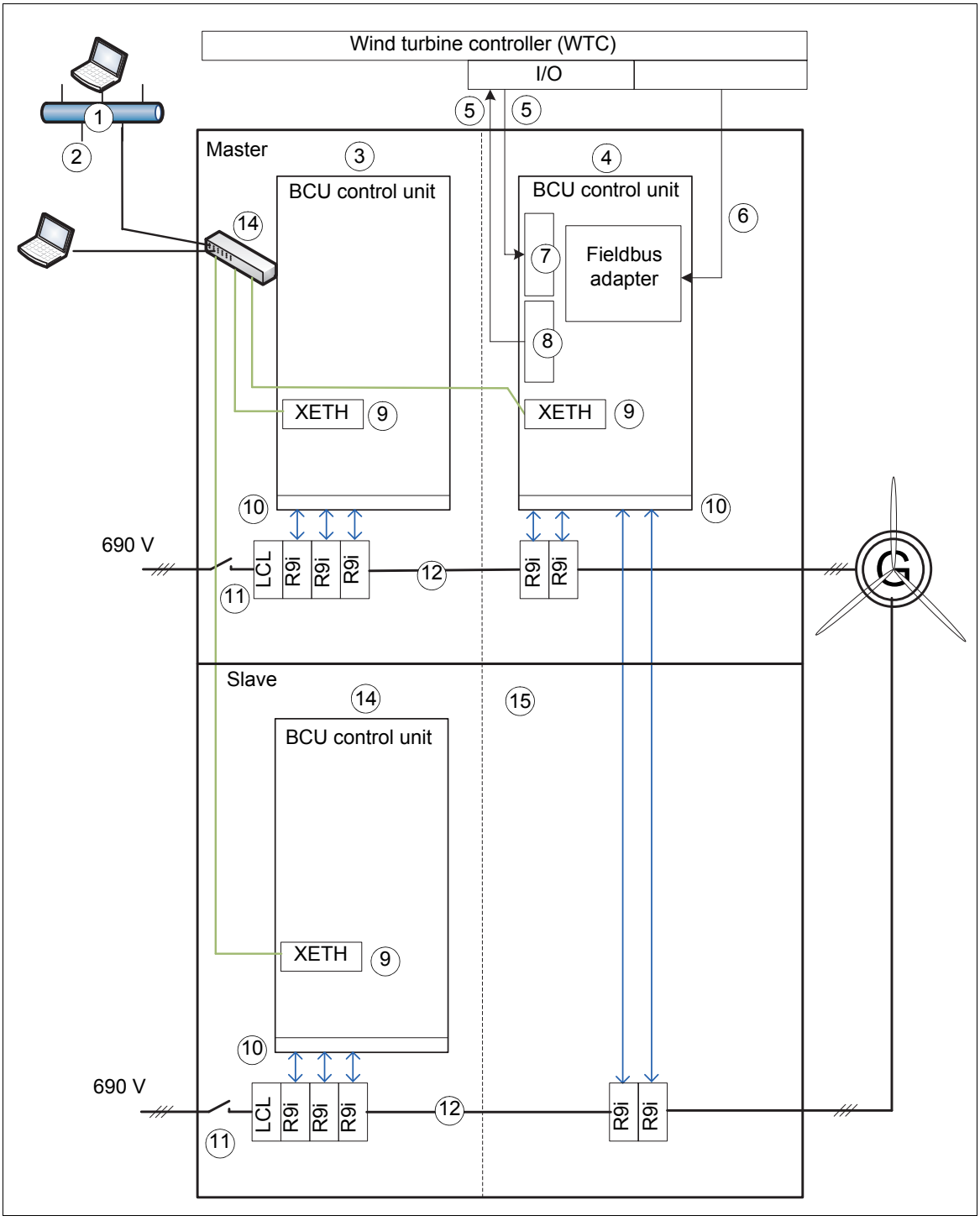
Large wind turbine converters consist of two or three parallel-connected converters, which are controlled as a single converter from the WTC point of view (see the figure on page 41):

- The generator-side converter units are divided into separate cabinets with independent main circuits, but all generator-side converter modules are controlled with a single generator-side converter control unit (master).
- The grid-side converter units are divided into separate cabinets as well, but they have control units of their own.
- The control unit of the generator-side converter acts as a master controller and combines these control units together to build a hardware-redundant wind turbine converter.

The signals and states of the grid-side converter which can be monitored via the generator-side converter control are combined signals and words of the parallel-connected grid-side units as in monitoring a single grid-side unit.

The master control unit controls the WTA function start commands and transfers the references to the WTA function. For more information, see the firmware manual.

This figure shows the control connections of an example converter with two parallel-connected converters.



No.	Description
1.	Park LAN Ethernet
2.	PC with Drive composer PC tool and Drive loader 2 firmware update tool
3.	Grid-side converter modules and BCU (master)
4.	Generator-side converter modules and BCU (master)
5.	Hardware signals
6.	Fieldbus
7.	Digital input XDI (DI1, DI2)

No.	Description
8.	Relay output XRO3
9.	Embedded Ethernet
10.	Optical power stage link
11.	Main circuit breaker
12.	Intermediate DC circuit
13.	Ethernet switch
14.	Grid-side converter, modules and BCU (slave)
15.	Generator-side converter modules (slave)

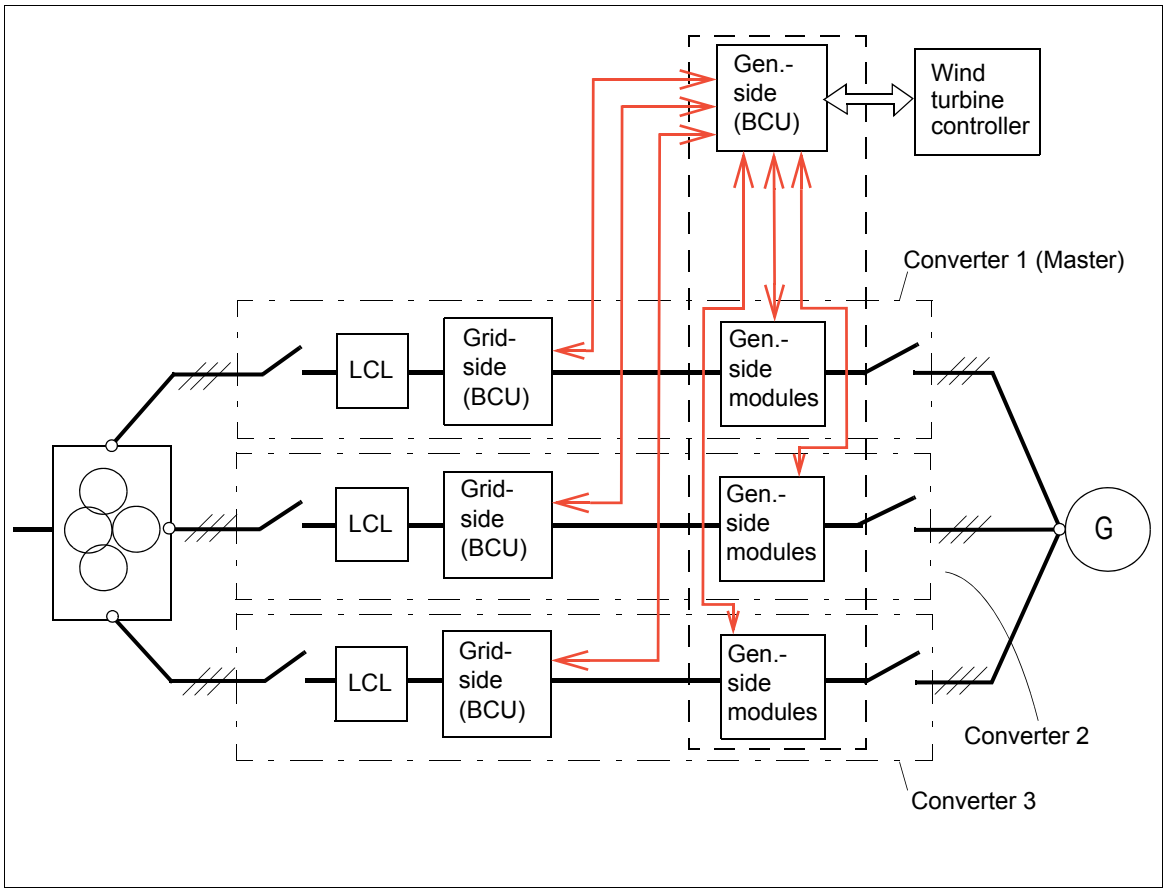
Reactive and active power balancing

The WTA function controls the reactive and active power balancing between the parallel-connected converters and creates the control interface between the single generator-side control unit (master) and independent parallel-connected grid-side control units.

Reactive and active power balancing and internal control of the converter are all automatic functions. For more information, see the firmware manual.

Common connection point at the generator side

Galvanic isolation on the grid side is performed with multiple transformer secondary windings (see the diagram below) or by using separate supply transformers.



The galvanic common connection point of parallel-connected converters must not exist on both the grid-side and generator-side simultaneously.

For more information, see the firmware manual.

Configuration

External and local control

The parallel-connected converter system with the WTA function is normally controlled and monitored externally from the WTC which is connected via fieldbus to the BCU unit of the generator-side converter.

During start-up, fault tracing and maintenance, the WTA function can be controlled and monitored locally from the Drive composer PC tool. The user can change parameters and view/reset the fault history. For more information, see the firmware manual.

Manual reconfiguration

You can reconfigure a parallel-connected converter system manually if one of the sub-converters is disconnected from the converter system. For more information, see the firmware manual.

Further information

Product and service inquiries

Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to abb.com/searchchannels.

Product training

For information on ABB product training, navigate to new.abb.com/service/training.

Providing feedback on ABB Drives manuals

Your comments on our manuals are welcome. Navigate to new.abb.com/drives/manuals-feedback-form.

abb.com/windconverters

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3AXD50000022022 Rev C (EN) 2020-04-27