

APstorage Sea Family ELS Series PCS Off-Grid AC Coupling White Paper

(For EU)

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1. Off-Grid AC Coupling Installation

The PV System is divided into PV System 1 and PV System 2.

PV System1 is the photovoltaic system on the grid-tied side, and PV System2 is the photovoltaic system on the off-grid side.

When PCS is in off-grid mode, the off-grid energy storage system consists of Battery, PCS, Transformer, Backup Load and PV System 2. PCS and PV System 2 forms an AC-coupled Microgrid.

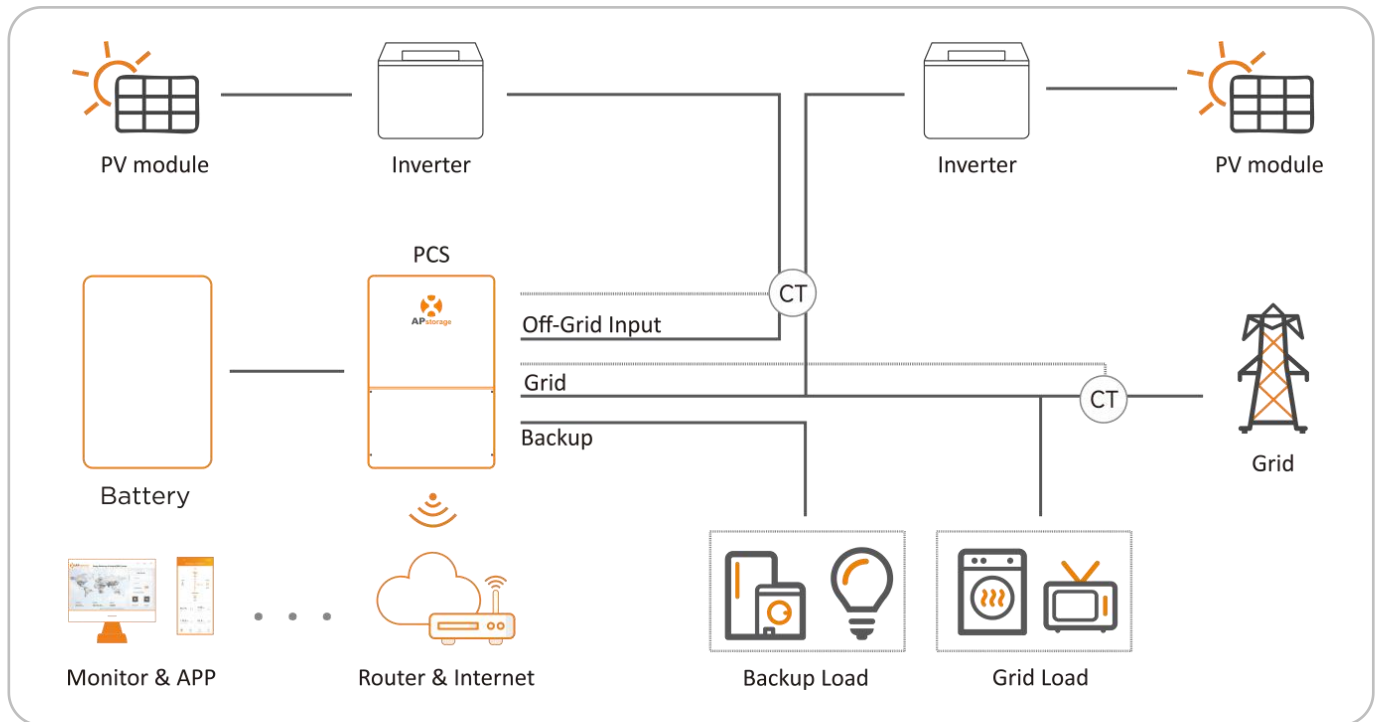


Figure 1 Schematic of the APStorage Energy Storage System

Check if the PV inverter is capable of Frequency Shift Power Control, which is a feature of inverter to reduce its power output by increasing its frequency.

If the PV inverter does have Frequency Shift Power Control feature, the power output of the photovoltaic inverter can be limited through Frequency Shift Power Control.

If the PV inverter does not have the Frequency Shift Power Control feature, the power output of the photovoltaic inverter can be limited through the PV System Switch.

Both solutions can also be used at the same time for a more stable solution.

1. Off-Grid AC Coupling Installation

1.1 Frequency Shift Power Control

1.1.1 Functional Overview

If the PV inverter is connected to the off-grid side of the PCS in the system, the PCS must be able to limit its output power. This limitation is necessary when the battery of the PCS is fully charged and the available power of the photovoltaic system exceeds the power demand of the connected load. In order to prevent the battery from overcharging, the PCS uses the measured the photovoltaic power and the requested charging power from battery to adjust the frequency of the microgrid, and the photovoltaic inverter adjusts the output power by detecting the change of the frequency of the microgrid.

The Frequency shift power control is enabled by default on PCS. At the same time, it is necessary to ensure that the PV System 2 is correctly connected to the Production CTs, the overfrequency load reduction function is enabled in PV system2, and is set according to the APstorage over-frequency load reduction parameter setting table.

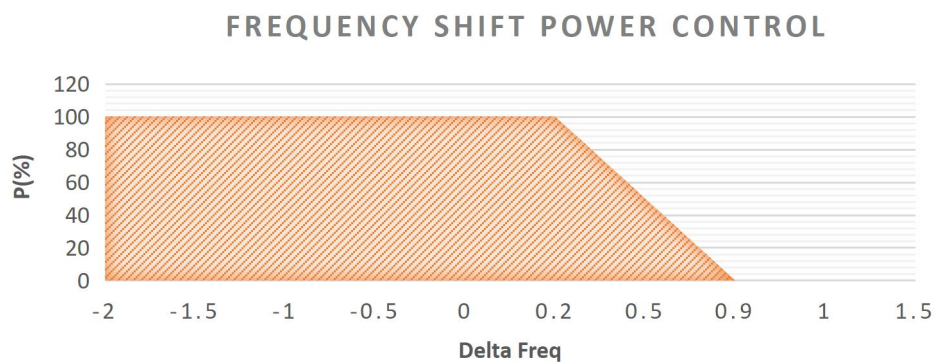


Figure 2 Example PV Inverter Function showing Power vs Delta Frequency

In the graph above, the horizontal axis is variation of the frequency, 0 is the rated frequency. The vertical axis represents the percentage of the current power to the rated power. The photovoltaic power changes with the microgrid frequency controlled by the PCS.



NOTE: Figure 2 The frequency change curve shown in Figure 2 is only for display purposes. The specific parameters of the photovoltaic inverter and PCS are set according to the local certification standards and APstorage over-frequency load reduction parameter setting table.

1. Off-Grid AC Coupling Installation

1.1.2 Wiring Instructions

1. Wire from PCS Backup Terminals L1/L2 to Backup Breaker in the Backup Service Panel.
2. Wire PV system 2 L1/L2 to PV Breaker 2 in the Backup Service Panel.



NOTE: If you need to use Frequency Shift Power Control and PV System Switch at the same time, refer to section 1.2

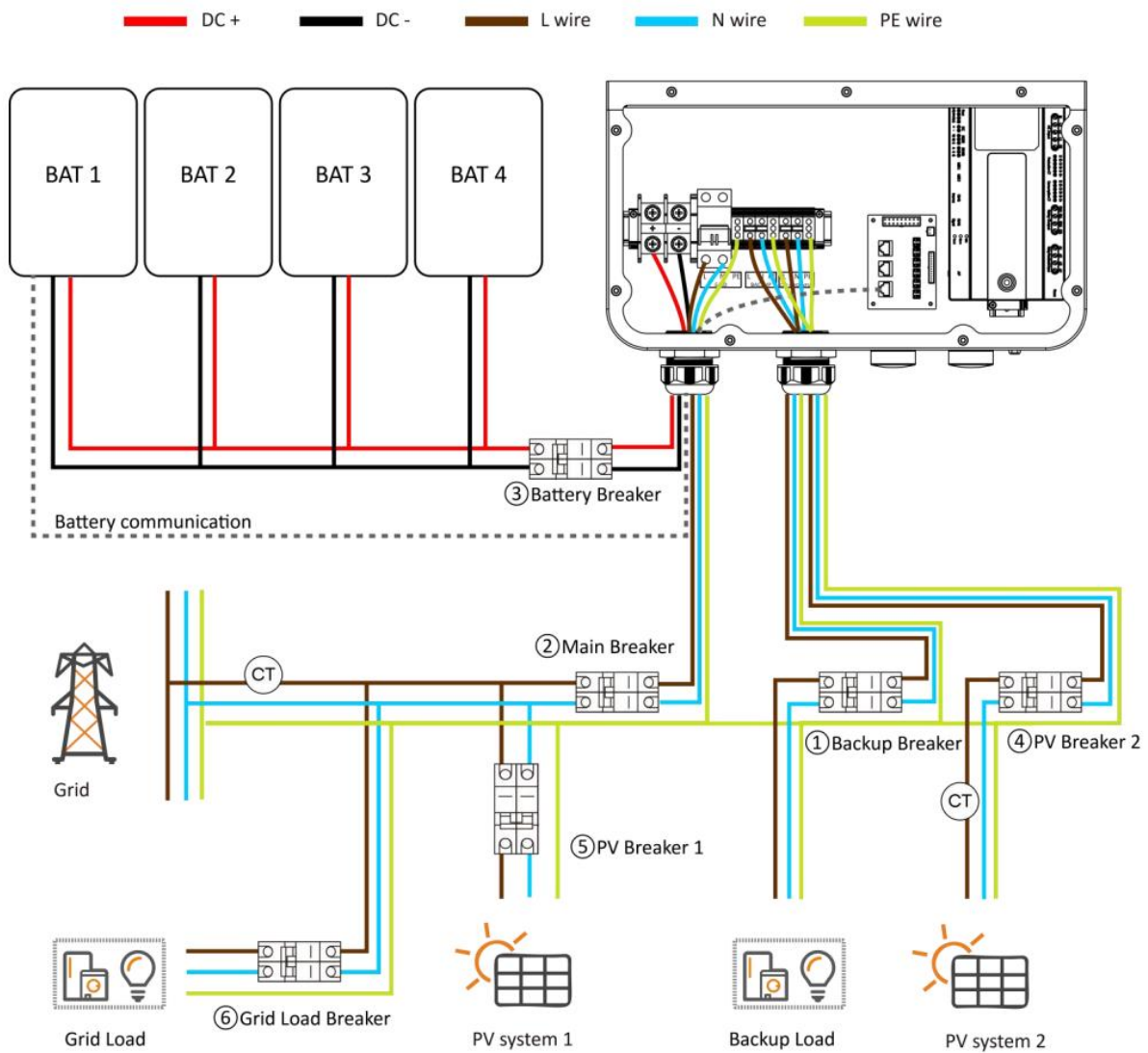


Figure 3 Frequency Shift Power Control System Wiring Diagram

1. Off-Grid AC Coupling Installation

1.2 PV System Switch

1.2.1 Functional Overview

If the PV inverter cannot effectively adjust the output Power through Frequency Shift Power Control, we propose the PV System Switch solution. Through the PV System Switch, we can disable the photovoltaic inverter to prevent the battery from being fully charged and the photovoltaic Situations where power cannot be stopped. We can replace the PV System 2 Breaker with an externally controllable PV contactor , together with the backup relay inside the PCS, controls the off-grid energy storage PV system:

- A) Backup relay inside the PCS: when the Battery SOC is lower than the lower limit of Backup SOC protection, the PCS stops supplying power to the load to ensure that the battery does not enter a state of power loss. When there is enough solar power to meet the starting conditions of PV System 2, PV System 2 charges the battery through the PCS.
- B) When the battery SOC is greater than Backup SOC limit, Backup Loads can be enabled.
- C) PV contactor: when the battery SOC is greater than the upper limit of off-grid charging SOC, PCS will disconnect the photovoltaic inverter to prevent battery overcharging and ensure the normal operation of Backup Load.
- D) When the battery SOC is lower than the upper limit of off-grid charging SOC recovery, PCS will wake up PV System 2 which will supply power to the energy storage system.

1. Off-Grid AC Coupling Installation

1.2.2 Wiring Instructions

1. Lead two wires from the R2N R2L terminal on the Relay output panel of the ECU in the PCS PV BOX, and connect these two wires to the auxiliary contact of the PV contactor. Note that the PV contactor is normally open AC contactor.

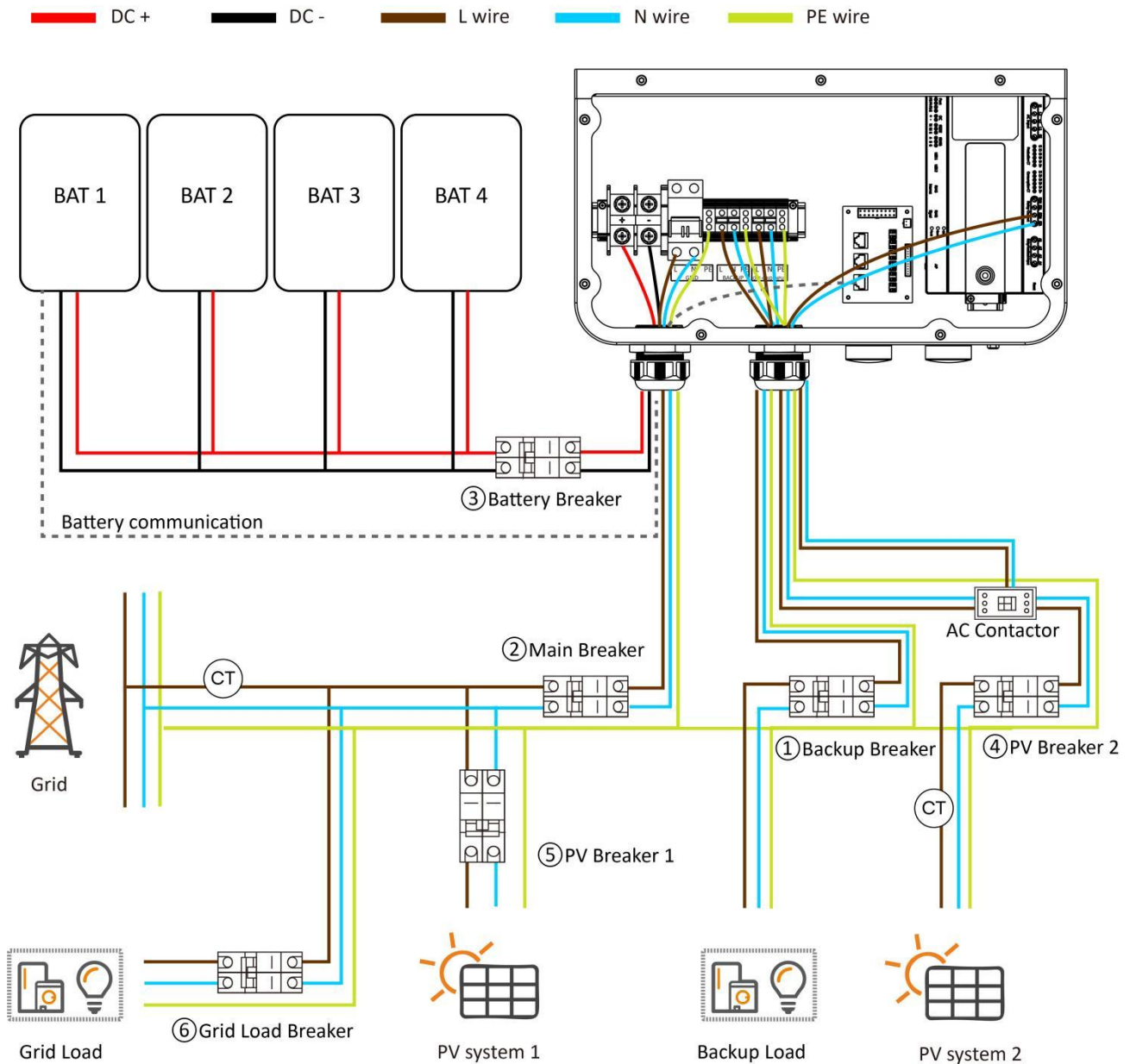


Figure 4 PV System Switch System Wiring Diagram

1. Off-Grid AC Coupling Installation

PV System to APstorage Pairing

1. Determine the maximum single load power rating (kW) to be backed up and select the absolute minimum number of PCS units required to meet the requirements of 2017 NEC 690.10->710.15(A). Up to 2 ELS 5K units can be connected in parallel.

2. Calculate the required energy storage capacity (kWh) based on the backup load estimate for the user-defined time period, capacity and the minimum number of batteries required.

3. Calculate the maximum power (PV System 2) of the photovoltaic system connected to the PCS in Table 1. Note the number is different if the PV inverter has Frequency Curtailment and/or not.

If the total power of the photovoltaic system is greater than the maximum power, the excess power (PV System1) is connected to the grid side.

Table 1: The maximum power of the photovoltaic system for storage system backup

ELS-5K units (1unit per 5kWac)	Battery power (kWac)	Max PV system power in System 2 with Frequency Shifting (kWac)
1	≤ 6.25	Battery power
1	≥ 6.25	6.25
2	≤ 12.5	Battery power
2	≥ 10	12.5

ELS-3K units (1unit per 3.68kWac)	Battery power (kWac)	Max PV system power in System 2 with Frequency Shifting (kWac)
1	≤ 4.6	Battery power
1	≥ 4.6	4.6
2	≤ 9.2	Battery power
2	≥ 9.2	9.2

ELS-5K units (1unit per 5kWac)	Battery power (kWac)	Max PV system power in System 2 without Frequency Shifting (kWac)
1	≤ 5	Battery power
1	≥ 5	5
2	≤ 10	Battery power
2	≥ 10	10

ELS-3K units (1unit per 3.68kWac)	Battery power (kWac)	Max PV system power in System 2 without Frequency Shifting (kWac)
1	≤ 3.68	Battery power
1	≥ 3.68	3.68
2	≤ 7.36	Battery power
2	≥ 7.36	7.36

1. Off-Grid AC Coupling Installation

Two calculation examples with Frequency Shifting are given below for reference:

Step 1: Figure out Battery Max Charge Power.

Step 2: Figure out PCS Charge Power

Step 3: Take the smaller number

Step 4: Multiply by 1.25 (If using Frequency Power Control)

Table 2: Examples Calculation of Off-grid Solar with Frequency Shifting

Examples Calculation of Off-grid Solar	
1 ELS-5K+1 APbattery-48V/5.76kWh	2 ELS-5K+HomeGrid 4 Stack
1. Battery Power = 2.5kW	1. Battery Power = 14.4kW
2. ELS Power = 5kW	2. ELS Power = 10kW
3. Battery Power is smaller than PCS Power	3. PCS Power is smaller than Battery Power
4. Off-grid PV power is 2.5kW	5. Off-grid PV power is $10\text{kW} \times 1.25 = 12.5\text{kW}$

How to use EMA App to set Frequency Shift Power Control and PV System Switch

If your PV inverter supports Frequency Shift Power Control, you can use Frequency Shift Power Control and PV System Switch at the same time to ensure stable system operation.

If using Frequency Shift Power Control,

- A) It is necessary to confirm that your photovoltaic inverter supports the Frequency Shift Power Control function. According to your country, set the photovoltaic inverter and PCS according to the local APstorage over-frequency load reduction parameter setting table, and follow the wiring instructions in 1.1.2 Wiring.



NOTE: If you need to use Frequency Shift Power Control and PV System Switch at the same time, you need to perform wiring according to 1.2.2.

- B) Connect to PCS through EMA Manager. For the operation process of APP connection, see Chapter 4 of APstorage Sea Family ELS Series PCS Installation & User Manual;
- C) Find Frequency Shift Power Control through EMA Manager, and it will run automatically after opening. (APP with pictures)

If using PV System Switch,

- A) It is necessary to confirm that your system equipment is wired according to the wiring instructions in Chapter 1.2.2;
- B) Connect to PCS through EMA Manager. For the operation process of APP connection, see Chapter 4 of APstorage Sea Family ELS Series PCS Installation & User Manual;
- C) Find the PV System Switch through EMA Manager, and the function will run automatically after opening. (APP with pictures)