

System description

Off-Grid Systems with SUNNY ISLAND 4.4M / 6.0H / 8.0H



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1 Information on this Document

1.1 Validity

This document is valid for off-grid systems with the following device types:

- SI4.4M-12 (Sunny Island 4.4M) with firmware version 1.00.xx.R
- SI6.0H-12 (Sunny Island 6.0H) with firmware version 1.00.xx.R
- SI8.0H-12 (Sunny Island 8.0H) with firmware version 1.00.xx.R
- MC-BOX-6.3-11 (Multicluster-Box 6)
- MC-BOX-12.3-20 (Multicluster-Box 12)
- MC-BOX-36.3-11 (Multicluster-Box 36)

1.2 Target Group

The tasks described in this document must only be performed by qualified persons. Qualified persons must have the following skills:

- Knowledge of how an inverter works and is operated
- Knowledge of how batteries work and are operated
- Training in the installation and commissioning of electrical devices and installations
- Knowledge of all applicable laws, standards and directives
- Knowledge of and compliance with this document and all safety information
- Knowledge of and compliance with the documents of the battery manufacturer with all safety information

1.3 Content and Structure of this Document

This document summarizes the specific information on off-grid systems with Sunny Island inverters.

Circuitry overviews provide the basic principle of how a system must be connected. The structure of the document specifies the chronological sequence for configuration and commissioning. This document does not replace the documentation of the individual products. You will find details and help in the event of difficulties in the documentation of the respective product.

1.4 Levels of warning messages

The following levels of warning messages may occur when handling the product.

DANGER

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

WARNING

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






CAUTION

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

NOTICE

Indicates a situation which, if not avoided, can result in property damage.

1.5 Symbols in the Document

Symbol	Explanation
	Information that is important for a specific topic or goal, but is not safety-relevant
	Example
<input type="checkbox"/>	Indicates a requirement for meeting a specific goal
<input checked="" type="checkbox"/>	Desired result
x	A problem that might occur
	This information is relevant for systems which are to be operated in parallel with utility grid. (e.g. SMA Flexible Storage System).
	
	Content is relevant for off-grid systems.

1.6 Typographies in the document

Typography	Use	Example
bold	<ul style="list-style-type: none"> • Messages • Terminals • Elements on a user interface • Elements to be selected • Elements to be entered 	<ul style="list-style-type: none"> • Connect the insulated conductors to the terminals X703:1 to X703:6. • Enter 10 in the field Minutes.
>	<ul style="list-style-type: none"> • Connects several elements to be selected 	<ul style="list-style-type: none"> • Select Settings > Date.
[Button]	<ul style="list-style-type: none"> • Button or key to be selected or pressed 	<ul style="list-style-type: none"> • Select [Enter].
[Key]		

1.7 Designation in the document

Complete designation	Designation in this document
Sunny Boy, Sunny Tripower	PV inverter

1.8 Explanation of Used Terms

Term	Explanation
External energy source	Grid-forming generators such as electric generators or utility grids
Stand-alone grid	Stand-alone grids are self-sufficient utility grids that are supplied with power from different energy sources. The Sunny Island forms the stand-alone grid and regulates the balance between the energy that is fed in and the energy that is used.
Off-grid system	All components belonging to the stand-alone grid (e.g., Sunny Island)

1.9 Additional Information

For more information, please go to www.SMA-Solar.com.

Title and information content	Type of information
"SUNNY ISLAND System Guide - System Solutions for Your Stand-Alone Power Supply"	Brochure
"Sunny Island Generator - Whitepaper"	Technical File
"Grounding in Off-Grid Systems"	Technical Information
"Design of Off-Grid Systems with Sunny Island Devices"	Planning Guidelines
"Multicluster Systems with Stand-Alone Grid or Increased Self-Consumption and Battery-Backup Function"	System Description

2 Safety

2.1 Intended Use

Off-grid systems with Sunny Island are used to set up self-sufficient utility grids. The Sunny Island forms the stand-alone grid as a voltage source. The Sunny Island regulates the balance between the energy fed in and energy used and features a management system that manages the battery, generators and loads. AC sources (e.g. PV inverters) supply loads and are used by the Sunny Island to recharge the battery. In order to be able to increase the availability of the off-grid system and reduce the battery capacity, the Sunny Island can use and control a generator as an energy source.

Off-grid systems with Sunny Island form single-phase or three-phase AC distribution grids.

The locally applicable standards and directives must also be observed for off-grid systems. Loads in off-grid systems are not protected against power failure.

The product is not suitable for supplying life-sustaining medical devices. A power outage must not lead to personal injury.

Loads connected to the Sunny Island must have an CE, RCM or UL identification label.

Only the device types SI6.0H-12 and SI8.0H-12 are suitable for single-phase single cluster systems and three-phase multi cluster systems (see planning guidelines "Design of Off-Grid Systems with Sunny Island Devices" at www.SMA-Solar.com). Several clusters may only be interconnected if the Multicluster-Box 6 / 12 (MC-BOX-12.3-20) / 36 is used.

The circuitry of the Sunny Island inverters forming a cluster and the circuitry of several clusters in a multicluster system must be carried out in accordance with this documentation (see Section 3 "Functions and Design", page 13).

In off-grid systems, the maximum output power of the non-adjustable AC current sources (e.g. wind turbine system or CHP plant) must not exceed the total power of all Sunny Island devices (for technical data, see the Sunny Island operating manual).

The connected PV inverters must be suitable for use in off-grid systems. The power of the PV system must be appropriate for the system (see planning guidelines "Design of Off-Grid Systems with Sunny Island Devices" at www.SMA-Solar.com).

The entire battery voltage range must be completely within the permissible DC input voltage range of the Sunny Island. The maximum permissible DC input voltage of the Sunny Island must not be exceeded. A battery fuse must be installed between the battery and the Sunny Island.

With lead-acid batteries, the battery room must be ventilated in accordance with the requirements of the battery manufacturer and with the locally applicable standards and directives (see documentation of the battery manufacturer).

The following conditions must be satisfied for lithium-ion batteries:

- The lithium-ion battery must comply with the locally applicable standards and directives and must be intrinsically safe.
- The battery management of the lithium-ion battery used must be compatible with the Sunny Island (see the technical information at "List of Approved Batteries").
- The lithium-ion battery must be able to supply enough current at maximum output power of the Sunny Island (for technical data see the Sunny Island operating manual).

An DC supply grid may not be established with the Sunny Island.

Use this product only in accordance with the information provided in the enclosed documentation and with the locally applicable standards and directives. Any other application may cause personal injury or property damage.

Alterations to the product, e.g. changes or modifications, are only permitted with the express written permission of SMA Solar Technology AG. Unauthorized alterations will void guarantee and warranty claims and in most cases terminate the operating license. SMA Solar Technology AG shall not be held liable for any damage caused by such changes.

Any use of the product other than that described in the Intended Use section does not qualify as the intended use. The enclosed documentation is an integral part of this product. Keep the documentation in a convenient place for future reference and observe all instructions contained therein.

2.2 Safety Information

This section contains safety information that must be observed at all times when working on or with the product.

To prevent personal injury and property damage and to ensure long-term operation of the product, read this section carefully and observe all safety information at all times.

DANGER

Danger to life from electric shock due to live voltage

High voltages are present in the live components of the inverter when in operation. Touching live components results in death or serious injury due to electric shock.

- Wear suitable personal protective equipment for all work on the product.
- Do not touch any live components.
- Observe all warning messages on the inverter and in the documentation.
- Observe all safety information of the battery manufacturer.
- Switch off or disconnect the following components from voltage sources in the following order before carrying out any work:
 - Sunny Island
 - The circuit breakers of the Sunny Island, the control and measurement voltages
 - All circuit breakers and load-break switches of the connected AC sources
 - Load-break switch of the battery fuse
- Ensure that no disconnected devices can be reconnected.
- After disconnecting the Sunny Island from voltage sources, wait at least 15 minutes for the capacitors to discharge completely before opening the doors.
- Before carrying out any work make sure that all devices are completely voltage-free.
- Cover or isolate any adjacent live components.

DANGER

Danger to life due to electric shock

Overvoltages (e. g. in the case of a flash of lightning) can be further conducted into the building and to other connected devices in the same network via network cables or other data cables if there is no overvoltage protection.

- Ensure that all devices in the same network and the battery are integrated in the existing overvoltage protection.
- When laying the network cables or other data cables outdoors, attention must be given to suitable overvoltage protection at the cable transition from the inverter or the battery outdoors to the inside of a building.

⚠ WARNING**Danger to life from electric shock due to circuit breakers that cannot be tripped**

In an off-grid system and battery-backup system, only the circuit breakers that can be tripped by the Sunny Island can be tripped in the event of a grid failure. Circuit breakers with a higher operating current cannot be tripped. Under fault conditions, a voltage that poses a danger to life may be present on accessible parts for several seconds.

- Check if a circuit breaker has a higher trip characteristic than the following circuit breakers which can be tripped:
 - SI4.4M-12: circuit breaker with trip characteristic B6 (B6A)
 - SI6.0H-12 and SI8.0H-12: circuit breaker with trip characteristic B16 (B16A) or circuit breaker with trip characteristic C6 (C6A)
- If a circuit breaker has a higher trip characteristic than the specified circuit breakers that can be tripped, you should also install a residual-current device of type A.

⚠ WARNING**Danger to life from electric shock due to overvoltages**

Overvoltages of up to 1500 V can occur in the stand-alone grid and in the battery-backup grid. If the connected loads have not been designed for these overvoltages, a voltage that poses a danger to life may be present on accessible parts for several seconds.

- Only connect loads that have a CE, RCM or UL designation. Loads with a CE, RCM or UL designation are designed for overvoltages of up to 1500 V.
- Operate the loads only when they are technically faultless and in an operationally safe state.
- Check the loads regularly for visible damage.

⚠ WARNING**Danger to life from electric shock due to damaged inverter**

Operating a damaged inverter can lead to hazardous situations that can result in death or serious injuries due to electric shock.

- Only use the inverter when it is technically faultless and in an operationally safe state.
- Check the inverter regularly for visible damage.
- Make sure that all external safety equipment is freely accessible at all times.
- Make sure that all safety equipment is in good working order at any time.

⚠ WARNING**Risk of crushing injuries due to moving PV array parts**

A generator can be started automatically by the Sunny Island. Moving parts in the PV array can crush or sever body parts.

- Operate the generator only with the specified safety equipment.
- Carry out all work on the generator in accordance with the manufacturer's specifications.

⚠ CAUTION**Risk of burns due to short-circuit currents on the disconnected inverter**

The capacitors in the DC input area of the inverter store energy. After the battery is isolated from the inverter, battery voltage is still temporarily present at the DC terminal. A short circuit at the DC terminal of the inverter can lead to burns and may damage the inverter.

- Wait 15 minutes before performing any work at the DC terminal or on the DC cables. This allows the capacitors to discharge.

⚠ CAUTION**Risk of burns due to hot enclosure parts**

Some parts of the enclosure can get hot during operation.

- Mount the inverter in such a way that it cannot be touched inadvertently during operation.

NOTICE**Damage to the product due to sand, dust or moisture penetration**

Sand, dust or moisture penetration can damage the inverter or impair its functionality.

- Do not open the inverter during a sandstorm, precipitation or when humidity exceeds 95%.
- Only perform maintenance work on the inverter when the environment is dry and free of dust.

NOTICE**Damage to the inverter due to electrostatic discharge**

Touching electronic components can cause damage to or destroy the inverter through electrostatic discharge.

- Ground yourself before touching any component.

NOTICE**Damage to the enclosure seal in subfreezing conditions**

If you open the product when temperatures are below freezing, the enclosure seals can be damaged. Moisture can penetrate the product then.

- Only open the product if the ambient temperature is not below -5°C .
- If a layer of ice has formed on the enclosure seal when temperatures are below freezing, remove it prior to opening the product (e.g. by melting the ice with warm air). Observe the applicable safety regulations.

2.3 Battery Safety Information

This section contains safety information that must be observed at all times when working on or with batteries.

To prevent personal injury or property damage and to ensure long-term operation of the batteries, read this section carefully and observe all safety information at all times.

⚠ WARNING**Danger to life due to incompatible lithium-ion battery**

An incompatible lithium-ion battery can lead to a fire or an explosion. With incompatible lithium-ion batteries, it is not ensured that battery management is intrinsically safe and will protect the battery.

- Ensure that the lithium-ion batteries are approved for use with the Sunny Island (see technical information “List of Approved Batteries” at www.SMA-Solar.com).
- If no lithium-ion batteries approved for the inverter can be used, lead-acid batteries can be used.
- Verify that the battery complies with locally applicable standards and directives and is intrinsically safe.

⚠ WARNING**Danger to life due to explosive gases**

Explosive gases may escape from the battery and cause an explosion.

- Protect the battery environment from open flames, embers and sparks.
- Install, operate and maintain the battery in accordance with the manufacturer’s specifications.
- Do not burn the battery and do not heat it beyond the permitted temperature.
- Additional measures for lead-acid batteries: Ensure that the battery room is sufficiently ventilated.

⚠ WARNING**Chemical burns due to battery electrolyte**

If handled inappropriately, battery electrolyte can leak from the battery and cause irritation to the eyes, respiratory system and skin.

- Install, operate, maintain and dispose of the battery according to the manufacturer’s specifications.
- Whenever working on the battery, wear suitable personal protective equipment such as rubber gloves, an apron, rubber boots and goggles.
- Rinse acid splashes thoroughly for a long time with clear water, and consult a doctor immediately.
- If acid fumes have been inhaled, consult a doctor immediately.

⚠ WARNING**Risk of burns due to flashes**

Short-circuit currents in the battery can cause heat build-up and flashes.

- Remove watches, rings and other metal objects prior to carrying out any work on the battery.
- Use insulated tools for all work on the battery.
- Do not place tools or metal parts on the battery.

⚠ CAUTION**Risk of burns due to hot battery components**

Improper battery connection may result in excessively high transition resistances. Excessive transition resistances give rise to localized heat build-up.

- Ensure that all pole connectors are connected with the connecting torque specified by the battery manufacturer.
- Ensure that all DC cables are connected with the connecting torque specified by the battery manufacturer.

NOTICE**Damage to the battery due to incorrect settings**

The set battery parameters influence the charging behavior of the inverter. The battery can be damaged by incorrect settings of the battery type, nominal voltage and capacity parameters.

- Set the correct battery type as well as the correct values for nominal voltage and battery capacity when configuring.
- Ensure that the values recommended by the manufacturer are set for the battery (refer to the technical data of the battery in the manufacturer documentation).

NOTICE**Permanent damage to the battery due to improper handling**

Improper set-up and maintenance of the battery can cause it to become permanently damaged. Logs can help to determine the cause.

- Comply with all requirements of the battery manufacturer with regard to mounting location.
- Check and log the status of the battery before performing maintenance work. Tip: Many battery manufacturers provide suitable logs.
 - Check the battery for visible damage and log.
 - Measure and log the fill level and acid density of FLA batteries.
 - In the case of lead-acid batteries, measure and log the voltages of the individual cells.
 - Perform and log the test routines required by the battery manufacturer.

3 Functions and Design

3.1 Off-Grid System Functions

Off-grid systems with one or several Sunny Island are self-sufficient utility grids that are being fed with energy from several AC power sources in the stand-alone grid (e.g., PV inverter) and grid-forming AC sources (e.g., from a generator). The Sunny Island forms the stand-alone grid as an AC voltage source and provides active and reactive power. The Sunny Island regulates the balance between the energy fed in and energy used and features a management system that manages the battery, generators and loads.

In order to be able to distribute the output power of the off-grid system to the loads, several Sunny Island inverters can be interconnected modularly.

Battery Management

Exact determination of the state of charge is a basic requirement for the correct operation of lead-acid batteries.

The Sunny Island battery management system for lead-acid batteries is based on an exact determination of the state of charge. By combining the three most common methods for recording the state of charge, the Sunny Island reaches a measuring accuracy of more than 95%. This way, battery overcharge and deep discharge are avoided.

Another advantage of the battery management system is the very gentle charging control. Depending on the battery type and situation, it selects automatically the optimum charging strategy. This means that overcharging can be reliably prevented and that the battery can be fully charged regularly. The available charge energy is used optimally at all times (see technical information "Battery Management" at www.SMA-Solar.com).

Generator Management

The Sunny Island can synchronize with a generator and connect directly, if necessary. When the stand-alone grid is connected to the PV array, the voltage and frequency in the stand-alone grid are regulated by the PV array.

The Sunny Island generator management allows for uninterruptible connection of the stand-alone grid to the generator and uninterruptible isolation from the generator. The generator management controls the generator via a start and stop signal. A generator current control ensures that the generator always remains at the optimum operating point. The generator management allows the use of generators that have a low output power in proportion to the nominal load (see technical document "Sunny Island Generator - Whitepaper" at www.SMA-Solar.com).

Load Control

The load control enables control of the AC sources in stand-alone grids, control of a generator, and the specific disconnection of loads.

The AC sources in the off-grid system are limited in their power output by the stand-alone grid frequency. In case of excess energy, the load control system increases the power frequency of the stand-alone grid. This limits the output power of the PV inverters, for example.

If there is not enough energy available for all loads or the battery is to be preserved, load control can request energy from a generator by means of the generator management. The generator management starts the generator and the off-grid system is supplied with sufficient energy.

If no generator is present in the off-grid system or the energy is not sufficient despite the generator being available, load control turns the loads off using load shedding. All loads are shed simultaneously with one-stage load shedding. A load shedding contactor sheds the noncritical loads during the first stage with two-stage load shedding. The remaining loads are shed during the second stage only when the state of charge declines further. This can further increase the availability of the stand-alone grid for critical loads.

3.2 Modular Design

3.2.1 Single System

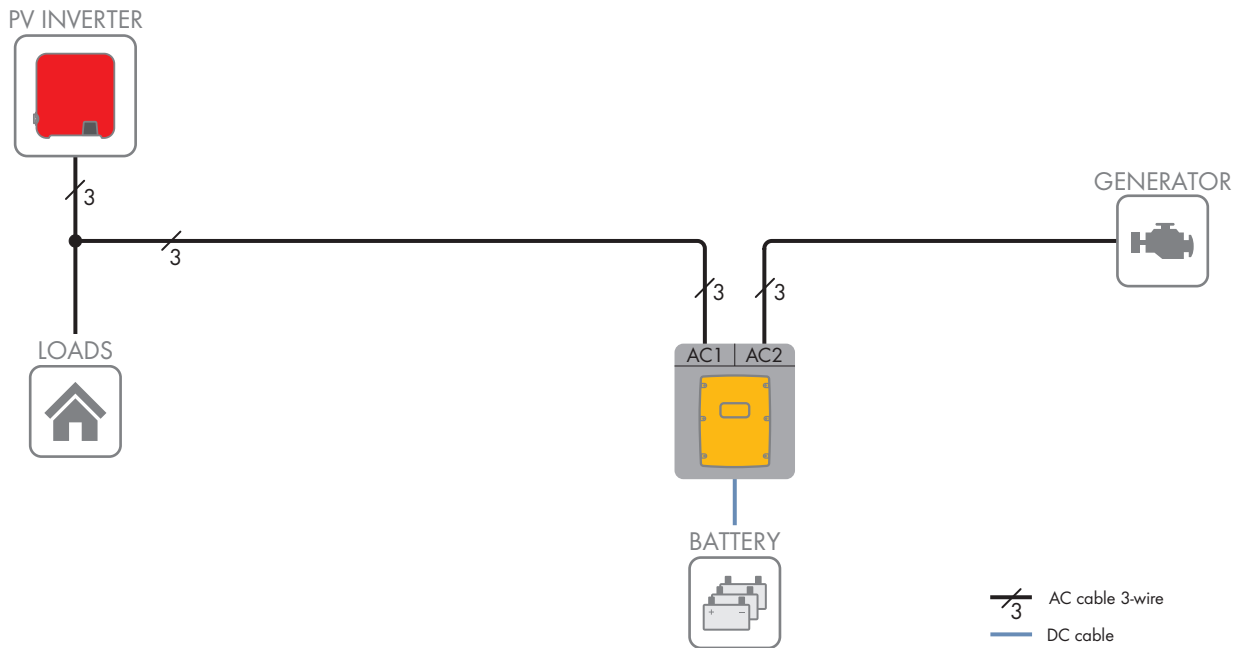


Figure 1: Principle of a single system

In a single system, one Sunny Island forms a single-phase stand-alone grid.

3.2.2 Single-Cluster System (Single-Phase)

i Required device types for single-phase single-cluster systems

In single-phase single-cluster systems, the Sunny Island inverters must be of device type SI6.0H-12 or SI8.0H-12.

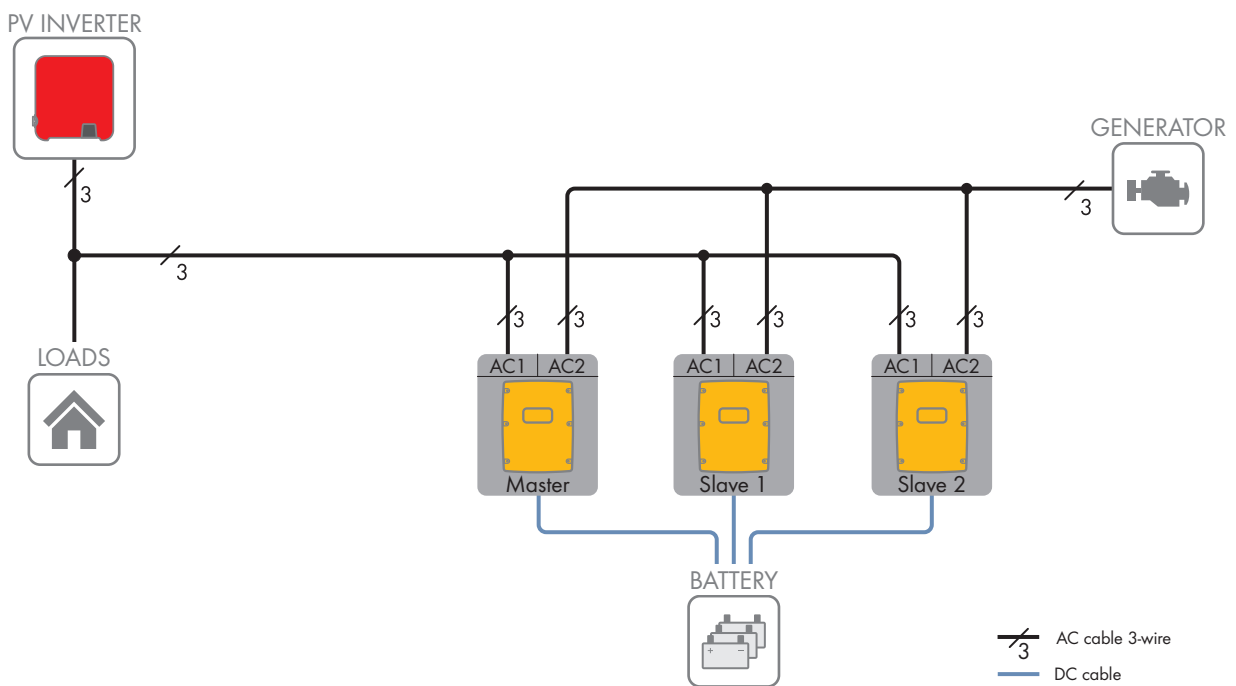


Figure 2: Principle of a single-phase single-cluster system

In a single-phase single-cluster system, up to three Sunny Island inverters are connected to one battery forming a cluster. The Sunny Island inverters are connected on the AC side to the same line conductor. If the device types within the cluster are different, the master must be an SI8.0H-12.

3.2.3 Single-Cluster System (Three-Phase)

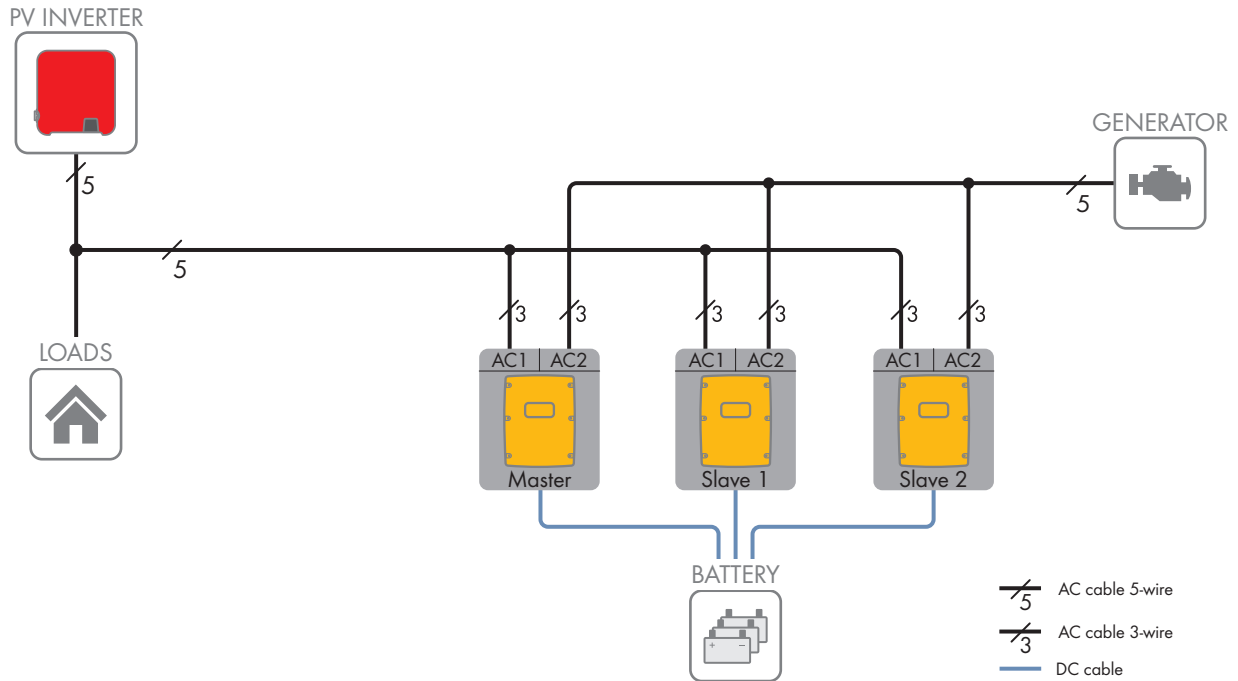


Figure 3: Principle of a three-phase single-cluster system

In a three-phase single-cluster system, up to three Sunny Island inverters are connected to one battery forming a cluster. The Sunny Island inverters are connected on the AC side to three different line conductors.

3.2.4 Multiclustler System

i Required device types for multiclustler systems

In multiclustler systems for stand-alone grids, the following device types must be used:

- SI6.0H-12 (Sunny Island 6.0H)
- SI8.0H-12 (Sunny Island 8.0H)
- MC-BOX-6.3-11 (Multiclustler-Box 6)
- MC-BOX-12.3-20 (Multiclustler-Box 12)
- MC-BOX-36.3-11 (Multiclustler-Box 36)

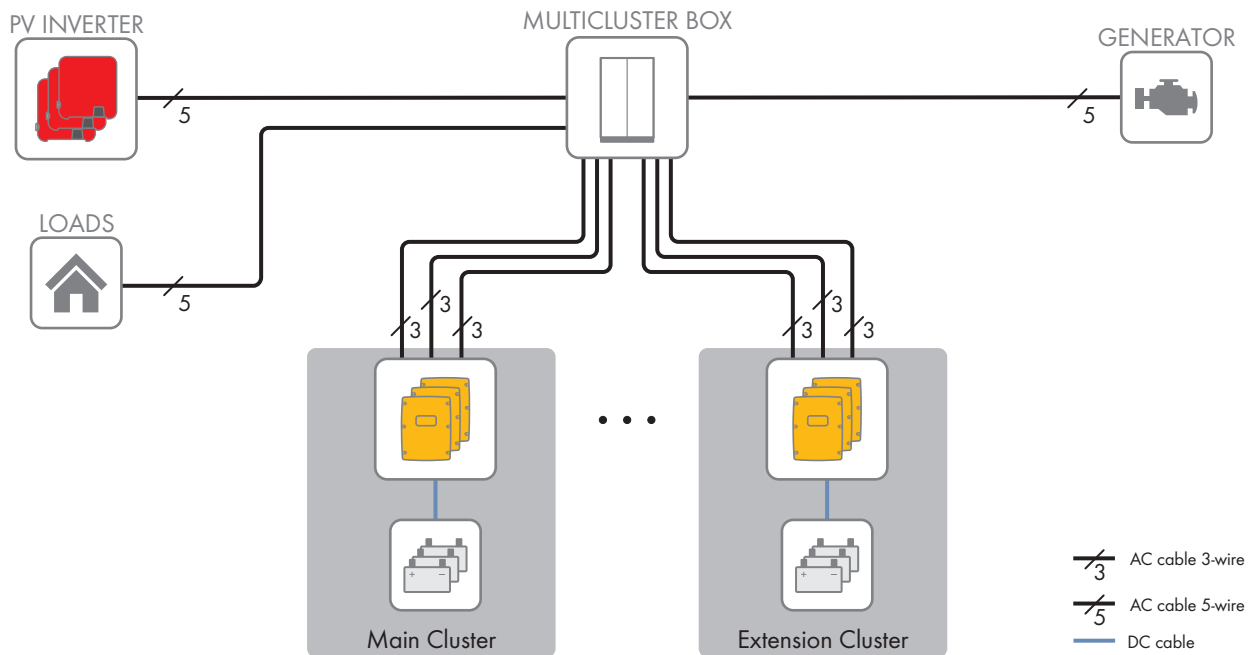


Figure 4: Principle of a multicluster system

Multicluster systems consist of several three-phase clusters. The individual clusters must be connected to a Multicluster-Box. The Multicluster-Box is an SMA multicluster technology device for off-grid systems, battery-backup systems and systems for increased self-consumption.

The Multicluster-Box is a main AC distribution board to which up to twelve clusters can be connected. Each three-phase cluster is made up of three DC-side, parallel-switched Sunny Island.

Only Sunny Island inverters of the same device type may be installed in a cluster: SI6.0H-12 or SI8.0H-12.

3.3 Information on Off-Grid Systems

Information on Batteries

Lithium-ion batteries in off-grid systems

In order to meet the requirements of off-grid systems, the Sunny Island has a high overload capacity. This overload capacity is subject to the battery being able to supply sufficient current. With lithium-ion batteries, this ampacity cannot be taken for granted.

- Check with the battery manufacturer whether the battery is suitable for off-grid systems with Sunny Island inverters. Pay special attention to the ampacity.

Recommendations for battery capacity

SMA Solar Technology AG recommends the following minimum battery capacities.

- Minimum battery capacity per Sunny Island inverter:
 - SI4.4M-12: 150 Ah
 - SI6.0H-12: 190 Ah
 - SI8.0H-12: 250 Ah
- Minimum battery capacity per 1000 Wp power of the PV system: 100 Ah

The sum of the individual battery capacities is the total minimum battery capacity and applies to a ten-hour electric discharge (C10). The minimum battery capacity must be observed to ensure stable operation of the system.

Information on Clusters

Clusters in multicluster systems

Device type	Potential device types within a cluster	Explanation
SI4.4M-12	-	The device type SI4.4M-12 must not be used in multicluster systems.
SI6.0H-12	SI6.0H-12 or SI8.0H-12	Only Sunny Island inverters of the same device type may be installed in a cluster: SI6.0H-12 or SI8.0H-12.
SI8.0H-12	SI6.0H-12 or SI8.0H-12	

Clusters in three-phase single-cluster systems

Device type	Potential device types within a cluster	Explanation
SI4.4M-12	SI4.4M-12	Only the device type SI4.4M-12 may be installed in a cluster.
SI6.0H-12	SI6.0H-12 or SI8.0H-12	A cluster can consist of one or both device types. If both device types within the cluster are used, the master must be of device type SI8.0H-12.
SI8.0H-12	SI6.0H-12 or SI8.0H-12	

Clusters in single-phase single-cluster systems

Device type	Potential device types within a cluster	Explanation
SI4.4M-12	-	The device type SI4.4M-12 must not be used in the single-phase cluster system.
SI6.0H-12	SI6.0H-12 or SI8.0H-12	A cluster can consist of one or both device types. If both device types within the cluster are used, the master must be of device type SI8.0H-12.
SI8.0H-12	SI6.0H-12 or SI8.0H-12	

Connection of the Sunny Island inverters in single-phase single-cluster systems

In a single-phase single-cluster system, the following cable lengths and conductor cross-sections must be designed the same way:

- From the generator to each Sunny Island
- From each Sunny Island to the AC distribution board
- From the battery fuse to each Sunny Island

The same design is a requirement for stable and symmetrical operation of the off-grid system.

Information on the PV System

Maximum PV system power

In off-grid systems, the maximum PV system power depends on the total power of the Sunny Island inverters.

- Maximum output power of the PV system per SI4.4M-12: 4600 W
- Maximum output power of the PV system per SI6.0H-12: 9200 W
- Maximum output power of the PV system per SI8.0H-12: 12000 W

The maximum output power of the PV system must be observed to ensure stable operation of the off-grid system.

3.4 Optional Devices and Functions

The following devices can be used optionally in an off-grid system:

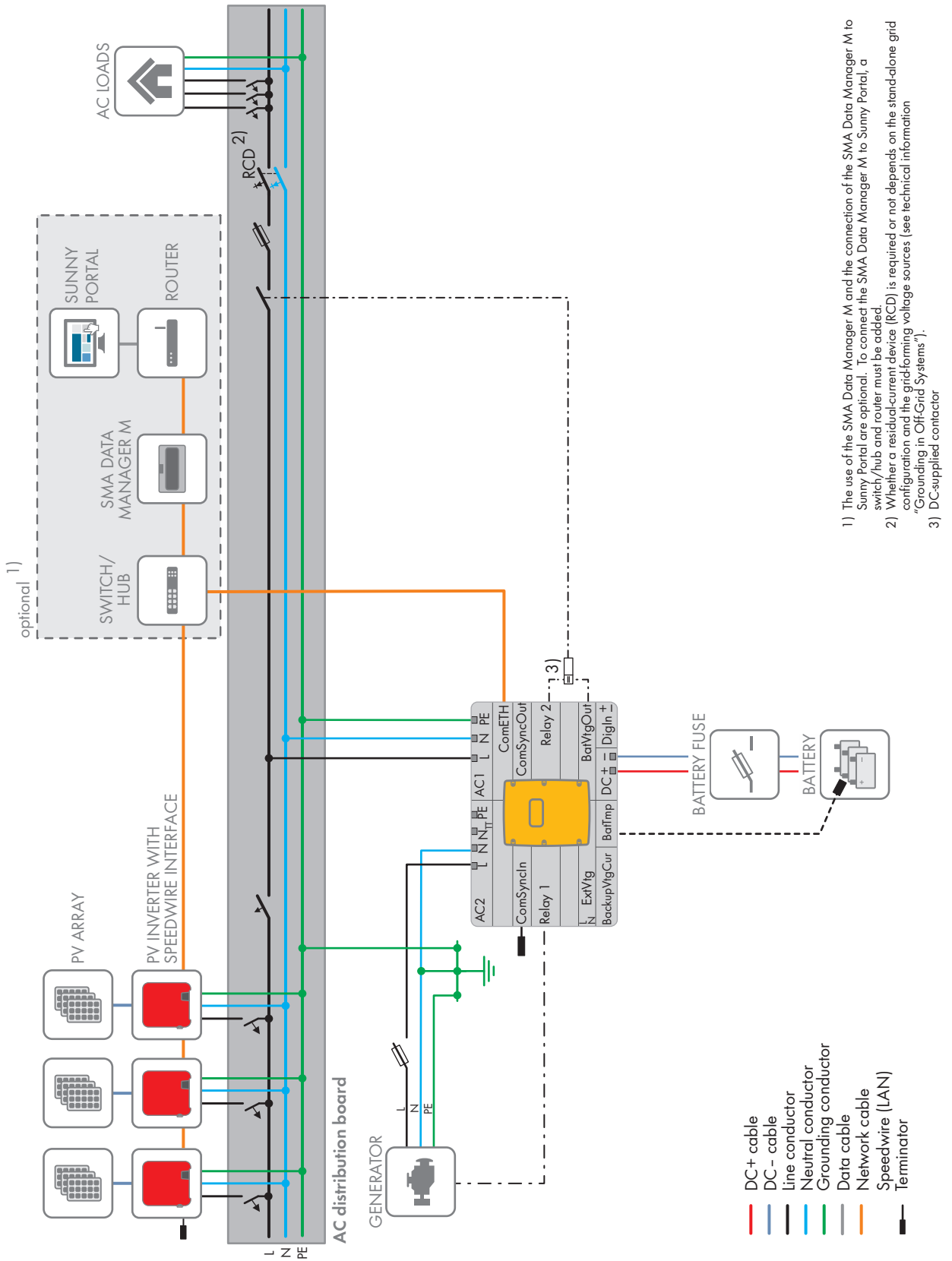
Component	Description
Load-shedding contactor	Contactor controlled by the Sunny Island for isolation of loads
SMA Cluster Controller	Remote monitoring and system configuration of the off-grid system
Battery current sensor	Shunt for measuring the battery current

Sunny Island offers the following functions for off-grid systems via two multifunction relays (see Sunny Island operating manual for more information on the connection):

Function	Description
Controlling PV arrays	A multifunction relay is activated when requested by the Sunny Island generator management. With the multifunction relay, you can control PV arrays with an electrical remote-start function or connect a signal generator for PV arrays with no autostart function.
Controlling load-shedding contactors	A multifunction relay is activated depending on the state of charge of the battery. Depending on the configuration of the Sunny Island, you can install a one-level load shedding with one multifunction relay or a two-level load shedding with two multifunction relays. You can adjust the thresholds for the state of charge of the battery depending on the time of day.
Time control for external processes	External processes can be time-controlled with a multifunction relay.
Display of operating states and warning messages	You can connect message devices to the multifunction relays to display operating states and warning messages of the Sunny Island. One of the following operating states and warning messages can be displayed for each multifunction relay: <ul style="list-style-type: none"> • The PV array is running and is connected. • A Sunny Island displays an error message of level 2 or higher. Only the error messages within a cluster are evaluated here. • A Sunny Island displays a warning. Only the warnings within a cluster are evaluated here. • The Sunny Island is in operation in a single system. • The respective cluster is in operation in a cluster system. • The Sunny Island is in derating in a single system. • The respective cluster is in derating in a cluster system.
Control of a battery-room fan	The multifunction relay is activated when the charging current causes the battery to emit gasses. A connected battery room fan is switched on for at least one hour.
Control of an electrolyte pump	Depending on the nominal energy throughput, the multifunction relay is activated at least once a day.
Use of excess energy	During the constant voltage phase, a multifunction relay is activated and thus controls additional loads that can put any excess energy of AC sources in the off-grid system (e.g., of a PV system) to good use.

4 Single System

4.1 Circuitry Overview



- 1) The use of the SMA Data Manager M and the connection of the SMA Data Manager M to Sunny Portal are optional. To connect the SMA Data Manager M to Sunny Portal, a switch/hub and router must be added.
- 2) Whether a residual-current device (RCD) is required or not depends on the stand-alone grid configuration and the grid-forming voltage sources (see technical information "Grounding in Off-Grid Systems").
- 3) DC-supplied contactor

Figure 5: Single System

4.2 Connection of the Sunny Island

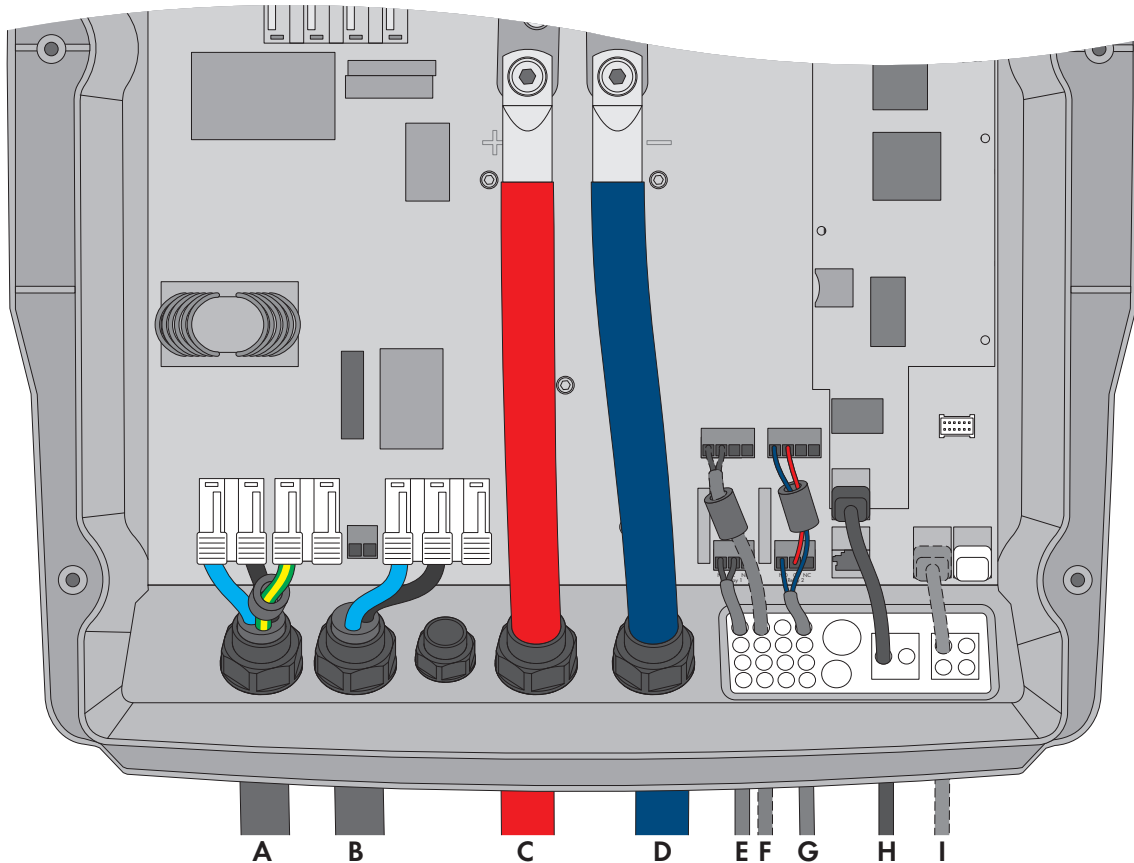


Figure 6: Connection of the Sunny Island

Position	Designation	Description / information
A	AC power cable of the stand-alone grid	Sunny Island: connection to AC1 Loads/SunnyBoys terminals L, N , and PE Conductor cross-section: maximum 16 mm ² Only use the supplied ferrite for PE .
B	AC power cable of the generator	Sunny Island: connection to AC2 Gen/Grid terminals L and N Conductor cross-section: maximum 16 mm ² The Sunny Island must be connected via a grounding conductor on the terminal AC1 or AC2 to the ground potential. The conductor cross-section of the grounding conductor must be at least 10 mm ² . If the conductor cross-section is smaller, an additional grounding conductor on the enclosure with the conductor cross-section of the AC power cable must connect the Sunny Island with the ground potential.
C	DC+ cable	Battery connection
D	DC- cable	Conductor cross-section: from 50 mm ² to 95 mm ² Cable diameters: 14 mm to 25 mm Torque: 12 Nm
E	Control cable, generator	Sunny Island: terminals Relay1 NO and Relay1 C Conductor cross-section: from 0.2 mm ² to 2.5 mm ²

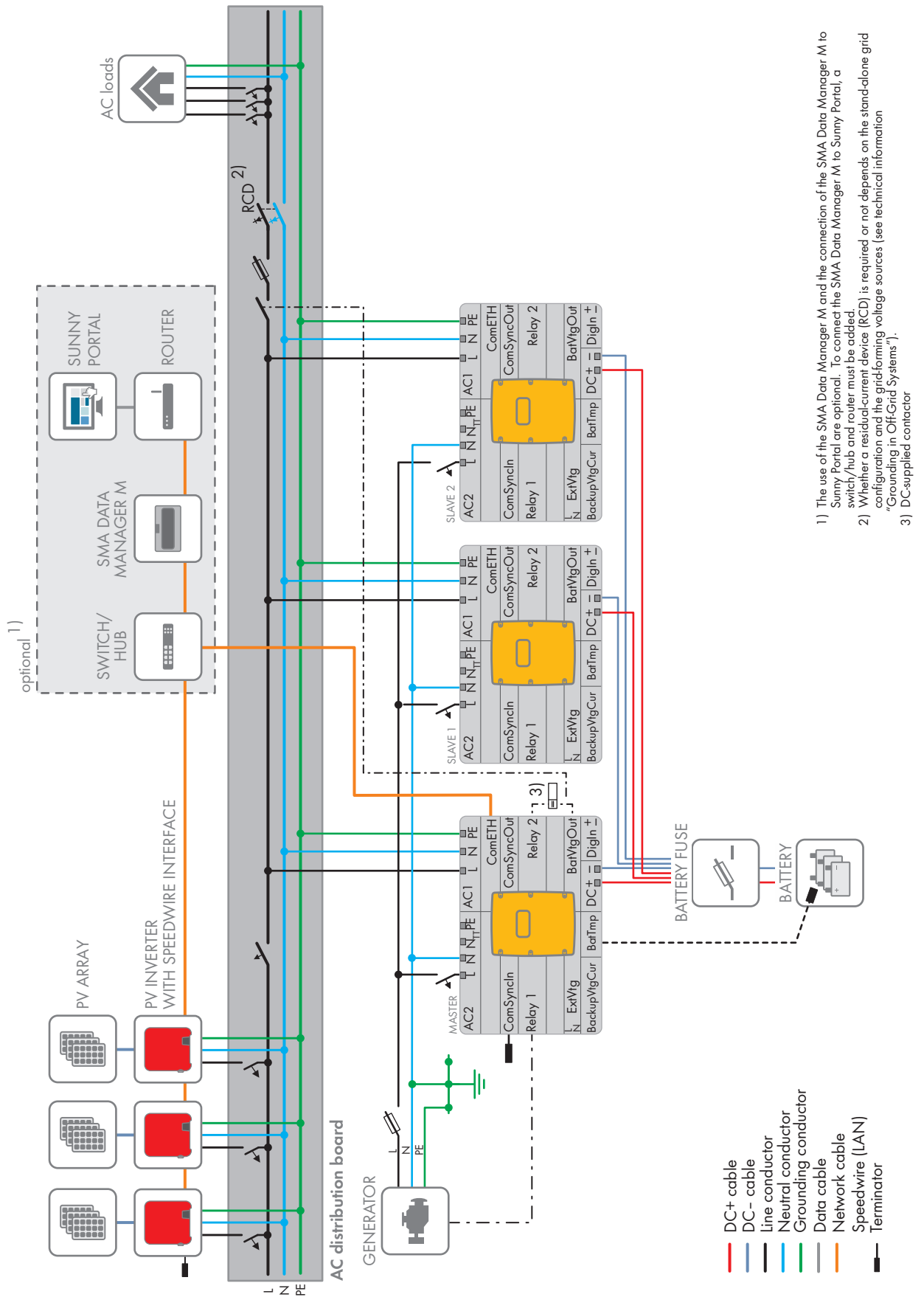
Position	Designation	Description / information
F	Measuring cable of the battery temperature sensor	<p>Sunny Island: terminal BatTmp</p> <p>You only have to connect a battery temperature sensor if lead-acid batteries are used.</p> <p>Mount the battery temperature sensor in the middle of the battery-storage system, in the upper third of the battery cell.</p> <p>Use the supplied ferrite.</p>
G	Control cable, load shedding	<p>Sunny Island: connect the control cable to terminals Relay2 NO and BatVtgOut -.</p> <p>Connect the terminals Relay2 C and BatVtgOut+ within the Sunny Island.</p> <p>Conductor cross-section: from 0.2 mm² to 2.5 mm²</p> <p>The complete DC voltage range is mapped at the terminal BatVtgOut. The connection BatVtgOut is current-limited and protected against short circuits. Use the supplied ferrite for BatVtgOut.</p>
H	Speedwire network cable	Terminal ComETH
I	Data cable to lithium-ion battery	<p>Sunny Island: terminal ComSyncln</p> <p>A data cable must be connected to the battery only when lithium-ion batteries are used. The communication bus must be equipped with a terminator on both ends.</p>

5 Single-Cluster System

5.1 Circuitry Overview Single-Phase Single-Cluster System

i Required device types for single-phase single-cluster systems

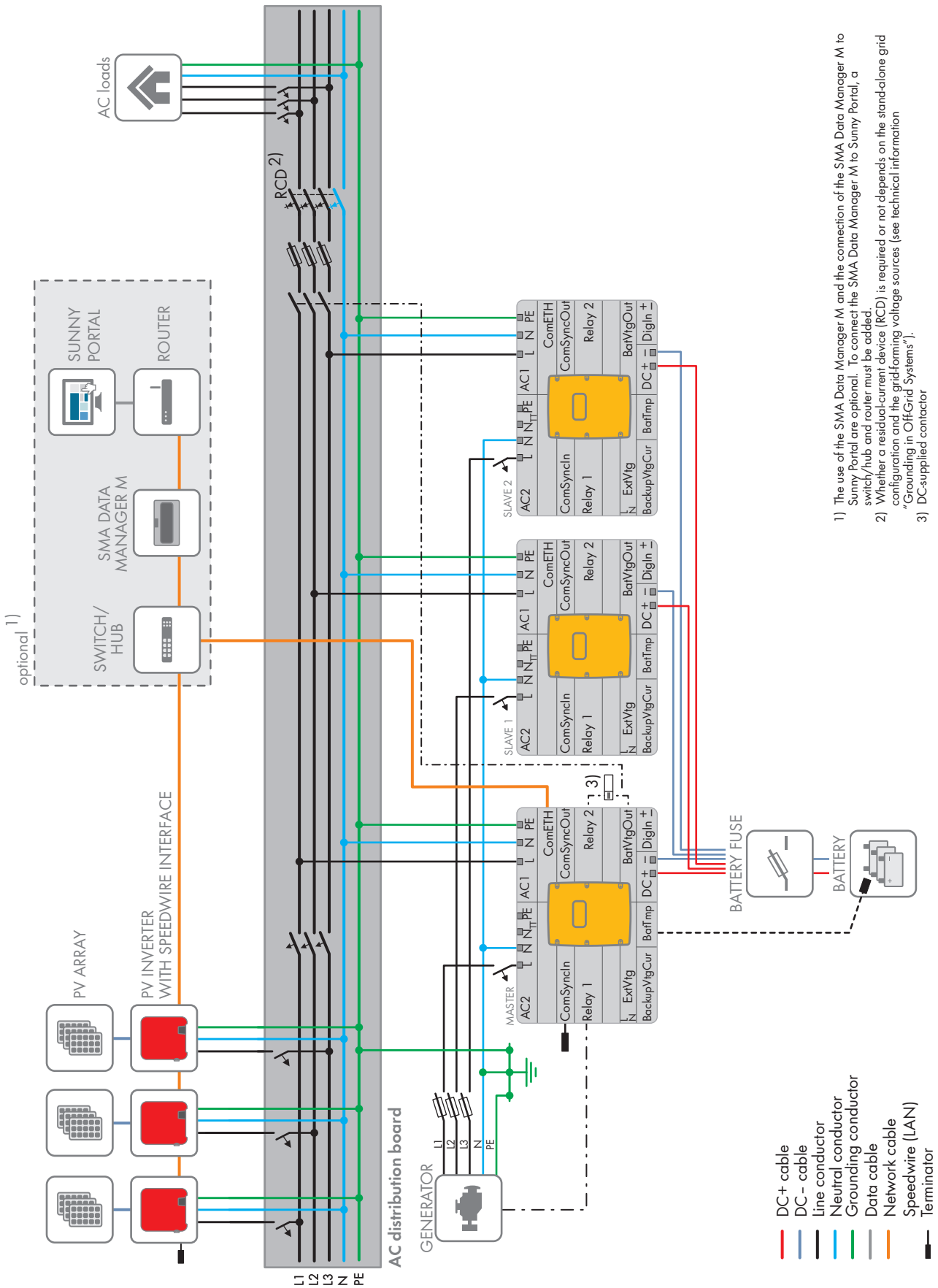
In single-phase single-cluster systems, the Sunny Island inverters must be of device type SI6.0H-12 or SI8.0H-12.



- 1) The use of the SMA Data Manager M and the connection of the SMA Data Manager M to Sunny Portal are optional. To connect the SMA Data Manager M to Sunny Portal, a switch/hub and router must be added.
- 2) Whether a residual-current device (RCD) is required or not depends on the stand-alone grid configuration and the grid-forming voltage sources (see technical information "Grounding in Off-Grid Systems").
- 3) DC-supplied contactor

Figure 7: Circuitry overview single-phase single-cluster system, only possible with SI6.0H-12 or SI8.0H-12

5.2 Circuitry Overview Three-Phase Single-Cluster System



- 1) The use of the SMA Data Manager M and the connection of the SMA Data Manager M to Sunny Portal are optional. To connect the SMA Data Manager M to Sunny Portal, a switch/hub and router must be added.
- 2) Whether a residual-current device (RCD) is required or not depends on the stand-alone grid configuration and the grid-forming voltage sources (see technical information "Grounding in Off-Grid Systems").
- 3) DC-supplied contactor

Figure 8: Circuitry overview three-phase single-cluster

5.3 Connecting Sunny Island Inverters

5.3.1 Connecting the Master

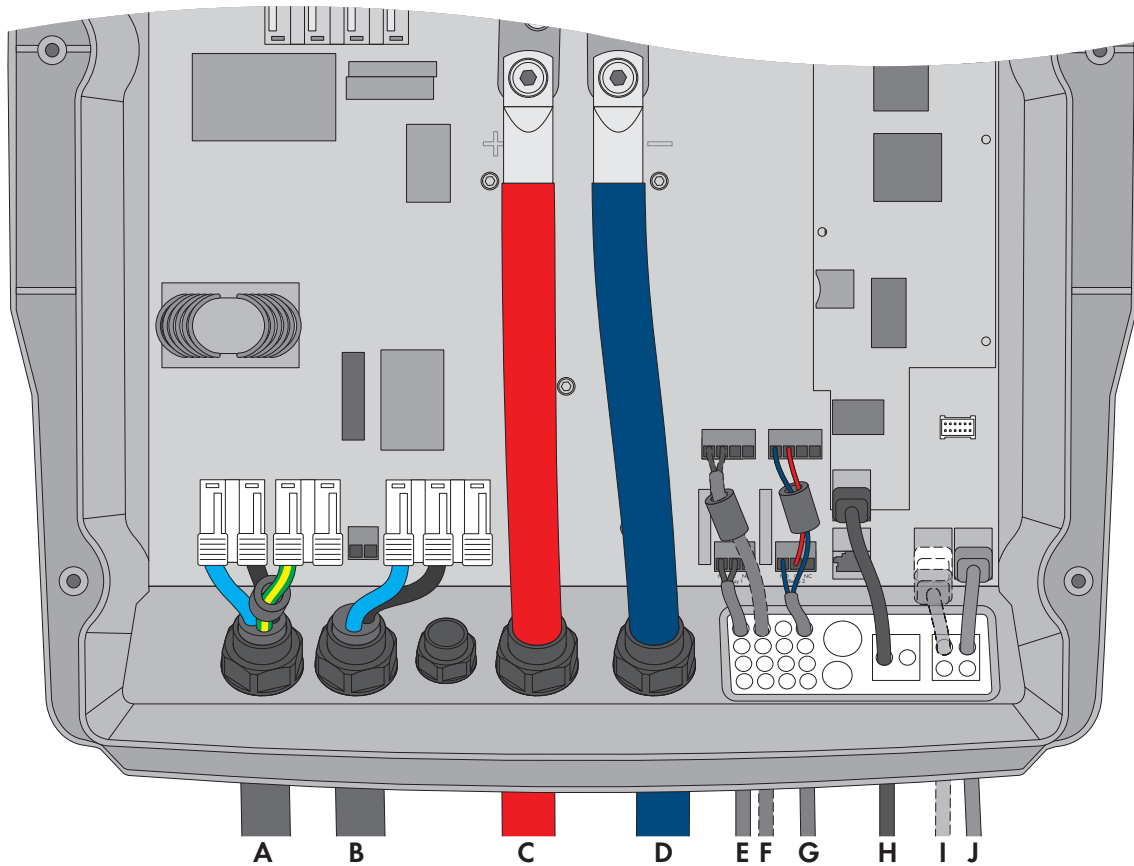


Figure 9: Connection of the master in the single-cluster system

Position	Designation	Description / information
A	AC power cable of the stand-alone grid	<p>Sunny Island: connection to AC1 Loads/SunnyBoys terminals L, N, and PE</p> <p>Single cluster system: connect master to line conductor L1.</p> <p>Conductor cross-section: maximum 16 mm²</p> <p>Only use the supplied ferrite for PE.</p>
B	AC power cable of the generator	<p>Sunny Island: connection to AC2 Gen/Grid terminals L and N</p> <p>Generator: connect master to line conductor L1.</p> <p>Conductor cross-section: maximum 16 mm²</p> <p>For a single-phase system, the cable length and the conductor cross-section must be identical on each Sunny Island.</p> <p>The Sunny Island must be connected via a grounding conductor on the terminal AC1 or AC2 to the ground potential. The conductor cross-section of the grounding conductor must be at least 10 mm². If the conductor cross-section is smaller, an additional grounding conductor on the enclosure with the conductor cross-section of the AC power cable must connect the Sunny Island with the ground potential.</p>

Position	Designation	Description / information
C	DC+ cable	Battery connection
D	DC- cable	<p>For a single-cluster system, the cable length and the conductor cross-section must be identical on each Sunny Island.</p> <p>Conductor cross-section: from 50 mm² to 95 mm²</p> <p>Cable diameters: 14 mm to 25 mm</p> <p>Torque: 12 Nm</p>
E	Control cable, generator	<p>Sunny Island: terminals Relay1 NO and Relay1 C</p> <p>Conductor cross-section: from 0.2 mm² to 2.5 mm²</p>
F	Measuring cable of the battery temperature sensor	<p>Sunny Island: terminal BatTmp</p> <p>You only have to connect a battery temperature sensor if lead-acid batteries are used.</p> <p>Mount the battery temperature sensor in the middle of the battery-storage system, in the upper third of the battery cell.</p> <p>Use the supplied ferrite.</p>
G	Control cable, load shedding	<p>Connect the control cable to terminals Relay2 NO and BatVtgOut - in the Sunny Island.</p> <p>Connect the terminals Relay2 C and BatVtgOut+ within the Sunny Island.</p> <p>Conductor cross-section: from 0.2 mm² to 2.5 mm²</p> <p>The complete DC voltage range is mapped at the terminal BatVtgOut. The connection BatVtgOut is current-limited and protected against short circuits. Use the supplied ferrite for BatVtgOut.</p>
H	Speedwire network cable	Terminal ComETH
I	Data cable for battery management	<p>Sunny Island: terminal ComSyncln</p> <p>A data cable must be connected to the battery only when lithium-ion batteries are used. The communication bus must be equipped with a terminator on both ends.</p>
J	Data cable for the internal communication in the cluster	<p>Sunny Island: terminal ComSyncOut</p> <p>Connection of internal communication bus of slave 1</p>

5.3.2 Connecting the Slaves

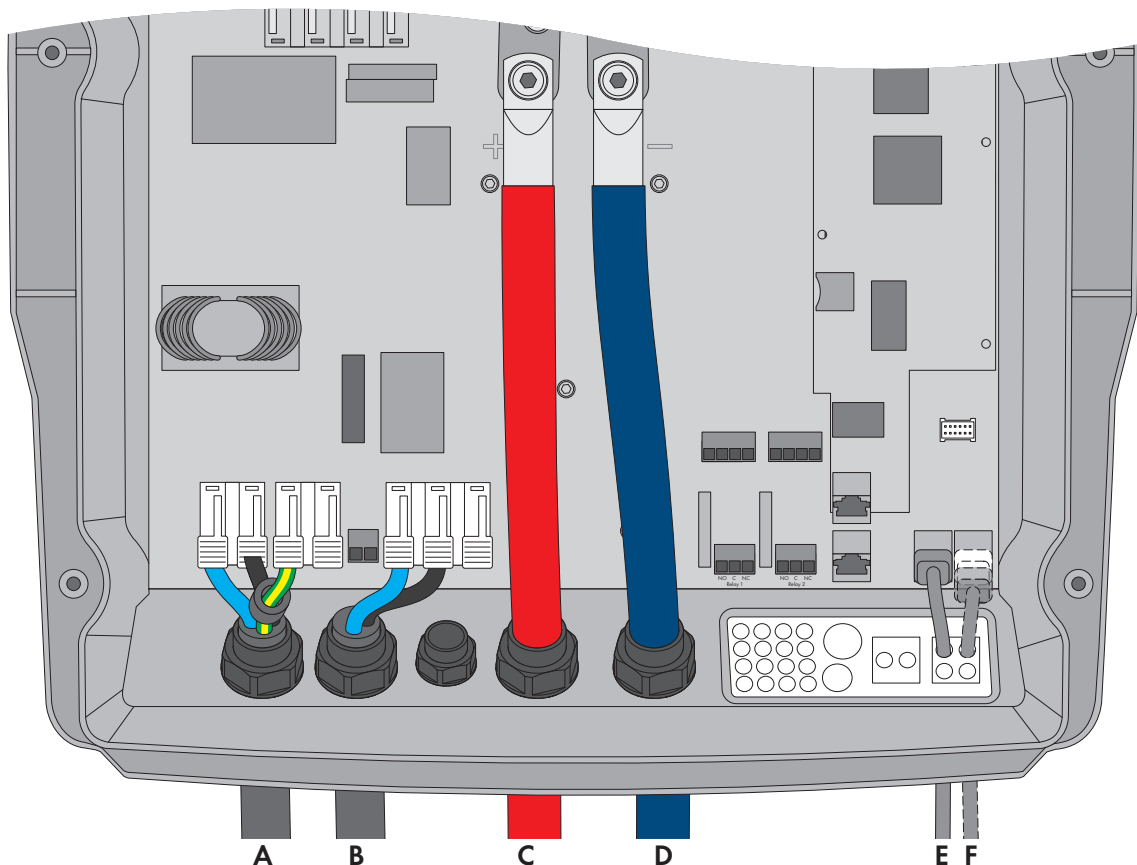


Figure 10: Connection of the slaves in a single-cluster system

Position	Designation	Description / information
A	AC power cable of the stand-alone grid	<p>Sunny Island: connection to AC1 Loads/SunnyBoys terminals L, N, and PE</p> <p>Single cluster system (single-phase): connect slave 1 and slave 2 to the line conductor L1.</p> <p>Single cluster system (three-phase): connect slave 1 to line conductor L2, connect slave 2 to line conductor L3.</p> <p>For a single-phase system, the cable length and the conductor cross-section must be identical on each Sunny Island.</p> <p>Conductor cross-section: maximum 16 mm²</p> <p>Only use the supplied ferrite for PE.</p>

Position	Designation	Description / information
B	AC power cable of the generator	<p>Sunny Island: connection of generator to AC2 Gen/Grid terminals L and N</p> <p>Generator: connect slave 1 to line conductor L2, connect slave 2 to line conductor L3.</p> <p>Conductor cross-section: maximum 16 mm²</p> <p>For a single-phase system, the cable length and the conductor cross-section must be identical on each Sunny Island.</p> <p>The Sunny Island must be connected via a grounding conductor on the terminal AC1 or AC2 to the ground potential. The conductor cross-section of the grounding conductor must be at least 10 mm². If the conductor cross-section is smaller, an additional grounding conductor on the enclosure with the conductor cross-section of the AC power cable must connect the Sunny Island with the ground potential.</p>
C	DC+ cable	Battery connection
D	DC- cable	<p>Conductor cross-section: from 50 mm² to 95 mm²</p> <p>Cable diameters: 14 mm to 25 mm</p> <p>Torque: 12 Nm</p>
E	Data cable for the internal communication in the cluster	<p>Sunny Island: terminal ComSyncln</p> <p>With slave 1: connection of internal communication bus of the master</p> <p>With slave 2: connection of internal communication bus of slave 1</p>
F	Data cable for the internal communication in the cluster	<p>Sunny Island: terminal ComSyncOut</p> <p>With slave 1: connection of internal communication bus of slave 2</p> <p>With slave 2: leave terminator plugged in. Slave 2 is connected to slave 1 only.</p>

6 Multicluster System

i Required device types for multicluster systems

In multicluster systems for stand-alone grids, the following device types must be used:

- SI6.0H-12 (Sunny Island 6.0H)
- SI8.0H-12 (Sunny Island 8.0H)
- MC-BOX-6.3-11 (Multicluster-Box 6)
- MC-BOX-12.3-20 (Multicluster-Box 12)
- MC-BOX-36.3-11 (Multicluster-Box 36)

You can find a circuitry overview in the Multicluster-Box documentation.

7 Commissioning

7.1 Commissioning Procedure

Before commissioning the system, you must make various settings. This section describes the procedure and gives an overview of the steps, which must always be performed in the prescribed sequence.

Procedure	See
1. Commission the inverter.	Sunny Island operating manual
2. Establish a connection to the user interface of the inverter. There are the following connection options available to choose from: <ul style="list-style-type: none"> • Direct connection via WLAN • Direct connection via Ethernet • Connection via Ethernet in the local network 	Sunny Island operating manual
3. Log into the user interface.	Sunny Island operating manual
4. Perform the basic configuration via the installation assistant: <ul style="list-style-type: none"> • Single system (system with one Sunny Island) • Single-cluster-system (system with three Sunny Island) • Multicluster system (system mit several three-phase cluster) Please note, that the personal SMA Grid Guard code for changing the grid-relevant parameters must be available after completion of the first ten operating hours (see "Application for the SMA Grid Guard code" available at www.SMA-Solar.com).	Sunny Island operating manual
5. Set the functions of the multifunction relay via the user interface.	Sunny Island operating manual
6. Start the system.	Sunny Island operating manual
7. Test the battery current sensor.	Section 7.2, page 30
8. Test the generator.	Section 7.3, page 31
9. Commission the PV system.	Section 7.5, page 32
10. Complete commissioning.	Section 7.7, page 33

7.2 Testing the Battery Current Sensor

When using lead-acid batteries, a battery current sensor may be installed to allow precise measurement of the battery current.

Requirement:

- The Sunny Island must be in operation (for information on starting the operation see the operating manual of the Sunny Island).

Procedure:

1. Switch on a load (e.g., a 1 kW radiant heater) and all associated protective devices in the AC distribution board.
2. Measure the battery current with a current clamp.
3. Activate the user interface of the inverter (see the operating manual of the Sunny Island).

4. Log in as Installer.
5. Read off the parameter **Battery > Battery > Current > Battery current**.

The value is positive and is within the measuring tolerance range.

Is the value not positive or is it outside the measuring tolerance range?

The value is negative because the measuring cables of the battery current sensor are connected with reverse polarity or the value itself is not within the measuring tolerance range since the incorrect battery current sensor type has been set.

- Install the battery current sensor correctly (see operating manual of the Sunny Island).
- Set the correct battery current sensor type (see operating manual of the Sunny Island).

7.3 Testing the Generator

Requirement:

- The Sunny Island must be in operation (for information on starting the operation see the operating manual of the Sunny Island).

Procedure:

1. Switch on the protective devices for the generator in the AC distribution board.
2. Switch on the circuit breakers of the AC loads.
3. Close the load-break switch of the generator.

The generator starts.

Does the generator not start?

The generator management does not request the generator.

or

The control cable connected does not transmit the start signal.

or

The generator is not ready for operation.

- Select the parameter **Generator > Manual control > Manual generator control** and set to **Start**. This starts the generator manually (see operating manual of the Sunny Island).
 - Eliminate any faults in the wiring.
 - Find out possible causes using the manual from the generator manufacturer and eliminate these.
4. Check via the user interface whether the parameter **AC-side > Measurements of external power connection > Reactive power > Phase L1 > Output external power connection phase L1** displays the feed-in power. When a feed-in power is displayed, the Sunny Island has switched the stand-alone grid to the generator after completing the warm-up time **Warm-up time of generator**.
If no feed-in power is displayed after completion of the warm-up time, check the event messages:
 - Select the **Events** menu via the user interface and rectify the cause of the displayed warning or error (see operating manual of the Sunny Island).

7.4 Testing the Load Shedding

Requirements:

- The system must not have a MC-BOX-6.3-11 or MC-BOX-36.3-11 installed. Load shedding is part of the Multicluster-Box in a system with MC-BOX-6.3-11 or MC-BOX-36.3-1.
- In a system with MC-BOX-12.3-20, the additional load-shedding contactor must be connected to a multifunction relay in the master of the extension cluster.
- The Sunny Island must be in operation (for information on starting the operation see the operating manual of the Sunny Island).

Procedure:

1. Activate the user interface of the inverter (see the operating manual of the inverter).
2. Log in as Installer.
3. Select the parameter **Device > Multifunction relay > Operating mode > Operating mode of multifunction relay**.
4. Note the parameter value of the load-shedding contactor.
5. Set the parameter of the load-shedding contactor to **Off**.
 - The load-shedding contactor sheds the loads.
 - Does the load-shedding contactor not shed the loads?
The multifunction relay for triggering the load-shedding contactor was incorrectly configured.

or

There is a fault in the wiring of the load-shedding contactor.

 - Check the configuration and eliminate the fault.
 - Ensure that the multifunction relay is correctly wired.
6. Set the load-shedding contactor parameter to the setting that has been noted down.

7.5 Commissioning the PV System

For operation in an off-grid system, the PV system must be configured for stand-alone mode.

Procedure:

1. Commission the PV system (see PV inverter documentation).
2. If the SMA PV inverters are not configured for stand-alone mode ex works, configure the country standard or country data set of the PV inverters for stand-alone mode (see the PV inverter documentation).

7.6 Testing Communication in the Multicluster System

1. Activate the user interface of the inverter (see the inverter operating manual).
2. Log in as Installer.
3. Activate the communication test on any master within the multicluster system:
 - Access the Sunny Island user interface for the selected master (see operating manual of the Sunny Island).
 - Log in as Installer.
 - Set the parameter **Activation of communication test between the clusters** to **On**.
4. Check the status of the communication test on each master within the multicluster system. For this, execute the following steps:
 - Access the Sunny Island user interface for the selected master (see operating manual of the Sunny Island).
 - Log in as Installer.
 - Select the parameter **Status of the communication test** and read off the value.
 - The parameter **Status of the communication test** has the value **OK**. The communication test is completed on the respective master.
 - Does the parameter **Status of the communication test** has the value **Wait**?
It is possible that the cabling of the communication bus is faulty.
 - Ensure that the cable length for the multicluster communication is not exceeded.
 - Ensure that all cables of the multicluster communication are correctly connected (see operating manual of the Sunny Island).

- Ensure that the terminators for the multicluster communication are correctly inserted (see operating manual of the Sunny Island).
5. When the communication test on each master within the multicluster system is completed, deactivate the communication test:
 - Access the Sunny Island user interface for the selected master (see operating manual of the Sunny Island).
 - Log in as Installer.
 - Set the parameter **Activation of communication test between clusters** to **Off**.

7.7 Complete Commissioning.

1. Adjust the configuration of the inverter to the system via the user interface (see operating manual of the Sunny Island). This way, you can increase the service life of the battery, for example.
2. When full charge of the battery is complete, switch on all circuit breakers and load-break switches.
3. In order to receive service assignments for the Sunny Island system, all system data must be recorded in the information sheet for Sunny Island systems and made available to Service (for information sheet see www.SMA-Solar.com).

i Load shedding in the first two operating hours

The state of charge (SOC) recorded by battery management and the available battery capacity (SOH) of the battery will deviate strongly in a newly connected battery from the actual SOC and SOH values. In the first two operating hours using the new battery, these deviations can lead to load shedding.

During operation, the values recorded by battery management will gradually approach the real values.

8 Contact

If you have technical problems with our products, please contact the SMA Service Line. The following data is required in order to provide you with the necessary assistance:

- Type of system installed (e.g. three-phase single-cluster system)
- Battery inverter:
 - Device type
 - Quantity
 - Serial numbers
 - Firmware version
 - Event message
- Type of the communication products connected
- Type and size of additional energy sources
- Type, power and maximum current for the generator (if present)
- Batteries:
 - Type
 - Nominal capacity and nominal voltage (with lead-acid batteries)

Deutschland	SMA Solar Technology AG	Belgien	SMA Benelux BVBA/SPRL
Österreich	Niestetal	Belgique	Mechelen
Schweiz	Sunny Boy, Sunny Mini Central, Sunny Tripower: +49 561 9522-1499	België	+32 15 286 730
	Monitoring Systems (Kommunikationsprodukte): +49 561 9522-2499	Luxemburg	SMA Online Service Center: www.SMA-Service.com
	Fuel Save Controller (PV-Diesel-Hybridsysteme): +49 561 9522-3199	Luxembourg	
	Sunny Island, Sunny Boy Storage, Sunny Backup: +49 561 9522-399	Nederland	
	Sunny Central, Sunny Central Storage: +49 561 9522-299	Česko	SMA Service Partner TERMS a.s.
	SMA Online Service Center: www.SMA-Service.com	Magyarország	+420 387 6 85 111
		Slovensko	SMA Online Service Center: www.SMA-Service.com
		Türkiye	SMA Service Partner DEKOM Ltd. Şti. +90 24 22430605
			SMA Online Service Center: www.SMA-Service.com
France	SMA France S.A.S.	Ελλάδα	SMA Service Partner AKTOR FM.
	Lyon	Κύπρος	Αθήνα
	+33 472 22 97 00		+30 210 8184550
	SMA Online Service Center : www.SMA-Service.com		SMA Online Service Center: www.SMA-Service.com
España	SMA Ibérica Tecnología Solar, S.L.U.	United Kingdom	SMA Solar UK Ltd.
Portugal	Barcelona		Milton Keynes
	+34 935 63 50 99		+44 1908 304899
	SMA Online Service Center: www.SMA-Service.com		SMA Online Service Center: www.SMA-Service.com

Italia	SMA Italia S.r.l. Milano +39 02 8934-7299 SMA Online Service Center: www.SMA-Service.com	Australia	SMA Australia Pty Ltd. Sydney Toll free for Australia: 1800 SMA AUS (1800 762 287) International: +61 2 9491 4200
United Arab Emirates	SMA Middle East LLC Abu Dhabi +971 2234 6177 SMA Online Service Center: www.SMA-Service.com	India	SMA Solar India Pvt. Ltd. Mumbai +91 22 61713888
ไทย	SMA Solar (Thailand) Co., Ltd. กรุงเทพฯ +66 2 670 6999	대한민국	SMA Technology Korea Co., Ltd. 서울 +82-2-520-2666
South Africa	SMA Solar Technology South Africa Pty Ltd. Cape Town 08600SUNNY (08600 78669) International: +27 (0)21 826 0600 SMA Online Service Center: www.SMA-Service.com	Argentina Brasil Chile Perú	SMA South America SPA Santiago de Chile +562 2820 2101
Other countries	International SMA Service Line Niestetal 00800 SMA SERVICE (+800 762 7378423) SMA Online Service Center: www.SMA-Service.com		

