

Integration requirements for hybrid inverters

Original text as published before the redesign of this article. Wording unchanged.

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This article follows the [device integration introduction article](#). Please check that article first.

The hybrid inverter (comprising the photovoltaic inverter, energy meter, battery pack, Battery Management System [BMS], and Power Conversion System [PCS]) **must support communication via the Modbus protocol**. The manufacturer must provide a complete register map that allow both **monitoring of system parameters** and **control of operational states**. The table below shows the typical registers of a BESS system.

Name	Description	Requirement Level	Data Type / Format	Unit	Read/Write Type
Battery Active Power	Measured DC active power of the battery system (positive = discharge, negative = charge)	Mandatory	INT16 / UINT16	kW	Read-only (Input Register)
Battery Voltage	Measured DC bus voltage of the battery system	Optional	INT16 / UINT16	V	Read-only (Input Register)
Battery Current	Measured DC current (positive = discharge, negative = charge)	Optional	INT16	A	Read-only (Input Register)
Battery State of Charge (SOC)	Remaining battery capacity as percentage of nominal capacity	Mandatory	UINT16	%	Read-only (Input Register)
Battery Capacity	Total capacity of the battery	Optional	INT16 / UINT16	kWh	Read-only (Input Register)
Battery State of Health (SOH)	Long-term battery condition indicator	Optional	UINT16	%	Read-only (Input Register)
Battery Power Setpoint	Requested active power of the battery module = command to charge/discharge (positive = discharge, negative = charge)	Mandatory	INT16	kW	Read/Write (Holding Register)
Battery Temperature (Cell Avg.)	Average cell temperature	Optional	INT16	°C	Read-only (Input Register)
Battery Min SOC	Minimal recommended state of charge	Optional	INT16	%	Read-only (Input Register)
Battery Max SOC	Maximal recommended state of charge	Optional	INT16	%	Read-only (Input Register)
Battery Max charge power	Maximum charging power on AC and/or DC site	Optional	INT16	%	Read-only (Input Register)
Battery Max discharge power	Maximum discharging power on AC and/or DC site	Optional	INT16	%	Read-only (Input Register)
Battery Enable / Disable Command	Remote command to enable or disable the BESS	Mandatory	BOOL (coil)	—	Write (Coil)
PV Active Power	Measured DC active power of the photovoltaic (PV) system	Mandatory	INT16 / UINT16	kW	Read-only (Input Register)
PV Voltage	Measured DC bus voltage of the PV system	Optional	INT16 / UINT16	V	Read-only (Input Register)
PV Current	Measured DC current	Optional	INT16	A	Read-only (Input Register)
PV Max Power Setpoint	Maximal PV active power = command of max power of the PV inverter	Desired	INT16	kW	Read/Write (Holding Register)
PV Enable / Disable Command	Remote command to enable or disable the PV	Mandatory	BOOL (coil)	—	Write (Coil)
PCS Active Power	Measured DC active power of the whole PCS (including battery and photovoltaic (PV))	Mandatory	INT16 / UINT16	kW	Read-only (Input Register)

Note: Not all combinations of Battery, PV and PCS setpoint control are possible. One depends on the other two. Therefore, the manufacturer can only provide two of them.

Additionally, the manufacturer must clearly specify the process and a list of registers that need to be set in order to achieve the desired charging/discharging operation. That usually includes setting a register to a remote control/VPP mode, enabling battery operation, providing regular heartbeat signal etc.

Operating modes

Hybrid inverters provide an internal EMS capable of performing operational modes like self-consumption, peak shaving, max production, max consumption, VPP etc. For that an additional electricity meter must be supplied and is usually connected to the grid. Additionally, the meter limits (import and export) must be provided. An operating mode can be set through a register.

The following operating modes are desired (not mandatory):

- Self-consumption

Stores surplus PV energy and discharges when demand exceeds generation.

- Peak shaving

Reduces peak grid demand by discharging during high load periods.

- Max consumption

Maximal charging up to the import grid limits

- Max production

Maximal discharging up to the export grid limits

- Schedule mode

Specification of power through days and hours of the week

- Virtual Power Plant (VPP)

Aggregated BESS coordinated for grid services and market participation.

- Frequency regulation

Rapid charge/discharge to stabilise grid frequency.

- Voltage support / reactive power

Provides reactive power to stabilise local grid voltage.