Remote Control Definition

Version: V1.5

FOX ESS

麦田能源

Table of contents

Change History

Version	Modifications	Modified by	Modified Date
V1.0	Initial release	Xing Yuting	2024.07.17
V1.1	1. Modify the description content and align the document description logic with Peak Shaving detachment is changed to work in any mode.	Wan Tengfei	2024.09.04
V1.2	1. Remove the Export limit in (1) (2) and (4) modes, and only keep (3) Meter 's Export limit, and add Import limit.	Xing Yuting	2024.09.09
V1.3	1. Add the unit kW after the parameter value 2. Modify and add new examples, and add notes 3. Modify the flow diagram and change the previous one-way arrows to one-way and two-way arrows (For example, if INV is scheduled to discharge, the arrow at the INV end is a one-way inDischarge. Except for the PV end, the arrows at other ends are bidirectional. Uncertain flow direction)	Xing Yuting	2024.09.12
V1.4	Communication protocol remains unchanged, but all other things are overridden and rewritten.	Xing Yuting	2024.09.14
V1.5	Based on V1.4, some examples are changed.	Xing Yuting	2024.09.18

The remote control functions defined in this document are valid in any FOX hybrid inverter (self-use/feed-in/peak-shaving, etc.).

When remote control is performed, it is completely independent of the FOX hybrid mode, however, it is possible to use some of the FOX hybrid mode limits such as the export limit (which is present in every FOX hybrid mode) and the import limit (which is currently only present in the FOX hybrid modes peak-shaving, and not in other modes such as For other modes such as self-use/feed-in, the import limit can be taken to be infinite).

1. Communication Protocol

Remote Control	R W	Bitfield 16	N/A	1	46001	1	**Bit 0:** Remote control enable 0: Disable 1: Enable **Bit1:** Definition for positive direction 0:power-generation system 1: power-consumption system **Bits 3:2 :** Controlled target 00: AC 01: Battery 10: Grid **(ct/Meter)** **11:AC (power from the grid is used first)** Bits 15:4 Reserved
Remote Timeout_Set	R W	U16	s	1	46002	1	
Remote Control Active Power Command	R W	I32	W	1	46003	2	
Remote Control Reactive Power Command	R W	I32	Var	1	46005	2	
Remote Timeout Countdown	RO	U16	s	1	46007	1	

Definition of term:

Remote Control: Enable, Direction, Control Object Definition

Remote Timeout_Set: If no remote control frame data is received within this time, exit

remote control mode, return to original mode

Remote Control Active Power Command: Control active power target value Remote Control Reactive Power Command: Control reactive power target value Remote Timeout Countdown: Set Remote Control time countdown

2. Remote Control Mode Definition

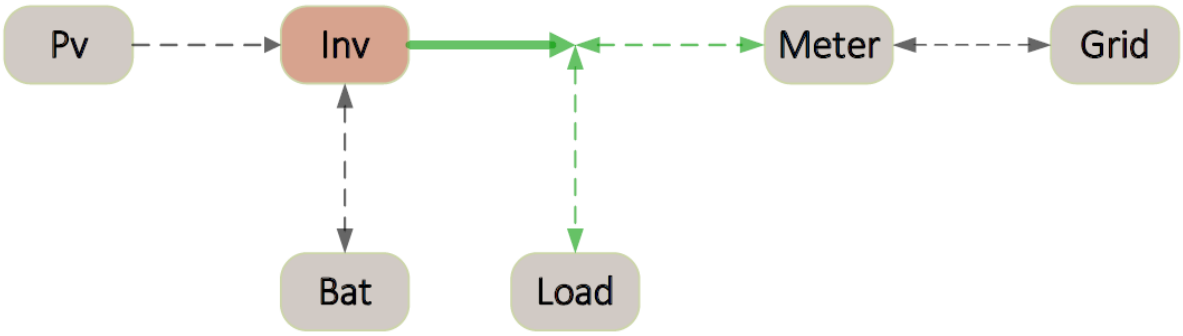
(1) 0: Inv outDischarge PV priority

Assume 46003 is set to AW

① **46001=B00 0 1** //target:AC discharge

AC Port discharge A W, **photovoltaic power generation is prioritized, followed by battery discharge** .

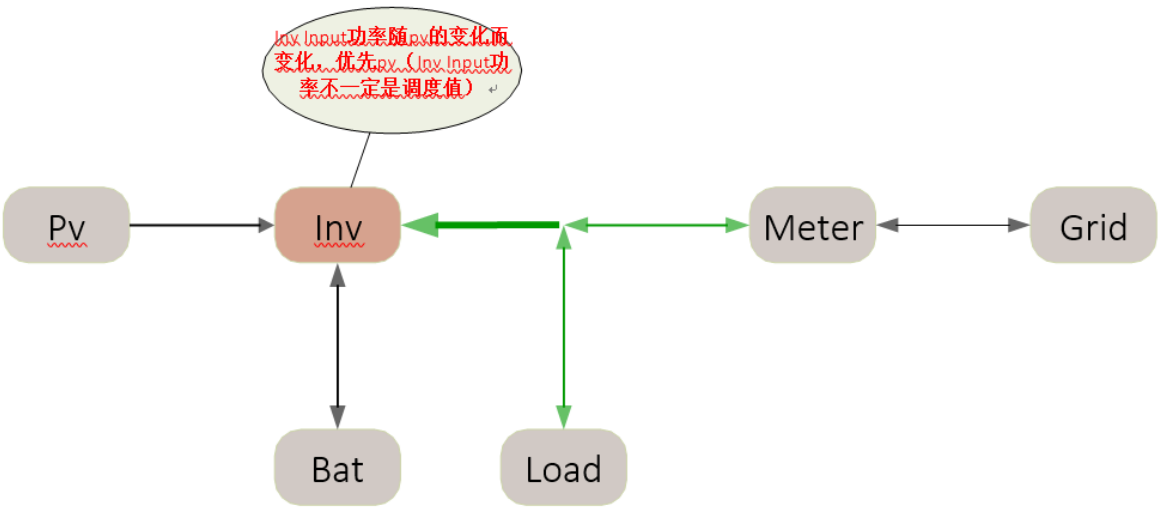
Bit0 1: Enable
Bit1 0: power-generation system
Bits 3:2 00:AC



② **46001=B00 1 1** //target:AC charging

Then the AC port charges AW **to meet the PV power charging power target, and AC charging is second** , and the charging power is limited by the BMS current limiting control.

Bit0 1: Enable
Bit1 1: power-consumption system
Bits 3:2 00:AC

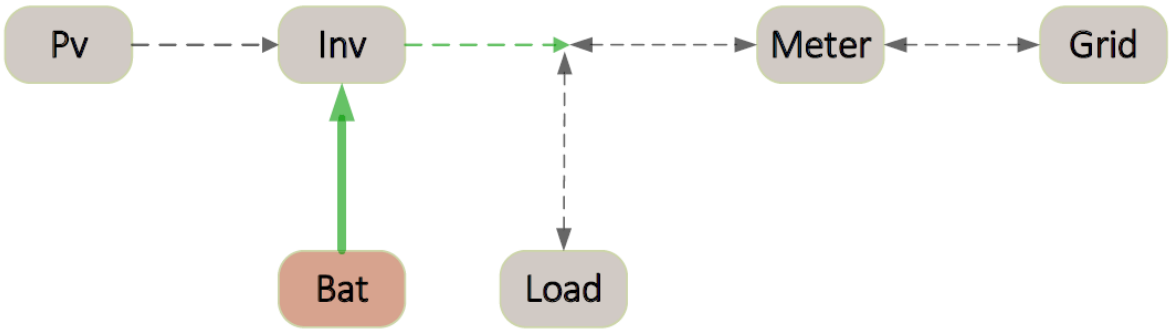

Inv Input功率随pv的变化而变化，优先pv（Inv Input功率不一定是调度值）
Pv
Inv
Meter
Grid
Bat
Load

(2) 1: Battery

① **46001=B01 0 1** //target: bat discharge

bat Port discharge A W, **battery discharge is prioritized, followed by photovoltaic discharge**, and the outDischarge power is limited to the rated power .

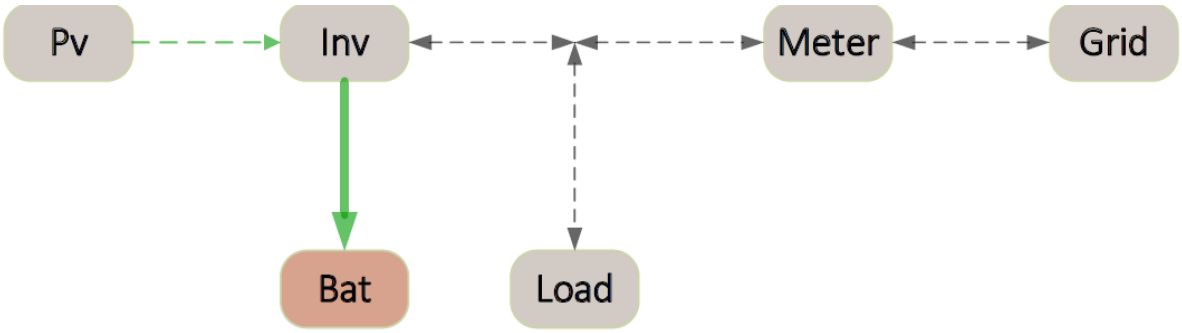
Bit0 1: Enable
Bit1 0: power-generation system
Bits 3:2 01: Battery



② **46001=B01 1 1** //target:bat charging

Then the bat port charges AW, with photovoltaic charging being the priority, followed by grid supplementation, and the charging power is limited by the BMS current limiting control.

Bit0 1: Enable
Bit1 1: power-consumption system
Bits 3:2 01:Battery



(3) 2: Meter

① **46001=B10 0 1** //target:Grid discharge

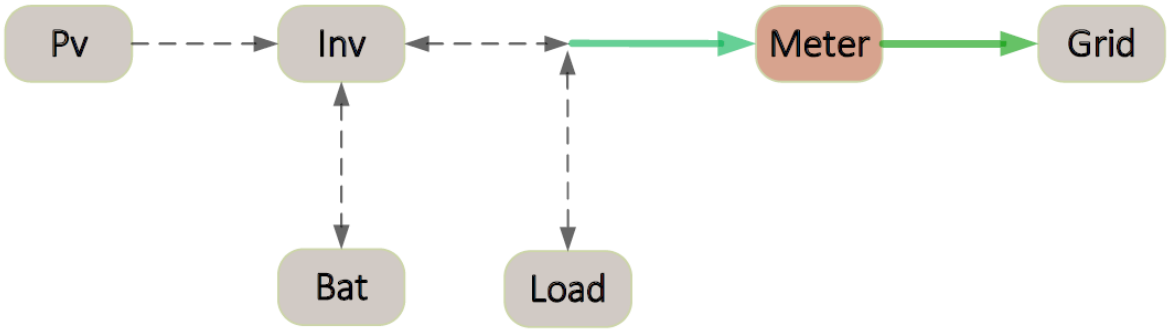
The Grid port discharges AW, **giving priority to photovoltaic power generation, followed by battery discharge**, and the outDischarge power is limited to the rated power.

The feeder power is limited by export limit and import limit.

Bit0 1: Enable

Bit1 0: power-generation system

Bits 3:2 10: Grid



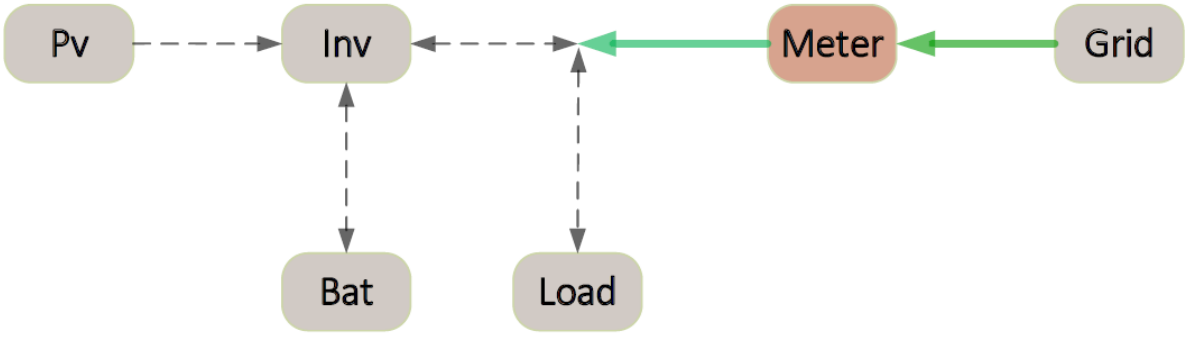
② **46001=B10 1 1** //target: Grid Charging

Then the Grid port charges AW, **giving priority to meeting the grid-side charging demand, followed by PV supplementation.** The charging power is limited by the BMS current limiting control, and the meter feed power is limited by the export limit and import limit.

Bit0 1: Enable

Bit1 1: power-consumption system

Bits 3:2 10: Grid

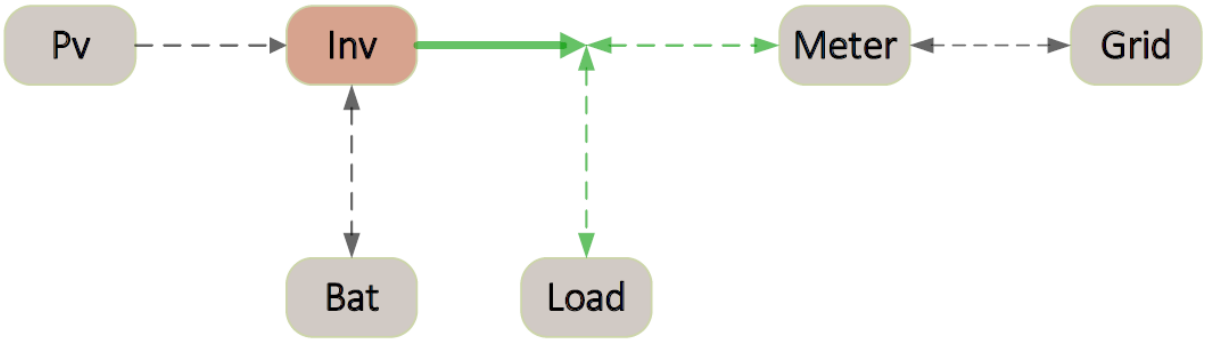


(4) 3: Inv outDischarge AC first

① **46001=B11 0 1** //target:AC discharge

AC Port discharge A W, **photovoltaic power generation is prioritized, followed by battery discharge** .

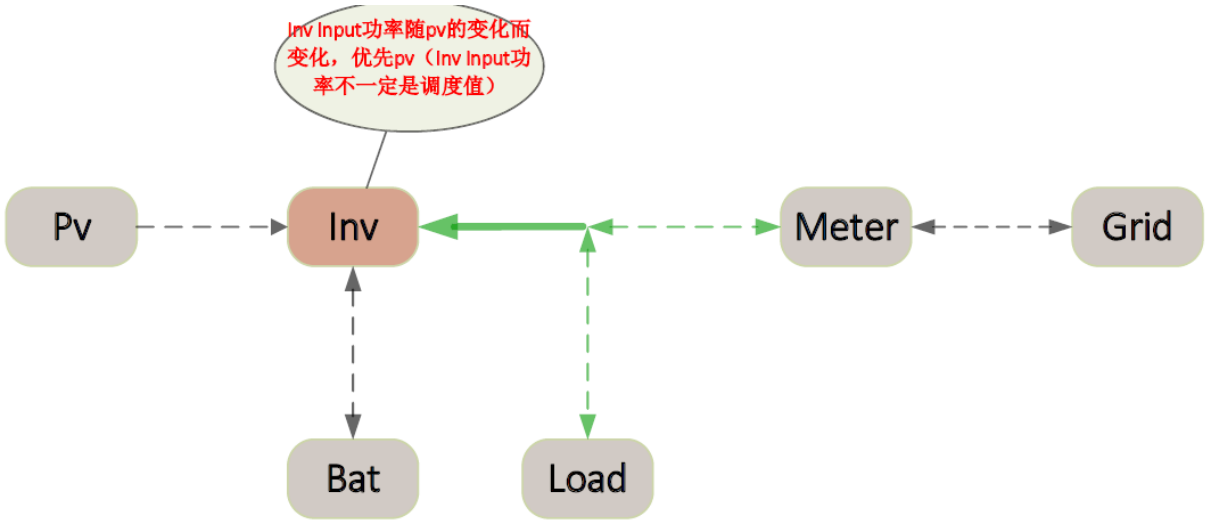
Bit0 1: Enable
Bit1 0: power-generation system
Bits 3:2 11:AC



② **46001=B111 1** //target:AC charging

Then the AC port charges AW, **meeting the AC power charging power target, and PV charging is second** , and the charging power is limited by BMS
Current limiting control.

Bit0 1: Enable
Bit1 1: power-consumption system
Bits 3:2 11:AC



Remark:

From now on, new remote control functions will be implemented according to the definition in this document. The ones that have already been implemented will remain unchanged for the time being.

3. Command Execution principle

This document V1.3 and before, to achieve the REMOTE CONTROL command set power as the main goal, first control, and then really cannot do, then limit.
After the customer feedback information summary, the customer neither has the strength to issue a reasonable REMOTE CONTROL set power command, nor the determination to fully implement the set power, so, from V1.4 onwards, the idea of making major adjustments, after receiving the command, the first do limit, set the power of the various limitations then set the control.

4. Power Balance Analysis

The energy storage machine has 3 powers, PV/BAT/INV, REMOTE CONTROL will only set the BAT or INV power, not the PV power.
PV, BAT, INV each has a usable power range, PV is 0 to rated power, BAT is charging and discharging rated power, INV is generating rated power. When power is balanced, each of the three power points, PV/BAT/INV, is located within its own available range (this refers to the hardware's natural available range).
(This refers to the hardware's natural available range, not the software's artificially limited available range).
When the BAT power is specified as the set power, the BAT power is only one power point, and then a suitable power point is found in the PV/INV available power interval to make the three powers balanced, which has multiple solutions. A single solution is then obtained using the so-called PV-first or INV-first constraints.
When the INV power is specified as the set power, the INV power is just one power point, and then there are multiple solutions when finding a suitable power in the PV/BAT available power interval respectively, making the three powers balanced. A single solution is then obtained using the so-called PV-first (PV is always preferred over BAT) constraint.
In extreme cases, it is not possible to find three power values to balance the three powers PV/BAT/INV, which is called no solution. When there is no solution, it is solved using the description of the priority problem below.

Priority problem:
1. in any BAT available power interval need to discharge (not BAT power command), as little as possible, try to use the PV first.
2. when charging is required within any BAT available power range (not BAT power command), try to charge as much as possible.
3. When both PV and INV need to charge BAT, the priority will depend on different modes.
4. The size and direction of the pre-processed power command (see below for the concept of pre-processing) may change compared to the original command. However, after the pre-processed power command enters the control loop, the direction will not be changed and the size can only be reduced.
5. When the available power range is all in the positive or all in the negative half-axis, if the power balance calculation cannot be solved, the actual value will only be allowed to be close to zero.
6. After satisfying the above 5 items, BAT has the highest priority because of safety issues, INV has the

second highest priority because of electricity cost issues only, and PV has the lowest priority because of power utilisation issues.

5. Algorithm implementation steps

5. 1 Setting value limitation

After receiving the REMOTE CONTROL set power instruction, the set value is first limited.
If it is BAT power command:
Combine with the BMS allowable charge/discharge current data, reduce the BAT power command to limit within the positive and negative range.
If strong charging or discharging is in progress, the BAT power command is further forced to the full positive or full negative range. At this point, the
BAT power command may instead become larger in amplitude and may change in direction compared to the original command.

In the case of a METER power command:
Combined with the current load power (can be positive or negative), it is directly converted to an INV power instruction (and the METER power instruction is an AC priority type INV power instruction by default).
If it is an INV power command:
Combine the INV rated power, over-temperature load limit, ripple-control limit, DRM limit, power limit ratio limit, export/import limit plus load power converted to INV power limit, over-frequency and over-voltage load shedding and other limiting conditions to reduce the INV power instruction to positive or negative.
The INV power command is reduced to a positive or negative range.
If under-frequency and under-voltage load up, or forced power generation or consumption, or export/import limit plus load power converted to INV power limit interval, etc. are in progress, the INV power is further forcibly assigned to the full positive or full negative interval. In this case, the INV power command may be larger in amplitude and change in direction compared to the original command.
In summary, if the original power command falls within the available power interval, the command value is used directly, and if it falls outside the available power interval, the command value is moved closer to the nearest interval boundary.

5. 2 Execute control in each segmentation mode

The power command that was preprocessed in the previous step is used as the control target to perform the power balance calculation. However, if a suitable power point cannot be found within the available power range of PV/BAT (for controlling INV power) or PV/INV (for controlling BAT power) so that the three powers can be balanced, the control target can only be abandoned, and at the same

time, the actual controlled INV power (or controlled BAT power) is reduced in the direction of zero power (i.e., the direction of the power of the preprocessed power command remains unchanged).

5.3 When there is a BMS strong charging instruction

If the BAT current calculated in step 2 is too small to recharge the battery, use the charging current requested by the BMS for strong charging as the BAT command and recalculate the PV/INV.

5.4 Examples

In all examples, the power instruction uses the pre-processed power in kW.

(1) INV instruction (PV priority)

(3) METER instruction (directly converted to INV instruction with current load power, INV priority), then same as (4)

(4) INV instruction (INV priority), mostly the same as (1), but different only when INV power is used and PV power is large.

(Examples are listed together, divided into left and right halves, with the same input conditions but different output results)

	(1)			**(3) and (4)**		
Input conditions	PV Output	BAT Output	INV Output	PV Output	BAT Output	INV Output
PV interval [0, 10] BAT interval [charge 10, discharge 10] INV instruction 0	10	Charge 10	0	10	Charge 10	0
PV interval [0, 10] BAT interval [charge 10, discharge 10] INV instruction send 2	10	Charge 8	Send 2	10	Charge 8	Send 2
PV interval [0, 10] BAT interval [charge 10, discharge 10] INV instruction use 2	10	Charge 10	Use 0 (The emphasis is on using 0, not Send 0)	8	Charge 10	Use 2

PV interval [0, 2] BAT interval [charge 2, discharge 2] INV command send 10	2	Discharge 2	Send 4	2	Discharge 2	Send 4
PV interval [0, 2] BAT interval [charge 2, discharge 2] INV instruction use 10	2	Charge 2	Use 0	0	Charge 2	Use 2
PV interval [0, 2] BAT range [charge 4, discharge 4] INV instruction use 10	2	Charge 4	Use 2	0	Charge 4	Use 4
PV interval [0, 4] BAT interval [charge 2, discharge 2] INV instruction use 10	2	Charge 2	Use 0	0	Charge 2	Use 2
PV interval [0, 10] BAT interval [charge 2, discharge 2] INV instruction send 2	4	Charge 2	Send 2	4	Charge 2	Send 2
PV interval [0, 10] BAT interval [release 1, release 3] INV instruction send 2	1	Discharge 1	Send 2	1	Discharge 1	Send 2
PV interval [0, 10] BAT interval [release 3, release 5] INV instruction send 2	0	Discharge 2	Send 2	0	Discharge 2	Send 2
PV interval [0, 10] BAT interval [30, 50] INV instruction send 2	0	Discharge 2	Send 2	0	Discharge 2	Send 2
PV interval [0, 10] BAT range [Recharge 4, Recharge 2] INV instruction use 10	4	Charge 4	Use 0	0	Charge 4	Use 4
PV interval [0, 0] BAT interval [Recharge 4, Recharge 4] INV command send 10	0	Charge 0	Send 0	0	Charge 0 (special condition see step 3)	Send 0

(2) BAT instruction (When BAT instruction is used, BAT has priority over PV. Unlike other instructions, BAT is located in the available interval, power is not forced to be specified, and PV has priority over BAT)

Setting Value	PV	Battery	AC output
PV interval [0, 10] BAT instruction 0 INV interval [use 10, send 10]	10	0	Send 10
PV interval [0, 10] BAT command charge 2 INV interval [use 10, send 10]	10	Charge 2	Send 8
PV interval [0, 10] BAT instruction Discharge 2 INV interval [use 10, send 10]	8	Discharge 2	Send 10
PV interval [0, 2] BAT command charge 10 INV interval [use 2, send 2]	2	Charge 4	Use 2
PV interval [0, 2] BAT command Discharge 10 INV interval [use 2, send 2]	0	Discharge 2	Send 2
PV interval [0, 10] BAT command charge 4 INV interval [use 2, send 2]	6	Charge 4	Send 2
PV interval [0, 10] BAT instruction Discharge 2 INV interval [use 4, send 4]	2	Discharge 2	Send 4
PV interval [0, 10] BAT command charge 4 INV interval [use 8, use 6]	0	Charge 4	Use 4
PV interval [0, 10] BAT instruction Discharge 4 INV interval [use 8, use 6]	0	Discharge 0	Send 0
PV interval [0, 10] BAT instruction Discharge 4 INV interval [6, 8]	4	Discharge 4	Send 8
PV interval [0, 10] BAT command Discharge 40 INV interval [6, 8]	0	Discharge 8	Send 8
PV interval [0, 2] BAT command charge 4 INV interval [6, 8]	2	Charge 2	Send 0
PV interval [0, 10] BAT command to charge 40 INV interval [use 8, use 6]	10	Charge 18	Use 8