CL 33 Inverters

Solutions Guide for Decentralized PV Systems (IEC Version)

990-91391

September 2020

http://solar.schneider-electric.com/

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Information About Your System

As soon as you open your product, record the following information and be sure to keep your proof of purchase.

Serial Number	____________________________
Product Number	____________________________
Purchased From	____________________________
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About

Purpose

The purpose of this solutions guide is to provide explanations for designing a de-centralized PV system using CL 33 PV inverters and Balance of System (BOS) components offered by Schneider Electric. It describes the interfaces required to implement this architecture and rules to design the solution.

Scope

This solutions guide provides technical information and design recommendations. It explains the design requirements of each system component and provides detailed explanations about how to select these components.

The information provided in this guide does not modify, replace, or waive any instruction or recommendations described in the *CL 33 QuickStart Guide (document number 990-91393)* or *CL 33 Owner's Guide (document number 990-91392)*, including warranties of Schneider Electric products. Always consult the product-specific installation or owner's guides of any Schneider Electric product when installing and using that product in decentralized PV system design using CL 33 inverters.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, ARC FLASH, AND FIRE

This document is in addition to, and incorporates by reference, the relevant product manuals for CL 33 PV inverters. Before reviewing this document, you must read the relevant product manuals. Unless specified, information on safety, specifications, installation and operation is as shown in the primary documentation received with the product. Ensure you are familiar with that information before proceeding.

Failure to follow these instructions will result in death or serious injury.

For help with designing a PV power plant, contact your Schneider Electric Sales Representative or visit the Schneider Electric website for more information at www.solar.schneider-electric.com.

Audience

This guide is intended for system integrators or engineers who plan to design a de-centralized PV system using Schneider Electric CL 33 inverters and other Schneider Electric offered equipment.

Information in this solutions guide is intended for qualified personnel. Qualified personnel have training, knowledge, and experience in:

- Analyzing application needs and designing PV de-centralized systems with transformer-less string inverters.
- Installing electrical equipment and PV power systems (up to 1000 V).
- Applying all applicable (local and international) installation codes.
- Analyzing and reducing the hazards involved in performing electrical work.
- Selecting and using Personal Protective Equipment (PPE).

Abbreviations and Acronyms

AC	Alternating current
ACB	Air circuit breaker
BOS	Balance of systems
DC	Direct current
LV	Low voltage
LVRT	Low voltage ride through
MCB	Miniature circuit breaker
MCCB	Molded case circuit breaker
MET	Meteorological file type
MPP	Maximum power point
MPPT	Maximum power point trackers
MV	Medium voltage
PCC	Point of common coupling
POC	Point of connection
PV	Photovoltaic (solar)
RCD	Residual current device
RCMU	Residual current monitoring unit
ROI	Return on investment
SCADA	Supervisory control and data acquisition
SPD	Surge protection device
STC	Standard test conditions
TMY	Typical meteorological year

Related Information

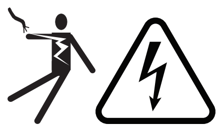
Find more information about Schneider Electric, as well as its products and services at: www.schneider-electric.com.

For specific information about Schneider Electric Solar products, visit: http://solar.schneider-electric.com/

Safety Information

Important Information

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER
DANGER indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

WARNING
WARNING indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

CAUTION
CAUTION indicates a hazardous situation which, if not avoided, **could result in** minor or moderate injury.

NOTICE
NOTICE is used to address practices not related to physical injury.

Please Note

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved. For more information, see *Audience*.

Product Safety Information

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, ARC FLASH, AND FIRE

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DANGER

HAZARD OF ELECTRIC SHOCK AND FIRE

Installation, including wiring, must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes, including relevant local, regional, and national regulations. Installation instructions are not covered in this Solution Guide, but are included in the relevant product manuals for the CL 33 inverter. Those instructions are provided for use by qualified installers only.

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1 Introduction

What's in This Chapter?

Advantages of a Decentralized PV Architecture

Decentralized PV systems are designed by installing small power inverters throughout a PV field area, in the vicinity of PV modules, to allow for connection of the strings as simply as possible.

Advantages of a decentralized PV architecture include:

- Easy adaptation of the solution to roof or plant specificities
- Easy installation of the inverters on roof or plant
- Easy electrical protection
- Easy connection to the grid
- Easy monitoring
- Easy system maintenance
- Greater energy production

Why Decentralize PV Solutions?

The advantages of decentralized system design are:

1. Lower cost and ease of installation:
   a. Smaller units are lighter weight and easier to handle.
   b. Inverters can be mounted directly on or underneath the photovoltaic (PV) mounting structures.
   c. Smaller units are easy and inexpensive to ship and can be installed by two people without heavy and expensive cranes.
   d. No concrete mounting pad required; unit mounted directly to a wall, pole or PV frame racking.
   e. Cost effective: No need to use a DC Combiner or separate DC disconnect (except when required by local installation codes).
2. Easy to service and increased energy harvest:
   a. If the inverter detects a failure event, only part of the field is affected versus a large portion of the field when a large inverter is used, which means minimal down time and greater return on investment (ROI).
   b. Multiple MPPTs allow greater installation flexibility and increased PV harvest.
   c. High efficiency for greater harvest.
3. Easy electrical protection:
   a. DC circuit length reduced up to the racking with short runs to inverters located next to PV panel strings.
   b. Lower DC cable losses.
   c. AC circuit is expanded, allowing for additional AC equipment, which is typically less expensive than DC equipment and available quickly and easily.

4. Easy adaptation to roof specificities:
   a. Ability to support different roof plan orientations.
   b. Heterogeneous layout of the strings is facilitated (unbalanced arrays).
   c. Obstacles on roofs and shadows or shading have less production impact.
5. Easy connection to the grid:
   a. CL 33 offers connectivity to both STAR and DELTA type windings.
   b. Multiple inverters could be paralleled to a single transformer for bigger power blocks.
6. Easy monitoring and Configuration:
   a. ModBus RS485 daisy chain capability.
   b. Monitoring ready with Conext Gateway .
   c. Easy configuration and firmware upgrade tools, such as the Insight Mobile App.

About CL 33 PV Inverters

Figure 1 CL 33 PV inverter

The CL 33 grid-tie inverter is a three phase transformer-less string inverter designed for high efficiency, easy installation, and maximum yield.

CL 33 inverters are designed for outdoor installation and are an ideal solution for decentralized power plants in multiple megawatt (MW) ranges. With high power density, light weight, market-leading power conversion efficiency, and wide input range Maximum Power Point Trackers (MPPTs), these inverters are an ideal solution for large scale PV plants.

WARNING

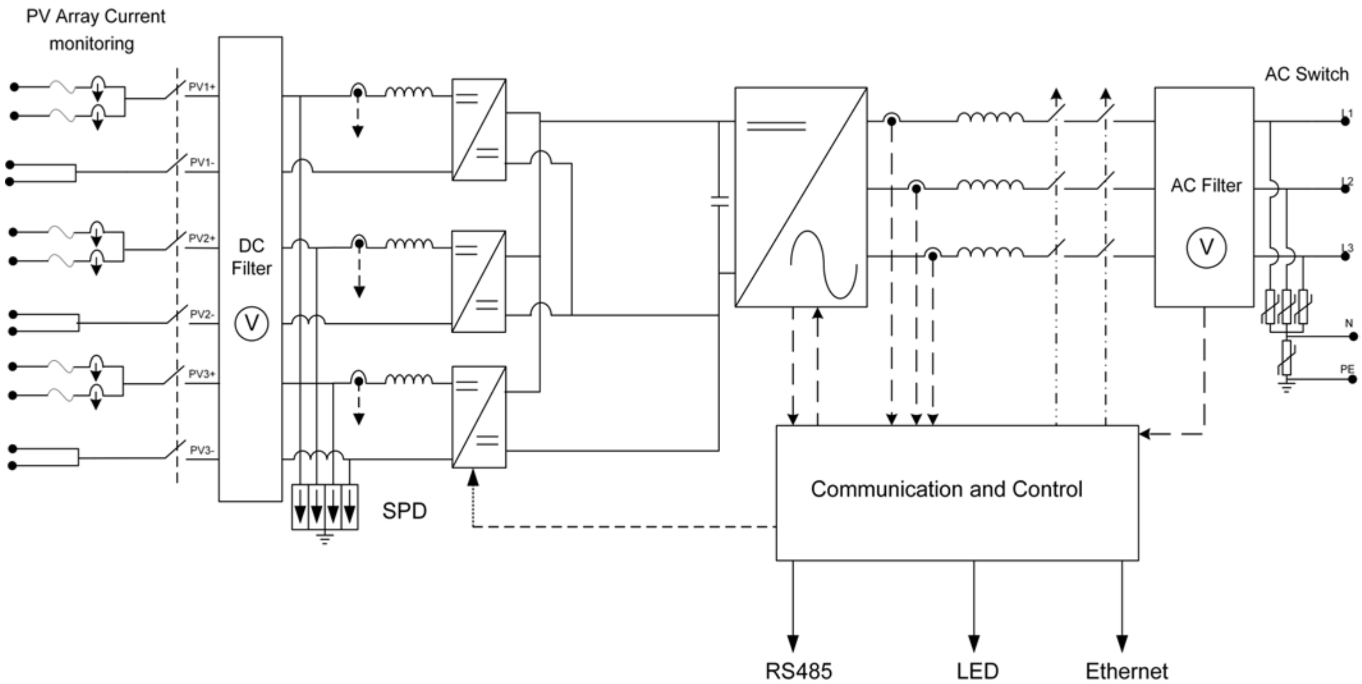
ELECTRIC SHOCK HAZARD

- Only use CL 33 inverters with PV modules that do not require the grounding of a DC polarity.
- Always refer to national and local installation and electrical codes when designing a power system.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

The inverter is designed to collect maximum available energy from the PV array by constantly adjusting its output power to track maximum power point (MPP) of the PV array. The inverter has three MPPT channels (MPPT1, MPPT2, MPPT3). A maximum of six (6) string inputs can be connected to the inverter's DC input side. The three independent PV arrays can operate at different peak power points to capture the maximum possible energy. The inverter accommodates PV arrays with open circuit voltages up to 1100 VDC. Due to its transformer-less design it has no galvanic isolation.

Figure 2 CL 33 block diagram



Key Specifications of the CL 33 Inverter

- CL 33 inverter: 36.3 kVA, 33 kW (1000 VDC systems)
- PV compatibility: Designed to work with 1100 V floating PV systems
- AC wiring output: 400 V, three-phase STAR or DELTA typ
- Operating MPPT voltage: 200 V–1000 V
- Full Power MPPT voltage: 550 V–850 V
- Over-panelling: supports high DC/AC over-panelling ratio (up to 1.5)
- Energy harvest (MPPT) efficiency: >99%
- Maximum power conversion efficiency: ~98.6%
- Power factor adjustment range: 0.8 capacitive to 0.8 inductive
- AC output current distortion: Low — (THD < 3%) @ nominal power
- Protection class: IP66 (electronics) protection class for installation in outdoor environments
- Operating temperature range: -30 to 60° C
- Inputs: six (6) string inputs with MC4 type connectors
- Modbus RS485 Loop-in Loop-out
- Firmware upgrade tools, such as the Insight Mobile App

- Integrated DC switch
- Built-in string monitoring
- Type 2 AC and Type 2 DC Surge Protection (SPD)
- Six (6) DC string inputs with MC4 type connectors (mating part supplied with inverter)

2 Decentralized Systems

What's in This Chapter?

PV System Modeling

Important aspects of PV system modeling are:

- Site
- Type of system
- Losses

PV Site

It is very important to interpret site conditions carefully and model the exact conditions in PV system design software. These conditions include, but are not limited to:

- shadow from surroundings
- ground slope
- layout boundary conditions
- rain water catchment areas
- PV module string arrangements
- shape of the layout
- obstacles (such as power lines, gas pipelines, rivers, and archaeological conditions)

Once all possible factors affecting the PV system design are listed and assessed, capacity of the selected PV installation site can be determined for further processing. Government agency permits and statutory clearances also depend on these factors. The cost of the land and overall PV system varies with respect to these conditions.

PV System

PV system installation can be grid tied, stand alone, or hybrid. It could be installed on a roof, car park, or facade, or it could be ground mounted. It may or may not have a tracking option installed.

Modeling of the system has to be planned using the most suitable option and must consider the main purpose of the installation.

Quantum and usage of generated electricity is a very important factor when deciding on the type of system. A good system design has high efficiency, flexibility, and a modular approach for faster and quicker installations. Large scale PV power plant design needs to carefully consider the response of the PV plant power output against dynamic conditions of the grid. Faster power curtailment or fault ride through capability of the inverter is important.

Selection of major components like PV modules, inverters, and mounting structures comprises most of the system modeling and design. These three components also affect the cost, output, and efficiency of the system.

A block of 990 kW (30 x 33) for ground mount solutions and 264 kW (8 x 33) for rooftop solutions can be configured and then multiplied several times to achieve the required capacity. A standard block is designed once for all respective components and repeated several times in the installation. This reduces the effort and time to design the complete solution and increases the flexibility and speed of construction. Manufacturing of components also becomes quicker as a standard block uses the available ratings of components and equipment. Ultimately, the overall design results in a solution that has been optimized from all perspectives.

Losses

Any PV system has two major types of losses; losses associated with meteorological factors and losses due to system components.

A carefully modeled PV system represents both types of loses accurately and realistically. PV system modelling should consider each aspect of the design and the components to simulate the scenario which represents the actual conditions very closely.

PV System Design Using CL 33 Inverters

For easy access, the CL 33 inverter's latest dataset and system component file (.OND file) is available with widely-used modeling software (PVsyst) and databases. These files are also available for download on the Schneider Electric solar web portal.

When designing standard blocks, consider the following points. This solutions guide will help you to design the DC and AC electrical components required for the balance of systems in a CL 33 inverter installation, based on these points.

- Overall system impedance (grid + transformer + cables) for parallel operation of inverters
- Voltage drop between inverter and point of connection (POC) to the grid
- Inverter's response time to grid instability or faults (Active and Reactive power curtailments and Low Voltage Ride Through (LVRT))
- Design of control and monitoring architecture

Both rooftop and ground mount systems can be modeled and designed using standard system blocks comprised of CL 33 inverters and user-defined PV modules and mounting solutions.

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Building Blocks of a Decentralized PV System

For a modular design approach, we recommend the following solution bricks or building blocks to design a decentralized PV power plant using CL 33 inverters.

Brick	Description	Supplier	Model
Inverters	CL 33	Schneider Electric	PVSCL33E
AC switch box (optional)	AC circuit breaker / switch	Schneider Electric	INS63Switch Disconnect
	Surge protection device	Schneider Electric	iPRD40 series
	Terminal blocks	Schneider Electric	Linergy-NSYTRV
	Enclosure	Third-party	---
AC combiner box (5 inputs)	AC circuit breaker (MCB)	Schneider Electric	iC60, iC120, NG125N-63A, Curve C ,4P (25kA) CB
	Terminal blocks	Schneider Electric	Linergy-NSYTRV
	Main bus bar	Third-party	Copper, 400V, 25kA
	AC disconnect switch	Schneider Electric	INS320-320A type switch-disconnect.4P
	Grounding terminal and bus	Third-party	---
	Surge protection device	Schneider Electric	At Main Bus - iPRD40r
	Enclosure	Either	---
AC re-combiner box (6 inputs)	AC circuit breaker (MCCB)	Schneider Electric	Compact NSX400N- 320A with Micrologic 1.3, 3P
	Terminal blocks	Schneider Electric	Linergy-NSYTRV
	Main bus bar	Third-party	Copper, 400V, 70kA
	AC air circuit breaker	Schneider Electric	NW25H1 - ACB
	Grounding terminal and bus	Third-party	---
	Surge protection device (optional)	Schneider Electric	iPRD 40r
	Enclosure	Schneider Electric or third-party	---
Transformer	LV-MV Dyn11 oil cooled / dry type transformer	Schneider Electric	1100kVA, oil immersed or dry type, Z < 6%, 20000V/400V, Dyn11
MV ring main system	MV RM6 or Flusarc type switchgear units	Schneider Electric	RM6 NE-IDI or Flusarc CB-C, 24kV, 16kA
DC solar PV cables	DC UV protected cables	Third-party	---
AC cables	AC LV and MV cables	Third-party	---
Communication and monitoring system	Monitoring and control	Schneider Electric	Schneider Electric options, such as Conext Gateway .
Earthing system	Bonding cable Clamps and Connectors	Third-party	---

Inverter Positioning and Location

DANGER

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PV system design and efficiency with CL 33 PV inverters are most effected by the location of inverter in the complete solution. Balance of system components and inverter wiring box models are variable depending on the location of the inverters and the length of power cables connecting them with AC combiners and re-combiners.

Four types of standard design blocks fit almost all types of installations. Each option has advantages and disadvantages with respect to other installations, but for each instance listed below, the respective option serves the purpose in most efficient manner.

Option 1

Inverters located on the PV field, electrically grouped in an AC combiner box on the field – Inverters mounted on the PV panel structures and intermediate AC paralleling

Option 2

Inverters grouped on the PV field by clusters “electrically” grouped in an AC combiner box on the field – Inverters mounted on dedicated structures connected to intermediate AC combiners

Option 3

Inverters spread on the field – Inverters mounted on PV panel structures and AC paralleling in MV stations

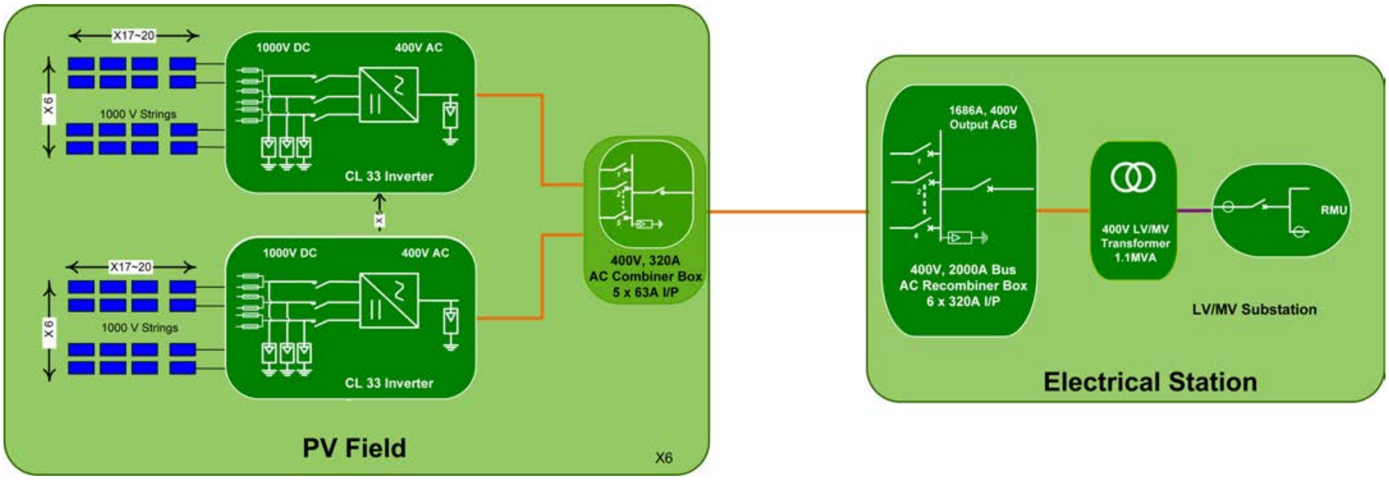
Option 4

DC distribution – Inverters close to an LV/MV substation on a dedicated structure and AC paralleling in an LV/MV substation

Option 1 – Inverters installed next to PV modules with first level AC Combiners

Inverters located on the PV field, electrically grouped in an AC combiner box on the field – Inverters mounted on the PV panel structures and intermediate AC paralleling.

Figure 3 Option 1: Standard block diagram



Advantages

- Shorter DC string cables
- Reduced DC I^2R losses
- High flexibility for layout design
- No need for a dedicated structure for inverter mounting
- Inverters close to PV modules, reducing the live portion of the system during a fault
- Covers most of the usable space within boundary
- Schneider Electric iC60 type NG125 type of breakers can be used in AC combiners – up to five inverters

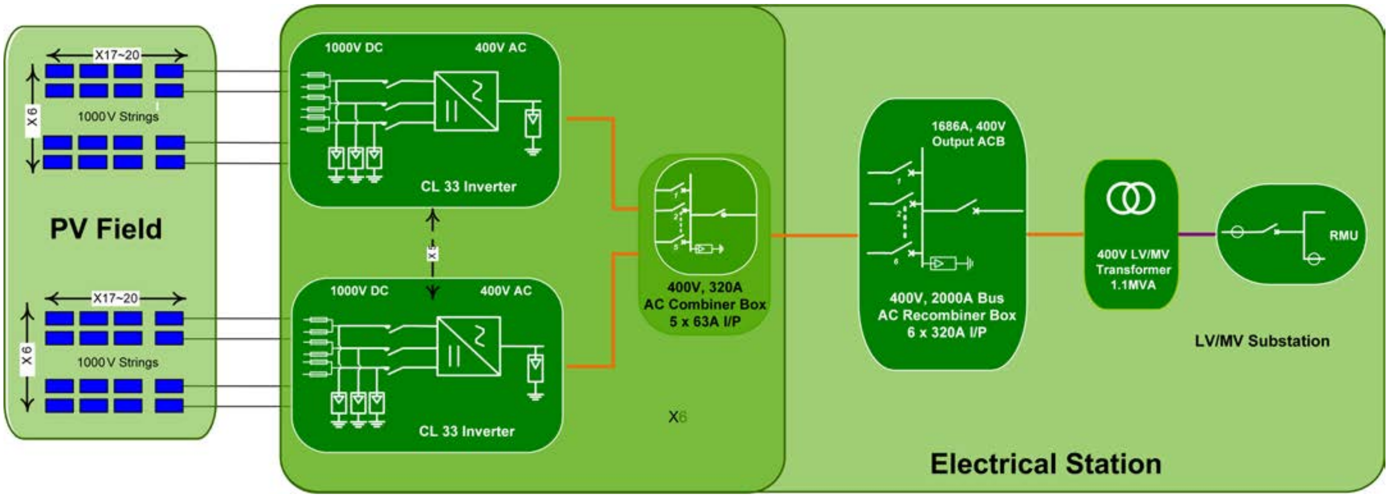
Disadvantages

- Requires an external AC switch immediately after the inverter
- Longer AC cables from the inverter to the first level of AC combiners
- Higher AC cable losses

Option 2 – Inverters installed next to AC combiner groups

Inverters grouped on the PV field by clusters “electrically” grouped in an AC combiner box on the field – Inverters mounted on dedicated structures connected to intermediate AC combiners.

Figure 4 Option 2: Standard block diagram



Advantages

- Shorter AC cables
- AC switch and external AC Surge Protection Device (SPD) not required if included in the AC combiner box
- Schneider Electric NG125 type of breakers can be used in AC combiners – up to five inverters

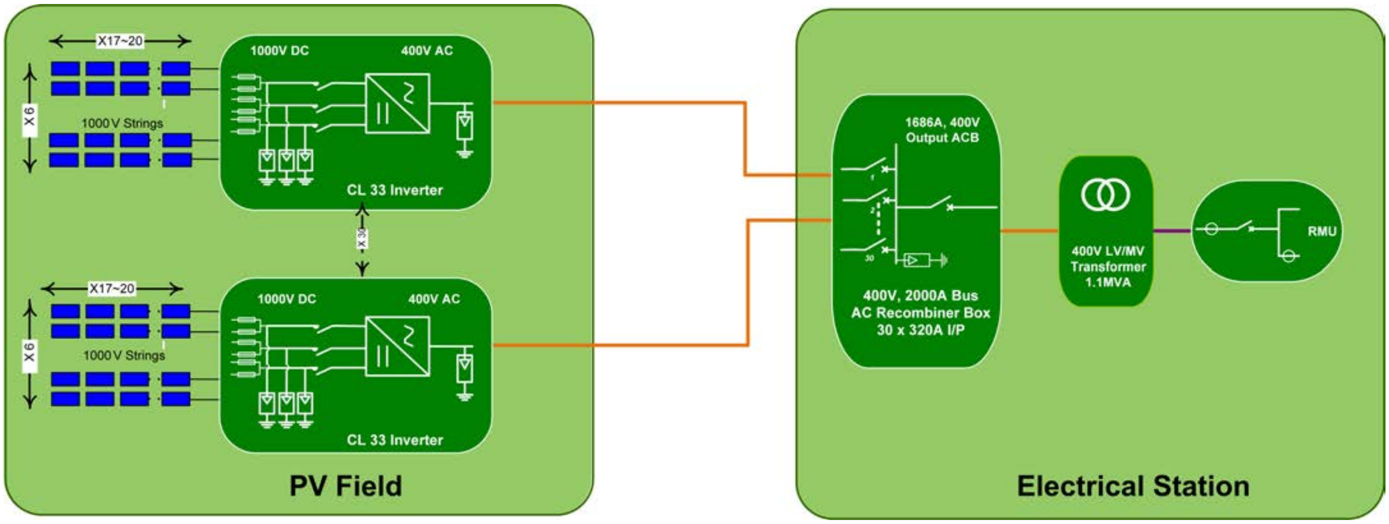
Disadvantages

- Longer DC string length might need higher size (cross section) of DC cable
- Dedicated mounting structures required for inverter and AC combiner mounting
- Higher DC cable losses
- Use of an RCD is probable

Option 3 – Inverters installed next to PV modules without first-level AC combiners

Inverters spread on the field – Inverters mounted on PV panel structures and AC paralleling in MV stations.

Figure 5 Option 3: Standard block diagram



Advantages

- Shorter DC string cables
- Reduced DC I^2R losses
- High flexibility for layout design
- No need for a dedicated structure for inverter mounting
- Inverters close to PV modules, reducing the live portion of the system during a fault
- Covers most of the usable space within boundary
- First level AC combiners eliminated resulting in cost savings

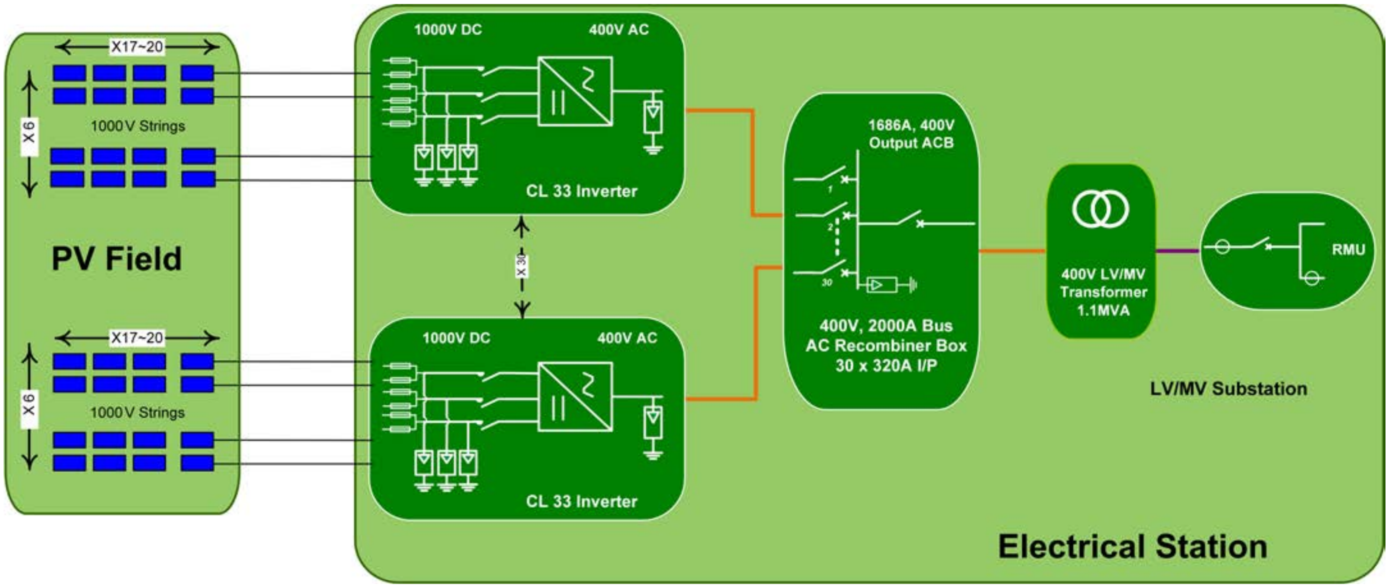
Disadvantages

- Requires an external AC switch immediately after the inverter
- Longer AC cables from inverter to AC combiners
- High AC cable losses
- Increased size of AC cable will require higher size of terminal blocks in external AC combiner boxes
- Use of an RCD is probable

Option 4 – Inverters installed next to LV/MV transformer

DC distribution – Inverters close to an LV/MV substation on a dedicated structure and AC paralleling in an LV/MV substation.

Figure 6 Option 4: Standard block diagram



Advantages

- Shorter AC cables
- High flexibility for layout design
- AC switch and AC SPD not required if included in AC combiner box
- Easy access to inverters for service and maintenance
- RCD not required

Disadvantages

- Longer DC string cables might require higher size of DC cable
- External DC switch box with SPD required to protect long DC strings
- Combining DC strings might lose the benefit of separate MPPT
- Dedicated structures required for inverter and AC combiner mounting at MV station
- Higher DC cable losses

3 System Design

What's in This Chapter?

DC System Design

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DC system design is comprised of:

- module and inverter technology assessment
- string sizing
- arrangement and interconnection of strings
- string cable sizing and length management
- DC combiner box sizing, if required
- string / array cable sizing
- routing up to the inverter's terminal

Out of the listed tasks, string sizing is the most important one as many other decisions depend on it, such as type and size of module mounting tables, interconnection arrangements, and cable routing.

String and Array Sizing Rules

To calculate string size:

1. Gather the following technical information:
   a. From the PV modules, find the following data:
      - Model of PV module to include
      - Maximum open circuit voltage V_{oc}
      - Maximum array short circuit current I_{sc}
      - Maximum power point voltage V_{mpp} and current I_{mpp}
      - Temperature coefficients for Power, Voltage, and Current
   b. From the inverter, find the following data:
      - Full power MPPT voltage range (550 V–850 V)
      - Operating voltage range (200 V–1000 V)
      - Maximum open circuit input voltage (1100 V)
      - Absolute Maximum short circuit current (120 A / 20 A per string)

c. From the available weather data, find the following data:
   - Highest and lowest temperature at the location of installation.
   - Typical meteorological year (TMY) or meteorological (MET) data set for location

2. Understand and follow the rules of string sizing:
   a. Series connected Modules should not have open circuit voltage higher than the maximum V_{oc} limit (1100 V)of the inverter.
   Number of modules per string x V_{oc} (at $t°_{min}$) < inverter V_{max}
   b. Combined short circuit current of all parallel connected strings should not be higher than the short circuit current rating of inverter (i.e. 120 A). This should include any derating as required by local codes for defining maximum I_{sc}.
   I_{sc} strings < inverter I_{max}
   c. Series connected modules should not have open circuit voltage lower than the lower limit of MPPT voltage range of inverter (550 V).
   Number of modules per string x V_{mp} (at $t°_{max}$) > inverter V_{min}

3. Calculate the minimum number of PV modules in series.
4. Calculate the maximum number of PV modules in series.
5. Calculate the total number of strings in parallel.

Use Case Example

Definitions

Ns_{min} = Minimum number of PV modules in series

V_{min} = Minimum voltage for maximum power point tracking

V_{oc} = Open circuit voltage of the PV panels

V_{minr} = Voltage at maximum power point in the month of maximum temperature

φ = Coefficient of variation of voltage with temperature

V_{mpp} = Voltage at the point of maximum power

T_c = Temperaure of the cell (average)

T_{amb} = Ambient temperature

I_{inc} = Incident radiation (maximum annual average)

NOCT = Nominal operation call temperature

I_{sc} = Short circuit of the module at STC

STC = Standard Test Conditions (STC) for measurement

PV Module: A typical 315 W_p Poly crystalline PV module

Inverter: CL 33 - 33 kW inverter

Weather conditions: Maximum high temperature 36 ºC, minimum low temperature -5 ºC

	$\Delta V_{oc}/T$ (φ)	V_{mpp}	V_{mpp} (70 ºC)	V_{oc}
$315W_p$ Poly-crystalline, 6 inch PV Module	-0.31	36.6	31.49	45.1

	V_{mpp} Min (full power)	V_{oc}	I_{sc}
CL 33 inverter	550 VDC	1100 VDC	20 ADC/string

STC conditions define the irradiation conditions and temperature of the solar cell, widely used to characterize the cells, PV modules and solar generators and defined as follows:

- Irradiance : 1,000 W/m^2
- Spectral distribution : Air Mass 1.5 G
- Cell temperature : 25 º C

NOCT conditions define the irradiation conditions and temperature of the solar cell, widely used to characterize the cells, PV Modules and solar generators and defined as follows:

- Irradiance : 800 W/m^2
- Spectral distribution : Air Mass 1.5 G
- Cell temperature : 20 º C
- Wind speed : 1 m/s

Minimum number of PV modules

CL 33 has a start up voltage of 250 V and an operating MPPT window from 550 V to 850 V. The minimum number of modules per PV string is important to ensure that 550 V remains the output voltage and the inverter gets early start up as often as possible.

The following calculations assume a high temperature of 36 ºC.

To determine the temperature of the cell in any situation, the following formula can be used.

$$T_c = T_{amb} + (I_{inc}\ (w/m^2) * (NOCT–20) / 800)$$

$$T_c = 36\ ºC + ((1000) * (47 – 20) / 800)) = 70\ ºC$$

To determine the temperature of the cell at STC, we use:

$$T = T_c - T_{stc}$$

$$T = 70\ ºC - 25\ ºC = 45\ ºC$$

To calculate the V_{mpp} of the module at the maximum temperature 70 ºC

$$V_{mpp}= V_{mpp\ (25\ ºC)} – (T \times V_{mpp\ (25\ ºC)} \times Ø / \text{Irradiance STC}))$$

$$V_{mpp}= 36.60\ V – (45 \times (36.60\ V \times 0.31\% / 1000)) = 31.49\ V\ @\ 70\ ºC$$

With this data we can calculate the minimum number of PV modules to be connected in series, to maintain full nameplate power

$$N_{s\ min} = (V_{min} / V_{mpp\ min})$$

$$N_{s\ min} = (550 / 31.49) = 17.46$$

Rounding it down, the answer is 17. This is the minimum amount of PV modules to be placed in series with each string to help ensure that the inverter functions at 1000 W/m^2 and 36 °C ambient temperature.

Maximum number of PV Modules

The maximum number of PV modules in a string for the CL 33 inverter is a ratio of the highest system voltage to the maximum open circuit voltage at the lowest temperature.

The following calculations assume a low temperature of -25 ºC.

For a list of definitions of terms used in the calculations, see *Definitions on page 33*.

To calculate the temperature needed for V_{oc} at - 5ºC:

$T = T_{amb} - T_{stc}$

T = - 5ºC - 25 ºC = - 30 ºC

To calculate the V_{oc}(of the module at minimum temperature - 5ºC.

$V_{oc\,(-5ºC)} = V_{oc\,(-25ºC)} – (T \times V_{oc\,(-25ºC)} \times Ø))$

$V_{oc\,(-5ºC)}$= 45.1 V – (- 30 x (45.1 V x 0.31% / 100)) = 49.29 V @ - 5ºC

With this data we can calculate the maximum number of PV Modules to be connected in series, to maintain full nameplate power.

$N_{s\,max} = (V_{max} / V_{max})r$

$N_{s\,min}$ = (1000 / 49.29 V) =20.28

Rounding it down, the answer will be 20. This is the maximum amount of PV modules to be placed in series with each string to ensure the functioning of the inverter at 1000 W/m^2 and -- 5ºC ambient temperature.

Number of strings in parallel

The maximum number of strings installed in parallel and connected to CL 33 inverters, will be calculated.

Limitation: Inverter can connect with up to 6 strings

Number of Strings = I_{sc} Inverter max / (I_{sc})

Max. # of parallel strings = 120 A/ 9.08 A = 13.2 strings

Rounding it down, the answer will be 13 strings.

Since we have physical connection limit of 6, we can use the maximum number of strings.

Table 1 Example of highest string sizing ratios

PV module type and rating	Mono Crystalline 275 W	Poly Crystalline 315 W
PV module series number	23	20
# of parallel strings	6	6
Total DC power	37950 W	37800 W
Inverter rated power	33000 W	33000 W
DC/AC ratio limit	1.15	1.15

Optimum DC-AC ratio

DC Ratio is based on STC conditions, but does not take into account the specific configuration of the project. The performance is a function of location and racking style. A highly optimized system, such as a 2-Axis tracker, will have a much higher performance advantage compared to a 5-degree fix tilt, for example. Likewise, a strong solar irradiance region will have a much higher energy potential than a weaker region. The amount of clipping losses will be based on the amount of relevant energy available vs. the inverter nameplate. As clipping exceeds 3%, there may be diminishing value to higher levels of DC Ratio.

Table 2 CL 33 inverter suggested DC oversizing range

Shallow Fix tilt (roof mount applications)	1.30 – 1.40
Steep Fix tilt (ground mount applications)	1.25 – 1.35
1-Axis Tracked (ground mount applications)	1.20 – 1.30
2-Axis Tracked (ground mount applications)	1.10 – 1.20

Schneider Electric recommends a maximum oversizing limit of 1.5. Higher DC ratios will require review by a Schneider Electric applications engineer.

Note: The CL 33 inverter is a fuse-less design. The PV input of the inverter would need external in-line fuse protection if it is required by country compliance standards. Designers and installers must consider this in preliminary design.

An inline fuse connector from third party sources can be used for CL 33 inverters, as shown in the Figure.

Recommended Basic Rules for String Formation

- Select an EVEN number for modules in a string to have simpler string interconnectivity over mounting structures.
- Try to maximize modules per string within V_{oc} and V_{mpp} limits of the inverter.
- The string formation should be designed in a way that cable management at the back of modules could be followed according to electrical installation rules using the shortest string cable length and minimum bends.
- Support the connectors and avoid a sharp bend from the PV module cable box.

NOTICE
HAZARD OF WIRING DAMAGE
Do not route cables such that they make a sharp bend as this can damage the wire's integrity.
Failure to follow these instructions can result in equipment damage.

- If possible, keep the PV module strings connected and formed in horizontal lines to avoid row shadow impact on all strings in each wing of racks or trackers.
- Follow the instructions of the PV module manufacturer to select portrait or landscape position of modules.
- Do not combine separate ratings of PV modules in one string.
- The CL 33 inverter is a transformer-less inverter, so none of the PV inputs can be used with grounded arrays. This inverter is designed only for use with floating/ungrounded arrays.

WARNING
HAZARD OF ELECTRIC SHOCK, EXPLOSION, ARC FLASH, AND FIRE
The CL 33 inverter must be only used with floating/ungrounded arrays.
Failure to follow these instructions can result in death, serious injury, or equipment damage.

Thin-Film modules designed to operate with floating arrays could be connected with the CL 33 inverter.

AC System Design

DANGER

HAZARD OF ELECTRIC SHOCK AND FIRE

Installation, including wiring, must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes, including relevant local, regional, and national regulations. Installation instructions are not covered in this Solutions Guide, but are included in the relevant product manuals for the CL 33 inverter. Those instructions are provided for use by qualified installers only.

Failure to follow these instructions will result in death or serious injury.

The AC system of a PV plant consists of an AC switch box (optional), AC combiner box, AC re-combiner box, AC cables, trenches, LV-MV transformer, ring main units at MV stations in the PV field, MV cable circuit, and MV station at the grid box.

AC low voltage circuits with high amounts of power need extreme care to achieve reliability, safety, and the highest level of system availability. Selection of circuit breakers (MCB and MCCBs), disconnect switches, protection devices and cables is key to achieving all three objectives.

Safety and availability of energy are the designer's prime requirements. Coordination of protection devices ensures these needs are met at optimized cost.

Implementation of these protection devices must allow for:

- statutory aspects, particularly relating to the safety of people
- technical and economic requirements

The chosen switchgear must:

- withstand and eliminate faults at optimized cost with respect to the necessary performance
- limit a fault's effect to the smallest part of the installation in order to ensure continuity of supply.

Achievement of these objectives requires coordination of protection device performance, necessary for:

- managing safety and increasing durability of the installation by limiting stresses
- managing availability by eliminating the fault by means of the circuit breaker immediately upstream.

The circuit breaker coordination means are:

- Cascading
- Discrimination

If the insulation fault is specifically dealt with by earth leakage protection devices, discrimination of the residual current devices (RCDs) must also be guaranteed.

Circuit Breaker Coordination

The term "coordination" concerns the behavior of two devices placed in series in electrical power distribution in the presence of a short circuit.

Cascading or back-up protection

This consists of installing an upstream circuit breaker D1 to help a downstream circuit breaker D2 to break short-circuit currents greater than its ultimate breaking capacity Icu D2. This value is marked Icu D2+D1.

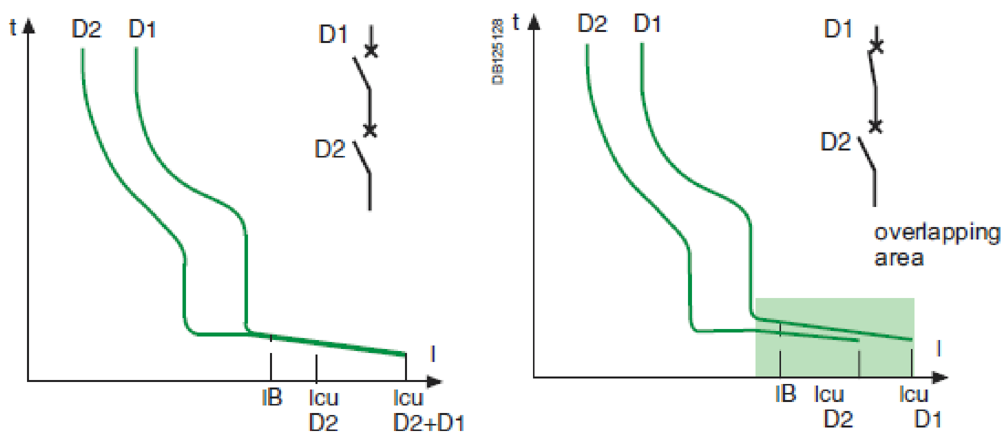
Standard IEC 60947-2 recognizes cascading between two circuit breakers. For critical points, where tripping curves overlap, cascading must be verified by tests.

Discrimination

This consists of providing coordination between the operating characteristics of circuit breakers placed in series so that, should a downstream fault occur, only the circuit breaker placed immediately upstream of the fault will trip.

Standard IEC 60947-2 defines a current value (Is) known as the discrimination limit such that if the fault current is less than the Is value, only the downstream circuit breaker D2 trips; if the fault current is greater than the Is value, both circuit breakers D1 and D2 trip. See *Table 3* for more information. Just as for cascading, discrimination must be verified by tests for critical points.

Figure 7 Summary information



Glossary:

- Isc(D1): Short-circuit current **at the point where D1** is installed
- IcuD1: Ultimate breaking capacity **of** D1.

Table 3 Discrimination data (IEC 60947-2)

	MSB Level A	Subdistribution switchboard Level B	Final distribution switchboard Level C
Switchboard data			
Nominal I	1000 to 6300 A	100 to 1000 A	1 to 100 A
Isc	50 kA to 150 kA	20 kA to 100 kA	3 kA to 10 kA
Thermal withstand Icw / EDW	***	*	* W
Continuity of supply	***	***	**
Circuit-breaker type	High current power circuit-breaker or moulded case circuit-breaker	Moulded case circuit-breaker	Miniature circuit-breaker
			
Standard IEC 60947-2	■	■	■ (1)
Trip unit			
Thermal magnetic electronic	 ■	□ (2) ■	 ■
Product data			
Standard In	800 to 6300 A	100 to 630 A	1 to 125 A
Icn	50 kA to 150 kA	25 kA to 150 kA	3 kA to 25 kA
Utilisation category	B	A	A
Limiting capacity	* (3)	***	***

■ **recommended or compulsory**
□ **possible**
*** **important**
** **normal**
* **not very important**

(1) For domestic use as per IEC 60898 standard.
(2) Possible up to 250 A.
(3) Le Sizing of the switchboard at level A means that this characteristic is not very important for standard applications.

Note: Discrimination and cascading can only be guaranteed by the circuit breaker manufacturer.

Installation standard IEC 60364 governs electrical installations of buildings. National standards, based on this IEC standard, recommend good coordination between the protection switchgear. They acknowledge the principles of cascading and discrimination of circuit breakers based on product standard IEC 60947-2.

For more details on Limitation, Cascading and Discrimination of circuit breakers refer to *Schneider Electric's Low Voltage Expert Guide No.5 – "Coordination of LV protection devices".*

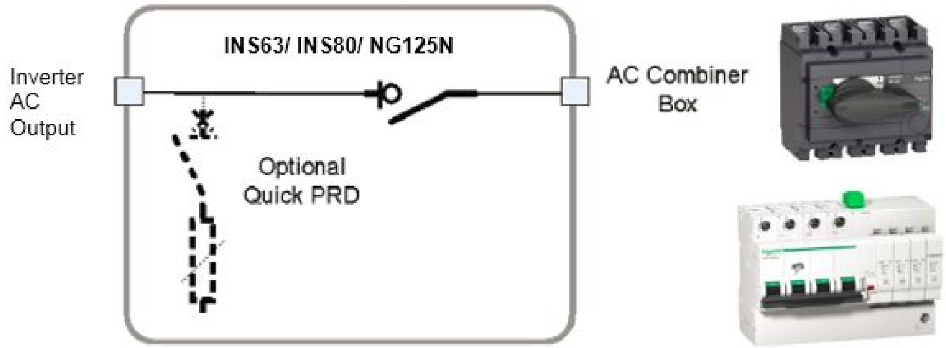
AC System Component Design

There are many components that may be used, depending on the configuration.

AC Switch Box (optional)

An AC switch box should be installed on the CL 33 inverter AC terminals, depending on the distance from the first AC combiner. *Table 4* lists the component part numbers for an AC switch box.

Figure 8 Optional AC switch box diagram



Function

The INS63/ INS80/ NG125N/ Acti 9 iC60 disconnects the inverter from the AC Combiner.

The IQuick PRD40r helps protect the inverter against voltage surges coming from AC lines.

Typical Use

1. The AC switch box is optional, but is necessary when:
   - The distance or an obstacle between the inverter and the AC combiner box prevents the safe disconnection of the inverters at the AC combiner box level
2. The AC switch box is located near the inverter and usually needs to be installed in an outdoor enclosure.
3. The AC switch box is used when there are long distances between the inverter and the AC combiner box.
4. You can increase the cross-section of the cables to reduce AC losses, for example:
   - If the cross-section area of the output cable is higher than 35 mm^2 (maximum cross-section of the cables at the AC terminal of the inverter), an AC switch box could be helpful to host higher-sized cable between the AC Combiner and the inverter.

Advantages of the Offer

1. There are two possible configurations of the AC box:
   - with surge protection
   - without surge protection

2. You can increase the cross-section of the cables to reduce AC losses - output cable terminals up to 70 mm^2. Up to 35 mm^2 can be directly connected to the upstream breaker (NG125). Larger cable sizes would need separate terminal blocks in the AC combiner and in the AC switch box, if required, due to high voltage drop.
3. Range for 33 kW (36.3 kVA).
4. There are two models:
   - ACSB01 with switch-disconnect only
   - ACSB02 with switch-disconnect and surge voltage protection

Table 4 Components needed for AC switch box configuration

Components	Model	Reference No.
AC switch	INS63, 4P	28902
Surge protection device	I Quick PRD40r	A9L16294
Enclosure	Thalassa PLS modular 12 for ACSB01 Thalassa PLS modular 24 for ACSB02	NSYPLS1827PLS12 NSYPLS2227DLS24

AC Cable Sizing

The output terminal block of CL 33 inverters can host up to 35 mm^2 copper or aluminum cable. Recommended cable types are four core for L1, L2, L3 and N and five core for additional PE connections.

AC cable sizing calculations must consider ampacity, voltage drop, short circuit calculation, and thermal de-rating of AC cables.

Total power loss due to AC cables must be designed to be <1%. To achieve this level, it is important to select a suitable cable size with the required ampacity, short circuit rating, voltage grade, and with low voltage drop.

Formulae commonly used to calculate voltage drop in a given circuit per kilometer of length.

$$\Delta U = \sqrt{3} I_B (R \cos\phi + X \sin\phi) L$$

$$\%Vd = \frac{100\Delta U}{Un}$$

Where:

X = inductive reactance of a conductor in Ω / km

Ø = phase angle between voltage and current in the circuit

I_B = full load current in amps

L = length of the cable in km

R = resistance of the cable conductor in Ω / km

X = inductive reactance of a conductor in Ω / km

U_n = phase-to-phase voltage

V_d = voltage drop

V_n = phase-to-neutral voltage

AC cable sizes between CL 33 inverters and AC combiner boxes will mostly depend on the distance between them. The maximum output current of the CL 33 inverter is 55.2 A and considering the de-rating factors due to cable laying methodology and thermal derating due to conduits, 35 mm^2 4 core AL cables are suitable in most instances.

The following table provides recommended maximum cable lengths from inverter to AC distribution box. We recommend that the installer or system designer performs a detailed cable sizing calculation for each inverter in order to calculate the power loss associated with suggested cables sizes.

Table 5 AC cable length and size

AC Cable Length	AC Cable Size (mm^2)A
1–50 m	35
50–100 m	55
>100 m	70 or higher

It is essential to calculate and consider the correct fault level on each combiner bus level in order to select the right size of cable, MCB, MCCB, RCD, surge protection and disconnect devices.

Use the following methodology to calculate cable sizing:

If the AC cable length exceeds 10 m (32.8 ft), the use of an AC switch box closer to the inverter is recommended. This switchbox can be used to connect an AC output cable higher than 35 mm^2, if required, to avoid voltage drop.

It is very important to consider both resistive and reactive components of voltage drop when calculating cable sizing. The reactive component of cable impedance plays an essential role in the parallel operation of inverters. The target should be to reduce the reactive impedance as much as possible to increase the number of parallel connected inverters at the LV winding of the transformer (considering intermediate AC distribution boxes).

AC Combiner Box

An AC combiner box is the first level of combiners, commonly located in the PV field in large utility scale projects. AC combiner boxes house the first level protection for inverters on the AC side .

Function

- Combines AC currents coming from several inverters
- Isolates the combiner box from the AC line
- Output - circuit breaker
- Circuit breaker (according to prospective current)

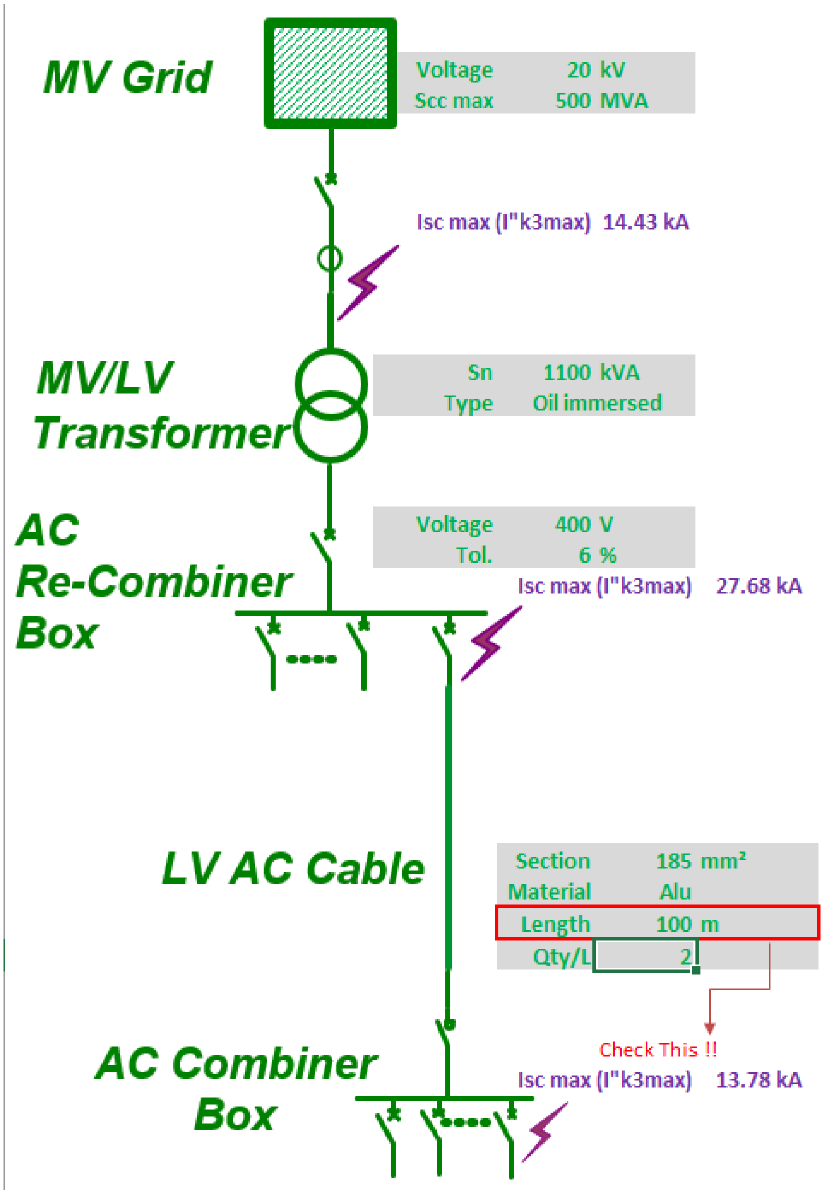
- Protects inverters against voltage surges from the AC line
- iPRD range for surge protection

Typical use

- The AC combiner box is located near the inverters.
- Use an AC combiner box when there is a long distance between the AC combiner box and the AC distribution box.
- The AC combiner box requires high cross-section terminals for output cabling.

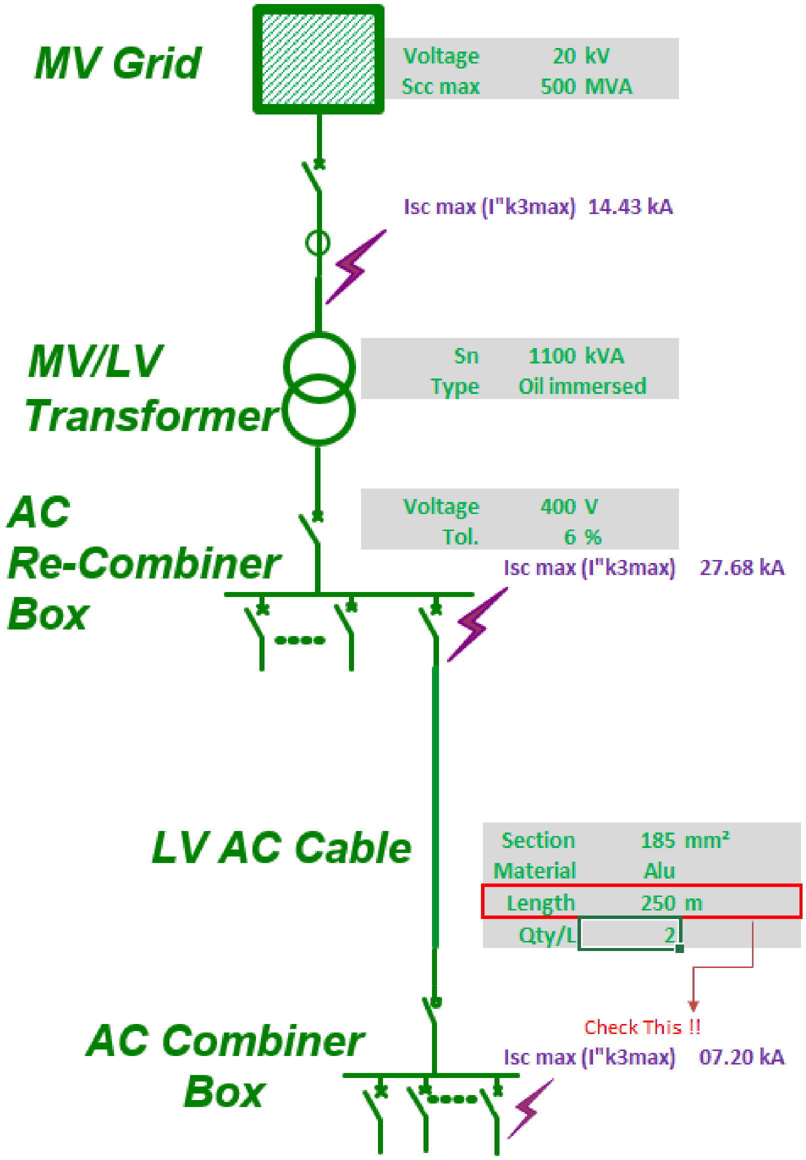
Depending on the number of inverters being combined at the AC combiner's busbar, the incoming lines can be protected using MCBs or MCCBs. Selection of this component depends on the rated circuit current, expected fault current, fault clearing time, and remote operation requirements. Length of the cable connected between the AC combiner output and the AC re-combiner input plays an important role as a longer cable length reduces the amount of fault current to break. See the following example circuit.

Figure 9 Example circuit with 100 m cable



The example circuit in *Figure 9* has 100 m length from the AC combiner to the AC re-combiner. The resulting fault level at the AC combiner bus bar is 13.78 kA and the choice of breaker is NG125N MCCB (25 kA).

Figure 10 Example circuit with 250 m cable



The example circuit in *Figure 10* has a 250 m length from the AC combiner to the AC re-combiner, and the fault current is reduced to 7.20 kA, allowing the selection of C120H MCB with 15 kA fault level.

Methodology to calculate the fault level at AC combiner bus bar

Example:

- The combiner box is connected to a re-combiner box via a 250 m, 185 mm^2 size aluminum cable
- The re-combiner box connects to a 1100 kVA 20 kV/400 V, 6% transformer

Fault level at the AC combiner bus bar = Voltage x Voltage correction factor C/ Fault impedance

$$= 400 \times 1.05 / (Z_{grid} + Z_{TR\text{-}LV} + Z_{cable})^* \sqrt{3}$$

$$= 400 \times 1.05 / \{ (R_{grid} + R_{TR\text{-}LV} + R_{cable})2 + (X_{grid} + X_{TR\text{-}LV} + X_{cable})2 \}1/2^* \sqrt{3}$$

First, calculate MV impedance:

$Z_{MV-GRID}$ = c x V^2/S_{CC} =1.1 x $20000^2/(500 \times 10^6)$ =0.88 Ω

In the case of high-voltage feeders with nominal voltages above 35 kV fed by overhead lines, the equivalent impedance Z_Q may in many cases be considered as a reactance, i.e. Z_Q=0 + jX_Q. In other cases, if no accurate value is knows for the resistance R_Q of network feeders, one may substitute R_Q=0.1 X_Q where X_Q=0.995 Z_Q.

$X_{MV\text{-}GRID}$ = .995 x 0.88=0.08788 Ω

$R_{MV\text{-}GRID}$ = Sqrt($Z_{MV-GRID}^2$- $X_{MV\text{-}GRID}^2$)=0.08756 Ω

Then, calculate Grid LV impedance from Grid MV values:

$X_{LV-GRID}$= $X_{MV-GRID}(V_{LV}^2/V_{MV}^2)$ = 3.5024 x 10^{-4} Ω;

$R_{LV-GRID}$= $R_{MV-GRID}(V_{LV}^2/V_{MV}^2)$ = 3. 5136 x 10^{-5} Ω;

We calculate the transformer LV Impedance for a 1100 KVA, 20 kV / 400 V transformer with the following details:

- Voltage factor c=1.05
- Short circuit impedance= 6%
- Load loss of 13000 W (copper losses)
- Short circuit power from grid: 500 MVA

Before calculating the transformer LV impedance, it is important to know the

following definitions:

C_{max} = voltage factor for calculating the maximum short circuit current

I_{rT} = rated current of the transformer on the low or high voltage side

K_T = impedance correction factor

A network transformer connects two or more networks at different voltages. For two winding transformers this impedance correction factor should be used when calculating the short circuit impedance.

P_{krT} = total loss in the transformer windings at the rated current

S_{rT} = rated apparent power of the transformer

U_{kr} = short circuit voltage at the rated current

U_{rT} = rated voltage of the transformer on the low or high voltage side

x_t = relative reactance of transformer

$X_{TR\text{-}LV}$ = LV winding reactance of the transformer

Z_T = transformer LV impedance

Before calculating the transformer LV impedance, calculate K_t and X_T using C_{max}.

Table 6 Voltage factor c

	Voltage factor c for the calculation of:	
Nominal voltage (U_n)	**maximum short-circuit currents c_{max}**[1]	**minimum short-circuit currents c_{min}**
Low voltage 100 V to 1000 V (IEC 60038)	1.05[2] 1.10[3]	0.95
Medium voltage >1 kV to 35 kV (IEC 60038)	1.10	1.00
High voltage[4] >35 kV (IEC 60038)	1.10	1.00

Impedance Correction Factor:

$$K_T = 0{,}95 \frac{c_{max}}{1+0{,}6\,x_T}$$

Transformer LV impedance $Z_{TR\text{-}LV}$

$$Z_T = \frac{u_{kr}}{100\,\%} \cdot \frac{U_{rT}^2}{S_{rT}}$$

$= K_T$ x 400 x 400 x 0.06/1100 x 1000

= 0.008407 Ohms

Where, K_T = 0.96328045

$R_{TR\text{-}LV}$

$$R_T = \frac{u_{kr}}{100\,\%} \cdot \frac{U_{rT}^2}{S_{rT}} = \frac{P_{krT}}{3 I_{rT}^2}$$

$= K_T$ x Losses kW / 3 x (Rated Current)^2

$= K_T$ x 13000 / 3x (1100 x 1000/(sqrt(3) x 400))^2

= 0.001655 Ohms

Note: Rated current = Number of inverters x Per inverter output current

$X_{TR\text{-}LV} = K_T$ x Sqrt(Z^2-R^2) = 0.008242 Ohms

[1] $C_{max}U_n$ should not exceed the highest voltage U_m for equipment of power systems

[2] For low voltage systems with a tolerance of +6%, for example systems renamed from 380 V to 400 V

[3] For low voltage systems with a tolerance of +10%

[4] If no nominal voltage is defined $c_{max}U_n = U_m$ or $c_{min}U_n$ = 0.90 x Um should be applied

$$X_T = \sqrt{Z_T^2 - R_T^2}$$

Cable Impedance :

Z_{cable} = Sqrt (R_{cable}^2 + X_{cable}^2)

185	mm^2 Cable
R (Ohms/km)	0.2091
X (Ohms/km)	0.08267
Length	250
Runs	2
Type	ALU

R_{cable} = Resistance @ 90°C x length / (runs x 1000)= 0.02613 Ohms

X_{cable} = Reactance x length / (runs x 1000) = 0.01033 Ohms

Fault level at AC combiner bus bar

= Voltage x Voltage correction factor C/ Fault impedance

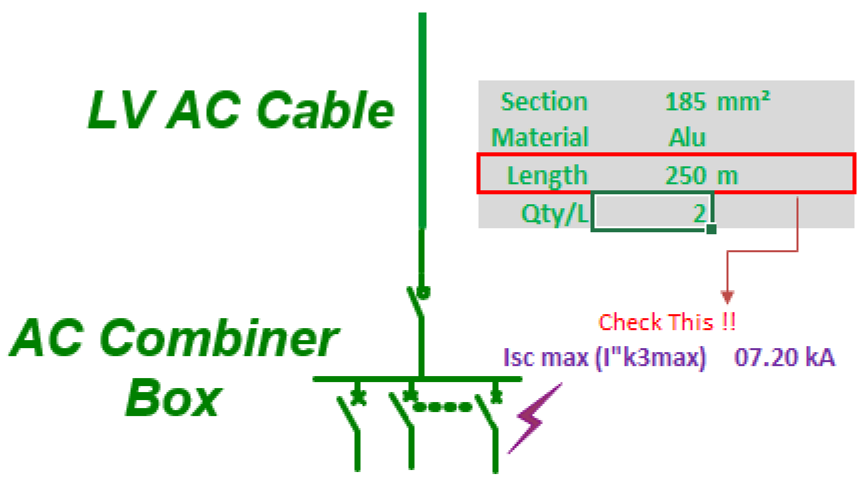
= 400 x 1.05 / { (R_{LVgrid}+R_{TR-LV}+ R_{cable})^2+ (X_{LVgrid}+X_{TR-LV} +X_{cable})^2 }$^{1/2}$ x √3

= 400 x 1.05 / { 0.02782^2 + 0.01892^2 }$^{1/2}$ x √3

= 7.20 kA

Selected circuit breaker for AC combiner inputs:

For this scenario, the following is the recommended circuit breakers with calculated fault current.



The example above results in around 7.20 kA. Generally, we see the fault level on AC Combiner buses within the range of 10 to 20 kA. For this application, we recommend using breakers in the NG125N category or higher to help ensure a minimum of 25 kA fault current rating at the AC combiner level.

Table 7 NG125N specifications

Device short name	NG125N
Poles description	4P
[I_n] rated current	63 A at 40 °C
Network type	AC
Trip unit technology	Thermal-magnetic
Curve code	C
Breaking capacity	25 kA
Utilization category	Category A
Suitability for isolation	Yes
Network frequency	50/60 Hz
Magnetic tripping limit	8 x In
[I_{cs}] rated service breaking capacity	18.75 kA 75 % x I_{cu}
[U_i] rated insulation voltage	690 V AC
[U_{imp}] rated impulse withstand voltage	8 kV
Contact position indicator	Yes

Selected Switch Disconnect for AC Combiner outputs:

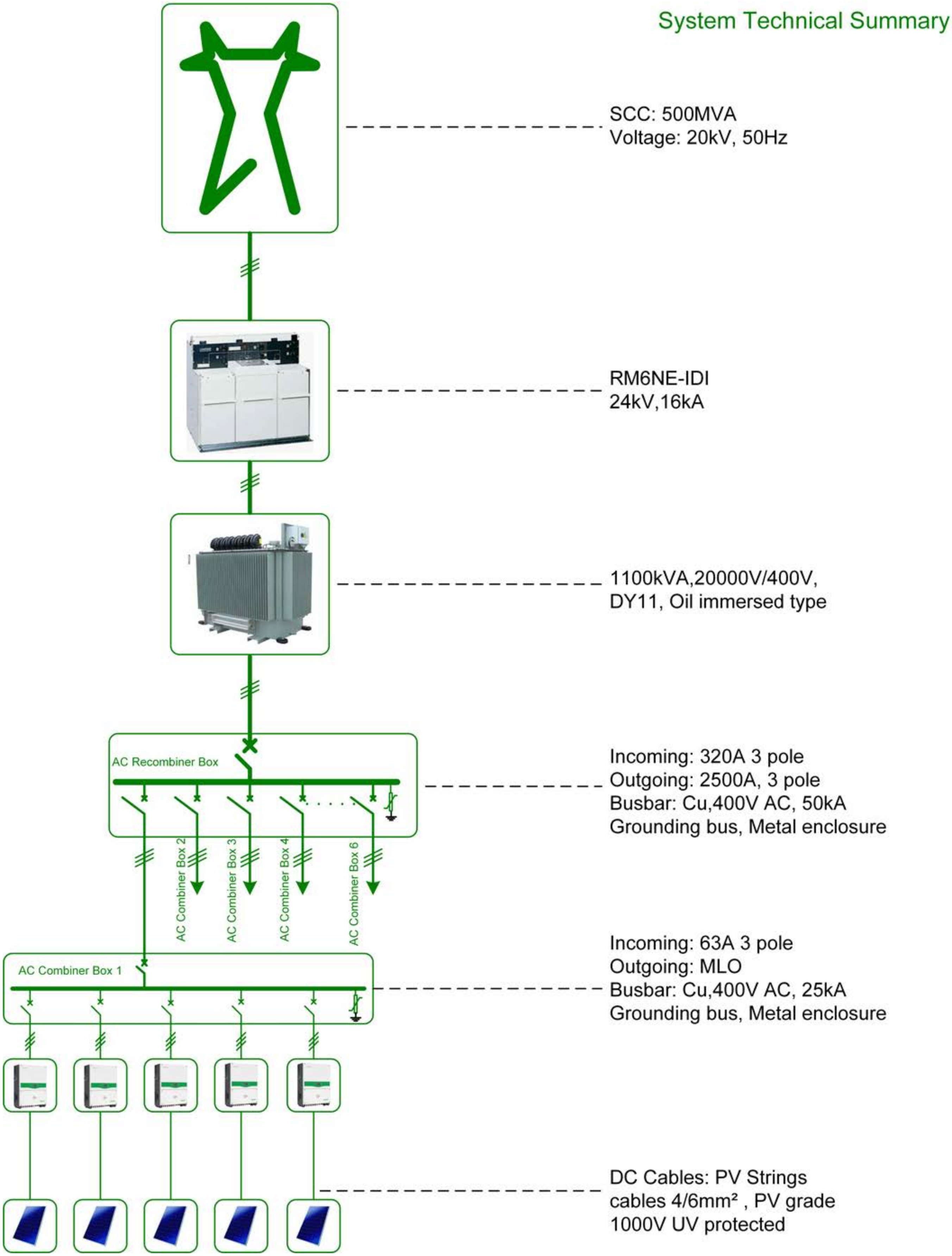
Selection of a switch-disconnect for the AC combiner box also depends on the fault current and nominal continuous current that the AC combiner box is going to handle.

For an AC combiner box combining five CL 33 inverters (5 x 33 kW = 165 kW), the operating current can be as high as 276 A (55.2 x 5). Considering the operating margin, a 320 A switch-disconnect that can withstand up to 20 kA fault current would be a good choice for this example. Compact INS320 type switch disconnects can be used for this purpose.

Table 8 Interpact INS320 specifications

Device short name	Interpact INS320	
Poles description	4P	
Network type	AC	
Network frequency	50/60 Hz	
$[I_e]$ rated operational current	320 A	
$[U_i]$ rated insulation voltage	750 V AC	
$[U_{imp}]$ rated impulse withstand voltage	8 kV	
$[I_{cm}]$ rated short-circuit making capacity	50 kA	
$[U_e]$ rated operational voltage	690 V AC	
Suitability for isolation	Yes	
Contact position indicator	Yes	

Figure 11 Recommended block architecture with five input AC Combiners



AC Re-combiner Box

An AC re-combiner box re-combines all AC combiner box inputs at one bus bar. The accumulated power flows to the transformer LV winding and gets transferred to the MV network.

The AC re-combiner box is usually located at an LV-MV station inside the kiosk or outside on a concrete pad. All inputs from AC combiners in the PV field are connected to the molded case type circuit breakers. The outputs to the LV transformer winding from the AC re-combiner box can be connected to either an MCCB or an air circuit breaker (ACB) depending on the space requirements.

Selection of the MCCB and ACB should follow similar rules as described for AC combiners. It is worth noting that discrimination and cascading of circuit breakers help to design a more accurate protection philosophy, as well as to save on capital costs due to the reduced fault level capacity of components.

The fault level at the transformer’s LV terminal will be mostly the same as the fault level on the AC re-combiner’s bus bar due to the short distance between the transformer and the re-combiner panel.

Grid MV and LV Impedance Values

Considering the MV connection at 20 kV and grid short circuit power of 500 MVA, the following values can be used to calculate grid impedance at the LV side of the transformer.

- MV voltage: 20 kV
- Short circuit power from grid: 500 MVA
- Transformer LV voltage: 400 V
- Voltage factor c for MV grid: 1.1
- Size of transformer: 1100 KVA

First calculate MV impedance:

$Z_{MV\text{-}grid} = (R_{MV\text{-}grid}^2 + X_{MV\text{-}grid}^2)^{1/2}$

$Z_{MV\text{-}grid}$ = c x Grid voltage/Grid current

$= 1.1 \times 20000^2 / (500 \times 10^6)$

= 0.88 Ohms

$X_{MV\text{-}grid} = 0.995 * Z_{MV\text{-}grid} = 0.995 \times 0.88$

= 0.8756

$R_{MV\text{-}grid} = (Z_{MV\text{-}grid}^2 - X_{MV\text{-}grid}^2)^{1/2} = 0.08788993$ Ohms

Then, calculate grid LV impedance from grid MV values:

$X_{LV\text{-}grid} = X_{MV\text{-}grid} \times (\text{LV Voltage}^2 / \text{MV Voltage}^2)$

$= 0.8756\ (400^2/20000^2)$

= 0.0003502 Ohms

$R_{LV\text{-}grid} = R_{MV\text{-}grid} \times (\text{LV Voltage}^2 / \text{MV Voltage}^2)$

$= 0.08788993\ (400^2/20000^2)$

$= 3.5156 \times 10^{-5}$ Ohms

Transformer Impedance Values

We calculate the transformer impedance for a 1100 KVA, 20 kV / 400 V transformer with the following details:

- Voltage factor c=1.05
- Short circuit impedance= 6%
- Load loss of 13000 W (copper losses),

Before we calculate the transformer impedance, it is important to know the

following definitions:

C_{max} = voltage factor for calculating the maximum short circuit current

I_{rT} = rated current of the transformer on the low or high voltage side

K_T = impedance correction factor

A network transformer connects two or more networks at different voltages. For two winding transformers this impedance correction factor should be used when calculating the short circuit impedance.

P_{krT} = total loss in the transformer windings at the rated current

S_{rT} = rated apparent power of the transformer

U_{kr} = short circuit voltage at the rated current

U_{rT} = rated voltage of the transformer on the low or high voltage side

x_t = relative reactance of transformer

$X_{TR\text{-}LV}$ = LV winding reactance of the transformer

Z_T = transformer LV impedance

Before we calculate the transformer LV impedance, we will calculate K_t and X_T using C_{max}.

Table 9 Voltage factor c

	Voltage factor c for the calculation of:	
Nominal voltage (U_n)	**maximum short-circuit currents c_{max}**[5]	**minimum short-circuit currents c_{min}**
Low voltage 100 V to 1000 V (IEC 60038)	1.05[6] 1.10[7]	0.95

[5] $C_{max}U_n$ should not exceed the highest voltage U_m for equipment of power systems

[6] For low voltage systems with a tolerance of +6%, for example systems renamed from 380 V to 400 V

[7] For low voltage systems with a tolerance of +10%

	Voltage factor c for the calculation of:	
Nominal voltage (U_n)	**maximum short-circuit currents c_{max}[5]**	**minimum short-circuit currents c_{min}**
Medium voltage >1 kV to 35 kV (IEC 60038)	1.10	1.00
High voltage[8] >35 kV (IEC 60038)	1.10	1.00

[5] $C_{max}U_n$ should not exceed the highest voltage U_m for equipment of power systems

[8] If no nominal voltage is defined $c_{max}U_n = U_m$ or $c_{min}U_n = 0.90 \times Um$ should be applied

Impedance Correction Factor:

$$K_T = 0{,}95 \frac{c_{max}}{1+0{,}6 x_T}$$

Transformer LV impedance $Z_{TR\text{-}LV}$

$$Z_T = \frac{u_{kr}}{100\,\%} \cdot \frac{U_{rT}^2}{S_{rT}}$$

= K_T x 400 x 400 x 0.06/1100x 1000

= .00840681 Ohms

Where, K_T = 0.96328045

$R_{TR\text{-}LV}$

$$R_T = \frac{u_{kr}}{100\,\%} \cdot \frac{U_{rT}^2}{S_{rT}} = \frac{P_{krT}}{3 I_{rT}^2}$$

= K_T x Losses kW / 3 x (Rated Current)^2

= K_T x 13000 / 3 x (1100 x 1000/400/1.732)^2

= 0.001655 Ohms

$X_{TR\text{-}LV}$ = K_T x Sqrt(Z^2-R^2) = 0.008243Ohms

$$X_T = \sqrt{Z_T^2 - R_T^2}$$

Fault level at AC re-combiner bus bar

= Voltage x Voltage correction factor C/ Fault impedance

= 400 x 1.05 / {(Z_{grid}+$Z_{TR\text{-}LV}$} x √3 x 1000

= 400 x 1.05 / {(R_{LVgrid}+$R_{TR\text{-}LV}$)^2 + (X_{LVgrid}+$X_{TR\text{-}LV}$)^2}$^{1/2}$ x √3 x 1000

= 400 x 1.05 / {0.001691^2 + 0.008594^2}$^{1/2}$ x √3 x 1000

= 27.68 kA

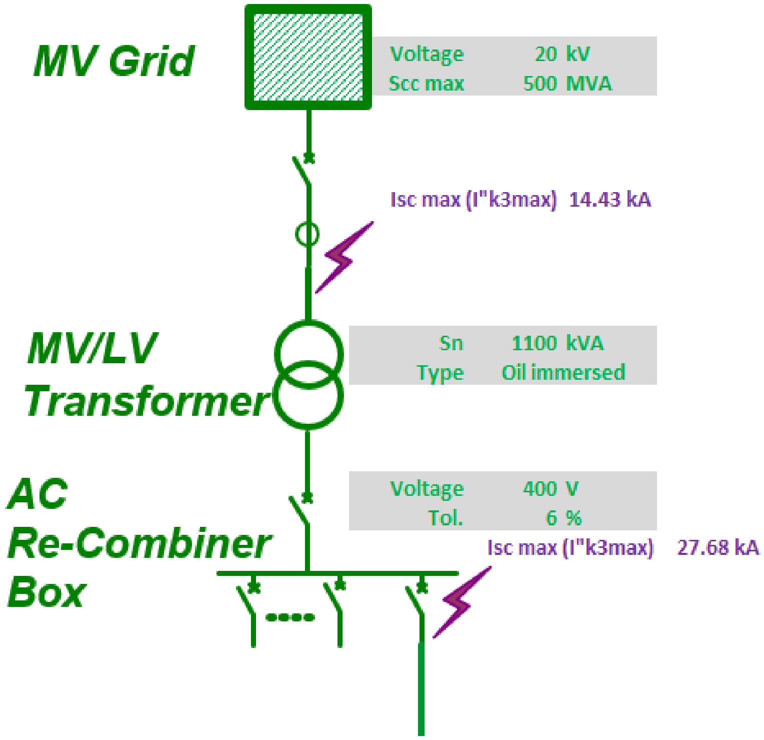
If a 36.3 kVA rating is used (for 0.9 PF operation), for a 1.1 MVA standard block, with 30 CL 33 inverters, six AC Combiner boxes combining five inverters each and each AC Combiner with five inverters, the AC re-combiner box will have six inputs, each with 276 A maximum current and respective fault level.

If a 33 kW rating is used (for 1 PF operation) for a 1.0 MVA standard block, with 30 CL 33 inverters, six AC Combiner boxes combining five inverters each, the AC re-combiner box will have six inputs, each with 276 A maximum current and respective fault level.

The length of cables between AC re-combiner and transformer (being very short) does not make much difference to the selection of the circuit breaker's fault level. Transformer impedance and grid short-circuit fault level makes a small difference but is not significant. The major difference comes from the size of the transformer and LV voltage level. Designers should consider this when designing the system.

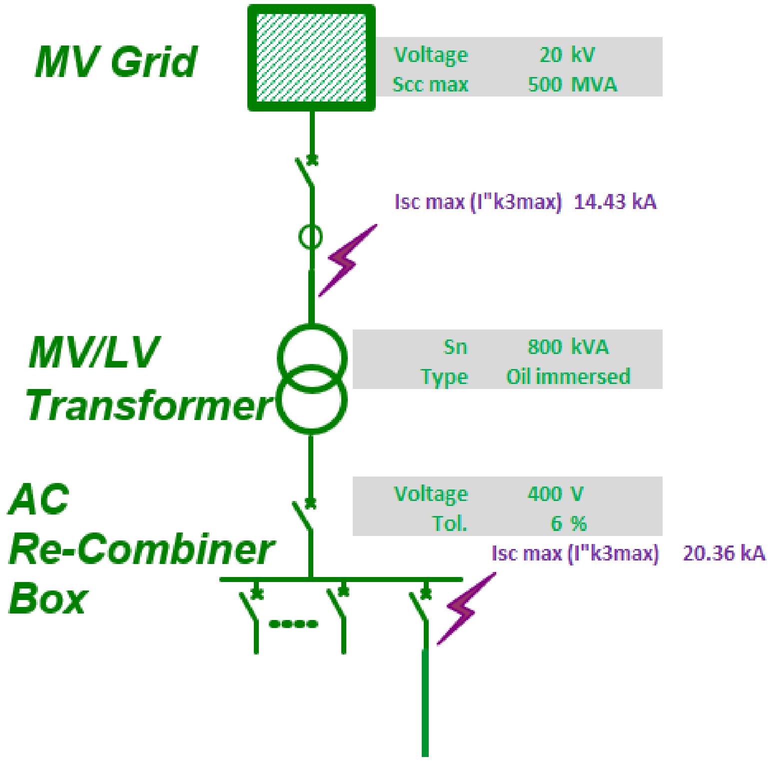
Figure 12 and *Figure 13* provide examples for understanding the dependency of circuit breaker selection on the bus bar fault level, as well as the dependency of the bus bar fault level in the selection of components.

Figure 12 Breaker selection with 1100 kVA transformer



When we replace the 1100 kVA transformer with a 800 KVA transformer, the fault level decreases significantly on the AC re-combiner's bus bar and NSX400N type breakers become eligible to be used for inputs.

Figure 13 Breaker selection with 800 kVA transformer



Recommended Circuit Breaker for AC Re-combiner Incoming:

We recommend using Compact NSX400N type Breakers for AC re-combiner input to have up to 50 kA fault current capacity.

Table 10 Compact NSX specifications

Device short name	Compact NSX	
Device short name	Compact NSX400N	
Poles description	3P	
Network frequency	50/60 Hz	
$[I_n]$ rated current	Up to 400 A (40 °C)	
$[U_i]$ rated insulation voltage	800 V AC 50/60 Hz	
$[U_{imp}]$ rated impulse withstand voltage	8 kV	
$[U_e]$ rated operational voltage	690 V AC 50/60 Hz	
Breaking capacity	50 kA I_{cu} at 380/415 V AC	

Selected circuit breaker for AC Re-combiner output:

output current of AC re-combiner

= Block kVA size x 1000 /sqrt 3 x Voltage

= 1100 x 1000 / 1.732 x 400

= 1588 A

Expected Fault level ~ 35 kA

With the above specification, the recommended circuit breaker is Masterpact NW25H1 – 2500A – 3 pole (fixed or removable) – with Micrologic trip unit.

Table 11 Masterpact NWH1 specifications

Device short name	Masterpact NW25
Poles description	AC
Network type	50/60 Hz
Suitability for isolation	Yes
Utilization category	Category B
Network frequency	50/60 Hz
Control type	Pushbutton
Mounting mode	Fixed
$[I_n]$ rated current	2500 A (40 °C)
$[U_i]$ rated insulation voltage	1000 V AC
$[U_{imp}]$ rated impulse withstand voltage	12 kV
$[I_{cm}]$ rated short-circuit making capacity	143 kA
$[U_e]$ rated operational voltage	690 V AC
Circuit breaker CT rating	2500 A
Breaking capacity	65 kA

Circuit Breaker Protection - Discrimination Table for Selection

To achieve the correct level of discrimination and cascading between selected circuit breakers, use the following tables. If the installed circuit breakers have different combinations, check the *“Complementary Technical Information”: Low voltage catalogue* for more discrimination tables.

Complementary technical information

Ue ≤ 440 V

Discrimination table

Upstream: Compact NSX400-630 Micrologic
Downstream: iDPN, iC60, C120, NG125-160, Compact NSX100-400

Upstream		NSX400F/N/H/S/L/R					NSX630F/N/H/S/L/R				
Trip unit		Micrologic					Micrologic				
Downstream	Rating (A)	400					630				
	Setting Ir	160	200	250	320	400	250	320	400	500	630
Discrimination limit (kA)											
IDPN		T	T	T	T	T	T	T	T	T	T
IDPNN		T	T	T	T	T	T	T	T	T	T
IC60N/H/L		T	T	T	T	T	T	T	T	T	T
Discrimination limit (kA)											
C120N/H	≤ 80	T	T	T	T	T	T	T	T	T	T
	100		T	T	T	T	T	T	T	T	T
	125			T	T	T	T	T	T	T	T
Discrimination limit (kA)											
NG125N/H/L	≤ 80	T	T	T	T	T	T	T	T	T	T
	100		T	T	T	T	T	T	T	T	T
	125			T	T	T	T	T	T	T	T
Discrimination limit (kA)											
NG160E/N/H	≤ 80	T	T	T	T	T	T	T	T	T	T
	100	T	T	T	T	T	T	T	T	T	T
	125		T	T	T	T	T	T	T	T	T
	160			T	T	T	T	T	T	T	T
Discrimination limit (kA)											
Compact NSX100 B/F/N/H/S/L/R TM-D	≤ 80	T	T	T	T	T	T	T	T	T	T
	100	T	T	T	T	T	T	T	T	T	T
Discrimination limit (kA)											
Compact NSX160 B/F/N/H/S/L TM-D	≤ 100	T	T	T	T	T	T	T	T	T	T
	125		T	T	T	T	T	T	T	T	T
	160			T	T	T	T	T	T	T	T
Discrimination limit (kA)											
Compact NSX250 B/F/N/H/S/L/R TM-D	≤ 100	4.8	4.8	4.8	4.8	4.8	T	T	T	T	T
	125		4.8	4.8	4.8	4.8	T	T	T	T	T
	160			4.8	4.8	4.8	T	T	T	T	T
	200				4.8	4.8		T	T	T	T
	250					4.8			T	T	T
Discrimination limit (kA)											
Compact NSX100 B/F/N/H/S/L/R Micrologic	40	T	T	T	T	T	T	T	T	T	T
	100	T	T	T	T	T	T	T	T	T	T
Discrimination limit (kA)											
Compact NSX160 B/F/N/H/S/L Micrologic	40	T	T	T	T	T	T	T	T	T	T
	100	T	T	T	T	T	T	T	T	T	T
	160			T	T	T	T	T	T	T	T
Discrimination limit (kA)											
Compact NSX250 B/F/N/H/S/L/R Micrologic	≤ 100	4.8	4.8	4.8	4.8	4.8	T	T	T	T	T
	160			4.8	4.8	4.8	T	T	T	T	T
	250					4.8			T	T	T
Discrimination limit (kA)											
Compact NSX400 F/N/H/S/L/R Micrologic	160						6.9	6.9	6.9	6.9	6.9
	200							6.9	6.9	6.9	6.9
	250								6.9	6.9	6.9
	320									6.9	6.9
	400										6.9

4	*Discrimination limit = 4 kA.*
T	*Total discrimination, up to the breaking capacity of the downstream circuit breaker.*
	No discrimination.

Complementary technical information

Ue ≤ 440 V

Protection discrimination

Upstream: Masterpact NW08-20 N1/H1/H2/L1 Micrologic
Downstream: iDPN, iC60, C120, NG125-160, Compact NSX100-630

Upstream		Masterpact NW08/12/16/20 N1/H1/H2/L1																				
Trip unit		Micrologic 2.0							Micrologic 5.0 - 6.0 - 7.0 Inst : 15 In							Micrologic 5.0 - 6.0 - 7.0 Inst : OFF						
Downstream	Rating (A)	800			1000	1250	1600	2000	800			1000	1250	1600	2000	800			1000	1250	1600	2000
	Setting Ir	320	630	800	1000	1250	1600	2000	320	630	800	1000	1250	1600	2000	320	630	800	1000	1250	1600	2000
Discrimination limit (kA)																						
iDPN, iDPNN		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
iC60		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
C120N/H		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
NG125N/H		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
NG125L		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
NG160E/N/H		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX100 B/F/N/H/S/L/R TM-D		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX160 B/F/N/H/S/L TM-D		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX250 B/F/N/H/S/L/R TM-D	≤ 125	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	160	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	200	T	T	T	T	T	T	T		T	T	T	T	T	T		T	T	T	T	T	T
	250		T	T	T	T	T	T		T	T	T	T	T	T		T	T	T	T	T	T
Compact NSX100 B/F/N/H/S/L/R Micrologic	40	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	100	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX160 B/F/N/H/S/L Micrologic	40	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	100	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	160	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX250 B/F/N/H/S/L/R Micrologic	≤ 100	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	160	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	250		T	T	T	T	T	T	T	T	T	T	T	T	T		T	T	T	T	T	T
Compact NSX400 F/N/H/S/L/R Micrologic	160	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	200	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	250	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	320		T	T	T	T	T	T		T	T	T	T	T	T		T	T	T	T	T	T
	400		T	T	T	T	T	T		T	T	T	T	T	T		T	T	T	T	T	T
Compact NSX630 F/N/H/S/L/R Micrologic	250	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	320		T	T	T	T	T	T		T	T	T	T	T	T		T	T	T	T	T	T
	400		T	T	T	T	T	T		T	T	T	T	T	T		T	T	T	T	T	T
	500			T	T	T	T	T			T	T	T	T	T			T	T	T	T	T
	630				T	T	T	T				T	T	T	T				T	T	T	T

T — *Total discrimination, up to the breaking capacity of the downstream circuit breaker.*

(blank) — *No discrimination.*

Complementary technical information

Ue ≤ 440 V

Protection discrimination

Upstream: Masterpact NW25-40 H1/H2, Masterpact NW40b-63 H1 Micrologic
Downstream: iDPN, iC60, C120, NG125-160, Compact NSX100-630, NS630b-3200

Upstream		Masterpact NW25/32/40 H1/H2			Masterpact NW40b 50/63 H1			Masterpact NW25/32/40 H1/H2			Masterpact NW40b 50/6 3H1			Masterpact NW25/32/40 H1/H2			Masterpact NW40b 50/63 H1		
Trip unit		Micrologic 2.0						Micrologic 5.0 - 6.0 - 7.0 Inst : 15 In						Micrologic 5.0 - 6.0 - 7.0 Inst : OFF					
Downstream	Rating (A)	2500	3200	4000	4000	5000	6300	2500	3200	4000	4000	5000	6300	2500	3200	4000	4000	5000	6300
Discrimination limit (kA)																			
iDPN, iDPNN		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
iC60		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
C120N/H		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
NG125N/H/L		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
NG160E/N/H		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX B/F/H/N/S/L/R TM-D	NSX100	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	NSX250	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX160 B/F/H/N/S/L TM-D		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX B/F/H/N/S/L/R Micrologic	NSX100	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	NSX250	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
F/H/N/S/L/R Micrologic	NSX400	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	NSX630	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NSX160 B/F/H/N/S/L Micrologic		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NS N Micrologic	NS630b	25	32	40	40	T	T	37.5	48	T	T	T	T	T	T	T	T	T	T
	NS800	25	32	40	40	T	T	37.5	48	T	T	T	T	T	T	T	T	T	T
	NS1000	25	32	40	40	T	T	37.5	48	T	T	T	T	T	T	T	T	T	T
	NS1250	25	32	40	40	T	T	37.5	48	T	T	T	T	T	T	T	T	T	T
	NS1600	25	32	40	40	T	T	37.5	48	T	T	T	T	T	T	T	T	T	T
Compact NS H Micrologic	NS630b	25	32	40	40	50	63	37.5	48	60	60	T	T	T	T	T	T	T	T
	NS800	25	32	40	40	50	63	37.5	48	60	60	T	T	T	T	T	T	T	T
	NS1000	25	32	40	40	50	63	37.5	48	60	60	T	T	T	T	T	T	T	T
	NS1250	25	32	40	40	50	63	37.5	48	60	60	T	T	T	T	T	T	T	T
	NS1600	25	32	40	40	50	63	37.5	48	60	60	T	T	T	T	T	T	T	T
Compact NS N Micrologic	NS1600b	25	32	40	40	50	63	37.5	48	60	60	T	T	T	T	T	T	T	T
	NS2000	25	32	40	40	50	63	37.5	48	60	60	T	T	T	T	T	T	T	T
	NS2500	25[1]	32	40	40	50	63	37.5[1]	48	60	60	T	T	T[1]	T	T	T	T	T
	NS3200		32[1]	40	40	50	63		48[1]	60	60	T	T		T[1]	T	T	T	T
Compact NS H Micrologic	NS1600b	25	32	40	40	50	63	37,5	48	60	60	75	T	T	T	T	T	T	T
	NS2000	25	32	40	40	50	63	37,5	48	60	60	75	T	T	T	T	T	T	T
	NS2500	25[1]	32	40	40	50	63	37,5[1]	48	60	60	75	T	T[1]	T	T	T	T	T
	NS3200		32[1]	40	40	50	63		48[1]	60	60	75	T		T[1]	T	T	T	T
Compact NS L Micrologic	NS630b	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	NS800	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	NS1000	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Compact NS LB Micrologic	NS630b	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
	NS800	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T

(1) With Ir upstream > 1,3 Ir downstream.

T	*Total discrimination, up to the breaking capacity of the downstream circuit breaker.*
4	*Discrimination limit = 4 kA.*
	No discrimination.

Important Aspects of a Decentralized System Design

Consider the following when designing a decentralized system:

- Residual current monitoring device selection
- Surge protection device selection
- Earthing system design
- Transformer selection
- Monitoring system design
- Grid connection
- Role of circuit impedance in parallel operation of multiple CL 33 inverters

Selection of Residual Current Monitoring Device (RCD)

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, ARC FLASH, AND FIRE

- An RCD must be selected by qualified personnel.
- For proper functioning of an RCD or RCMU only use the type of RCD or RCMU that matches the type of residual current expected: AC, DC, or mixed.

Failure to follow these instructions will result in death or serious injury or may result in damage to the inverter, the system, or both.

“Residual current” refers to the leakage current from an electrical system to the ground, often as a result of a “ground fault”. Leakage currents can flow through a human body to ground resulting in a risk of electric shock, injury or burns, and can cause overheating and risk of fire. A Residual Current Device (RCD) is used to detect these currents and disconnect the circuit from the source automatically when the values of these residual currents exceed the predefined limits.

A Residual Current Monitoring Unit (RCMU) is similar to an RCD except it does not contain the disconnection function and can only activate an alarm. The residual current may be a pure alternating current (AC), a pure direct current (DC), or a current with both AC and DC components. For proper functioning of an RCD or RCMU only use the type of RCD or RCMU that matches the type of residual current expected: AC, DC, or mixed.

In some jurisdictions, RCDs are required to be installed on AC circuits in which photovoltaic (PV) inverters are connected. In a grid-tied PV system with a non-isolated inverter, it is possible for a ground fault on the PV system to cause DC residual current in the AC part of the system. Therefore, if an RCD is required on the AC circuit, its proper selection requires awareness of the properties of the inverter. Many inverters contain RCD or RCMU functions to protect against or warn of ground faults in the PV array, and of the limitations of such PV residual current functions.

The IEC 60755 standard specifies three different types of RCDs, defined by their ability to sense, properly trip, and withstand different types of current:

- Type AC - sensitive to residual sinusoidal alternating current (AC).
- Type A - sensitive to residual sinusoidal alternating current (AC) or pulsed direct current (DC).
- Type B - sensitive to residual AC, pulsed DC, or smooth DC currents.

Only Type B RCDs are able to withstand and properly function in the presence of a DC residual current component exceeding 6 mA. These different types of RCDs are marked with specific symbols, as defined in IEC 60755.

The white paper (available at https://solar.schneider-electric.com/), *“Guidance on Proper Residual Current Device Selection for Solar Inverters”* by K. Ajith Kumar and Jim Eichner, provides more guidance on the requirements and selection of RCDs.

The CL 33 inverter has a built-in RCMU. This continuous RCD is set at 300 mA (or higher for larger systems) and a sudden change detector with limits as listed in the following table (based on DIN/VDE 0126-1-1, EN/IEC 62109-2, and other standards):

Residual current sudden change	Maximum time to inverter disconnection from the main
30 mA	300 ms
60 mA	150 ms
150 mA	40 ms

Selection of a Surge Protection Device

DANGER

HAZARD OF ELECTRIC SHOCK AND FIRE

Installation, including wiring, must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes, including relevant local, regional, and national regulations. Installation instructions are not covered in this Solutions Guide, but are included in the relevant product manuals for the CL 33 inverter. Those instructions are provided for use by qualified installers only.

Failure to follow these instructions will result in death or serious injury.

Surge arrestors help to protect the electrical wiring, components, and system from lightning surges. The role of a surge arrester is to drive the lightning current to the earth in very short time (<350 microseconds). However, surge arrestors are not intended to be exposed to permanent over voltages. Extended exposure may create a short circuit and may damage the switch board.

Consider the following when selecting surge protection:

- The protection level of the SPD must be lower than the impulse withstand voltage level of the equipment protected by the SPD.
- For a TNC earthing scheme, 3P SPDs should be used.
- For a TNS earthing scheme, 3P+N SPDs should be used.

- If the PV system is installed in the vicinity (within 50 m) of a lightning protection rod or lightning termination, a Type 1 SPD will be required to help safeguard the inverter from lightning discharge currents because it is used to conduct the direct lightning current, propagating from the earth conductor to the network conductors.
- Geographical conditions cause the specific level of lightning flash density. Based on the level of lightning flash density and commercial value of the equipment protected, the level of surge protection and the fault level (kA) of the SPD must be decided.
- After choosing the surge protection device for the installation, the appropriate disconnection circuit breaker must be chosen. Its breaking capacity must be compatible with the installation's breaking capacity and each live conductor must be protected, for example, 3P+N SPD must be combined with a 4P MCCB or MCB.

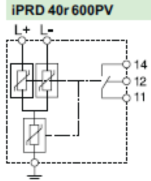
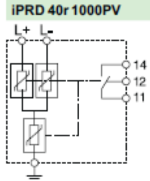
Use of SPDs on DC Circuits

iPRD PV-DC type surge protection devices should be installed in a switchboard either inside the building or in a weatherproofed location outside. Removable iPRD PV-DC surge arresters allow damaged cartridges to be replaced quickly.

The surge arrester base can be turned over to allow the phase/neutral/earth cables to enter through either the top or the bottom. These cables offer remote reporting of the “cartridge must be changed” message.

Table 12 SPD specifications

Catalogue numbers

Internal diagram	Imax (kA) Maximum discharge current	In (kA) Nominal discharge current	Up (kV) Protection level			U_{CPV} (V) (1) Maximum steady state voltage			Width in module of 9 mm	Cat. no.
			L+/⏚	L-/⏚	L+/L-	L+/⏚	L-/⏚	L+/L-		
iPRD 40r 600PV										
	40	15	2,8	2,8	2,8	840	840	840	6	**A9L40271**
iPRD 40r 1000PV										
	40	15	3.9	3.9	3.9	1000	1000	1000	6	**A9L40281**

(1) Ucpv ≥ 1.2 x Uoc stc (Uoc stc: maximum no-load voltage of the photovoltaic generator "photovoltaic module manufacturer's data")

Depending on the distance between the "generator" part and the "conversion" part, it may be necessary to install two or more surge arresters to help ensure protection of each of the two parts.

Calculation for DC Surge Protection

To help protect the inverter, you need to have protection level of:

U_p (surge arrester) < 0,8 U_w (inverter)

If the distance between the PV module and the inverter is greater than 10 m a second surge protection should be installed closed to the PV module, except if:

$U_p < 0{,}5U_w$ (module), where U is the impulse withstand.

The CL 33 is category III:

impulse withstand U_w = 6 kV

The 1000 V modules are usually category A:

impulse withstand is U_w= 8 kV

iPRD40r 1000 V DC surge arrestor:

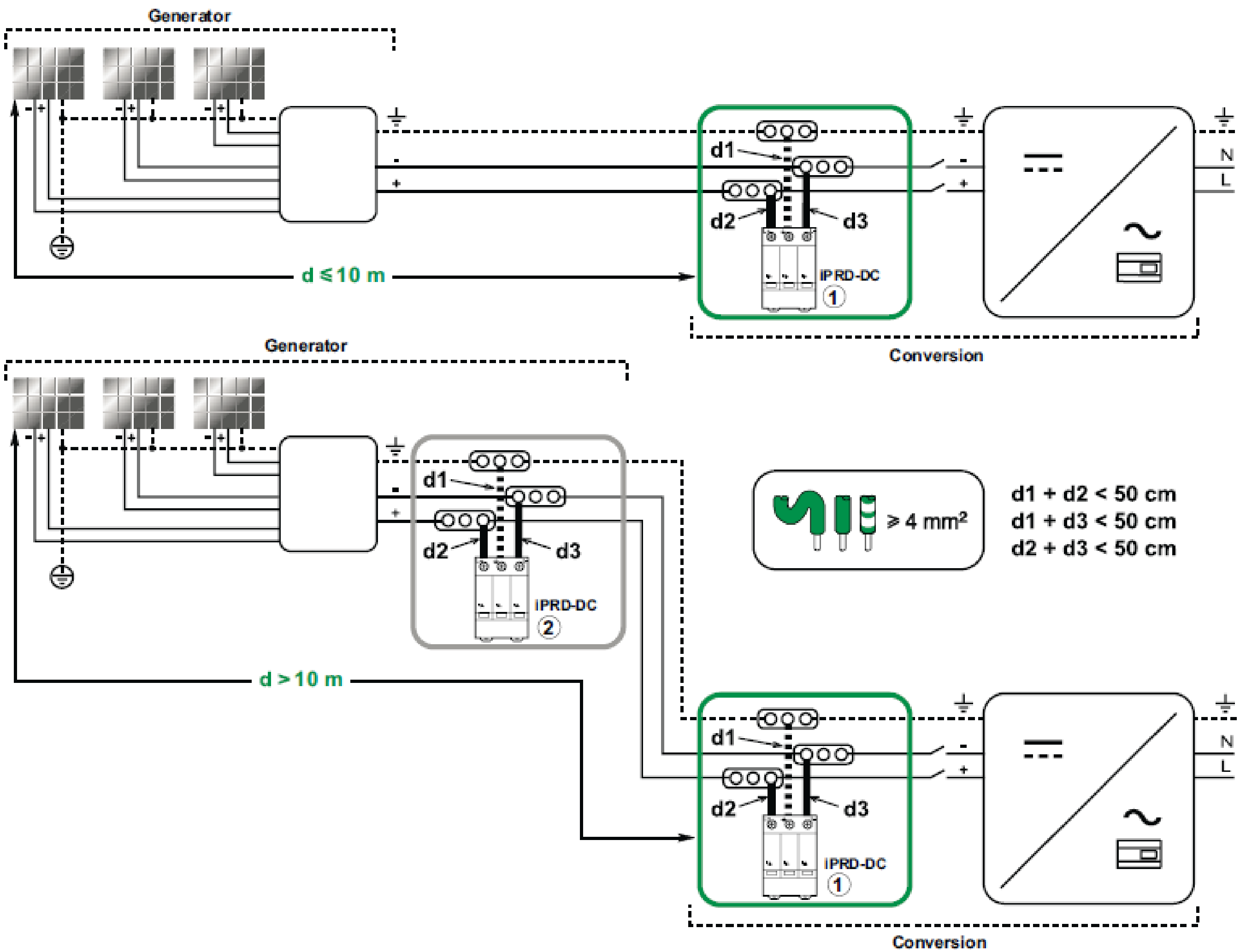
U_p = 3.9 kV

So 3.9 < 0.8 x 6 = 4.8 kV: protection of the inverter is good

And 3.9 < 0.5 x 8 = 4 kV: no need of additional surge arrestor to protect the modules.

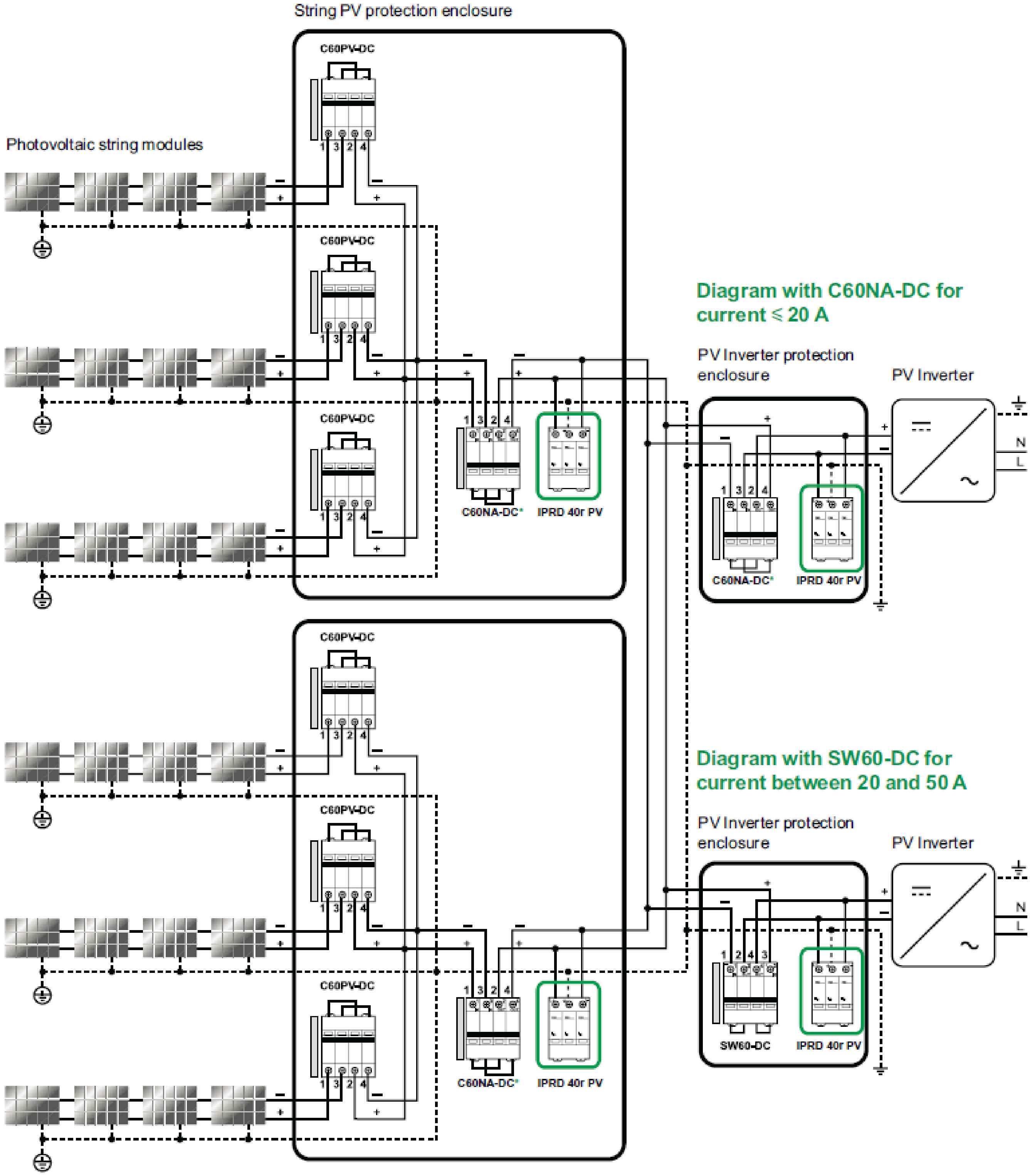
The following diagram indicates the additional SPD requirement considering that the impulse withstand voltage of the PV module is less than the U_p of the SPD inside the CL 33 inverter.

Figure 14 Additional SPD requirements



The following is a use case example to understand the installation of SPDs.

Figure 15 Installation of SPDs



If there is a scenario where the PV architecture is without an earthed polarity on the DC side and with either a PV inverter or galvanic isolation, the following things are required:

- Protection for each string of photovoltaic modules with a C60PV-DC installed in the junction box near the PV modules

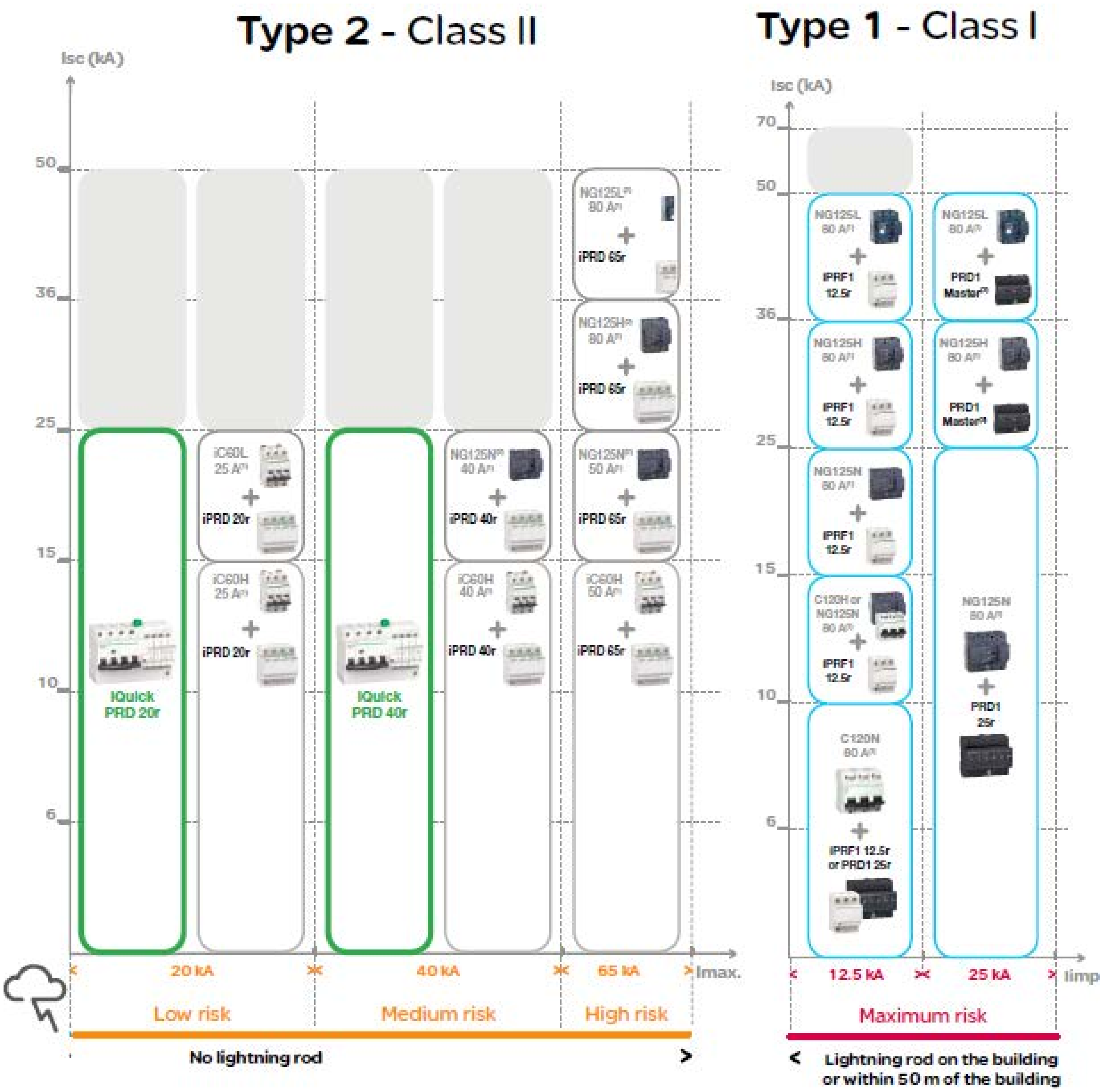
- An insulation monitoring device on the DC side of the PV inverter in order to indicate first earth fault and shut down the inverter as soon as it occurs.

Restarting the inverter will be possible only after eliminating the earth fault.

Schneider Electric has certified coordination between the surge arrester and its disconnection circuit breaker (IEC 61643-11 2005 version). The following diagram indicates the possible coordination with Type 2 SPDs.

For installations with a lightning rod within 50 m of area, Type 1 SPD's should be used in co-ordination with the following disconnection devices.

Figure 16 Coordination of SPDs with disconnection devices



Use of SPDs on AC Circuits

To help protect the AC output circuit it is important to select right size of Type 2 SPD:

- This AC SPD provides Type 2 protection to the inverter from AC system surges from the grid. For the protection of the AC low voltage systems, we recommend selecting the type of SPD based on the country code and the area lightning protection requirements.
- We recommend using suitable circuit disconnecting means with an SPD device outside the inverter wiring box.
- The Type 2 PCB-mounted surge protection provided inside the CL 33 wiring box is not meant to protect AC LV grid components.
- For more effective surge protection, shorten the length of the cables. Lightning is a phenomenon that generates high frequency voltage. 1 m length of cable crossed by a lightning current generates an approximate overvoltage of 1000 V.
- Consider intermediate earthing terminals inside the switch boards to shorten the cable lengths. IEC 60364-5-534 mandates to restrict the overall length of the cables (connected to the SPD and terminating to ground) up to 50 cm.

In 3-phase AC LV systems, surge protection also depends on the type of earthing system that is followed for the wiring of 3 phases and neutral. *Figure 17*, *Figure 18*, and *Figure 19* show examples that illustrate the connection of the SPDs in AC LV circuits.

Figure 17 TN-S Earthing System, 3-Phase + Neutral

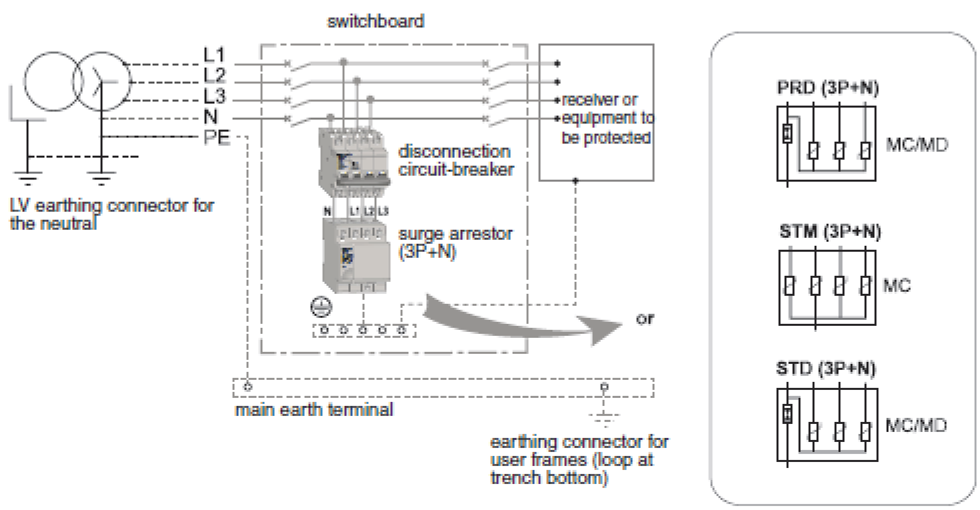


Figure 18 TN-C Earthing System, 3-Phase

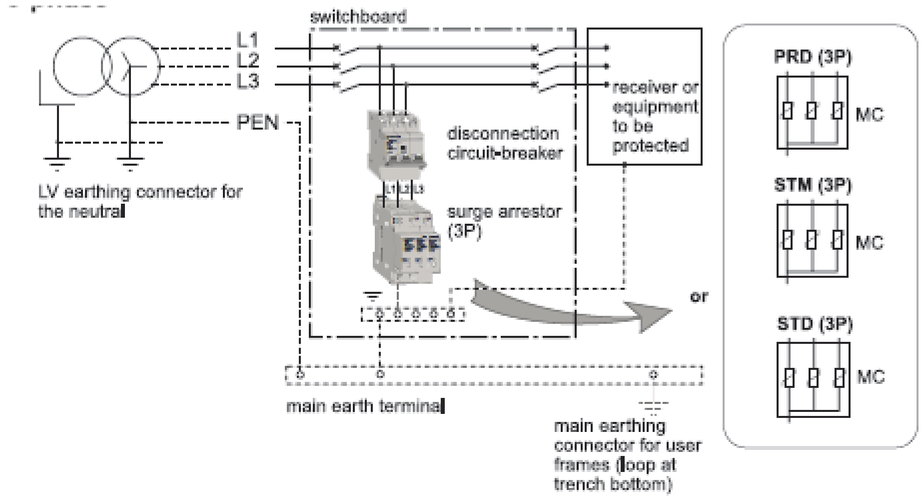
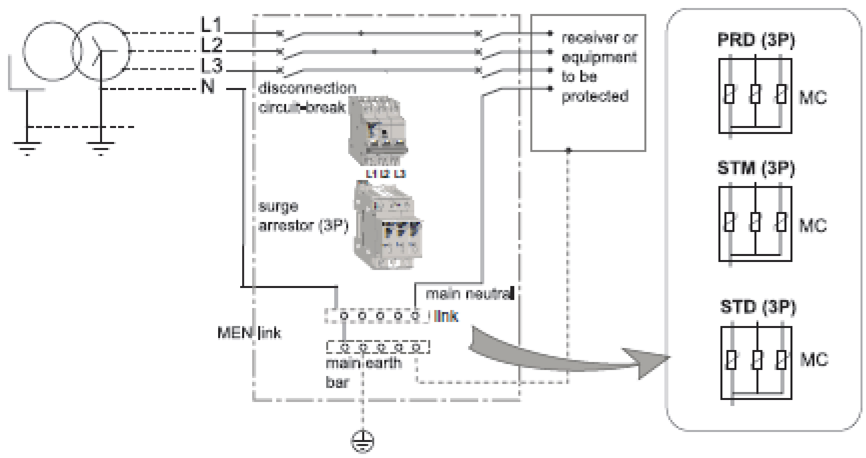


Figure 19 MEN Earthing System, 3-Phase



Earthing/Grounding System Design

The described different earthing schemes (often referred to as the type of power system or system earthing arrangements) characterize the method of earthing the following:

- the installation downstream of the secondary winding of a MV/LV transformer
- the exposed conductive-parts of the LV installation supplied from the transformer

The methods chosen govern the measures necessary to help protect against indirect-contact hazards.

The earthing system is comprised of three sets of options, decided by the designer of an electrical distribution system or installation:

- The type of connection of the electrical system (which is generally of the neutral conductor) and of the exposed parts to earth electrode(s)
- A separate protective conductor, or protective conductor plus neutral conductor together as a single conductor

- The use of earth fault protection for overcurrent protective switchgear which clears only relatively high fault currents or the use of additional relays able to detect and clear small insulation fault currents to earth

In practice, these options have been grouped and standardized, as explained below.

Each of these options provides standardized earthing systems with advantages and drawbacks:

- Connection of the exposed conductive parts of the equipment and of the neutral conductor to the PE conductor results in equi-potentiality and lower over voltages, but it increases earth fault currents.
- A separate protective conductor is costly even if it has a small cross sectional area, but it is much less likely to be polluted by voltage drops and harmonics, etc. than a neutral conductor is. Leakage currents are also avoided in extraneous conductive parts.
- Installation of residual current protective relays or insulation monitoring devices are much more sensitive and, in many circumstances, are able to clear faults before heavy damage occurs (motors, fires, electrocution). The protection offered is also independent with respect to changes in an existing installation.

Earthing for PV Systems

DANGER

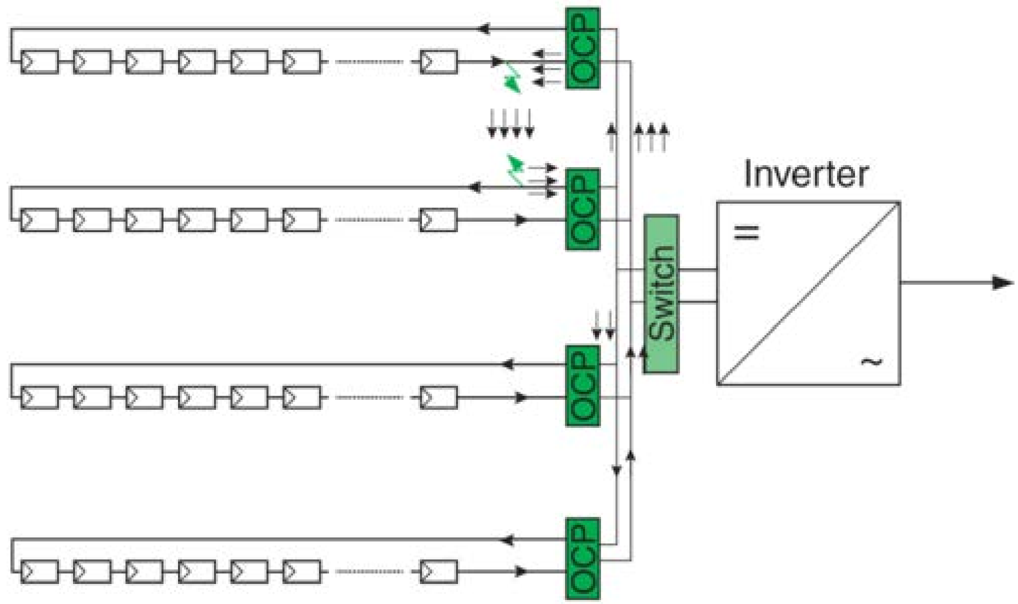
HAZARD OF ELECTRIC SHOCK, EXPLOSION, ARC FLASH, AND FIRE

- Ground faults must be identified by insulation monitoring or overcurrent protection devices and cleared by qualified personnel without delay.
- Under no situation should a double ground fault be allowed to occur.
- Ensure correct insulation and earthing practices are followed.

Failure to follow these instructions will result in death or serious injury.

PV systems are either insulated from the earth or one pole is earthed through an overcurrent protection. In both set-ups, therefore, there can be a ground fault in which current leaks to the ground. If this fault is not cleared, it may spread to the healthy pole and give rise to a hazardous situation where fire could break out. Even though double insulation makes such an eventuality unlikely, it deserves full attention.

Figure 20 Reverse current



Selected insulation monitoring devices or overcurrent protection in earthed systems must detect the first fault and staff must address the first fault and clear it without delay.

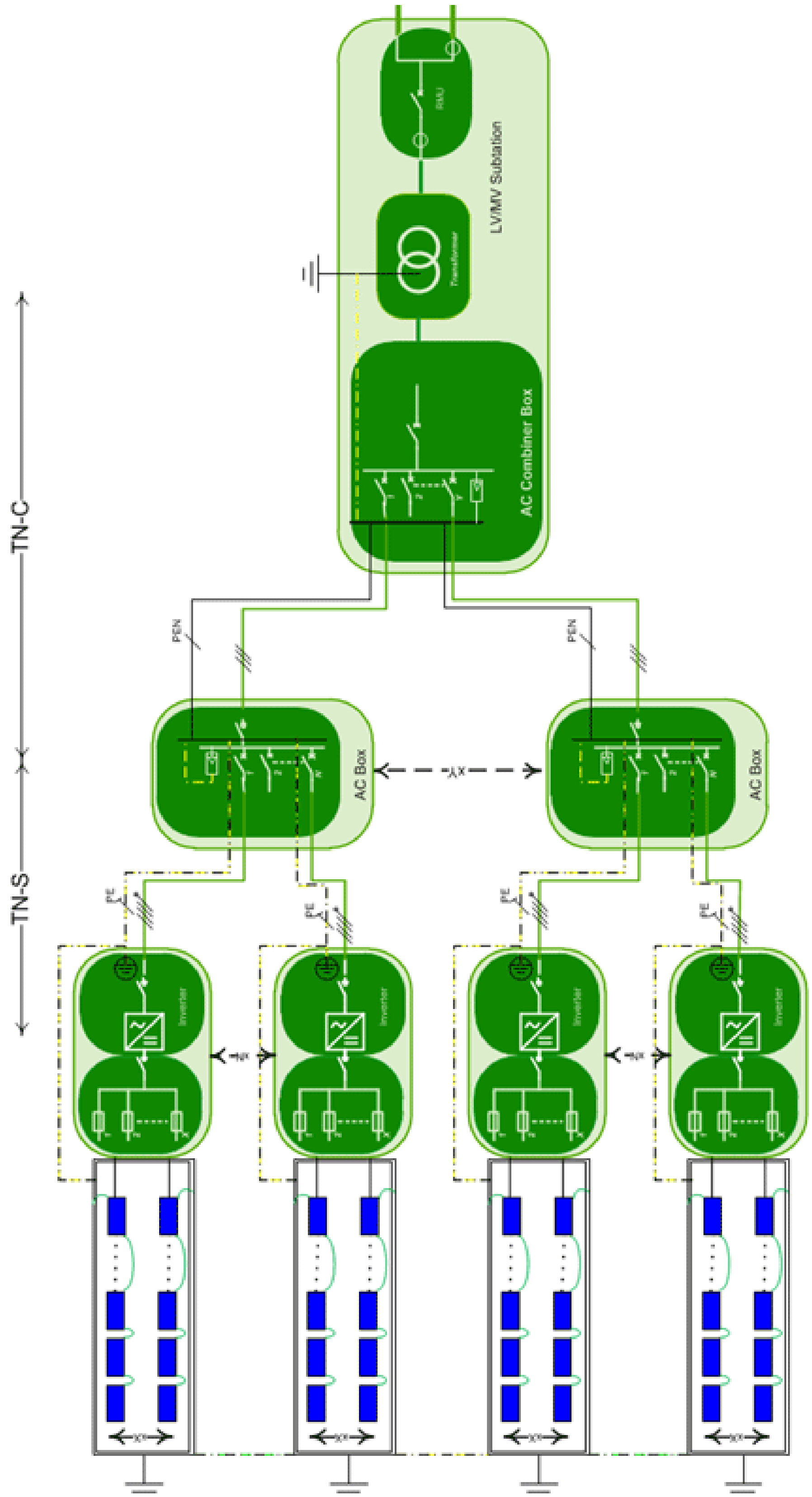
For the following two reasons, the double fault situation must be avoided:

- The fault level could be low (for example, two insulation faults or a low short circuit capability of the generator in weak sunlight) and below the tripping value of the overcurrent protection (circuit breaker or fuses). However, a DC arc fault does not spend itself, even when the current is low. It could be a serious hazard, particularly for PV modules on buildings.
- Circuit breakers and switches used in PV systems are designed to break the rated current or fault current with all poles at open-circuit maximum voltage (UOC MAX). To break the current when UOC MAX is equal to 1100 V, for instance, four poles in series (two poles in series for each polarity) are required. In double ground fault situations, the circuit breaker or switches must break the current at full voltage with only two poles in series. Such switchgear is not designed for that purpose and could sustain irreparable damage if used to break the current in a double-ground fault situation.

The ideal solution is to prevent double ground faults from arising. Insulation monitoring devices or overcurrent protection in grounded systems detects the first fault. However, although the insulation fault monitoring system usually stops the inverter, the fault is still present. Qualified personnel must locate and clear it without delay. In large generators with sub arrays protected by circuit breakers, it is highly advisable to disconnect each array when that first fault has been detected but not cleared within the first few hours.

Figure 21 shows an example of earthing circuit connections for a de-centralize PV design.

Figure 21 Earthing circuit connections



Country and area installation codes for earthing PV systems must be followed when sizing the earthing conductor. Selection of system components like SPDs, MCCB and MCB, disconnect switches, panel enclosures, and cables should be in accordance with the type of earthing system followed by the utility and required by the type of installed transformer. Typical practices followed by local area safety council and fire-fighting departments should be taken into consideration when designing the PV system earthing scheme.

Transformer Selection

Transformers for PV applications are designed with respect to the size of the AC block. We recommend multiples of a 1100 kVA block for large MW scale plants. Smaller residential or commercial plants, which need to connect to utility POC at medium voltage levels, can be ranged anywhere between 33 kW to 990 kW.

⚠ ⚠ WARNING

HAZARD OF ELECTRIC SHOCK, EXPLOSION, ARC FLASH, AND FIRE

Connect the AC output of the CL 33 inverter to a suitably rated isolation transformer that is appropriate for the overall system design and that meets the technical requirements described in this document.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Follow these guidelines when selecting a transformer:

- A shield winding is recommended as a dU/dt filter between the low voltage and high voltage windings.
- LV-MV impedance Z (%) for the transformer must be nominally 6%. In case of multiple LV windings, Z (%) refers to a simultaneous short circuit on all LV terminals.
- Configuration of the MV transformer should take into account the local grid frequency and should meet local and regional standards.
- Dyn11 or Dyn1 type transformers should be connected with CL 33 inverters. The LV voltage of the transformer should match the inverter’s AC output voltage and MV voltage should match the grid connection voltage. CL 33 inverters can also connect to Delta type networks. Choose the transformer based on utility network requirements.
- For multiple inverters connected on one transformer secondary winding, the low voltage (inverter-side) windings of the MV transformer can only be configured as floating Wye (Dyn11). If the MV side of the system is grounded Wye, use of a floating Wye on the inverter side may not be allowed by the local utility. Make sure you understand your system configuration and the utility’s rules before installation.

Figure 22 Parallel connection of multiple inverters to transformer winding

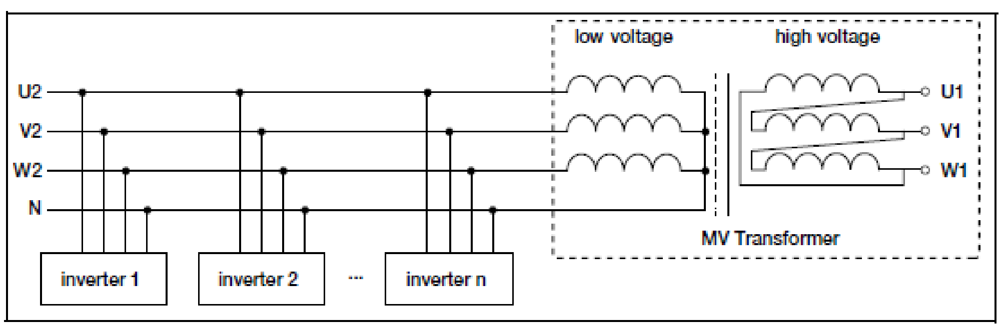


Table 13 lists the generalized power loss values for transformer ratings and impedance, based on standard transformer sizes, according to EU regulation 548/2014 – Ecodesign.

Table 13 Power loss values for transformer ratings and impedance

		Load losses (Copper)				No load losses (Iron)				
Ucc	Sn	Dk	Ck	Bk	Ak	E0	D0	C0	B0	A0
4%	50 kVA	1350 W	1100 W	870 W	750 W	190 W	145 W	125 W	110 W	90 W
	100 kVA	2150 W	1750 W	1475 W	1250 W	320 W	260 W	210 W	180 W	145 W
	160 kVA	3100 W	2350 W	2000 W	1700 W	460 W	375 W	300 W	260 W	210 W
	250 kVA	4200 W	3250 W	2750 W	2350 W	650 W	530 W	425 W	360 W	300 W
	315 kVA	5000 W	3900 W	3250 W	2800 W	770 W	630 W	520 W	440 W	360 W
	400 kVA	6000 W	4600 W	3850 W	3250 W	930 W	750 W	610 W	520 W	430 W
	500 kVA	7200 W	5500 W	4600 W	3900 W	1100 W	880 W	720 W	610 W	510 W
	630 (4%)	8400 W	6500 W	5400 W	4600 W	1300 W	1030 W	860 W	730 W	600 W
6%	630 (6%)	8700 W	6750 W	5600 W	4800 W	1200 W	940 W	800 W	680 W	560 W
	800 kVA	10500 W	8400 W	7000 W	6000 W	1400 W	1150 W	930 W	800 W	650 W
	1000 kVA	13000 W	10500 W	9000 W	7600 W	1700 W	1400 W	1100 W	940 W	770 W
	1250 kVA	16000 W	13500 W	11000 W	9500 W	2100 W	1750 W	1350 W	1150 W	950 W

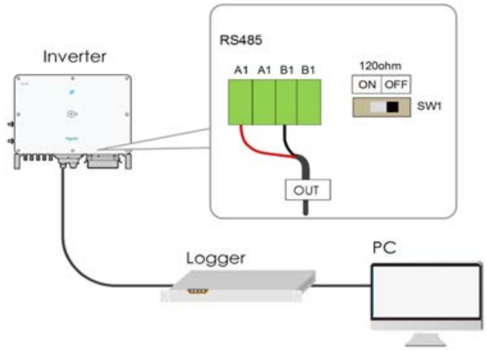
For multi-MW PV systems, we recommend paralleling a maximum of 30 CL 33 inverters to each LV winding of transformer with lower impedance and a slightly oversized (up to 10%) transformer would support smooth parallel operation of inverters. We recommend using standard transformer sizes readily available on the market to avoid long manufacturing time and higher market prices.

Schneider Electric offers Minera PV type high-efficiency oil-immersed transformer for photovoltaic systems up to 1250 kVA and 36 kV, 50/60 Hz.

Monitoring System Design

CL 33 inverters offer options to connect over Modbus RS485. Two ports (RJ45) for each Modbus RTU are provided. A data-logger, such as Conext Gateway , could be configured to connect with the inverter and use the data logged by the inverter to display over the monitoring portal. CL 33 inverters offer standard Sunspec Modbus protocol for connectivity with Conext Gateway .

Figure 23 Modbus RS485



For designing the communication architecture, we recommend keeping the length of Modbus RS485 loops under 1000 m (length from monitoring data-logger to the last inverter).

If multiple inverters are inter-connected by daisy chain, the first and last inverters in the chain must be terminated with a 120 W resistor (set SW1 to OFF). If there is a single inverter, it must be terminated with a 120 W resistor (set SW1 to OFF).

Conext Gateway specifies the limit of total number of inverters connected over a daisy chain (mostly up to 32) but this is an important parameter to know while designing the communication circuit for CL 33 inverters.

Conext Gateway is pre-tested and qualified for plug and play.

For more information, visit:

Schneider Electric options: http://solar.schneider-electric.com/

Grid Connection

The connection of the PV plant to the utility grid terminates at the point of common coupling (PCC). Schneider Electric provides a grid box solution for achieving utility requirements at the PCC. Generally, the grid box consists of the following components:

- An MV switchgear of rated grid voltage, current, and fault current breaking capacity
- Tariff metering for Utility and Check Metering for PV plant owner
- PV plant controller
- A supervisory, Control and Data Acquisition system for the PV plant (if required by either the utility or the client)
- PV plant service transformer
- AC power distribution box
- Communication center for SCADA systems and PV plant security (optional)
- Main weather station of PV plant

Depending on the equipment and system, the size and quantity of the grid box could change.

Along with basic monitoring capability, Schneider Electric offers advanced, state-of- the-art PV plant SCADA systems with the Conext control monitoring platform, as requested by client.

Contact Schneider Electric for further information about configuring SCADA systems, PV plant communication, and grid controller offers.

Role of Circuit Impedance in Parallel Operation of Multiple CL 33 PV Inverters

The following recommendations are intended to help with the continuous parallel operation of CL 33 inverters:

- Restrict the AC cable impedance up to 1% of power loss.
- Restrict the Transformer impedance (between LV and HV winding) up to 6%.
- If a three winding transformer is used (HV-LV-LV) including above point, also maintain the short circuit impedance of minimum or greater than 9% between each LV winding.
- Oversize (by 10%) the transformer kVA capacity with respect to installed inverter kW capacity.
- The AC cable sizing calculation should also consider the reactive impedance of cables and not just resistive. Grid impedance is an important parameter for this consideration.
- Calculate the grid impedance at PCC before designing the overall PV plant circuit.

4 Layout Optimization

What's in This Chapter?

Layout Design Rules

DANGER

HAZARD OF ELECTRIC SHOCK AND FIRE

Installation, including wiring, must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes, including relevant local, regional, and national regulations. Installation instructions are not covered in this Solution Guide, but are included in the relevant product manuals for the CL 33 inverter. Those instructions are provided for use by qualified installers only.

Failure to follow these instructions will result in death or serious injury.

The following layout design recommendations can be used to design standard blocks using CL 33 inverters:

- Selection of the structural design should be based on the string length and the number of strings connected to each inverter.
- Arrangement of modules on the PV racking should be decided in-line with the length of string to reduce the DC string cable route length. In case of single axis trackers, this requirement becomes more stringent from both inverter and tracker's perspective.
- Location of the inverter should be decided prior to defining the block size.
- Connection of the strings to the inverter and use of a DC array combiner will be dependent on the location of the PV inverter.
- Location of the AC array combiner box and LV-MV station should be selected in line with the block size, to divide blocks and reduce the cable length from teh AC combiners to the LV-MV station.
- In most cases, the standard defined block should be duplicated multiple times to help avoid wiring mistakes and shorten the installation time.

5 Frequently Asked Questions

What's in This Chapter?

FAQ

DANGER

HAZARD OF ELECTRIC SHOCK AND FIRE

Installation, including wiring, must be done by qualified personnel to ensure compliance with all applicable installation and electrical codes, including relevant local, regional, and national regulations. Installation instructions are not covered in this Solutions Guide, but are included in the relevant product manuals for the CL 33 inverter. Those instructions are provided for use by qualified installers only.

Failure to follow these instructions will result in death or serious injury.

Planning and Installation FAQ

Do I need to contact Schneider Electric at the time of designing a PV system configuration for proposal?

Schneider Electric does not provide any proposal for designing a PV system. However Schneider Electric has .OND files of CL 33 inverters which can be used with PV Syst for Designing a PV system.

What type of support can I have from Schneider Electric for designing configuration of my PV system?

Schneider Electric provides reference documentation for designing the system, for example, a solutions guide, owner's guide, training material etc. Contact us for any additional information or services.

Do I need assistance from Schneider Electric for the first installation of CL 33 inverters?

No. For first installation, follow Schneider Electric's *CL 33 Owner's Guide (document number 990-91392)*. Identify any possible hazardous conditions, use a certified installer, and follow recommended installation practices. In case of any difficulties, you can contact Schneider Electric for assistance.

Which parameters I do have to confirm and use to order CL 33 inverters?

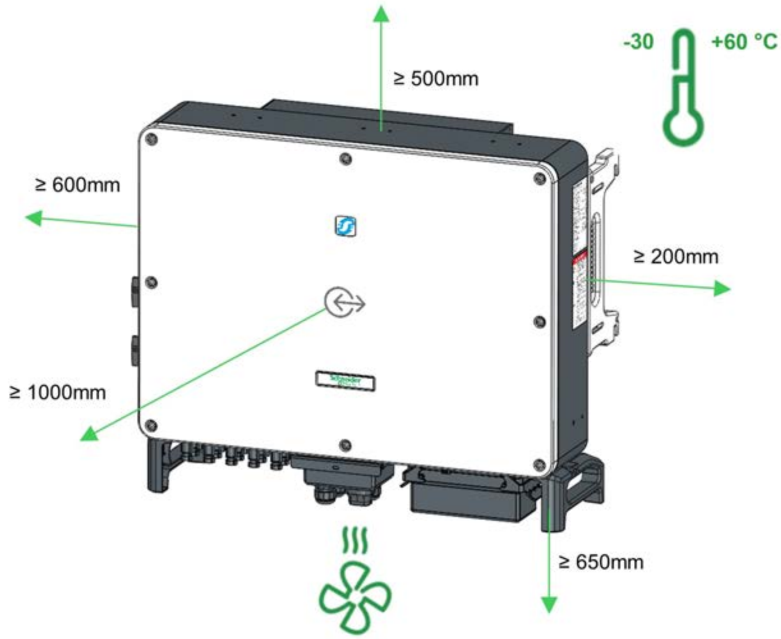
Unlike centralized inverters, CL 33 PV inverters are simple to configure and install. Since it is simple, there is not any technical information sheet to fill in in order to buy these inverters. Schneider Electric's sales representatives can help you to buy the right type of inverter and associated wiring box. This solutions guide can be used to select the right wiring box.

Can I install the CL 33 inverter in an outdoor location?

The CL 33 inverter is rated for outdoor use. It can be installed as described in the *CL 33 QuickStart Guide (document number 990-91393)*. In any installation, keep the inverter LCD screen protected from direct exposure to sun.

How much space do I need to install CL 33 inverters side by side?

Figure 24 Installation space between inverters



What type of monitoring system can I use with CL 33 inverters?

Schneider Electric CL 33 inverters are compatible with Conext Gateway monitoring solutions. Contact your Schneider Electric sales representative to plan this in advance.

Can I remotely reset (on or off) the inverter over Modbus?

Yes.

Downloading Files FAQ

What is the Schneider Electric customer care contact information for technical support?

You can find customer care contact details in your respective region at: http://solar.schneider-electric.com/tech-support/

Where can I find an Installation manual for CL 33 inverters?

You can find the Installation manual for CL 33 inverters under **Downloads** at:

https://solar.schneider-electric.com/product/conext-cl33-string-inverter-iec/

Where can I find the test certificates for CL 33 inverter?

You can find CL 33 inverter certifications at: https://solar.schneider-electric.com/product/conext-cl33-string-inverter-iec/

What type of warranty does Schneider Electric offer for CL 33 inverters?

Warranty terms for CL 33 inverters depends on the region of installation. You can find the information about standard warranty at: https://solar.schneider-electric.com/product/conext-cl33-string-inverter-iec/

How can I update the firmware version of CL 33 inverters?

CL 33 inverter firmware is available at:
https://solar.schneider-electric.com/product/conext-cl33-string-inverter-iec/

You can download the latest firmware and upload it using the Insight Mobile App on your Mobile phone. Each time a CL 33 inverter is being installed, the installer should check for revisions and use the latest firmware version available on this website.

Where can I find the CL 33 OND file for PVsyst simulation?

You can find OND files for PVsyst simulation at:
https://solar.schneider-electric.com/product/conext-cl33-string-inverter-iec/

Is there any tool from Schneider Electric to help me size the strings for my installation?

No. Schneider Electric Clients can obtain help from Sales Application engineers to size correct strings or use a third party software like PVsyst.

Wiring and Cabling FAQ

Which other system components Schneider Electric can offer?

Follow the chart provided in *PV System Modeling on page 22* to check the offers from Schneider Electric.

What type of wiring schemes can CL 33 inverters be connected to?

CL 33 inverters can be connected to TN-C, TN-C-S, TN-S, TT,and IT wiring schemes.

Can I install third party components inside the wiring box?

No. Components installed inside the wiring box are tested in the factory before dispatch and hold warranty for the product. If any external component is installed inside the wiring box, that may void warranty.

What is the solution if my AC cable size is higher than the terminal size of the CL 33 inverter?

An external AC terminal box has to be used in certain situations. This box will have input from the inverter with the maximum cable size the inverter terminal can fit (35 mm^2). The output terminal of this AC box can have higher sized cables as required by design.

Is it possible to have a different wiring box for CL 33 inverters?

CL 33 inverters are offered with only one type of wiring box (built-in, not separate). Details of components are as described in the datasheet.

Is it mandatory to use an AC circuit breaker at the output of CL 33 wiring box?

We recommend that you use the circuit breaker to support the AC surge protection device.

What is the brief specification of DC and AC Surge protection devices provided in the wiring box of the CL 33 inverters?

CL 33 wiring boxes are equipped with Type 2 DC and AC surge protection devices.

What type and size of cable could be connected to the output of CL 33 inverters?

Terminals: L1 ,L2, L3, N and PE
Terminal type: Screw
Min/max cable copper: 5 wires with N 16-35 mm^2
Cable outer diameter: 20-50 mm

Transformer FAQ

What type of transformer can I connect to CL 33 inverters?

See *Important Aspects of a Decentralized System Design on page 63*.

Dyn11 or Dyn1 type transformers should be connected with CL 33 inverters. The LV voltage of the transformer should match the inverter’s AC output voltage and MV voltage should match the grid connection voltage. CL 33 inverters can also connect to Delta type networks. Choose the transformer based on utility network requirements.

How does the choice of transformer affect the inverter's operating capability?

The inverter’s operational capability depends on the transformer in two ways:

1. Parallel operation of inverter: The inverter’s parallel operation is a function of short circuit impedance (Z%); the transformer is a circuit component with a very large impedance which equates to a large proportion of the overall circuit impedance. We recommend keeping the impedance of the transformer as low as possible.
2. CL 33 inverter supports TN-C, TN-C-S, TN-S, TT,and IT wiring schemes. When the transformer is selected, it is important to match:
    a. utility side winding requirement with the point of connection
    b. low voltage side winding requirement with the inverter’s operational compatibility

Do I need to oversize my transformer when I connect to multiple CL 33 inverters?

We recommend equal or oversized transformers for CL 33 inverters, especially when there is a large number of CL 33 inverters connected in parallel to one transformer low voltage winding. We recommend you oversize the transformer by 10%, however this is not mandatory.

Specification FAQ

Is the power measurement inside CL 33 inverters good enough for tariff metering?

Power measurement inside CL 33 inverters takes place with built-in sensors. The power reading is calculated based on voltage and current sensors measurement within the inverter, each with 1% accuracy. Generally, tariff metering has stringent requirements for accuracy and other compliances related to utility. You must discuss this requirement in detail with your utility company.

What is the maximum oversizing I can achieve for CL 33 inverters?

Maximum oversizing for CL 33 inverter could be up to 50% (1.5 DC-AC ratio). If more than 50% oversizing is required, please contact your local Sales application engineer for technical assessment in string sizing. In any scenario, the limits of short circuit current for the inverter should not be violated. For more details, read the string sizing application note available on our website.

What is the power factor limit CL 33 inverters are capable of operating within?

CL 33 can operate within 0.8 leading to 0.8 lagging power factor limit.

Does the CL 33 inverter support LVRT, HVRT requirement?

Yes. LVRT, HVRT requirement is specified in the respective PV grid code of the country. CL 33 inverter firmware is programmed to follow the LVRT, HVRT requirement (curve) during certification for each country. Contact us to learn the list of countries CL 33 inverters are certified for.

Is there anti-islanding protection provided in CL 33 inverters?

Yes. CL 33 inverters are equipped with anti-islanding protection.

What is the output operating voltage range (capability and limits) and response to network voltage sags?

The CL 33 inverter will deliver full power at unity power factor with +30% and -5% grid voltage variation.

What is the latency to set the output of the inverter to 0% from 100%?

Latency is 2 seconds (maximum); typically 1 second.

What is the latency to set the output of the inverter to 100% from 0%?

Latency is 2 seconds (maximum); typically 1 second.

Can I control the output of the inverter in 1% steps? What is the time resolution?

1% steps is possible and latency is 2 seconds (maximum); typically 1 second.

How long does it take for a firmware upgrade over Ethernet for a single inverter?

Approximately 10 to 15 minutes.

What is the value of the CL 33 inverter's impedance?

Calculation of the impedance at 175 Hz (R and X)
R + jX = 0.006 – j58.299
Resistance = 0.006 ohm
Reactance = -58.299j

What is the switching frequency for CL 33 inverters?

Boost converter = 16 kHz
Inverter=16 kHz

Does the CL 33 inverter store any data? How much data and what is stored?

Preservation machine operation and fault information:

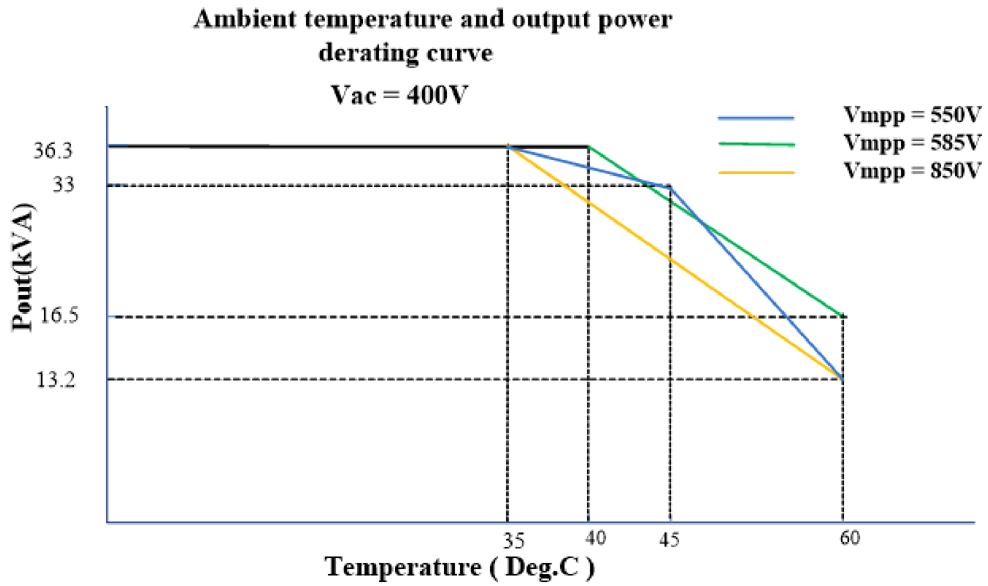
1. Operation information (five minutes per day over the last 30 days).
2. Recent fault information recording (last 400 entries).
3. Recently recorded event information recording (last 400entries).

4. Monthly and annual energy production
    a. power curve (7 days)
    b. generating capacity (approximately 365 days)
    c. monthly energy output (180 months)
    d. generating capacity (30 years)

De-rating FAQ

When does the temperature de-rating begin for CL 33 inverters? How much does it de-rate?

Figure 25 Power derating due to temperature

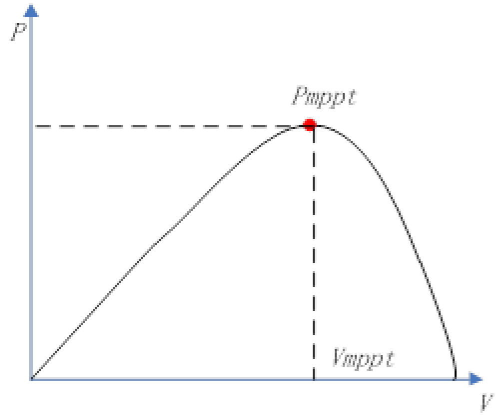


What is the CL 33 inverter's de-rating with respect to AC output voltage?

When AC voltage increases, it will not result in derating, just power limitation. This is because at the same power, current decreases. Power decreases only when AC voltage decreases, because after current reaches rated maximum current, it can not be increased. At the same time, if the power decrease is due to a grid voltage decrease, the inverter won't display "derating". The output power values at Vdc 585 V are:

Vmin = 180 V: S=16.5 kVA
Vnom = 220 V: 36.3 kVA @ 40 °C
Vmax = 305 V: 36.3 kVA @ 40 °C

Can you explain a detailed DC voltage vs. power curve for operating, de-rating and off conditions with respect to specific voltage or range of voltages?



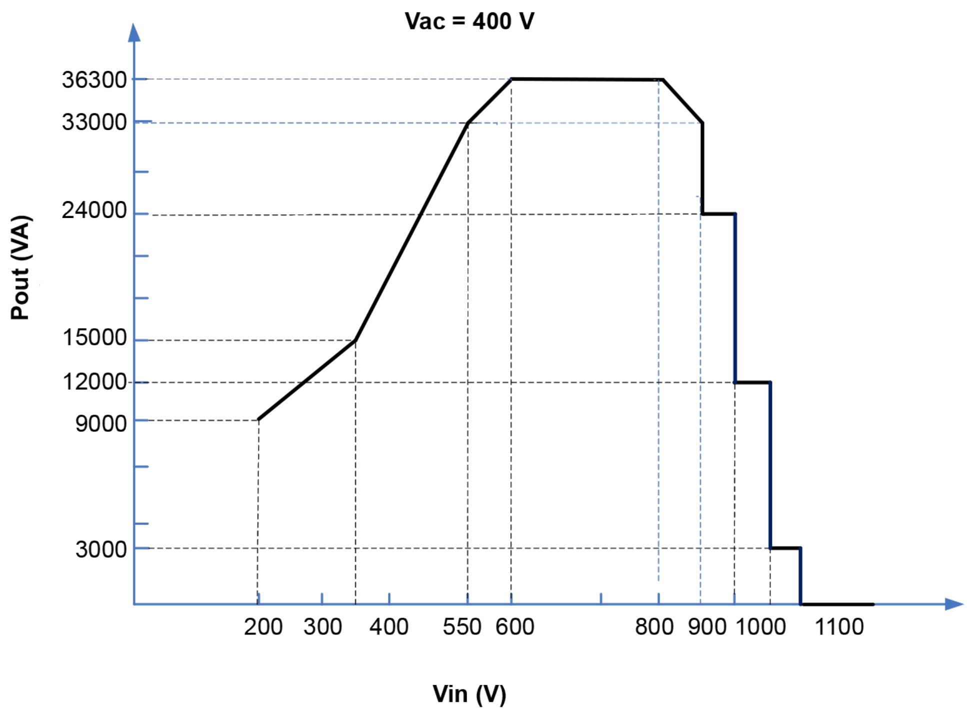
MPPT voltage range: 200 ~ 1000 V

Full MPPT voltage range: 550 ~ 850 V

Maximum voltage: 1000 V

Starting voltage: 250 V

See the diagram below for more details.



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As standards, specifications, and designs change from time to time, please ask for confirmation of the information given in this publication.

For other country details please contact your local Schneider Electric Sales Representative or visit the Schneider Electric Solar Business website at: http://solar.schneider-electric.com/

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