Planning Guidelines

SMA FLEXIBLE STORAGE SYSTEM with Battery-Backup Function

Circuitry Overviews, Schematic Diagrams and Material Lists



ENGLISH

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1 SMA Flexible Storage System with Battery-Backup Function

1.1 Purpose of a Battery-Backup System

Any time a grid failure happens, a PV system disconnects from the utility grid and the loads connected to the particular household grid are no longer supplied with energy.

A grid failure lasting for a longer period can have serious consequences for the parties concerned such as:

- Households and companies would have to manage without heat, light, telephone and computer.
- Cold chains could be interrupted.
- For example, if stable ventilation systems or heat lamps lose power in a farming business.

One solution for bridging this supply gap is to convert existing PV systems into battery-backup systems.

An SMA Flexible Storage System with battery-backup function (battery-backup system) takes care of the uninterrupted supply of the loads with electricity during a grid failure. An automatic transfer switching device disconnects the household grid with the PV system from the utility grid. When this happens, a battery inverter forms a battery-backup grid and the PV system can supply the loads. When the energy demand of the active loads exceeds the current power of the PV system, the battery will provide the energy shortfall.

1.2 Design and Function of a Battery-Backup System

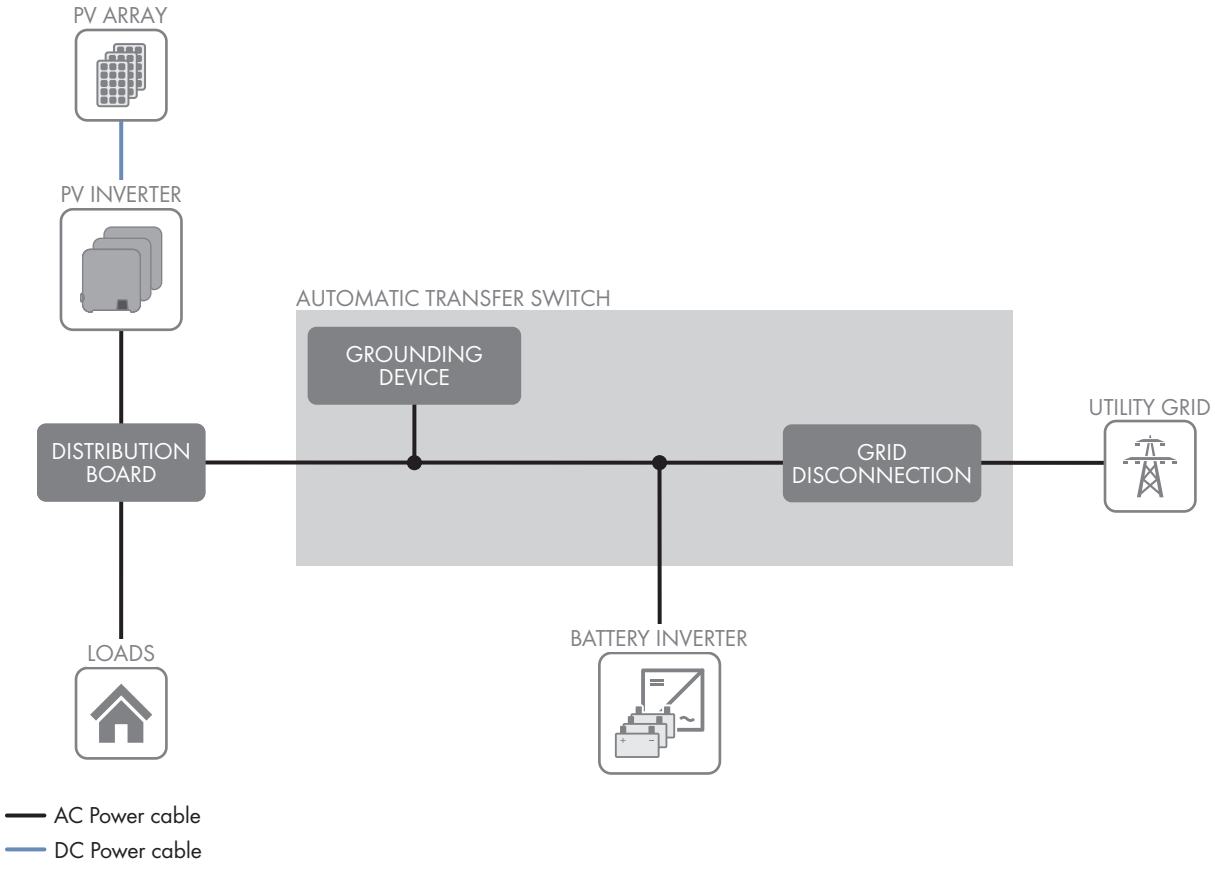


Figure 1: Basic design of a battery-backup system

Devices of the SMA Flexible Storage System

Component	Function
Battery inverter	In the event of grid failure, the battery inverter forms a battery-backup grid and regulates the energy distribution in this battery-backup grid. In parallel grid operation, the battery inverter is responsible for the optimization of self-consumption or internal power supply. The following battery inverters are used in battery-backup systems: • Sunny Island 4.4M / 6.0H / 8.0H • Sunny Boy Storage 3.7 / 5.0 / 6.0 In a three-phase household grid, a single-phase battery inverter can only be connected to one line conductor and thus only monitor one line conductor for a grid failure. When the grid failure happens, all line conductors of the household grid, however, are disconnected from the utility grid.
Battery (not shown graphically)	The battery stores excess energy from the PV system. In parallel grid operation, this buffered PV energy is used to optimize self-consumption or internal power supply, and in the event of grid failure, it is used for supplying the loads.
Battery fuse (not shown graphically)	When using the Sunny Island with lead-acid batteries, a battery fuse must be installed. As an external DC fuse, the battery fuse safeguards the battery connection lines of the battery inverter. Furthermore, the battery fuse enables DC-side disconnection of the battery inverter. Lithium-ion batteries do not usually need an external battery fuse (see manufacturer documentation).

Devices of the automatic transfer switching device

The structure of the automatic transfer switching device depends on the country-specific requirements. That is why only the most important components of an automatic transfer switching device are described in the following.

Component	Function
Grid disconnection	The functional group grid disconnection is part of the automatic transfer switch of the battery-backup system and disconnects the battery-backup grid from the utility grid in the event of grid failure.
Phase coupling (not shown graphically)	The phase coupling is an optional function for a single-phase battery-backup system that is connected to a three-phase household grid. With single-phase battery-backup systems, only one battery inverter is connected to the automatic transfer switching device. Therefore, in the event of grid disconnection, without phase coupling only one line conductor (e.g. L1) of the household grid is protected against grid failure. In this case, the other two line conductors (e.g. L2 and L3) cannot be protected. Phase coupling enables combined switching of the line conductors in the event of grid disconnection. As a result, the other two line conductors are also supplied with voltage. This means that, in the event of grid failure, a three-phase utility grid becomes a single-phase utility grid. Phase coupling can be switched on independently for the line conductors L2 und L3.
Grounding device	In the case of all-pole disconnection, the functional group grounding device is part of the automatic transfer switch of the battery-backup system and enables protection against indirect contact with live components. For this, the grounding device connects the neutral conductor and the protective grounding in stand-alone mode (neutral grounding).

2 Bridging Time and Self-Consumption Quota

This section describes a method by which you can estimate bridging time and self-consumption quota for an SMA Flexible Storage System with battery-backup function. For the battery capacity, an empirical value of a typical battery-backup system is assumed and verified by means of the estimate. In the example, the assumed values for the energy demand of the loads in a private household, the peak power of the PV system and the battery capacity are characteristic of a battery-backup system in a four-person single-family household in Germany.

Step 1: Estimation of self-consumption quota for an SMA Flexible Storage System

Input data (example):

- Peak power of the PV system: 5000 Wp
- Annual energy demand: 5000 kWh
- Total battery capacity: 10000 Wh, of which the Sunny Island uses 50% for intermediate storage of PV energy.

The usable battery capacity therefore amounts to 5000 Wh.

$$\frac{\text{Peak power}}{\text{Annual energy requirement}} = \frac{5{,}000\ \text{Wp}}{5{,}000\ \text{kWh}} = 1\ \text{Wp/kWh}$$

$$\frac{\text{Usable battery capacity}}{\text{Annual energy demand}} = \frac{5000\ \text{Wh}}{5000\ \text{kWh}} = 1\ \text{Wh/kWh}$$

Transfer the calculated values to the diagram to estimate the self-consumption quota.

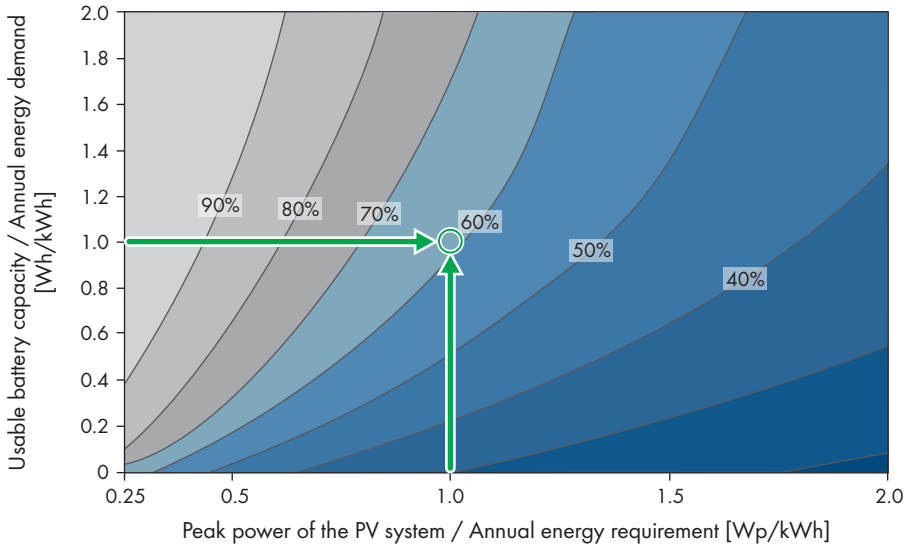


Figure 2: Estimation of the self-consumption quota with intermediate storage

The estimate reveals that the self-consumption quota, with energy management with intermediate storage, is approximately 60%.

Step 2: Estimation of energy demand in the event of grid failure

Input value:

- Annual energy demand: 5000 kWh

$$\frac{\text{Annual energy requirement}}{365\ \text{days}} = \frac{5000\ \text{kWh}}{365\ \text{days}} = 13.6/\text{kWh}$$

It can be assumed that during a grid failure, electrical energy will be used sparingly, e.g. by switching off energy-intensive loads. As a result, the daily energy demand of 13.6 kWh can be reduced. In this case, at a reduction by 40%, the energy demand of this household will be around 8 kWh in the event of a 24-hour grid failure.

Step 3: Estimation of PV generation during a grid failure

The peak power of the PV system is at 5000 Wp. In Germany in the winter, it can be assumed that 0.7 kWh/kWp will be generated. Hence, an energy yield from PV production of 3.5 kWh between sunrise and sunset is derived.

Step 4: Calculation of battery capacity required for the battery-backup function

Input value:

- Daily energy demand of the household: 8 kWh
- Daily energy yield from PV production: 3.5 kWh

Battery capacity = Energy demand − PV generation = 8 kWh − 3.5 kWh = 4.5 kWh

The required battery capacity amounts to 4.5 kWh. In Step 1, a battery capacity of 10 kWh was assumed. Thus, in this example 45% of the battery capacity will be needed as energy reserve for grid failure on a winter day.

Result

With lead-acid batteries, the default value of 45% of a Sunny Island parameter battery capacity is reserved for the battery-backup function in winter operation. This value is within the value range of 15% to 60% in which the battery capacity must range (see Section 3.6.3.1, page 14). Thus, the battery used for the SMA Flexible Storage System is also adequate for the battery-backup function.

3 Operating Conditions of a Battery-Backup Grid

3.1 Certifications and Licenses

In which countries the battery-backup system may be used depends primarily on the licenses and certifications of the battery inverter. Coordinate with the grid operator which certification must be provided for operation (information on certifying the battery inverter see www.SMS-Solar.com).

Another thing to take into account when selecting the operation site is the availability of automatic transfer boxes in each country (see Section 5.2, page 29).

3.2 Utility Grid

i Only utility grid permitted as external energy source

The only permitted external energy source in the battery-backup grid is the utility grid. Even when using the Sunny Island, the battery-backup system does not support the operation with a generator (e.g. diesel generator).

Residual-current monitoring unit:

☐ If an external residual-current device is required, install a residual-current device which trips at a residual current of 100 mA or higher (for details on selecting a residual-current device, see the Technical Information "Criteria for Selecting a Residual-Current Device" at www.SMA-Solar.com).

i Special conditions for use of the battery-backup grid with Sunny Island in Belgium

The utility grid connected to the automatic transfer switching device must generally be a TN or TT system. In Belgium, the utility grid can be designed to function as an IT system that is, however, grounded to the neutral point of the source.

This results in a hybrid form of an IT and TT system. Compared with a TT system, this hybrid form is not equipped with a neutral conductor. With this installation, the following restriction applies when using the battery-backup system:

- If the utility grid functions as an IT system that is grounded to the neutral point of the source, the connected battery-backup system must be single-phase.

Characteristics of the battery-backup grid

Characteristic	Single-phase battery-backup grid with Sunny Island or Sunny Boy Storage	Three-phase battery-backup grid with Sunny Island
Utility grid	TN or TT system	
	Single-phase or three-phase	Three-phase
Behavior of the battery inverters in the event of grid failure	One Sunny Island or one Sunny Boy Storage supplies the battery-backup grid.	Three Sunny Island inverters switched in parallel on the DC side supply each line conductor with the corresponding phase.
Recognition of grid failure	Grid failure is only recognized on the line conductor which is connected to the battery inverter (e.g. L1).	Grid failure is recognized on all line conductors.
Supply of the loads in the event of grid failure	Only some of the loads are supplied (e.g. the loads connected to L1).	All loads are supplied.
Grid feed-in by the PV inverters in the event of grid failure	Only single-phase PV inverters can feed energy into the grid.	Single-phase and three-phase PV inverters can feed energy into the grid.

Characteristic	Single-phase battery-backup grid with Sunny Island or Sunny Boy Storage	Three-phase battery-backup grid with Sunny Island
Phase coupling in the battery-backup grid	Phase coupling is possible.	Phase coupling is not possible.
Rotating magnetic field in the battery-backup grid	No: even with phase coupling, the battery-backup grid remains single-phase.	Yes: three Sunny Island inverters form a three-phase battery backup grid with rotating magnetic field.

Phase coupling

If three-phase loads are connected to a single-phase utility grid with phase coupling, SMA Solar Technology AG cannot rule out damage to the three-phase loads. With phase coupling, single-phase loads only must be connected to the battery-backup grid.

Battery-backup grid with or without all-pole disconnection

Type of grid disconnection	All-pole disconnection	Non-all-pole disconnection
Operating principle	In the event of grid failure, a tie switch disconnects all line conductors and the neutral conductor from the utility grid.	In the event of grid failure, a tie switch disconnects all line conductors from the utility grid. The neutral conductor of the battery-backup grid remains permanently connected to the utility grid.
Criterion for use	If the technical connection requirements of the grid operator or the locally applicable standards and directives call for all-pole disconnection, you must install the battery-backup system with all-pole disconnection.	If the technical connection requirements of the grid operator or the locally applicable standards and directives prohibit disconnection of the neutral conductor, you must install the battery-backup system without all-pole disconnection.

3.3 Miniature Circuit Breaker in the Household Distribution

In the event of a grid failure, the battery inverter creates a battery-backup grid (TN-S grid configuration). Therefore, only the battery inverter can trip circuit breakers and residual-current devices in the household distribution in case of a grid failure. The residual-current device in the automatic transfer switching device is not able to do that. It only protects the battery inverter in parallel grid operation.

The circuit breakers in the household distribution must therefore comply with the maximum tripping characteristics listed for the battery inverter.

Sunny Island

Device type	Maximum tripping characteristics
SI4.4M-12 / SI4.4M-13 (Sunny Island 4.4M)	B6 (B6A)
SI6.0H-12 / SI6.0H-13 (Sunny Island 6.0H)	B16 (B16A)
SI8.0H-12 / SI6.0H-13 (Sunny Island 8.0H)	B16 (B16A)

If circuit breakers are installed up to the mentioned tripping characteristic, the battery inverter is able to fulfill the required automatic disconnection of supply with the respective disconnection times in accordance with VDE 0100-410. If a circuit breaker has a higher tripping characteristic, an additional residual-current device of type A must be installed in the loads distribution. In doing so, an already existing residual-current device of type A can also be used.

Sunny Boy Storage

Device type	Maximum tripping characteristics
SBS3.7-10 (Sunny Boy Storage 3.7)	B6 (B6A)
SBS5.0-10 (Sunny Boy Storage 5.0)	B6 (B6A)
SBS6.0-10 (Sunny Boy Storage 6.0)	B16 (B16A)

If a miniature circuit breaker has a higher trip characteristic, the Sunny Boy Storage does not switch off the miniature circuit breaker in the event of a fault.

3.4 Switching Times for Loads

The SMA Flexible Storage System with battery-backup function does not fulfill the requirements of an uninterruptible power supply as per IEC 62040. In the event of grid failure, an automatic transfer switching device disconnects the battery-backup grid from the utility grid. After disconnection, the loads and the PV system are not supplied for approximately five to seven seconds, until the battery-backup system can provide active power and reactive power again.

If any single load (e.g. a computer) requires an uninterruptible power supply in compliance with the standard or a switching time shorter than five to seven seconds, this load will need a separate uninterruptible power supply in accordance with IEC 62040.

Longer switching periods for phase coupling

Loads integrated in the battery-backup grid via phase coupling have a higher switching time, as the SMA Flexible Storage System with battery-backup function connects phase coupling with a time delay.

- Maximum switching time for Sunny Island: 15 seconds
- Maximum switching time for Sunny Boy Storage: 10 seconds

3.5 PV Inverters

3.5.1 Suitable PV Inverters

No three-phase PV inverters in single-phase battery-backup systems

In the event of grid failure, only single-phase PV inverters can feed their output power into a single-phase battery-backup grid. Three-phase PV inverters cannot feed into the single-phase battery-backup grid. Thus, three-phase PV inverters are not recommended for single-phase battery-backup systems. Possible solutions are:

- Replace the three-phase PV inverter by a combination of single-phase PV inverters, e.g. two Sunny Boy 4.0 inverters instead of one Sunny Tripower 8000TL.
- Select a sufficiently large battery capacity to ensure the supply of the loads from the battery only over the entire bridging time.

For a SMA Flexible Storage System with battery-backup function, only PV inverters are suitable that can limit the active power depending on frequency (for information on frequency-dependent active power limitation see the Technical information "SMA GRID GUARD 10.0 - Grid management services through SMA Inverter"). In the following PV inverters you can activate frequency-dependent active power limitation as of the indicated firmware version.

PV inverter	Firmware version*
Sunny Boy (SB)	
SB1.5-1VL-40 / SB2.5-1VL-40	1.01.07.R
SB2.0-1VL-40	02.05.01.R
SB3.0-1AV-40 / SB3.6-1AV-40 / SB4.0-1AV-40 / SB5.0-1AV-40	01.02.18.R

PV inverter	Firmware version*
SB3.0-1AV-41 / SB3.6-1AV-41/ SB4.0-1AV-41 / SB5.0-1AV-41 / SB6.0-1AV-41 for use in Germany SB3.0-1AV-41 / SB3.6-1AV-41/ SB4.0-1AV-41 / SB5.0-1AV-41 / SB6.0-1AV-41 for use outside Germany	1.01.31.R 1.01.32.R
SB 1300TL-10 / 1600TL-10 / 2100TL-10	4.52
SB 2500TLST-21 / 3000TLST-21	2.50.41.R
SB 3300-11	4.03
SB 3800-11	4.02
SB 2000HF-30 / 2500HF-30 / 3000HF-30	2.30.07.R
SB 3000TL-21 / 3600TL-21 / 4000TL-21 / 5000TL-21	2.51.02.R
Sunny Tripower (STP)	
STP 5000TL-20 / 6000TL-20 / 7000TL-20 / 8000TL-20 / 9000TL-20 / 10000TL-20 / 120000TL-20	2.50.01.R
STP 8000TL-10 / 10000TL-10 / 12000TL-10 / 15000TL-10 / 17000TL-10	2.51.02.R
STP 15000TL-30 / 20000TL-30 / 25000TL-30	2.82.03.R
STP 15000TLEE-10 / 20000TLEE-10	2.54.03.R
STP3.0-3AV-40 / STP4.0-3AV-40 / STP5.0-3AV-40 / STP6.0-3AV-40	2.13.07.R
STP8.0-3AV-40 / STP10.0-3AV-40	1.01.18.R

* With older firmware versions, a firmware update is required (see manual of the PV inverter).

3.5.2 Maximum AC Power of the PV Inverters

The AC power that the PV inverters are permitted to feed into the battery-backup system is limited mainly by the rated power of the battery inverter.

Type of battery-backup system	Device type	Battery inverter*	PV inverter**
Single-phase system with Sunny Island	SI4.4M-12 / SI6.0H-13 (Sunny Island 4.4M)	3.3 kW	4.6 kW
	SI6.0H-12 / SI6.0H-13 (Sunny Island 6.0H)	4.6 kW	9.2 kW
	SI8.0H-12 / SI8.0H-13 (Sunny Island 8.0H)	6.0 kW	12 kW
Single-phase system with one Sunny Boy Storage	SBS3.7-10 (Sunny Boy Storage 3.7)	3.68 kW	4.9 kW
	SBS5.0-10 (Sunny Boy Storage 5.0)	5.00 kW	6.7 kW
	SBS6.0-10 (Sunny Boy Storage 6.0)	6.00 kW	7.7 kW

Type of battery-backup system	Device type	Battery inverter*	PV inverter**
Three-phase system with one Sunny Island	SI4.4M-12 / SI6.0H-13 (Sunny Island 4.4M)	9.9 kW	13.8 kW
	SI6.0H-12 / SI6.0H-13 (Sunny Island 6.0H)	13.8 kW	27.6 kW
	SI8.0H-12 / SI8.0H-13 (Sunny Island 8.0H)	18.0 kW	36 kW

* Rated power of the battery inverter

** Maximum AC power of the PV inverters

When estimating the maximum AC power of the PV inverters, the following factors can also be considered:

- The yield of the PV power is influenced by the solar irradiation on site. As a result, the AC power output of the the PV inverters can be reduced.
- Local regulations can call for permanent limitation of active power feed-in to a fixed amount or a percentage share of the installed nominal PV system power. This can also lower the AC power output of the PV inverters.

3.5.3 Frequency-Dependent Control of Active Power at the PV Inverter

If PV inverters are to be used in an SMA Flexible Storage System with battery-backup function, they must limit their active power as a function of frequency. The manner of the frequency-dependent active power limitation complies with the locally applicable standards and directives (for further information see Technical information "SMA GRID GUARD 10.0 - Grid management services through SMA Inverter").

3.6 Batteries

3.6.1 Recommendations for Battery Capacity

SMA Solar Technology AG recommends the following minimum battery capacities when using the Sunny Island. The recommended battery capacities must be observed to ensure stable operation of the system.

Battery-backup system	Battery capacity for a ten-hour electric discharge (C10)
Single-phase battery-backup system with SI4.4M-12 / SI4.4M-13 (Sunny Island 4.4M)	100 Ah
Single-phase battery-backup system with SI6.0H-12 / SI6.0H-13 (Sunny Island 6.0H)	120 Ah
Single-phase battery-backup system with SI8.0H-12 / SI8.0H-13 (Sunny Island 8.0H)	160 Ah
Three-phase battery-backup system with three SI4.4M-12 / SI4.4M-13 (Sunny Island 4.4M)	300 Ah
Three-phase battery-backup system with three SI6.0H-12 / S16.0H-13 (Sunny Island 6.0H)	360 Ah
Three-phase battery-backup system with three SI8.0H-12 / SI8.0H-13 (Sunny Island 8.0H)	480 Ah
Single-phase battery-backup system with SBS3.7-10 (Sunny Boy Storage 3.7)	see Technical Information "Approved batteries and battery communication connection"
Single-phase battery-backup system with SBS5.0-10 (Sunny Boy Storage 5.0)	
Single-phase battery-backup system with SBS6.0-10 (Sunny Boy Storage 6.0)	

3.6.2 Supported Batteries

Sunny Island

The Sunny Island supports lead-acid batteries of types FLA and VRLA as well as various lithium-ion batteries. It is important to observe the capacity:

- Lead-acid batteries with a capacity of 100 Ah to 10000 Ah can be connected.
- Lithium-ion batteries with a capacity of 50 Ah to 10000 Ah can be connected.

This corresponds to a maximum storage capacity of 480 kWh for a battery with 48 V and 10000 Ah.

A lithium-ion battery is especially suited for intermediate storage of PV energy due to its high cycle stability. The lithium-ion batteries must be compatible with the Sunny Island:

- The battery must comply with the locally applicable standards and directives and must be intrinsically safe.
- The Sunny Island must only be operated in connection with an intrinsically safe lithium-ion battery approved by SMA Solar Technology AG (see Technical Information “List of Approved Batteries” at www.SMA-Solar.com).
- If no lithium-ion battery approved for the Sunny Island can be used, use a lead-acid battery.

Sunny Boy Storage

The Sunny Boy Storage must only be operated in connection with an intrinsically safe lithium-ion battery approved by SMA Solar Technology AG (see Technical Information "Approved batteries and battery communication connection" at www.SMA-Solar.com).

Lithium-ion battery for Sunny Island and Sunny Boy Storage

The battery management of lithium-ion batteries controls the operation of the battery. To enable battery management, the lithium-ion battery must be connected to the battery inverter via a data cable.

In the case of compatible lithium-ion batteries, SMA Solar Technology AG has only tested the interaction between the battery inverter and the battery management of the lithium-ion battery. For information on other technical properties of the batteries, please contact the respective manufacturer of the lithium-ion battery.

i Lithium-ion batteries in battery-backup systems

In order to meet the requirements of battery-backup systems in the event of grid failure, the battery inverter has an overload capacity. To be able to use this overload capacity, the output powers and output currents of the battery inverter must be taken into consideration when selecting the battery (for Sunny Island see Technical information “List of Approved Batteries”, for Sunny Boy Storage see Technical information "Approved batteries and battery communication connection").

3.6.3 Battery use

3.6.3.1 Battery Use by the Sunny Island

In many regions, the PV energy available largely depends on the season and the hours of sunshine. The discharge behavior can be adjusted to the location and time by the Sunny Island.

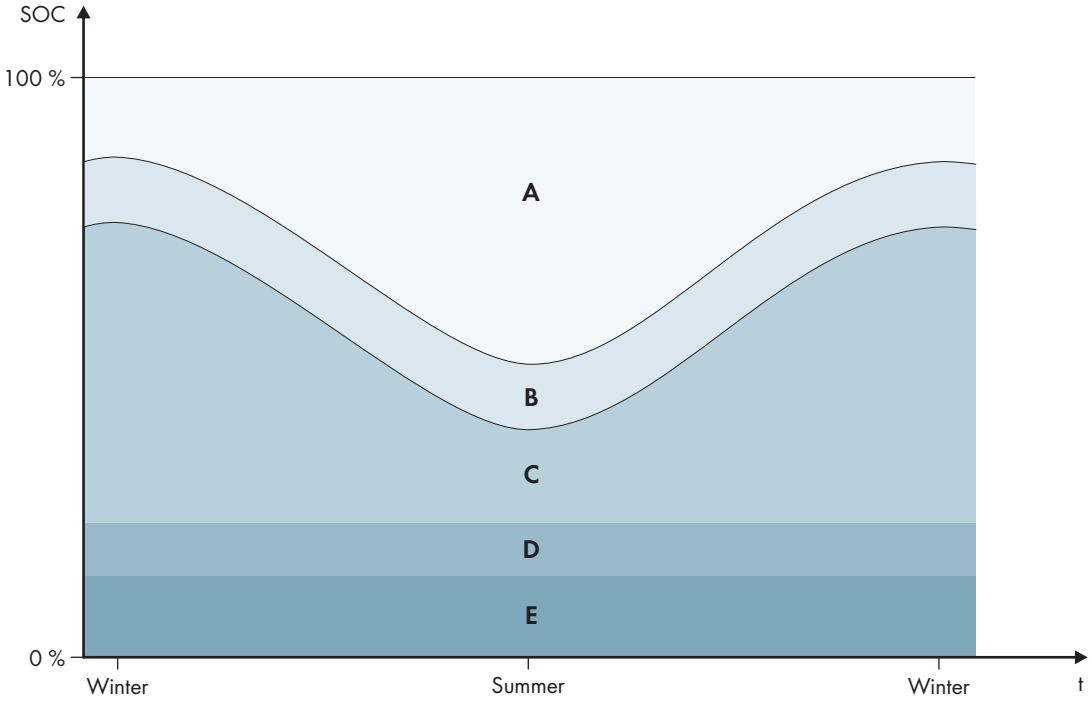


Figure 3: Ranges of the battery state of charge as a function of the season for the northern hemisphere (example)

Position	Range	Explanation
A	**Self-consumption area (SlfCsmp)**	Range for intermediate storage
B	**State of charge conservation area (PVRes)**	Range for maintenance of the battery state of charge
C	**Backup power area (BURes)**	Range for battery-backup function
D	**Deep discharge protection area (BatRes)**	Range for protection against deep discharge
E	**Deep discharge area (ProtRes)**	Range for protection in the event of deep discharge

Due to the seasonal battery operation of the Sunny Island, a larger range is reserved for the battery backup function in winter than in summer. This makes sense, as consumption in summer is lower and the PV yield is also much higher in summer. The limits for the ranges of battery state of charge are predetermined for lead-acid batteries and lithium-ion batteries by the following value ranges of the Sunny Island inverter.

Range	Lead-acid battery		Lithium-ion battery	
	Shortest day*	**Longest day****	**Shortest day***	**Longest day****
Self-consumption area	65% to 100%	45% to 100%	30% to 100%	28% to 100%
State of charge conservation area	60% to 65%	40% to 45%	25% to 30%	23% to 28%

Range	Lead-acid battery		Lithium-ion battery	
	Shortest day*	Longest day**	Shortest day*	Longest day**
Backup power area	15% to 60%	15% to 40%	13% to 25%	13% to 23%
Deep discharge protection area	10% to 15%	10% to 15%	3% to 13%	3% to 13%
Deep discharge area	0% to 10%	0% to 10%	0% to 3%	0% to 3%

* December 21 (northern hemisphere) or June 21 (southern hemisphere)

** June 21 (northern hemisphere) or December 21 (southern hemisphere)

The value ranges for lithium-ion batteries reserve a smaller proportion of battery capacity for the battery-backup function: 10% of battery capacity in summer and 12% of battery capacity in winter. Therefore, the proportion available for intermediate storage is correspondingly larger.

3.6.3.2 Battery Use by the Sunny Boy Storage

Range	Parameter (technical term)	Battery inverter behavior
A	Self-consumption range (SlfCsmp)	The battery inverter uses the batteries within this range for increased self-consumption and for the "Time-of-Use" and "Peak Load Shaving" functions that can be configured in the power profile.
C	Minimum width of backup power range (BURes)	Range for battery-backup operation during grid failure This range is set to 0% by default. If an automatic transfer switching device is connected, the range must be set depending on your needs. The setting value refers to the user SOC. Utility grid available: When the upper limit of C is reached, the battery inverter goes into standby mode. The batteries remain switched on. Excess PV energy is used for conserving the battery charge. When the SOC in range C has decreased by the set value of range B, the battery inverter recharges the batteries with 3 A from the utility grid. If the set value of the parameter for range B is less than the set value of the parameter for range C, the batteries are recharged in range D first.

Range	Parameter (technical term)	Battery inverter behavior
B	Range for maintaining battery state of charge (PVRes)	Utility grid available: The battery inverter checks the current SOC every 24 hours. If the SOC is in range D, the batteries are recharged with 3 A from the utility grid until the upper limit of range C is reached. During battery-backup operation: The battery inverter starts up every two hours for approx. six minutes and attempts to charge the batteries with PV energy. If no excess PV energy is available, the battery inverter switches to standby mode.
D	Minimum width of deep-discharge protection range (BatRes)	Once the limit from B to D is reached, the battery and battery inverter switch off. The battery-backup operation can be enabled by switching on the black-start switch of the battery inverter. If the battery is not recharged after six minutes, the battery-backup operation will be stopped. No automatic start-up process will be initiated after two hours. When range D is reached and the utility grid is available, the battery inverter charges the batteries with 3 A from the utility grid.
E	Lower limit of the deep-discharge protection range for disconnection (ProtRes)	If range E is reached during battery-backup operation, the batteries are switched off. The battery inverter is also switched off due to a lack of DC voltage. When range E is reached and the utility grid is available, the battery inverter charges the batteries with 3 A from the utility grid until range A is reached.

3.7 Battery inverter

3.7.1 Overload capacity of the battery inverters

3.7.1.1 Maximum Power Consumption of the Loads with Sunny Island

The maximum power consumption of the loads during the day and the type of battery-backup system determine the device type and the number of battery inverters. In a single-phase battery backup system with Sunny Island, for instance, the maximum power consumption of the loads must be less than the maximum power of the Sunny Island for a duration of 30 min at 25°C.

Type of battery-backup system	Maximum power*	Device type	Number of inverters
Single-phase	4.4 kW	SI4.4M-12 / SI4.4M-13 (Sunny Island 4.4M)	1
	6 kW	SI6.0H-12 / SI6.0H-13 (Sunny Island 6.0H)	
	8 kW	SI8.0H-12 / SI8.0H-13 (Sunny Island 8.0H)	

Type of battery-backup system	Maximum power*	Device type	Number of inverters
Three-phase	13.2 kW	SI4.4M-12 / SI4.4M-13 (Sunny Island 4.4M)	3
	18 kW	SI6.0H-12 / SI6.0H-13 (Sunny Island 6.0H)	
	24 kW	SI8.0H-12 / SI8.0H-13 (Sunny Island 8.0H)	

* Maximum power of the battery inverter inverter for 30 minutes at 25°C and 230 V

Short-term overload during grid failure

Short-term overload peaks of the loads can be compensated by the battery inverter within its technical power limits (see operating manual of the inverter inverter at www.SMA-Solar.com). However, the DC cabling from the battery inverter to the battery must be designed to withstand this overload operation.

3.7.1.2 Maximum Power Consumption of all Loads with Sunny Boy Storage

The maximum power consumption of the loads during the day and the type of battery-backup system determine the device type and the number of battery inverters. In a single-phase battery backup system with Sunny Boy Storage, the maximum power consumption of the loads must be less than the maximum power of the Sunny Boy Storage for a duration of 1 min at 25°C.

Type of battery-backup system	Maximum power of the inverter for one minute at 25°C and 230 V	Device type	Number of inverters
Single-phase	4.6 kW	SBS3.7-10 (Sunny Boy Storage 3.7)	1
	6.4 kW	SBS5.0-10 (Sunny Boy Storage 5.0)	
	7.5 kW	SBS6.0-10 (Sunny Boy Storage 6.0)	

3.7.2 Functions of the Sunny Boy Storage for the Battery-Backup System

Black start function

The inverter has a black start function and an auxiliary battery that provides energy for the black start. In battery-backup systems, you have the possibility to install a standard switch for black starting the inverter and battery. The black-start switch is used to start the battery-backup operation manually in the event of grid failure if the battery and inverter are in sleep mode and, therefore, are unable to provide energy. When the black-start switch is switched on manually, the energy from the auxiliary battery is made available in order to automatically switch the battery and therefore also the inverter from sleep mode to operation in order that the inverter can make energy available from the battery. You can stop the battery-backup operation by switching it off manually. To enable the black-start function, at least one battery capable of black start must be connected to input A.

Battery-backup operation with empty battery

When the battery is fully discharged during a grid failure, the battery inverter cannot initially provide any AC voltage.

If there is sufficiently high PV power, the PV inverter charges the battery until a preset state of charge has been reached (usually 5%). If there is no PV power available, the start-up is canceled and no more AC voltage is provided. The battery inverter attempt starting up again when a defined waiting time has expired or a black start has been requested.

After five attempts, the battery inverter terminates the start-up and switches to sleep mode. The battery inverter can then only be started manually using the black start switch.

3.8 Communication

Electricity supply of communication devices

During a grid failure, only the devices in the battery-backup grid are supplied with current. If the router, the optional switch or other communication devices are not supplied with electricity, many of the inverters' capabilities in the battery-backup system are limited or unavailable.

- Connect the electricity supply of the router and the optional network switches to the battery-backup grid.

Requirements for the Speedwire network

The battery inverter and the Sunny Home Manager 2.0 can be directly interconnected via Speedwire. If more than two devices are to communicate via Speedwire or the Sunny Home Manager 2.0 is to establish an internet connection to the Sunny Portal, a Speedwire network is required.

Requirements:

☐ All Speedwire devices must be connected to the same router.

☐ The router and the optional network switch must fully support Multicast.

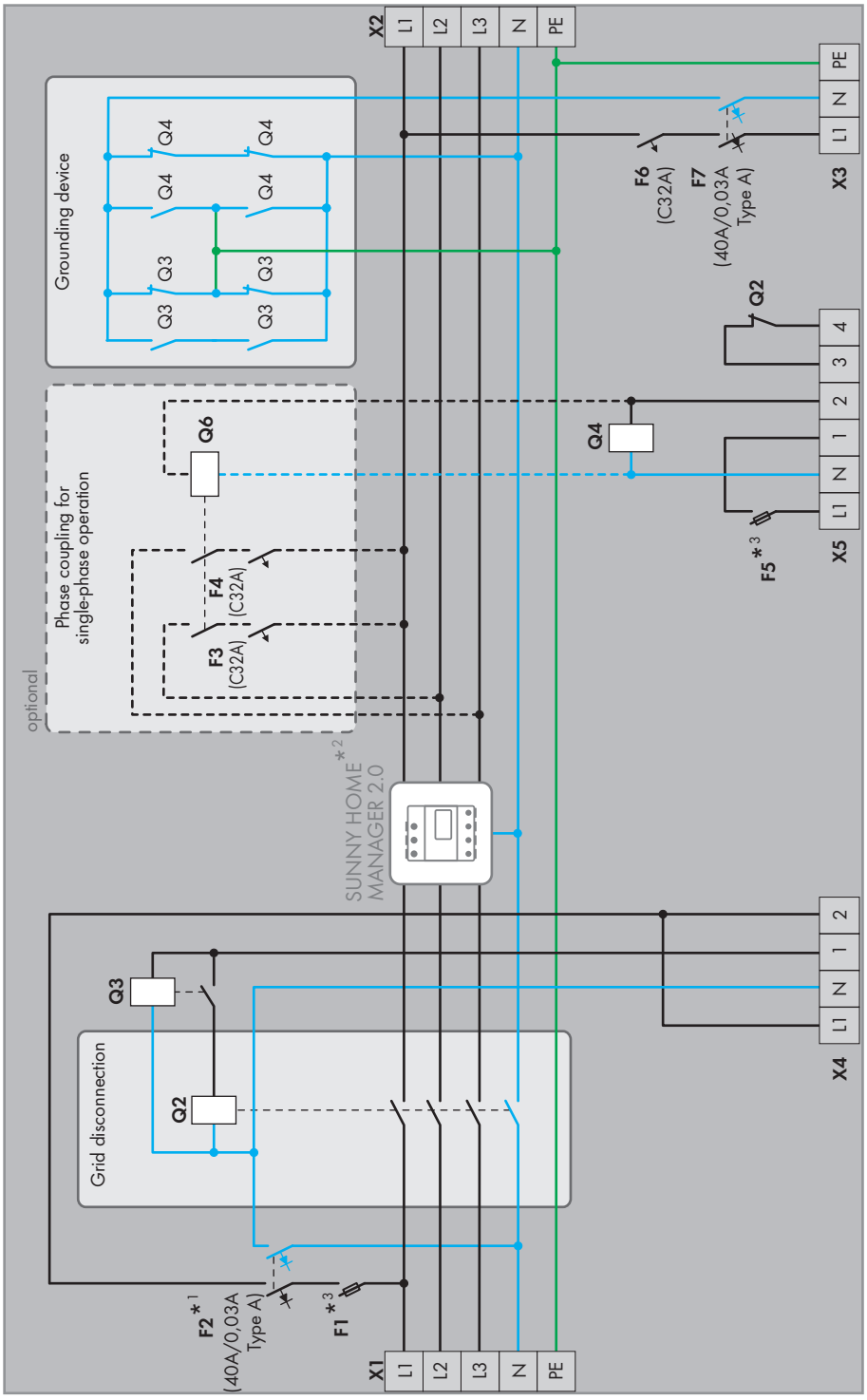
☐ The router must support "Internet Enabled Devices" with the SIP and STUN interfaces.

Most common routers and network switches support Multicast and "Internet Enabled Devices".

4 Electrical Connection

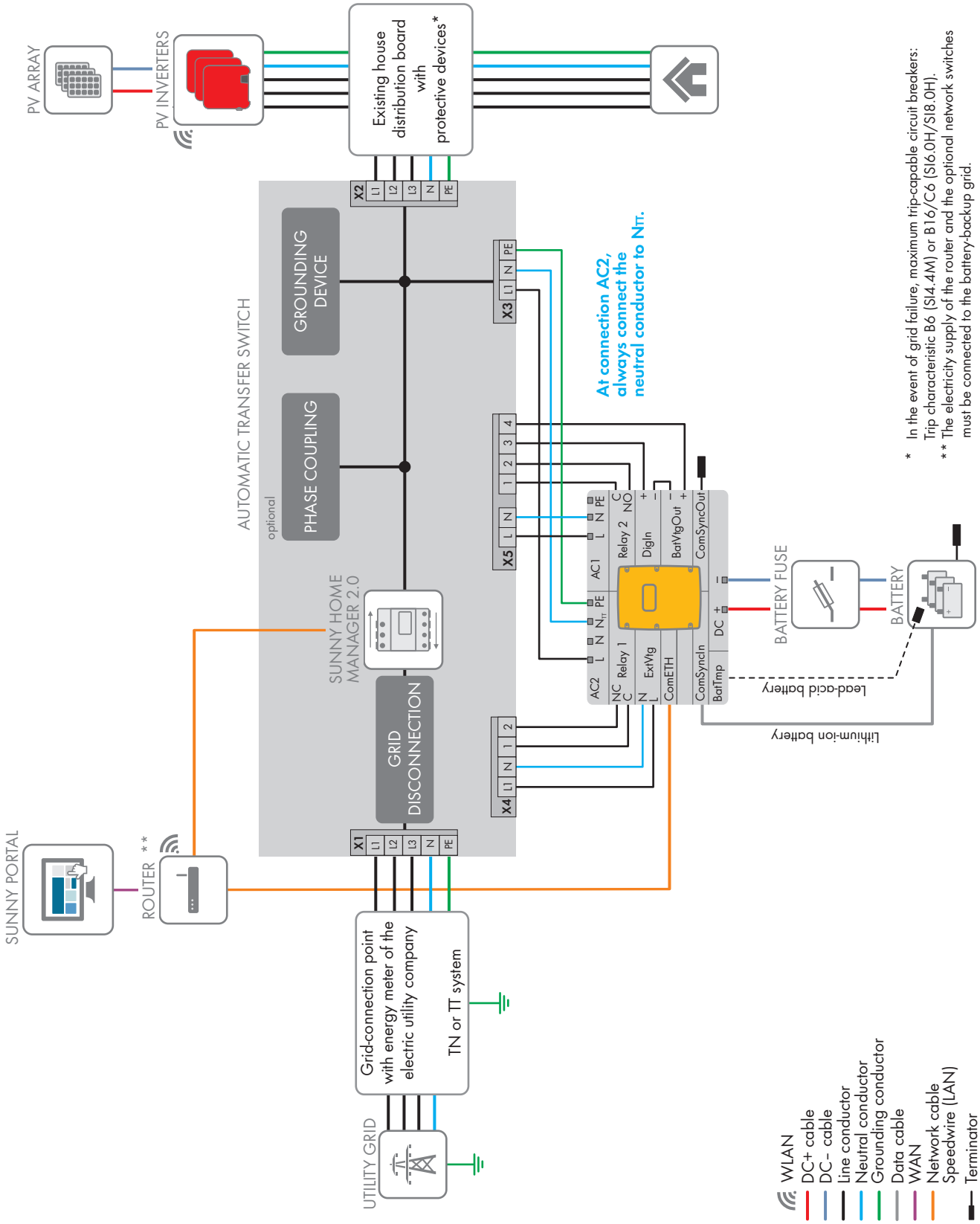
4.1 Connection of Battery-Backup Systems with Sunny Island

4.1.1 Automatic Transfer Switching Device for Single-Phase Battery-Backup System with All-Pole Disconnection

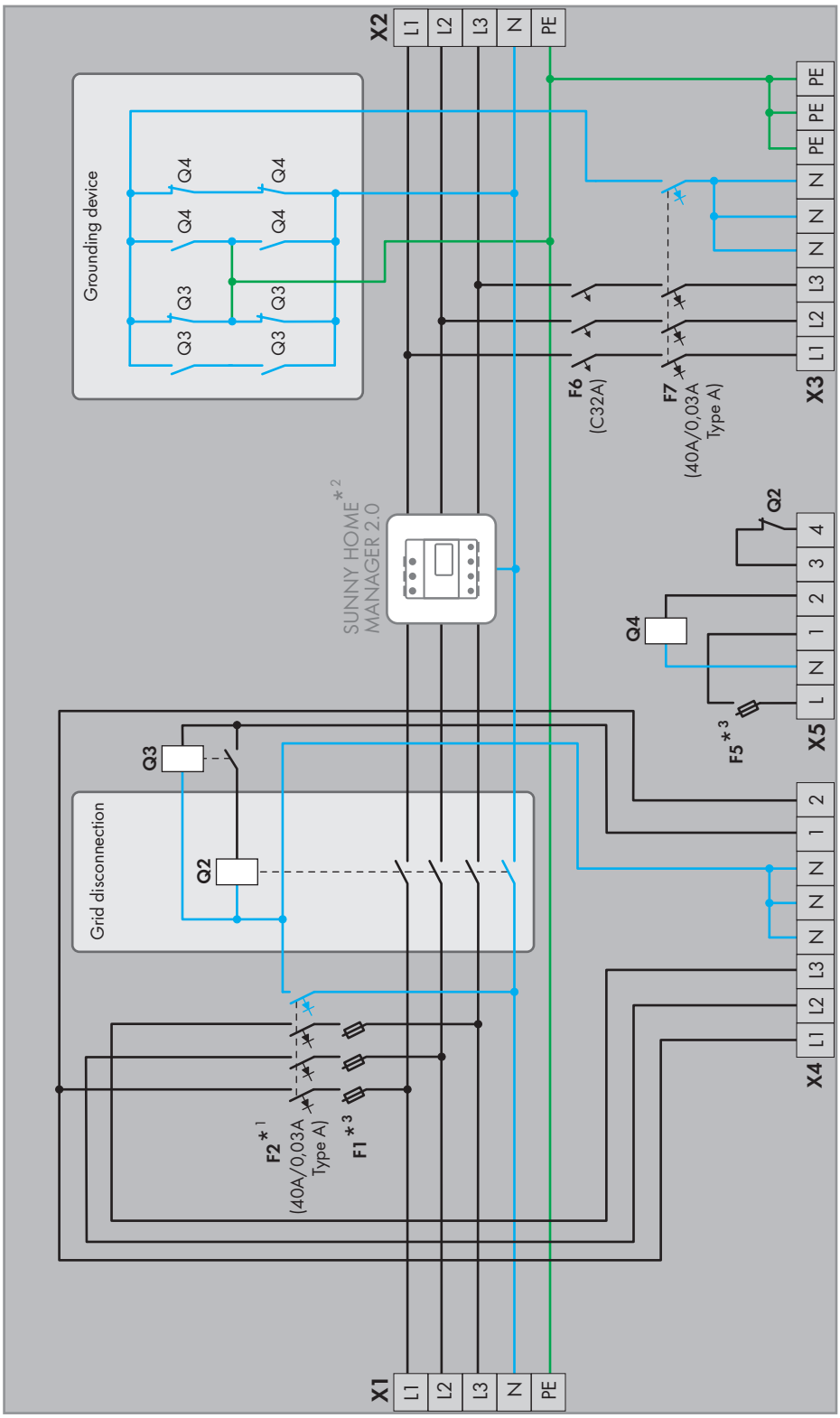


*1 Only when connecting to a TT grid, the line conductor and the neutral conductor must be fused.
*2 Not required for systems without increased self-consumption.
*3 Requirements for thermal fuse used: 1 A, nominal cold resistance of at least 0.2 Ω and melting integral max. 1A2s. The indicated values in brackets are recommended by SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

4.1.2 Circuitry Overview for single-Phase Battery-Backup System with All-Pole Disconnection

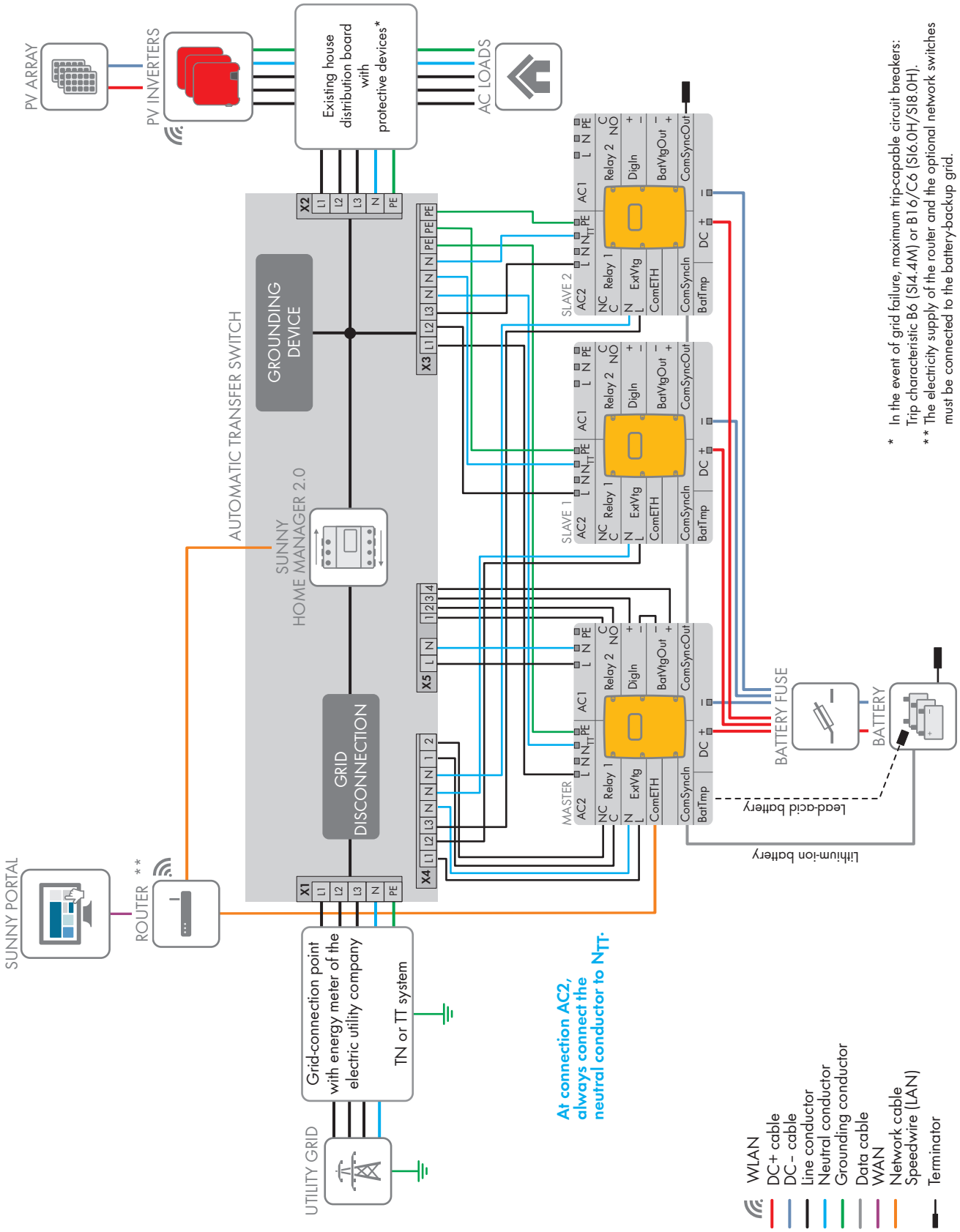


4.1.3 Automatic Transfer Switching Device for Three-Phase Battery-Backup System with All-Pole Disconnection

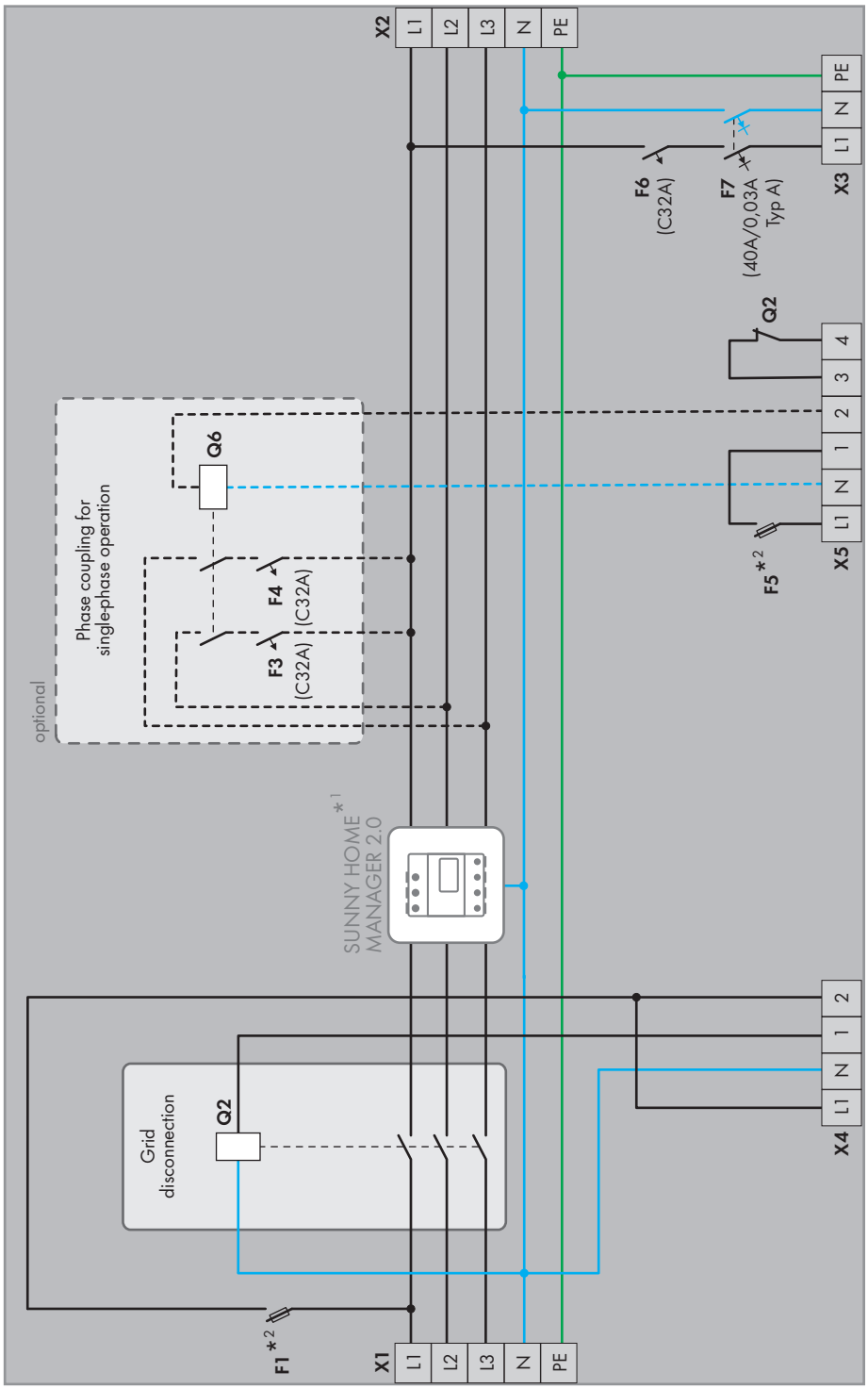


*1 Only when connecting to a TT grid, the line conductor and the neutral conductor must be fused.
*2 Not required for systems without increased self-consumption.
*3 Requirements for thermal fuse used: 1 A, nominal cold resistance of at least 0.2 Ω and melting integral max. 1A2s. The indicated values in brackets are recommended by SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

4.1.4 Circuitry Overview for Three-Phase Battery-Backup System with All-Pole Disconnection

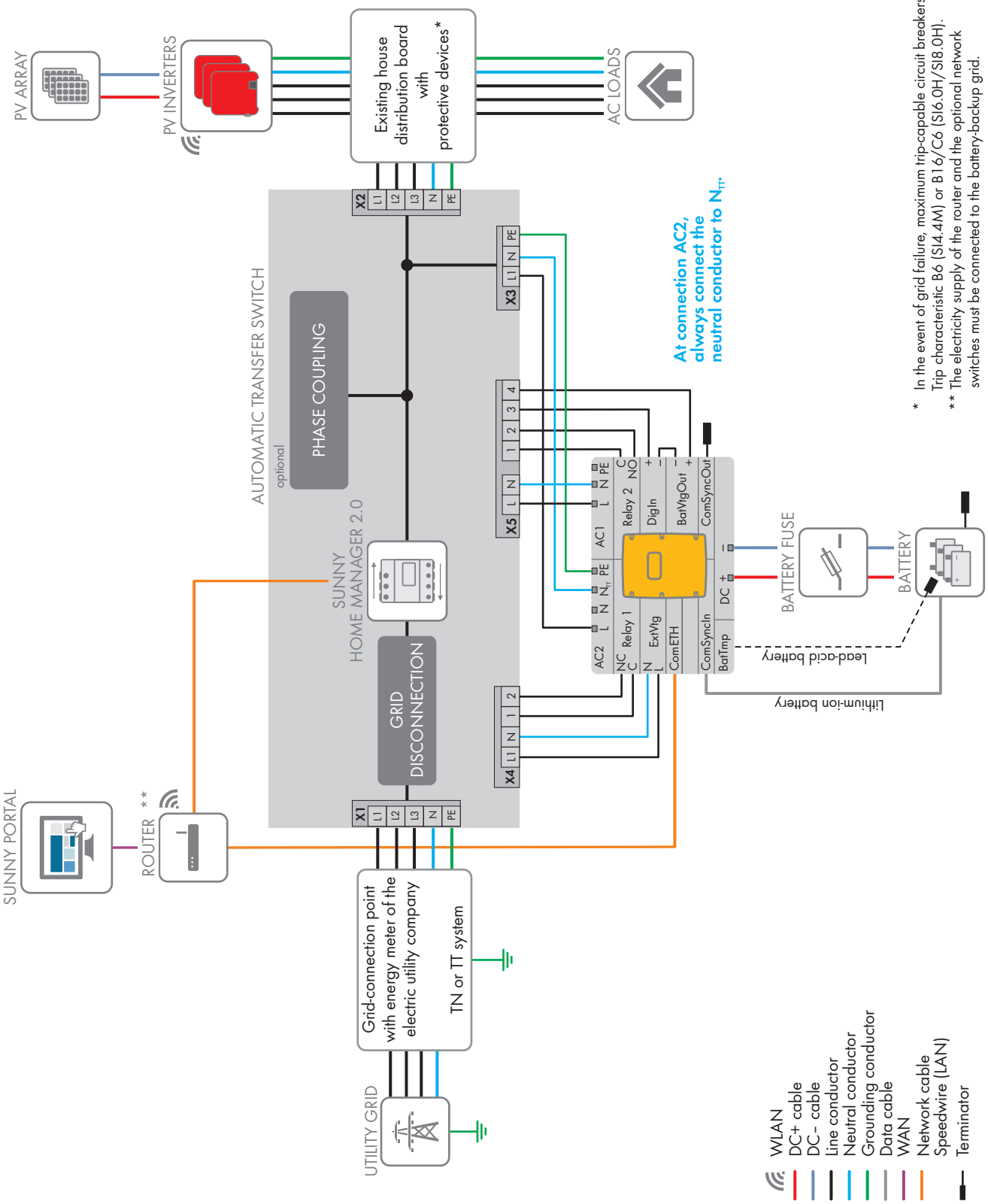


4.1.5 Automatic Transfer Switching Device for Single-Phase Battery-Backup System without All-Pole Disconnection

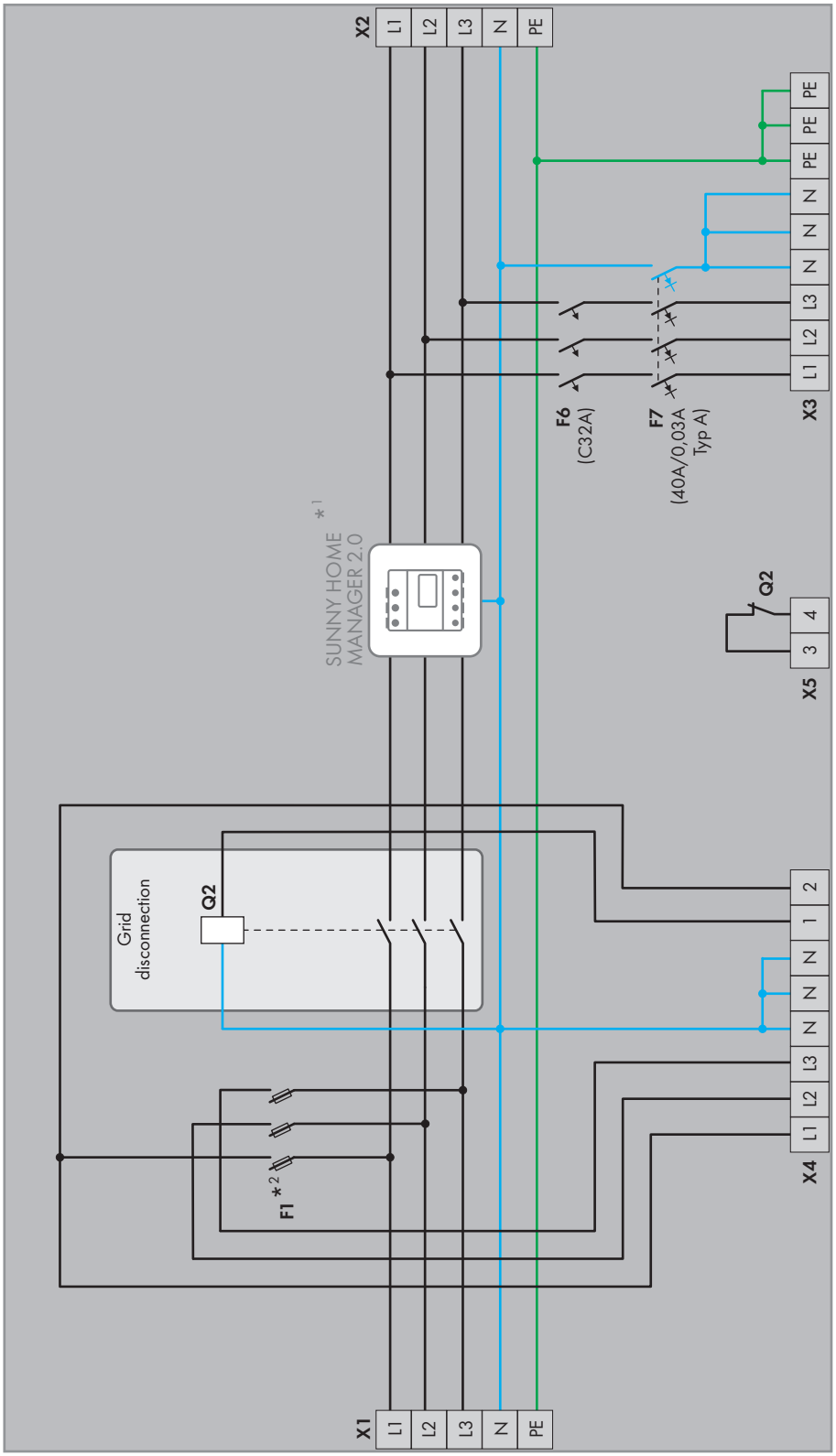


*1 Not required for systems without increased self-consumption.
*2 Requirements for thermal fuse used: 1 A, nominal cold resistance of at least 0.2 Ω and melting integral max. 1A2s.
The indicated values in brackets are recommended by SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

4.1.6 Circuitry Overview for Single-Phase Battery-Backup System without All-Pole Disconnection

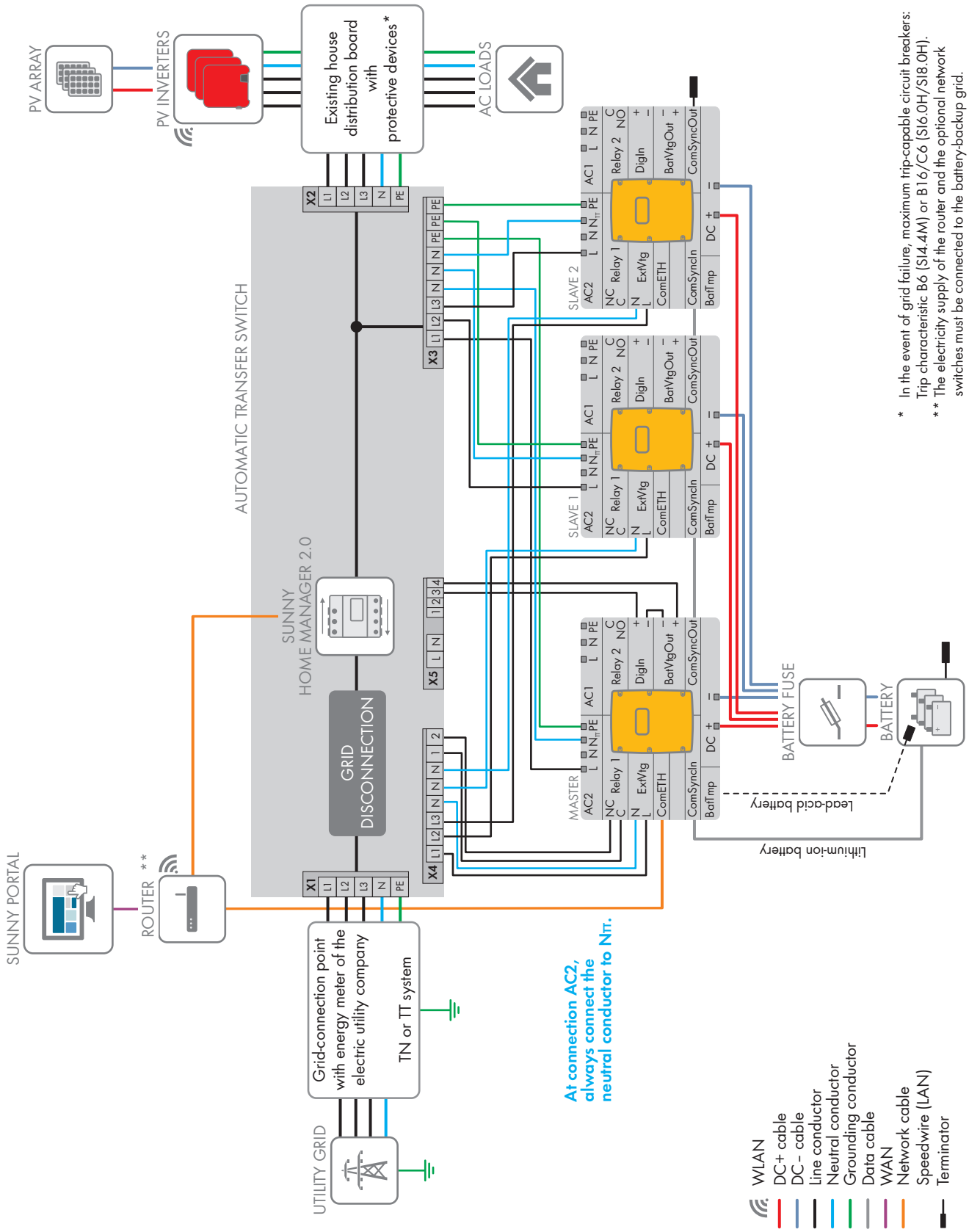


4.1.7 Automatic Transfer Switching Device for Three-Phase Battery-Backup System without All-Pole Disconnection



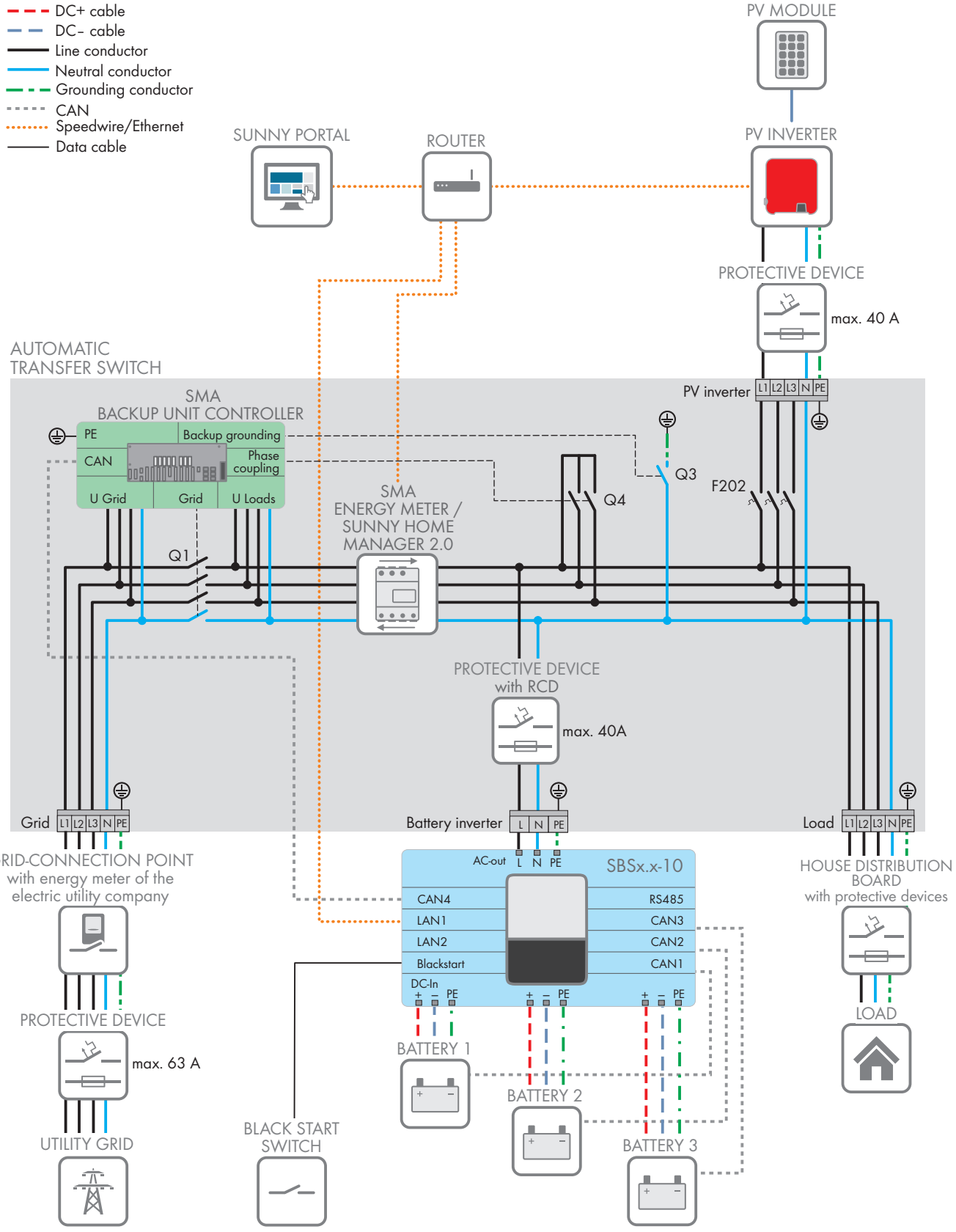
*1 Not required for systems without increased self-consumption.
*2 Requirements for thermal fuse used: 1 A, nominal cold resistance of at least 0.2 Ω and melting integral max. 1A2s.
The indicated values in brackets are recommended by SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

4.1.8 Circuitry Overview for Three-Phase Battery-Backup System without All-Pole Disconnection

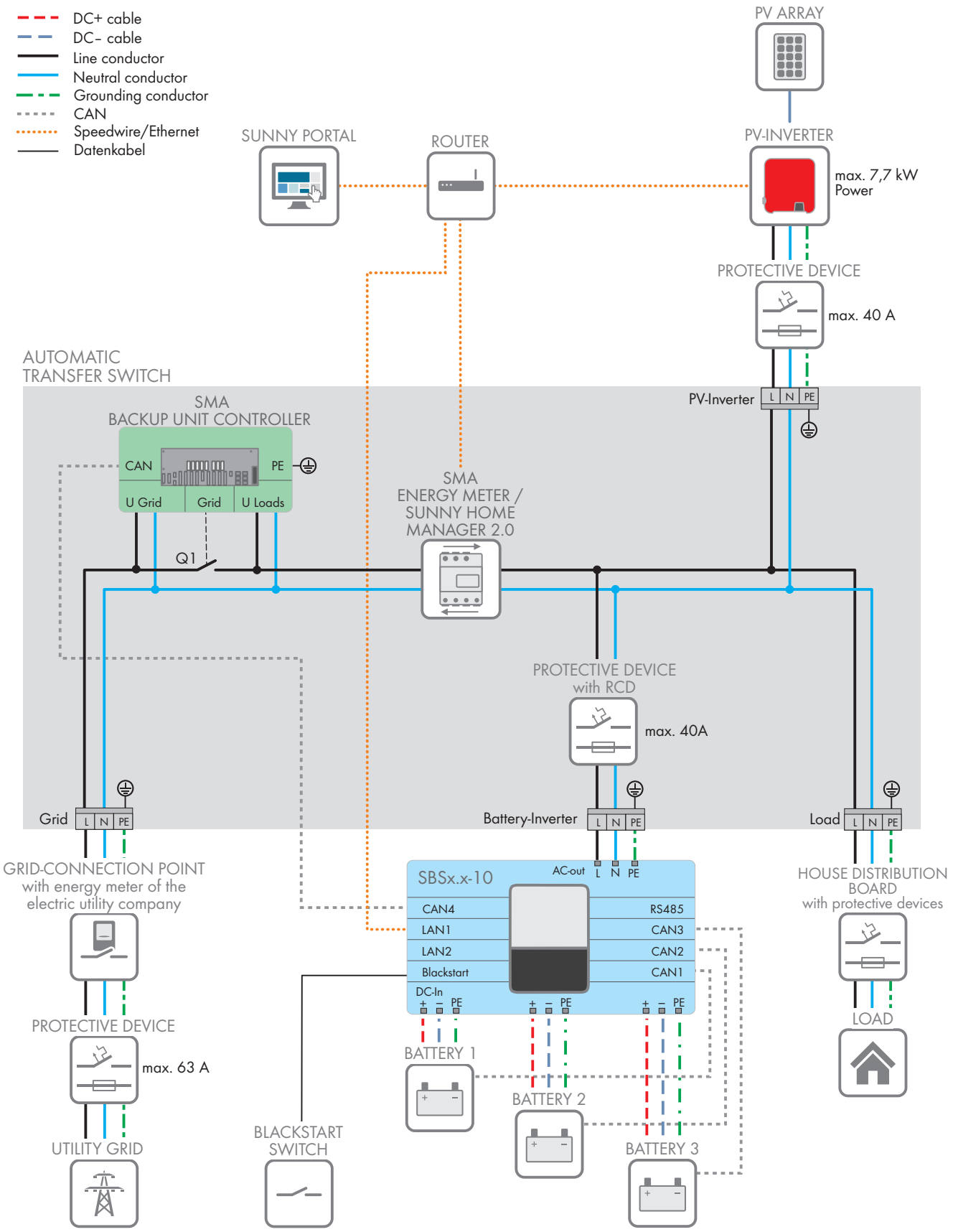


4.2 Connection of Battery-Backup Systems with Sunny Boy Storage

4.2.1 Circuitry Overview for single-Phase Battery-Backup System with All-Pole Disconnection



4.2.2 Circuitry Overview for Single-Phase Battery-Backup System without All-Pole Disconnection



5 Automatic Transfer Switching Device

5.1 Requirements of VDE Application Guide 2510-2

The requirements below apply only for systems for which the following properties are all applicable:

- The system is a system with increased self-consumption (SMA Flexible Storage System) or a system with increased self-consumption and battery-backup function (battery-backup system).
- The grid operator or the locally applicable standards and guidelines require compliance with the above-mentioned Application Guide.

  Currently, only the grid operators in Germany require compliance with the above-mentioned Application Guide.

In accordance with the scope of VDE application guide 2510-2, a manufacturer's system is regarded as a complete energy storage system only if products are used that have been approved by the manufacturer (see Technical information "List of Approved Batteries" of the battery inverter). If products are used that have not been approved by SMA Solar Technology AG, the installer is deemed to be the manufacturer of the system.

The requirements of VDE application guide 2510-2 are fulfilled if the installation is carried out in the accordance with the technical documentation of the battery inverter.

5.2 Procurement of the Automatic Transfer Switching Device

Automatic transfer switching device for the Sunny Island

It is recommend that you order the automatic transfer switching device for the Sunny Island as a complete switch cabinet unit.

Technical characteristics			Procurement	From enwitec electronic GmbH & Co.KG:
Single-phase	Three-phase	All-pole disconnection		Part number
x	–	x	Order from enwitec electronic GmbH & Co.KG or set up independently.	10012551*
–	x	x	Order from enwitec electronic GmbH & Co.KG or set up independently.	10012571*

* This automatic transfer switching device has been checked by SMA Solar Technology AG. More automatic transfer switching devices can be acquired from enwitec electronic GmbH & Co.KG.

When using the Sunny Island, it is also possible to procure the required devices of the automatic transfer switching device from specialist dealers and to build the switch cabinet independently. In Germany, the application guide 2510-2 must be observed among other things.

Automatic transfer switching device for the Sunny Boy Storage

The automatic transfer switching device with the Sunny Boy Storage is always single phase. According to the requirements at the operation site, the automatic transfer switching device can be designed with or without all-pole disconnection or optionally equipped with phase coupling.

The automatic transfer switching device for the Sunny Boy Storage must be ordered as a finished switch cabinet from enwitec electronic GmbH & Co.KG or Limtronik GmbH. You must not build the automatic transfer switching device by yourself. The automatic transfer switching device listed in the following table has been checked by SMA Solar Technology AG. More automatic transfer switching devices can be acquired from enwitec electronic GmbH & Co.KG or Limtronik GmbH.

Technical characteristics			enwitec electronic GmbH & Co.KG:	Limtronik GmbH:
Operation site (utility grid)	**Single-phase PV inverter**	**For three-phase PV inverters**	**Part number**	**Part number**
Germany, Austria, Switzerland (three-phase utility grid)	x	-	10012945	in planning
Germany, Austria, Switzerland (three-phase utility grid)	x	x	10012856	in planning
Italy (single-phase utility grid)	x	-	10013490	-
Italy (three-phase utility grid)	x	x	10013491	-
Great Britain	x	-	10013687	-
Australia	x	-	-	SBS-ABU-63.1-AU-10*

* This automatic transfer switching device can be ordered at SMA Solar Technology AG.

5.3 Rules for the Connection of the Automatic Transfer Switching Device

Connecting the automatic transfer switch	Sunny Island	Sunny Boy Storage
Connection of the PV system	The automatic transfer switching device is not a distribution board for the PV system. You must also install the necessary protective devices for the PV system.	The PV system can be connected directly to the automatic transfer switching device.

Connecting the automatic transfer switch	Sunny Island	Sunny Boy Storage
Connection of the loads	The automatic transfer switching device is not a distribution board for the loads. You must additionally install the necessary protective devices for the loads. You may use suitable protective devices in the household distribution. Make sure that the trigger conditions of the miniature circuit breakers in the household distribution match the installed battery-backup system in each case (see Section 3.3, page 9).	
Dimensioning of the tie switch	Regardless of all-pole or non-all-pole disconnection, you must adjust the ampacity of the tie switch in accordance with the local requirements (see Section 3.1, page 8). The tie switch in the automatic transfer switching device must have an ampacity that is designed for at least the operating range of the upstream fuse (for the ampacity of the tie switch, see the documentation of the automatic transfer switching device or the tie switch).	Regardless of all-pole or non-all-pole disconnection, you must adjust the ampacity of the tie switch in accordance with the local requirements (see Section 3.1, page 8). The tie switch in the automatic transfer switching device must have an ampacity that is designed for at least the operating range of the upstream fuse (for the ampacity of the tie switch, see the documentation of the automatic transfer switching device).

5.4 For Battery-Backup Systems with Sunny Island: Material Lists for Automatic Transfer Switching Devices

5.4.1 Material for Automatic Transfer Switching Device of a Single-Phase Battery-Backup System with All-Pole Disconnection

The following table refers to the design of the battery-backup system with Sunny Island and summarizes the configuration of the automatic transfer switching device as suggested in the schematic diagram. You will need to procure the material for configuring your automatic transfer switching device from your distributor.

i Design of the devices in the automatic transfer switching device

The indicated values for the devices are recommended SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

Position	Material	Number of units	Design
F1	Thermal fuse for protecting the control cables and measuring cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s
F2	Residual-current device for control and measuring cables*	1	40 A/0.03 A, 1-pole + N, type A
F3, F4	Miniature circuit breaker for protection of phase coupling**	2	32 A, C rating, 1-pole
F5	Thermal fuse for protecting the control cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s

Position	Material	Number of units	Design
F6	Circuit breaker for protection of the Sunny Island	1	32 A, C rating, 1-pole
F7	Residual-current device	1	40 A/0.03 A, 1-pole + N, type A
Q2	Contactor for grid disconnection	1	400 V, 63 A bei AC-1, AC-7a, 4 no
	Auxiliary switch for feedback	1	1 nc
Q3	Contactor for grounding device	1	400 V, 40 A at AC-1, AC-7a, 2 no 2 nc
	Auxiliary switch for Q1 locking mechanism	1	1 no
Q4	Contactor for grounding device	1	400 V, 40 A at AC-1, AC-7a, 2 no 2 nc
Q6	Phase coupling contactor**	1	400 V, 63 A bei AC-1, AC-7a, 2 no
X1	3-conductor through terminal	3	16 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X2	3-conductor through terminal	3	16 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X3	3-conductor through terminal	1	10 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	10 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	1	10 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm

Position	Material	Number of units	Design
X4	3-conductor through terminal	3	2.5 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	2.5 mm², 1-pole, 3 contact points, blue
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X5	3-conductor through terminal	4	1.5 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal (L)	1	6 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal (N)	1	6 mm², 1-pole, 3 contact points, blue
	End plate for through terminal, 3-conductor	2	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
Z1	Sunny Home Manager 2.0	1	–

* Required in TT grid configuration only

** Phase coupling is optional

Configuration suggestion

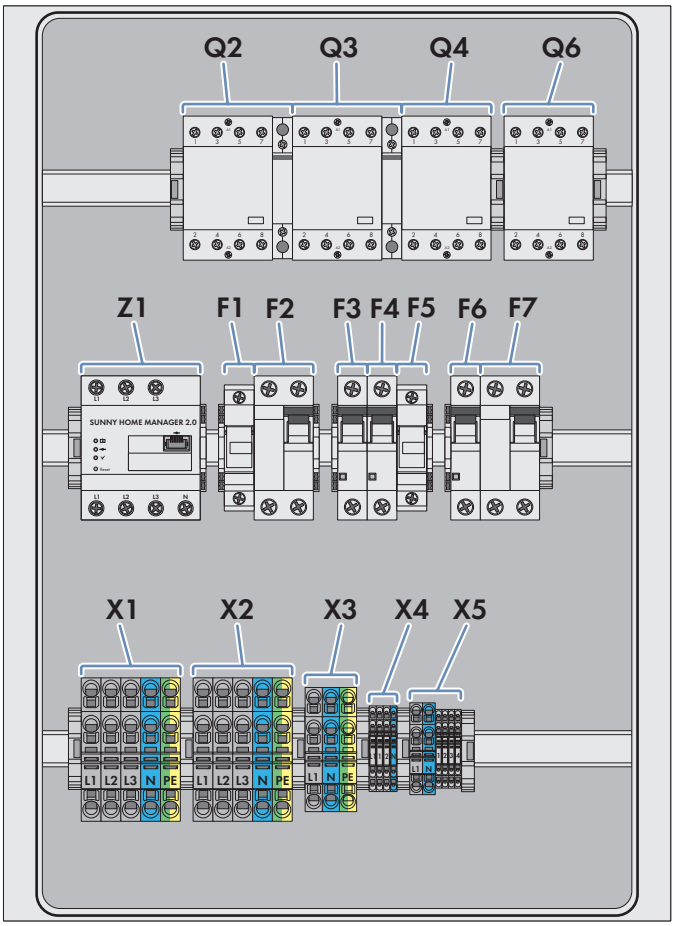


Figure 4: Configuration suggestion for single-phase automatic transfer switching device with all-pole disconnection

5.4.2 Material for Automatic Transfer Switching Device of a Three-Phase Battery-Backup System with All-Pole Disconnection

The following table refers to the design of the battery-backup system with Sunny Island and summarizes the configuration of the automatic transfer switching device as suggested in the schematic diagram. You will need to procure the material for configuring your automatic transfer switching device from your distributor.

Design of the devices in the automatic transfer switching device

The indicated values for the devices are recommended SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

Position	Material	Number of units	Design
F1	Thermal fuse for protecting the control cables and measuring cables and for protecting the multifunction relay in the Sunny Island	3	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s
F2	Residual-current device for control and measuring cables*	1	40 A/0.03 A, 1-pole + N, type A
F5	Thermal fuse for protecting the control cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s

Position	Material	Number of units	Design
F6	Circuit breaker for protection of the Sunny Island	1	32 A, C rating, 1-pole
F7	Residual-current device	1	40 A/0.03 A, 3-pole + N, type A
Q2	Contactor for grid disconnection	1	400 V, 63 A bei AC-1, AC-7a, 4 no
	Auxiliary switch for feedback	1	1 nc
Q3	Contactor for grounding device	1	400 V, 40 A at AC-1, AC-7a, 2 no 2 nc
	Auxiliary switch for Q1 locking mechanism	1	1 no
Q4	Contactor for grounding device	1	400 V, 40 A at AC-1, AC-7a, 2 no 2 nc
X1	3-conductor through terminal	3	16 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X2	3-conductor through terminal	3	16 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X3	3-conductor through terminal	3	10 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	3	10 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	3	10 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm

Position	Material	Number of units	Design
X4	3-conductor through terminal	5	2.5 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	3	2.5 mm², 1-pole, 3 contact points, blue
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X5	3-conductor through terminal	4	1.5 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal (L)	1	6 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal (N)	1	6 mm², 1-pole, 3 contact points, blue
	End plate for through terminal, 3-conductor	2	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
Z1	Sunny Home Manager 2.0	1	–

* Required in TT grid configuration only

Configuration suggestion

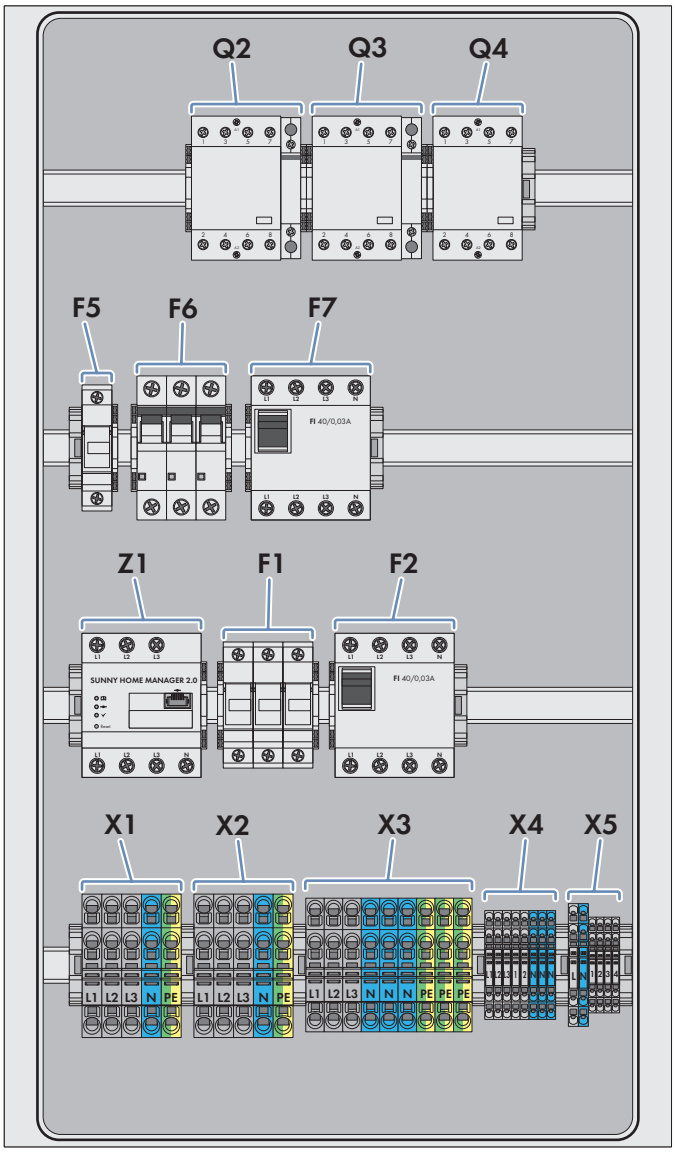


Figure 5: Configuration suggestion for three-phase automatic transfer switching device with all-pole disconnection

5.4.3 Material for Automatic Transfer Switching Device of a Single-Phase Battery-Backup System without All-Pole Disconnection

The following table refers to the design of the battery-backup system with Sunny Island and summarizes the configuration of the automatic transfer switching device as suggested in the schematic diagram. You will need to procure the material for configuring your automatic transfer switching device from your distributor.

Design of the devices in the automatic transfer switching device

The indicated values for the devices are recommended SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

Position	Material	Number of units	Design
F1	Thermal fuse for protecting the control cables and measuring cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s

Position	Material	Number of units	Design
F3, F4	Miniature circuit breaker for protection of phase coupling*	2	32 A, C rating, 1-pole
F5	Thermal fuse for protecting the control cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s
F6	Circuit breaker for protection of the Sunny Island	1	32 A, C rating, 1-pole
F7	Residual-current device	1	40 A/0.03 A, 1-pole + N, type A
Q2	Contactor for grid disconnection	1	400 V, 63 A bei AC-1, AC-7a, 4 no
	Auxiliary switch for feedback	1	1 nc
Q6	Phase coupling contactor*	1	400 V, 63 A bei AC-1, AC-7a, 2 no
X1	3-conductor through terminal	3	16 mm^2, 1-pole, 3 contact points, gray
	3-conductor through terminal	1	16 mm^2, 1-pole, 3 contact points, blue
	3-conductor through terminal	1	16 mm^2, 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X2	3-conductor through terminal	3	16 mm^2, 1-pole, 3 contact points, gray
	3-conductor through terminal	1	16 mm^2, 1-pole, 3 contact points, blue
	3-conductor through terminal	1	16 mm^2, 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X3	3-conductor through terminal	1	10 mm^2, 1-pole, 3 contact points, gray
	3-conductor through terminal	1	10 mm^2, 1-pole, 3 contact points, blue
	3-conductor through terminal	1	10 mm^2, 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm

Position	Material	Number of units	Design
X4	3-conductor through terminal	3	2.5 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	2.5 mm², 1-pole, 3 contact points, blue
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X5	3-conductor through terminal	4	1.5 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal (L)	1	6 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal (N)	1	6 mm², 1-pole, 3 contact points, blue
	End plate for through terminal, 3-conductor	2	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
Z1	Sunny Home Manager 2.0	1	–

* Phase coupling is optional

5.4.4 Material for Automatic Transfer Switching Device of a Three-Phase Battery-Backup System without All-Pole Disconnection

The following table refers to the design of the battery-backup system with Sunny Island and summarizes the configuration of the automatic transfer switching device as suggested in the schematic diagram. You will need to procure the material for configuring your automatic transfer switching device from your distributor.

Design of the devices in the automatic transfer switching device

The indicated values for the devices are recommended SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

Position	Material	Number of units	Design
F1	Thermal fuse for protecting the control cables and measuring cables and for protecting the multifunction relay in the Sunny Island	3	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A²s
F6	Circuit breaker for protection of the Sunny Island	1	32 A, C rating, 1-pole
F7	Residual-current device	1	40 A/0.03 A, 3-pole + N, type A
Q2	Contactor for grid disconnection	1	400 V, 63 A bei AC-1, AC-7a, 4 no
	Auxiliary switch for feedback	1	1 nc

Position	Material	Number of units	Design
X1	3-conductor through terminal	3	16 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X2	3-conductor through terminal	3	16 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	1	16 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X3	3-conductor through terminal	3	10 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	3	10 mm², 1-pole, 3 contact points, blue
	3-conductor through terminal	3	10 mm², 1-pole, 3 contact points, yellow-green
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X4	3-conductor through terminal	5	2.5 mm², 1-pole, 3 contact points, gray
	3-conductor through terminal	3	2.5 mm², 1-pole, 3 contact points, blue
	End plate for through terminal, 3-conductor	1	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
X5	3-conductor through terminal	2	1.5 mm², 1-pole, 3 contact points, gray
	End plate for through terminal, 3-conductor	2	–
	Group marker carrier for end clamp	1	–
	End clamp	1	Width: 10 mm
Z1	Sunny Home Manager 2.0	1	–

5.5 Sequence of the Switching Operations in the Automatic Transfer Switching Device

5.5.1 Switching Operations in the Automatic Transfer Switching Device for Sunny Boy Storage

This section describes the operating principle of the automatic transfer switching device as exemplified by the single-phase battery-backup system with Sunny Boy Storage and with all-pole disconnection (see Section 4.2.1, page 27). When looking at the other automatic transfer switching devices, the following differences are important:

- In battery-backup systems without all-pole disconnection, no grounding device is required.
- Phase coupling is optional.

Basically, the SMA Backup Unit Controller controls all switching operations of the contactors in the automatic transfer switching device according to the specifications of the Sunny Boy Storage. The SMA Backup Unit Controller is installed in each automatic transfer switching device.

Operating principle of the tie switch - behavior in the event of grid failure

The tie switch disconnects the battery-backup grid from the utility grid in the event of grid failure or if the utility grid has breached the thresholds for voltage and frequency. The contactor **Q1** is the tie switch with all-pole disconnection. If a redundant grid disconnection is required, a contactor **Q2** must be installed in addition.

The Sunny Boy Storage detects a power failure via the SMA Backup Unit Controller as soon as the grid voltage falls below a defined limiting value, from which the battery inverter can no longer switch the contactors. After the grid failure has been detected, the tie switch disconnects the battery-backup system from the utility grid and forms a battery-backup grid. Transitioning to the battery-backup operation starts with a very slow increase of the AC voltage in the battery-backup grid of 0 V up to the defined limiting value of the grid voltage (soft start). The contactor **Q3** connects the neutral conductor with the ground potential of the battery-backup grid. The ground monitoring and the monitoring of the feedback contact of the **Q1** contactor begin. By monitoring the feedback contact, closing of **Q1** and **Q2** is blocked. Subsequently, the AC voltage in the battery-backup grid is slowly increased further until the nominal voltage is reached (e.g. to 230 volts).

Operating principle of the tie switch - behavior when grid power is restored

When the utility grid is available again, the Sunny Boy Storage detects this via the SMA Backup Unit Controller. The Sunny Boy Storage switches off the battery-backup grid with the PV inverters. Then, the **Q3** contactor disconnects the neutral conductor from the ground potential of the battery-backup grid again. Now follows the closing of the tie switch **Q1** (if present, also **Q2**). After an interruption, the Sunny Boy Storage is then reconnected to the utility grid and the loads are powered by the utility grid again. The time until the battery-backup system is connected with the utility grid varies due to a mandatory waiting time. This waiting time is stored in a country data set of the Sunny Boy Storage according to the country-specific requirements.

Function of the grounding device

In some countries (e.g. in Germany) the neutral conductor of the battery-backup grid must not remain connected to the utility grid in the event of a grid failure. That is why the neutral conductor must be connected with the ground potential of the battery-backup grid in battery-backup operation. Establishing this neutral grounding is the function of the grounding device, which consists of contactor **Q3**. The contactor **Q3** is controlled by the SMA Backup Unit Controller.

Operating principle phase coupling

The phase coupling contactor **Q4** is controlled by the SMA Backup Unit Controller. If the phase coupling is activated in the event of a grid failure, the Q4 contactor connects the unsupplied line conductors with the supplied line conductors.

In the event of grid failure, the line conductor that is connected with the Sunny Boy Storage is supplied with voltage first. Then the phase coupling combines the two other line conductors. When the utility grid is available again, the phase coupling disconnects the combined line conductors.

5.5.2 Switching Operations in the Automatic Transfer Switching Device for Sunny Island

Differences between automatic transfer switching devices for single-phase and three-phase battery-backup systems with Sunny Island

This section describes the operating principle of the automatic transfer switching device as exemplified by the single-phase Sunny Island battery-backup system with all-pole disconnection (see Section 4.1.1, page 19). When looking at the other automatic transfer switching devices, the following differences are important:

- The function of the tie switch and grounding device of a three-phase automatic transfer switching device is analogous to that of the single-phase automatic transfer switching device.
- In battery-backup systems without all-pole disconnection, no grounding device is required.
- Phase coupling is optional and is only suitable for battery-backup grids with single-phase PV inverters and single-phase loads.

Operating principle of the tie switch with all-pole disconnection

The tie switch disconnects the battery-backup grid from the utility grid in the event of grid failure or if the utility grid has breached the thresholds for voltage and frequency. The contactor **Q2** is the tie switch with all-pole disconnection.

The control voltage of contactors **Q2**, and **Q3** is equal to the voltage of a line conductor of the utility grid. This means that the tie switch can only be activated when grid voltage is present. An auxiliary contact of contactor **Q3** locks contactor **Q2**. Contactors **Q3** and **Q2** are controlled by multifunction relay **Relay1** of the Sunny Island inverter. If multifunction relay **Relay1** is in non-operative mode, contactors **Q2** and **Q3** activate. If contactor **Q3** is in non-operative mode, contactor **Q2** will also go into non-operative mode and be locked.

In the event of a total grid failure, contactors **Q2** and **Q3** go into non-operative mode due to the lack of control voltage and they disconnect the battery-backup grid with all poles from the utility grid. The Sunny Island also measures the voltage of the utility grid. For this, the Sunny Island is connected with the same line conductor as the control voltage of contactors **Q2** and **Q3**. When a deviation from country-specific voltage and frequency thresholds of the utility grid occurs, multifunction relay **Relay 1** is activated. Contactors **Q2** and **Q3** remain in non-operative mode or go into non-operative mode.

When the utility grid is available again, the Sunny Island detects this. The Sunny Island synchronizes the battery-backup grid with the utility grid. Following successful synchronization, multifunction relay Relay1 goes into non-operative mode and contactors **Q2** and **Q3** are activated. The battery-backup grid is again connected to the utility grid.

Operating principle of the tie switch without all-pole disconnection

The tie switch disconnects the battery-backup grid from the utility grid in the event of grid failure or if the utility grid has breached the thresholds for voltage and frequency. The contactor **Q2** is the tie switch without all-pole disconnection.

The control voltage of contactor **Q2** is the voltage at line conductor **L1** of the utility grid. This means that the tie switch can only be activated when grid voltage is present. Contactor **Q2** is controlled by the multifunction relay **Relay1** of the Sunny Island. If multifunction relay **Relay1** is in non-operative mode, contactor **Q2** activates.

In the event of a total grid failure, contactor **Q2** goes into non-operative mode due to the lack of control voltage and disconnects the battery-backup grid from the line conductors of the utility grid. The Sunny Island also measures the voltage of the utility grid. For this, the Sunny Island is connected with the same line conductor as the control voltage of contactor **Q2**. When a deviation from the country-specific voltage and frequency thresholds of the utility grid occurs, multifunction relay **Relay 1** is activated. Contactor **Q2** remains in non-operative mode or goes into non-operative mode.

When the utility grid is available again, the Sunny Island detects this. The Sunny Island synchronizes the battery-backup grid with the utility grid. Following successful synchronization, multifunction relay **Relay1** goes into non-operative mode and contactor **Q2** activates. The battery-backup grid is again connected to the utility grid.

Operating principle of the grounding device

Contactors **Q3** and **Q4** form the grounding device. Contactors **Q3** and **Q4** are controlled by both multifunction relays of the Sunny Island. Triggering of contactor **Q3** occurs simultaneously with contactor **Q2** of the tie switch. If contactor **Q2** deactivates and the tie switch opens, contactor **Q3** connects the neutral conductor in the battery-backup grid to the grounding conductor. In addition, the Sunny Island uses multifunction relay **Relay 2** to control contactor **Q4**. When multifunction relay **Relay 2** is activated, contactor **Q4** is activated and also connects the neutral conductor to the grounding conductor. This arrangement ensures that the neutral conductor of the battery-backup grid in battery-backup operation is always connected to ground.

Operating principle of phase coupling

Contactor **Q6** forms the phase coupler. If multifunction relay **Relay2** activates on the Sunny Island, contactor **Q6** activates and connects the unsupplied line conductors via circuit breakers **F3** and **F4** with the supplied line conductor.

In the event of grid failure, the line conductor that is connected with the Sunny Island is supplied with voltage first. Then the phase coupling combines the two other line conductors. When the utility grid is available again, the phase coupling disconnects the combined line conductors. Only the line conductor that is connected to the Sunny Island is not interrupted on connection to the utility grid.

6 Planning Mounting Locations

The following products within the SMA Flexible Storage System with battery-backup function impose requirements on the installation site which must be taken into account at the planning stage.

- Sunny Island 4.4M / 6.0H / 8.0H with:
  - Battery
  - Battery fuse
  - Automatic transfer switching device with Sunny Home Manager 2.0
- Sunny Boy Storage 3.7 / 5.0 / 6.0 with:
  - Battery
  - Automatic transfer switching device with optional Sunny Home Manager 2.0

The following points should be considered as early as the planning stage:

- The minimum clearances to walls, objects, SMA products or other technical devices must be complied with.
- The ambient conditions at the planned deployment sites must meet the requirements the individual products place on the mounting locations.
- The maximum cable routes and radio ranges between the listed SMA products and to other devices must be feasible.
- The cable cross-sections and conductor materials of the planned cables must meet the requirements of the listed products.
- The battery room must meet the requirements of the battery manufacturer.
- Only when using the Sunny Island with a lead-acid battery: A battery fuse must be installed between the DC connection of the Sunny Island and the battery (for the requirements for the battery fuse see the inverter operating manual).

Links to additional information can be found at www.SMA-Solar.com:

Title and information content	Type of information
Sunny Home Manager 2.0	Operating manual
SMA Energy Meter	Installation manual
SUNNY ISLAND 4.0M / 6.0H / 8.0H	Operating manual
Sunny Boy Storage 3.7 / 5.0 / 6.0	Operating manual

The requirements made on the installation site of the automatic transfer switching device are listed in the manufacturer documentation of the switch cabinet and its components.

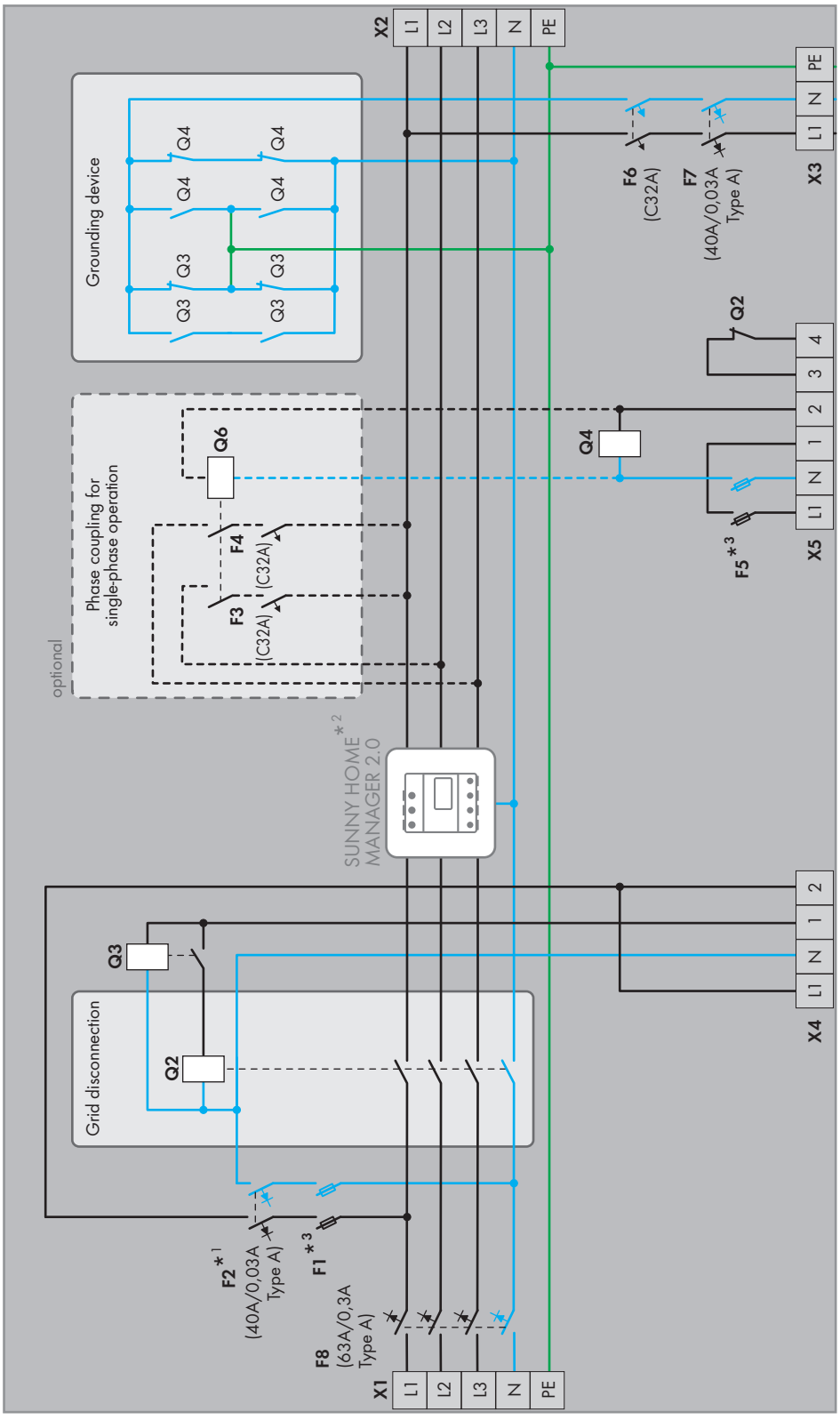
The requirements for the mounting location of the PV inverters used are listed in the manuals for the PV inverters.

7 Explanation of Used Terms

Term	Explanation
Self-consumption	Generated PV power is consumed at the site where it is generated. Self-consumption is made up of direct consumption and battery charging.
Intermediate storage	Battery charging and discharging as a measure of energy management The intermediate storage enables the consumption of PV energy independent of the time of generation, e.g. in the evening or during bad weather. This means that time-controlled electrical appliances can also be operated with PV energy.
Battery-backup grid	Part of a household grid which is supplied by the battery-backup system in the event of grid failure.
Battery-backup system	In the event of grid failure, a battery-backup system supplies loads with energy and a PV system disconnected from the utility grid with voltage.
Parallel grid operation	The parallel grid operation is one of several operating modes in a PV system. In parallel grid operation the PV system feeds the generated PV energy into the utility grid. In parallel grid operation, the battery inverter is responsible for the optimization of self-consumption or internal power supply.
PV system	System in which PV modules convert part of the solar radiation into electrical energy. The PV system consists of the PV modules and at least one PV inverter.
Bridging time	Time from the grid failure until restoration of the utility grid which is bridged by the battery-backup system.
Automatic transfer switch with battery-backup function	disconnects the battery-backup grid from the utility grid in the event of grid failure.
Switching time	Time needed by the battery-backup system to restore the supply of the loads in case of grid failure.
Cycle stability	Characteristic for the service life of a battery The cycle stability indicates how many times a battery can be discharged and charged before the available battery capacity falls below a specific value (see the battery manufacturer's specifications).

8 Only for Belgium: connection of battery-backup systems with Sunny Island

8.1 Automatic Transfer Switching Device for Single-Phase Battery-Backup System in Belgium



*1 Only when connecting to a TT grid, the line conductor and the neutral conductor must be fused.
*2 Not required for systems without increased self-consumption.
*3 Requirements for thermal fuse used: 1 A, nominal cold resistance of at least 0.2 Ω and melting integral max. 1A2s. The indicated values in brackets are recommended by SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

Figure 6: Schematic diagram of the single-phase automatic transfer switch for Belgium

8.2 Circuitry Overview for Single-Phase Battery-Backup System in Belgium

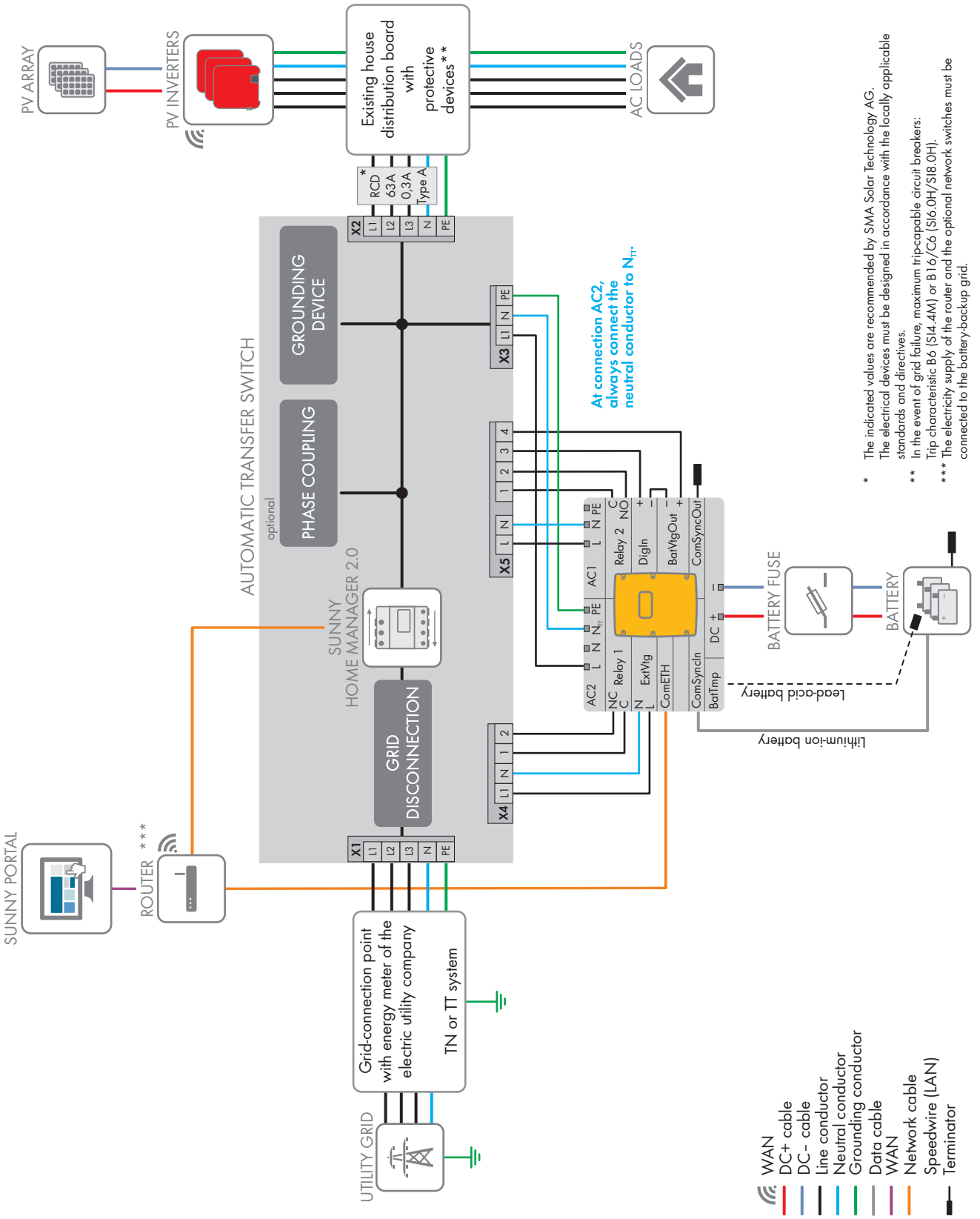


Figure 7: Connection of the automatic transfer switching device with all-pole disconnection for Belgium

8.3 Material for Automatic Transfer Switching Device of a Single-Phase Battery-Backup System in Belgium

The following table refers to the design of the battery-backup system with Sunny Island and summarizes the configuration of the automatic transfer switching device as suggested in the schematic diagram. You will need to procure the material for configuring your automatic transfer switching device from your distributor.

Design of the devices in the automatic transfer switching device

The indicated values for the devices are recommended SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

Position	Material	Number of units	Description
F1	Thermal fuse for protecting the control cables and measuring cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s, all poles
F2, F3, F4	(see Section 5.4.1, page 31)		
F5	Thermal fuse for protecting the control cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s, all poles
F6	Circuit breaker for protection of the Sunny Island	1	32 A, C rating, all poles
F7	(see Section 5.4.1, page 31)		
F8	Residual-current device	1	63 A/0.3 A, 3-pole + N, type A
Q1 to Q6	(see Section 5.4.1, page 31)		
X1 to X5			

8.4 Automatic Transfer Switching Device for Three-Phase Battery-Backup System in Belgium

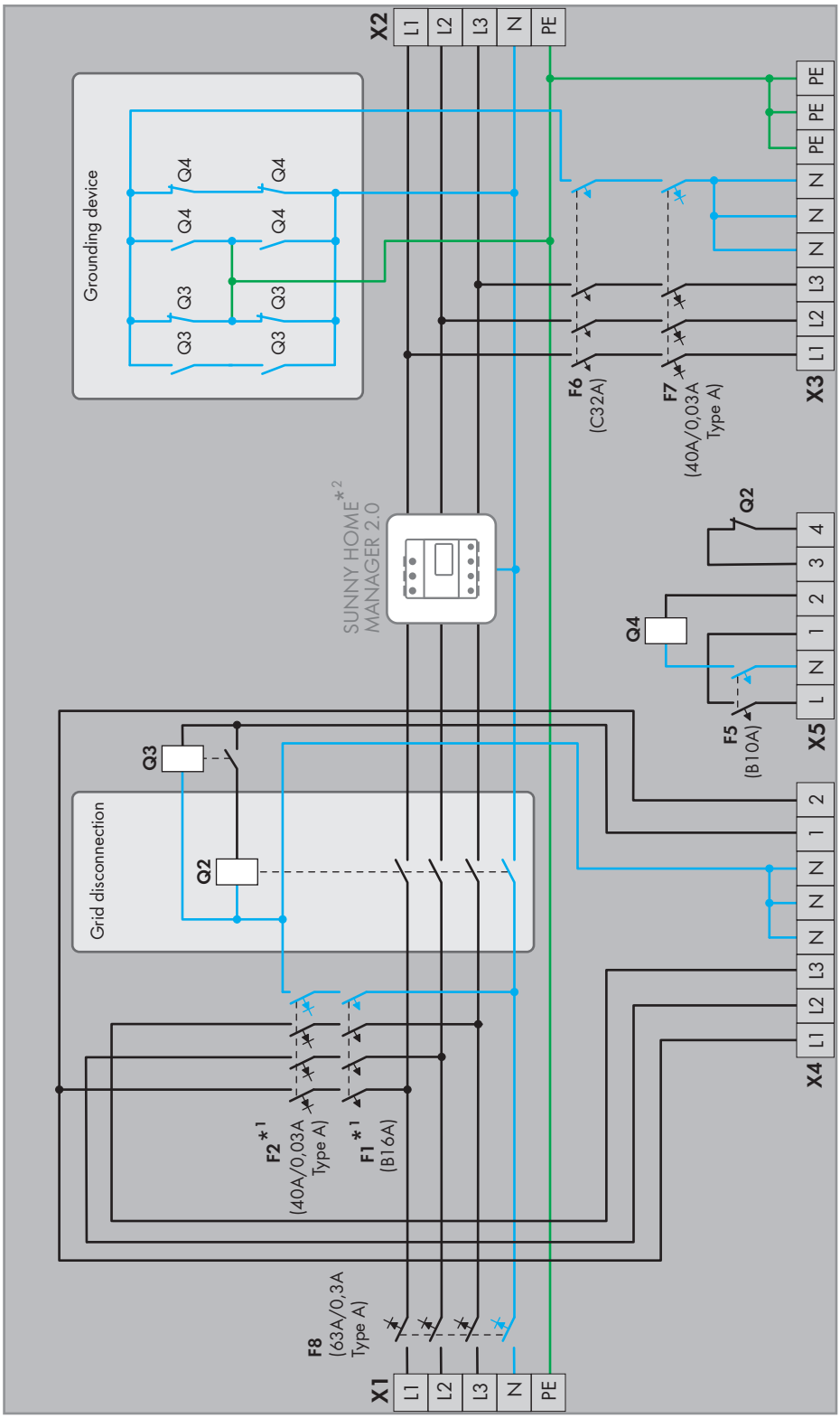


Figure 8: Schematic diagram of the three-phase automatic transfer switch for Belgium

8.5 Circuitry Overview for Three-Phase Battery-Backup System in Belgium

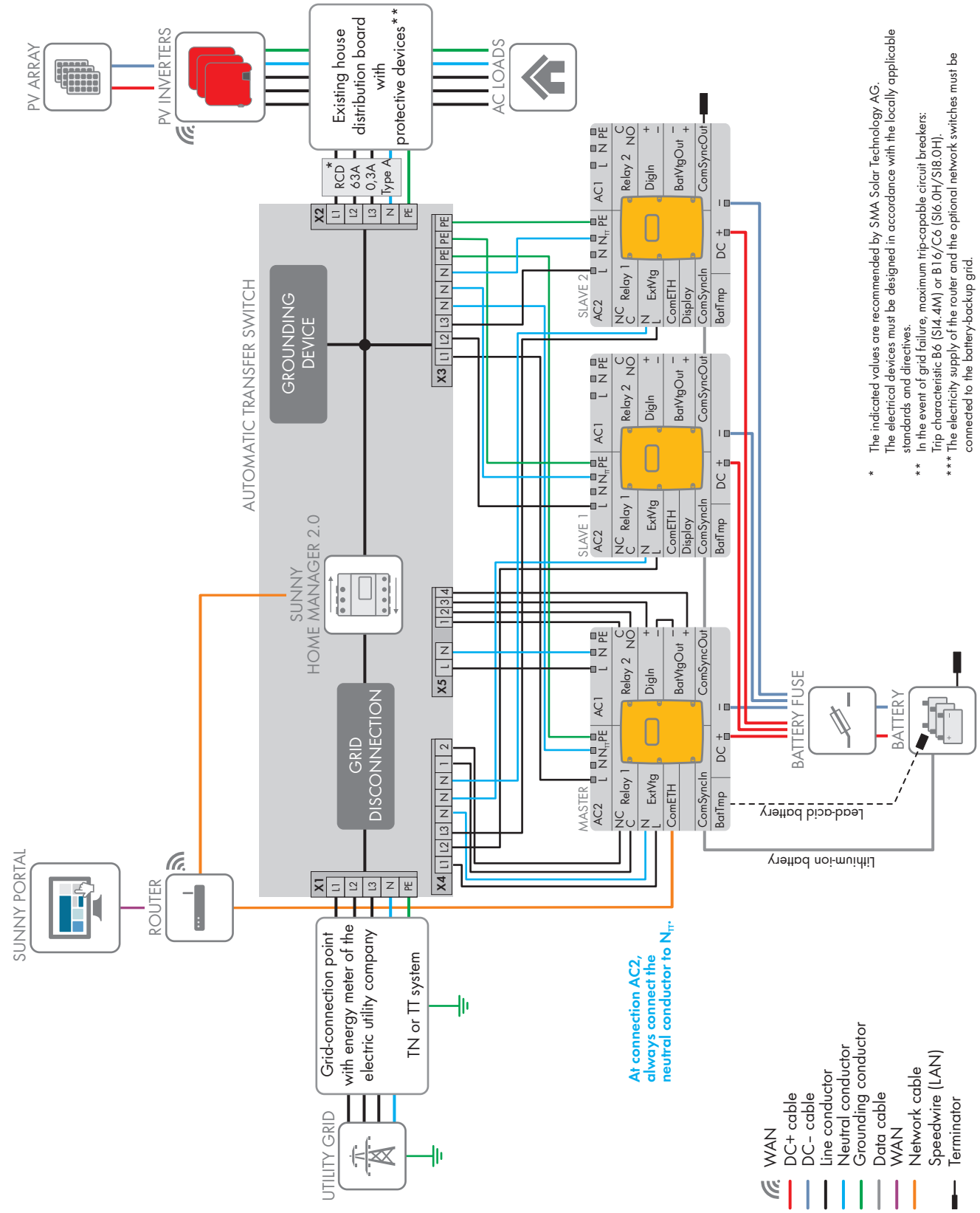


Figure 9: Connection of the automatic transfer switching device with all-pole disconnection for Belgium

8.6 Material for Automatic Transfer Switching Device of a Three-Phase Battery-Backup System in Belgium

The following table refers to the design of the battery-backup system with Sunny Island and summarizes the configuration of the automatic transfer switching device as suggested in the schematic diagram. You will need to procure the material for configuring your automatic transfer switching device from your distributor.

Design of the devices in the automatic transfer switching device

The indicated values for the devices are recommended SMA Solar Technology AG. The electrical devices must be designed in accordance with the locally applicable standards and directives.

Position	Material	Number of units	Description
F1	Thermal fuse for protecting the control cables and measuring cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s, all poles
F2, F3, F4	(see Section 5.4.2, page 34)		
F5	Thermal fuse for protecting the control cables and for protecting the multifunction relay in the Sunny Island	1	1 A, cold resistance of at least 0.2 Ω, melting integral of max. 1 A^2s, all poles
F6	Circuit breaker for protection of the Sunny Island	1	32 A, C rating, 3-pole, all poles
F7	(see Section 5.4.2, page 34)		
F8	Residual-current device	1	63 A/0.3 A, 3-pole + N, type A
Q1 to Q6	(see Section 5.4.2, page 34)		
X1 to X5			


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