ABB INDUSTRIAL DRIVES

ACS880 multidrives, Optimal grid control (option +N8053)

Supplement

ACS880 multidrives, Optimal grid control (option +N8053)

Supplement

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Introduction to the manual

Contents of this chapter

This chapter describes the contents of the manual. It also contains information on the applicability, safety and intended audience.

Applicability

This document is a supplement to ACS880-207 IGBT supply units hardware manual (3AUA0000130644 [English]), ACS880-204 IGBT supply modules hardware manual (3AUA0000131525 [English]), ACS880-207LC IGBT supply units hardware manual (3AXD50000174782 [English]) and ACS880-204LC IGBT supply modules hardware manual (3AXD50000284436 [English]). The supplement is applicable to the optimal grid control functionality of ACS880 IGBT supply control program, version 3.0x and later.

For information on firmware-related issues (parameters, faults, warnings etc.) concerning optimal grid control functionality, see *Optimal grid control of ACS880 IGBT supply control program supplement* (3AXD50000164745 [English]). For information on ACS880 IGBT supply control program, see *ACS880 IGBT supply control program firmware manual* (3AUA0000131562 [English]).

Licensing

Optimal grid control functionality is in use only when the license key N8053 has been activated on the ZMU-02 memory unit. This has been done at the factory for a unit with the option +N8053.

You can see the license information with the Drive Composer PC tool or ACS-AP-x control panel in **System info - Licenses**.

If the license key for the optimal grid control is missing, the converter indicates fault *6E1F Licensing fault*. Auxiliary code in the event logger indicates the plus code of missing license, in this case N8053. For further assistance, contact your local ABB representative.

Safety instructions

WARNING!
Follow all safety instructions of the drive before you install, commission, or use the drive. For single drives, the complete safety instructions are given at the beginning of the hardware manual. For multidrive safety instructions, see *Safety instructions for ACS880 multidrive cabinets and modules* (3AUA0000102301 [English]) for air-cooled units, and *Safety instructions for ACS880 liquid-cooled multidrive cabinets and modules* (3AXD50000048633 [English]) for liquid-cooled units.

Read the software function specific warnings and notes before changing the default settings of the function. For each function, the warnings and notes are given in the subsection the function or the related user-adjustable parameters.

Target audience

This manual is intended for people who design, commission, or operate the drive system.

Terms and abbreviations

Term/ Abbreviation	Description
BAMU	Auxiliary measurement unit
BCU	Type of control unit
DC link	DC circuit between rectifier and inverter
Drive	Frequency converter for controlling AC motors
Frame, frame size	Physical size of the drive or power module
IGBT	Insulated gate bipolar transistor
IGBT supply unit	IGBT supply module(s) under control of one control board, and related components.
Inverter unit	Inverter module(s) under control of one control board, and related components. One inverter unit typically controls one motor.
ISU	IGBT supply unit
LCL filter	Inductor-capacitor-inductor filter
Power module	Common term for drive module, inverter module, supply module, brake chopper module etc.
Supply unit	Supply module(s) under control of one control board, and related components.
THD	Total harmonic distortion

Related documents

Cabinet-installed multidrive manuals

Manual	Code
General manuals	
ACS880 multidrive cabinets and modules safety instructions	3AUA0000102301
ACS880 liquid-cooled multidrive cabinets and modules safety instructions	3AXD50000048633
ACS880 multidrive cabinets and modules electrical planning instructions	3AUA0000102324
ACS880 liquid-cooled multidrive cabinets and modules electrical planning instructions	3AXD50000048634
ACS880 multidrive cabinets mechanical installation instructions	3AUA0000101764

Manual	Code
ACS880 liquid-cooled multidrive cabinets mechanical installation instructions	3AXD50000048635
CIO-01 I/O module for distributed I/O bus control user's manual	3AXD50000126880
Supply unit manuals	
ACS880-207 IGBT supply units hardware manual	3AUA0000130644
ACS880-207LC IGBT supply units hardware manual	3AXD50000174782
ACS880 IGBT supply control program firmware manual	3AUA0000131562
ACS880 multidrives, Optimal grid control (option +N8053) supplement	3AXD50000220717
Optimal grid control of ACS880 IGBT supply control program supplement	3AXD50000164745
ACS880-307 +A003 diode supply units hardware manual	3AUA0000102453
ACS880-307 +A018 diode supply units hardware manual	3AXD50000011408
ACS880 diode supply control program firmware manual	3AUA0000103295
ACS880-907 regenerative rectifier units hardware manual	3AXD50000020546
ACS880 regenerative rectifier control program firmware manual	3AXD50000020827
Inverter unit manuals	
ACS880-107 inverter units hardware manual	3AUA0000102519
ACS880-107LC inverter units hardware manual	3AXD50000196111
ACS880 primary control program firmware manual	3AUA0000085967
ACS880 primary control program quick start-up guide	3AUA0000098062
Manuals for application programs (Crane, Winder, etc.)	
Brake unit and DC/DC converter unit manuals	
ACS880-607 1-phase brake units hardware manual	3AUA0000102559
ACS880-607LC 1-phase brake units hardware manual	3AXD50000481491
ACS880-607 3-phase brake units hardware manual	3AXD50000022034
ACS880 (3-phase) brake control program firmware manual	3AXD50000020967
ACS880-1607 DC/DC converter units hardware manual	3AXD50000023644
ACS880-1607LC DC/DC converter units hardware manual	3AXD50000431342
ACS880 DC/DC converter control program firmware manual	3AXD50000024671
Option manuals	
ACS880-1007LC liquid cooling unit user's manual	3AXD50000129607
ACS-AP-x assistant control panels user’s manual	3AUA0000085685
Drive composer start-up and maintenance PC tool user’s manual	3AUA0000094606
Manuals for I/O extension modules, fieldbus adapters, safety options etc.	

You can find manuals on the Internet. See www.abb.com/drives/documents. For manuals not available in the document library, contact your local ABB representative.

Multidrive module manuals

Manual	Code
General manuals	
ACS880 multidrive cabinets and modules safety instructions	3AUA0000102301
ACS880 liquid-cooled multidrive cabinets and modules safety instructions	3AXD50000048633
ACS880 multidrive cabinets and modules electrical planning instructions	3AUA0000102324

Manual	Code
ACS880 liquid-cooled multidrive cabinets and modules electrical planning instructions	3AXD50000048634
Drive modules cabinet design and construction instructions	3AUA0000107668
BCU-02/12/22 control units hardware manual	3AUA0000113605
CIO-01 I/O module for distributed I/O bus control user's manual	3AXD50000126880
Supply module manuals	
ACS880-204 IGBT supply modules hardware manual	3AUA0000131525
ACS880-204LC IGBT supply modules hardware manual	3AXD50000284436
ACS880 IGBT supply control program firmware manual	3AUA0000131562
ACS880 multidrives, Optimal grid control (option +N8053) supplement	3AXD50000220717
Optimal grid control of ACS880 IGBT supply control program supplement	3AXD50000164745
ACS880-304 +A003 diode supply modules hardware manual	3AUA0000102452
ACS880-304…+A018 diode supply modules hardware manual	3AXD50000010104
ACS880-304LC+A019 diode supply modules hardware manual	3AXD50000045157
ACS880 diode supply control program firmware manual	3AUA0000103295
ACS880-904 regenerative rectifier modules hardware manual	3AXD50000020457
ACS880 regenerative rectifier control program firmware manual	3AXD50000020827
Inverter module manuals and guides	
ACS880-104 inverter modules hardware manual	3AUA0000104271
ACS880-104LC inverter modules hardware manual	3AXD50000045610
ACS880 primary control program firmware manual	3AUA0000085967
ACS880 primary control program quick start-up guide	3AUA0000098062
Brake module and DC/DC converter module manuals	
ACS880-604 1-phase brake chopper modules hardware manual	3AUA0000106244
ACS880-604LC 1-phase brake chopper modules hardware manual	3AXD50000184378
ACS880-604 3-phase brake modules hardware manual	3AXD50000022033
ACS880 (3-phase) brake control program firmware manual	3AXD50000020967
ACS880-1604 DC/DC converter modules hardware manual	3AXD50000023642
ACS880-1604LC DC/DC converter modules hardware manual	3AXD50000371631
ACS880 DC/DC converter control program firmware manual	3AXD50000024671
Module package hardware manuals	
ACS880-04 module packages hardware manual	3AUA0000138495
ACS880-14 and -34 module packages hardware manual	3AXD50000022021
Option manuals	
ACS880-1007LC liquid cooling unit user's manual	3AXD50000129607
ACX-AP-x assistant control panels user’s manual	3AUA0000085685
BAMU-12C auxiliary measurement unit hardware manual	3AXD50000117840
Drive composer start-up and maintenance PC tool user’s manual	3AUA0000094606
Drive application programming (IEC 61131-3) manual	3AUA0000127808

Manual	Code
Installation frames for ACS880 multidrive modules hardware manual	3AXD50000010531
Manuals and quick guides for I/O extension modules, fieldbus adapters, safety functions modules, etc.	

See www.abb.com/drives/documents for all manuals on the Internet.

You can find all documentation related to the multidrive modules on the Internet at https://sites-apps.abb.com/sites/lvacdrivesengineeringsupport/content.

Cybersecurity disclaimer

This product is designed to be connected to and to communicate information and data via a network interface. It is Customer's sole responsibility to provide and continuously ensure a secure connection between the product and Customer network or any other network (as the case may be). 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.

2

Operation description

Contents of this chapter

This chapter describes the operation of ACS880 grid converter.

Overview

A grid converter is an IGBT supply unit equipped with optimal grid control functionality. The grid converter can be used to produce an island AC grid. It is also possible to use grid converters in parallel with generators to support the operation of a distributed power system. The grid converter produces sinusoidal three-phase AC voltages from the DC link voltage of the system. AC voltage magnitude and frequency can be defined by the user.

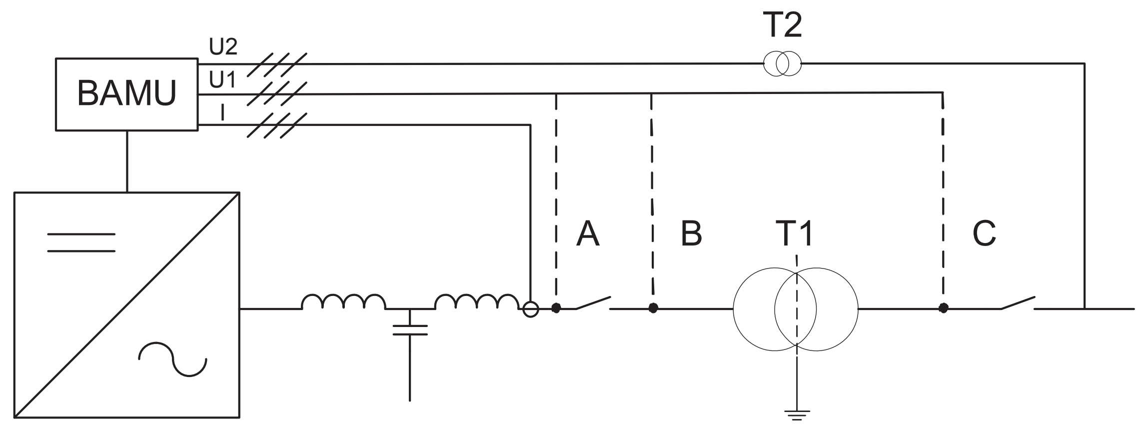
A grid converter can be used in eg. marine applications where ordinary power grid connection is not available. For further details, see *Optimal grid control of ACS880 IGBT supply control program supplement* (3AXD50000164745 [English]).

Safety

WARNING!
AC terminals of a grid converter can carry dangerous voltage even though the main disconnecting device of the drive is open. Grid converter can start and it can be started even though its AC terminals are unconnected, the main disconnecting device of the drive is open or there is no supplying AC power network.

Voltage and current measurements

BAMU board is an essential part of a grid converter. It is a multipurpose measurement unit for voltage and current measurements. It has two 3-phase voltage inputs and one 3-phase current input. The following table shows how BAMU board can be used for measuring current I and voltages U1 and U2 of a grid converter. U1 measurement is mandatory, U2 measurement is done only when synchronization is needed. Note that the figure below is an illustrative figure showing possible measurement locations. For further information, see delivery-specific circuit diagrams and *BAMU-12C auxiliary measurement unit hardware manual* (3AXD50000117840 [English]).



I	Always measured from grid-side terminals of an LCL filter. Direction of positive current using default parametrization is towards the converter.
U1	Three options: A) measured from grid-side terminals of an LCL filter B) measured after main circuit breaker (MCB) from grid-side terminals C) measured from the grid-side of the supply transformer. If secondary voltage exceeds 690 V, a measurement transformer needs to be used.
U2	Always measured from the point where synchronization is needed. Measurement transformer with equivalent effect on voltage vector to any transformers between U1 and U2 measurements is required. For example, if option B is used for U1, T2 must be identical with T1 in terms of phase shift and voltage ratio.
T1	Supply transformer
T2	Measurement transformer

Recommended nominal primary measurement range of the current transformer for BAMU I measurement is 130% of the nominal AC current (I_N) of the IGBT supply unit. Secondary current is 1 A.

BAMU board is typically located in incoming cubicle.

BAMU board is included in the delivery of a cabinet-installed unit when the license N8053 is ordered. In a module delivery, BAMU board and its accessories need to be ordered and installed separately by the user. See *ACS880-204 IGBT supply modules hardware manual* (3AUA0000131525 [English]) for air-cooled units and *ACS880-204LC IGBT supply modules hardware manual* (3AXD50000284436 [English]) for liquid-cooled units.

Synchronization

Internal synchronization using U1 is performed when the converter is started. This synchronization method is the default option for synchronizing to an existing grid on start-up and is typically the only synchronization needed by applications.

External synchronization using U2 can be used for synchronizing the grid formed by the converter (or a cluster of converters) to another grid. This operation typically results in a small power transient in the system, which must be absorbed by DC-forming devices. This synchronization method is typically needed when there are two separate microgrids created on board a vessel (eg. starboard and port sides) and these sides need to be connected over a bus tie.

Restrictions for using optimal grid control functionality

ABB recommends to use always a supply transformer with a static shielding. If there is no static shielding, the customer must

- make sure that there are no devices sensitive to common mode voltage connected to the AC grid that the grid converter is connected to,
- arrange the attenuation of the common mode current. If there are several grid converters connected to the same AC grid and DC link, the circulating common mode current between the grid converters must be prevented by using transformers.

3

Dimensioning

Contents of this chapter

This chapter describes the dimensioning (current derating) curves that are used for selecting an ACS880 grid converter for a certain application.

Information of this chapter is applicable to air-cooled and liquid-cooled ACS880 IGBT supply units of frame size R8i (and multiples). The derating based on the electrical properties of the grid is considered. For derating based on other conditions, such as ambient temperature or installation altitude, see appropriate hardware manual.

Sign convention

The sign convention used with grid converter is the load sign convention, which means that the grid converter is considered as load. This is the same sign convention as with standard IGBT supply unit. Positive current direction is from grid to the grid converter and as a result active power is positive if equipment in the grid (formed by the grid converter) supplies power to the grid converter, and negative if it consumes power (eg. resistive load). Similarly, the reactive power is considered as if the grid converter was a passive component.

Example of the effect of the sign convention: Assume that a symmetric resistor-inductor load is connected to the grid created by the grid converter. The load consumes active power (resistor) and is inductive. From the grid converter point of view, since load sign convention is used, the power flow through the grid converter is negative active power and capacitive reactive power.

Derating curves in continuous operation conditions

When selecting the grid converter, continuous operation conditions must be taken into account. The derating factors are:

- Grid voltage or grid voltage range (grid converter output), K_U
- Grid frequency, K_f
- Maximum continuous load current, I_{load}
- Maximum load current THD, K_{THD}
- Phase angle of the load current, ie. amount of reactive load, K_φ
- DC link voltage of the grid converter, K_{DC}
- Load current unbalance, $K_{unbalance}$

Grid voltage and frequency are typically well known, and also the maximum continuous load is known. Current THD (total harmonic distortion) and the amount of reactive current may be more difficult to estimate depending on the application. These, however, may have a big effect on the dimensioning so they should be realistically approximated to avoid selecting too large converter. DC link voltage depends on the load type: nonlinear loads and highly reactive loads require higher DC link voltage than linear resistive loads. Also, higher DC link voltage reduces the loadability of the converter. The total derating factor K_T is

$$K_A = K_U\, K_f\, K_\varphi\, K_{THD} \quad (1)$$

$$K_T = \min(K_A, K_{DC}, K_{unbalance}) \quad (2)$$

Most of the derating factors are simply multiplied together, but since some factors affect different components, other factors only act as a limit and thus the minimum value of the factors is used.

Taking all the factors into account, the continuous grid converter output current can be calculated from the nominal AC current of the IGBT supply unit:

$$I_{grid\ converter} = I_{ISU}\, K_T \quad (3)$$

The equation can be re-arranged to select the IGBT supply unit based on the load current:

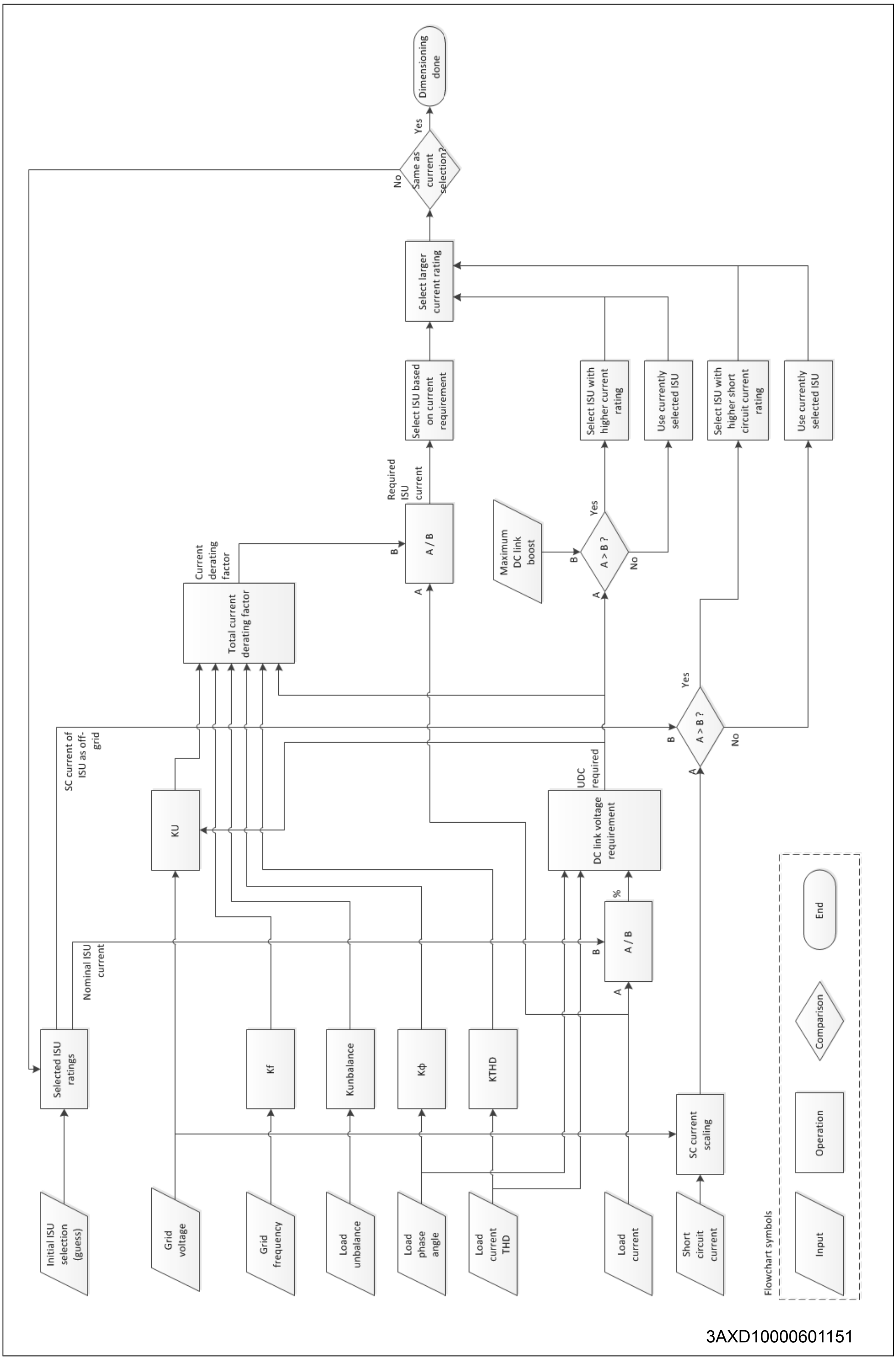
$$I_{ISU} = I_{grid\ converter} / K_T \quad (4)$$

The nominal DC link voltage is calculated from the nominal AC voltage of the IGBT supply unit by taking the peak voltage of the AC main voltage:

$$U_{DC,nominal} = \sqrt{2}\, U_{AC,nominal} \quad (5)$$

Note that in practice the DC link voltage needs to be about 3% above the nominal DC voltage calculated with equation above. For more details on DC link voltage margin, see section *DC link voltage requirement (page 26)*.

The flowchart below describes the dimensioning flow for a grid converter. Since multiple parameters affect each other and the nominal ratings of the IGBT supply unit also affect some derating factors, it is necessary to iterate the selection or calculate the derating factors for multiple drive sizes and then select a suitable one.


Initial ISU selection (guess)
Grid voltage
Grid frequency
Load unbalance
Load phase angle
Load current THD
Load current
Short circuit current
Selected ISU ratings
Kf
Kunbalance
Kϕ
KTHD
SC current scaling
Nominal ISU current
SC current of ISU as off-grid
KU
A / B
%
DC link voltage requirement
UDC required
Total current derating factor
Current derating factor
A / B
Required ISU current
Maximum DC link boost
A > B ?
A > B ?
Yes
No
A
B
Select ISU based on current requirement
Select ISU with higher current rating
Use currently selected ISU
Select ISU with higher short circuit current rating
Use currently selected ISU
Select larger current rating
Same as current selection?
Dimensioning done
Flowchart symbols
Input
Operation
Comparison
End
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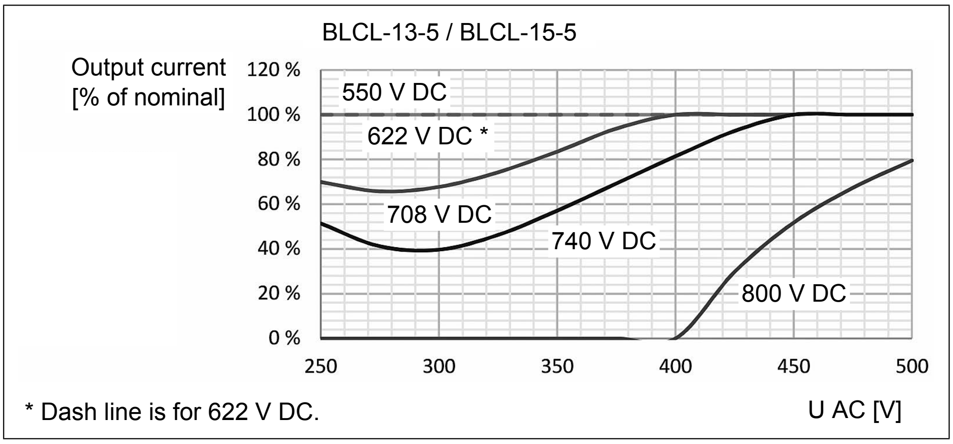
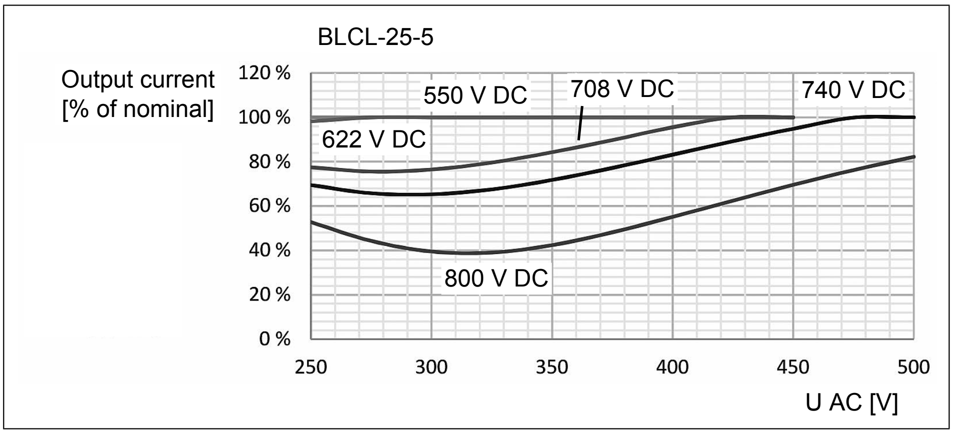
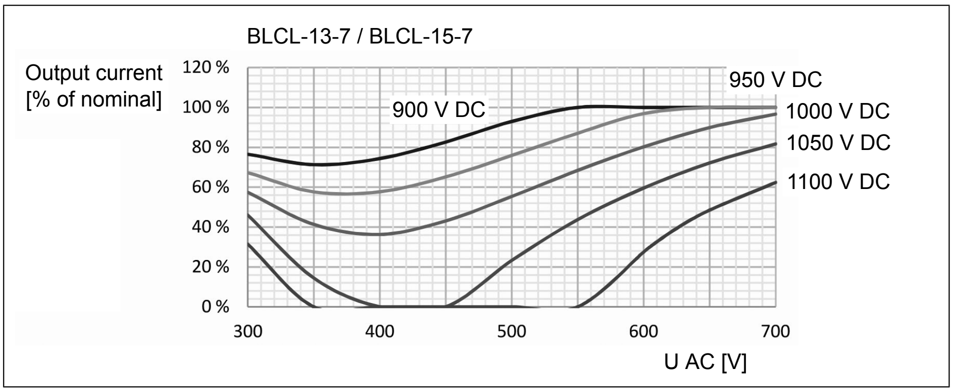
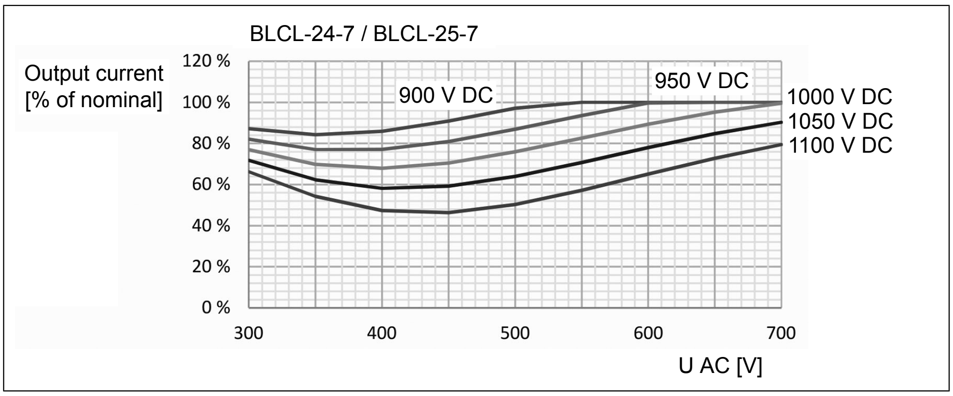
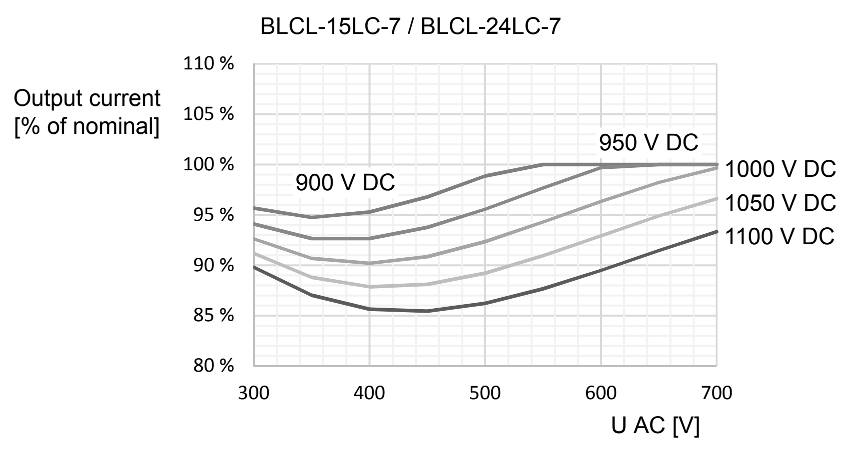
Voltage derating, factor K_U

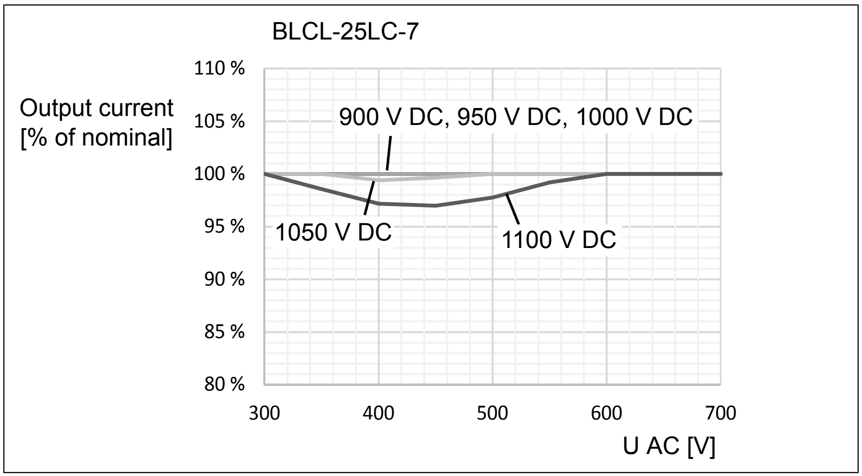












Select the derating curve according to the LCL filter type that is used with the desired IGBT supply unit type. Voltage derating factor depends on grid voltage and DC link voltage. To be able to calculate the derating factor, the DC link voltage requirement must be known. For calculating the DC link voltage, see section *DC link voltage requirement (page 26)*.

To be able to calculate the voltage derating factor, the relative AC voltage and DC link voltage boost must be calculated according to equations below, while limiting the result accordingly.

$$U_{AC,\%} = U_{AC}\sqrt{2} / U_{DC},\ 0 \le U_{AC,\%} \le 1 \quad (6)$$

$$U_{DC,\%} = U_{DC} / (U_{AC,nominal}\ \sqrt{2}) - 1.0 \quad (7)$$

Using the relative voltages, a voltage stress factor K_{Stress} can be calculated with following equation.

$$K_{Stress} = 0.353\ U_{AC,\%}^3 - 0.865\ U_{AC,\%}^2 + 0.635\ U_{AC,\%} - 0.04 + 0.105\ U_{DC,\%} \quad (8)$$

Using the voltage stress factor, the voltage derating factor can be calculated with following equations, limiting the output when necessary.

$$C = 1.0 - B\ K_{Stress},\ 0 \le C \quad (9)$$

$$K_U = \sqrt{(C / A)},\ 0 \le K_U \le 1 \quad (10)$$

where A and B are coefficients that depend on the LCL filter used according to the table below.

Coefficient	BLCL-13-5 BLCL-15-5	BLCL-25-5	BLCL-13-7 BLCL-15-7	BLCL-24-7 BLCL-25-7	BLCL-24LC-7 BLCL-15LC-7	BLCL-25LC-7
A	0.150	0.260	0.254	0.336	0.60	0.5
B	8.785	8.000	8.875	7.761	4.70	4.43

For example, assuming following operation conditions:

- ISU nominal voltage $U_{AC,nominal}$ = 690 V AC
- Grid voltage formed by the grid converter U_{AC} = 525 V AC
- DC link voltage produced by the DC supply U_{DC} = 1030 V DC
- LCL filter type is BLCL-25-7

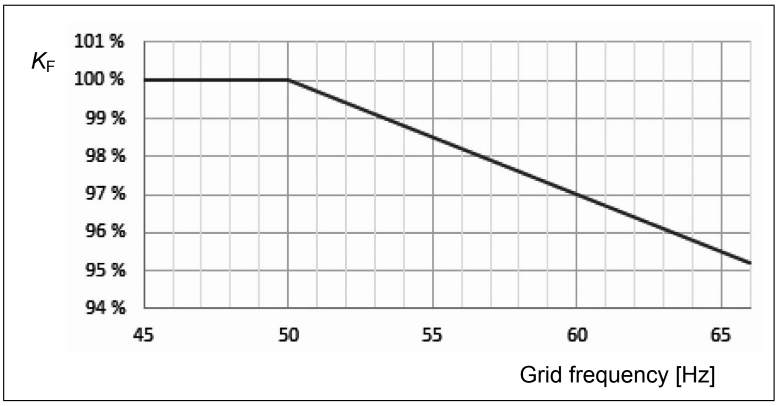
The calculations give

- Actual AC voltage in percent is $U_{AC,\%}$ = 525×√2 / 1030 = 72% = 0.72 (equation (6))
- Actual DC link boost in percent is $U_{DC,\%}$ = 1030 / (690×√2) - 1.0 = 5.6% = 0.056 (equation (7))
- Voltage stress factor then is K_{Stress} = 0.106 (equation (8))
- Derating factor is K_U = √(0.177 / 0.336) = 0.726 = 72.6% (equations (9) and (10))

If the DC link voltage is boosted from the nominal, an additional derating factor shown in section *DC link voltage derating, factor K_{DC} (page 25)*, needs to be taken into account also.

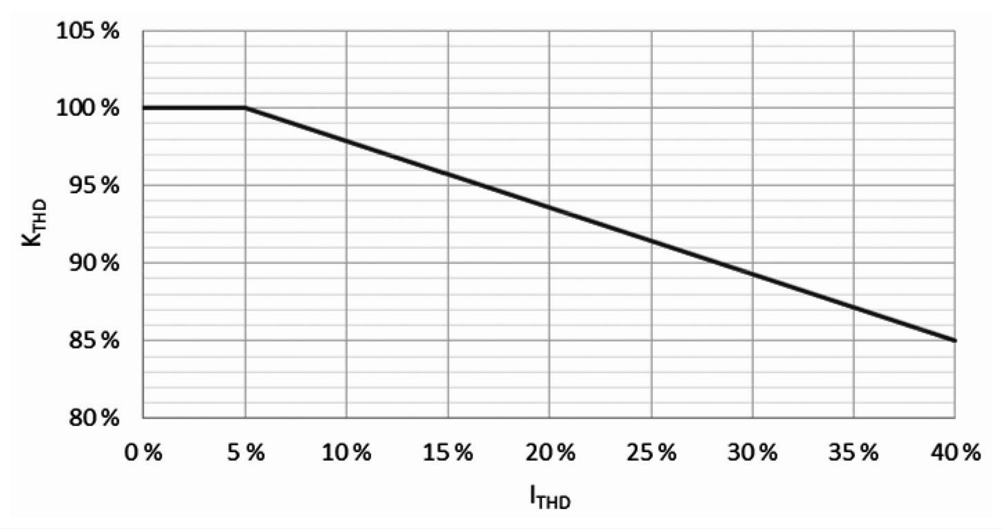
This factor assumes that the load is resistive, linear and symmetric and that grid frequency is 50 Hz. Nonlinearity, nonresistive loads, load unbalance and different grid frequencies are taken into account with other factors.

Output frequency derating, factor K_F



Above 50 Hz the output current is derated 0.3% / Hz.

Load current THD derating, factor K_{THD}



Above 5% load current THD, the current is derated 0.43% / 1% THD.

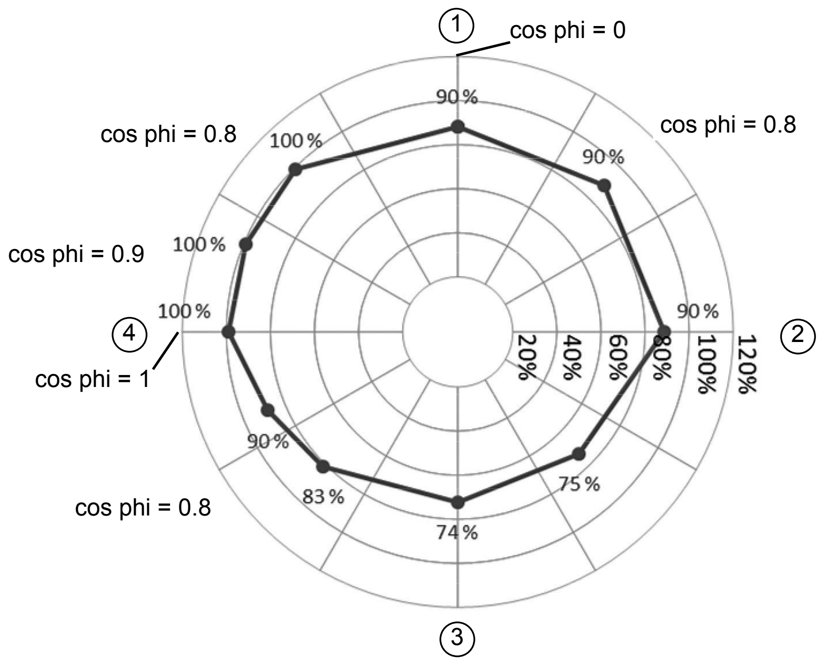
The load in the figure above is considered to be symmetric, having linear resistive component and also 6-phase diode bridge load. The diode bridge is assumed to have a 3-phase AC choke, inductance of which is selected so that at nominal load its current THD is 40%.

Also note that the curve assumes that the grid converter is supplied with IGBT supply unit or similar supply, with low amount of low-frequency ripple in the DC link. If a diode supply or similar with high amount of low-frequency ripple is used, derating may be steeper.

When the load current THD increases, also the DC link voltage required to produce that current increases. This relation is described in section *DC link voltage requirement (page 26)*. If the DC link voltage increases above the nominal DC link voltage (grid voltage is high and current THD is high), additional derating is required according to section *DC link voltage derating, factor* K_{DC} *(page 25)*.

Load phase angle derating / reactive current, factor K_φ

Air-cooled units



Reactive power derating factor K_φ as the variable of the load phase angle:	
1.	Positive, capacitive, current leads voltage
2.	Positive, load produces power
3.	Negative, inductive, current lags voltage
4.	Negative, load consumes power

The amount of reactive power affects also the loadability of the converter. The basic rating is given for negative active power and the output current needs to be derated if there is reactive power or if the active power is positive. The figure above shows the derating factor depending on the phase angle of the load current.

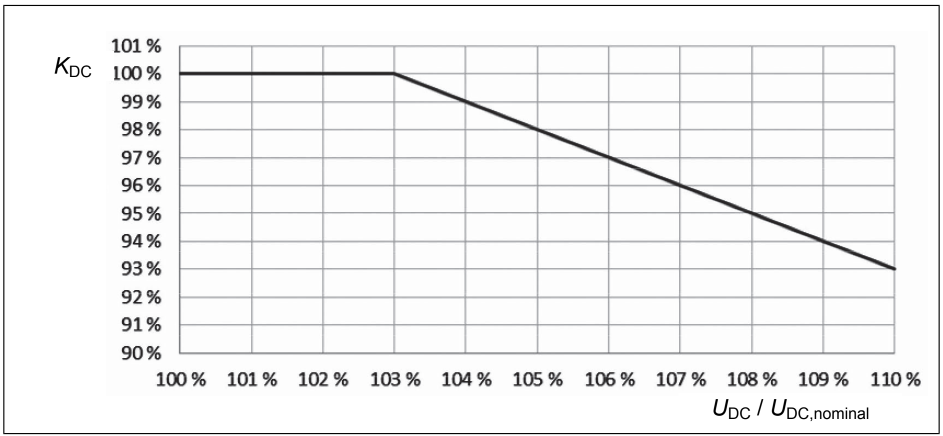
Generating reactive power may also require higher DC link voltage, which in turn may cause additional derating. DC link voltage requirements are described in section *DC link voltage requirement (page 26)* and DC link voltage effect on derating in sections *Voltage derating, factor K_U (page 20)* and *DC link voltage derating, factor K_{DC} (page 25)*.

Liquid-cooled units

There is no need for derating as a function of load phase angle (ie. K_φ = 1).

DC link voltage derating, factor K_{DC}

Air-cooled units



DC link voltage derating is 1% for each 1% of DC link voltage boost above 103%. Derating factor can be calculated with following equation:

$$K_{DC} = \min(1.0,\ 1.0 - (U_{DC,percent} - 1.03)) \quad (11)$$

Liquid-cooled units

There is no need for separate DC link voltage derating (K_{DC}) to determine the total derating factor K_T (equation 2) of the liquid-cooled units. The effects of high DC link voltage are covered by the voltage derating factor K_U.

DC link voltage requirement

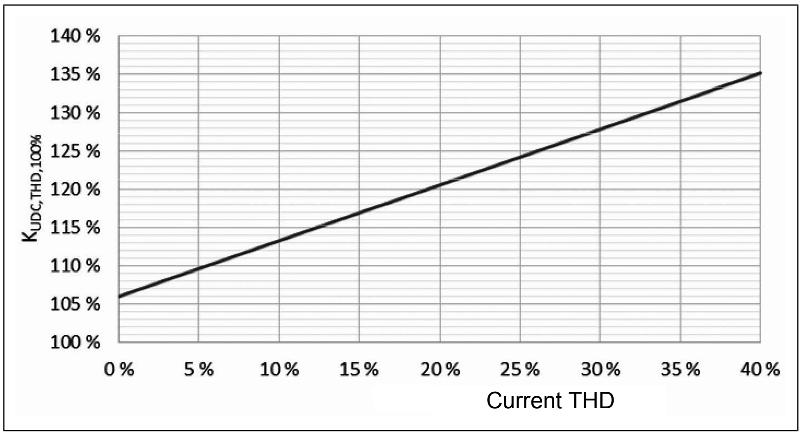
DC link voltage may need to be increased from nominal because harmonic current compensation needs to have certain voltage margin from AC voltage peak value to DC link voltage. Also reactive current, especially capacitive reactive current, needs higher than nominal DC link voltage to be able to produce the required current.

The total DC link voltage required, compared to the nominal value, can be calculated with

$$U_{DC} = U_{DC,nominal}\, K_{UDC,THD}\, K_{UDC,\varphi} = \sqrt{2}\, U_{AC}\, K_{UDC,THD}\, K_{UDC,\varphi} \qquad (12)$$

where $K_{UDC,THD}$ is the DC link voltage increase required by the load current THD, ie. harmonic current compensation, and $K_{UDC,\varphi}$ is the DC link voltage increase required by reactive current. Note that even when current is sinusoidal (THD = 0%), there is some amount of DC link voltage margin required according to the figure below.

The following figure shows DC link voltage compared to nominal when converter is at full load (current is nominal).



The curve follows approximately function (THD as 0% = 0 and 40% = 0.4)

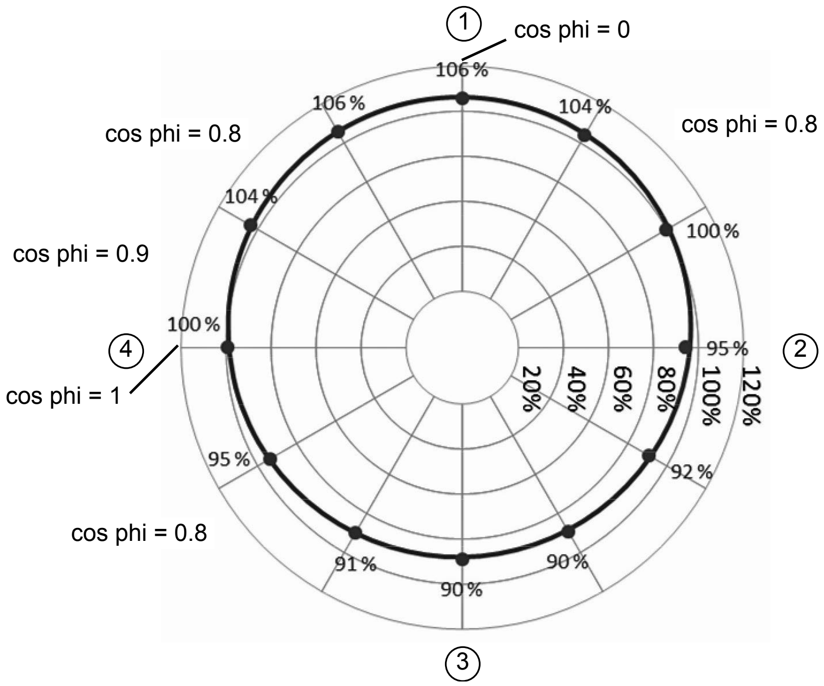
$$K_{UDC,THD,100\%} = 1.06 + 0.73\ \mathrm{THD} \qquad (13)$$

The curve is given for full load, the margin for partial loads can be calculated with

$$K_{UDC,THD} = 1.03 + I_{load,percent}\,(K_{UDC,THD,100\%} - 1.03) \qquad (14)$$

which means that in no-load case, DC link voltage needs to be 103% of nominal, and between no-load and full load a linear fit between 103% and the respective DC link voltage margin value can be used. $I_{load,percent}$ is load current in percent of nominal current rating of IGBT supply unit.

For reactive power, the following curve must be used in addition to the THD related curve to get the required DC link voltage multiplier in full load condition. For the sign convention used, see section *Sign convention (page 17)*.



U_{DC} required for reactive power, full load $K_{UDC,\varphi,100\%}$:	
1.	Positive, capacitive, current leads voltage
2.	Positive, load produces power
3.	Negative, inductive, current lags voltage
4.	Negative, load consumes power

A linear fit equation can also be used for the loading between no load and full load.

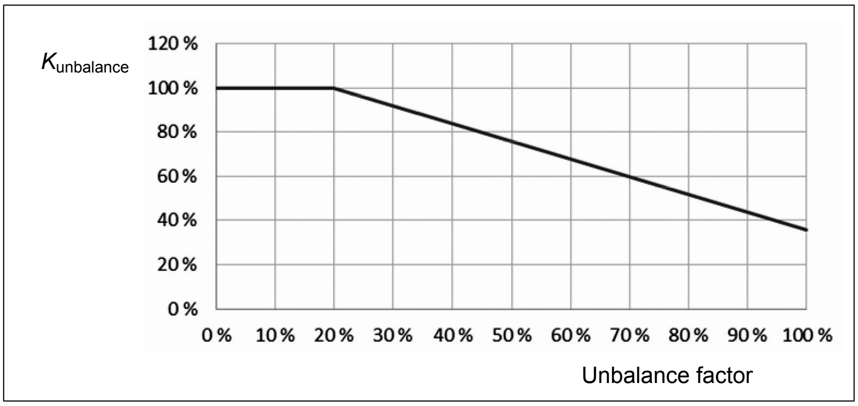
$$K_{UDC,\varphi} = 1.0 + I_{load,percent}\,(K_{UDC,\,\varphi,100\%} - 1.0) \qquad (15)$$

Note that the curve above is given for nominal current rating of IGBT supply unit; however at all phase angles nominal current is not allowed but must be derated according to the figure in section *Load phase angle derating / reactive current, factor K_φ (page 24)*.

If the DC link voltage requirement is not reached, the grid converter cannot supply the harmonic current components or reactive current components completely. As a result, output voltage quality will decrease and output voltage THD will increase.

Load unbalance derating, factor $K_{unbalance}$

The following curve shows maximum available current in relation to phase unbalance. Phase unbalance is defined so that the difference of maximum and minimum phase current is compared to maximum phase current. Thus 100% unbalance is achieved when one phase is not loaded at all, while all current flows through the remaining two phases.



Unbalance factor is calculated with

$$\text{Unbalance} = (\max(I_{L1,RMS}, I_{L2,RMS}, I_{L3,RMS}) - \min(I_{L1,RMS}, I_{L2,RMS}, I_{L3,RMS})) / \max(I_{L1,RMS}, I_{L2,RMS}, I_{L3,RMS}) \quad (16)$$

The derating factor is 0.8% for each percent of unbalance above 20%.

Short-circuit current

Air-cooled units

The grid converter supplies short-circuit (overload) current for 5 seconds maximum. If the short-circuit (overload) condition is not cleared by that time, the converter trips on overcurrent.

400 V and 500 V units

The maximum short-circuit current must be limited to 85% of the rated current of the IGBT supply unit, and the continuous output current must be limited to 80% to prevent the grid converter from tripping to overcurrent fault when a short-circuit happens under load.

In addition, a transformer with at least 5% leakage inductance (calculated from the rated current of the IGBT supply unit) must be used at the output of the grid converter. The inductance values for IGBT supply module types are listed in the table below.

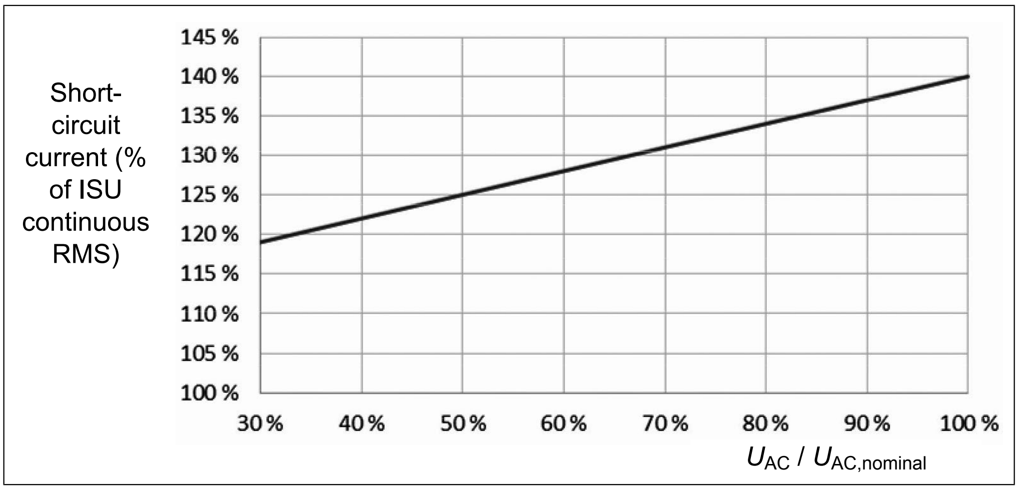
IGBT supply module type	L phase [µH]
U_N = 400 V	
ACS880-204-0420A-3	87
ACS880-204-0580A-3	64
ACS880-204-0810A-3	46
ACS880-204-1130A-3	33
ACS880-204-1330A-3	28
ACS880-204-1580A-3	24
ACS880-204-2350A-3	16
ACS880-204-3110A-3	12

IGBT supply module type	L phase [µH]
ACS880-204-4620A-3	8
U_N = 500 V	
ACS880-204-0400A-5	117
ACS880-204-0530A-5	87
ACS880-204-0730A-5	64
ACS880-204-1040A-5	45
ACS880-204-1420A-5	33
ACS880-204-2120A-5	22
ACS880-204-2800A-5	17
ACS880-204-4150A-5	12

If it is not necessary for the grid converter to supply short-circuit current and tripping is tolerated in the situation, the continuous current can be higher than 80% if derating calculation leads to a higher value.

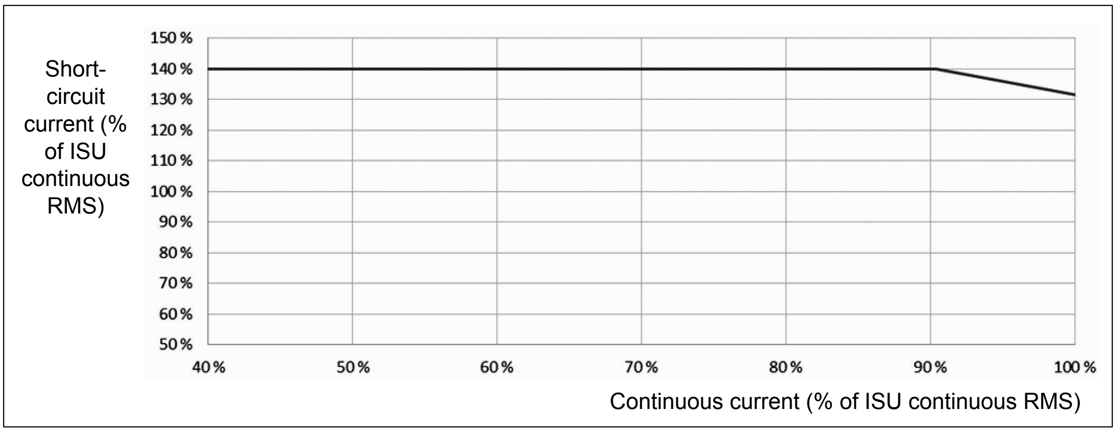
690 V units

The maximum short-circuit current supplied by the grid converter depends on the output voltage. The following curve shows the relationship between output voltage (percent of the drive nominal voltage) and maximum short-circuit current.



The curve is based on the nominal (continuous) current rating of the IGBT supply unit. Current available from the grid converter is less especially with lower grid voltage. See section *Voltage derating, factor K_U (page 20)*.

If the output current rating is close to the nominal rating of IGBT supply unit, the short-circuit current limit must be lowered to guarantee that no overtemperature trip occurs during the fault. The following curve shows the available short-circuit current relative to the continuous load current of the grid converter, in percent of nominal current rating of IGBT supply unit.



Liquid-cooled units

The grid converter supplies short-circuit (overload) current for 2 seconds maximum. If the short-circuit (overload) condition is not cleared by that time, the converter trips on overcurrent.

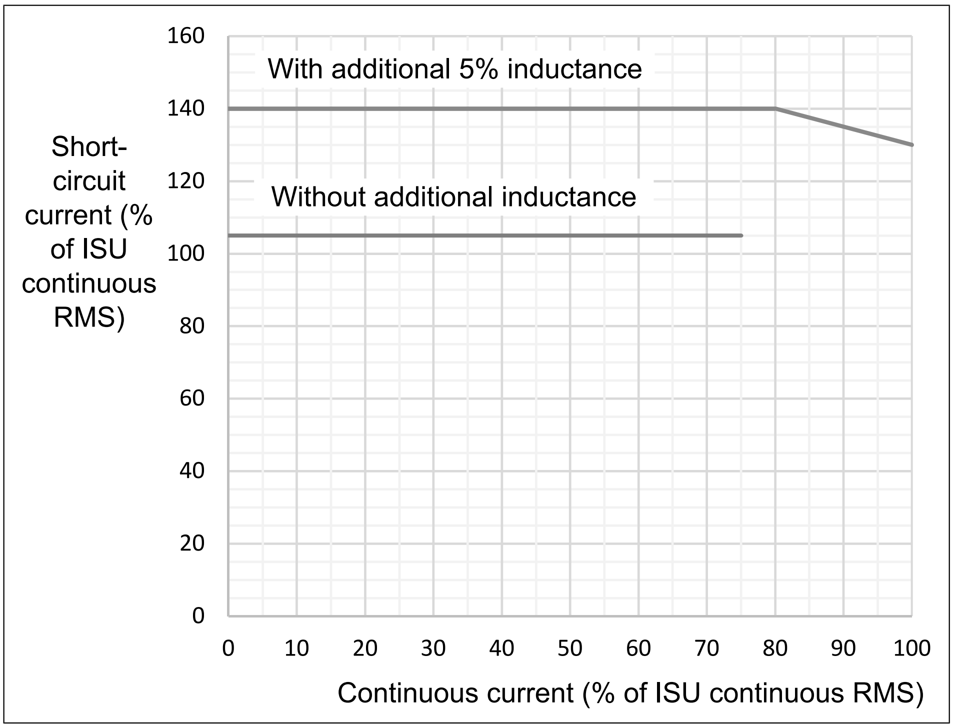
The maximum short-circuit current and continuous output current must be limited according to the figure below to prevent the grid converter from tripping to overcurrent fault when a short-circuit happens under load.

The short-circuit current supplying capability depends on the total inductance at the converter output. If additional inductance is connected to the converter output (eg. transformer leakage inductance), the short-circuit current limits can be extended from the situation without additional inductance. 5% inductance values (calculated from rated current) for IGBT supply module types are listed in the table below.

IGBT supply module type	**L phase [µH]**
U_N = 690 V	
ACS880-204LC-0360A-7	177
ACS880-204LC-0400A-7	159
ACS880-204LC-0450A-7	141
ACS880-204LC-0480A-7	133
ACS880-204LC-0560A-7	114
ACS880-204LC-0620A-7	103
ACS880-204LC-0700A-7	91
ACS880-204LC-0770A-7	83
ACS880-204LC-0930A-7	69
ACS880-204LC-1090A-7	59
ACS880-204LC-1180A-7	54
ACS880-204LC-1360A-7	47
ACS880-204LC-1500A-7	43
ACS880-204LC-1800A-7	36
ACS880-204LC-2020A-7	32
ACS880-204LC-2220A-7	29
ACS880-204LC-2670A-7	24
ACS880-204LC-2930A-7	22
ACS880-204LC-3320A-7	20
ACS880-204LC-3840A-7	17

IGBT supply module type	L phase [µH]
ACS880-204LC-4360A-7	15
ACS880-204LC-5240A-7	13
ACS880-204LC-5810A-7	11

The figure below shows the current limits without additional inductance, and with 5% inductance (calculated from the rated current of the IGBT supply unit).



Downstream fuse protection ratings

Because of limited short-circuit current, the rating of the downstream fuse is critical so that it burns in short enough time in all cases. The following table shows the maximum allowed size of different circuit breakers depending on the IGBT supply unit type, current and short-circuit current rating.

Air-cooled units

Type ACS880-204-…	Nom. current [A AC]	Short-circuit current, 5 s [A AC]	Miniature circuit breaker (IEC 60898-1) Max. size (Instantaneous tripping 0.1 s)							Fuse (IEC 60269-1:2006)			
			Char.	B		C		D		gG Max. size		aM Max. size	
			Coeff.	5	% of nom.	10	% of nom.	20	% of nom.	5 s based		0.5 s based [1]	
										[A]	% of nom.	[A]	% of nom.
U_N = 400 V													
0420A-3	423	360	63 A		15%	32 A	8%	16 A	4%	63 A	15%	25 A	6%
0580A-3	576	490	80 A		14%	40 A	7%	20 A	3%	80 A	14%	35 A	6%
0810A-3	810	689	125 A		15%	63 A	8%	32 A	4%	100 A	12%	50 A	6%
1130A-3	1125	956	125 A		11%	80 A	7%	40 A	4%	160 A	14%	63 A	6%
1330A-3	1332	1132	125 A		9%	100 A	8%	50 A	4%	160 A	12%	80 A	6%
1580A-3	1584	1346	125 A		8%	125 A	8%	63 A	4%	200 A	13%	100 A	6%
2350A-3	2349	1997	125 A		5%	125 A	5%	80 A	3%	250 A	11%	125 A	5%
3110A-3	3105	2639	125 A		4%	125 A	4%	125 A	4%	315 A	10%	200 A	6%
4620A-3	4617	3924	125 A		3%	125 A	3%	125 A	3%	500 A	11%	250 A	5%
U_N = 500 V													
0400A-5	396	337	63 A		16%	32 A	8%	16 A	4%	63 A	16%	25 A	6%
0530A-5	531	451	80 A		15%	40 A	8%	20 A	4%	80 A	15%	35 A	7%
0730A-5	729	620	100 A		14%	50 A	7%	25 A	3%	100 A	14%	40 A	5%
1040A-5	1035	880	125 A		12%	80 A	8%	40 A	4%	125 A	12%	63 A	6%
1420A-5	1422	1209	125 A		9%	100 A	7%	50 A	4%	160 A	11%	80 A	6%
2120A-5	2115	1798	125 A		6%	125 A	6%	80 A	4%	250 A	12%	125 A	6%
2800A-5	2799	2379	125 A		4%	125 A	4%	100 A	4%	315 A	11%	160 A	6%
4150A-5	4149	3527	125 A		3%	125 A	3%	125 A	3%	400 A	10%	250 A	6%
U_N = 690 V													
0310A-7	306	428	80 A		26%	40 A	13%	20 A	7%	80 A	26%	32 A	10%
0370A-7	369	516	100 A		27%	50 A	14%	25 A	7%	80 A	22%	40 A	11%
0540A-7	540	756	125 A		23%	63 A	12%	32 A	6%	125 A	23%	50 A	9%
0720A-7	720	1008	125 A		17%	100 A	14%	50 A	7%	160 A	22%	80 A	11%
1050A-7	1053	1474	125 A		12%	125 A	12%	63 A	6%	200 A	19%	100 A	9%
1570A-7	1566	2192	125 A		8%	125 A	8%	100 A	6%	250 A	16%	160 A	10%
2070A-7	2070	2898	125 A		6%	125 A	6%	125 A	6%	400 A	19%	200 A	10%
3080A-7	3078	4309	125 A		4%	125 A	4%	125 A	4%	500 A	16%	315 A	10%
4100A-7	4104	5745	125 A		3%	125 A	3%	125 A	3%	630 A	15%	400 A	10%
5130A-7	5130	7182	125 A		2%	125 A	2%	125 A	2%	800 A	16%	500 A	10%
													3AXD10000601151

[1] Overload needs to be controlled.

Liquid-cooled units

Type ACS880-204LC-…	Nom. current [A AC]	Short-circuit current, 2 s [A AC]	Miniature circuit breaker (IEC 60898-1) Max. size (Instantaneous tripping 0.1 s)							Fuse (IEC 60269-1:2006)			
			Char.	B		C		D		gG Max. size		aM Max. size	
			Coeff.	5	% of nom.	10	% of nom.	20	% of nom.	0.1 s based		0.5 s based [1]	
										[A]	% of nom.	[A]	% of nom.
U_N = 690 V													
0360A-7	360	378	63 A		18%	32 A	9%	16 A	4%	32 A	9%	25 A	7%
0400A-7	400	420	80 A		20%	40 A	10%	20 A	5%	32 A	8%	32 A	8%
0450A-7	450	473	80 A		18%	40 A	9%	20 A	4%	40 A	9%	35 A	8%
0480A-7	480	504	100 A		21%	50 A	10%	25 A	5%	40 A	8%	40 A	8%
0560A-7	560	588	100 A		18%	50 A	9%	25 A	4%	40 A	7%	40 A	7%
0620A-7	620	651	125 A		20%	63 A	10%	32 A	5%	50 A	8%	50 A	8%
0700A-7	700	735	125 A		18%	63 A	9%	32 A	5%	50 A	7%	50 A	7%
0770A-7	770	809	125 A		16%	80 A	10%	40 A	5%	50 A	6%	63 A	8%
0930A-7	930	977	125 A		13%	80 A	9%	40 A	4%	63 A	7%	63 A	7%
1090A-7	1090	1145	125 A		11%	100 A	9%	50 A	5%	80 A	7%	80 A	7%
1180A-7	1180	1239	125 A		11%	100 A	8%	50 A	4%	80 A	7%	80 A	7%
1360A-7	1360	1428	125 A		9%	125 A	9%	63 A	5%	80 A	6%	100 A	7%
1500A-7	1500	1575	125 A		8%	125 A	8%	63 A	4%	100 A	7%	125 A	8%
1800A-7	1800	1890	125 A		7%	125 A	7%	80 A	4%	100 A	6%	125 A	7%
2020A-7	2020	2121	125 A		6%	125 A	6%	100 A	5%	125 A	6%	160 A	8%
2220A-7	2220	2331	125 A		6%	125 A	6%	100 A	5%	125 A	6%	160 A	7%
2670A-7	2670	2804	125 A		5%	125 A	5%	125 A	5%	160 A	6%	200 A	7%
2930A-7	2930	3077	125 A		4%	125 A	4%	125 A	4%	160 A	5%	200 A	7%
3320A-7	3320	3486	125 A		4%	125 A	4%	125 A	4%	200 A	6%	250 A	8%
3840A-7	3840	4032	125 A		3%	125 A	3%	125 A	3%	200 A	5%	315 A	8%
4360A-7	4360	4578	125 A		3%	125 A	3%	125 A	3%	250 A	6%	315 A	7%
5240A-7	5240	5502	125 A		2%	125 A	2%	125 A	2%	250 A	5%	400 A	8%
5810A-7	5810	6101	125 A		2%	125 A	2%	125 A	2%	315 A	5%	400 A	7%
													3AXD10001008774

[1] Overload needs to be controlled.

4

Example circuit diagrams

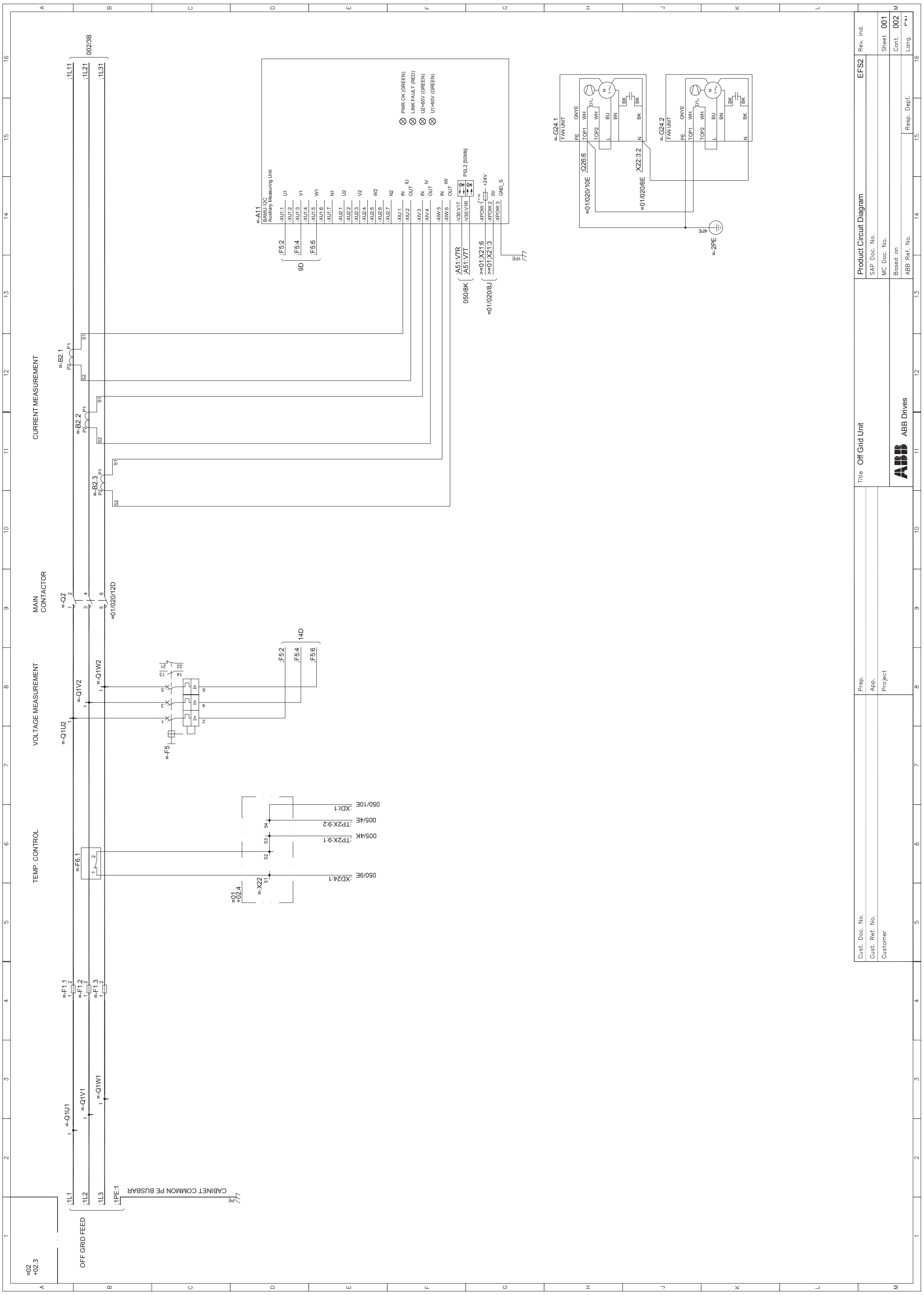
Contents of this chapter

This chapter contains example circuit diagrams of an ACS880 grid converter.

Note: These diagrams do not necessarily match the installation-specific circuit diagrams of a tailor-made cabinet-installed unit.

The purpose of these diagrams is to help in:

- understanding the internal connections and operation of the converter
- learning how to wire a grid converter.



OFF GRID FEED
CABINET COMMON PE BUSBAR
TEMP. CONTROL
VOLTAGE MEASUREMENT
MAIN CONTACTOR
CURRENT MEASUREMENT
=-A11
Auxiliary Measuring Unit
FAN UNIT
Product Circuit Diagram
Off Grid Unit
ABB Drives
EFS2

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