LUNA2000-(107-241) Series Commercial and Industrial Hybrid Cooling Grid Forming ESS Solution

User Manual (Microgrid, SmartMGC5000B)

Issue 05

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About This Document

Purpose

This document describes the networking architecture, communication logic, operation and maintenance (O&M) methods, installation, cable connection, check and preparation before power-on, and system commissioning, power-off, and power-on operations of the commercial and industrial (C&I) microgrid energy storage solution based on the SmartMGC5000B microgrid controller (also referred to as SmartMGC).

The safety precautions, product introduction, site selection requirements, and maintenance information of the devices involved in the solution are described in the user manuals or maintenance manuals of the corresponding devices. For details, see **C Reference Documents**.

"Grid forming" refers to grid forming operation in off-grid mode.

Statement

In this document, LUNA only refers to a specific model of Huawei Smart String Grid Forming ESS.

In this document, MERC only refers to a specific model of Huawei Smart PV Optimizer.

Intended Audience

This document is intended for:

- Technical support engineers
- Hardware installation engineers
- Commissioning engineers

Symbol Conventions

The symbols that may be found in this document are defined as follows.

Symbol	Description
DANGER	Indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
WARNING	Indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation which, if not avoided, could result in equipment damage, data loss, performance deterioration, or unanticipated results. NOTICE is used to address practices not related to personal injury.
NOTE	Supplements the important information in the main text. NOTE is used to address information not related to personal injury, equipment damage, and environment deterioration.

Change History

Changes between document issues are cumulative. The latest document issue contains all the changes in earlier issues.

Issue 05 (2026-03-30)

Updated **1.1.1 On/Off-Grid PV+ESS (PQ/VSG) System**.

Updated **3.2 Wiring Solutions**.

Updated **1.1.1.2 Networking Architecture of the On/Off-Grid PV+ESS (PQ/VSG) System**.

Updated **1.1.1.3 On/Off-Grid PV+ESS (PQ/VSG) System Configuration**.

Updated **1.1.2.1 Networking Architecture of the Off-Grid PV+ESS System**.

Updated **1.1.2.2 Off-Grid PV+ESS System Configuration**.

Updated **1.3 Technical Specifications**.

Updated **2 O&M Methods**.

Updated **5.1 On/Off-Grid PV+ESS (PQ/VSG) System**.

Updated **5.2 Off-Grid PV+ESS System**.

Updated **6.3.1 Setting ESS Startup Authorization**.

Updated **6.3.2 Updating the Software Version**.

Updated **C Reference Documents**.

Issue 04 (2026-01-08)

Updated **1.1 Networking Architecture**.

Updated **3.2 Wiring Solutions**.

Updated **6.4 Commissioning Using the Deployment Wizard**.

Updated **6.5 Protection Parameter Detection**.

Updated **6.6 Switch Inspection**.

Updated **7 Microgrid Control**.

Issue 03 (2025-12-08)

Updated **3.2.1 Wiring Solution of the On/Off-Grid PV+ESS (PQ/VSG) System**.

Updated **6.4 Commissioning Using the Deployment Wizard**.

Issue 02 (2025-10-25)

Updated **1.1 Networking Architecture**.

Updated **1.3 Technical Specifications**.

Updated **3.1 Cable Connection Process**.

Updated **3.2 Wiring Solutions**.

Added **6.1 Deployment Process**.

Updated **6.3 Preparations Before Deployment**.

Updated **6.5 Protection Parameter Detection**.

Updated **8 System Operations**.

Issue 01 (2025-09-01)

This issue is used for first office application (FOA).

Contents

1 Solution Introduction

NOTICE

This microgrid solution does not provide the system-level redundancy backup function. If a device fails or the ESS reaches the end-of-charge/discharge SOC, the microgrid may collapse. As this solution does not provide professional UPSs, it is not applicable to scenarios that have high requirements on uninterruptible power supply.

1.1 Networking Architecture

The C&I microgrid energy storage solution has the following networking architectures: on/off-grid PV+ESS (PQ/VSG) system (seamed or seamless switching) and off-grid PV+ESS system.

1.1.1 On/Off-Grid PV+ESS (PQ/VSG) System

The on/off-grid PV+ESS (PQ/VSG) system applies to C&I campuses where the power grid capacity is insufficient, capacity expansion is difficult, or power is limited during peak hours. The system supports economical operation policy in on-grid mode and has disaster recovery capabilities. When the utility power grid experiences an outage or the system disconnects from the grid as required, the PV +ESS system can operate in off-grid mode to provide emergency power to critical loads. During on-grid operation, the backup power SOC can be set (optional) to reserve power for off-grid emergency power supply.

In this system, the ESS adopts low-voltage AC coupling, and the microgrid system implements on-grid and off-grid operation through the on/off-grid switch. When the system is off-grid, the ESS functions as the primary power supply to implement grid forming, and the PV system and ESS supply power to critical loads.

The solution supports seamed or seamless on/off-grid switching. You can select the switching mode as required in deployment settings.

NOTICE

In the seamed on/off-grid switching mode, when the PV+ESS system is on-grid, do not disconnect it from the mains by turning off a switch. Otherwise, switching overvoltage may occur. You are advised to shut down the PV and ESS arrays and then disconnect the PV+ESS system from the mains if needed.

NOTE

In the seamed on/off-grid switching mode, if an ATS is available for connecting loads to the genset, the ATS may automatically perform transfer during on/off-grid switching because the SmartMGC does not detect the ATS and genset status. You can increase the ATS transfer delay to more than 10 seconds (for example, 20 seconds) to avoid overlapping with the seamed switching time. Otherwise, the ATS may be triggered or the genset may be started/shut down.

The on/off-grid PV+ESS (PQ/VSG) system must meet the related constraints. For details, see **1.1.1.1 On/Off-Grid PV+ESS (PQ/VSG) System Solution Description**. **1.1.1.2 Networking Architecture of the On/Off-Grid PV+ESS (PQ/VSG) System** shows the networking architecture. **1.1.1.3 On/Off-Grid PV+ESS (PQ/VSG) System Configuration** lists the components.

1.1.1.1 On/Off-Grid PV+ESS (PQ/VSG) System Solution Description

SmartMGC I/O Port Description (for the On/Off-Grid Switch Control)

- If the I/O control loop of the on/off-grid switch operates at AC voltage, select the DO4(HV) port for switch-off control, the DO7(HV) port for direct switch-on control, and the DI4(HV) port for switch status feedback.
- If the I/O control loop of the on/off-grid switch operates at DC voltage (range: 12–30 V), select the DO8(HV) or DO4(HV) port for switch-off control, the DO7(HV) port for direct switch-on control, and the DI4(HV) port for switch status feedback. If the switch status feedback loop operates at DC voltage (range: 12–30 V), an intermediate relay is required to convert the signal into an AC signal and then send the signal to the SmartMGC. If the switch status feedback loop operates at AC voltage, the signal can be sent directly.
- If the I/O control loop of the on/off-grid switch operates at DC voltage (range: 110 or 220 V), select the DO8(HV) port switch-off control, the DO7(HV) port for switch-on control (an intermediate relay is required to convert the signal of the switch DC control loop through the auxiliary DO contact into an AC signal and then send the signal to the SmartMGC), and the DI4(HV) ports for direct switch status feedback.

Table 1-1 SmartMGC connection to the on/off-grid switch under different I/O loop voltage conditions

Switch-On/Off Control Loop	AC Control Loop	DC Control Loop (12–30 V)	DC Control Loop (110 or 220 V)
DO8(HV) for switch-off control (fast DO)	×	√ (Preferred)	√
DO4(HV) for switch-off control	√	√	×
DO7(HV) for switch-on control	√	√	An intermediate relay is required to convert the signal of the switch DC control loop through the auxiliary DO contact into an AC signal and then send the signal to the SmartMGC.
DI4(HV) for status feedback	√	• If the signal is DC, an intermediate relay is required to convert the signal into an AC signal and then send the signal to the SmartMGC. • If the signal is AC, the signal can be sent directly.	√

NOTICE

- The pulse current capability of DO1(HV) to DO8(HV) of the SmartMGC is ≤ 5 A @ 200 ms.
- The switch-off control loop of DO8(HV) can operate at DC voltage (12–220 V).
- The control loop of DO1(HV) to DO7(HV) can operate at AC voltage (100–277 V) or DC voltage (12–30 V).
- The DI4(HV) loop (switch status feedback) can operate only at 100 V/220 V/230 V/277 V AC voltage or 110 V/220 V DC voltage.

Application Constraints on Seamless On/Off-Grid Switching

Table 1-2 Application constraints on seamless on/off-grid switching

Constraint	Affected Function	Description
Grid code compliance[a]	The solution conflicts with the frequency/ voltage fault ride-through requirements of the grid code.	When HVRT/LVRT or fault ride-through occurs, the PV+ESS system quickly disconnects from the power grid and cannot provide reactive power within the time range specified by the grid code. This may violate the requirements of the local power grid company and cause admission risks. To use the seamless on/off-grid switching mode, you need to obtain the permission from the local power grid company.
	Requirements for the inverter HVRT/LVRT specified by the grid code	In the high PV-to-ESS ratio scenario, the microgrid compatibility function of the inverter must be enabled to prevent switching failures caused by overvoltage due to excessive PV power during seamless switching. When the grid voltage fluctuation exceeds the threshold, the inverter automatically reduces the output current to a value close to 0 rapidly.
	Impact on anti-islanding requirements of grid codes	When the power grid fails, the implementation mode of anti-islanding is changed from device shutdown to off-grid operation. That is, the system disconnects from the grid connection point to isolate the external power grid and provide islanding protection only for the external power grid.
ESS SOC range during on-grid operation	SOC operating range	It is recommended that the SOC range be 10% to 90%, with an absolute maximum range of 5% to 95%.
Anti-disturbance capability	During on-grid operation, if grid disturbances (excluding power outages) reach the detection threshold, the system mistakenly switches to off-grid mode.	If voltage or frequency disturbances in the AC power grid (excluding power outages) reach the detection threshold, the PV+ESS system switches from on-grid to off-grid operation and subsequently resynchronizes back to on-grid mode. This process consumes the limited number of switching cycles for the on/off-grid switch.

Constraint	Affected Function	Description
Load	Do not configure loads beyond the allowed range.	The device may shut down due to overload protection if the load exceeds the limit and the power grid or load fluctuates.
Note a: The seamed on/off-grid switching mode is recommended if the power grid requirements need to be strictly followed.		

Current Detection at the Grid Connection Point and Meter-free Configuration

The SmartMGC implements on/off-grid switching control. It directly collects voltage and current data to detect the grid connection point status and control the system, and does not require a meter.

DANGER

When using the SmartMGC to detect the voltage and current at the grid connection point, ensure that the following conditions are met:

- It must be installed inside a power distribution cabinet or box. Do not install it in an exposed position to prevent electrical hazards caused by accidental contact.
- Before replacing the SmartMGC or maintaining the CT loop, ensure that the CT loop is powered off and the jumper bar of the CT loop is correctly connected.

CAUTION

When using the SmartMGC to detect the voltage and current at the grid connection point, ensure that the following requirements for the CT specifications are met:

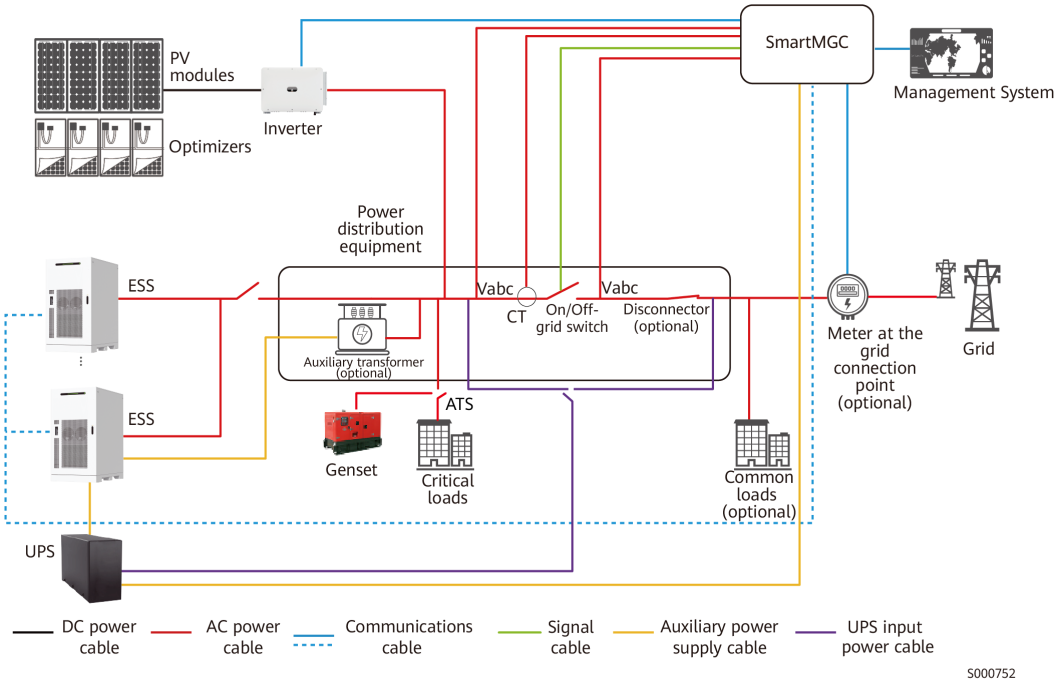
- The rated current on the secondary side of the CT is 5 A, and the accuracy class is ≥ 0.5. If higher accuracy is required, the recommended accuracy class is ≥ 0.5S.
- The recommended rated load capacity of the CT is ≥ 5 VA, and the cable length between the CT and the SmartMGC is ≤ 5 m.
- The minimum rated load capacity of the CT is 2.5 VA, and the cable length between the CT and the SmartMGC is ≤ 2 m.
- The secondary side cable is a copper cable, and the cross-sectional area of the CT secondary side cable is ≥ 1.5 mm^2. If a terminal block is available, it is recommended that the cross-sectional area of the cable between the secondary side of the CT and the terminal block be ≥ 2.5 mm^2.

1.1.1.2 Networking Architecture of the On/Off-Grid PV+ESS (PQ/VSG) System

Scenario 1: On/Off-Grid PV+ESS (PQ/VSG) System

- During on-grid operation, both the PV system and ESS work in PQ mode. The ESS supports three-phase four-wire without an isolation transformer. The SmartMGC serves as the controller and supports functions including maximum self-consumption, TOU, and off-grid power backup. After the grid experiences an outage, the system can automatically switch to off-grid mode. Then the ESS works in VSG grid forming mode and the PV system works in PQ grid following mode.
- The solution supports seamed or seamless on/off-grid switching. You can select the switching mode as required in deployment settings.
- If a genset is used, the ATS must be used for switching power supplies on the load side.
- Meter at the grid connection point (optional). If the loads exceed the ESS load-carrying capacity, non-critical loads can be installed outside the on/off-grid switch. During on-grid operation, the meter monitors the power at the grid connection point.

Figure 1-1 Networking architecture of the on/off-grid PV+ESS (PQ/VSG) system

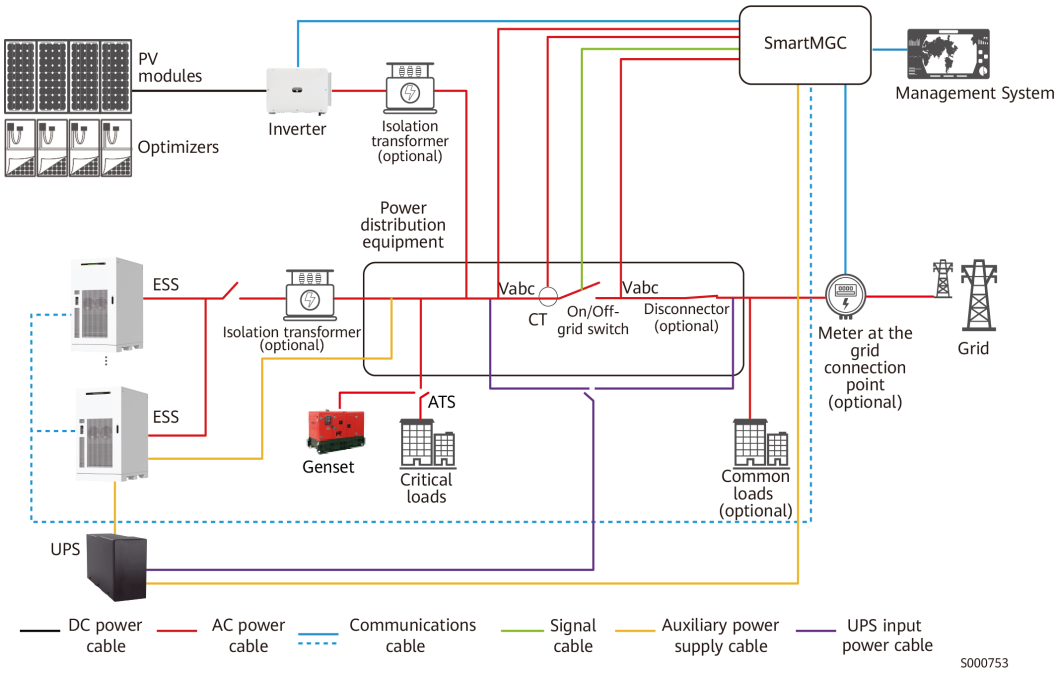


Scenario 2: On/Off-Grid PV+ESS (PQ/VSG) System (Low-Voltage Scenarios with Isolation Transformers)

- The PV+ESS system can be connected to a three-phase 200–240 V power grid through isolation transformers.
- The manual (semi-automatic) switching mode in Japan is supported (seamed on/off-grid switching).

- The automatic switching mode in Latin America is supported (seamed/seamless on/off-grid switching).
- If a genset is used, the ATS must be used for switching power supplies on the load side.
- Meter at the grid connection point (optional). If the loads exceed the ESS load-carrying capacity, non-critical loads can be installed outside the on/off-grid switch. During on-grid operation, the meter monitors the power at the grid connection point.

Figure 1-2 Networking architecture of the on/off-grid PV+ESS (PQ/VSG) system (low-voltage scenarios with isolation transformers)



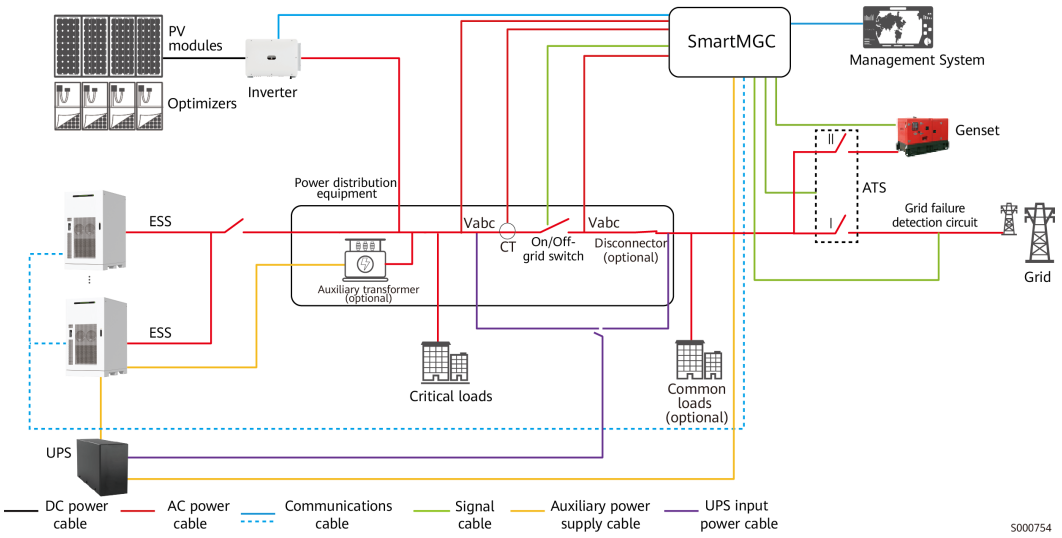
Scenario 3: On/Off-Grid PV+ESS+Genset Seamless Switching (PQ/VSG) + Grid/Genset ATS Switching System

- This solution applies to scenarios with an unstable mains supply where power outages or disturbances frequently occur (for example, in Africa), the mains outage duration is long, and the economic dispatch control requirements for the grid connection point are not high.
- During on-grid operation, only the PV system and ESS are available. The PV +ESS seamless on/off-grid switching is supported. After the system is disconnected from the grid, the ESS works in VSG grid forming mode and the PV system works in PQ grid following mode.
- When the ESS SOC is insufficient, the genset can be connected. The genset works in grid forming mode and is connected through the ATS on the mains side. The ESS works in PQ grid following mode.
- The capacity of the genset to be started must be greater than the load capacity to meet the requirements for independent load carrying. Reserve sufficient spinning reserve margin to ensure load stability.
- After the mains is restored, the ESS switches from PQ mode to VSG mode, and the on/off-grid switch is automatically turned off. The genset

automatically shuts down, the ATS switches to the mains supply, and the on/off-grid switch is turned on to restore the grid connection.

- The system must meet the functional requirements of the genset and ATS.

Figure 1-3 Networking architecture of the on/off-grid PV+ESS+genset seamless switching (PQ/VSG) + grid/genset ATS switching system



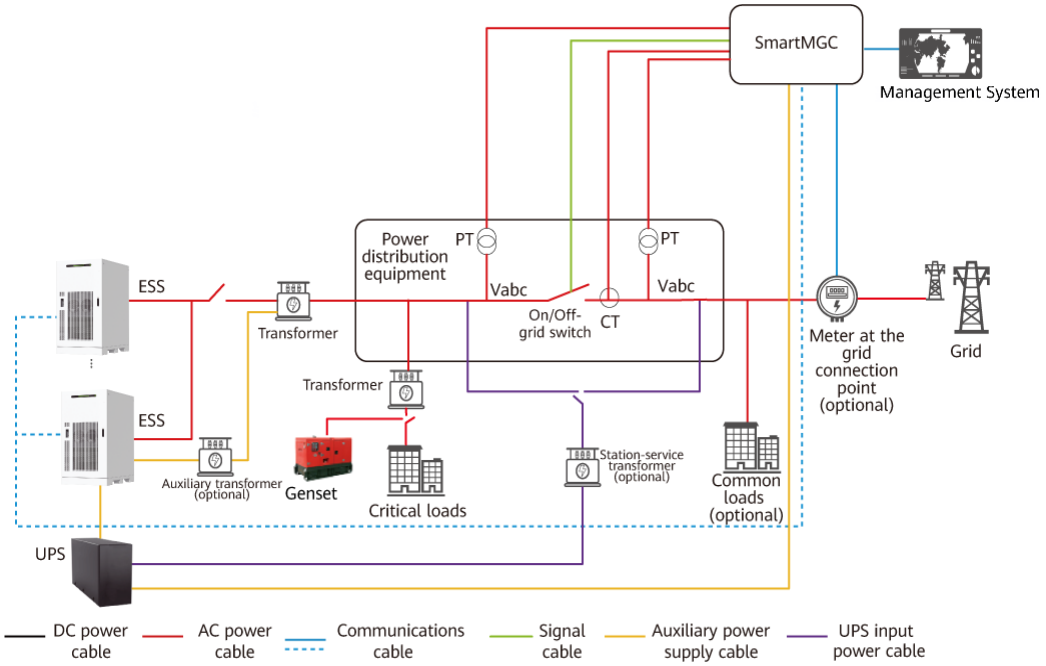
Scenario 4: On/Off-Grid (PQ/VSG) System (Medium-Voltage Scenarios with Transformers)

- This solution applies to scenarios with an unstable mains supply where power outages occasionally occur and the mains outage duration is short.
- If a genset is used, the ATS must be used for switching power supplies on the load side.
- Meter at the grid connection point (optional). If the loads exceed the ESS load-carrying capacity, non-critical loads can be installed outside the on/off-grid switch. During on-grid operation, the meter monitors the power at the grid connection point.
- During on-grid operation, the third-party EMS can perform power dispatch, and the backup power SOC is controlled and reserved by the third-party EMS. During on/off-grid switching and off-grid operation, these functions are controlled by the SmartMGC.

NOTICE

The third-party EMS performs power dispatch only during on-grid operation. Do not send other control instructions. Otherwise, on/off-grid switching failure or microgrid collapse may occur.

Figure 1-4 Networking architecture of the on/off-grid system (medium-voltage scenarios with transformers)



1.1.1.3 On/Off-Grid PV+ESS (PQ/VSG) System Configuration

Table 1-3 Components of the on/off-grid PV+ESS (PQ/VSG) system

Name	Model/ Specifications	Quantity	Remarks
Smart String Grid Forming Energy Storage System (ESS)	• LUNA2000-241-2S1 • LUNA2000-215-2S10 • LUNA2000-215-2S11 • LUNA2000-161-2S11 • LUNA2000-107-1S11	≤ 20	Purchased from the Company.

Name	Model/ Specifications	Quantity	Remarks
Smart PV inverter (inverter)	• SUN2000-30K-MC0 • SUN2000-40K-MC0 • SUN2000-50K-MC0 • SUN2000-29.9KTL-M3 • SUN2000-30KTL-M3 • SUN2000-33KTL-NH • SUN2000-36KTL-M3 • SUN2000-40KTL-M3 • SUN2000-40KTL-NH • SUN2000-50KTL-M3 • SUN2000-50KTL-ZHM3 • SUN2000-50KTL-NHM3 • SUN2000-50KTL-M0 • SUN2000-50KTL-JPM0 • SUN2000-60KTL-M0 • SUN2000-60KTL-JPM0 • SUN2000-75KTL-M1 • SUN2000-100KTL-M1 • SUN2000-100KTL-M2 • SUN2000-110KTL-M2 • SUN2000-110KTL-INM0	≤ 30	Purchased from the Company. The maximum PV-to-ESS ratio is 1:1 when the ESS is used with SUN2000-50KTL-M0, SUN2000-50KTL-JPM0, SUN2000-60KTL-M0, and SUN2000-60KTL-JPM0. The maximum PV-to-ESS ratio is 2:1 when the ESS is used with inverters of other models. • In the same PV system, a maximum of two inverter models can be used. The inverter with a larger power is preferentially deployed. • Inverters from the Company shall not be used together with those from other vendors.

Name	Model/ Specifications	Quantity	Remarks
	• SUN2000-111KTL-NHM0 • SUN2000-115KTL-M2 • SUN2000-50K-MGL0-BR • SUN2000-50K-MGL0 • SUN2000-75K-MGL0-BR • SUN2000-80K-MGL0 • SUN2000-150K-MG0-ZH • SUN2000-150K-MG0 • SUN5000-150K-MG0-ZH • SUN5000-150K-MG0		
Smart PV Optimizer (SUN2000P)	• SUN2000-450W-P2 • SUN2000-600W-P • MERC-1300W-P • MERC-1100W-P	Depending on the actual quantity of PV modules	Purchased from the Company. • SUN2000-29.9KTL-M3, SUN2000-30KTL-M3, SUN2000-33KTL-NH, SUN2000-36KTL-M3, SUN2000-40KTL-M3, and SUN2000-40KTL-NH support the SUN2000P. • SUN2000-50KTL-ZHM3/M3/NHM3 supports only MERC-1300W-P or MERC-1100W-P. • MERC-1300W-P or MERC-1100W-P is mandatory for SUN5000-150K-MG0/MG0-ZH.

Name	Model/ Specifications	Quantity	Remarks
SmartMGC	SmartMGC5000B	1	Purchased from the Company. SmartMGC functions as a controller and does not require a meter at the grid connection point. It supports current transformer (CT) and potential transformer (PT). The specifications must meet the following requirements: • The rated current on the secondary side of the CT is 5 A, and the accuracy class is ≥ 0.5. If higher accuracy is required, the recommended accuracy class is ≥ 0.5S. • The rated voltage on the secondary side of the PT is 100–380 V, or the voltage is directly connected (Uan/Ubn/Ucn: 57.7–277 V, Uab/Ubc/Uac: 100–480 V).
Meter at the grid connection point	• DTSU666-HW • YDS60-80 • DHSU1079-ZT • DTSU71C	1	Purchased from the Company (optional). When the microgrid networking architecture includes common loads, the meter the grid connection point must be configured.
Management system	-	1	The Company's software is required. Install the app and then complete the deployment settings on the app.

Name	Model/ Specifications	Quantity	Remarks
Power distribution equipment (including the on/off-grid switch)	**On/Off-grid switch**: • Supports I/O signal feedback and remote control. • Works with a common switch (switch-off time < 80 ms, including arc extinguishing) to implement 150 ms switching. • Works with a common switch (switch-off time < 35 ms, including arc extinguishing) to implement 60 ms switching. • Works with a fast switch (supporting DC DO control, switch-off time without loads < 15 ms) to implement 20 ms switching. • Works with a switch (recommended switch-off time < 80 ms, including arc extinguishing) for automatic seamed switching. • In the semi-automatic seamed switching scenario in Japan, there is no requirement on the switch-on/off time.	1	Prepared by the customer. The on/off-grid switch shall meet the local power distribution requirements. It can be a 3-pole or 4-pole switch. If a 4-pole switch is required (that is, the neutral wire must be disconnected), the on/off-grid switch must be linked with the internal grounding switch. The fast switch supports DC DO control. **NOTICE** • The pulse current capability of DO1(HV) to DO8(HV) of the SmartMGC is ≤ 5 A @ 200 ms. • The switch-off control loop of DO8(HV) can operate at DC voltage (12–220 V). • The control loop of DO1(HV) to DO7(HV) can operate at AC voltage (100–277 V) or DC voltage (12–30 V). • The DI4(HV) loop (switch status feedback) can operate only at 100 V/220 V/230 V/277 V AC voltage or 110 V/220 V DC voltage.

Name	Model/ Specifications	Quantity	Remarks
	• Works with a common medium-voltage switch (switch-off time < 80 ms, including arc extinguishing) to implement 300 ms switching.		
	Power distribution cabinet (PDC): • For details about the dimensions, IP rating, and color, see the description of the vendor or customer requirements. • The cables from the inverter and ESS to the PDC shall be at least 5 m long.	1	Prepared by the customer. **NOTICE** The PDC must have sufficient space for installing the SmartMGC, meter, CT, and UPS.

Name	Model/ Specifications	Quantity	Remarks
	UPS: • Power: ≥ 1 kVA, online UPS, 220 V AC • Backup time ≥ 1 hour. If the system is off-grid for a long time, the UPS backup time is ≥ 48 hours. • To ensure reliable power supply to the UPS, the UPS power supply shall be provided from either side of the on/off-grid switch, whichever side is available. The UPS power supply is controlled by the relay.	1	Prepared by the customer. **NOTICE** The specifications of the UPS must meet the power consumption requirements of the ESS auxiliary power supply. • Dynamic performance: Transient peak power ≥ 500 W/cabinet (to cope with inrush current during device startup) • Shutdown power consumption: ≤ 30 W/cabinet in standby mode (to reduce continuous power consumption) • Steady-state power consumption: 30–100 W/cabinet in operating mode (to ensure basic monitoring functions)
	Auxiliary transformer: • Auxiliary transformer that converts the grid voltage to 220 V • Transformer capacity: 5 kVA x N (quantity of ESSs)	Depending on the actual networking architecture	Prepared by the customer (optional). • When the rated AC grid voltage is ≤ 415 V, the **MAINS** port of the ESS can obtain power from the PCS terminal inside the ESS or from a power supply outside the ESS. • When the rated AC grid voltage is > 415 V (420/440/480 V), the ESS auxiliary power supply must be a power supply connected from outside the ESS. An auxiliary transformer is added to convert the grid voltage into 220 V single-phase power and supply the power to the **MAINS** port of the ESS.

Name	Model/ Specifications	Quantity	Remarks
	CT	3	Prepared by the customer (optional). CT specifications requirements: • The rated current on the secondary side of the CT is 5 A, and the accuracy class is ≥ 0.5. If higher accuracy is required, the recommended accuracy class is ≥ 0.5S.
	PT	3	Prepared by the customer (optional). PT specifications requirements: The voltage on the secondary side is 100–380 V, and the accuracy class is ≥ 0.2.
	Isolation transformer: • Supports the grid frequency of 50/60 Hz. • Matches the ESS capacity in an array. • Supports long-term stable operation carrying loads of 1.1 times its rated capacity.	1	Prepared by the customer (optional). Applies to low-voltage scenarios with isolation transformers or medium-voltage scenarios. The ESS is connected to the isolation transformer in three-phase four-wire mode. This design is applicable to specific areas where the grid voltage is low. An isolation transformer is configured to ensure a safe and stable connection between the ESS and the grid.
Disconnector	Configured based on the capacity of the grid connection point.	1	Prepared by the customer (optional).

Name	Model/ Specifications	Quantity	Remarks
Genset	Three-phase	Depending on the actual requirements	Prepared by the customer (optional). • Solution 1 (genset connected through the ATS on the load side): The genset is switched by the ATS on the load side, and the SmartMGC does not control the genset (preferred solution). Applies to scenarios 1, 2, and 4. • Solution 2 (genset connected through the ATS on the mains side): The SmartMGC controls the genset, and the ATS controls the switching between the primary power supply and the secondary power supply. Applies to scenario 3.
Automatic transfer switch (ATS)	Dual power supply switching device	1	

Name	Model/ Specifications	Quantity	Remarks
			NOTICE • The ATS must support I/O status position feedback. • The ATS working mode must be set to no line priority. Do not set it to Line 1 priority (active/ standby mode). • The genset supports I/O startup and shutdown control, and the frequency deviation is less than 0.1 Hz and the voltage deviation is less than 2% during stable operation. • The genset capacity must be greater than the load capacity to meet the requirements for independent load carrying. • Grid detection is required: The mains status is reported to the DI(HV) port of the SmartMGC through the ATS, or an external grid failure detection relay is connected (supporting dry contact signal feedback) to determine whether the grid recovers.

1.1.2 Off-Grid PV+ESS System

The off-grid PV+ESS system applies to remote areas and islands without electricity. The ESS and the PV system are controlled and coordinated to supply power.

In this system, the ESS functions as the primary power supply to implement grid forming, and the PV system and ESS supply power to loads.

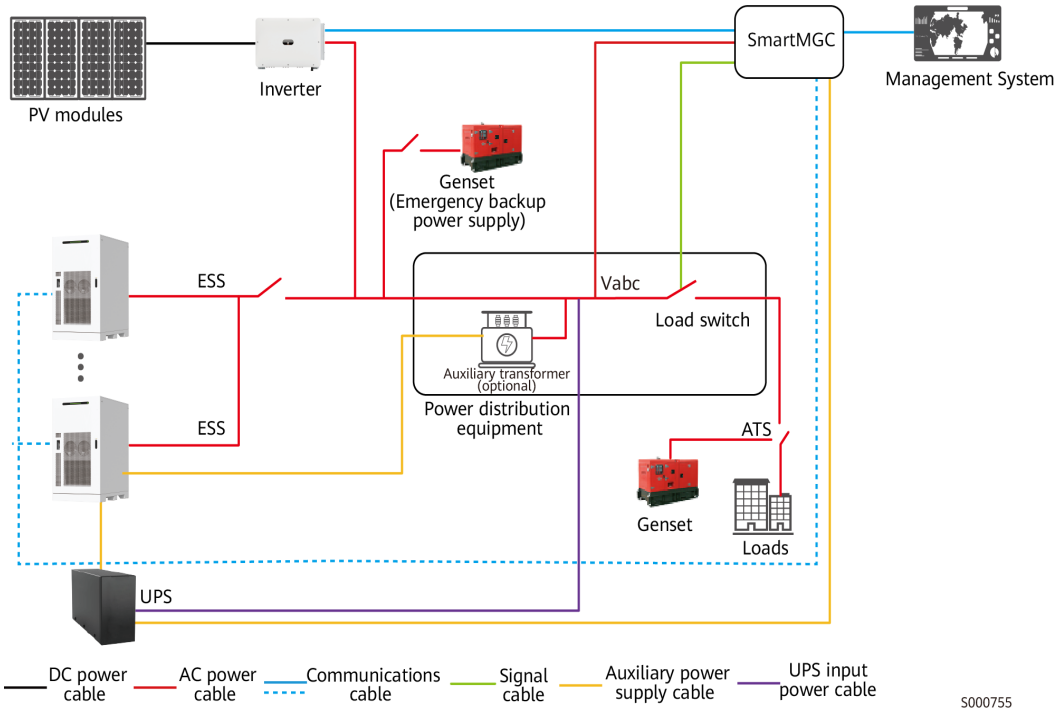
1.1.2.1 Networking Architecture of the Off-Grid PV+ESS System shows the networking architecture of the off-grid PV+ESS system. **1.1.2.2 Off-Grid PV+ESS System Configuration** lists the components.

1.1.2.1 Networking Architecture of the Off-Grid PV+ESS System

Scenario 1: Off-Grid PV+ESS System (Without Genset or with Genset Connected Through the ATS on the Load Side)

- PV+ESS low-voltage coupling
- If a genset is used, the ATS must be used for switching power supplies on the load side.
- The ESS supports three-phase four-wire without an isolation transformer, and the system is grounded at the neutral point.
- The off-grid system supports hierarchical load management.

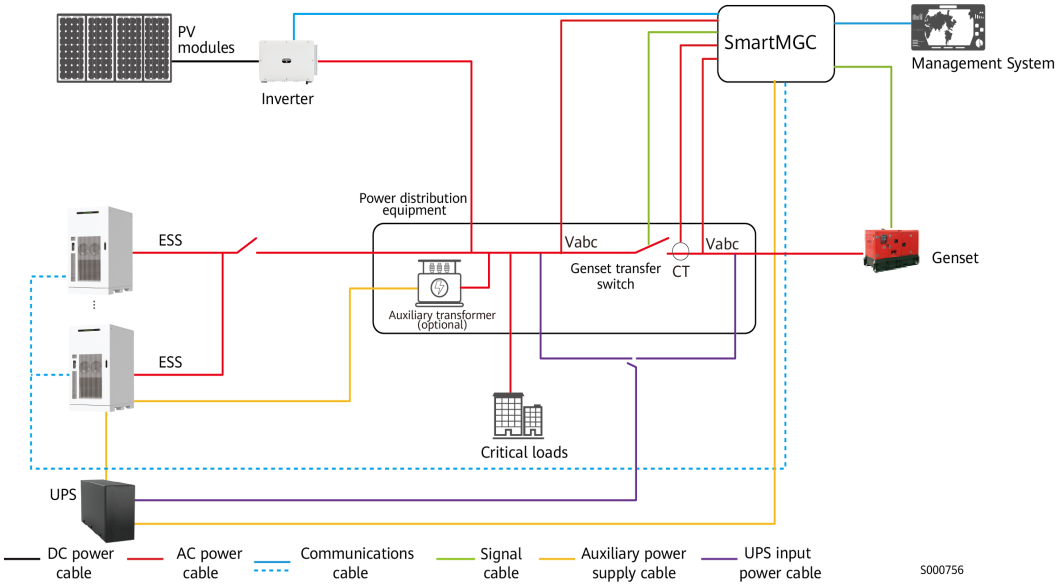
Figure 1-5 Networking architecture of the off-grid PV+ESS system (without genset or with genset connected through the ATS on the load side)



Scenario 2: Off-Grid PV+ESS System (Genset as the Power Supply with Its Startup/Shutdown Controlled by the SmartMGC)

For the off-grid PV+ESS operation, when the ESS SOC is insufficient, the genset can be connected to the system and works together with the ESS in grid forming mode.

Figure 1-6 Networking architecture of the off-grid PV+ESS system (genset as the power supply with its startup/shutdown controlled by the SmartMGC)



1.1.2.2 Off-Grid PV+ESS System Configuration

Table 1-4 Components of the off-grid PV+ESS system

Name	Model/Specifications	Quantity	Remarks
Smart String Grid Forming Energy Storage System (ESS)	• LUNA2000-241-2S1 • LUNA2000-215-2S10 • LUNA2000-215-2S11 • LUNA2000-161-2S11 • LUNA2000-107-1S11	≤ 20	Purchased from the Company.

Name	Model/Specifications	Quantity	Remarks
Smart PV inverter (inverter)	• SUN2000-30K-MC0 • SUN2000-40K-MC0 • SUN2000-50K-MC0 • SUN2000-29.9KTL-M3 • SUN2000-30KTL-M3 • SUN2000-33KTL-NH • SUN2000-36KTL-M3 • SUN2000-40KTL-M3 • SUN2000-40KTL-NH • SUN2000-50KTL-M3 • SUN2000-50KTL-ZHM3 • SUN2000-50KTL-NHM3 • SUN2000-50KTL-M0 • SUN2000-50KTL-JPM0 • SUN2000-60KTL-M0 • SUN2000-60KTL-JPM0 • SUN2000-75KTL-M1 • SUN2000-100KTL-M1 • SUN2000-100KTL-M2 • SUN2000-110KTL-M2 • SUN2000-110KTL-INM0 • SUN2000-111KTL-NHM0 • SUN2000-115KTL-M2	≤ 30	Purchased from the Company. The maximum PV-to-ESS ratio is 1:1 when the ESS is used with SUN2000-50KTL-M0, SUN2000-50KTL-JPM0, SUN2000-60KTL-M0, and SUN2000-60KTL-JPM0. The maximum PV-to-ESS ratio is 2:1 when the ESS is used with inverters of other models. • In the same PV system, a maximum of two inverter models can be used. The inverter with a larger power is preferentially deployed. • Inverters from the Company shall not be used together with those from other vendors. • The inverters shall not be used together with optimizers.

Name	Model/Specifications	Quantity	Remarks
	• SUN2000-50K-MGL0-BR • SUN2000-50K-MGL0 • SUN2000-75K-MGL0-BR • SUN2000-80K-MGL0 • SUN2000-150K-MG0-ZH • SUN2000-150K-MG0 • SUN5000-150K-MG0-ZH • SUN5000-150K-MG0		

Name	Model/Specifications	Quantity	Remarks
SmartMGC	SmartMGC5000B	1	Purchased from the Company. SmartMGC functions as a controller and does not require a meter at the grid connection point. It supports current transformer (CT) and potential transformer (PT). The specifications must meet the following requirements: • The rated current on the secondary side of the CT is 5 A, and the accuracy class is ≥ 0.5. If higher accuracy is required, the recommended accuracy class is ≥ 0.5S. • The rated voltage on the secondary side of the PT is 100–380 V, or the voltage is directly connected (Uan/Ubn/Ucn: 57.7–277 V, Uab/Ubc/Uac: 100–480 V).
Management system	-	1	The Company's software is required. Install the app and then complete the deployment settings on the app.
Power distribution equipment	**Load switch (I/O control):** Supports I/O status feedback and control.	1	Prepared by the customer. Load switch required when no genset is available or the genset is connected through the ATS on the load side.

Name	Model/Specifications	Quantity	Remarks
	UPS: • Power: ≥ 1 kVA, online UPS, 220 V AC • Recommended power backup duration ≥ 48 hours	1	Prepared by the customer. For details about the capacity configuration, see **A Off-Grid UPS Capacity Configuration**. **NOTICE** The specifications of the UPS must meet the power consumption requirements of the ESS auxiliary power supply. • Dynamic performance: Transient peak power ≥ 500 W/cabinet (to cope with inrush current during device startup) • Shutdown power consumption: ≤ 30 W/cabinet in standby mode (to reduce continuous power consumption) • Steady-state power consumption: 30–100 W/cabinet in operating mode (to ensure basic monitoring functions)

Name	Model/Specifications	Quantity	Remarks
	Auxiliary transformer: ● Auxiliary transformer that converts the grid voltage to 220 V ● Transformer capacity: 5 kVA x N (quantity of ESSs)	Depending on the actual networking architecture	Prepared by the customer (optional). ● When the rated AC grid voltage is ≤ 415 V, the **MAINS** port of the ESS can obtain power from the PCS terminal inside the ESS or from a power supply outside the ESS. ● When the rated AC grid voltage is > 415 V (420/440/480 V), the ESS auxiliary power supply must be a power supply connected from outside the ESS. An auxiliary transformer is added to convert the grid voltage into 220 V single-phase power and supply the power to the **MAINS** port of the ESS.
	CT	3	Prepared by the customer (optional). CT specifications requirements: ● The rated current on the secondary side of the CT is 5 A, and the accuracy class is ≥ 0.5. If higher accuracy is required, the recommended accuracy class is ≥ 0.5S.

Name	Model/Specifications	Quantity	Remarks
	Power distribution cabinet (PDC): • For details about the dimensions, IP rating, and color, see the description of the vendor or customer requirements. • The cables from the inverter and ESS to the PDC shall be at least 5 m long.	1	Prepared by the customer. **NOTICE** • The PDC must have sufficient space for installing the SmartMGC, auxiliary transformer, and UPS. • In the PV+ESS low-voltage coupling system, the neutral point must be reliably grounded using the TN-S or TN-C-S system.

Name	Model/Specifications	Quantity	Remarks
Genset	Three-phase	1	Prepared by the customer (optional). ● Solution 1 (without genset or with genset connected through the ATS on the load side): When the genset is switched by the ATS on the load side, the SmartMGC does not control the genset. ● Solution 2 (genset connected on the power supply side with its startup and shutdown controlled by the SmartMGC): The SmartMGC controls the genset. – The genset supports I/O startup/ shutdown control and status feedback, and the switch-on time is less than 80 ms. – The genset capacity must be greater than the load capacity to meet the requirements for independent load carrying. – A CT is required. – A genset transfer switch is required. **NOTICE** In the off-grid scenario, ensure that an emergency power supply is available and the maintenance conditions are met.
ATS	Dual power supply switching device	1	

Name	Model/Specifications	Quantity	Remarks
Genset transfer switch	• Supports I/O signal feedback and remote control. • Works with a common switch (switch-on/off time < 80 ms).	1	Configured for the off-grid PV+ESS system when solution 2 is used (genset connected on the power supply side with its startup and shutdown controlled by the SmartMGC).

1.2 Communication Logic

One SmartMGC manages multiple ESSs and inverters, and one meter to form an array. In the array:

- The inverters communicate with the SmartMGC and the meter communicates with the SmartMGC over RS485.
- The ESSs communicate with the SmartMGC over FE or optical fibers in star or ring topology.
- The maximum communication distance of the SmartMGC is as follows:
  - RS485: 1000 m
  - FE: 100 m

Select any of the following topologies based on the quantities of ESSs in the array and the deployment of optical fibers.

Typical Scenario 1: SmartMGC+ESS FE Ring Topology

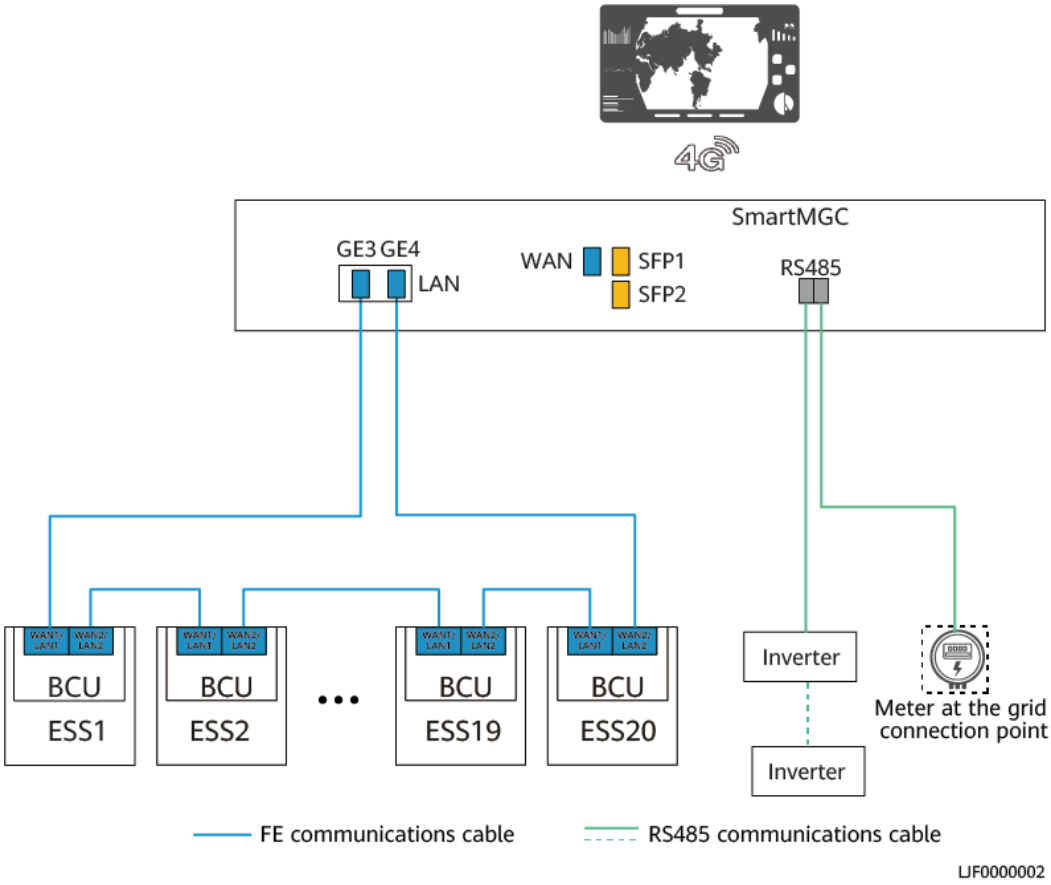
In this scenario, the SmartMGC is configured.

- A single FE ring network supports a maximum of 20 ESSs, and the distance between any two nodes is less than 100 m.
- One SmartMGC can connect to a maximum of 20 ESSs.
- The ESSs are connected through FE communications ports (WAN1/LAN1 and WAN2/LAN2).
- Network cables with a shield layer are recommended.

NOTICE

If the ESS FE ring topology is implemented, the ESS must be connected to the GE3 and GE4 ports of the SmartMGC. Otherwise, the SmartMGC cannot communicate with the ESS properly.

Figure 1-7 SmartMGC+ESS FE ring topology (connected to the GE3 and GE4 ports of the SmartMGC)

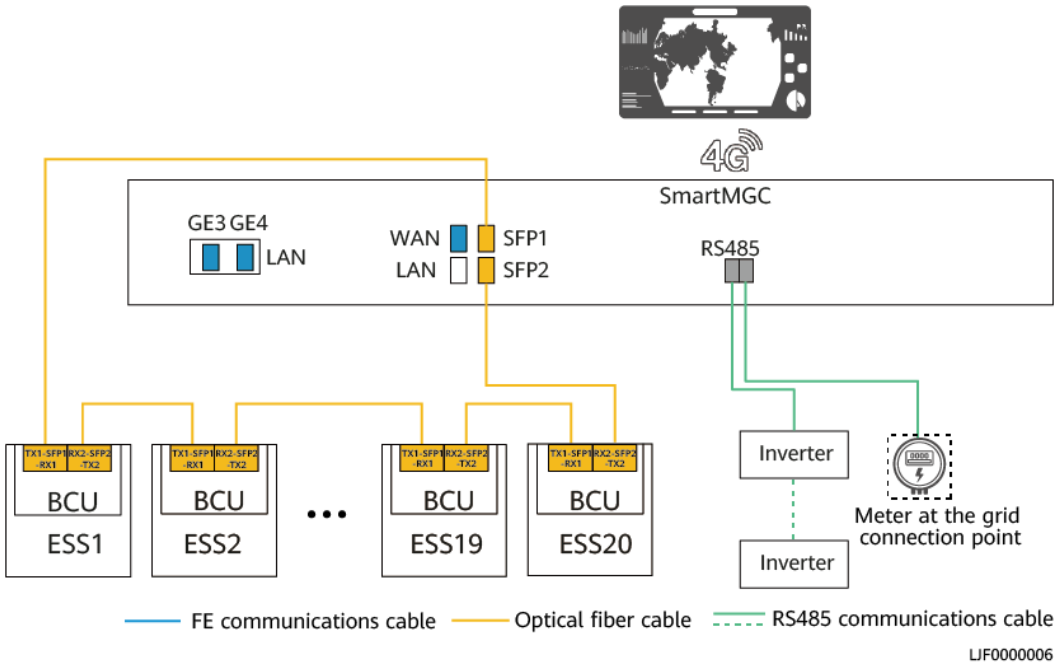


Typical Scenario 2: SmartMGC+ESS Fiber Ring Topology

In this scenario, the SmartMGC is configured. The SmartMGC is connected to 20 ESSs through the optical fiber ring network.

- One fiber ring network supports a maximum of 20 ESSs.
- One SmartMGC can connect to a maximum of 20 ESSs.
- The ESSs are connected through optical fiber ports (TX1-SFP1-RX1 and RX2-SFP1-TX2).

Figure 1-8 SmartMGC+ESS fiber ring topology (dashed boxes indicate optional devices)



1.3 Technical Specifications

Table 1-5 Technical specifications

Function	Technical Specifications	Remarks
Parallel connection of multiple devices	One SmartMGC supports a maximum of 20 ESSs and 30 inverters connected in parallel.	-
PV+ESS low-voltage coupling	• Low-voltage coupling of the ESS and inverter is supported. • The cable length from the ESS and the inverter to the power distribution cabinet shall be greater than or equal to 5 m, respectively.	For details about the supported inverter models, see **Table 1-3**.
ESS health diagnosis	Supported	This feature needs to be used in the management system.
Design tool	Supported	-
ESS safety black box	Supported	-
Off-grid operation	Supported	-

Function		Technical Specifications	Remarks
Off-grid THDu		2%	-
Earthing system		TN-S/TN-C-S/TN-C/TT	-
PV-to-ESS ratio		< 2:1	For details about the maximum PV-to-ESS capacity ratio for different ESS models, see **Table 1-6**.
ESS black start		Supported	-
On/Off-grid switching	Seamed switching	• Supports planned and unplanned on/off-grid switching. • Supports manual (semi-automatic) on/off-grid switching. • Supports automatic on/off-grid switching. – Switching time for one ESS: 3s – Switching time for multiple ESSs: 10s • Provides an on/off-grid switching control interface.	• The ESS manufactured in and before December 2024 does not support this feature. • On/Off-grid (PQ/VSG) seamed switching time: from the time when the on/off-grid switch is turned off to the time when the AC power is formed.

Function		Technical Specifications	Remarks
	Seamless switching	• Supports planned and unplanned on/off-grid switching and does not require a third-party protective relay. – Works with a common switch (switch-on/off time < 80 ms) to implement unplanned islanding within 150 ms. – Works with a common switch (switch-on/off time < 35 ms) to implement unplanned islanding within 60 ms. – Works with a fast switch (switch-off time without loads < 5 ms) to implement unplanned islanding within 20 ms. • Supports grid synchronization and reconnection.	• The ESS manufactured in and before December 2024 does not support this feature. • On/Off-grid (PQ/VSG) seamless switching solution requires the coordination of multiple devices, including the grid connection point detection device and PCS. The target function can be implemented only when each component operates correctly according to the preset logic.
On-grid scheduling feature[a]	Maximum self-consumption	Supported	-
	TOU	Supported	-
	TOU (fixed power)	Supported	-
	Demand limit	Supported	This feature can be used together with maximum self-consumption/TOU.
	Capacity limit	Supported	This feature can be used together with maximum self-consumption/TOU.
	Limited feed-in (including zero feed-in)	Supported	This feature can be used together with maximum self-consumption/TOU and capacity/demand limit.

Function		Technical Specifications	Remarks
	Phase-level power limit control	Supported	• The ESS manufactured in and before December 2024 does not support this feature. • This feature can be enabled only in export limitation mode. • This feature can be used together with maximum self-consumption/TOU and capacity/ demand limit.
	Power factor/ Reactive power control for the grid connection point	Supported	-
Loading capacity (based on the rated ESS capacity Pn)	Total load[b]	≤ (2/3) x Pn	• Single-phase rated capacity = (1/3) x Pn • Load of each phase ≤ (2/3) x Single-phase rated capacity, that is, Load of each phase ≤ (2/3) x (1/3) x Pn
	Non-linear load	• Half-wave rectification load ≤ (1/20) x Pn • The total current harmonics of loads comply with specifications or standards.	-
	Unbalanced load	• No load to two phases: ≤ (2/3) x (2/3) x Pn • No load to one phase: ≤ (2/3) x (1/3) x Pn	• Single-phase rated capacity = (1/3) x Pn • Load of each phase ≤ (2/3) x Single-phase rated capacity, that is, Load of each phase ≤ (2/3) x (1/3) x Pn

Function		Technical Specifications	Remarks
	Motor load	• Load of motors that use direct on line (DOL) starters, star-delta starters, or soft starters ≤ (1/10) x Pn • Load of motors that use star-delta starters ≤ (1/5) x Pn • Load of motors that use variable frequency drives ≤ (2/3) x Pn	• If there are other basic loads, the load of motors to be connected and disconnected shall be decreased accordingly in the same proportion. (The inrush current of the asynchronous motor startup shall be ≤ 8 x Rated current. Otherwise, you are advised to add a frequency converter.) • If there are asynchronous motor loads and common non-impact loads in the system, the load capacity is calculated as follows: [A x 10 + (3/2) x B] ≤ Pn. – A: load capacity of the asynchronous motor – B: other common load capacity
	Capacity of transformer switch-on/off	≤ (1/2) x Pn	-
Note a: The off-grid scenario does not involve the on-grid scheduling feature and on/off-grid switching. Note b: Total load of the LUNA2000-107-1S11 model ≤ (3/5) x Pn.			

Table 1-6 Maximum PV-to-ESS capacity ratio for different ESS models

Model	Maximum PV-to-ESS Ratio
LUNA2000-241-2S1	2:1
LUNA2000-215-2S10	2:1

Model	Maximum PV-to-ESS Ratio
LUNA2000-215-2S11	2:1
LUNA2000-161-2S11	1.8:1
LUNA2000-107-1S11	1.2:1

NOTE

The following conditions must be met for mixed use of ESS models with different C-rates:

- A maximum of two models can be used together.
- Preferentially configure the model with more battery packs. If the capacity needs to be supplemented, use a model with fewer battery packs (161 kWh or 107 kWh).
- The PV-to-ESS ratio and loading capability are configured based on the rated power of the model with more battery packs.
- In on-grid (PQ) mode, the system operates at the minimum C-rate. (Choose **Settings** > **Grid Connection Control** > **ESS Control** > **Control Mode** > **ESS Parameters** and set **Scheduling mode** to **Energy first**.)

Examples:

Assume that x units of the 215 kWh model and y units of the 107 kWh model are configured. The following conditions shall be met:

- $x \geq y$
- The loading capability is (x * 108 kW * 2/3).
- The maximum PV capacity is (x * 108 kW * 2).
- In on-grid mode, the system operates at 0.5CP: Choose **Settings** > **Grid Connection Control** > **ESS Control** > **Control Mode** > **ESS Parameters** and set **Scheduling mode** to **Energy first**.

2 O&M Methods

Table 2-1 O&M methods

O&M Method	Description	Main Application Scenario	Reference Document
SmartMGC WebUI	A PC is connected to the SmartMGC to manage the ESSs, inverters, and the meter in the array.	Microgrid control	**SmartMGC5000 User Manual**
Management system	The management system is deployed on a public network. It displays the current and historical running status of power plants and supports intelligent alarm reporting, analysis, diagnosis, and O&M.	Viewing plant information and managing devices at a site after deployment and commissioning	-

3 Installation and Cable Connection

This section describes the process, precautions, and connections for installing devices and connecting cables in the solution. For details, see the user manuals or quick guides of the corresponding devices. To obtain the documents, see **C Reference Documents**.

NOTICE

- On/Off-grid scenario: For the TN-S, TN-C-S, TT, and TN-C systems, the neutral wires of the ESS and inverter must be connected to the power distribution cabinet (power distribution bus), and the power distribution cabinet is connected to the power grid. The neutral wire of the power grid must be grounded.
- Off-grid scenario: For the TN-S, TN-C-S, TT, and TN-C systems, the neutral wires of the ESS and inverter must be connected to the power distribution cabinet (power distribution bus), and the neutral wire of the power distribution system must be grounded.
- For the TN-C system, no residual current device is required.
- If the neutral wire of the system is not grounded, the **PCS Grounding Abnormal** alarm will be triggered during on/off-grid switching or off-grid black start, causing the ESS to shut down for protection.
- The power distribution and electrical connections of the PV+ESS system must comply with the installation regulations of the devices and the country or region where the devices are located.

3.1 Cable Connection Process

Step 1 Install the ESSs.

Ensure that the foundation levelness meets the requirements (height difference ≤ 3 mm). For details about the site selection requirements, see **HUAWEI LUNA2000-(107-215) Series Commercial and Industrial Hybrid Cooling Grid Forming ESS User Manual**.

Step 2 (Optional) Install the inverters and SUN2000P.

Step 3 (Optional) Install the meter.

Step 4 Install the SmartMGC.

Step 5 Install the PE cables.

- The device enclosure shall be reliably grounded. Ensure that the PE cables are reliably connected.
- To enhance the corrosion resistance of a ground terminal, you are advised to apply silicone grease or paint on it after connecting a PE cable.

Step 6 Install the AC power cables.

AC power cables must be connected in the same phase sequence for all ESSs, inverters, power distribution cabinets, and transformers in the array.

Step 7 Install the communications cables.

For the cable connections, see **Communication Logic**.

----End

3.2 Wiring Solutions

NOTICE

- When the rated AC grid voltage is ≤ 415 V, the **MAINS** port of the ESS can obtain power from the PCS terminal inside the ESS or from a power supply outside the ESS.
- When the rated AC grid voltage is > 415 V (420/440/480 V), the ESS auxiliary power supply must be a power supply connected from outside the ESS. An auxiliary transformer is added to convert the grid voltage into 220 V single-phase power and supply the power to the **MAINS** port of the ESS.

3.2.1 Wiring Solution of the On/Off-Grid PV+ESS (PQ/VSG) System

During off-grid operation, if the neutral wire must not be disconnected from the grid (for details, see the local grid requirements), use a 3-pole on/off-grid switch. If a 4-pole switch is used, the neutral wire shall not be connected to this switch.

During off-grid operation, if the neutral wire must be disconnected from the grid (for details, see the local grid requirements), use a 4-pole on/off-grid switch.

NOTICE

In the scenario where a 4-pole on/off-grid switch is used: After the system disconnects from the power grid, the 4-pole on/off-grid switch disconnects the neutral wire. As a result, the system is not grounded, and the **PCS Grounding Abnormal** alarm will be triggered during on/off-grid switching or off-grid black start, causing the ESS to shut down for protection. In this case, you need to add an earthing switch on the microgrid side:

- When the 4-pole on/off-grid switch is turned off, the earthing switch will be turned on to ensure that the neutral wire is grounded in off-grid mode.
- When the 4-pole on/off-grid switch is turned on, the earthing switch will be turned off to ensure that the PV+ESS system is grounded through the neutral wire on the mains side.

Scenario 1: On/Off-Grid PV+ESS (PQ/VSG) System

The following figures are only simplified electrical diagrams. For details, see the actual electrical diagrams of the power distribution cabinet.

- **Figure 3-1** and **Figure 3-2** use the TN-S system with a common 4-pole switch as an example.

Figure 3-1 Wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (using the TN-S system with a common 4-pole MCCB as an example)

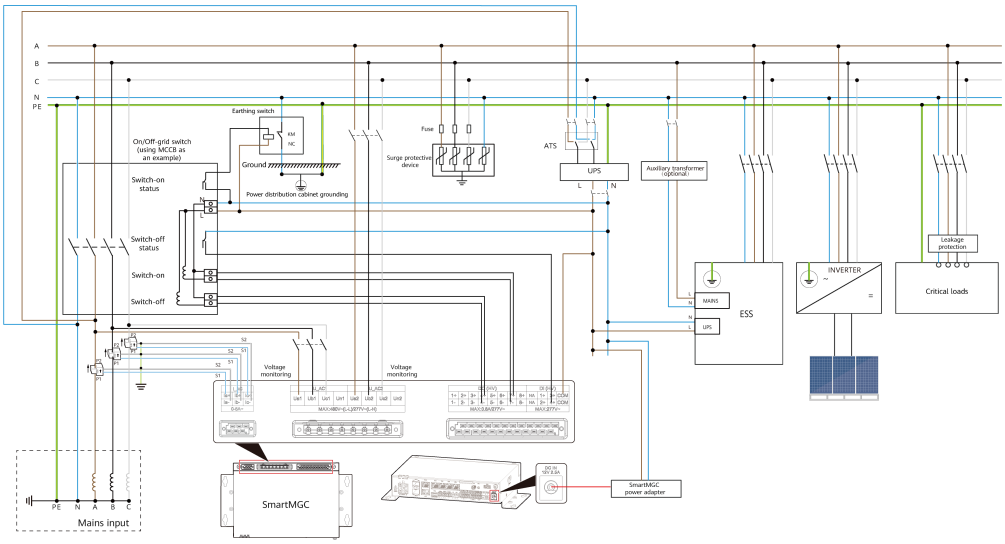
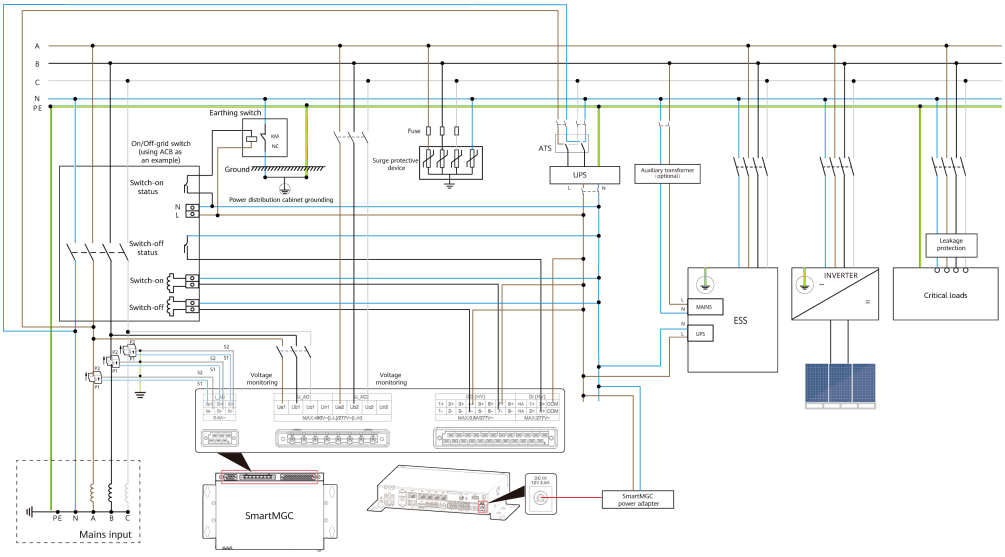


Figure 3-2 Wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (using the TN-S system with a common 4-pole ACB as an example)

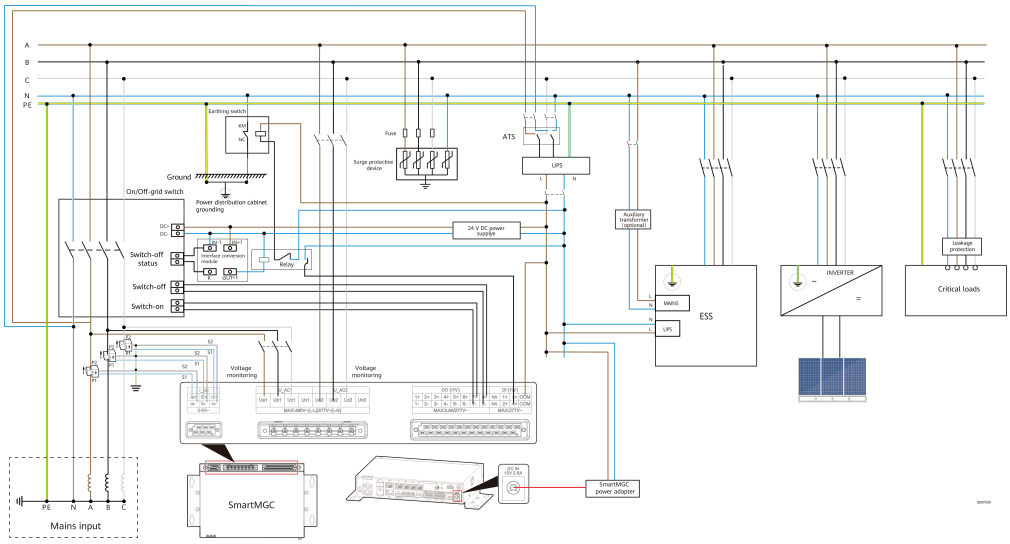


The wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system is described as follows:

- The DI4(HV) port of the SmartMGC receives the actual working status of the on/off-grid switch to monitor the on-grid or off-grid status of the grid connection point.
- The DO7(HV) port of the SmartMGC controls the on/off-grid switch to switch on.
- The DO4(HV) port of the SmartMGC controls the on/off-grid switch to switch off.
- The two power supplies are automatically switched to ensure the power supply of the UPS in on-grid and off-grid operations.
- The PV and ESS general power ports are connected to the power distribution system, including the neutral wires.
- The wires for functional earthing (neutral wire) and protective earthing (PE wire) of the power distribution system are connected to the customer's ground grid outside the cabinet, respectively. Do not short-circuit the two wires inside the cabinet. The specifications of the wire for functional earthing shall be the same as those of the general power cables.
- The neutral wire of the mains must be grounded.

- **Figure 3-3** uses the TN-S system with a fast 4-pole switch as an example.

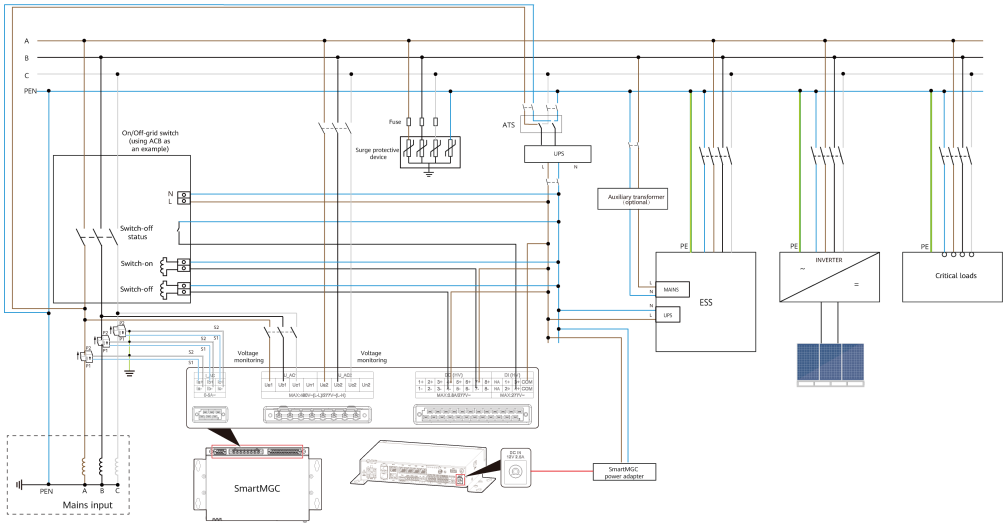
Figure 3-3 Wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (using the TN-S system with a fast 4-pole switch as an example)



– If the I/O control loop of the on/off-grid switch operates at DC voltage (range: 12–30 V), preferentially select the DO8(HV) port of the SmartMGC for switch-off control of the on/off-grid switch.
– If the switch status feedback loop operates at DC voltage (range: 12–30 V), an intermediate relay is required to convert the signal into an AC signal and then send the signal to the SmartMGC. If the switch status feedback loop operates at AC voltage, the signal can be sent directly.

- Figure 3-4 uses the TN-C system with a common 3-pole switch as an example.

Figure 3-4 Wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (using the TN-C system with a common 3-pole switch as an example)

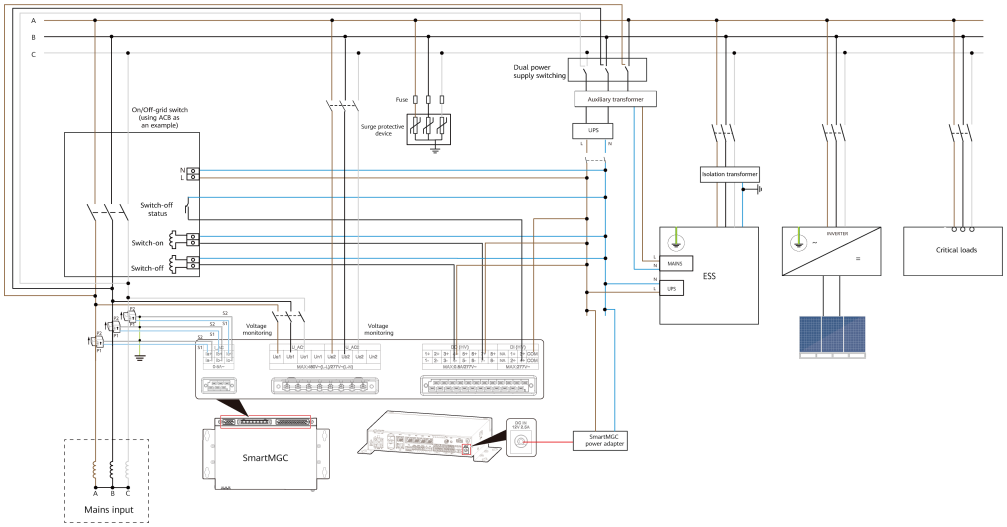


TN-C system:

– The neutral wire of the system must not be disconnected. Only a 3-pole switch can be used.

  - No residual current device is required.
- **Figure 3-5** uses the IT system with a common 3-pole switch as an example.

Figure 3-5 Wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (using the IT system with a common 3-pole switch as an example)



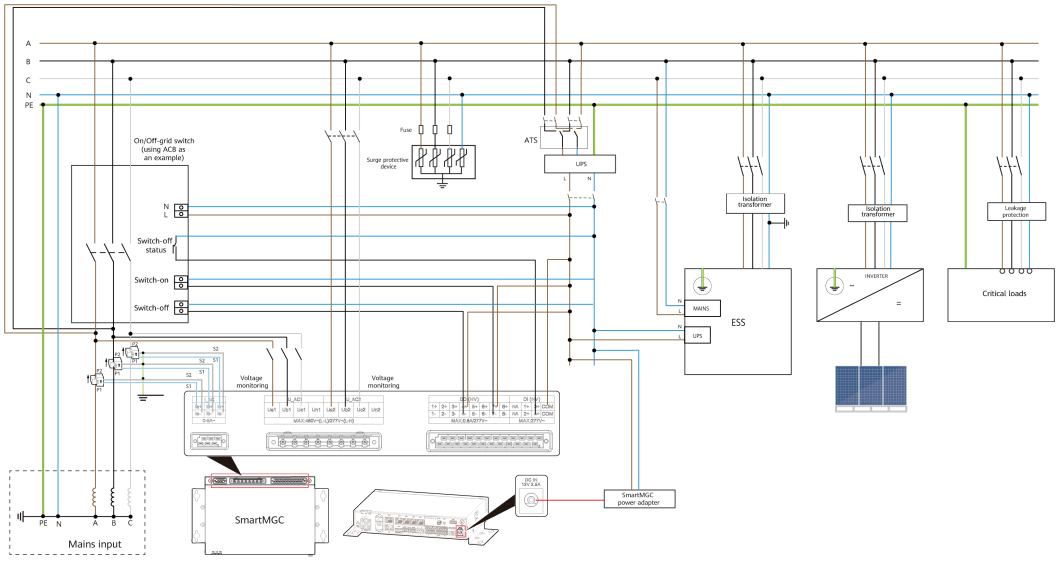
IT system:

- The neutral point of the mains is not grounded.
- The auxiliary transformer outputs single-phase power (220 V AC) to the ESS auxiliary power supply and the UPS.
- The ESS is connected to the isolation transformer in three-phase four-wire mode, and then the isolation transformer is connected to the power grid. The neutral point of the isolation transformer (on the ESS side) must be grounded.

Scenario 2: On/Off-Grid PV+ESS (PQ/VSG) System (Low-Voltage Scenarios with Isolation Transformers)

Figure 3-6 is only a simplified electrical diagram. For details, see the actual electrical diagram of the power distribution cabinet.

Figure 3-6 Wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (using the TN-S system with a common 3-pole switch as an example)



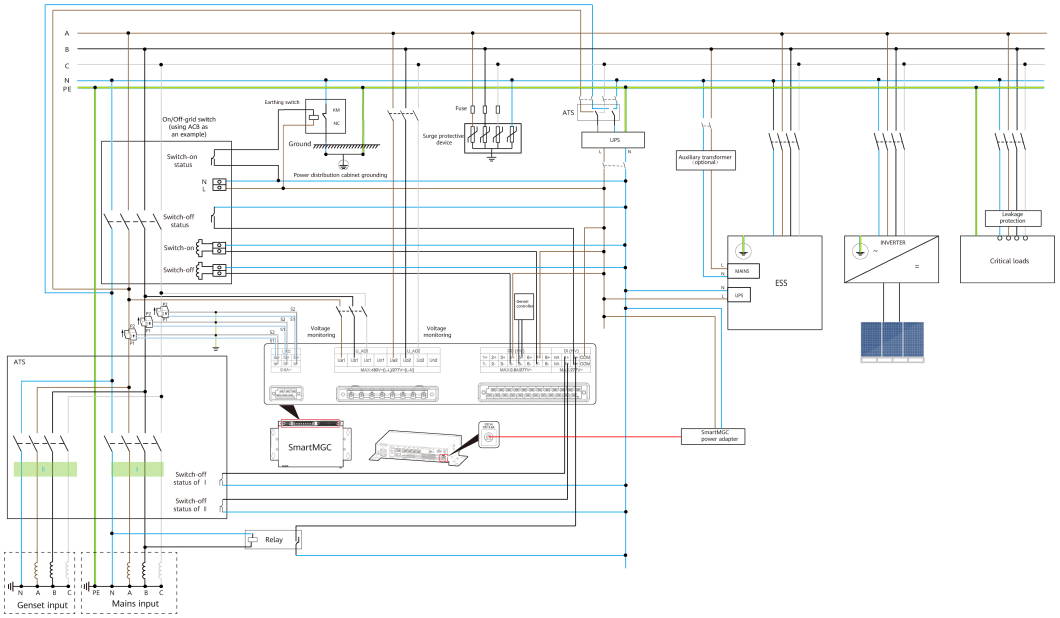
The wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (low-voltage scenarios with isolation transformers) is described as follows:

- The DI4(HV) port of the SmartMGC receives the actual working status of the on/off-grid switch to monitor the on-grid or off-grid status of the grid connection point.
- The DO7(HV) port of the SmartMGC controls the on/off-grid switch to switch on.
- The DO4(HV) port of the SmartMGC controls the on/off-grid switch to switch off.
- The two power supplies are automatically switched to ensure the power supply of the UPS in on-grid and off-grid operations.
- Some regions (for example, Japan) involve manual control scenarios where the DO control output cable does not need to be connected.
- The ESS is connected to the isolation transformer in three-phase four-wire mode, and then the isolation transformer is connected to the power grid. The neutral point of the isolation transformer (on the ESS side) must be grounded.

Scenario 3: On/Off-Grid PV+ESS+Genset Seamless Switching (PQ/VSG) + Grid/Genset ATS Switching System

Figure 3-7 is only a simplified electrical diagram. For details, see the actual electrical diagram of the power distribution cabinet.

Figure 3-7 Wiring diagram of the on/off-grid PV+ESS+genset seamless switching (PQ/VSG) + grid/genset ATS switching system (using a 4-pole switch as an example)



The wiring diagram of the on/off-grid PV+ESS+genset seamless switching (PQ/VSG) + grid/genset ATS switching system is described as follows:

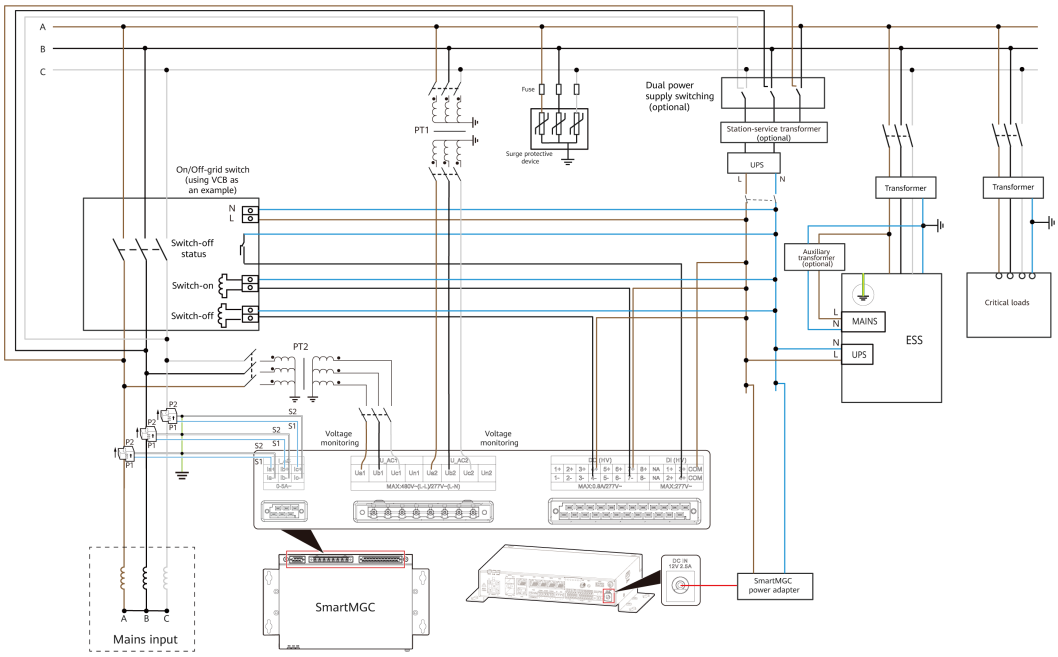
- The DI1(HV) port of the SmartMGC receives the actual working status of the ATS I on the grid side to report the switch-off status of the mains switch (primary power supply).
- The DI2(HV) port of the SmartMGC receives the actual working status of the ATS II on the grid side to report the switch-off status of the genset switch (secondary power supply).
- The DI3(HV) port of the SmartMGC receives the valid state of grid power recovery to monitor the switch-off status of the switch on the grid side.
- The DI4(HV) port of the SmartMGC receives the actual working status of the on/off-grid switch to monitor the on-grid or off-grid status of the grid connection point.
- The DO7(HV) port of the SmartMGC controls the on/off-grid switch to switch on.
- The DO5(HV) port of the SmartMGC controls the genset startup at high level. If pulse control is required, use DO5(HV) for startup control and DO6(HV) for shutdown control. The DO port of the SmartMGC is a passive node and supports the loop working voltage of 24 V DC or 220 V AC. You need to configure the voltage based on the specifications of the genset controller.
- The DO4(HV) port of the SmartMGC controls the on/off-grid switch to switch off.
- The two power supplies are automatically switched to ensure the power supply of the UPS in on-grid and off-grid operations.
- The PV and ESS general power ports are connected to the power distribution system, including the neutral wires.

- The neutral wire of the mains must be grounded.

Scenario 4: On/Off-Grid PV+ESS (PQ/VSG) System (Medium-Voltage Scenarios with Transformers)

Figure 3-8 is only a simplified electrical diagram. For details, see the actual electrical diagram of the power distribution cabinet.

Figure 3-8 Wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (medium-voltage scenarios with transformers)



The wiring diagram of the on/off-grid PV+ESS (PQ/VSG) system (medium-voltage scenarios with transformers) is described as follows:

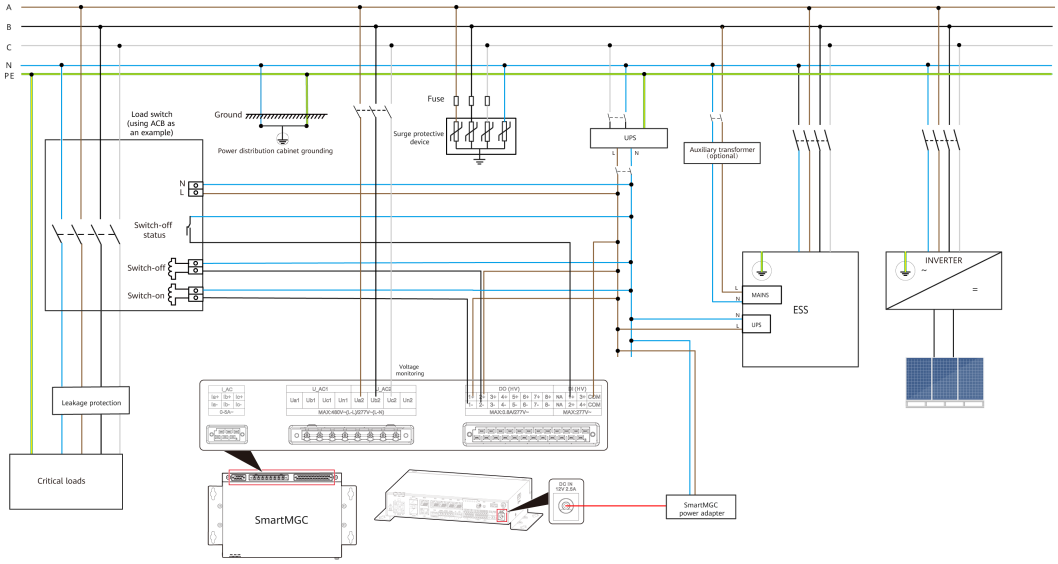
- The DI4(HV) port of the SmartMGC receives the actual working status of the on/off-grid switch to monitor the on-grid or off-grid status of the grid connection point.
- The DO7(HV) port of the SmartMGC controls the on/off-grid switch to switch on.
- The DO4(HV) port of the SmartMGC controls the on/off-grid switch to switch off.
- The two power supplies are automatically switched to ensure the power supply of the UPS in on-grid and off-grid operations.
- The ESS is connected to the isolation transformer in three-phase four-wire mode, and then the isolation transformer is connected to the power grid. The neutral point of the isolation transformer (on the ESS side) must be grounded.

3.2.2 Wiring Solution of the Off-Grid PV+ESS System

Scenario 1: Off-Grid PV+ESS System (Without Genset or with Genset Connected Through the ATS on the Load Side)

Figure 3-9 is only a simplified electrical diagram. For details, see the actual electrical diagram of the power distribution cabinet.

Figure 3-9 Wiring diagram of the off-grid PV+ESS system (using the TN-S system as an example)



The wiring diagram of the off-grid PV+ESS system (without genset or with genset connected through the ATS on the load side) is described as follows:

- The SmartMGC is used as a controller to control the off-grid operation of the PV+ESS system.
- The DI1(HV) port of the SmartMGC receives the actual working status of the critical load switch to monitor whether the critical loads have power supply.
- The DO1(HV) port of the SmartMGC controls the critical load switch to switch on, restoring the power supply to critical loads.
- The DO2(HV) port of the SmartMGC controls the critical load switch to switch off, performing load shedding of critical loads.
- The PV and ESS general power ports are connected to the power distribution system, including the neutral wires.
- The wires for functional earthing (neutral wire) and protective earthing (PE wire) of the power distribution system are connected to the customer's ground grid outside the cabinet, respectively. Do not short-circuit the two wires inside the cabinet. The specifications of the wire for functional earthing shall be the same as those of the general power cables.

NOTICE

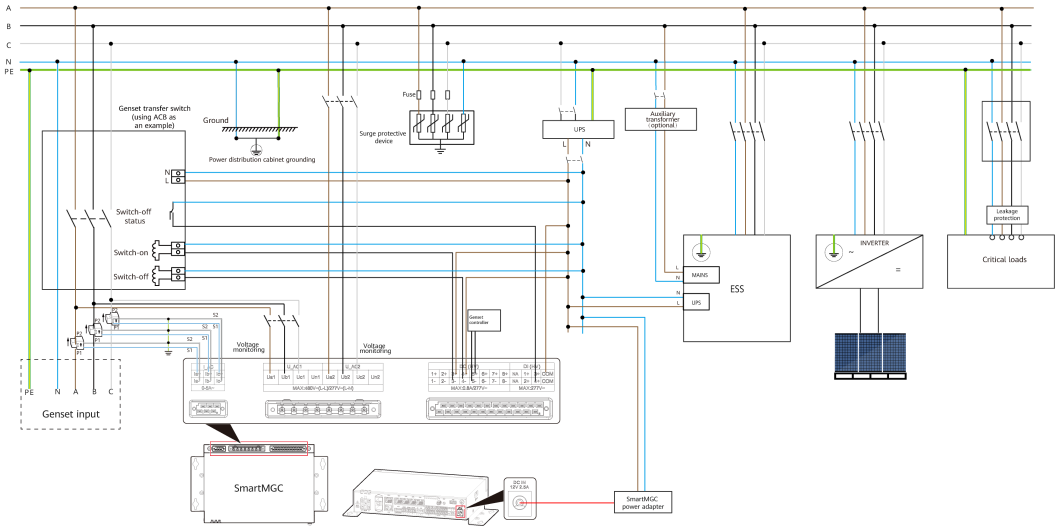
Hierarchical load management is supported, including critical, minor, and common loads.

- The DI1(HV) port of the SmartMGC receives the actual working status of the critical load switch to monitor whether the critical loads have power supply.
- The DI2(HV) port of the SmartMGC receives the actual working status of the minor load switch to monitor whether the minor loads have power supply.
- The DI3(HV) port of the SmartMGC receives the actual working status of the common load switch to monitor whether the common loads have power supply.
- The DO1(HV) and DO2(HV) ports of the SmartMGC control the critical load switch to switch on and off.
- The DO3(HV) and DO4(HV) ports of the SmartMGC control the minor load switch to switch on and off.
- The DO5(HV) and DO6(HV) ports of the SmartMGC control the common load switch to switch on and off.

Scenario 2: Off-Grid PV+ESS System (Genset Startup/Shutdown Controlled by the SmartMGC)

Figure 3-10 is only a simplified electrical diagram. For details, see the actual electrical diagram of the power distribution cabinet.

Figure 3-10 Wiring diagram of the off-grid PV+ESS system (genset startup/shutdown controlled by the SmartMGC)



The wiring diagram of the off-grid PV+ESS system is described as follows:

- The DI4(HV) port of the SmartMGC receives the actual working status of the genset transfer switch.
- The DO5(HV) port of the SmartMGC controls the genset startup at high level. If pulse control is required, use DO5(HV) for startup control and DO6(HV) for

shutdown control. The DO port of the SmartMGC is a passive node and supports the loop working voltage of 24 V DC or 220 V AC. You need to configure the voltage based on the specifications of the genset controller.

- The DO3(HV) port of the SmartMGC controls the genset transfer switch to switch on.
- The DO4(HV) port of the SmartMGC controls the genset transfer switch to switch off.
- The PV and ESS general power ports are connected to the power distribution system, including the neutral wires.
- The wires for functional earthing (neutral wire) and protective earthing (PE wire) of the power distribution system are connected to the customer's ground grid outside the cabinet, respectively. Do not short-circuit the two wires inside the cabinet. The specifications of the wire for functional earthing shall be the same as those of the general power cables.

NOTICE

- The DI1(HV) port of the SmartMGC receives the actual working status of the critical load switch to monitor whether the critical loads have power supply.
- The DO1(HV) and DO2(HV) ports of the SmartMGC control the critical load switch to switch on and off.

4 Check and Preparation Before Power-On

NOTICE

Do not open the cabinet door when the humidity is high (relative humidity ≥ 80% continuously), for example, on rainy days. If the cabinet door is open for 0.5 hour or longer when the humidity is high, manually perform forced dehumidification. Otherwise, the equipment may fail or the microgrid may collapse. Perform dehumidification as follows:

1. Check that the auxiliary AC power supply to the ESS is powered on. In off-grid scenarios, the genset or other external auxiliary power supply is used. In on/off-grid scenarios, the power grid supplies auxiliary power when available.
2. Log in to the SmartMGC WebUI and choose **Monitoring** > **ESS** > **Running Parameters** to access the page for setting running parameters.
3. Choose **Basic Parameters** > **Forced dehumidification control** and set **Forced dehumidification control** to **Start**.
4. Click **Settings**. After the setting is successful, the manual dehumidification starts. View the alarm information to check that the system has started forced dehumidification. The alarm will be automatically cleared after the dehumidification is complete, which takes more than 10 minutes.

Step 1 Perform the check before power-on by referring to the "Check Before Power-On" section in the user manual of each device.

NOTICE

Ensure that all cables are properly connected and insulated, and meet specifications.

Step 2 Check whether the phase sequence of the AC power cables between the ESS and the power distribution equipment is consistent.

If not, adjust the wiring sequence of the AC power cables.

Step 3 Check the switch status.

1. Check that the switch between the ESS AC side and the power distribution equipment is turned off.

2. Check that the switch between the inverter AC side and the power distribution equipment is turned off.

Step 4 Check that the wires for functional earthing (neutral wire) and protective earthing (PE wire) are connected to the customer's ground grid outside the cabinet, respectively. Use an insulation tester to check the resistance between the neutral wire and the ground (the normal resistance is close to zero).

Step 5 Perform acceptance tests for the ESS thermal runaway suppression system.

⚠ CAUTION

You can perform system power-on and commissioning only after the acceptance tests for the ESS thermal runaway suppression system are passed.

1. Remove foreign objects from the ESS, collect auxiliary materials, and take away flammable objects such as cardboards.
2. Perform the following steps to power on the ESS auxiliary power supply:
   - On-grid scenario: The power grid supplies power to the UPS, and the UPS supplies power to the ESS and the SmartMGC.
   - Off-grid scenario: The UPS supplies power to the ESS and the SmartMGC.
3. Log in to the SmartMGC WebUI. The following alarms shall not be generated. If any of the following alarms is generated, clear the alarm according to the alarm handling suggestions:
   - 3884 Smoke Detector Alarm
   - 3890 Heat Detector Alarm
   - 3885 High Concentration of Combustible Gas
   - 3886 Combustible Gas Detector Communication Failed
   - 3887 Combustible Gas Detector Faulty
   - 3888 Temperature and Humidity Sensor Communication Failed
   - 3889 Temperature and Humidity Sensor Faulty
   - 3893 Fire Alarm

----End

5 Device Power-On

DANGER

Wear insulated gloves and use insulated tools to prevent electric shocks or short circuits.

CAUTION

During the power-on procedure, power off the batteries immediately if any fault is detected. Rectify the fault before proceeding with the procedure.

5.1 On/Off-Grid PV+ESS (PQ/VSG) System

Power on the on/off-grid PV+ESS (PQ/VSG) system when an external power supply is available.

Figure 5-1 Power-on process of the on/off-grid PV+ESS (PQ/VSG) system

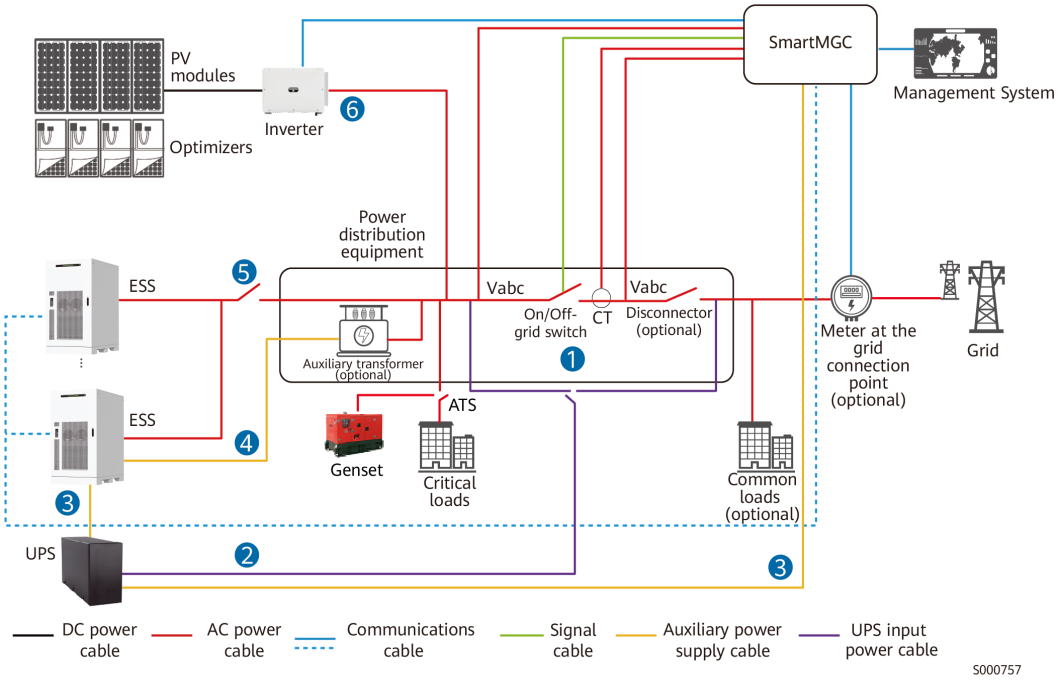


Table 5-1 Power-on process description of the on/off-grid PV+ESS (PQ/VSG) system

Step	Task	Power-On Operation
1	Powering on the power distribution equipment	Turn on the on/off-grid switch in the power distribution equipment.
2	Powering on the UPS	1. Turn on the UPS power switch on the power distribution equipment side. 2. Start the UPS.
3	Powering on the UPS-SmartMGC auxiliary power supply	1. Turn on the SmartMGC power switch on the UPS side. 2. Turn on the switch on the SmartMGC side: Turn on the power switch (if any) between the SmartMGC and the UPS based on site requirements.
	Powering on the UPS-ESS auxiliary power supply	For details, see **Power-On Operations**.
4	Powering on the ESS auxiliary power supply (for LTMS and other devices)	

Step	Task	Power-On Operation
5	Powering on the ESS AC side	
6	Powering on the inverter	**Select a power-on method based on the inverter model.** **Method 1:** 1. Set the DC SWITCH to ON. When you hear a click, the switch is completely turned on. 2. Check that the indicators are not steady red. **Method 2:** 1. Set the DC SWITCH 1 (MAIN SWITCH) to ON. When you hear a click, the switch is completely turned on. 2. Check the status of the PV connection indicator. If it is steady green, set DC SWITCH 2 and DC SWITCH 3 to ON. 3. Check that other indicators are not steady red.
Note: For details about the switch layout and operations of the devices prepared by the customer, see the documents provided by the vendors.		

5.2 Off-Grid PV+ESS System

Power on the off-grid PV+ESS system when the UPS can supply power, the genset is not running, and the power distribution equipment has no power supply.

Figure 5-2 Power-on process of the off-grid PV+ESS system

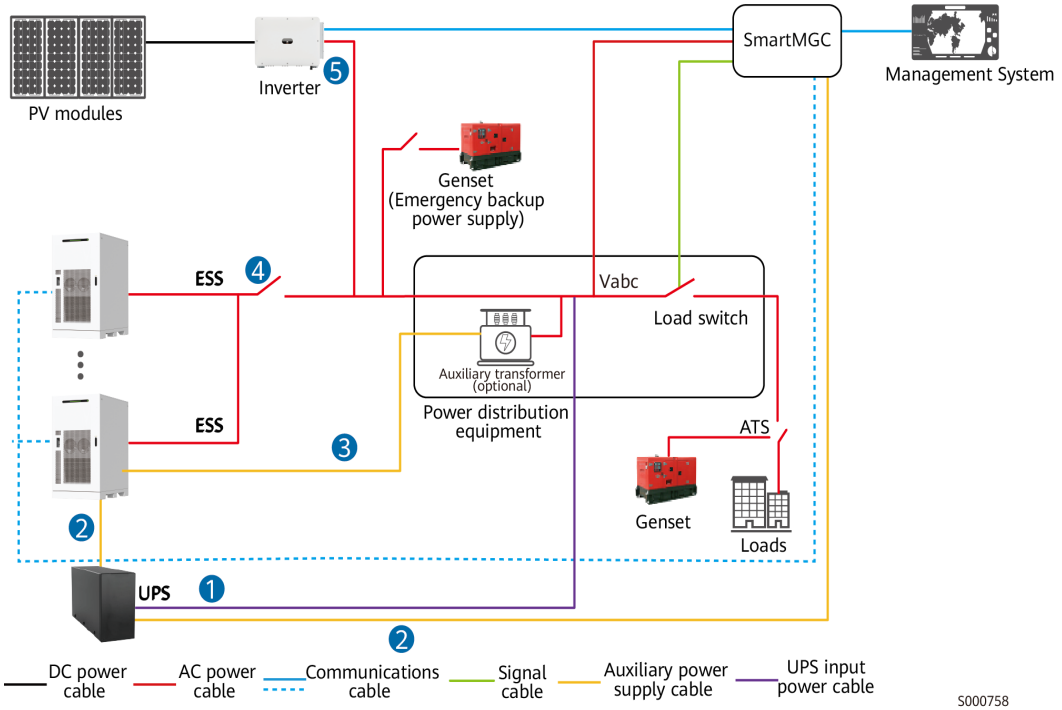


Table 5-2 Power-on process description of the off-grid PV+ESS system

Step	Task	Power-On Operation
1	Starting the UPS	For details, see the documents provided by the vendor.
2	Powering on the UPS-SmartMGC auxiliary power supply	1. Turn on the SmartMGC power switch on the UPS side. 2. Turn on the switch on the SmartMGC side: Turn on the power switch (if any) between the SmartMGC and the UPS based on site requirements.
	Powering on the UPS-ESS auxiliary power supply (for black start)	For details, see **Power-On Operations**.
3	Powering on the ESS auxiliary power supply (for LTMS and other devices)	
4	Powering on the ESS AC side	

Step	Task	Power-On Operation
5	Powering on the inverter	**Select a power-on method based on the inverter model.** **Method 1:** 1. Set the DC SWITCH to ON. When you hear a click, the switch is completely turned on. 2. Check that the indicators are not steady red. **Method 2:** 1. Set the DC SWITCH 1 (MAIN SWITCH) to ON. When you hear a click, the switch is completely turned on. 2. Check the status of the PV connection indicator. If it is steady green, set DC SWITCH 2 and DC SWITCH 3 to ON. 3. Check that other indicators are not steady red.
Note: For details about the switch layout and operations of the devices prepared by the customer, see the documents provided by the vendors.		

6 System Commissioning

6.1 Deployment Process

You are advised to perform deployment and commissioning and set the mode based on the specific scenario.

Table 6-1 Microgrid commissioning sequence

Scenario	Operation
Automatic on/off-grid PV +ESS (PQ/VSG) system	1. Prepare for the deployment (on the app). For details, see **6.3 Preparations Before Deployment**. 2. Complete the commissioning according to the deployment wizard (on the app). For details, see **6.4 Commissioning Using the Deployment Wizard**. 3. (Optional) If the seamless switching scenario is involved, set the protection parameters for seamless switching (on the WebUI). For details, see **6.5 Protection Parameter Detection**. 4. Perform the switch inspection (on the WebUI). For details, see **6.6 Switch Inspection**. 5. (Optional) Complete the microgrid control configuration based on the application scenario and requirements (on the WebUI). For details, see **7.1 On/Off-Grid PV+ESS (PQ/VSG) System**.

Scenario	Operation
Off-grid PV+ESS system	1. Prepare for the deployment (on the app). For details, see **6.3 Preparations Before Deployment**. 2. Complete the commissioning according to the deployment wizard (on the app). For details, see **6.4 Commissioning Using the Deployment Wizard**. 3. Perform the switch inspection (on the WebUI). For details, see **6.6 Switch Inspection**. 4. (Optional) Complete the microgrid control configuration based on the application scenario and requirements (on the WebUI). For details, see **7.2 Off-Grid PV+ESS System**.

6.2 Preparations and WebUI Login

For details, see the app quick guide and **SmartMGC5000 User Manual**.

6.3 Preparations Before Deployment

6.3.1 Setting ESS Startup Authorization

Prerequisites

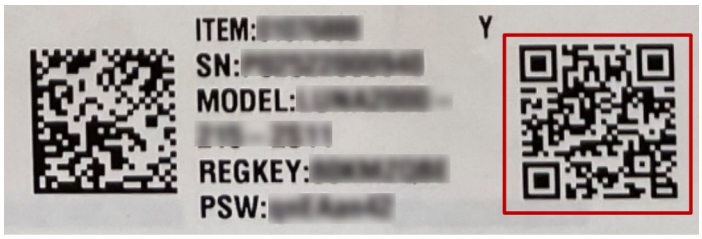
- Install devices and connect cables according to the site selection requirements and cable installation sections in the ESS user manual. If these requirements are not met, the startup authorization code may not be issued. As a result, the ESS cannot be started.
- Before connecting to the WLAN of the ESS, ensure that the ESS is powered on and the WLAN is enabled.
- The WLAN function has been enabled on the mobile phone.
- Keep the mobile phone within 5 m away from the device. Otherwise, the communication signal quality between the app and the device may be affected.

Procedure

Figure 6-1 ESS startup authorization procedure

1. Obtaining a verification code:
   a. Log in to the app, scan the WLAN QR code on the ESS (the QR code on the right of the SN on the device), and **connect to the WLAN of the ESS**.

      Figure 6-2 QR code example (for reference only; the actual QR code on the device prevails)

      NOTE

      - For the first connection to the device WLAN, log in with the initial password. You can obtain the initial WLAN password from the label on the device.
      - If the login screen is not displayed after you scan the QR code, check whether your phone is correctly connected to the device WLAN. If not, manually select and connect to the WLAN. The WLAN name of the product consists of "product name-product SN".
      - If the message **This WLAN network has no Internet access. Connect anyway?** is displayed when you connect to the built-in WLAN, tap **CONNECT**. Otherwise, you cannot log in to the system. The actual UI and messages may vary with mobile phones.
      - If the WLAN of the ESS cannot be found or the connection fails, press the WiFi button for 1s to 6s to start the WLAN module:

   b. Log in to the local commissioning screen of the ESS as the **installer** user, and obtain **Verification code**.

      NOTE

      Set the password as prompted at the first login.

2. Apply for **Startup password**.

NOTE

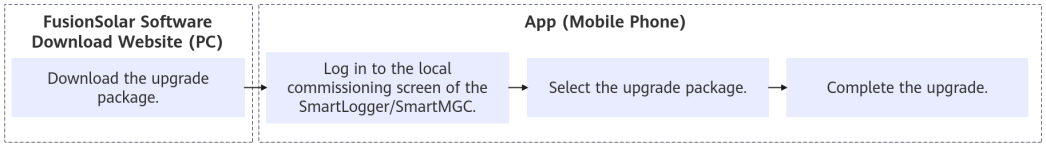
To apply for the **Startup password**, contact the device vendor or its authorized supervision service provider on the Power-Partner app.

3. Enter the **Startup password** to complete the ESS startup authorization.

   Use the app to scan the WLAN QR code on the ESS to log in to the local commissioning screen of the ESS as the **installer** user, enter the **Startup password**, and tap **Authorized**.

6.3.2 Updating the Software Version

Figure 6-3 Device upgrade procedure



Downloading the Upgrade Package (from the FusionSolar Software Download Website)

1. Log in to the **FusionSolar Software Download** website using the product customer account on a PC and download the latest software packages of the SmartMGC, ESS, and inverter.

   NOTE

   To protect software integrity, mitigate the risk of software package implantation or tampering, and enhance software supply chain safety, you are advised to install **ICS Lite** on your PC, which can automatically verify the digital signature of the software package.

   Table 6-2 Software download path

Device	Path
SmartLogger	**SmartLogger5000B**
ESS	**LUNA2000B**

2. After downloading the software packages from the website, import them from the PC to the mobile phone where the upgrade is to be performed.

Upgrading the Device Version (App)

1. Log in to the app, scan the WLAN QR code on the SmartMGC, and **connect to the WLAN of the SmartMGC**.
2. Log in to the local commissioning screen of the SmartMGC and choose **Maintenance** > **Upgrade**.
3. Tap **Select upgrade package** under the title of the device to be upgraded on the **Select device** screen, and select the upgrade package as prompted.

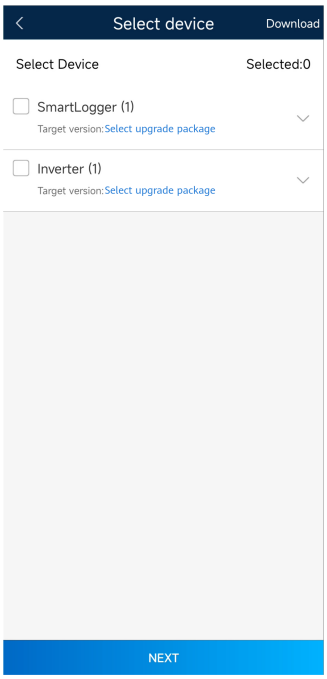
NOTE

How to select the upgrade package:

- iOS mobile phone: After downloading the upgrade package from the website and storing it on the mobile phone, hold down the file to share it to the app. Then the upgrade package is directly displayed on the screen for selecting the upgrade package.
- Android mobile phone: Choose **Select upgrade package** > **From a local directory** to access the phone folder and manually select the upgrade package.

4. Tap **Finish** to return to the **Select device** screen.
5. Select the device with the upgrade package imported, tap **NEXT**, and upgrade the device as prompted.

Figure 6-4 Device upgrade

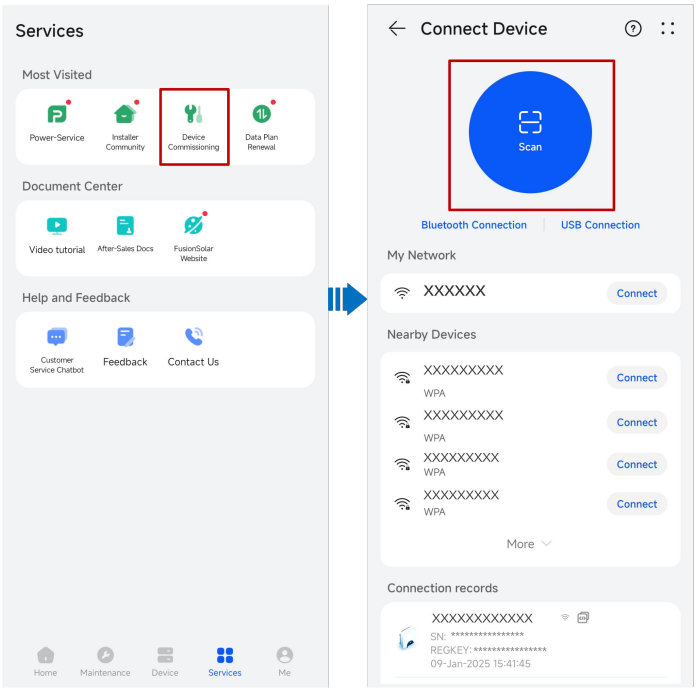


6.4 Commissioning Using the Deployment Wizard

Connecting Devices

Step 1 Tap **Device Commissioning** on the **Services** screen, scan the QR code on the SmartMGC, and connect to the WLAN of the device as prompted.

Figure 6-5 Connecting to device WLAN



NOTE

- The WLAN name of the device consists of "device name-device SN".
- For the first connection, log in with the initial password. You can obtain the initial WLAN password from the device label, that is, the characters following "PSW".
- Ensure account security by changing the password periodically. Your password might be stolen or cracked if it is left unchanged for extended periods. If a password is lost, the device cannot be accessed. In these cases, the Company shall not be liable for any loss.
- If the login screen is not displayed after you scan the QR code, check whether your phone is correctly connected to the device WLAN. If not, manually select and connect to the WLAN.
- If **This WLAN network has no Internet access. Connect anyway?** message is displayed when you connect to the built-in WLAN, tap **CONNECT**. Otherwise, you cannot log in to the system. The actual UI and messages may vary with mobile phones.
- If the WLAN of the SmartMGCcannot be found or the connection fails, press the RST button for 1s to 3s to start the WLAN module. After the COM indicator keeps steady on for 2 minutes, you can connect the app to the device WLAN.

Step 2 Log in to the local commissioning screen as the **Installer** and access **Quick Settings**.

NOTE

- Set the password as prompted at the first login.
- To ensure account security, protect the password by changing it periodically, and keep it secure.

----End

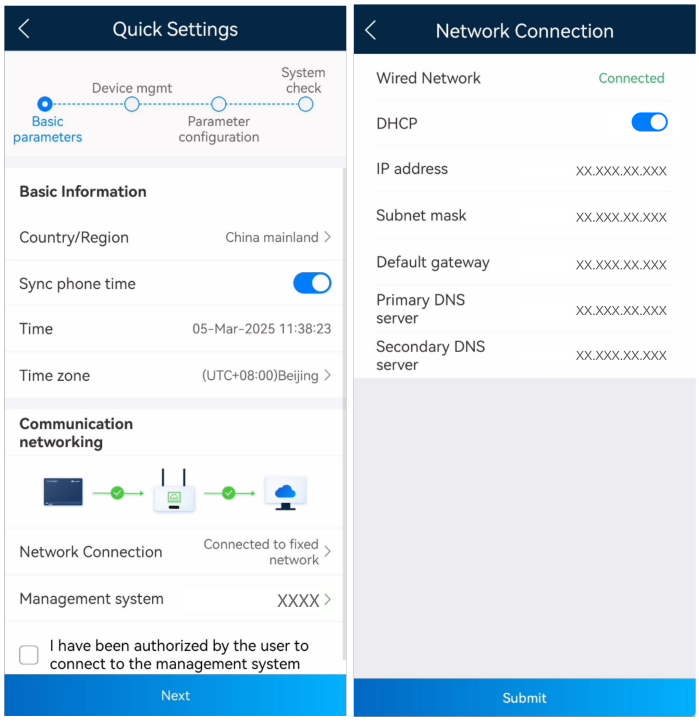
Commissioning Using the Deployment Wizard

Step 1 Basic parameters

NOTE

Ensure that the router supports the 2.4 GHz frequency band and covers the device location. Otherwise, the device cannot connect to the router, and the communication between the device and the management system will be abnormal.

Figure 6-6 Basic parameters



- **Network Connection**:

  After the **Quick Settings** screen is displayed, the system automatically connects to the network (for connecting to the management system). Tap the option area on the right of **Network Connection** to set related parameters of **Wired Network** or **Mobile network**.

  NOTE

  - If the automatic network connection fails, check whether the network cable has been connected or the SIM card has been installed.

Table 6-3 Network connection parameters

Connection Method	Description
Wired Network	The WAN port of the SmartMGC supports IP address obtaining using DHCP and automatic registration. If the router does not support DHCP, disable DHCP and manually assign an IP address.

Connection Method	Description
Mobile network	**Network mode**: Set this parameter based on the SIM card network mode.
	APN mode: The default value is **Automatic**. If Internet access using dial-up is not supported in **Automatic** mode, set this parameter to **Manual**. In this case, set the parameters related to the SIM card with the information obtained from the carrier.

- **Management system**: The system automatically displays the default domain name. Tap the option area on the right of **Management system** and set related parameters as required. Select **I have been authorized by the user to connect to the management system.** and tap **Next** to connect to the management system.

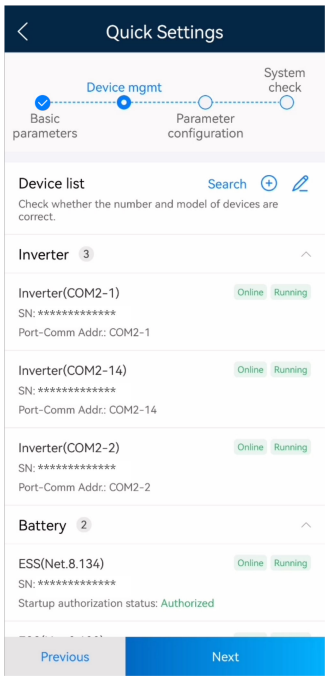
Table 6-4 Management system connection parameters

Parameter	Description
Domain Name	Set the IP address or domain name. Domain name: intl.fusionsolar.huawei.com
Third-party EMS Parameters	To connect a third-party management system, select a protocol based on the third-party management system protocol.

Step 2 Device Management

- Tap **Search** to discover the device. Auto discovery does not apply to third-party whitelisted devices, such as the EMI and power meter. You need to tap **+** to add them manually. For details about the supported EMI and power meter models, see the **SmartMGC5000 User Manual** and **SmartLogger5000B User Manual**.

Figure 6-7 Device management



Step 3 Parameter configuration

Figure 6-8 Parameter configuration

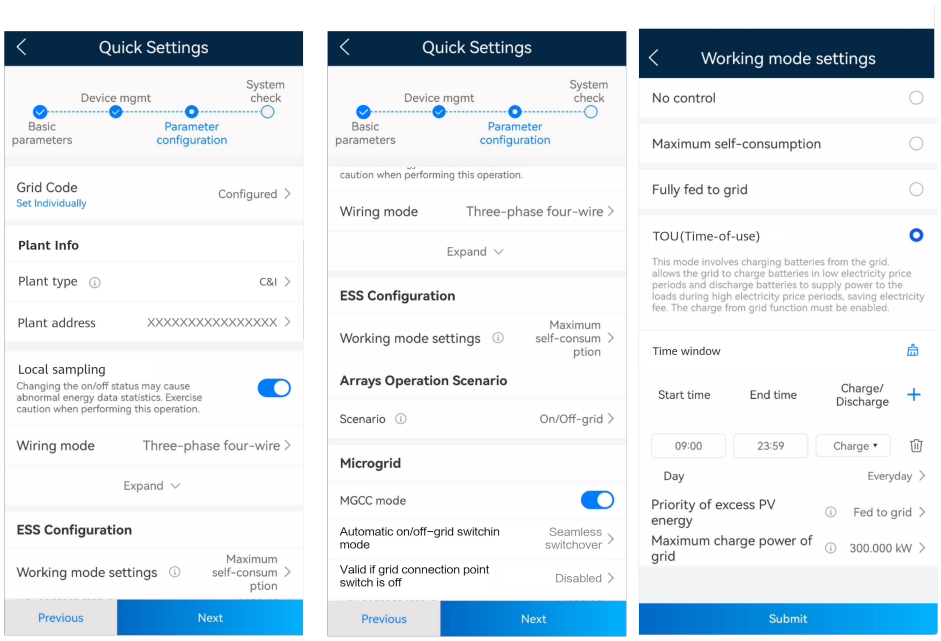


Table 6-5 Basic configuration

Category	Parameter	Description
Grid Code	**Grid Code**	Select the local grid code.
Plant Info	**Plant type**	Set this parameter to **C&I**.

Category	Parameter	Description
	Plant postal code	Set this parameter to the local postal code of the plant.
	Plant address	**Plant address** is displayed when **Plant type** is set to **C&I**. Set this parameter to the address of the plant.
ESS Configuration	**Working mode settings**	• On-grid operation: Set this parameter to **Maximum self-consumption**, **Time-of-use (TOU)**, or **No control** (only for commissioning) based on the actual application scenario. • Off-grid operation: Set this parameter to **No control**.
Arrays Operation Scenario	**Scenario**	• In the off-grid scenario, set this parameter to **Off-grid**. The PV +ESS system forms an independent microgrid to supply power to loads and does not need the grid supply. • In the **Seamless switchover** or **Seamed switching** scenario, set this parameter to **On/Off-grid**. The PV+ESS system can run in on-grid or off-grid mode. The system supports bidirectional switching between the two modes. The grid supply is required in this scenario.

Table 6-6 Grid connection point sampling configuration

Parameter	Description
Local sampling	Set whether to enable **Local sampling**. After it is enabled, it can be used as a grid connection point meter with CT and PT sampling cables connected.
Wiring mode	This parameter is displayed when **Local sampling** is enabled. Set **Output mode** based on the actual cable connection.
Primary voltage of grid PT (V)	This parameter is displayed when **Local sampling** is enabled. The voltage is collected through the U_AC1 port. • If no PT is used, the primary and secondary voltages on the power grid side are set based on the rated voltage on the power grid side. • If a PT is used, the primary and secondary voltages on the power grid side are set based on the actual specifications of the PT.
Secondary voltage of grid PT (V)	
Primary voltage of microgrid PT (V)	This parameter is displayed when **Local sampling** is enabled. Voltage is sampled through the U_AC2 port. • If PT sampling is unavailable, set the primary and secondary voltages on the microgrid side based on the actual rated voltage on the microgrid side. • If PT sampling is available, set the primary and secondary voltages on the microgrid side based on the actual specifications of the PT.
Secondary voltage of microgrid PT (V)	

Parameter	Description
Primary current of CT (A)	This parameter is displayed when **Local sampling** is enabled. The CT is connected to the I_AC port to collect current data. Set these parameters based on the actual specifications of the CT.
Secondary current of CT (A)	
CT wiring direction	Select the CT wiring direction based on the actual cable connection.

Step 4 Set microgrid parameters.

Table 6-7 Microgrid parameters

Category	Parameter	Description	Remarks
Microgrid	**MGCC mode**	This parameter is disabled by default. In the microgrid scenario, if this parameter is enabled, the microgrid control function is enabled. When the microgrid is off-grid, the SmartEMO function and functions involved in power adjustment and ESS control will be invalid.	This parameter is displayed when **Scenario** is set to **On/Off-grid** or **Off-grid**.
	Automatic on/off-grid switching mode	• **Not controlled**: The system does not perform any operation. The user manually controls on/off-grid switching. • **Seamed switching**: The system automatically switches off the circuit breaker at the grid connection point and performs the corresponding sequence control process. This switching mode usually takes a certain period of time and may result in a short-time power supply interruption. • **Seamless switching**: The system can quickly complete the on/off-grid switching without causing a power supply interruption. If rapid on/off-grid switching is required, set **Status of rapid power loss detection**[1] to **Enable**.	This parameter is displayed when **Scenario** is set to **On/Off-grid** and **MGCC mode** is enabled.
[1]: You can choose **Set** > **Microgrid Parameters** > **On/Off-Grid Switching** to set this parameter.			

- In the microgrid scenario, if **Scenario** is set to **On/Off-grid**, **MGCC mode** is enabled, and **Automatic on/off-grid switching mode** is set to **Seamed switching**, the parameters are described as follows.

Table 6-8 Microgrid parameters (seamed switchover mode)

Category	Parameter	Description	Remarks
Microgrid	**Seamed on/off-grid switching mode**	This parameter is displayed when **Automatic on/off-grid switching mode** is set to **Seamed switching**. Set this parameter to **Automatic** or **Manual**.	-
	Valid if grid connection point switch is off	– If the switch-off terminal (NO) or switch-on terminal (NC) of the circuit breaker at the grid connection point is connected, set this parameter to **Enabled**. If the switch-off terminal (NC) or switch-on terminal (NO) of the circuit breaker at the grid connection point is connected, set this parameter to **Enabled**. – System cable connections: ▪ DI4 (HV): reports the Off state of the switch at the grid connection point. ▪ DO7 (HV): turns on the switch at the grid connection point. ▪ DO8 (HV): turns off the switch at the grid connection point (fast port); needs to connect to the DC power supply. ▪ DO4 (HV): turns off the switch at the grid connection point (common port); supports the DC or AC power supply.	This parameter is displayed when **Scenario** is set to **On/Off-grid** and **MGCC mode** is enabled.

- In the microgrid scenario, if **Scenario** is set to **On/Off-grid**, **MGCC mode** is enabled, and **Automatic on/off-grid switching mode** is set to **Seamless switchover**, the parameters are described as follows.

Table 6-9 Microgrid parameters (seamless switchover mode)

Category	Parameter	Description	Remarks
Microgrid	**Valid if grid connection point switch is off**	– If the switch-off terminal (NO) or switch-on terminal (NC) of the circuit breaker at the grid connection point is connected, set this parameter to **Enabled**. If the switch-off terminal (NC) or switch-on terminal (NO) of the circuit breaker at the grid connection point is connected, set this parameter to **Enabled**. – System cable connections: ▪ DI4 (HV): reports the Off state of the switch at the grid connection point. ▪ DO7 (HV): turns on the switch at the grid connection point. ▪ DO8 (HV): turns off the switch at the grid connection point (fast port); needs to connect to the DC power supply. ▪ DO4 (HV): turns off the switch at the grid connection point (common port); supports the DC or AC power supply.	This parameter is displayed when **Scenario** is set to **On/Off-grid** and **MGCC mode** is enabled.
Genset control	**Genset control**	Set whether to enable **Genset control**. If the genset needs to be directly controlled, set this parameter to **Enable**.	This parameter is displayed when **Automatic on/off-grid switching mode** is set to **Seamless switchover**.

Category	Parameter	Description	Remarks
	Genset control mode	Set this parameter based on the genset startup/shutdown control mode. – Pulse: ▪ DO5 (HV): starts the genset. ▪ DO6 (HV): shuts down the genset. – Level: ▪ DO5 (HV): starts the genset at high level. ▪ DO6 (HV): shuts down the genset at low level.	This parameter is displayed when **Genset control** is enabled.
	Genset rated active power (kW)	Set the rated active power of the genset. **NOTE** Ensure that the value is the same as the rated active power on the genset nameplate.	This parameter is displayed when **Genset control** is set to **Enable** and **Automatic on/off-grid switching mode** is set to **Seamless switchover**.
	Valid if grid-side switch is off	– Set this parameter to **Disabled** or **Enabled**. If the grid-side switch-on terminal of the transfer switch is connected, set this parameter to **Disabled**. If the grid-side switch-off terminal of the transfer switch is connected, set this parameter to **Enabled**. – DI1 (HV): grid-side switch-off status feedback.	This parameter is displayed when **Genset control** is enabled.

Category	Parameter	Description	Remarks
	Valid if genset-side switch is off	– Set this parameter to **Disabled** or **Enabled**. If the genset-side switch-on terminal of the transfer switch is connected, set this parameter to **Disabled**. If the genset-side switch-off terminal of the transfer switch is connected, set this parameter to **Enabled**. – DI2 (HV): genset-side switch-off status feedback.	
	Valid if grid power recovers	– Set this parameter to **Disabled** or **Enabled**. If the normally open (NO) terminal of the power failure detection relay is connected, set this parameter to **Disabled**. If the normally closed (NC) terminal of the power failure detection relay is connected, set this parameter to **Enabled**. – DI3 (HV): grid power recovery status feedback.	

- In the microgrid scenario, if **Scenario** is set to **Off-grid** and **MGCC mode** is enabled, the parameters are described as follows.

Table 6-10 Microgrid parameters (off-grid mode)

Category	Parameter	Description	Remarks
Genset control	**Genset control**	Set whether to enable **Genset control**. If the genset needs to be directly controlled, set this parameter to **Enable**.	This parameter is displayed when **Off-grid** is set to **Off-grid** and **MGCC mode** is enabled.

Category	Parameter	Description	Remarks
	Genset control mode	Set this parameter based on the genset startup/shutdown control mode. – Pulse: ▪ DO5 (HV): starts the genset. ▪ DO6 (HV): shuts down the genset. – Level: ▪ DO5 (HV): starts the genset at high level. ▪ DO6 (HV): shuts down the genset at low level.	This parameter is displayed when **Genset control** is enabled.
	Genset rated active power (kW)	Set the rated active power of the genset. **NOTE** Ensure that the value is the same as the rated active power on the genset nameplate.	This parameter is displayed when **Genset control** is enabled.
	Transfer switch	– Set whether the transfer switch is connected. – System cable connections: ▪ DI4 (HV): reports the Off state of the transfer switch. ▪ DO7 (HV): turns on the transfer switch. ▪ DO8 (HV): turns off the transfer switch.	This parameter is displayed when **Scenario** is set to **Off-grid** and **MGCC mode** is enabled.
	Valid if transfer switch is off	Set this parameter to **Disabled** or **Enabled**. If the switch-on terminal of the transfer switch is connected, set this parameter to **Disabled**. If the switch-off terminal of the transfer switch is connected, set this parameter to **Enabled**.	This parameter is displayed when **Scenario** is set to **Off-grid** and **MGCC mode** is enabled.

Category	Parameter	Description	Remarks
Load control	**Critical load switch**	– Specifies whether the critical load switch is connected. – System cable connections: ▪ DI1 (HV): reports the Off state of the critical load switch. ▪ DO1 (HV): turns on the critical load switch. ▪ DO2 (HV): turns off the critical load switch.	This parameter is displayed when **Scenario** is set to **Off-grid** and **MGCC mode** is enabled.
	Valid if critical load switch is off	Set this parameter to **Disabled** or **Enabled**. Set this parameter to **Disabled** if the switch-on terminal of the major load switch is connected. Set this parameter to **Enabled** if the switch-off terminal of the major load switch is connected.	
	Minor load switch	– Specifies whether the minor load switch is connected. – System cable connections: ▪ DI2 (HV): reports the Off state of the minor load switch. ▪ DO3 (HV): turns on the minor load switch. ▪ DO4 (HV): turns off the minor load switch.	
	Valid if minor load switch is off	Set this parameter to **Disabled** or **Enabled**. Set this parameter to **Disabled** if the switch-on terminal of the minor load switch is connected. Set this parameter to **Enabled** if the switch-off terminal of the minor load switch is connected.	

Category	Parameter	Description	Remarks
	Common load switch	– Specifies whether the common load switch is connected. – System cable connections: ▪ DI3 (HV): reports the Off state of the common load switch. ▪ DO5 (HV): turns on the common load switch. ▪ DO6 (HV): turns off the common load switch.	This parameter is displayed when **Genset control** is disabled.
	Valid if common load switch is off	Set this parameter to **Disabled** or **Enabled**. Set this parameter to **Disabled** if the switch-on terminal of the common load switch is connected. Set this parameter to **Enabled** if the switch-off terminal of the common load switch is connected.	

Step 5 System check

After the current screen is displayed, the system automatically checks **Networking status**, **Alarm status**, **Device status**, and **Version check**. After the check is complete, you can tap **Check Again** to perform the check again. You need to tap **Start test** to trigger **Connection Test**. After the check is complete, you can tap **Try Again** to perform the check again.

Figure 6-9 System check

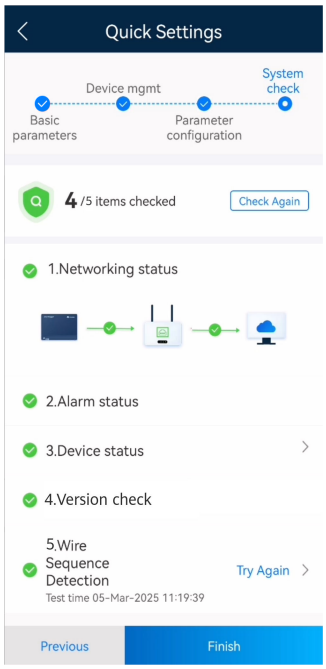


Table 6-11 System check

Check Type	Description
Networking status	Check whether the management system is successfully connected and whether the mobile network signal is weak.
Alarm status	Check whether there are active alarms.
Device status	Check whether **Running status** is set to **Faulty** or **communication status** is set to **Offline**.
Version check	Check whether all devices in the device list need to be updated. **NOTE** After the update is complete, you can return to the **System check** screen to continue the deployment. However, if the SmartMGC is restarted during the update, the app will be disconnected from the WLAN of the device. As a result, the deployment cannot continue.
Connection Test	Check whether the communication between devices is normal, whether the PT/CT cable connection and the A/B/C wire sequences of the PCS AC cables are normal, and identify possible faults. You can identify and rectify faults by viewing rectification suggestions to ensure that the system runs properly. **NOTE** • This function applies only to the C&I Hybrid Cooling Grid Forming ESS and is displayed in the scenario with multiple cabinets. • In the off-grid scenario, ensure that the load has been disconnected and then perform **Connection Test**. In the on-grid scenario, connection check is required only in the zero feed-in scenario with three-phase imbalance phase-level power control.

Step 6 Tap **Finish**, set **Array Startup/Shutdown** as required, and perform function commissioning as required.

Step 7 Set and confirm the following parameters after the deployment is complete.

- Set **Output mode** for the inverter and ESS.
  - Inverter: Tap **Device monitoring**, select the inverter, choose **Set** > **Grid parameters**, and set **Output mode** based on the actual cable connection mode of the inverter.
  - ESS: Tap **Device monitoring**, select the ESS, choose **Set** > **Power Parameters** > **Grid parameters**, and set **Output mode** of the ESS to **Three-phase four-wire**.
- Check whether **Grid code** of the ESS are correctly set. If not, correct it.
  - Tap **Device monitoring**, select the ESS, and choose **Settings** > **Power Parameters** > **Grid parameters**. Check the **Grid code** parameter and configure the local grid code as required.

----End

6.5 Protection Parameter Detection

The implementation of the target function involves the coordination of multiple devices. Parameters of each component must be set according to the rules. It is recommended that default settings be retained for protection parameters of the SmartMGC and ESS. To change the settings, contact the Company's engineers. Check the protection parameters through the SmartMGC WebUI.

- Check the protection parameters of the SmartMGC: Choose **Settings** > **Microgrid Control** > **Advanced Control Configuration** > **Protective Relay Configuration** and check whether the protection parameters of the SmartMGC are the same as those in **Table 6-12**. If not, modify the parameters according to **Table 6-12**.

  The protection parameters of the SmartMGC are used only in the seamless switching scenario.
- Check the off-grid protection parameters of the ESS: Choose **Monitoring** > **ESS** > **Running Parameters** and check whether the off-grid protection parameters are the same as those in **Table 6-12**. If not, modify the parameters according to **Table 6-12**.
  - In the seamed switching scenario, the ESS operates based on the grid code protection parameters when the ESS is in on-grid PQ mode, and operates based on the off-grid protection parameters when the ESS is in off-grid VSG mode.
  - In the seamless switching scenario, the ESS operates based on the off-grid protection parameters when the ESS is in on-grid PQ mode or off-grid VSG mode.
  - In the off-grid scenario, the ESS operates based on the off-grid protection parameters.

Table 6-12 Protection parameter description

Working Condition	SmartMGC		ESS	
Overvoltage protection	**Threshold for triggering section I overvoltage protection**	1.1 x Un[a]	**Off-grid level-1 overvoltage protection threshold**	1.1 x Un[a]
	Delay of section I overvoltage protection	10000	**Duration threshold for off-grid level-1 overvoltage protection**	15000
	Threshold for triggering section II overvoltage protection	1.2*Un[a]	**Off-grid level-2 overvoltage protection threshold**	1.2 x Un[a]
	Delay of section II overvoltage protection	200	**Duration threshold for off-grid level-2 overvoltage protection**	10500
	/	/	**Off-grid level-3 overvoltage protection threshold**	1.3 x Un[a]
	/	/	**Duration threshold for off-grid level-3 overvoltage protection**	300
	/	/	**Off-grid level-4 overvoltage protection threshold**	1.3 x Un[a]
	/	/	**Duration threshold for off-grid level-4 overvoltage protection**	300
Undervoltage protection	**Threshold for triggering section I undervoltage protection**	0.9 x Un[a]	**Off-grid level-1 undervoltage protection threshold**	0.85*Un[a]

Working Condition	SmartMGC		ESS	
	Delay of section I undervoltage protection	10000		10500
	Threshold for triggering section II undervoltage protection	0.8 x Un[a]		0.75*Un[a]
	Delay of section II undervoltage protection	0		1000
	/	/		0.75*Un[a]
	/	/		1000
	/	/		0.75*Un[a]
	/	/		1000
Overfrequency protection	**Threshold for triggering section I overfrequency protection**	fn[b] + 2		1.08*fn[b]
	Delay of section I overfrequency protection	500		1000
	/	/		1.09*fn[b]
	/	/		800
	/	/		1.1 x fn[b]
	/	/		700
	/	/		1.1 x fn[b]
	/	/		700
Underfrequency protection	**Threshold for triggering section I underfrequency protection**	fn[b] – 2		0.92*fn[b]
	Delay of section I underfrequency protection	500		1000

Working Condition	SmartMGC		ESS	
	/	/		0.91*fn[b]
	/	/		800
	/	/		0.9 x fn[b]
	/	/		700
	/	/		0.9 x fn[b]
	/	/		700
Frequency change rate protection	**Threshold for triggering section I protection if ROCOF increases**	5	/	/
	Threshold for triggering section I protection if ROCOF decreases	5	/	/
	Delay of section I protection if ROCOF increases	140	/	/
	Delay of section I protection if ROCOF decreases	140	/	/
Rapid power loss detection	**Threshold for triggering rapid power loss detection**	80	/	/
Note a: Rated voltage of the power grid. Note b: Rated frequency of the power grid.				

6.6 Switch Inspection

Switch inspection is to manually turn on and off the on/off-grid switch or load switch in order to check whether the switch is correctly configured.

DANGER

- Ensure that the equipment is not damaged before you operate the on/off-grid switch or load switch. Otherwise, electric shocks or fire may occur.
- When operating the on/off-grid switch or load switch, wear insulated gloves and use insulated tools to prevent electric shocks or short circuits.
- Non-standard and improper operations may result in fire or electric shocks.
- Prevent foreign matter from entering the equipment during operations. Otherwise, short circuits, equipment damage, load power derating, power failure, or personal injury may occur.

NOTE

Switch inspection is performed on the WebUI.

On/Off-Grid Switching (Seamed/Seamless)

Step 1 Choose **Settings** > **Microgrid Control** > **General Basic Settings** > **Microgrid Settings** and set **Microgrid scenario** to **On/Off-grid (PQ/VSG)**. Set **Automatic on/off-grid switching mode** to **Not controlled**.

Step 2 Choose **Maintenance** > **Device Management** > **Startup/Shutdown**, click **Shut Down**, click **All array devices** from the drop-down list to shut down the devices.

Step 3 Check whether the DI4(HV) cable is properly connected for the switch-off status feedback port of the on/off-grid switch.

Manually turn on or off the on/off-grid switch onsite, and choose **Overview** > **Sampling Info** to check whether the DI4 status changes.

- If the status changes, the DI4(HV) cable is properly connected.
- If the status does not change, check the DI4(HV) cable connection and rectify the fault.

Step 4 Check onsite that the on/off-grid switch is turned on and that **On/Off-grid status** is **On-grid** under **Settings** > **Microgrid Control** > **On/Off-Grid Switching** > **Switching Control**.

Step 5 Choose **Settings** > **Microgrid Control** > **On/Off-Grid Switching** > **Switching Control** and click **Switch to off-grid**. Then check onsite whether the on/off-grid switch is actually turned off.

If the on/off-grid switch is not turned off, check the DO4(HV)/DO8(HV) cable connection for the switch-off control port of the on/off-grid switch.

Step 6 Choose **Settings** > **Microgrid Control** > **On/Off-Grid Switching** > **Switching Control** and click **Switch to on-grid**. Then check onsite whether the on/off-grid switch is actually turned on.

If the on/off-grid switch is not turned on, check the DO7(HV) cable connection for the switch-on control port of the on/off-grid switch.

Step 7 (Optional) Check the following parameters only when the genset is connected through the ATS on the mains side. Choose **Settings** > **Microgrid Control** >

General Basic Settings and check whether **Valid if grid-side switch is off** and **Valid if genset-side switch is off** are normal. Example:

- **Valid if grid-side switch is off**:
  - If the actual status of the ATS I switch is Off and the DI1(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**.
  - If the actual status of the ATS I switch is Off and the DI1(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**.
  - If the actual status of the ATS I switch is On and the DI1(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Closed**.
  - If the actual status of the ATS I switch is On and the DI1(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Open**.
- **Valid if genset-side switch is off**:
  - If the actual status of the ATS II switch is Off and the DI2(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**.
  - If the actual status of the ATS II switch is Off and the DI2(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**.
  - If the actual status of the ATS II switch is On and the DI2(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Closed**.
  - If the actual status of the ATS II switch is On and the DI2(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Open**.

----End

Off-Grid

Step 1 Choose **Settings** > **Microgrid Control** > **General Basic Settings** > **Microgrid Settings** and set **Microgrid scenario** to **Off-grid**.

Step 2 Choose **Maintenance** > **Device Management** > **Startup/Shutdown**, click **Shut Down**, click **All array devices** from the drop-down list to shut down the devices.

Step 3 Manually switch on or off the load switch onsite to check whether the load switch functions properly.

1. Manually switch on or off the load switch and check whether the status of the critical load switch changes on the SmartMGC WebUI under **Settings** > **Microgrid Control** > **Scheduling Control** > **Load Control**.
   - If the status changes, the DI1(HV) cable is properly connected.
   - If the status does not change, check whether the DI1(HV) cable is properly connected for the switch-off status feedback port of the load switch.
2. Check the minor load switch in the same way.

   If the connection status of the minor load switch does not change when the onsite switch status changes, check whether the DI2(HV) cable is properly connected for the switch-off status feedback port of the load switch.
3. Check the common load switch in the same way.

   If the connection status of the common load switch does not change when the onsite switch status changes, check whether the DI3(HV) cable is properly connected for the switch-off status feedback port of the load switch.

Step 4 Choose **Settings** > **Microgrid Control** > **Scheduling Control** > **Load Control** > **Critical load switch status** and check that the **Off** button is available. Click **Off** and then check onsite whether the actual status of the load switch is off. If no, check whether the DO2(HV) cable is properly connected for the switch-off control port of the load switch.

- Check the minor load switch in the same way. After you click **Off**, if the switch is not turned off onsite, check whether the DO4(HV) cable is properly connected for the switch-off control port of the load switch.
- Check the common load switch in the same way. After you click **Off**, if the switch is not turned off onsite, check whether the DO6(HV) cable is properly connected for the switch-off control port of the load switch.

Step 5 Choose **Settings** > **Microgrid Control** > **Scheduling Control** > **Load Control** > **Critical load switch status** and check that the **On** button is available. Click **On** and then check onsite whether the actual status of the load switch is on. If no, check whether the DO1(HV) cable is properly connected for the switch-on control port of the load switch.

- Check the minor load switch in the same way. After you click **On**, if the switch is not turned on onsite, check whether the DO3(HV) cable is properly connected for the switch-on control port of the load switch.
- Check the common load switch in the same way. After you click **On**, if the switch is not turned on onsite, check whether the DO5(HV) cable is properly connected for the switch-on control port of the load switch.

Step 6 (Optional) Check the following parameters only when the genset is controlled by the SmartMGC. Choose **Settings** > **Microgrid Control** > **General Basic Settings** and check whether **Switch disconnection effective state** is normal. Example:

- If the actual status of the transfer switch is Off and the DI4(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**.
- If the actual status of the transfer switch is Off and the DI4(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**.
- If the actual status of the transfer switch is On and the DI4(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Closed**.
- If the actual status of the transfer switch is On and the DI4(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Open**.

----End

7 Microgrid Control

7.1 On/Off-Grid PV+ESS (PQ/VSG) System

7.1.1 Seamed Switching Scenario

Step 1 Log in to the SmartMGC WebUI, choose **Monitoring** > **Logger** > **Running Parameters** > **Scenario**, and ensure that **Scenario** is set to **On/Off-grid** and **MGCC mode** is set to **Enable**.

Step 2 Choose **Settings** > **Microgrid Control** > **General Basic Settings** and set general basic parameters.

Table 7-1 Microgrid settings

Parameter	Description
Automatic on/off-grid switching mode	Set this parameter to **Seamed switching**.
Seamed on/off-grid switching mode	This parameter is displayed when **Automatic on/off-grid switching mode** is set to **Seamed switching**. Set this parameter to **Automatic** or **Manual**.

Table 7-2 Connection settings

Parameter	Description
DI port status if on/off-grid switch is off	• Set this parameter to **DI port status if on/off-grid switch is off**. – If the actual status of the switch is Off and the DI4(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**. – If the actual status of the switch is Off and the DI4(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI4(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI4(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Open**. • System cable connections: – DI4(HV): reports the Off state of the switch at the grid connection point. – DO7(HV): turns on the switch at the grid connection point. – DO8(HV): turns off the switch at the grid connection point (fast port); needs to connect to the DC control power supply. – DO4(HV): turns off the switch at the grid connection point (slow port); supports the DC or AC control power supply.

Step 3 Choose **Settings** > **Microgrid Control** > **Scheduling Control** and set scheduling control parameters.

Table 7-3 Array SOC parameters

Parameter	Description
Array end-of-charge SOC	Specifies the array end-of-charge SOC. The default value is 100%. When the SOC of the ESS reaches the preset value, the ESS stops charging.
Array end-of-discharge SOC	Specifies the array end-of-discharge SOC. The default value is 5%. When the SOC of the ESS reaches the preset value, the ESS stops discharging.

Parameter	Description
Backup power SOC for capacity/ demand control	The reserved power, which is used for capacity/demand control, ensures that the ESS can meet capacity/demand control requirements. The value of this parameter affects the peak shaving capability. A larger value indicates a stronger peak shaving capability. This parameter is displayed when **Demand limit** is set to **Active power limit** or **Apparent power limit**, or **Capacity limit** is set to **Current limit**.
Max. SOC for charging on/off-grid ESS	Set the maximum SOC for charge in off-grid mode. The default value is 95%. Set the parameter based on the actual situation. To ensure reliable operations of the microgrid, the recommended value range is [85, 98] and this parameter must be ≤ (**Array end-of-charge SOC** – 5%).
Min. SOC for discharging on/off-grid ESS	Set the minimum SOC for discharge in off-grid mode. The default value is 5%. Set the parameter based on the actual situation. To ensure reliable operations of the microgrid, the recommended value range is [5, 15] and this parameter must be ≥ (**Array end-of-discharge SOC** + 5%).

Table 7-4 Black start parameters

Parameter	Description	Remarks
Min. PV voltage for black start	After the irradiance recovers, the inverter PV voltage increases. If the PV1 voltage of an inverter is greater than or equal to the value of this parameter, the black start may be started.	This parameter is displayed when **Automatic black start after irradiance restoration** is set to **Enable**.
Min. estimated power for black start	Before setting this parameter, ensure that the southbound inverter supports irradiance estimation. Set this parameter to a percentage of the ESS rated power. The default value is 10% of the ESS rated power. When the irradiance is restored, if the estimated PV output power of the inverter is greater than the minimum estimated power for the black start, the black start is automatically performed.	

Table 7-5 Off-grid power backup

Parameter	Description
Off-grid power backup	Set this parameter to **Enable**. The off-grid power backup function is enabled. When the SOC is less than or equal to **Min. SOC for off-grid power backup**, the ESS stops discharging to maintain sufficient power for off-grid operation.
Min. SOC for off-grid power backup	Set **Min. SOC for off-grid power backup** in on-grid mode. The default value is 40%. The value range is [10, 90]. The precision of the off-grid backup power SOC is 1%. This parameter is displayed when **Off-grid power backup** is set to **Enable**.
Prioritize off-grid power backup	When this function is enabled, if the current ESS SOC is ≤ (**Min. SOC for off-grid power backup** – 3%), the ESS will be charged preferentially by the PV system or the grid.
Draw power from grid for off-grid power backup	This parameter is displayed when **Prioritize off-grid power backup** is set to **Enable**. • **Disable**: The ESS is not allowed to obtain power from the grid for off-grid power backup. • **Enable**: The ESS is allowed to obtain power from the grid for off-grid power backup.
Charge power for off-grid power backup	Set the power for charging the ESS by the grid for off-grid power backup.

Table 7-6 Voltage baseline

Parameter	Description
Off-grid voltage reference source	• **PCS port voltage**: The voltage level of the PCS is used as the baseline. • **Voltage at grid connection point or load side**: The setting of **Voltage baseline** is used as the baseline.
Voltage baseline	Specifies the voltage baseline as the off-grid voltage reference source. This parameter is displayed when **Off-grid voltage reference source** is set to **Voltage at grid connection point or load side**.

NOTE

Array end-of-charge SOC > **Max. SOC for charging on/off-grid ESS** ≥ **Backup power SOC for capacity/demand control** ≥ **Min. SOC for off-grid power backup** > **Min. SOC for discharging on/off-grid ESS** > **Array end-of-discharge SOC**

Step 4 Choose **Settings** > **Microgrid Control** > **On/Off-Grid Switching** and set on/off-grid switching parameters. This parameter is displayed when **Seamed on/off-grid switching mode** is set to **Automatic**.

Table 7-7 Parameter settings

Parameter	Description
Auto switching to on-grid	• **Enable**: If the mains voltage is stable, the system automatically switches from off-grid to on-grid state after the synchronization of the SmartMGC is successful. • **Disable**: The function of automatic switching from off-grid to on-grid state is disabled.
Setting value of live voltage	Set the allowed error range of the mains voltage. If the voltage is within α[1]% of the rated voltage, the voltage is considered stable.
Continuous power available for	Set the minimum time for which the mains voltage remains stable.
[1]: α ≤ Setting value of live voltage ≤ 110	

Table 7-8 Switching control

Parameter	Description
On/Off-grid status	Displays the on/off-grid status. You can click **Switch to on-grid** or **Switch to off-grid** to switch between on-grid and off-grid.
Status of switching to off-grid	
Status of switching to on-grid	

Table 7-9 Description of the on/off-grid PV+ESS (PQ/VSG) seamed switching scenario

Scenario	Mode	Command and Operation Between the SmartMGC and Devices
From on-grid to off-grid	Automatic mode	1. Grid failure is detected. 2. The on/off-grid switch is automatically turned off. 3. The SmartMGC sends a command to set **Working Mode** from **PQ** to **VSG** under **Monitoring** > **ESS** > **Running Parameters** > **Feature Parameters** to start the ESS. 4. The SmartMGC sends a command to set **Microgrid compatibility** to **Enable** under **Monitoring** > **Inverter** > **Running Parameters** > **Feature Parameters**. 5. The SmartMGC sends a command to start the inverter and ESS.
	Manual mode	1. The user turns off the on/off-grid switch locally. 2. The SmartMGC detects that the on/off-grid switch is turned off. 3. The SmartMGC sends a command to set **Working Mode** from PQ to VSG under **Monitoring** > **ESS** > **Running Parameters** > **Feature Parameters**. 4. The SmartMGC sends a command to set **Microgrid compatibility** to **Enable** under **Monitoring** > **Inverter** > **Running Parameters** > **Feature Parameters**. 5. The SmartMGC sends a command to start the inverter and ESS.
From off-grid to on-grid	Automatic mode	1. The user sets **Auto switching to on-grid** to **Enable** on the SmartMGC WebUI. 2. Grid recovery is detected. 3. The SmartMGC sends a command to shut down the inverter and ESS. 4. The SmartMGC sends a command to turn on the on/off-grid switch and receives the switch-on status. 5. The SmartMGC sends a command to switch **Working Mode** from **VSG** to **PQ** under **Monitoring** > **ESS** > **Running Parameters** > **Feature Parameters**. 6. The SmartMGC sends a command to set **Microgrid compatibility** to **Disable** under **Monitoring** > **Inverter** > **Running Parameters** > **Feature Parameters**. 7. The SmartMGC sends a command to start the inverter and ESS.

Scenario	Mode	Command and Operation Between the SmartMGC and Devices
	Manual mode	1. The user manually shuts down the PV+ESS system on the SmartMGC WebUI: Choose **Maintenance** > **Device Management** > **Startup/Shutdown** and select **All array devices** under **Shut Down**. 2. The user turns on the on/off-grid switch locally. 3. The SmartMGC detects that the on/off-grid switch is turned on and the system connects to the power grid. 4. The SmartMGC sends a command to switch **Working Mode** from **VSG** to **PQ** under **Monitoring** > **ESS** > **Running Parameters** > **Feature Parameters**. 5. The SmartMGC sends a command to start the ESS. 6. The SmartMGC sends a command to set **Microgrid compatibility** to **Disable** under **Monitoring** > **Inverter** > **Running Parameters** > **Feature Parameters**. 7. The SmartMGC sends a command to start the inverter.

Step 5 Choose **Settings** > **Microgrid Control** > **Advanced Control Configuration** > **Control Policy Configuration** and set control policy configuration parameters.

NOTE

- For the parameters on the **Off-Grid Steady-State Configuration** and **On/Off-Grid Switching Configuration** pages, contact Huawei engineers for configuration instructions.
- Parameters related to **On/Off-Grid Switching Configuration** are displayed when **Seamed on/off-grid switching mode** is set to **Automatic**.

Table 7-10 Control policy configuration

Parameter	Description
Automatic PCS recovery	Specifies whether to enable the function of automatic recovery in case of abnormal PCS shutdown. • **Enable**: During off-grid operation, when the SmartMGC detects that the PCS shuts down abnormally and causes system power failure, the SmartMGC automatically attempts to perform black start to restore the power supply. • **Disable**: If the PCS shuts down abnormally, the SmartMGC does not automatically perform black start.

Parameter	Description
Automatic black start retries upon PCS fault	This parameter is displayed when **Automatic PCS recovery** is set to **Enable**. Set this parameter to **Automatic black start retries upon PCS fault**.
Automatic black start after irradiance restoration	Specifies whether to enable automatic black start after irradiance restoration. The default value is **Enable**. • **Enable**: During off-grid operation, automatic black start is performed after the irradiance restores. • **Disable**: Automatic black start is not performed after the irradiance restores.

----End

7.1.2 Seamless Switching Scenario

Step 1 Log in to the SmartMGC WebUI, choose **Monitoring** > **Logger** > **Running Parameters** > **Scenario**, and ensure that **Scenario** is set to **On/Off-grid** and **MGCC mode** is set to **Enable**.

Step 2 Choose **Settings** > **Microgrid Control** > **General Basic Settings** and set general basic parameters.

Table 7-11 General basic parameters

Parameter	Description
Automatic on/off-grid switching mode	Set this parameter to **Seamless switching**. If rapid on/off-grid switching is required, set **Status of rapid power loss detection** to **Enable**. **NOTE** After **Status of rapid power loss detection** is set to **Enable**, the system can quickly switch between on-grid and off-grid modes. However, the system may switch to the off-grid mode when the grid power fluctuates. Exercise caution when enabling this parameter.

Table 7-12 Connection settings

Parameter	Description
DI port status if on/off-grid switch is off	• Set this parameter to **DI port status if on/off-grid switch is off**. – If the actual status of the switch is Off and the DI4(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**. – If the actual status of the switch is Off and the DI4(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI4(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI4(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Open**. • System cable connections: – DI4(HV): reports the Off state of the switch at the grid connection point. – DO7(HV): turns on the switch at the grid connection point. – DO8(HV): turns off the switch at the grid connection point (fast port); needs to connect to the DC control power supply. – DO4(HV): turns off the switch at the grid connection point (slow port); supports the DC or AC control power supply.
Generator set control	Specifies whether to set **Generator set control** to **Enable**. This parameter is displayed when **Automatic on/off-grid switching mode** is set to **Seamless switching**. Enable this parameter when the genset needs to be directly controlled by SmartMGC.
Generator Set Control Method	Set this parameter to **Pulse** or **Level**. This parameter is displayed when **Generator set control** is set to **Enable**. • Set this parameter according to the genset start/stop control mode. • Pulse: – DO5(HV): starts the genset. – DO6(HV): shuts down the genset. • Level: – DO5(HV): starts the genset at high level when closed. – DO6(HV): starts the genset at low level when open.

Parameter	Description
Valid if grid-side switch is off	• Set this parameter to **Valid if grid-side switch is off**. This parameter is displayed when **Generator set control** is set to **Enable**. – If the actual status of the switch is Off and the DI1(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**. – If the actual status of the switch is Off and the DI1(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI1(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI1(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Open**. • DI1(HV): reports the Off state of the grid switch.
Valid if genset-side switch is off	• Set this parameter to **Valid if grid-side switch is off**. This parameter is displayed when **Generator set control** is set to **Enable**. – If the actual status of the switch is Off and the DI2(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**. – If the actual status of the switch is Off and the DI2(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI2(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI2(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Open**. • DI2(HV): reports the Off state of the genset switch.
Power grid electricity restored to normal operation	• Set this parameter to **Power grid electricity restored to normal operation**. This parameter is displayed when **Generator set control** is set to **Enable**. – If the grid power is recovered (available) and the DI3(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**. – If the grid power is recovered (available) and the DI3(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**. • DI3(HV): reports the state of grid power recovery.

Step 3 Choose **Settings** > **Microgrid Control** > **Scheduling Control** and set scheduling control parameters.

Table 7-13 Array SOC parameters

Parameter	Description
Array end-of-charge SOC	Specifies the array end-of-charge SOC. The default value is 100%. When the SOC of the ESS reaches the preset value, the ESS stops charging.
Array end-of-discharge SOC	Specifies the array end-of-discharge SOC. The default value is 5%. When the SOC of the ESS reaches the preset value, the ESS stops discharging.
Backup power SOC for capacity/ demand control	The reserved power, which is used for capacity/demand control, ensures that the ESS can meet capacity/demand control requirements. The value of this parameter affects the peak shaving capability. A larger value indicates a stronger peak shaving capability. This parameter is displayed when **Demand limit** is set to **Active power limit** or **Apparent power limit**, or **Capacity limit** is set to **Current limit**.
Max. SOC for charging on/off-grid ESS	Set the maximum SOC for charge in off-grid mode. The default value is 95%. Set the parameter based on the actual situation. To ensure reliable operations of the microgrid, the recommended value range is [85, 98] and this parameter must be ≤ (**Array end-of-charge SOC** – 5%).
Min. SOC for discharging on/off-grid ESS	Set the minimum SOC for discharge in off-grid mode. The default value is 5%. Set the parameter based on the actual situation. To ensure reliable operations of the microgrid, the recommended value range is [5, 15] and this parameter must be ≥ (**Array end-of-discharge SOC** + 5%).

Table 7-14 Black start parameters

Parameter	Description	Remarks
Min. PV voltage for black start	After the irradiance recovers, the inverter PV voltage increases. If the PV1 voltage of an inverter is greater than or equal to the value of this parameter, the black start may be started.	This parameter is displayed when **Automatic black start after irradiance restoration** is set to **Enable**.

Parameter	Description	Remarks
Min. estimated power for black start	Before setting this parameter, ensure that the southbound inverter supports irradiance estimation. Set this parameter to a percentage of the ESS rated power. The default value is 10% of the ESS rated power. When the irradiance is restored, if the estimated PV output power of the inverter is greater than the minimum estimated power for the black start, the black start is automatically performed.	

Table 7-15 Off-grid power backup

Parameter	Description
Off-grid power backup	Set this parameter to **Enable**. The off-grid power backup function is enabled. When the SOC is less than or equal to **Min. SOC for off-grid power backup**, the ESS stops discharging to maintain sufficient power for off-grid operation.
Min. SOC for off-grid power backup	Set **Min. SOC for off-grid power backup** in on-grid mode. The default value is 40%. The value range is [10, 90]. The precision of the off-grid backup power SOC is 1%. This parameter is displayed when **Off-grid power backup** is set to **Enable**.
Prioritize off-grid power backup	When this function is enabled, if the current ESS SOC is ≤ (**Min. SOC for off-grid power backup** – 3%), the ESS will be charged preferentially by the PV system or the grid.
Draw power from grid for off-grid power backup	This parameter is displayed when **Prioritize off-grid power backup** is set to **Enable**. • **Disable**: The ESS is not allowed to obtain power from the grid for off-grid power backup. • **Enable**: The ESS is allowed to obtain power from the grid for off-grid power backup.
Charge power for off-grid power backup	Set the power for charging the ESS by the grid for off-grid power backup.

Table 7-16 Voltage baseline

Parameter	Description
Off-grid voltage reference source	• **PCS port voltage**: The voltage level of the PCS is used as the baseline. • **Voltage at grid connection point or load side**: The setting of **Voltage baseline** is used as the baseline.
Voltage baseline	Specifies the voltage baseline as the off-grid voltage reference source. This parameter is displayed when **Off-grid voltage reference source** is set to **Voltage at grid connection point or load side**.

Table 7-17 Genset control parameters

Parameter	Description	Remarks
Generator Set Start-up Energy Storage SOC	When the ESS SOC reaches the preset value, the genset starts.	This parameter is displayed when **Generator set control** is set to **Enable**.
Generator set stops energy storage SOC	When the ESS SOC reaches the preset value, the genset stops.	
Generator Set Start/Stop Judgment Time	Specifies the time for determining whether to start or stop the genset.	
Maximum output power ratio of the generator set	Specifies the maximum output power ratio of the genset.	
Rated active power of the generator set	Specifies the rated active power of the genset.	

NOTE

Array end-of-charge SOC > **Max. SOC for charging on/off-grid ESS** ≥ **Backup power SOC for capacity/demand control** ≥ **Min. SOC for off-grid power backup** > **Min. SOC for discharging on/off-grid ESS** > **Array end-of-discharge SOC**

Step 4 Choose **Settings** > **Microgrid Control** > **On/Off-Grid Switching** and set on/off-grid switching parameters.

Table 7-18 Parameter settings

Parameter	Description
Auto switching to on-grid	• **Enable**: If the mains voltage is stable, the system automatically switches from off-grid to on-grid state after the synchronization of the SmartMGC is successful. • **Disable**: The function of automatic switching from off-grid to on-grid state is disabled.
Setting value of live voltage	Set the allowed error range of the mains voltage. If the voltage is within α[1]% of the rated voltage, the voltage is considered stable.
Continuous power available for	Set the minimum time for which the mains voltage remains stable.
Max switching time	Specifies the maximum duration for switching from off-grid to on-grid. The value must be greater than the synchronization check duration of the SmartMGC.
[1]: α ≤ Setting value of live voltage ≤ 110	

Table 7-19 From on-grid to off-grid

Scenario	Command and Operation Between the SmartMGC and Devices
Unplanned switching from on-grid to off-grid	1. The grid fails. 2. When detecting the grid failure, the SmartMGC automatically turns off the on/off-grid switch. 3. The SmartMGC sends a command to set **Microgrid compatibility** to **Enable** under **Monitoring** > **Inverter** > **Running Parameters** > **Feature Parameters**. 4. The SmartMGC sends a command to switch **Working Mode** from **PQ** to **VSG** under **Monitoring** > **ESS** > **Running Parameters** > **Feature Parameters**. 5. The SmartMGC receives the switch-off signal from the on/off-grid switch and sends the switch-off signal to the ESS. 6. The system switches to off-grid operation.

Scenario	Command and Operation Between the SmartMGC and Devices
Planned switching from on-grid to off-grid	1. The user clicks **Switch to off-grid** on the SmartMGC WebUI. 2. The SmartMGC sends a command to adjust the power at the grid connection point. 3. The SmartMGC sends a command to set **Microgrid compatibility** to **Enable** under **Monitoring** > **Inverter** > **Running Parameters** > **Feature Parameters**. 4. The SmartMGC checks whether the power adjustment at the grid connection point is successful. If yes, it sends a command to turn off the on/off-grid switch and the system enters off-grid state. If no, the switching failed, an alarm is reported, and on-grid operation continues.

Table 7-20 From off-grid to on-grid

Scenario	Command and Operation Between the SmartMGC and Devices
Auto switching to on-grid	1. The user sets **Auto switching to on-grid** to **Enable** on the SmartMGC WebUI. 2. The SmartMGC checks that the grid voltage is stable. 3. The SmartMGC performs secondary voltage and frequency regulation, and executes synchronization check and switch-on. 4. The SmartMGC checks whether the on/off-grid switch is turned on successfully. – If yes, the switching from off-grid to on-grid is successful. – If no, an alarm about switching failure is sent.
Manual switching to on-grid	1. The user clicks **Switch to on-grid** on the SmartMGC WebUI. 2. The SmartMGC checks that the grid voltage is stable. 3. The SmartMGC performs secondary voltage and frequency regulation, and executes synchronization check and switch-on. 4. The SmartMGC checks whether the on/off-grid switch is turned on successfully. – If yes, the switching from off-grid to on-grid is successful. – If no, an alarm about switching failure is sent.

Step 5 Choose **Settings** > **Microgrid Control** > **Advanced Control Configuration** > **Control Policy Configuration** and set control policy configuration parameters.

NOTE

- For the parameters on the **Off-Grid Steady-State Configuration**, **Protective Relay Configuration**, and **On/Off-Grid Switching Configuration** pages, contact Huawei engineers for configuration instructions.
- Parameters related to **On/Off-Grid Switching Configuration** are displayed when **Seamed on/off-grid switching mode** is set to **Automatic**.

Table 7-21 Control policy configuration

Parameter	Description
Automatic PCS recovery	Specifies whether to enable the function of automatic recovery in case of abnormal PCS shutdown. • **Enable**: During off-grid operation, when the SmartMGC detects that the PCS shuts down abnormally and causes system power failure, the SmartMGC automatically attempts to perform black start to restore the power supply. • **Disable**: If the PCS shuts down abnormally, the SmartMGC does not automatically perform black start.
Automatic black start retries upon PCS fault	This parameter is displayed when **Automatic PCS recovery** is set to **Enable**. Set this parameter to **Automatic black start retries upon PCS fault**.
Automatic black start after irradiance restoration	Specifies whether to enable automatic black start after irradiance restoration. The default value is **Enable**. • **Enable**: During off-grid operation, automatic black start is performed after the irradiance restores. • **Disable**: Automatic black start is not performed after the irradiance restores.

----End

7.2 Off-Grid PV+ESS System

Step 1 Log in to the SmartMGC WebUI, choose **Monitoring** > **Logger** > **Running Parameters** > **Scenario**, and ensure that **Scenario** is set to **Off-grid** and **MGCC mode** is set to **Enable**.

Step 2 Choose **Settings** > **Microgrid Control** > **General Basic Settings** and set general basic parameters.

Table 7-22 Connection settings

Parameter	Description
Critical load switch	Specifies whether the critical load switch is connected. System cable connections: • DI1(HV): reports the Off state of the critical load switch. • DO1(HV): turns on the critical load switch. • DO2(HV): turns off the critical load switch.
Valid if critical load switch is off	Set this parameter to **Open** or **Closed**. • Set this parameter to **Open** when the switch-on terminal of the critical load switch is connected. • Set this parameter to **Closed** when the switch-off terminal of the critical load switch is connected.
Minor load switch	Specifies whether the minor load switch is connected. System cable connections: • DI2(HV): reports the Off state of the minor load switch. • DO3(HV): turns on the minor load switch. • DO4(HV): turns off the minor load switch.
Valid if minor load switch is off	Set this parameter to **Open** or **Closed**. • Set this parameter to **Open** when the switch-on terminal of the minor load switch is connected. • Set this parameter to **Closed** when the switch-off terminal of the minor load switch is connected.
Common load switch	Specifies whether the common load switch is connected. System cable connections: • DI3(HV): reports the Off state of the common load switch. • DO5(HV): turns on the common load switch. • DO6(HV): turns off the common load switch.
Valid if common load switch is off	Set this parameter to **Open** or **Closed**. • Set this parameter to **Open** when the switch-on terminal of the common load switch is connected. • Set this parameter to **Closed** when the switch-off terminal of the common load switch is connected.
Generator set control	Specifies whether to enable **Generator set control**. This parameter must be enabled when the SmartMGC controls the startup and shutdown of the genset.

Parameter	Description
Generator Set Control Method	Set this parameter to **Pulse** or **Level**. This parameter is displayed when **Generator set control** is set to **Enable**. ● Pulse: – DO5(HV): starts the genset. – DO6(HV): shuts down the genset. ● Level: – DO5(HV): starts the genset at high level when closed. – DO6(HV): starts the genset at low level when open.
Switch disconnection effective state	● Set this parameter to **Switch disconnection effective state**. – If the actual status of the switch is Off and the DI4(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Open**. – If the actual status of the switch is Off and the DI4(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI4(HV) port status is **Open** in **Overview** > **Sampling Info**, set this parameter to **Closed**. – If the actual status of the switch is On and the DI4(HV) port status is **Closed** in **Overview** > **Sampling Info**, set this parameter to **Open**. ● System cable connections: – DI4(HV): reports the Off state of the transfer switch. – DO3(HV): turns on the transfer switch. – DO4(HV): turns off the transfer switch.

Step 3 Choose **Settings** > **Microgrid Control** > **Scheduling Control** and set off-grid scheduling control parameters.

Table 7-23 Array SOC parameters

Parameter	Description
Max. SOC for charging off-grid ESS	Set the maximum SOC for charge in off-grid mode. The default value is 95%. Set the parameter based on the actual situation. To ensure reliable operations of the microgrid, the recommended value range is [85, 98] and this parameter must be ≤ (**Array end-of-charge SOC** – 2%).

Parameter	Description
Min. SOC for discharging off-grid ESS	Set the minimum SOC for discharge in off-grid mode. The default value is 5%. Set the parameter based on the actual situation. To ensure reliable operations of the microgrid, the recommended value range is [5, 15] and this parameter must be ≥ (**Array end-of-discharge SOC** + 2%).
SOC for turning on critical load switch	This parameter is displayed when the critical load switch is connected. When the array SOC is greater than or equal to the value of this parameter, the critical load switch is turned on.
SOC for turning off critical load switch	This parameter is displayed when the critical load switch is connected. If the array SOC is less than or equal to the value of this parameter, the critical load switch is turned off.
SOC for turning on minor load switch	This parameter is displayed when the minor load switch is connected. When the array SOC is greater than or equal to the value of this parameter, the minor load switch is turned on.
SOC for turning off minor load switch	This parameter is displayed when the minor load switch is connected. If the array SOC is less than or equal to the value of this parameter, the minor load switch is turned off.
SOC for turning on common load switch	This parameter is displayed when the common load switch is connected. When the array SOC is greater than or equal to the value of this parameter, the common load switch is turned on.
SOC for turning off common load switch	This parameter is displayed when the common load switch is connected. If the array SOC is less than or equal to the value of this parameter, the common load switch is turned off.

Table 7-24 Black start parameters

Parameter	Description	Remarks
Min. PV voltage for black start	After the irradiance recovers, the inverter PV voltage increases. If the PV1 voltage of an inverter is greater than or equal to the value of this parameter, the black start may be started.	This parameter is displayed when **Automatic black start after irradiance restoration** is set to **Enable**.

Parameter	Description	Remarks
Min. estimated power for black start	Before setting this parameter, ensure that the southbound inverter supports irradiance estimation. Set this parameter to a percentage of the ESS rated power. The default value is 10% of the ESS rated power. When the irradiance is restored, if the estimated PV output power of the inverter is greater than the minimum estimated power for the black start, the black start is automatically performed.	

Table 7-25 Voltage baseline

Parameter	Description
Off-grid voltage reference source	• **PCS port voltage**: The voltage level of the PCS is used as the baseline. • **Voltage at grid connection point or load side**: The setting of **Voltage baseline** is used as the baseline.
Voltage baseline	Specifies the voltage baseline as the off-grid voltage reference source. This parameter is displayed when **Off-grid voltage reference source** is set to **Voltage at grid connection point or load side**.

Table 7-26 Switch control

Parameter	Description
Generator Set Switching Status	Controls whether to connect the genset to the microgrid. This parameter is displayed when **Generator set control** is set to **Enable**.
Automatic load control status	Displays the automatic load control status.
Critical load switch status	Display whether loads are connected or disconnected. This function is used to detect the load switch status. Before the detection, shut down the array. • **On**: Loads are connected. • **Off**: Loads are disconnected.
Minor load switch status	
Common load switch status	

Table 7-27 Genset control parameters

Parameter	Description	Remarks
Generator Set Start-up Energy Storage SOC	When the ESS SOC reaches the preset value, the genset starts.	This parameter is displayed when **Generator set control** is set to **Enable**.
Generator set stops energy storage SOC	When the ESS SOC reaches the preset value, the genset stops.	
Generator Set Start/Stop Judgment Time	Specifies the time for determining whether to start or stop the genset.	
Maximum output power ratio of the generator set	Specifies the maximum output power ratio of the genset.	
Rated active power of the generator set	Specifies the rated active power of the genset.	

NOTE

- **Array end-of-charge SOC** > **Max. SOC for charging off-grid ESS** > **Min. SOC for discharging off-grid ESS** > **Array end-of-discharge SOC**
- **SOC for turning on common load switch** > **SOC for turning on minor load switch** > **SOC for turning on critical load switch**
- **SOC for turning off common load switch** > **SOC for turning on minor load switch** > **SOC for turning off critical load switch**

Table 7-28 Off-grid PV+ESS system (description of the load shedding and automatic recovery process)

Scenario	Command and Operation Between the SmartMGC and Devices
Off-grid	1. The ESS is off-grid and running properly. 2. The load switch control can be classified into three levels: critical, minor, and common, with the same control logic but distinguished by different SOC configurations. 3. If the current ESS SOC is less than or equal to SOC for turning off the load switch, the SmartMGC sends a command to turn off the load switch, powering off all corresponding loads. 4. After load shedding, if PV power is generated to charge the ESS and the ESS SOC is greater than or equal to SOC for turning on the load switch, the SmartMGC sends a command to turn on the load switch, supplying power to loads. 5. If no PV power is available to charge the ESS and the ESS SOC is less than or equal to **Min. SOC for discharging off-grid ESS**, the ESS is shut down within 5 minutes. 6. After the ESS is shut down, if the following conditions are met, the ESS will be black-started and the PV+ESS system will resume operation: – The PV1 voltage on the DC side of an inverter is greater than or equal to **Min. PV voltage for black start** for at least 1 hour. – Estimated array PV output power ≥ **Min. estimated power for black start** – ESS SOC ≥ **Array end-of-discharge SOC** 7. If the ESS SOC is less than **Array end-of-discharge SOC**, the PV+ESS system shuts down and remote black start cannot be performed. In this case, technical engineers are required to handle the problem onsite.

Step 4 Choose **Settings** > **Microgrid Control** > **Advanced Control Configuration** > **Control Policy Configuration** and set advanced control configuration parameters.

Table 7-29 Advanced control configuration parameters

Parameter	Description
Automatic PCS recovery	Specifies whether to enable the function of automatic recovery in case of abnormal PCS shutdown. • **Enable**: During off-grid operation, when the SmartMGC detects that the PCS shuts down abnormally and causes system power failure, the SmartMGC automatically attempts to perform black start to restore the power supply. • **Disable**: If the PCS shuts down abnormally, the SmartMGC does not automatically perform black start.
Automatic black start retries upon PCS fault	This parameter is displayed when **Automatic PCS recovery** is set to **Enable**. Set this parameter to **Automatic black start retries upon PCS fault**.
Automatic black start after irradiance restoration	Specifies whether to enable automatic black start after irradiance restoration. The default value is **Enable**. • **Enable**: During off-grid operation, automatic black start is performed after the irradiance restores. • **Disable**: Automatic black start is not performed after the irradiance restores.
PV charging upon black start	Specifies whether to set **PV charging upon black start** to **Enable**. If the current SOC of the ESS is too low, black start may fail. If this parameter is set to **Enable**, black start can be performed when the irradiance is sufficient.
Automatic load connection/ shedding	• **Enable**: The automatic load connection/shedding function is enabled. When you manually operate the load switch, this function is temporarily locked. This function can be restored only after this parameter is set to **Enable** or the black start is successful. • **Disable**: The automatic load connection/shedding function is disabled.

----End

8 System Operations

NOTICE

- In the seamless on/off-grid scenario, if the ESS SOC is less than **Array end-of-discharge SOC**, perform the following operations to start the ESS:
  - For the on-grid operation:
    - If the ESS SOC is greater than 0%, set **Array end-of-discharge SOC** to a value within the range of [0, ESS SOC) and then start the ESS. After it is started, restore the value of **Array end-of-discharge SOC**.
    - If the ESS SOC is 0%, charge the ESS and then start it after the ESS SOC is greater than **Array end-of-discharge SOC**.
  - For the off-grid operation:
    - If the ESS SOC is greater than 0%, start the ESS through the array black start.
    - If the ESS SOC is 0%, charge the ESS and then start it through the array black start.

Starting the Array on the SmartMGC WebUI for the On-Grid Operation

Prerequisites:

- The mains supply is stable.
- The on/off-grid switch is turned on.

Procedure:

Step 1 Choose **Maintenance** > **Device Management** > **Startup/Shutdown** and select the devices to be started.

Step 2 Click **Start** and click **Selected devices** from the drop-down list to start the devices.

NOTE

Click **Start** and click **All array devices**, **All array inverters**, **All array ESSs**, or **All array PCSs** from the drop-down list to start all corresponding devices.

----End

Starting the Array Using the Black Start Function for the Off-Grid Operation (When the UPS Has Power)

Prerequisites:

- Turn off the load switch, that is, disconnect the loads.
- It is recommended that black start be performed only when the ESS SOC is greater than 2%. Otherwise, the black start may fail. If the ESS SOC is 0%, charge the ESS first.
- The plant design shall ensure that the inrush current of each load line does not cause overcurrent protection after black start is successful.
- The control logic of black start is implemented by the MGCC, and the power supply for startup is the ESS.
- During black start, the secondary loops such as the SmartMGC and the auxiliary power supplies of the ESS shall have a power supply source, which can be provided by the UPS.
- During black start, the ESS array shall have adequate dischargeable energy and power for the black start (depending on the load transformer specifications and inrush current in the system).
- To prevent PCS protection caused by the excitation inrush current when the load transformer is switched on during black start, the load transformer and lines also need to be started simultaneously.
- In off-grid scenarios, it is recommended that the SOC during ESS charge/discharge operations in the scenario where the microgrid control is implemented by the SmartMGC range from 10% to 90% to ensure that the black start function works properly.

Procedure:

Choose **Settings** > **Microgrid Control** > **Black Start** to view the black start status and perform black start manually.

Parameter	Description
Current Battery SOC	View the current battery SOC.
Black Start Progress	View the black start progress.

Parameter	Description
Status	• Black start failed. Cause: All ESSs are offline. • Black start failed. Cause: No ESS is available for black start. • Black start failed. Cause: No PCS is available for black start. • Black start failed. Cause: No PCS is prepared for black start. • Black start failed. Cause: No PCS has established the voltage for black start. • Manual black start in progress • Automatic black start in progress: The current ESS SOC is higher than **Array end-of-discharge SOC**. – When **MGCC mode** is set to **Enable**, **Microgrid scenario** is set to **On/Off-grid (PQ/VSG)**, and the on/off-grid switching mode is automatic, black start is automatically triggered if the plant is switched from on-grid to off-grid operation due to mains outage. – When **MGCC mode** is set to **Enable**, **Microgrid scenario** is set to **On/Off-grid (PQ/VSG)**, and the on/off-grid switching mode is manual, black start is automatically triggered if you turn off the on/off-grid switch locally to switch the plant from on-grid to off-grid operation manually. – When **MGCC mode** and **Automatic PCS recovery** are set to **Enable**, black start is automatically triggered if the voltage on the ESS AC side is abnormal (less than 30% of the rated voltage on the ESS AC side) and the PCS in the ESS is shut down abnormally. – When **MGCC mode** is set to **Enable** and **Microgrid scenario** is set to **Off-grid**, if the solar irradiance recovers for inverters and no PCS is running, turn off the load switch and then the black start is automatically triggered. • Black start succeeded.

Starting the ESS by Pressing the Local Black Start Button for the Off-Grid Operation (When the UPS Has No Power)

Prerequisites:

- Turn off the load switch, that is, disconnect the loads.
- Before the first deployment, turn off the AC switch of the ESS.
- It is recommended that black start be performed only when the ESS SOC is greater than 2%. Otherwise, the black start may fail. If the ESS SOC is 0%, charge the ESS first.

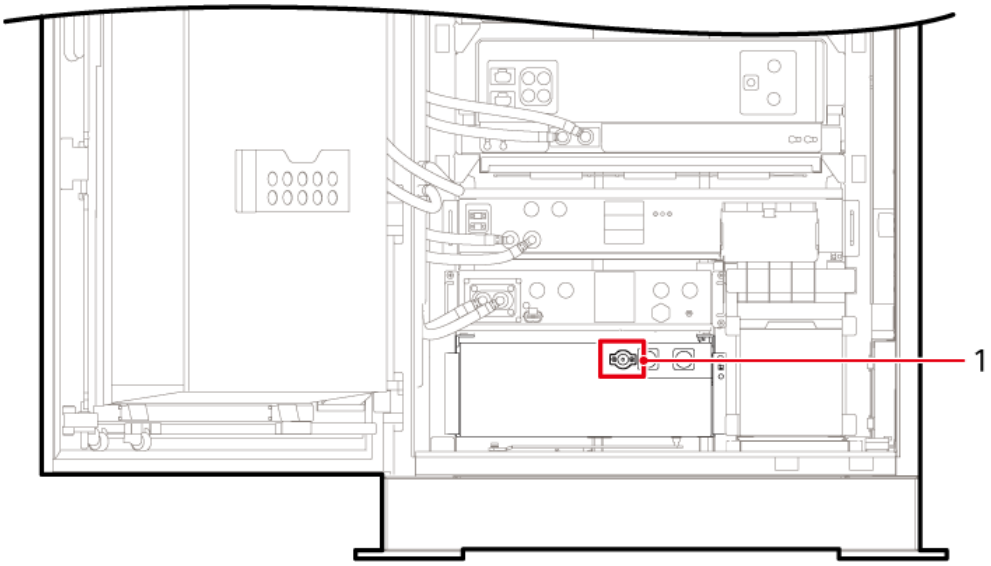
Procedure:

Open the ESS door, hold down the black start button on the RCM in the ESS for more than 10 seconds, close the door, and wait for the black start.

NOTICE

Press the black start button twice at an interval of at least 1 minute.

Figure 8-1 Black start button



1	Black start button

NOTE

If the humidity in the cabinet is high, dehumidification will be triggered after the black start is successful.

9 System Power-Off

If you need to power off the system during maintenance, use the SmartMGC to power off the system.

Step 1 Send a shutdown command. Log in to the SmartMGC WebUI.

1. Choose **Maintenance** > **Device Management** > **Startup/Shutdown** and select the devices to be shut down.
2. Click **Shut Down** and click **Selected devices** from the drop-down list to shut down the devices.

Step 2 Power off the devices: Turn off the main power switches and then the auxiliary power switches of the devices by referring to the operations of **Device Power-On** in the reverse order.

DANGER

Wear insulated gloves and use insulated tools to prevent electric shocks or short circuits.

NOTE

To prevent local operations on switches during subsequent power-on, you are advised not to turn off the auxiliary power switches.

----End

A Off-Grid UPS Capacity Configuration

ESS Quantity	UPS Battery Capacity[a] (kWh)	12 V Battery Ampere-Hour[b] (Ah)	24 V Battery Ampere-Hour[c] (Ah)	48 V Battery Ampere-Hour[d] (Ah)
1	2.88	240	120	60
2	4.32	360	180	90
3	5.76	480	240	120
4	7.2	600	300	150
5	8.64	720	360	180
6	10.08	840	420	210
7	11.52	960	480	240
8	12.96	1080	540	270
9	14.4	1200	600	300
10	15.84	1320	660	330
11	17.28	1440	720	360
12	18.72	1560	780	390
13	20.16	1680	840	420
14	21.6	1800	900	450
15	23.04	1920	960	480
16	24.48	2040	1020	510
17	25.92	2160	1080	540
18	27.36	2280	1140	570
19	28.8	2400	1200	600

ESS Quantity	UPS Battery Capacity[a] (kWh)	12 V Battery Ampere-Hour[b] (Ah)	24 V Battery Ampere-Hour[c] (Ah)	48 V Battery Ampere-Hour[d] (Ah)
20	30.24	2520	1260	630
Note a: Battery capacity = [Power consumption of the SmartMGC + Total power of ESS auxiliary power supplies (Single ESS auxiliary power x Quantity of ESSs)] x Backup time/1000 Note b: 12 V battery ampere-hour = Battery capacity x 1000/12 Note c: 24 V battery ampere-hour = Battery capacity x 1000/24 Note d: 48 V battery ampere-hour = Battery capacity x 1000/48				

B Connecting to a Device on the App

1. Log in to the app and choose **Services** > **Device Commissioning**.
2. Connect to the device WLAN as prompted.

   NOTE

   - The WLAN name of the device consists of "device name-device SN".
   - For the first connection, log in with the initial password. You can obtain the initial WLAN password from the device label, that is, the characters following "PSW".
   - Ensure account security by changing the password periodically. Your password might be stolen or cracked if it is left unchanged for extended periods. If a password is lost, the device cannot be accessed. In these cases, the Company shall not be liable for any loss.
   - If the login screen is not displayed after you scan the QR code, check whether your phone is correctly connected to the device WLAN. If not, manually select and connect to the WLAN.
   - If **This WLAN network has no Internet access. Connect anyway?** message is displayed when you connect to the built-in WLAN, tap **CONNECT**. Otherwise, you cannot log in to the system. The actual UI and messages may vary with mobile phones.
   - If the WLAN of the SmartMGCcannot be found or the connection fails, press the RST button for 1s to 3s to start the WLAN module. After the COM indicator keeps steady on for 2 minutes, you can connect the app to the device WLAN.
3. Select a login user, enter the login password, and tap **Log in**.

   NOTE

   - Set the password as prompted at the first login.
   - After logging out, wait for 60 seconds before logging in to the app as another user. Otherwise, the login will fail.
   - To ensure account security, protect the password by changing it periodically, and keep it secure.

C Reference Documents

Device	Document
ESS	• **HUAWEI LUNA2000-(107-241) Series Commercial and Industrial Hybrid Cooling Grid Forming ESS User Manual** • **HUAWEI LUNA2000-(107-241) Series Commercial and Industrial Hybrid Cooling Grid Forming ESS Quick Guide**

Device	Document
Inverter	• SUN2000-(20KTL, 29.9KTL, 30KTL, 36KTL, 40KTL)-M3 Series User Manual • SUN2000-(20KTL, 29.9KTL, 30KTL, 36KTL, 40KTL)-M3 Series Quick Guide • SUN2000-(20KTL-M3, 33KTL-NH, 40KTL-NH) User Manual • SUN2000-(20KTL-M3, 33KTL-NH, 40KTL-NH) Quick Guide • SUN2000-(50KTL-ZHM3, 50KTL-M3, 50KTL-BRM3) User Manual • SUN2000-(50KTL-ZHM3, 50KTL-M3, 50KTL-BRM3) Quick Guide • SUN2000-50KTL-NHM3 User Manual • SUN2000-50KTL-NHM3 Quick Guide • SUN2000-(50KTL, 60KTL, 65KTL)-M0 User Manual • SUN2000-(50KTL, 60KTL, 65KTL)-M0 Quick Guide • SUN2000-(50KTL-JPM0, 50KTL-JPM1, 63KTL-JPM0) User Manual • SUN2000-(50KTL-JPM0, 50KTL-JPM1, 63KTL-JPM0) Quick Guide • SUN2000-(75KTL, 100KTL, 110KTL, 125KTL) Series User Manual • SUN2000-(75KTL, 100KTL, 110KTL, 125KTL) Series Quick Guide • SUN2000-(75KTL-M1, 100KTL-M2, 110KTL-M2, 115KTL-M2) User Manual • SUN2000-(100KTL, 110KTL)-M2 Quick Guide (STAUBLI) • SUN2000-(75KTL-M1, 100KTL-M2, 110KTL-M2, 115KTL-M2) Quick Guide (Amphenol) • SUN2000-111KTL-NHM0 User Manual (large current) • SUN2000-111KTL-NHM0 Quick Guide (large current) • SUN2000-(50K, 75K, 80K, 150K)-MG Series User Manual • SUN2000-(50K, 75K, 80K, 150K)-MG Series Quick Guide • SUN5000-(150K-MG0-ZH,150K-MG0) User Manual • SUN5000-(150K-MG0-ZH, 150K-MG0) Quick Guide • SUN2000-50K-MC0 User Manual

Device	Document
	• SUN2000-50K-MC0 Quick Guide • SUN2000-(30K, 40K)-MC0 Series User Manual • SUN2000-(30K, 40K)-MC0 Series Quick Guide
SUN2000P	• HUAWEI MERC-(1300W, 1100W)-P Smart PV Optimizer User Manual • HUAWEI MERC-(1300W, 1100W)-P Smart PV Optimizer Quick Guide • SUN2000 Smart PV Optimizer User Manual • SUN2000-(600W-P, 450W-P2) Smart PV Optimizer Quick Guide • SUN2000-450W-P Smart PV Optimizer Quick Guide
SmartMGC	• SmartMGC5000 User Manual • SmartMGC5000 Quick Guide
Power meter	• DTSU666-HW Smart Power Sensor Quick Guide • YDS60-80 Smart Power Sensor Quick Guide • DTSU71C Smart Power Sensor Quick Guide • DHSU1079-ZT Smart Power Sensor Quick Guide

D Digital Power Customer Service

https://digitalpower.huawei.com/robotchat/

E Contact Information

If you have any questions about this product, please contact us.

https://digitalpower.huawei.com

Path: **About Us** > **Contact Us** > **Service Hotlines**

To ensure faster and better services, we kindly request your assistance in providing the following information:

- Model
- Serial number (SN)
- Software version
- Alarm ID or name
- Brief description of the fault symptom

NOTE

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F Acronyms and Abbreviations

A

ACB	air circuit breaker
ATS	automatic transfer switch

C

CT	current transformer

D

DHCP	Dynamic Host Configuration Protocol

E

EMS	energy management system
ESS	energy storage system

F

FE	fast Ethernet

M

MCCB	molded case circuit breaker

P

PCS	power control system
PT	potential transformer

S

SFP	small form-factor pluggable
SOC	state of charge
SOH	state of health

T

TOU	time-of-use pricing
TCP	Transmission Control Protocol

U

UPS	uninterruptible power supply

V

VCB	vacuum circuit breaker