GPM PPC

User Guide

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Overview

GPM PPC acts as a master to drive all photovoltaic (PV) devices in a plant.The GPM PPC coordinates the local controls of the (PV) inverters, to achieve the desired setpoints at the point of interconnection (POI).

The GPM PPC is an overall control that allows the plant to be friendlier with the grid and meet the requirements imposed by the Transmission System Operator (TSO). It implements a closed-loop control in real time, which allows sending fast and refreshed commands to the inverters, to achieve the setpoints. The data acquisition and the sending of commands relies on the RTU SmartBridge (RTUSMB) system that connects the GPM PPC and the drivers of the inverters.

The GPM PPC reads the measurement from the POI and sends orders (active and reactive setpoints) to all inverters or FACTS. If there are capacitor banks present in the plants, it sends them orders to connect or disconnect. Then, the inverters perform their own controls to follow their master (GPM PPC) orders.

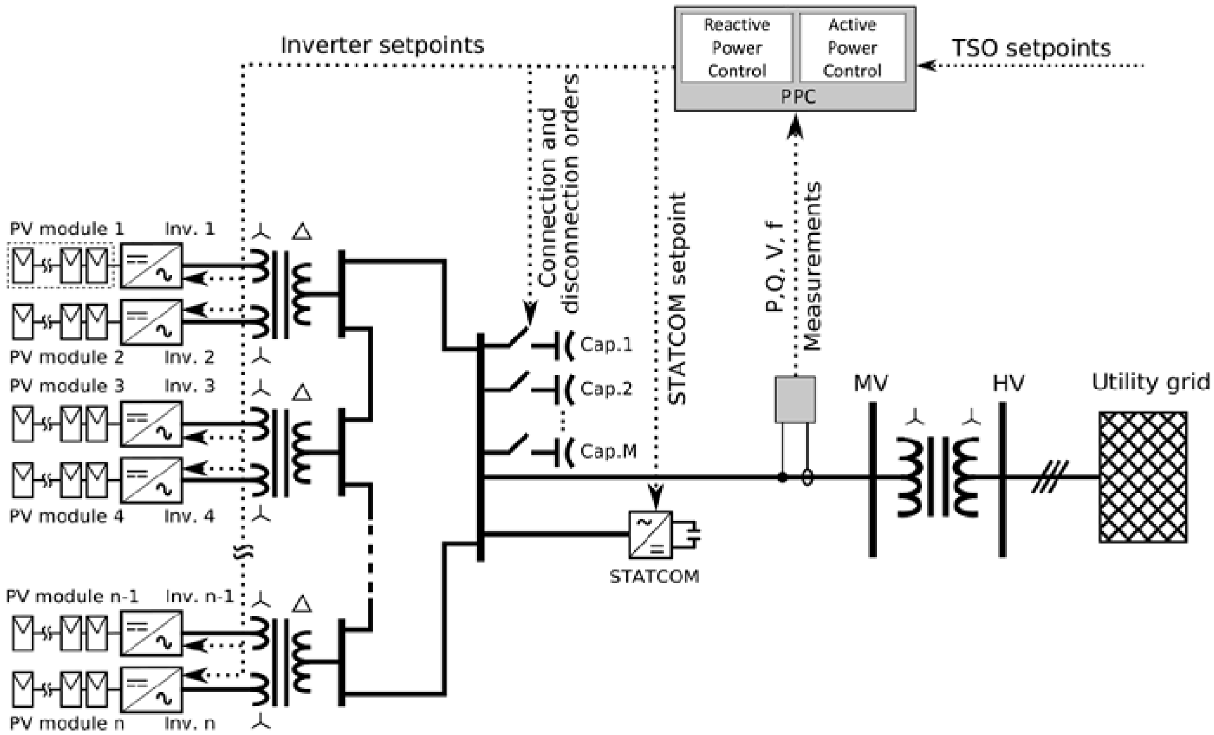
> ☆ IMPORTANT: In the case of fault ride through (FRT), inverters and FACTS omit the orders from the GPM PPC, because grid codes require rapid response during fault events and communication delays would lead the PV plant to FRT requirement non-compliance.

Structure

The GPM PPC contains two main plant control structures, one for active power control and one for reactive power control. Once GPM PPC calculates the commands to accomplish the enabled setpoints or controls, it sends them to the RTUSMB, which adapts them at each inverter and STATCOM.

The GPM PPC controls power generation and output by measuring actual power production, comparing it to the expected power setpoint, and sending a new setpoint to correct any deviations.

Typical large-scale PV plant layout including the proposed power plant control schemes



Commands

The GPM PPC delivers the commands to the SMB, based on the measurements of point of interconnection (POI). The SMB distributes the commands of active and reactive power in the whole plant. This guarantees the correct active and reactive power values to fulfill the requirements in the POI.

The plant operator and the system operator can send setpoints and enable or disable controls by means the PV SCADA or the Substation RTU, respectively.

After sending the endpoints, the GPM PPC uses the measurements of the POI, calculates and delivers the commands needed to fulfill the necessities, lowering or augmenting the active and reactive power at the POI. The command is unique to all inverters, enabling different inverters ratings and cloud coverage conditions, as the GPM PPC readjusts the percentage commands to meet the requirements.

The GPM PPC can control not only inverters, but all devices in a plant (STATCOMS, battery inverters and capacitor banks).

Requirements for commissioning

Commissioning is the process of testing that every element of a plant is properly installed and functioning correctly. This takes place at the end of construction, before beginning production operations and handing the plant over to the owner or to the operations manager. For the purposes of the GPM PPC, commissioning involves testing only the inverters.

> ☆ IMPORTANT:
>
> The grid operator and must agree on the requirements for the acceptance tests before commissioning the GPM PPC.

The GPM Power Plant Controller (GPM PPC) controls the entire renewable power plant (RPP) according to your plant's specifications. At the time of commissioning, the plant must meet the following requirements:

- All connected devices are commissioned and feeding electric current into the utility grid.
- The communication network is installed, and the system can reach all devices involved in the control system.
- Remote access to the system network is available.
- Scheduling takes the weather forecast into consideration.
- Depending on the cybersecurity policies of your organization, it may be necessary to be able to connect to the system through a VPN for commissioning, services and maintenance purposes.

Depending on the behavior of the inverters, it may be necessary to adjust their parameters to fine-tune their performance.

The following points must be guaranteed before the GPM PPC commissioning:

1. The Power Meter is measuring at the Point of Interconnection (POI).
2. The Power Meter has a scale factor that allows measuring from the minimum and maximum readable parameters according to the power flow specifications at the POI.
3. The Power Meter can publish at least the following measurements:
   - Total AC Active Power
   - Total AC Reactive Power
   - Frequency
   - Power Factor
   - Voltage A-N
   - Voltage B-N
   - Voltage C-N

4. The Power Meter is available through Modbus TCP protocol and reachable from the monitoring devices.
5. The Power Meter publishes the new measuring values at the Modbus Map within the timeframes stipulated by the grid operator (for example, less than 100 ms).
6. The Power Meter is successfully commissioned and tested.
7. At least, the 90% of the power converters are successfully commissioned and energized.
8. The Power Converters or Controllers are available through Modbus TCP protocol and reachable from the monitoring devices.

> ⓘ NOTE: If the inverters use protocols other than Modbus TCP, a protocol converter is required. The protocol converter may be provided by GPM or a third-party provider.

9. The Power Converters or Controllers must be successfully configured and tested to:
   - Respond to the external setpoints for active power (*P*) and reactive power (*Q*) through Modbus TCP protocol.
   - Not respond with a power ramp dynamic. If this feature is necessary, the power ramp response must be performed by the GPM PPC.
   - Not have any limitation of Power Factor.
10. In an open-loop test, the Power Converters or Controllers must reach the steady state response in less than a fifth part of the Grid Code specification within the accuracy established.
11. The available active power to tune the controllers of the GPM PPC must be greater than the 50% of the rated power of the plant.
12. The minimum time window required to perform to perform the full commissioning of the GPM PPC with the utility grid permissions is equal to six hours.

> ☆ IMPORTANT: The time frames may change depending on the specific requirements of each client, as well as limitations of the plant and its grid.

Item	Name	Description	Tentative schedule [min]
1	Monitoring	services testing.	60
2	Open loop	Setpoint sending directly over the inverters.	30

3	Active Power	*P* loop calibration with 0.1 per-unit (*pu*) steps.	60
4	Reactive Power	*Q* loop calibration with 0.05 steps.	60
5	a. Voltage setpoint b. Voltage reference	a. *Vs* loop calibration with 0.005 steps of *Vnom*. b. AVR test within the Grid Code with *V* simulated.	60

ⓘ NOTE: Depending on the Grid Code, the voltage regulation is done either though a voltage reference or through a setpoint control. Only one control will be scheduled.

6	Power Factor	PF test within the Grid Code bounds.	30
7	Frequency Droop	Over & Underfrequency tests with simulated values.	60

PPC controls

Controls are commands that you configure for the GPM PPC to send to individual inverters or to the entire plant. These can be pre-defined modes for production (for example, Night Control) or individual setpoints that you can input and send manually.

> ⓘ NOTE: The different control parameters must be agreed between GPM and a representative from the client organization or the grid operator.

To find out the number of available inverters, the GPM PPC monitors the status of communication and the power available for each inverter. If the communication quality is good and the inverter is also generating, it is considered as available.

The total active and reactive power that the plant has in the POI are fixed values and are the values that are subsequently used to calculate the setpoints sent to the inverters which can be sent relative or in absolute value.

The control strategy is based on different control loop algorithms.

Control loop

The control loop consists of three steps:

1. Acquire the plant state, including the measurements in the POI.
2. Calculate commands and setpoints.
3. Send commands and setpoints to the equipment.

The external setpoints sent to the GPM PPC should be among the limits related to the configuration parameters. Otherwise, the setpoints values are saturated to these limits.

Available control algorithms at the point of interconnection

The available the control algorithms at the point of interconnection (POI) are:

- Active power: active power curtailment.
- Reactive power: reactive power reference closed-loop control.
- Frequency stability: active power injection/absorption due to frequency variations.
- Voltage controls:
  - Droop control (characteristic curve Q-V).
  - Closed-loop control.
- Power factor: power factor reference closed-loop control.
- Ramp control: active and reactive Power if needed.
- SVC or STATCOMS: reactive compensation device.
- BESS: Battery Energy Storage Station control.
- Fault-handling: fault-voltage ride-through.

Production control modes

Production control modes define how to limit the power output of a plant to meet the requirements and limitations of the electrical grid. This allows the GPM PPC to maintain a constant and dynamic control in real time over every device in the plant to ensure that it is providing the correct amount of power at any given moment.

The available modes are:

- Active power:limits the active power output of the plant independently of sudden increases in irradiance.
- Active power reserve mode: reserves a percentage of the plant's available maximum active power in the event of an under-frequency scenario.

There are two GPM interfaces where you can activate production control modes:

- GPM HMI PPC.
- GPM SCADA PPC plugin.

> ⓘ NOTE: It is also possible to activate production control modes through Modbus.

Active power control

In active power control mode, the GPM PPC limits the active power output of the plant independently of sudden increases in irradiance. The GPM PPC controls the input of active power at the point of interconnection (POI) and adjusts the commands to the inverters, reducing them if necessary.

The GPM PPC controls the active power exchange with the grid by sending active power commands to the inverters. With the measurements of active power at the POI, the GPM PPC performs active power control and establishes a maximum outgoing active power.

The the GPM PPC performs the active power control as shown in the figure of the layout in the Overview section (including the proposed control schemes). The control is divided into three sections:

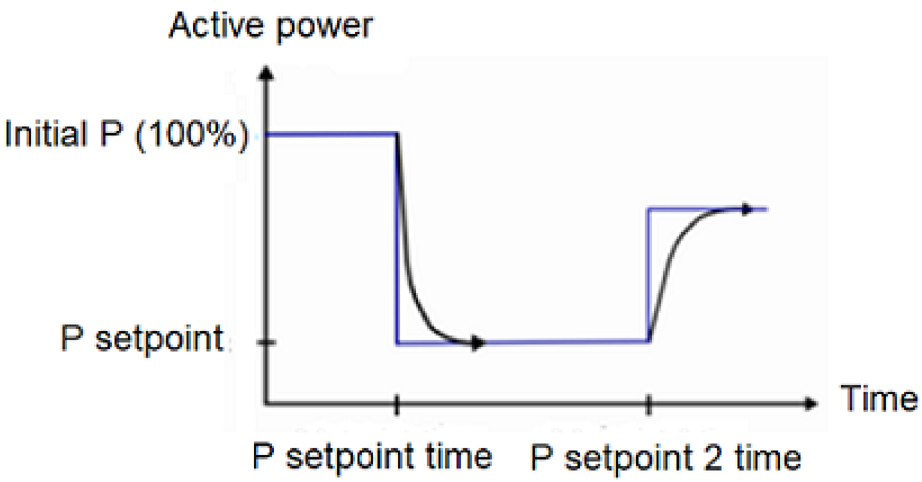
- Reference computation block
- Controller
- Dispatch system

The reference computation block calculates the active power setpoint that must be achieved at POI. The GPM PPC can curtail the actual active power output to the setpoint (fixed or variable). The setpoints can be sent by two separate operators, in both the local and the remote modes of the GPM PPC.

Absolute active power control

When active power control with different setpoints applies, the maximum power (P max) value leads from the plant's maximum active power. It is a fixed configured value that prevents the GPM PPC from sending active commands higher than the nominal inverter capabilities. If the plant does not respond with the value that the GPM PPC sends, it becomes saturated and the anti-windup comes into play to reduce the accumulated error.

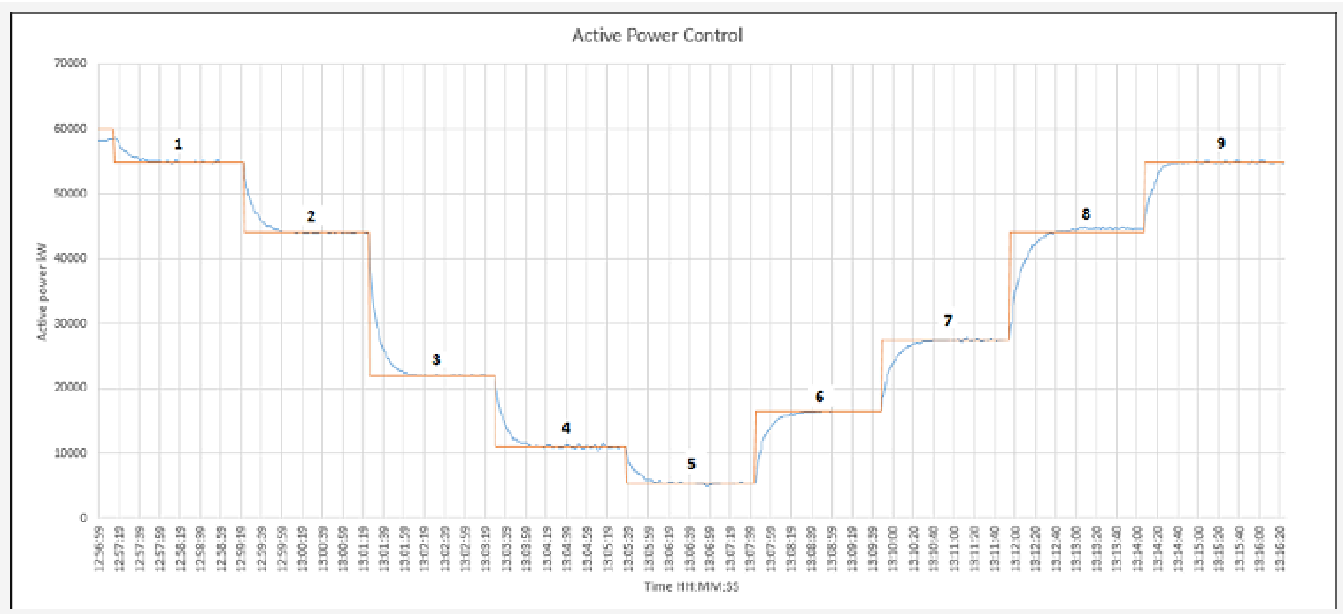
Absolute active power control



Real active power control

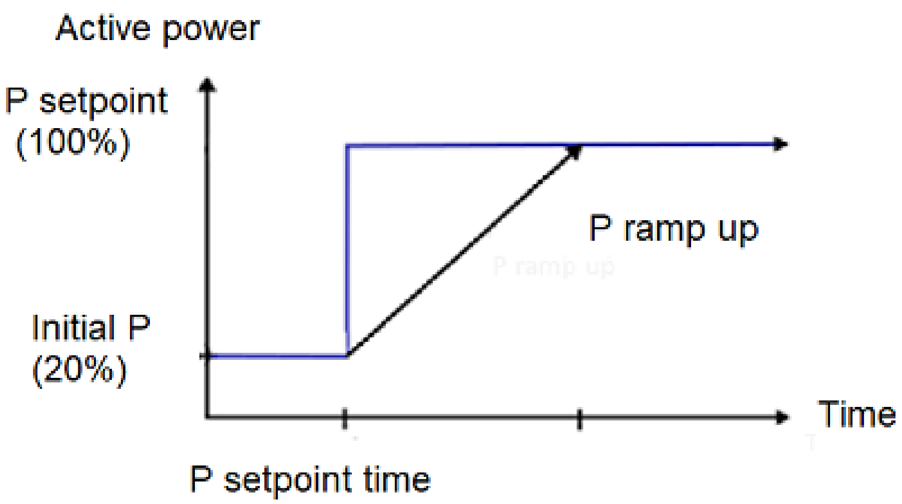
The system continuously applies a frequency droop to modify the desired active power setpoint ($P^*_{pre\text{-}ramp}$) at the GPM PPC, even if the TSO sends a curtailment setpoint (P_{TSO}). Furthermore, the active control implements a ramp rate or gradient that provides the GPM PPC the capability to fulfill the gradient meter. The active power at POI can be increased or decreased according with a configured ramp rate (MW/min) if the variation of the active power is given by a change in the active power curtailment setpoint, not by irradiance variation.

Real active power control example



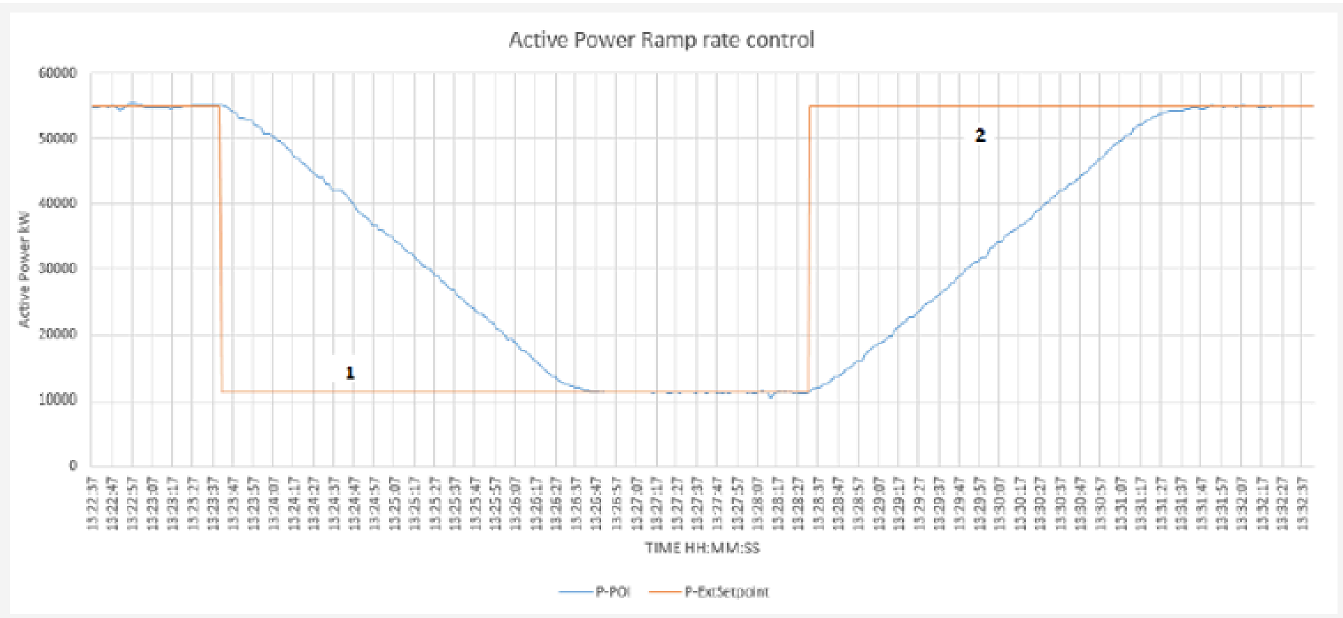
A ramp rate controller limits $P^*_{pre\text{-}ramp}$ by computing the desired active power at the POI, P^*. If there is no curtailment event, P_{TSO}, is set to the nominal PV plant power, P_{plant}. It is also possible to apply this ramp rate limitation to the reactive power output. The figure below shows the behavior of the GPM PPC.

Active power ramp rate control



The figure below shows a real example of the GPM PPC active power ramp rate enable GPM PPC.

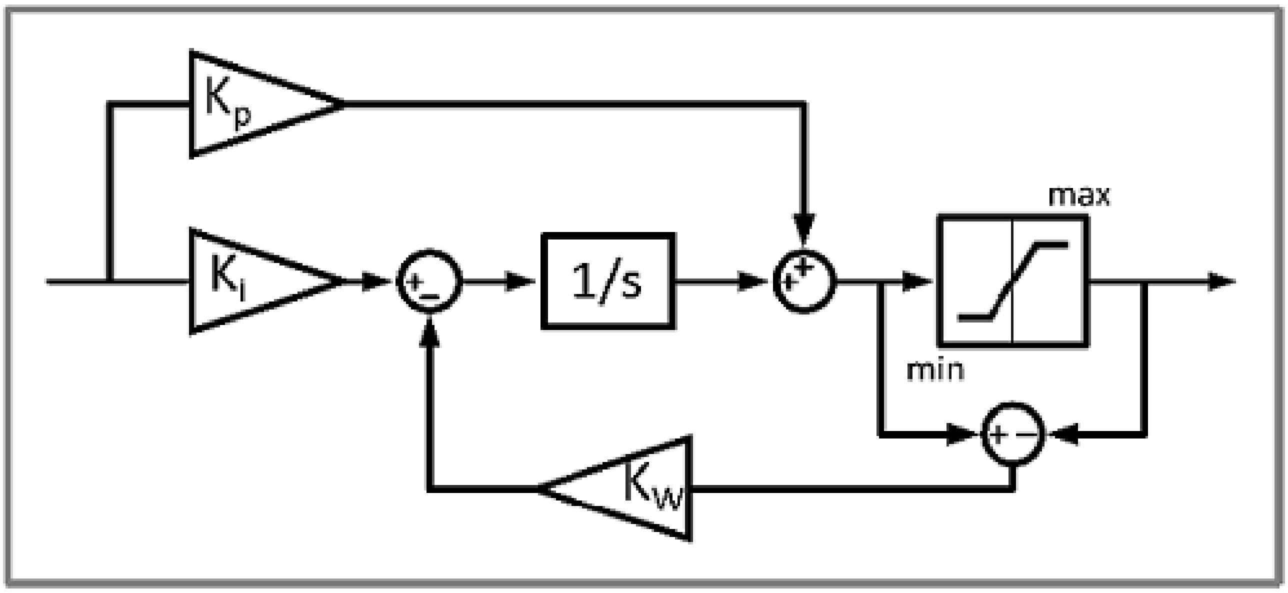
Active power ramp rate control example



PI controller scheme

Once P^* is obtained, the controller computes the total aggregated power (P_{tot},) that must be generated by all PV inverters. The controller is based on a typical PI controller (see figure PI controller scheme used in the igure PI controller scheme used in the PPC), with anti-wind-up, ensuring that the error between P^* and the measured power al POI, P, is "0" in a steady state. The saturable non-windup proportional integral (PI) controller makes it possible to create a command to reduce the error generated. The non-windup makes the GPM PPC react faster to reference changes after a period of saturated operation.

PI controller scheme



The dispatch system takes the P_{tot} and distributes it among all PV inverters. The P_{tot} is dispatched as a percentage, so there is only one signal to send, regardless of different PV inverter power ratings. This divides P_{tot} by the nominal PV plant power (P_{plant}), effect in every loop performed by the GPM PPC, to obtain α, which is then sent to all inverters. Each inverter receives the α signal and computes its local active power setpoint according to the following expression, where $P_{nom,i}$ and $P^*_{inv,i}$ are the nominal active power and the local active power setpoint of the inverter i respectively:

$P^*_{inv,\,i} = \alpha \times P_{nom,\,i}$

The value in the point of interconnection is finally the setpoint sent, if it is lower than the active power available by irradiance. The active power depends directly on the irradiance, so if this falls, the active power falls accordingly. In case of an increase in irradiance, the GPM PPC curtails the power at the setpoint level that is being applied.

Active Power Reserve Mode

Active power reserve mode reserves a percentage of the plant's available maximum active power in the event of an under-frequency scenario. This is useful when plants are required to operate by reserving a percentage of the available active power.

The active power reserve mode calculates a suitable active power setpoint by subtracting the reserve percentage of the plant's maximum power from the available power input.

The reserve percentage can be configured by Modbus. The available active power must be provided by an external data source. The active power setpoint is computed through the following expression:

$$P^* = P_{available} - (reserve\ \% \ - P_{max})$$

Frequency control

Frequency control reduces the active power exchanged with the grid by changing the outgoing power to bring the frequency back to the nominal deadband.

Depending on the frequency measured at the POI, the GPM PPC reacts to follow the configured droop characteristic. If the frequency grows over the nominal value and the dead band configured in the measurement point, the plant reduces the active power value injected following the droop curve:

$$Pout = Poi - Pref \times \left(\frac{1}{m/100}\right) \times \left(\frac{f_{grid} - f_{start}}{f_{nom}}\right)$$

Where the variables are:

- f_{nom}: nominal frequency
- f_{grid}: grid frequency
- m: droop value in percentage
- f_{start}: constant value
- Poi: depending on the type of control, can be equal to:
  - Active power at the POI when the frequency is over f_{start}. (F Droop base power type 0).
  - Active power setpoint sent by the SO (F Droop base power type 1).
- Pref: depending on the type of control, can be equal to:
  - Maximum active power (F Droop reference type 0).
  - Active power value at the POI (F Droop reference type 1).

Maximum power

The maximum power for frequency droop reference type "0" can be modified to a value that differs from the actual plant's maximum power. This is done by changing the frequency droop maximum power parameter. If the parameter is set to "0", the frequency droop max power will be the same as the plant's maximum power.

> ⓘ NOTE: If the droop value is not given by the client or the utility, but the f_{start} and f_{stop} values are known, the droop value in percentage (m) is calculated using the following expression:
>
> $m = \left(\frac{|fstart - fstop|}{fnom}\right) \times 100[\ \%\ ]$

Frequency control modes

In some cases, the grid code requires two different set of droops for both over-frequency and under-frequency control. To address this, two droop controls are available with their corresponding modes:

- Droop controls: adjust power in relation to a threshold, following a pre-defined gradient.
  - Over-frequency droop control
  - Under-frequency droop control
- Frequency-sensitive mode (FSM): adjust power in relation to a threshold, following up to four pre-defined gradients.
  - Over-frequency FSM (two gradients)
  - Under-frequency FSM (two gradients)
- Non-dynamic control modes: when a pre-defined frequency is reached, the system sends a pre-defined active power setpoint during a set amount of time.

Over-frequency control

Over-frequency control decreases the active power injection in case of over-frequency events . The behavior of the control is goverened by pre-configured thresholds and droops.

There are two over-frequency control modes:

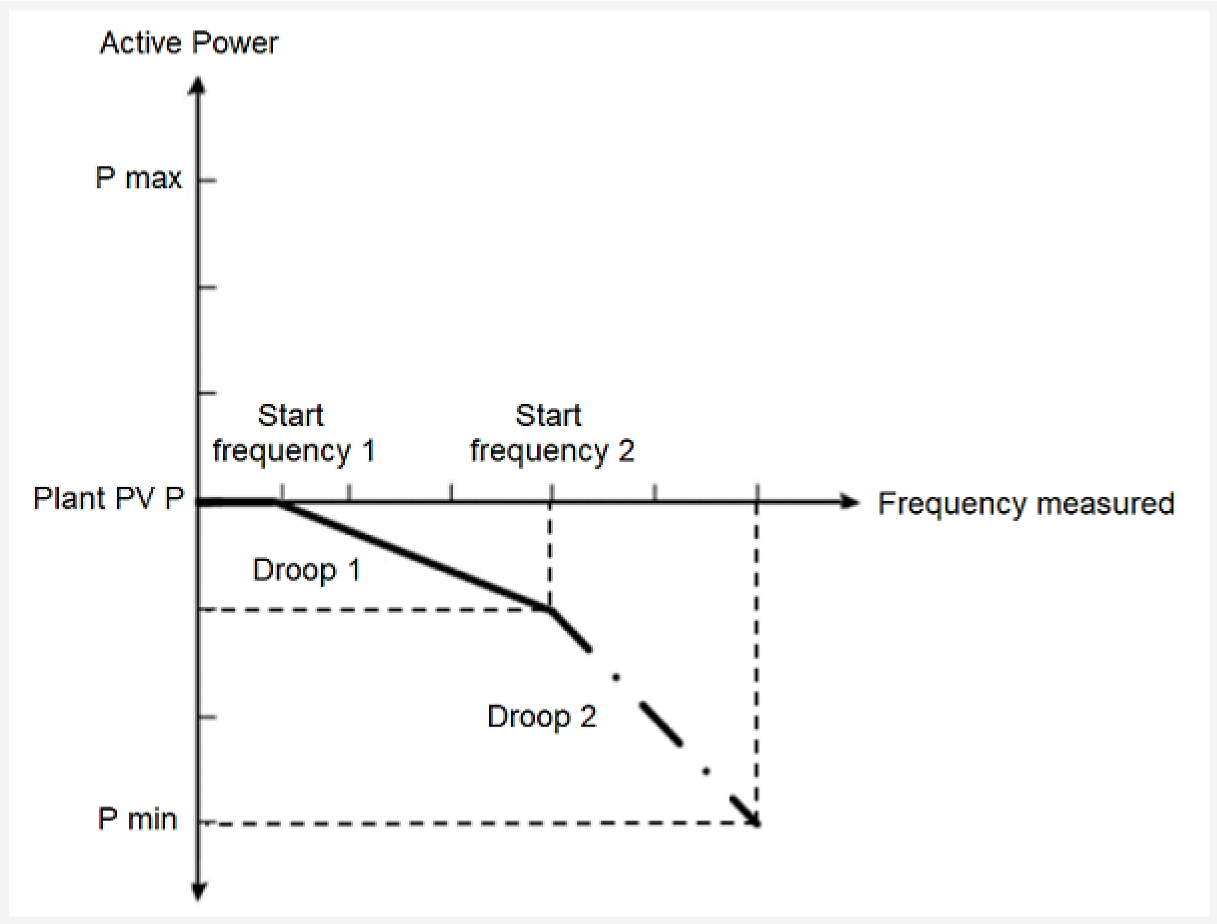
- Droop control
- STR-STP

Over-frequency control mode (Droop control)

In this mode, the GPM PPC performs the frequency control depending on a specified droop and the starting point of the frequency control.

The behavior of this mode is shown in the following figure:

Over-frequency control mode 2



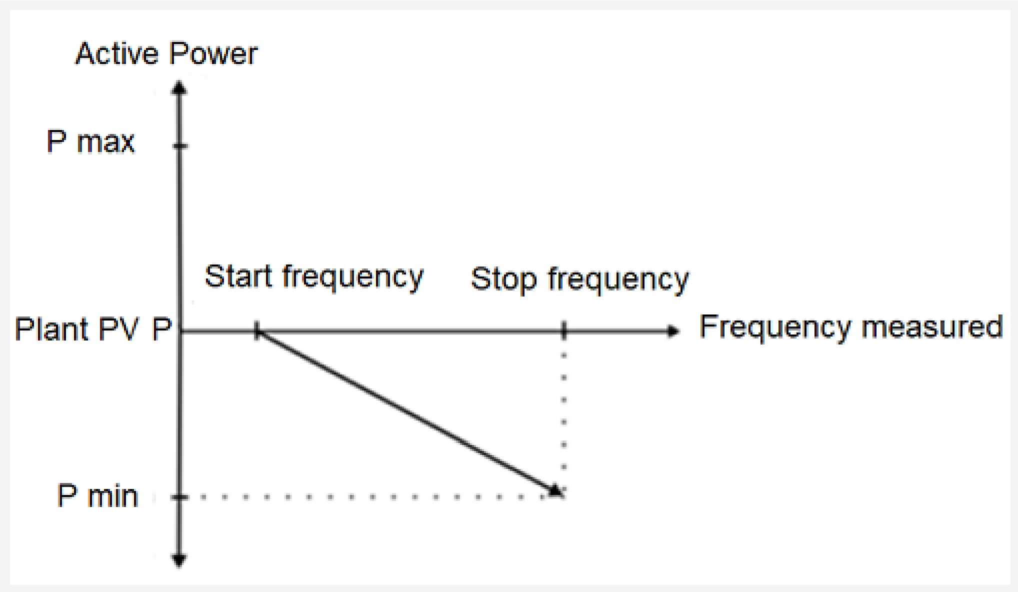
Over-frequency control (STR-STP)

In this mode, the GPM PPC performs the frequency control depending on a start-frequency value and a stop-frequency value.

> ⓘ NOTE: This method is no longer the default for most grid codes. Before using it, verify that it is the preferred control in your grid, country or region.

The behavior of this mode is shown in the following figure:

Over-frequency control mode 1



Under-frequency control

Under-frequency control decreases the active power injection in case of under-frequency events. The behavior of the control is governed by pre-configured thresholds and droops.

There are two under-frequency control modes:

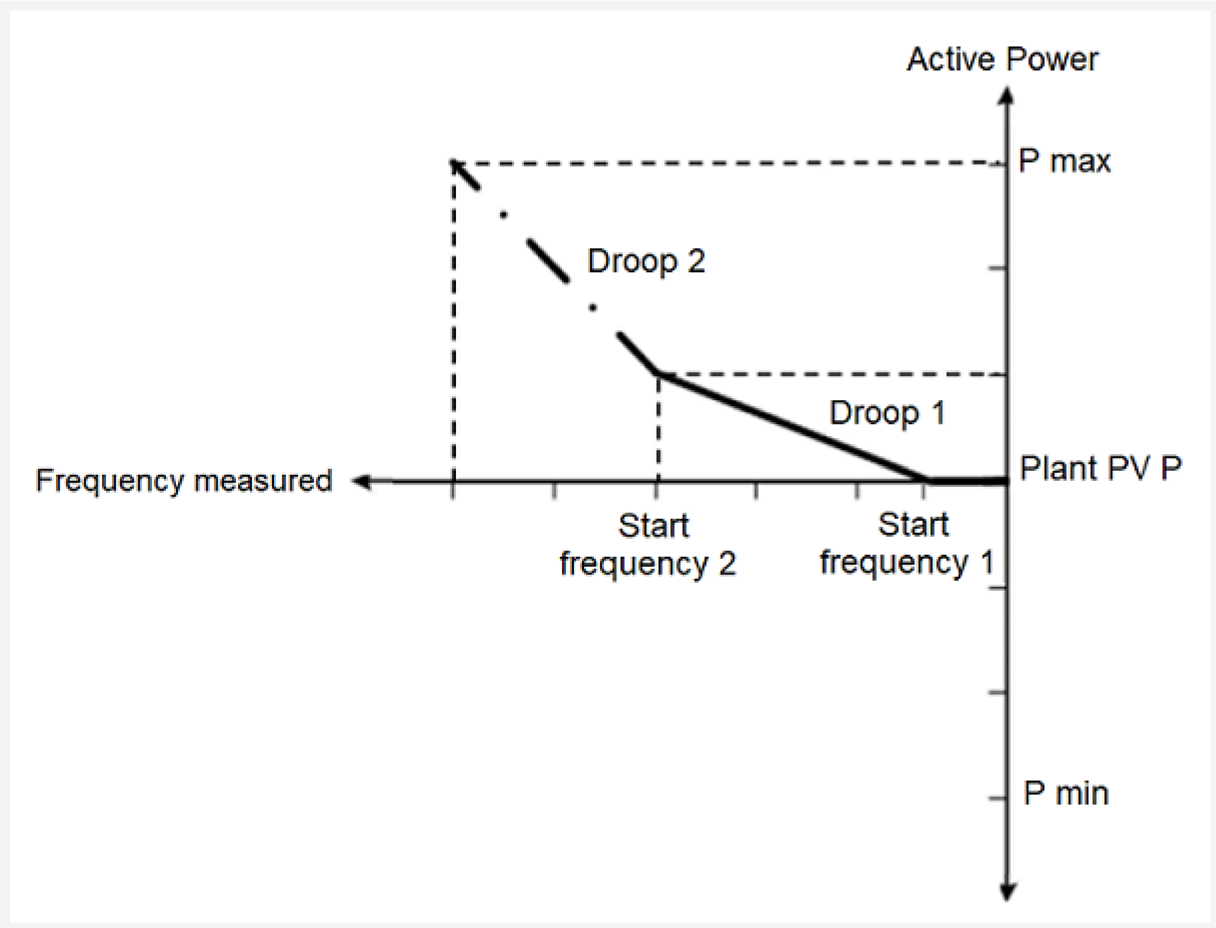
- Droop control
- STR-STP control

Under-frequency control mode (Droop control)

In this mode, the GPM PPC performs the frequency control depending on a specified droop and the starting point of the frequency control.

The behavior of this mode is shown in the following figure:

Under-frequency control mode 2



Under-frequency control (STR-STP)

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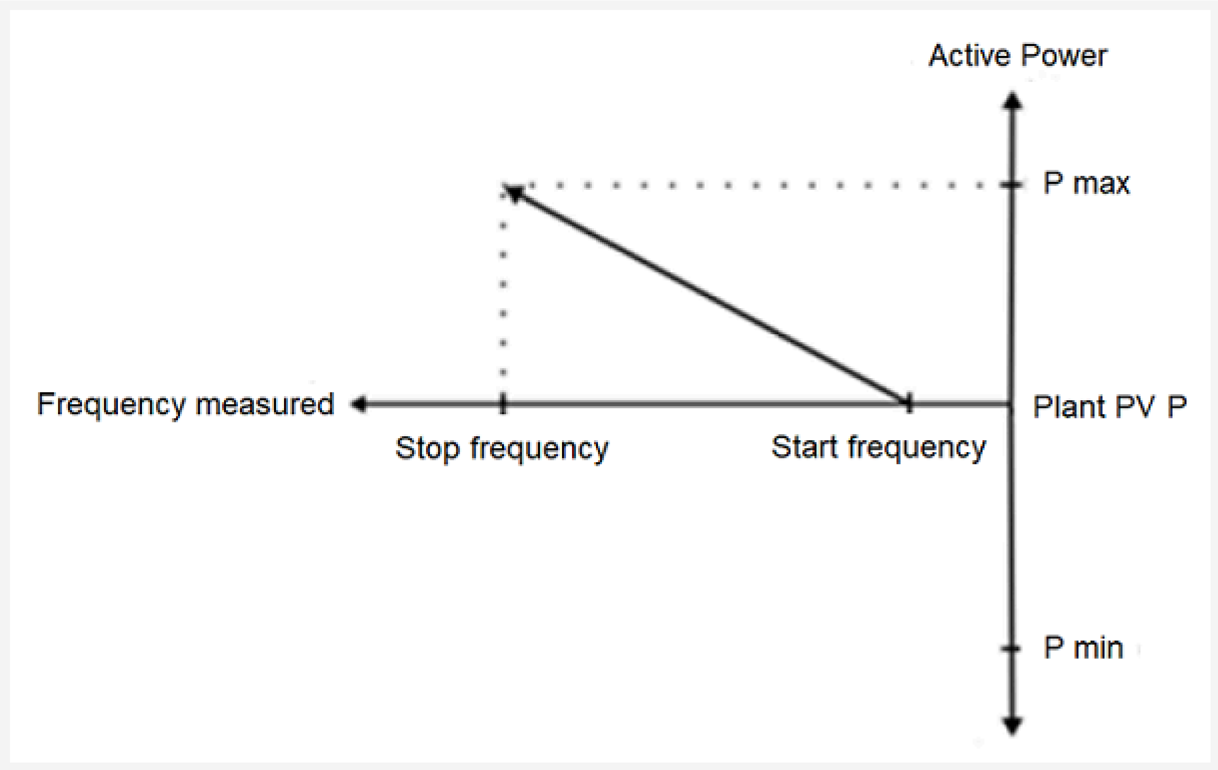
The behavior of this mode is shown in the following figure:

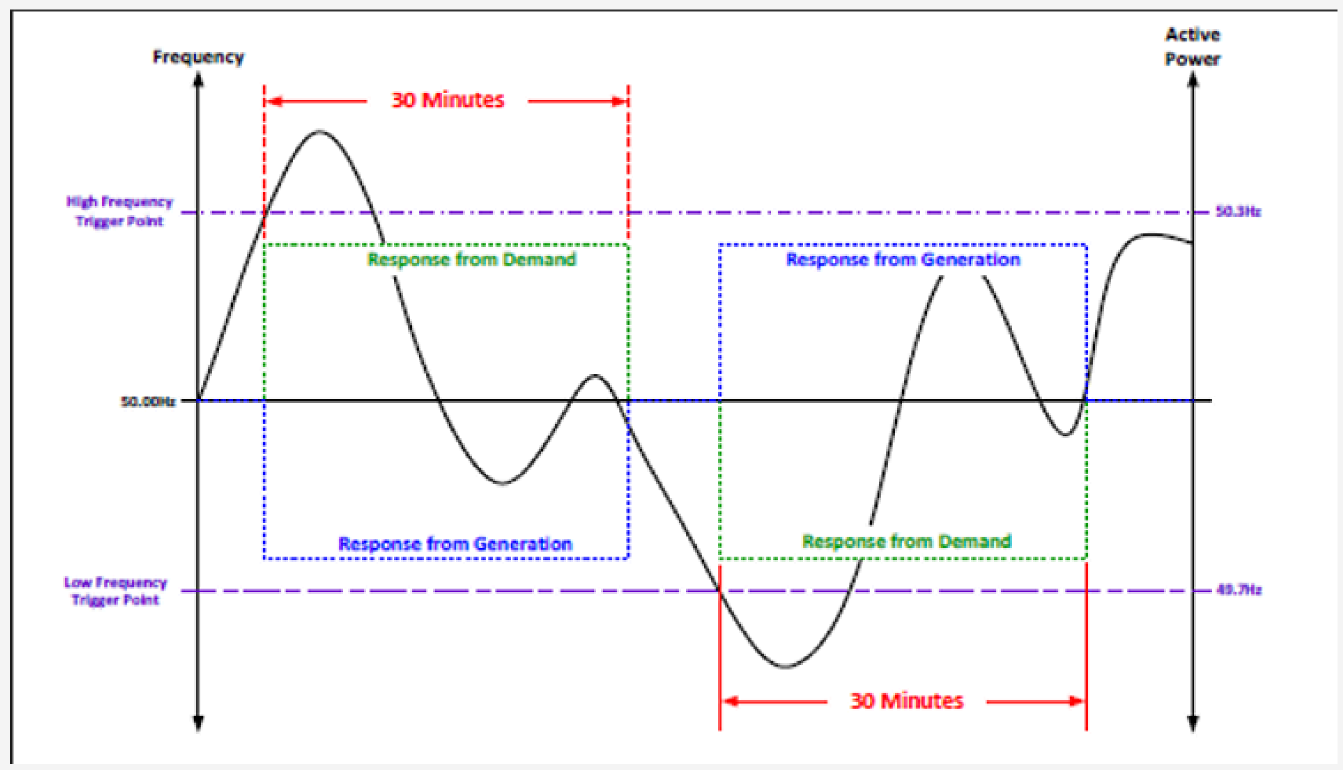
Under-frequency control mode 1



Non-dynamic over-frequency and under-frequency control

The GPM PPC guarantees non-dynamic responses to the frequency reaching a trigger value by regulating the plant to a given setpoint for a specified amount of time. Once the time set reaches out, the GPM PPC may remain in idle state during a setting time depending on the response configuration. After this status, the GPM PPC will regulate normally in accordance with the POI conditions.

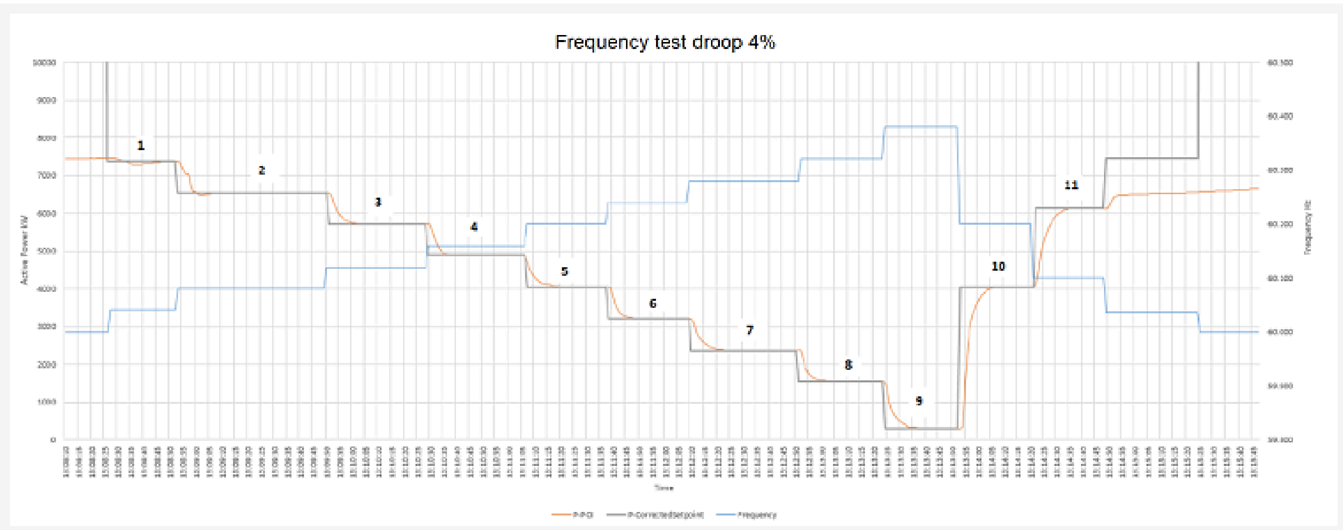
Example of a non-dynamic response to a varying frequency. Source: ENA EREC G99



Non-dynamic over-frequency control

The following figure shows an example of the non-dynamic over-frequency control performed by the GPM PPC:

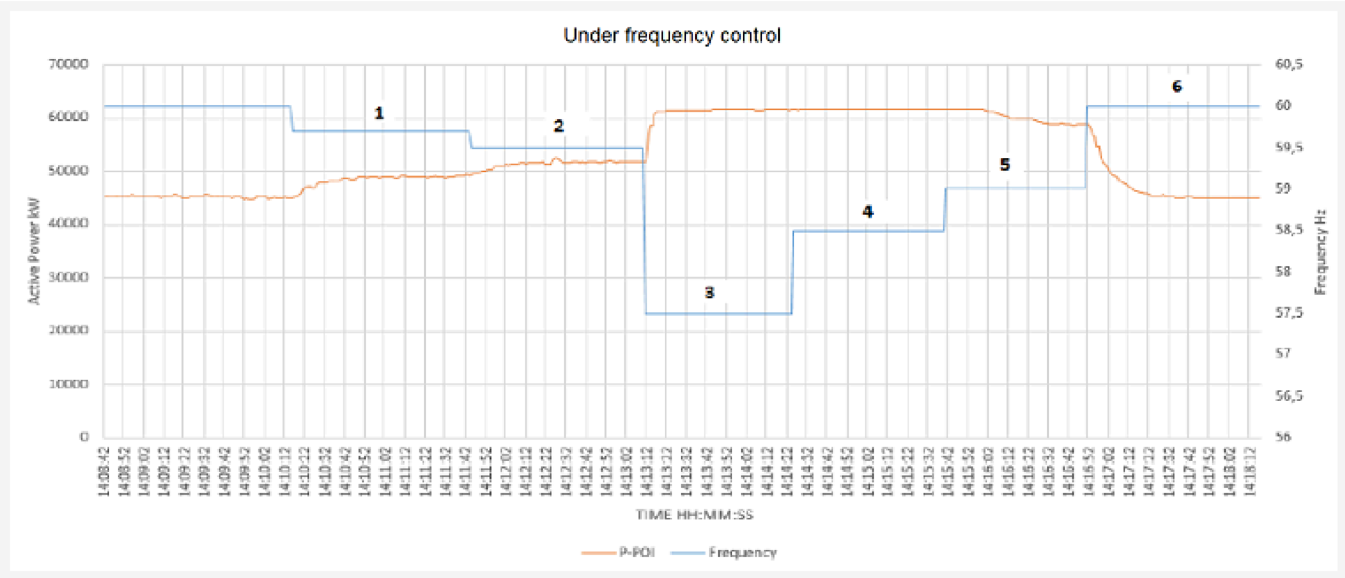
Over-frequency control example



Non-dynamic under-frequency control

The following figure shows an example of the non-dynamic under-frequency control performed by the GPM PPC:

Under-frequency control example



Grid support control modes

Grid support control modes:

- Capacitor bank control logic
- Power factor control
- Reactive power control
- Voltage droop control
- Voltage closed-loop PI controller

Capacitor bank control logic

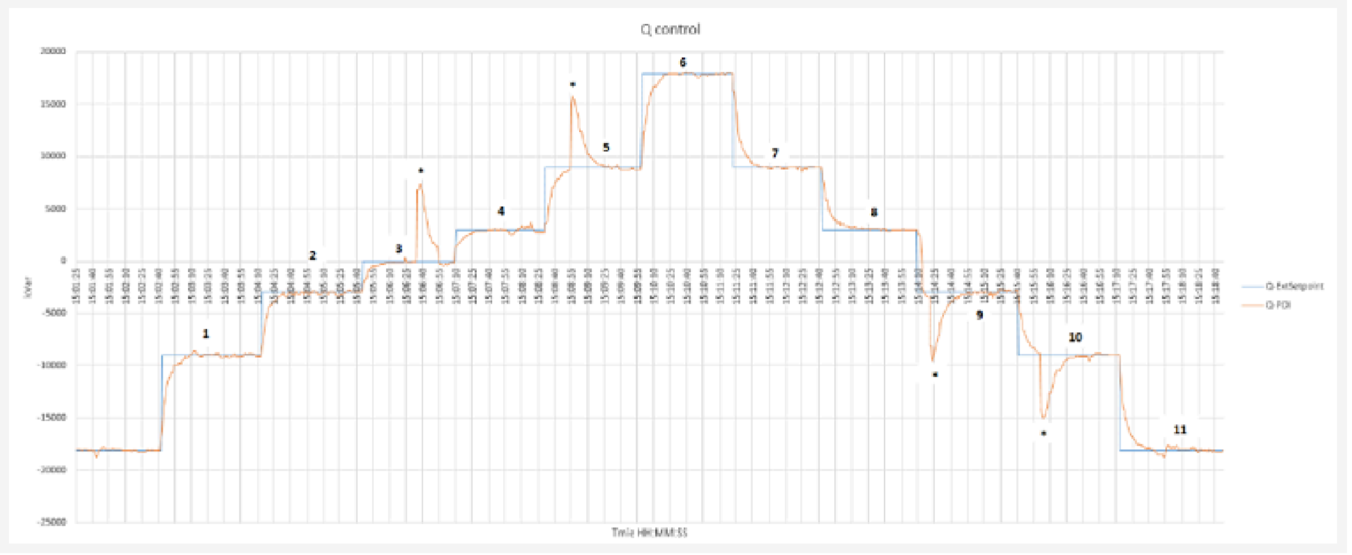
At this point, if *Q** is capacitive, capacitor banks (if they are available) generate a major part of *Q**. This is performed by taking the setpoint and calculating the reactive power order to inverters by means of a controlled PI.

The process follows five steps:

1. Connection to the first set of capacitor banks.
2. Adjustment of the moment of connection and disconnection.
3. Finer control performed by FACTS device.
4. Further control by PV inverters to calculate the total reactive power setpoint to the FACTS device in per unit system.
5. PV inverters receive the β signal and compute their local reactive power setpoint.

The figure below is a real example of the reactive power control mode test where the GPM PPC complies when demanding capacitive and inductive reactive power:

Real reactive power control example



Connection to capacitor banks

The active power at POI must be higher than a certain threshold (*PCAP CONNECTION MIN*) to connect the first set of capacitor banks. The following expression describes the connection/ disconnection orders for the following capacitor bank to be operated:

$$SET_{CAP} = Q_{ORDER\ \ TO\ \ INVERTERS} > \left(1 + HYST_{CONNECTION}\right) \times Q_{CAP}\ \&\ P_{MEAS} > P_{CAP\ \ CONNECTION\ \ MIN}$$

Adjustment for connection and disconnection

In expression (2), *QCAP* is the reactive power supplied by a capacitor bank at nominal voltage, *QORDER TO INVERTERS* is the output of the reactive power command that is sent to the inverters, and *HYSTCONNECTION* and *HYSTDISCONNECTION* are two hysteresis parameters that allow adjusting the connection and disconnection moment.

> ⓘ NOTE:
>
> In case it is specifically required by the customer, *HYSTDISCONNECTION* and *HYSTCONNECTION* should be equal.

$$RESET_{CAP} = Q_{ORDER\ \ TO\ \ INVERTERS} < -\left(1 - HYST_{DISCONNECTION}\right) \times Q_{CAP}$$

FACTS device control

A factor $K \in [0,1]$ determines the amount of reactive power that is supplied only by FACTS devices. In a first stage, $QFACTS1$ is calculated according to the following expression, with a maximum absolute value of $K \cdot QFACTS1$, where $QFACTS$ is the nominal reactive power of the FACTS device and N is the number of connected capacitor banks:

$$Q_{FACTS1} = Q^* - N \times Q_{CAP}$$

PV inverters control

The controller computes the rest of reactive power that FACTS plus PV inverters have to supply, Q_{tot}. This is carried out by a PI controller, as shown in the Real reactive power control example figure. The corresponding p.u. value β is calculated by dividing Q_{tot} by Q_{plant}, where Q_{plant} is the nominal reactive power of the PV plant. At this point, as the available reactive power remaining in FACTS device is $(1-K) \cdot QFACTS$, the additional part of FACTS contribution is calculated as $\beta \cdot (1-K) \cdot QFACTS$. The total reactive power setpoint to the FACTS device in per unit system is calculated as the following expression:

$$\gamma = \frac{Q_{FACTS1} + Q_{FACTS} \cdot \beta \cdot (1 - K)}{Q_{FACTS}}$$

PV inverters compute local reactive setpoint

At the final stage, each PV inverter i receives the β signal and computes its local reactive power setpoint according to the following expression, where $Q_{nom,i}$ and $Q^*_{inv,i}$ are the nominal reactive power and the local reactive power setpoint of the inverter i respectively:

$$Q^*_{inv,\, i} = \beta \times Q_{nom,\, i}$$

Power factor control

Power factor control mode instantly calculates the necessary reactive power requirement at the POI. This ensures that, with the instant active power, a constant power factor is obtained at the POI.

The GPM PPC can make the plant follow a power factor setpoint in the POI. From the measurements of active power in the POI and the values of the setpoint, the GPM PPC creates a reactive power command for the inverters that modifies the power factor in the POI.

Once the GPM PPC generates the reactive power setpoint internally, based on the measurements of active power and the power factor setpoint, the control algorithm is the same as reactive power control.

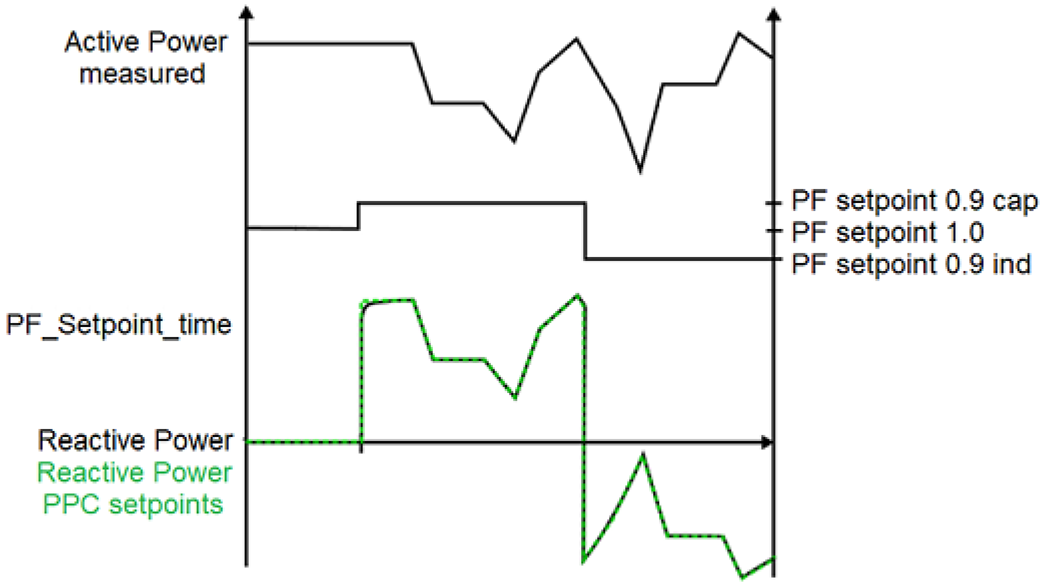
The GPM PPC varies the reactive command either in case of power factor setpoint change or measured active power deviation. The reactive power control is performed as seen in the Power factor control diagram. When the power factor setpoint is set, the corresponding desired reactive power is calculated using the following equation, where Power (P) is the measured active power at POI and $cos(\varphi)TSO$ is the power factor setpoint:

$$Q^*_{pre} - ramp = P \times \frac{\sin(\varphi)_{TSO}}{\cos(\varphi)_{TSO}}$$

> ⓘ NOTE: * Cap Bank Enabled/Disabled

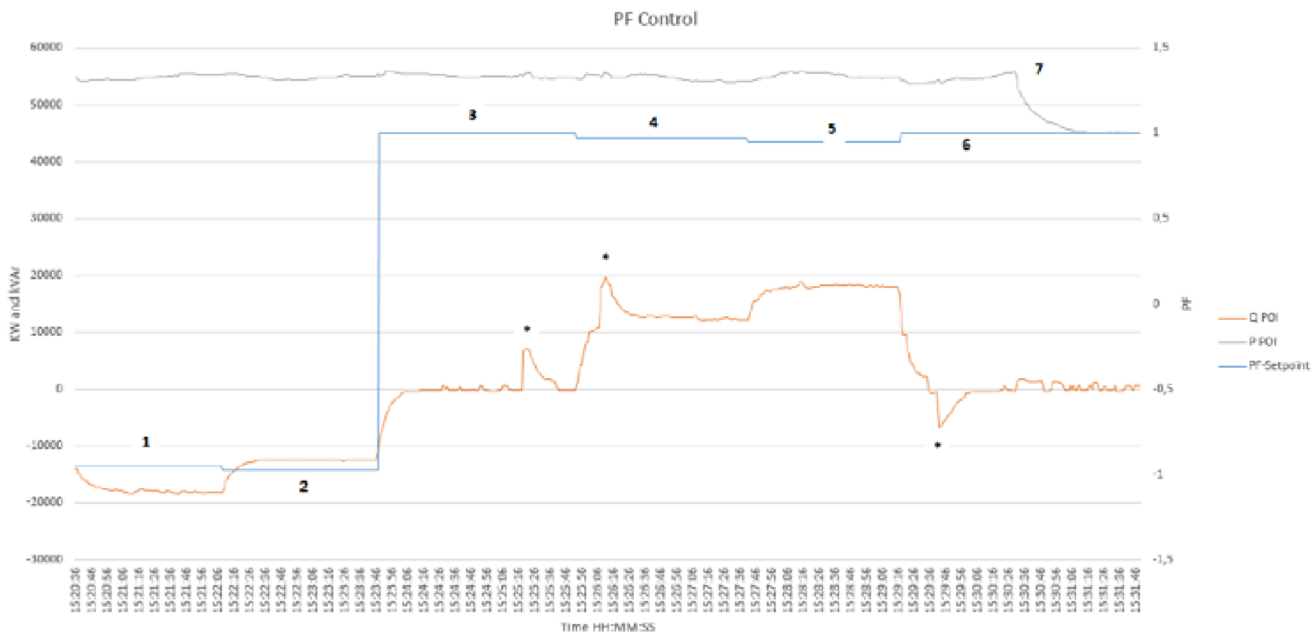
Once $Q^*_{pre\text{-}ramp}$ is obtained, it can be limited (or not, depending on the grid code) by a ramp rate limiter obtaining the desired reactive power at PCC, Q^*. At this point, if Q^* is capacitive, capacitor banks (if they are available) generate a major part of Q^*.

Power factor control diagram



The next figure shows an example of the power factor control performed by the GPM PPC.

GPM PPC **Power factor control example**



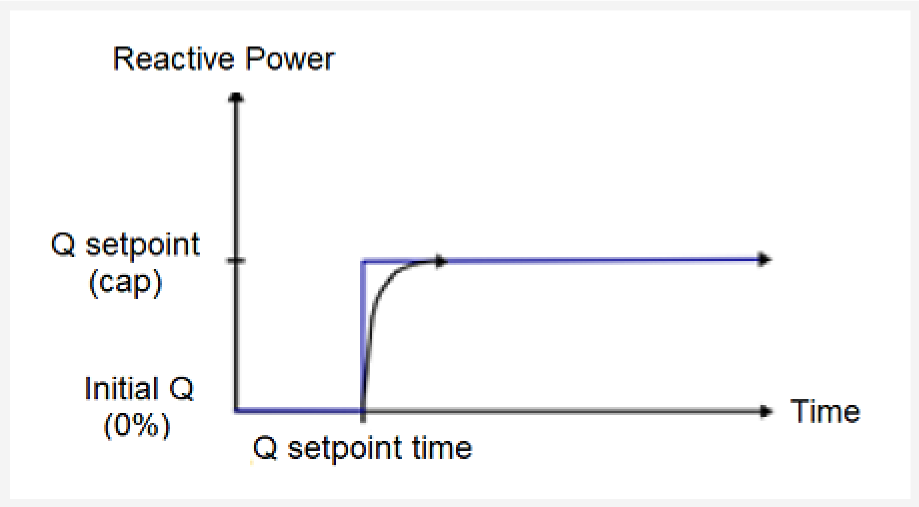
Reactive power control

The GPM PPC can achieve a reactive power setpoint imposed by the on-site operator, by sending commands with the necessary reactive power value to the inverters.

The GPM PPC uses reactive power measurements of the POI taken by the plant meter. The reactive power control works in relation with the maximum values of reactive power achievable (i.e., the saturation limits of the plant).

The figure below shows how the GPM PPC calculates the error when a new setpoint or a variation in the reactive power is given, and how it can curtail the actual reactive power output to a fixed or variable setpoint.

Reactive power control



The control is divided into three parts:

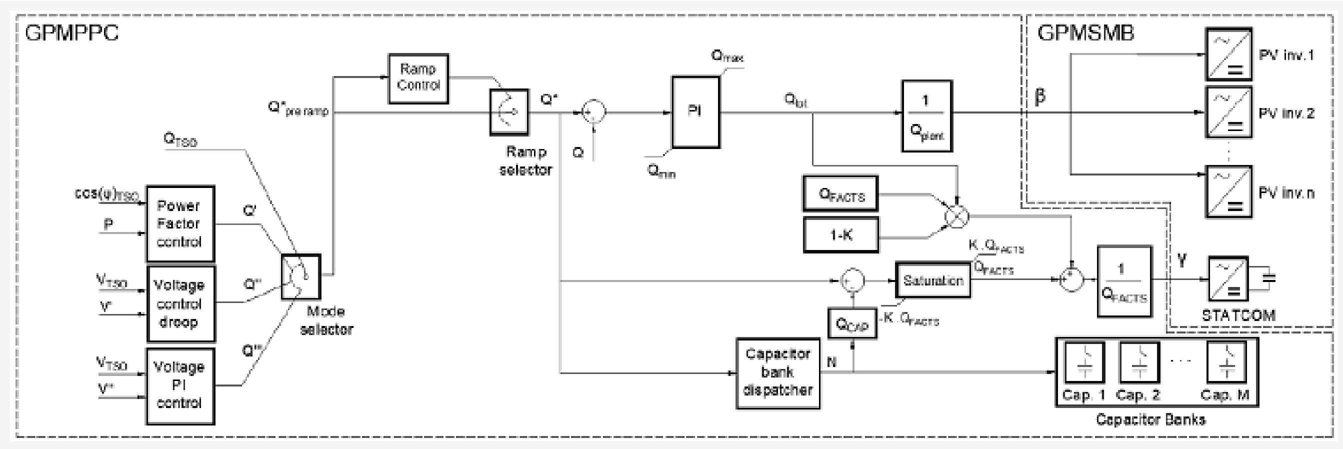
- Reference computation block: calculates the reactive power setpoint that must be achieved at POI.
- Controller:
- Dispatch system:

The non-windup makes the GPM PPC react faster to changes in references after a period of saturated operation.

The *QTOT* is divided by the plant maximum reactive power capability, being the result a per unit value, effective to every inverter. In every loop performed by the GPM PPC, the error is lower due to the fact that the commands sent in the previous loops are being accomplished by the inverter.

The reactive power control is performed by the GPM PPC similarly to the active power control. The next figure depicts its corresponding scheme.

PPC and SmartBridge reactive control strategy



FACTS devices

In addition to PV inverters, FACTS devices or capacitor banks are commonly found in a PV plant, so the control is designed for a generic PV plant which can contain all these elements. For this purpose, we established a priority criterion:

1. Capacitor banks are managed to deliver a major part of reactive power (only when capacitive power is required). These banks deliver discrete blocks of reactive power, so the fine regulation is performed by FACTS and PV inverters.

   FACTS have priority over PV inverters, as they are installed for this application. However, when a FACTS device reaches a specified level of reactive power (not necessarily its nominal power) the remaining amount of reactive power is delivered by both FACTS and PV inverters.

2. If the TSO sends a reactive power setpoint, *QTSO*, then Q**pre-ramp*=*QTSO*. When power factor setpoint is set, the corresponding desired reactive power is calculated as:

   $$Q*_{pre} - ramp = P \times \frac{\sin(\varphi)_{TSO}}{\cos(\varphi)_{TSO}}$$

3. Once Q* Is obtained, it can be limited (or not, depending on the grid code) by a ramp rate limiter obtaining the desired reactive power at Q*.

Voltage droop control

The GPM PPC can adjust the voltage at the POI through the plant's reactive power capability. The reactive power delivered is proportional to the voltage difference between a given setpoint and the actual voltage measured at the POI.

With the measurements of the voltage and reactive power at POI, the GPM PPC controls the voltage by sending a reactive power command to the inverters. The variation on the reactive power exchanged is given by a Droop characteristic.

Once the reactive power setpoint is generated, the GPM PPC controls the reactive power as explained in the section on Reactive Power Control (Q control).

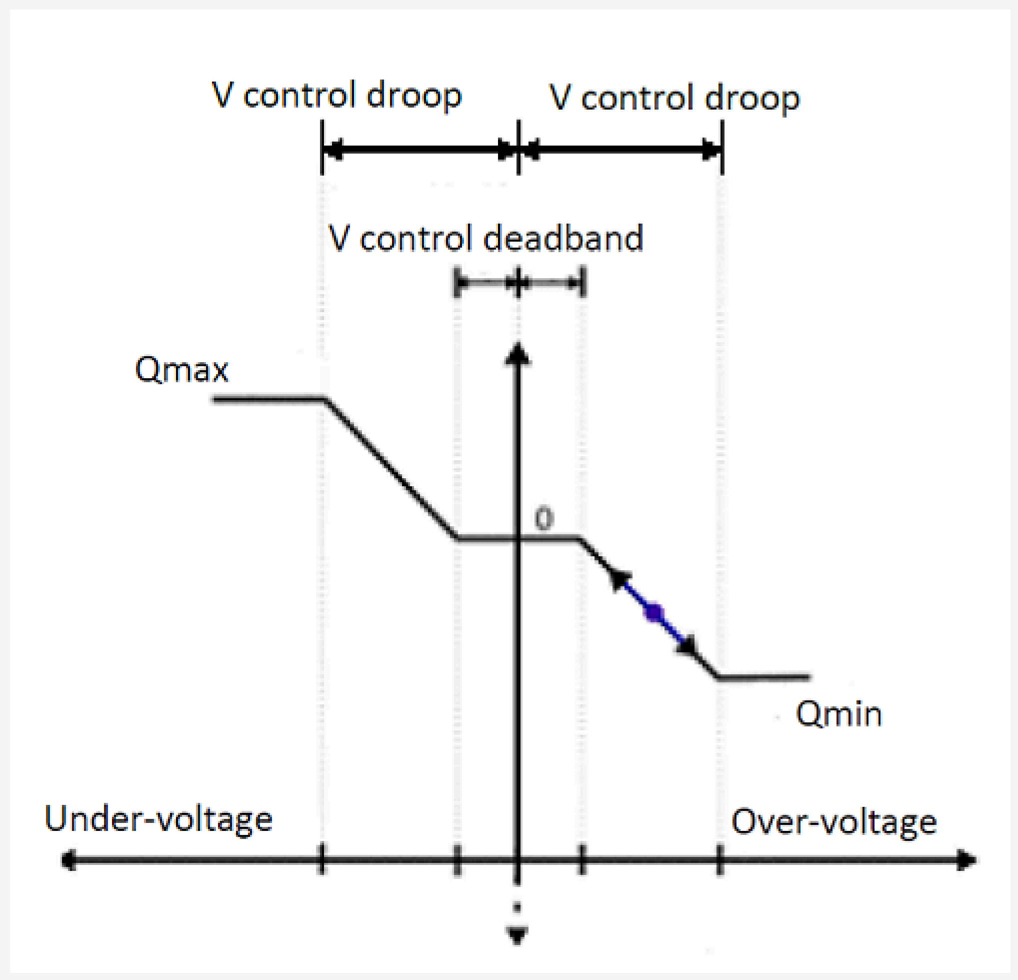
Depending on the voltage measured at the POI, the GPM PPC reacts following the configured droop characteristic. If the voltage grows over the nominal value in the measurement point, the plant must respond absorbing a reactive power value following the droop curve.

Unlike frequency regulation actions, voltage regulation actions do not require simultaneous operations to comply with the grid code (for example, reactive power setpoint plus voltage droop). The GPM PPC implements a mode selector to determine how to calculate the desired reactive power setpoint, $Q^*_{pre\text{-}ramp}$.

When a voltage droop mode is set, the $Q^*_{pre\text{-}ramp}$ is calculated according to a curve depicted in the figure below:

> ⓘ NOTE:
>
> In this case, due to the operation of the whole plant, it is necessary to filter the voltage measurement, *V*, to obtain the droop input, *V'*.

Voltage droop curve

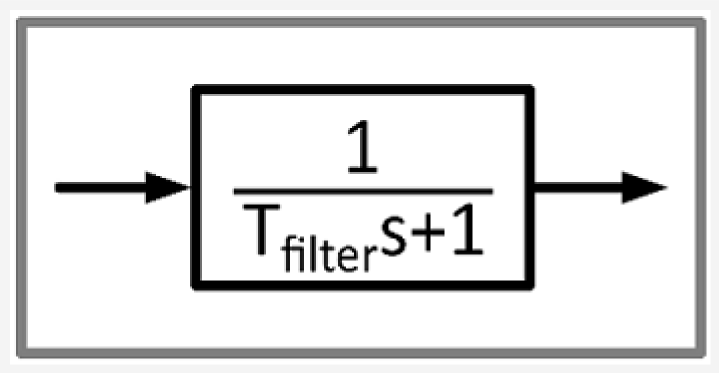


Filtering

Filtering avoids multiple connections/disconnections of the capacitor banks. Each connection of a capacitor bank provokes a voltage increase, decreasing Q' and the corresponding capacitor disconnection.

Applying the filter and a hysteresis to the capacitor bank dispatcher avoids multiple connections/ disconnections. When there are no capacitor banks, the time constant of the filter is set to 0.

First order filter for voltage measurements



The GPM PPC applies a closed loop control with a PI controller and droop characteristic to regulate the voltage measured in the POI using Reactive Power.

> ⓘ NOTE: When setting the reactive power limits for the overvoltage and undervoltage droops, both the maximum and minimum reactive power limits must be positive.

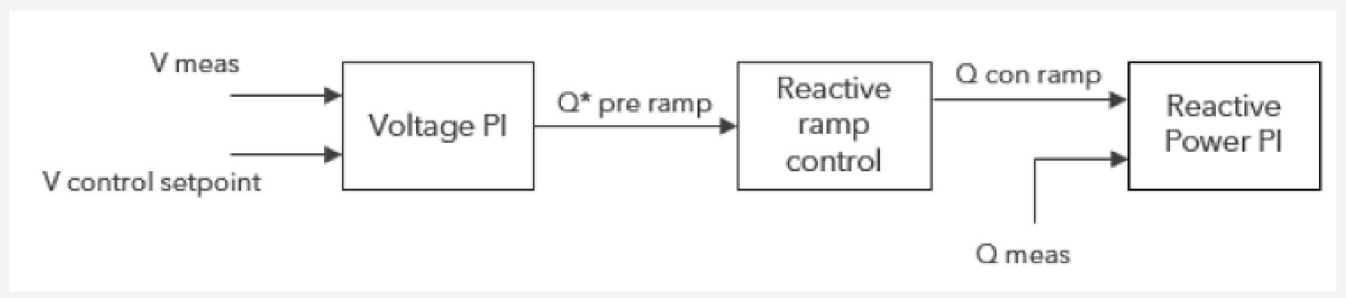
Voltage closed-loop PI controller

The GPM PPC can achieve a reactive power setpoint imposed by the on-site operator, by sending commands with the necessary reactive power value to the inverters.

As shown in figure Functional block diagram of the voltage PI controller, the GPM PPC calculates the error when a new voltage setpoint is given. The control is divided into the reference computation block, the controller and the dispatch system. The reference computation block calculates the reactive setpoint that must be achieved at POI in terms of the voltage setpoint requested.

Once the reactive power setpoint is generated, the GPM PPC controls the reactive power as explained in the section on Reactive Power Control (Q control).

Functional block diagram of the voltage PI controller



Night control mode

The GPM PPC can automatically detect that the night mode is enabled. It then executes the controls configured to work in this mode and send commands to the inverters with the necessary values for active and reactive power during the night-time.

> ⓘ NOTE: Night control mode can have different active and reactive power setpoints from the ones used during the day-time.

The night control mode has three levels of activation:

1. Overall night control mode flag.
2. Active and reactive control loops.
3. Different control modes, as needed.

Forced low power mode

Forced low power mode is useful when plants are set to produce very low active power values for testing purposes, or for short shutdowns. The GPM PPC detects that the active power setpoints are very low and not enter into night control mode, thus maintaining this intentional low power mode without activating any new setpoints. This activates a flag showing that the GPM PPC has entered forced low active.

To prevent unwanted dynamics when the active power setpoint is increased, the GPM PPC steps up the active power in two steps:

1. Enabling the active power PI control to initialize correctly.
2. Tracking of the active power setpoint.

Maximum apparent power mode

Maximum apparent power mode limits the maximum apparent power that plants can produce. To do this, the GPM PPC prioritizes either the active or the reactive power, and computes a limit for the non-prioritized power setpoint. A maximum apparent power (S) value can be configured into the parameters of the GPM PPC for this purpose. When prioritizing active power, Q_{MAX} is computed using the following expression:

$$Q_{MAX} = \sqrt{S_{MAX}^2 - P_{GEN}^2}$$

In maximum apparent powe rmode, the active power follows whatever setpoint is being produced at a given time. The reactive power must always be lower than Q_{MAX}. Similarly, when in Q priority, the maximum power (P_{MAX}) is computed using:

$$P_{MAX} = \sqrt{S_{MAX}^2 - Q_{GEN}^2}$$

Fault ride-through mode

Fault ride-through mode prevents new setpoints from being sent during a fault event, based on upper and lower fault voltage limits configured in the GPM PPC. The GPM PPC detects whether any of the phase voltages exceeds the upper and lower voltage limits and enter fault ride through mode.

When faults occur in the vicinity of the power plant, the voltage measurements at the point of interconnection (POI) may vary in ways that temporarily complicate grid operation. Most grid codes establish that plants must be capable of maintaining a certain setpoint during the fault and recovering control after the event ends. Due to the speed at which the plant must react to these faults, the inverters are required to produce the reactive power.

Generally, when the fault event ends, certain dynamics can be observed in the measurements at the POI. It is possible to configure a freeze time parameter in order to prevent any interactions with the GPM PPC regaining control over the plant. This freeze time determines when the GPM PPC starts sending new setpoints to the inverters after the voltage re-enters the normal operation zone.

Power oscillation damping control

Power oscillation damping (POD) control acts against inter-area power oscillation. When this mode is active, the GPM PPC analyzes the measurements at the point of interconnection (POI) and detects whether there is an oscillation within the desired frequency limits. After detecting an oscillation, the GPM PPC bypasses PI control and sends setpoints to the inverters in counterphase to the oscillation, thus increasing its damping ratio.

The GPM PPC can act both on the active power and the reactive power output of the plant for the POD control. If the GPM PPC is set to the active power POD control, the signal analysis and detection is performed on the frequency measurements at the POI. In contrast, reactive power POD mode be active uses the voltage measurement.

> ☆ IMPORTANT: For correct operation of the POD, the loop time of the
>
> GPM PPC
> must be at least 10 times faster than the period of the disturbance that is going to be damped. Otherwise, the GPM PPC may not be capable of damping the oscillation and even drive the system into instability.

Hybrid GPM PPC

The Hybrid GPM PPC can control both photovoltaic (PV) plants and battery energy storage systems (BESS) in real time. In contrast with single technology renewable plants which produce their power from only one centrally controlled power source, hybrid sites introduce increased complexity.

The different nature of the power provided by PV plants is strictly one-directional. When combined with the storage flexibility of the BESS, it allows for a large number of possible services and requirements. In this way, the hybrid GPM PPC architecture includes all the available control modes, enabling it to meet the requirements imposed by the TSOs, while managing the required active power at the POI by distributing it between the PV plant and the BESS.

The hybrid GPM PPC adds an additional control architecture which distributes the power setpoint of the GPM PPC between the BESS and the PV inverters, while allowing site operators to choose between different control modes and functionalities. These hybrid control modes provide increased flexibility to the operation of the power plant, and allow the user to manage the power output of the BESS following different criteria.

The control modes and functionalities he hybrid GPM PPC are:

- Modes:
  - Bess dispatch: BESS operated independently; PV regulates POI.
  - Fast frequency response: instant frequency support provided by the BESS.
  - PV-BESS coordinated: PV generation prioritized; BESS regulates POI.
  - Active power reserve: configurable percentage of available power reserved for grid support.
  - Arbitrage/Bidding: BESS activation following a bidding request.
- Functionalities:
  - BESS and PV power limitation: hard limit imposed to minimum and maximum BESS output power.
  - SoC limit derate: imposes maximum and minimum SoC for the BESS.
  - Balancing SoC: balancing functionality for the BESS battery racks.

BESS dispatch

In BESS dispatch mode, the hybrid GPM PPC maintains a determined active power setpoint at the point of interconnection (POI), imposed by the control of the regular GPM PPC, while at the same time allowing the site operator to independently control the behavior of the BESS.

The operator can manage the BESS output power using three different sub-modes:

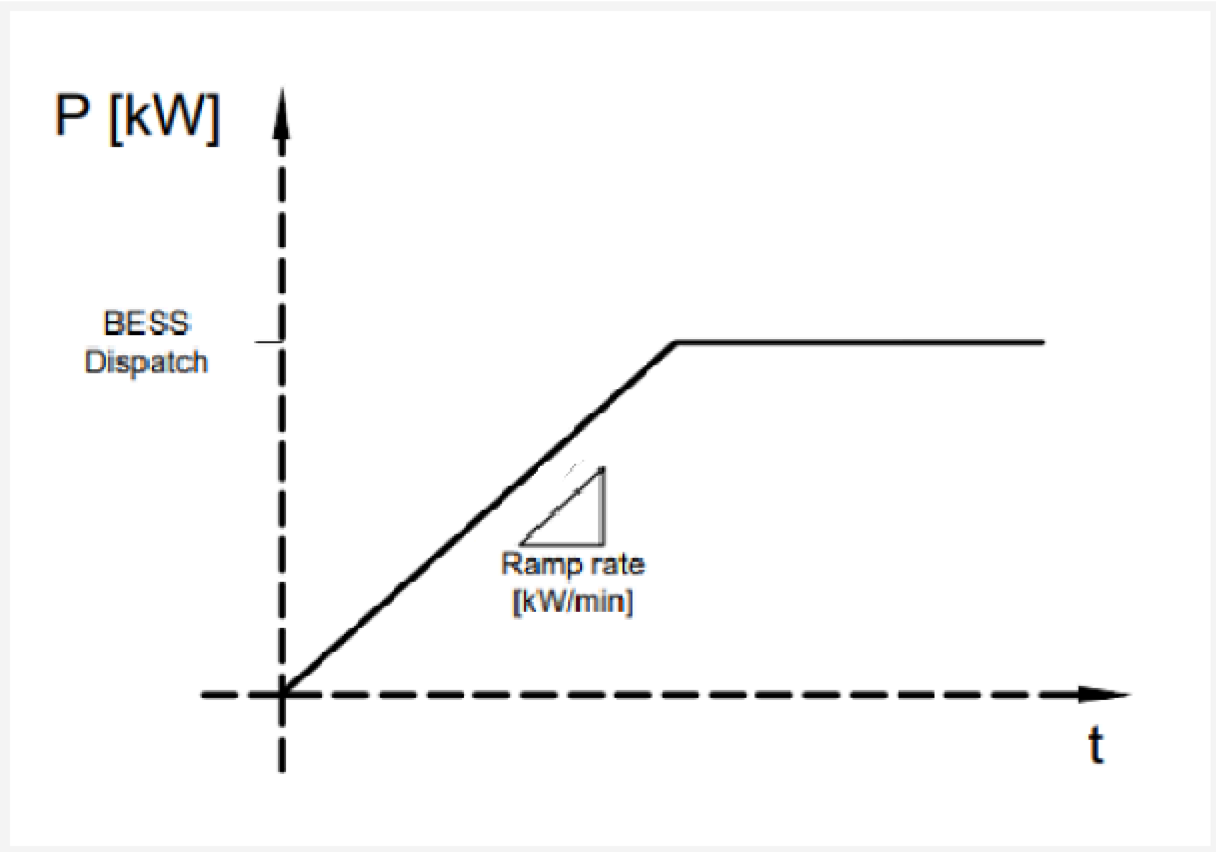
- Regular dispatch: determines a BESS dispatch value for the system.
- SoC droop sub-mode: the average state of charge of the BESS remains equal to a reference value.
- SoC target sub-mode: defines an average SoC target for the BESS system, and the time duration which the charging/discharging process takes to achieve the desired SoC value

During the operation of the BESS dispatch mode, the hybrid GPM PPC regulates the active power setpoint sent to the PV inverters to control the injected power at the POI.

Regular dispatch

In regular dispatch sub-mode, site operators can determine a BESS dispatch value in [kW] for the system to follow. To achieve a smooth active power change at the point of interconnection (POI), it is possible to configure a BESS ramp rate in [kW/min].

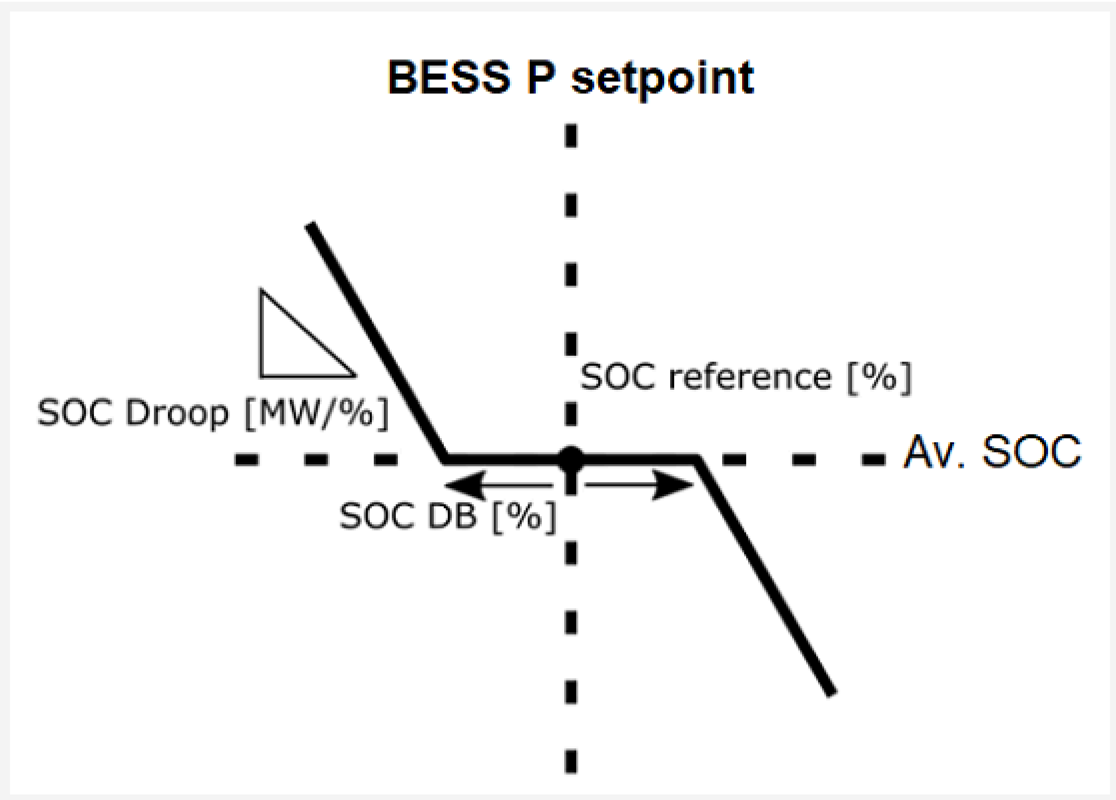
Regular dispatch



SoC droop

The SoC droop sub-mode maintains the average state of charge (SoC) of the BESS, equal to a reference value determined by the site operator. The hybrid PPC regulates the charging/ discharging rate at which the BESS operates depending on how far the instantaneous SoC is from the reference value. This way, the droop parameters (for example,the SoC reference value [%] or the SoC droop rate [kW/%]), are fully configurable, as well as a certain death-band [%], in which the BESS active power setpoint is null.

SoC droop mode dispatch

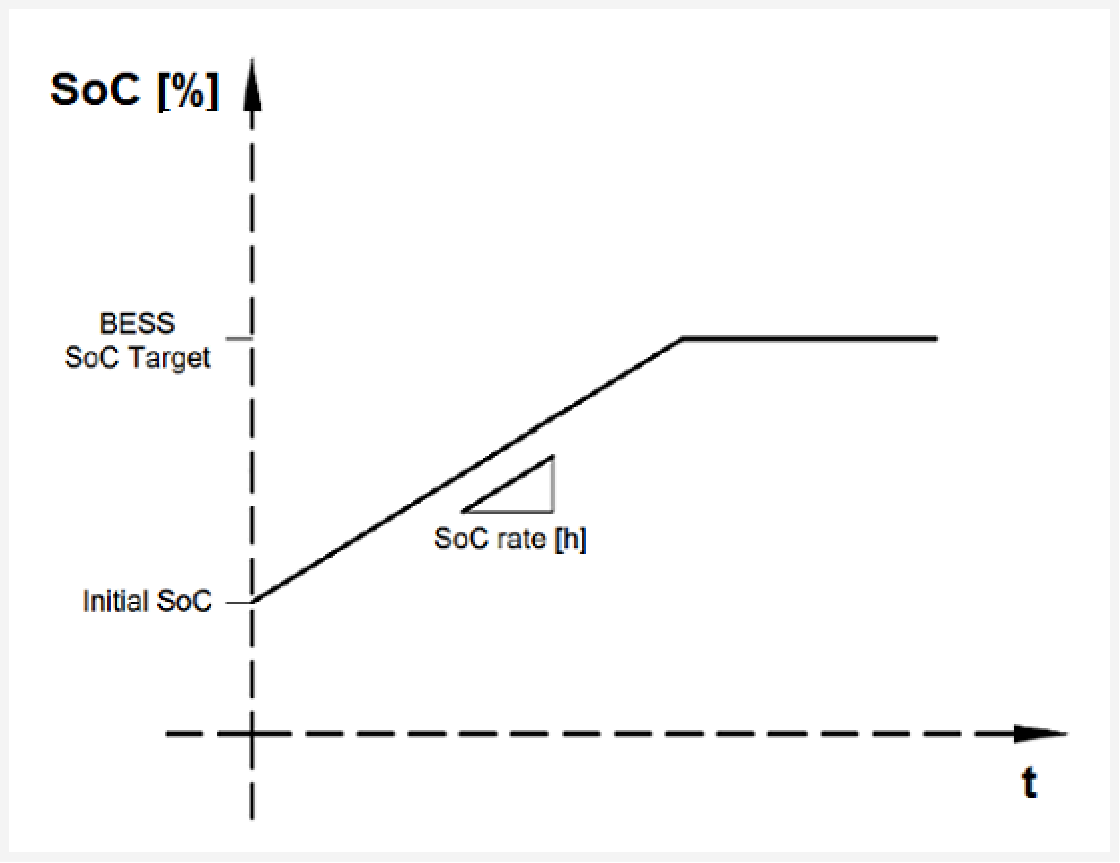


State of charge target

In state of charge (SoC) target sub-mode, site operators can define an average SoC target (%) for the BESS system and the time duration (h). The charging/discharging process of the BESS uses these values to achieve the desired SoC value. The hybrid PPC determines the active power setpoint required for the BESS to fulfill the site operator command, which remains constant until the target is reached. Once the instantaneous SoC is equal to the target value, the BESS system shuts down, maintaining the requested SoC value.

Additionally, site operators can fix the BESS output power (kW) at which the system is charged/discharged until the SoC target is achieved, instead of imposing the time duration of the process.

SoC target mode



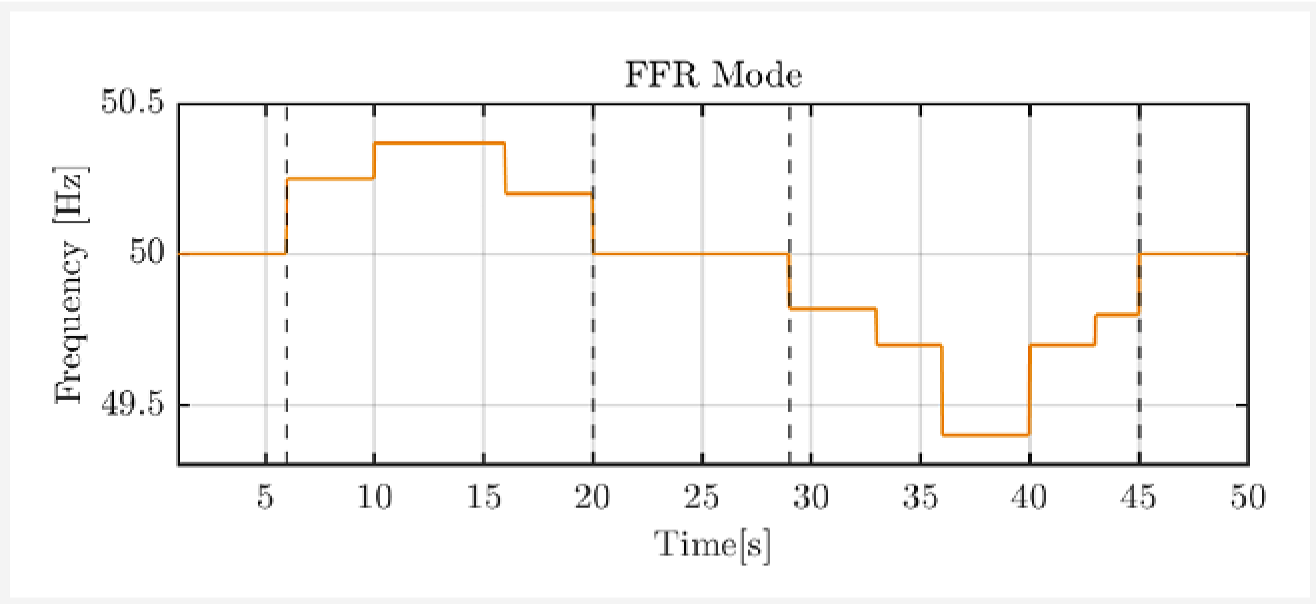
Fast frequency response

The fast frequency response (FFR) mode offers grid support to regulate frequencies exclusively using the BESS, while maintaining the PV generation undisturbed. While the system operates within the nominal frequency range, the PPC active power setpoint is provided exclusively by the PV inverters, while the BESS remains shut down. When the system detects a frequency event, the frequency droop of the PPC instantly determines the required increase (in case of underfrequency) or decrease (in case of overfrequency) of output power at the POI. Simultaneously, the BESS is triggered to provide a very fast response to supply the increase or decrease of active power determined by the PPC. In this way, the BESS provides the whole power differential, while the active power setpoint sent to the PV inverters is frozen during the frequency event.

Although the BESS is responsible for providing the support needed for frequency events in FFR mode, an additional parameter allows the site operator to decide whether the power decrease needed at the POI during an overfrequency event is provided by the BESS operation, or whether it is provided by the curtailment of the PV generation. In this case, the BESS would only operate to offer grid support during underfrequency events, providing the increase of active power needed to mitigate the event.

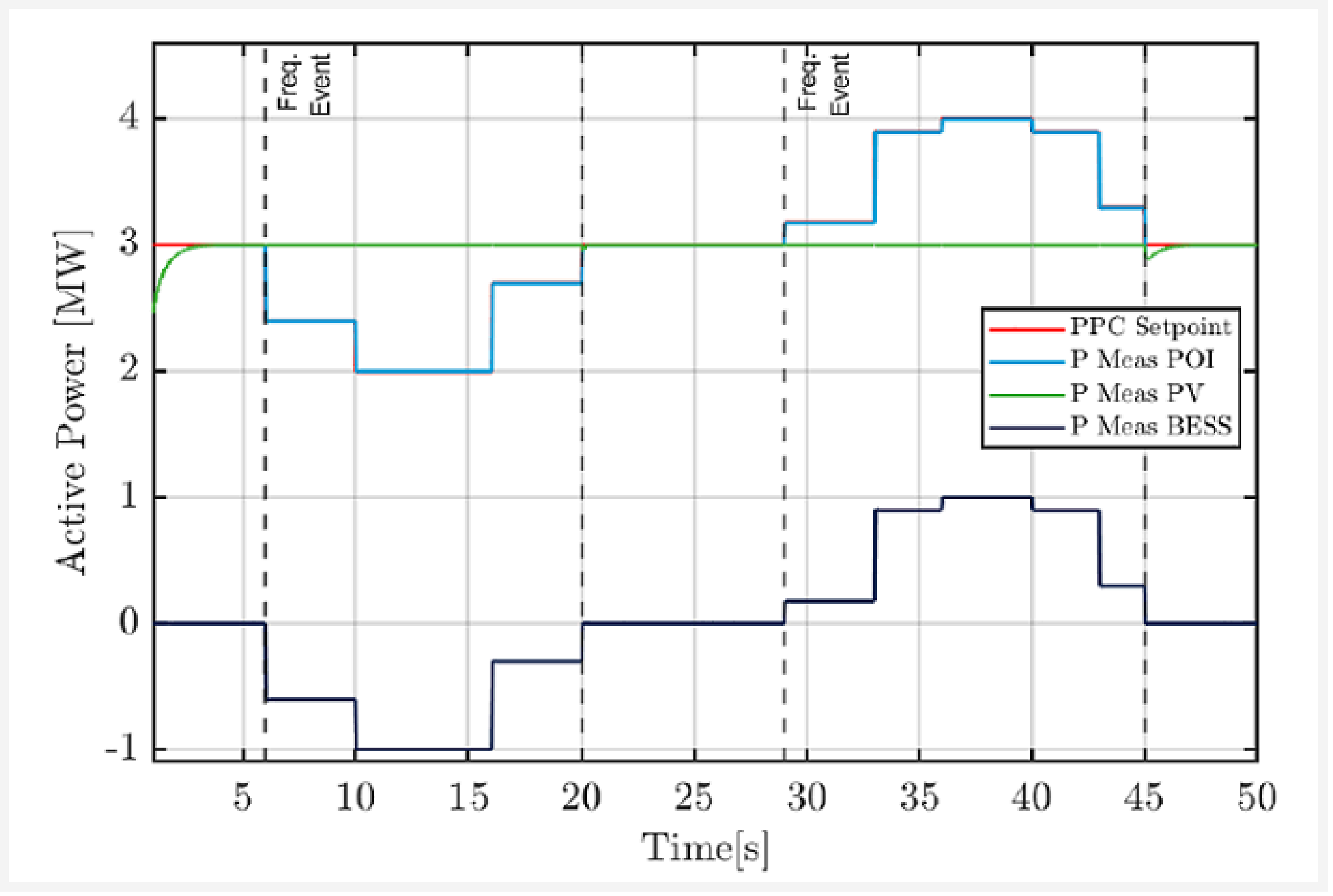
Simulate frequency FFR mode

Simulate Frequency FFR Mode



Active power response in FFR mode

Active Power Response in FFR Mode



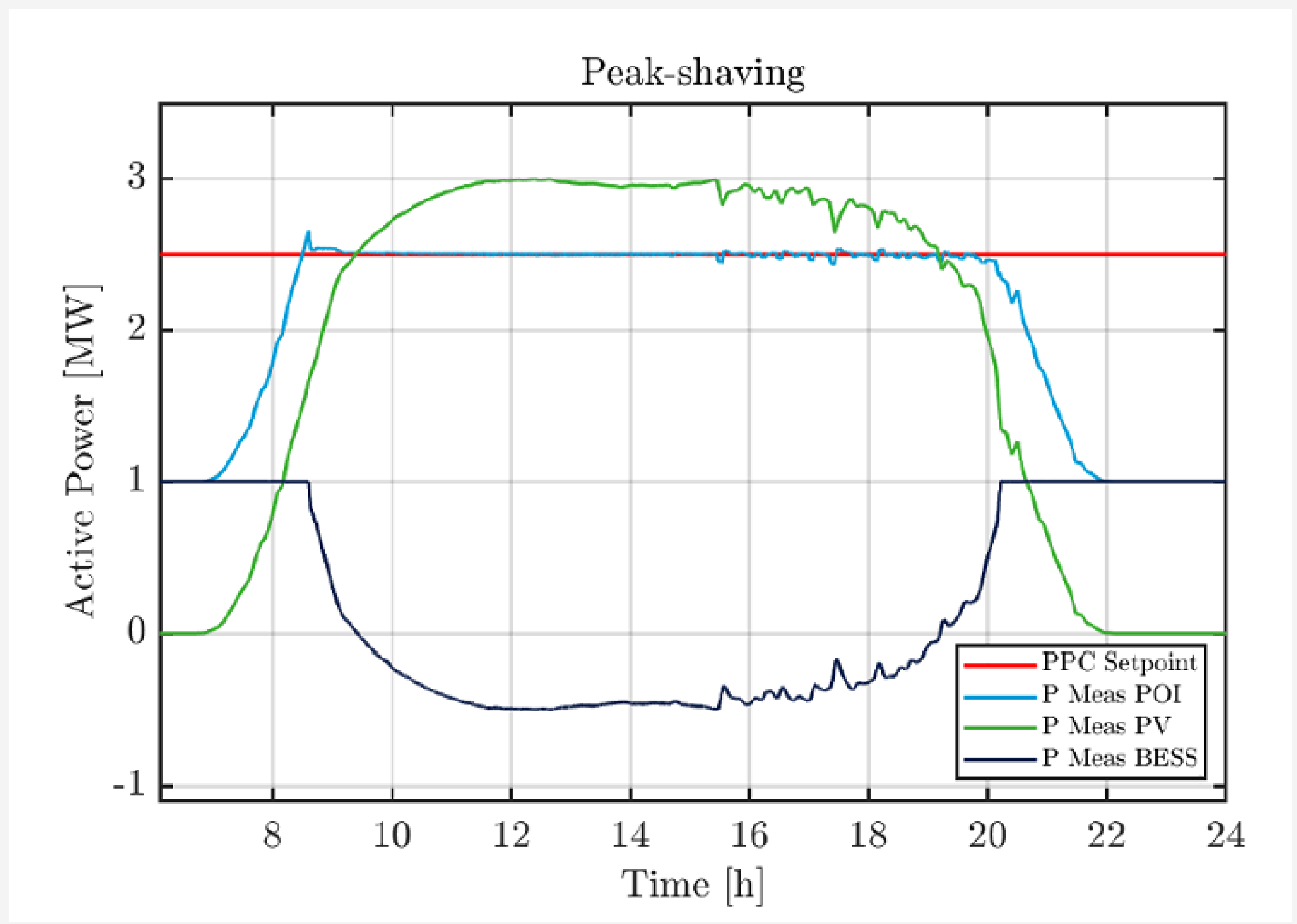
PV-BESS coordinated mode

The PV-BESS coordinated mode controls the hybrid plant by using the BESS to comply with the PPC setpoints, while minimizing the curtailment of photovoltaic (PV) generation. This prioritizes PV generation, while using the BESS to regulate at the point of interconnection (POI), by charging or discharging when needed. The PV generation is only curtailed when:

$(P_{PPC,\ POI} + P_{BESS,\ min}) < P_{PV}$

This operational mode allows plant operators to perform various services (for example, peak shaving), as well as to favor the maximum PV generation at any time, while complying with the POI active power requirements during frequency events, or during the activation of power ramps.

Peak shaving capabilities



The ability to configure the BESS operational limits regarding maximum power of charge/ discharge is especially useful for this operational mode, since the plant operator can decide whether to perform the peak-shaving service by only charging the BESS, or by not discharging the BESS until a certain moment of the day.

Active power reserve

The active power reserve mode allows site operators to reserve a certain amount of power while storing excess energy, ensuring an efficient hybrid power plant management. When a frequency event is detected, the full active power capacity of the plant is deployed to respond and offer full grid support.

The active power reserve mode is based on the same working principle as the PV-BESS coordinated mode, with the reservation of a configurable percentage of the total active power developed by the plant. In this way, the generation of the system follows a determined power setpoint sent by the PPC by minimizing the PV generation curtailment. A certain percentage of active power generated, fixed by the site operator, is absorbed by the BESS. Consequently, the power flow at the point of interconnection (POI) remains below the maximum instantaneous capacity of the hybrid plant.

Arbitrage/Binding

The arbitrage/bidding mode freezes the PV setpoint, and the BESS is used exclusively to rapidly fulfill the required setpoint at the point of interconnection (POI). This operational mode is similar to the fast frequency response (FFR) mode, since the BESS shuts down unless a bidding process is activated (in the FFR, this is a frequency event). In this manner, the system can follow the bidding request for a short period of time without any unwanted dynamics between the BESS and the PV generation.

> ⓘ NOTE: This mode should only be activated when the bidding is taking place.

BESS and PV power limitation

The BESS and PV power limitation GPM's Hybrid PPC independently modifies the maximum charging and discharging active power limit of the BESS. In this way, site operators can manually set a hard limit to the output power of the BESS, by imposing a value below the nominal power of the device.

If no limit is imposed, the nominal active power limits of the BESS remains fixed. Additionally, it is also possible to configure the maximum PV power capacity, to define a hard limit for the PV generation.

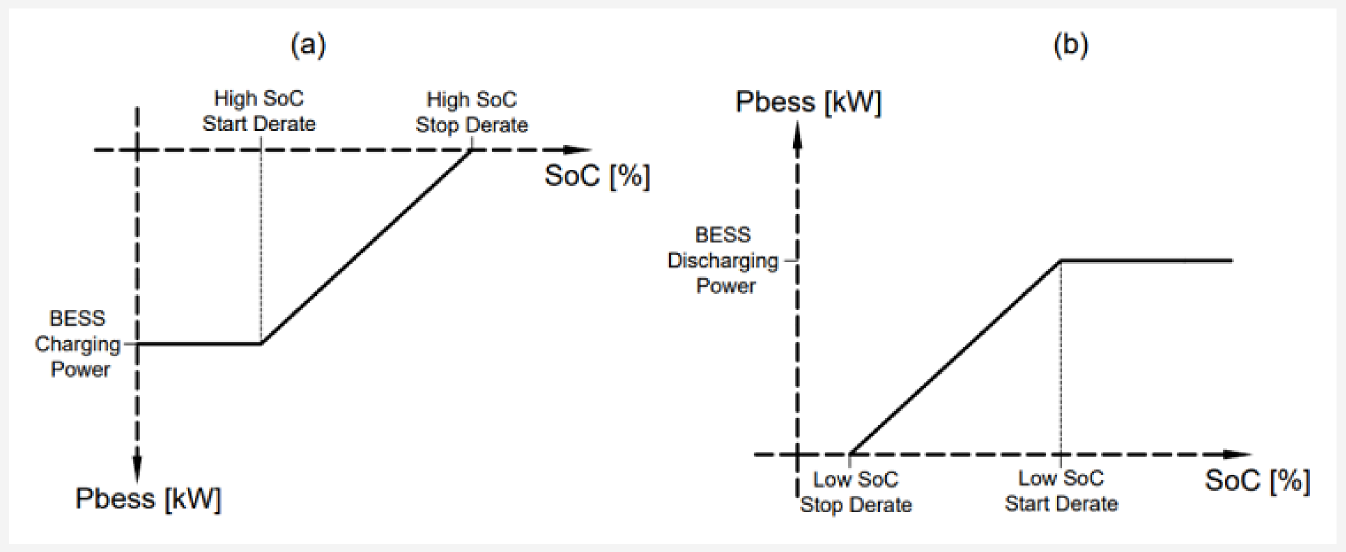
SoC limit derate

The state of charge (SoC) limit derate functionality consists of the gradual limitation of the maximum charging or discharging active power of the BESS, depending on the instantaneous SoC of the battery racks.

Battery suppliers tend to set limits to the operation of the BESS when certain SoC limitations are reached, forcing the battery rack out of service. If no additional control is applied, a given control mode could request maximum power from the battery that suddenly reaches the lower or higher SoC limit, causing a big power step as the BESS active power output reaches 0.

To prevent this unwanted behavior, the SoC limit derate functionality gradually limits the maximum active power output of the BESS once the SoC of the battery rack reaches a value configured by the site operator. In this way, the maximum charging/discharging power of the system is linearly reduced, until the maximum allowed SoC is reached. The figure below illustrates how the functionality prevents the BESS from causing an active power step by limiting the maximum charging power (a) and the maximum discharging power (b):

SoC limit derating capabilities



Site operators can independently enable or disable the charging and discharging SoC derate. They can also define the "start" and "stop" SoC values at which the control block operates.

If both the SoC limit derate and the BESS power limitation functionalities are enabled, the hybrid PPC applies the most restrictive limitation.

Balancing SoC

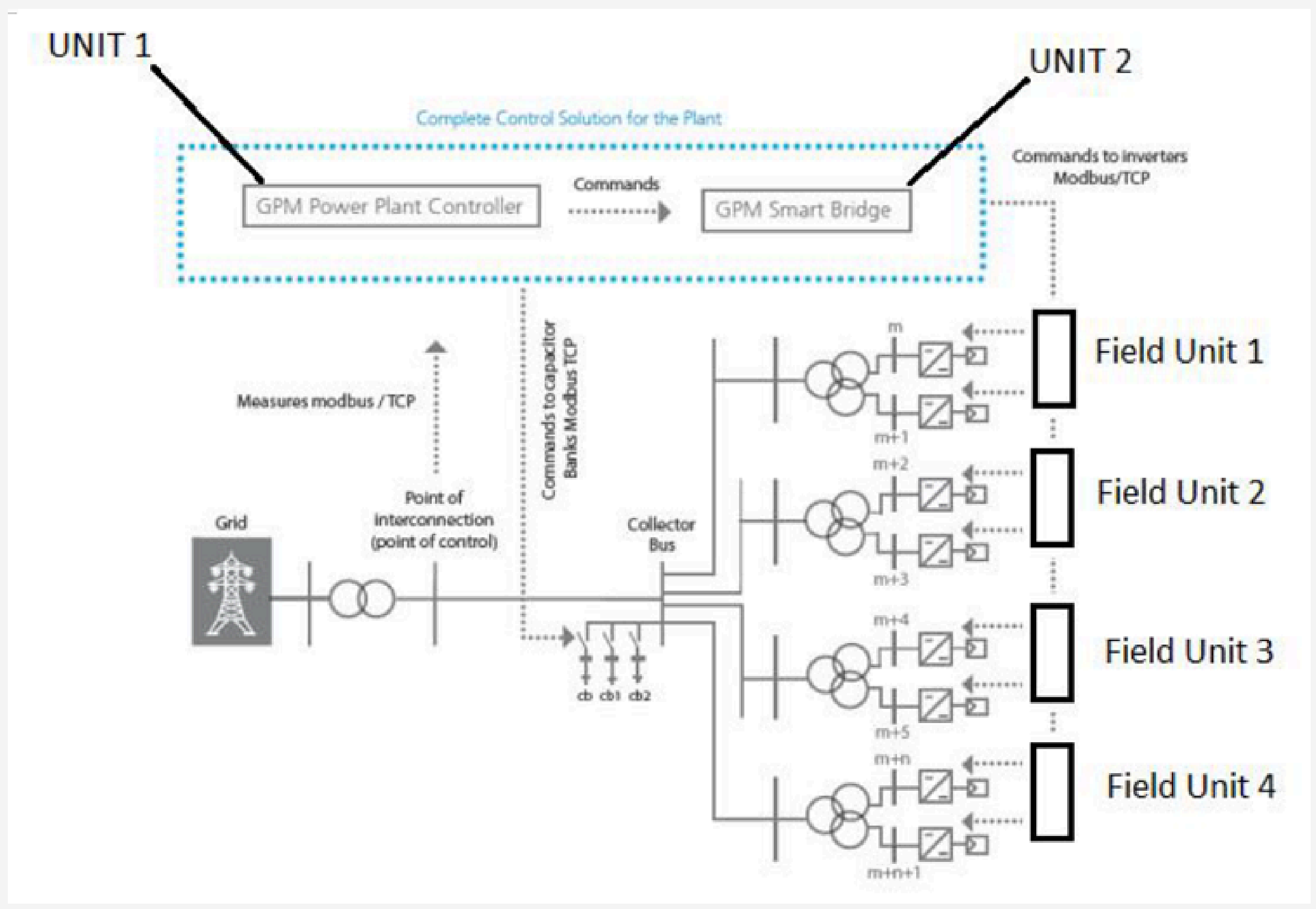
The balancing state of charge (SoC) functionality consists of the homogenization of the SoC of the different battery racks that compose the BESS. This control block distributes the BESS active power setpoint between the different BESS inverters, depending on the SoC of each individual sub-system, thus balancing the system and obtaining a homogenized average state of charge.

Site operators can activate or deactivate the balancing SoC functionality of the system. If this control block is deactivated, the individual active power setpoint sent to the BESS inverters is equal for all sub-systems.

Hardware

The GPM PPC is composed normally by two hardware units, but this is not the only solution, other configurations may be applied.

A typical plant configuration



In fact, the GPM PPC needs all the other RTUs in the field:

UNIT 1	UC-8112	Power Plant Controller
UNIT 2	UC-8112	RTU SMB and other connection/adaptation SW, like SMB, Cap Banks
All the Field RTUs	UC-8112	Running Moxa process inside.

- The PPC can also be commanded using PV+ but a windows machine is needed anyway to configure it.

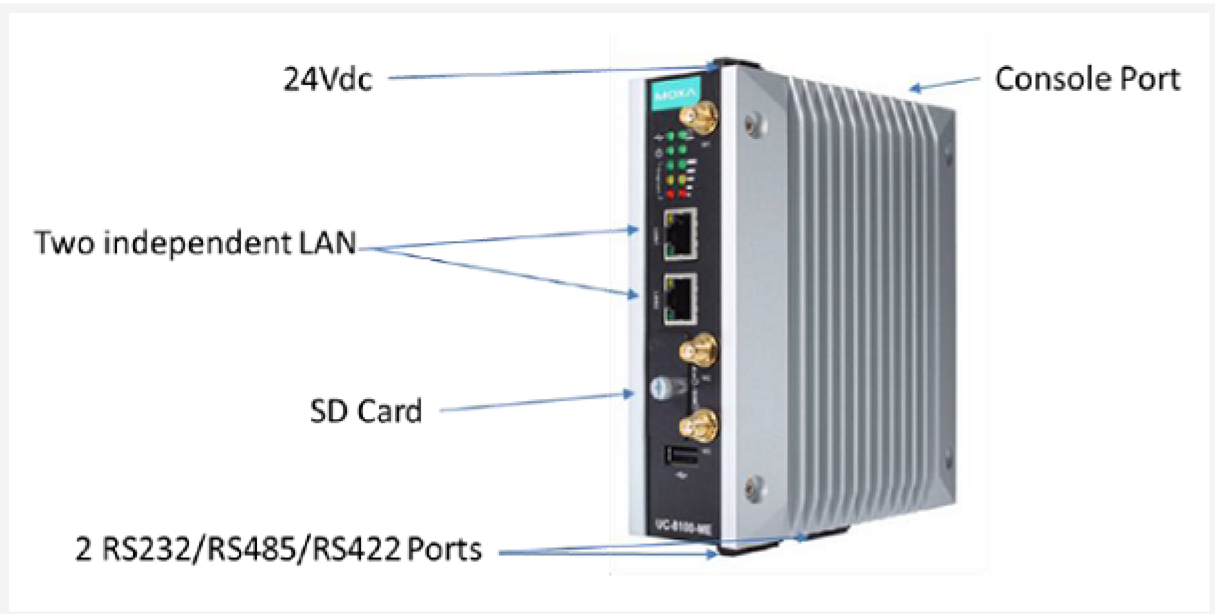
- The PPC UNIT Runs the Algorithm. Closed loop and PI controller.
- The RTU Smart Bridge Unit adapts the Setpoints (P and Q orders) to the inverters.
- The Cap Banks SW adapts also how the Capacitor banks need to be commanded.
- The Configuration of the RTU SMB allows the SW "know" the Number of Inverters and "where" they are.
- The RTU SMB sends a UDP message inside the LAN of the plant. This means that all the devices in the plant will receive this message (the infield IA240/ UC-8112). They will transmit this order to the inverter using Modbus RTU/TCP.

Moxa UC8112 RTU / DAM

Main characteristics:

- Two independent LAN:
  - For internet access.
  - To acquire data from TCP devices.
  - LAN2 only used when the moxa needs to be in two different ranges or LAN.
- SD:
  - Normally 16Gb to store data if internet access is down.
  - Stores backups or other information.
- Console port:
  - RS232 used with specific Moxa Cable.
  - Allows direct connection with putty.
- 2 RS232/RS485/RS422:
  - Software configurable.
  - Internal selectable pull up (jumper) for RS485/RS422, configured upon reception.
  - NOT isolated.
  - Retrieves data from devices CLOSE to the UC8112. Never for field buses (strings, trackers, distance sensors).

Moxa UC8112 – RTU / DAM



Servers

The recommended server model to use with the GPM PPC is the HPE ProLiant DL380 Gen10. It is possible to use other server models, because the server characteristics depend on the project requirements.

HPE ProLiant DL380 Gen10 Server

External equipment

The primary external equipment with which the GPM PPC interacts are inverters. GPM provides a list of recommended meters, which have been tested for compatibility.

Meters

The following meters are tested and recommended by GPM for use with the PPC:

Janitza UMG511	PowerLogic PM511x
Janitza UMG605	PowerLogic PM5310
Janitza UMG96RM	PowerLogic PM5320
Janitza UMG96S	PowerLogic PM5330
PowerLogic ION6200	PowerLogic PM5340
PowerLogic ION7x50	PowerLogic PM5350
PowerLogic ION73xx	PowerLogic PM556x
PowerLogic ION7400	PowerLogic PM8000
PowerLogic ION8600	SATEC PM1xx
PowerLogic ION8650	SEL 735
PowerLogic PM1200	

ⓘ NOTE: Other meter models are also compatible with the GPM PPC, with specific Modbus maps.

User interfaces

GPM offers two different interfaces for users to interact with the GPM PPC:

- GPM SCADA.
- GPM HMI PPC.

These interfaces allow you to interact with the plant through the GPM PPC Modbus map, where you can test the communications with the meter and manage the different controls by enabling or disabling them, and sending different setpoint commands.

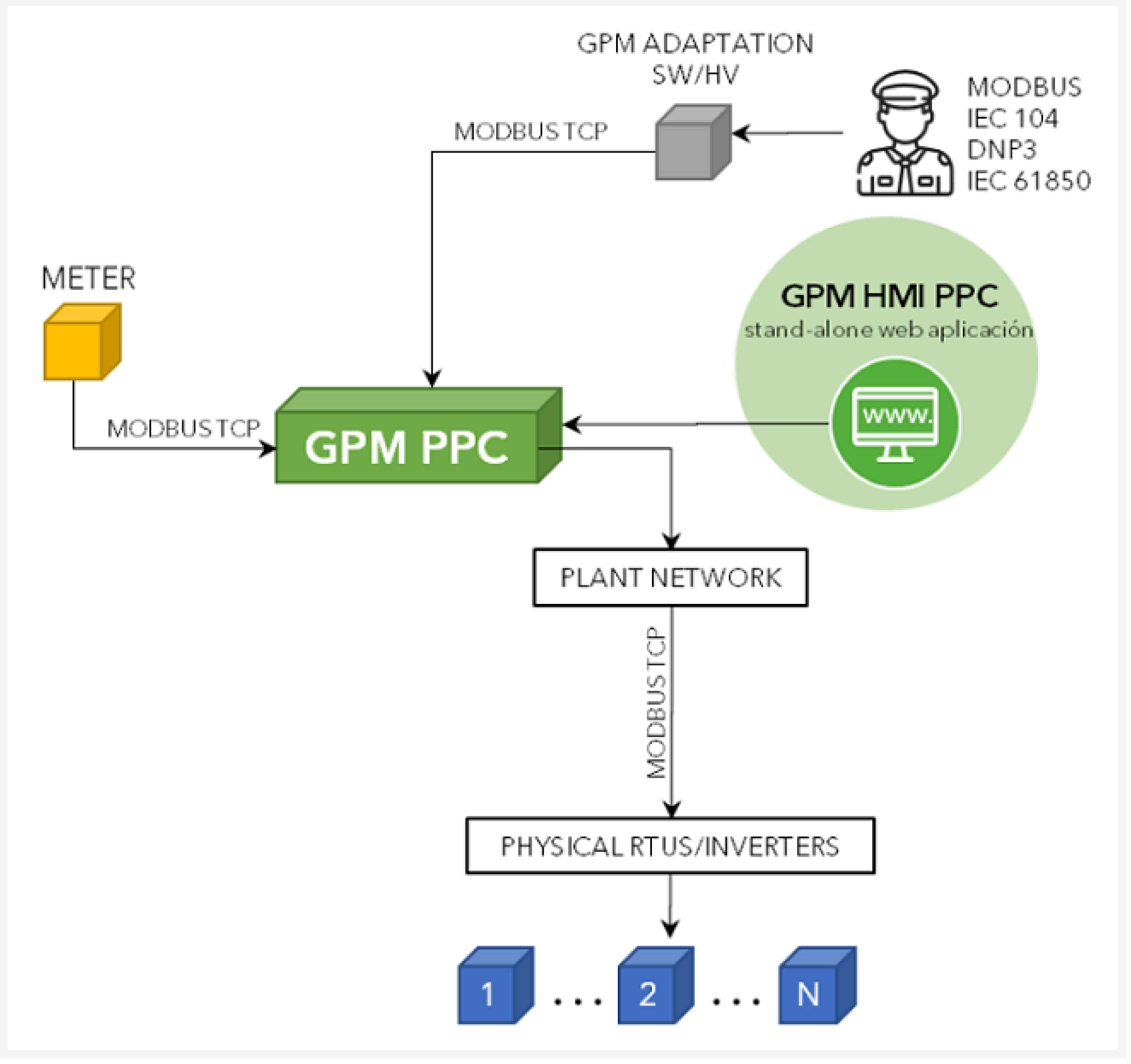
> ⓘ NOTE:
>
> It is also possible to interact with the GPM PPC through a third-party SCADA.

GPM SCADA

GPM SCADA is a local, in-plant supervisory control and data acquisition management solution that allows you to control individual devices and execute full-plant commands, while also providing real time (1-second) data for all parameters. GPM executes commands for device and plant controls with local GPM SCADA servers.When combined with the GPM PPC, GPM SCADA can meet any defined control requirement needed a renewable energy plant.

General scheme for field configuration with GPM SCADA

Example of the field configuration when the GPM SCADA is used



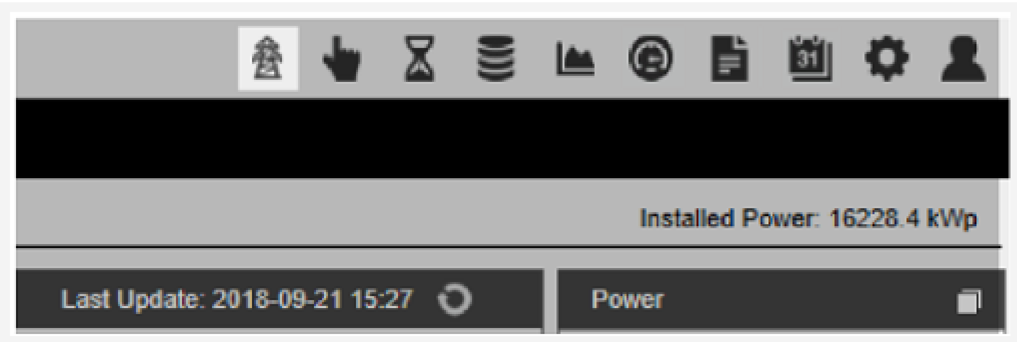
Design of the User Interface

The Power Plant Control (PPC) allows you to control your plant by sending commands to its physical devices.

The PPC module also contains tools to monitor your plant's performance without leaving the interface, providing you with all the necessary tools to take quick decisions and act accordingly.

To access the PPC, click the icon on the Upper Bar.

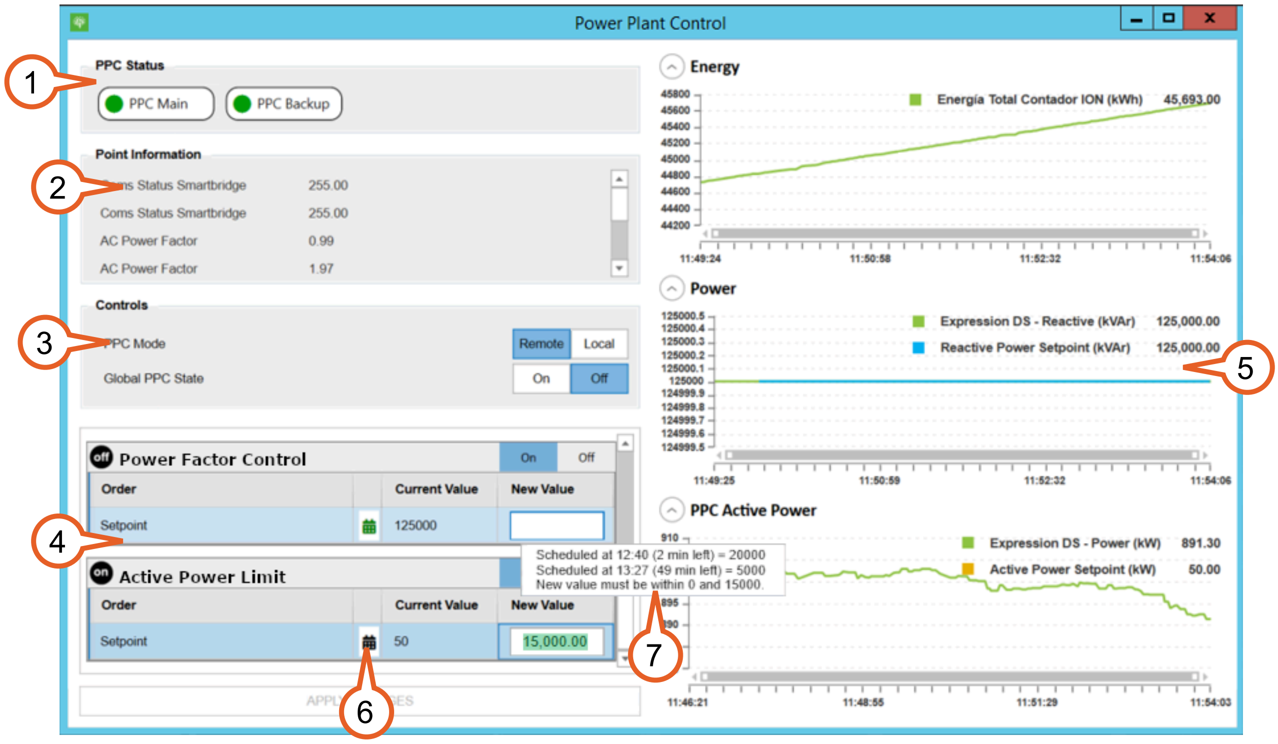
Power Plant Controller view



> ⚠ CAUTION: Use extreme caution and follow all the safety procedures before performing any action from the PPC module. These actions directly impact the plant.

> ⚠ CAUTION: For security reasons, actions taken in the PPC module are protected by a password and stored in the application log.

PPC module



1. PPC Status: displays the communication status of the PPCs installed in the plant.
2. Point information: displays a pre-configured set of parameters that allow you to monitor your plant's performance.
3. **Quick controls**: click to change the PPC Mode and the Global PPC Status.
4. **Set point controls**: control your plant performance by sending Set Point values to your PPCs.

   Click **Apply Changes** to send the values to your PPCs.
5. Live charts: monitor your plant's performance in real time to see the effect of the Set Points values that you send to the PPCs.
   You can drag and drop on a chart to zoom in and collapse and expand graphs using the ⌄ and ⌃ icons.
6. icon: displays the status of the scheduled command. If you click it, you can access the **Scheduler** dialog, where you can view and edit the scheduled command.
7. Active schedules: if you hover over the *New Value* input box, a tooltip containing information about the active schedules appears.

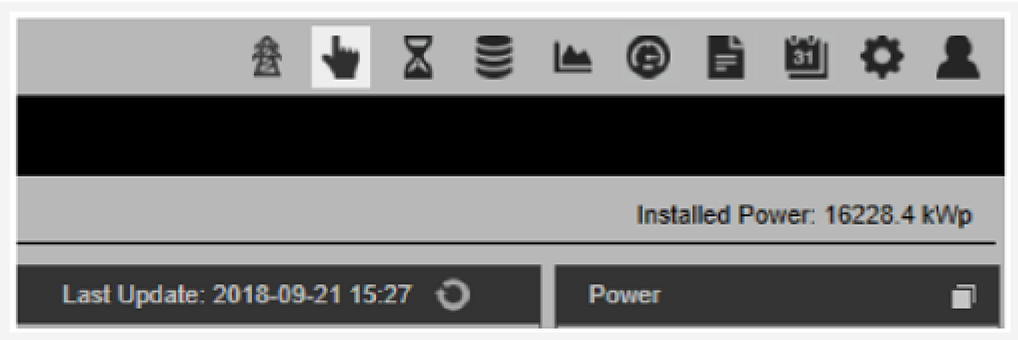
Commands control view

The Commands Control view allows you to monitor, manage, and send pre-configured command sequences to the physical elements in your portfolio. The module is divided in three tabs:

- Commands
- Command History
- Command Retry Queue

To access the Commands Control module, click the icon on the Upper Bar.

Commands Control view

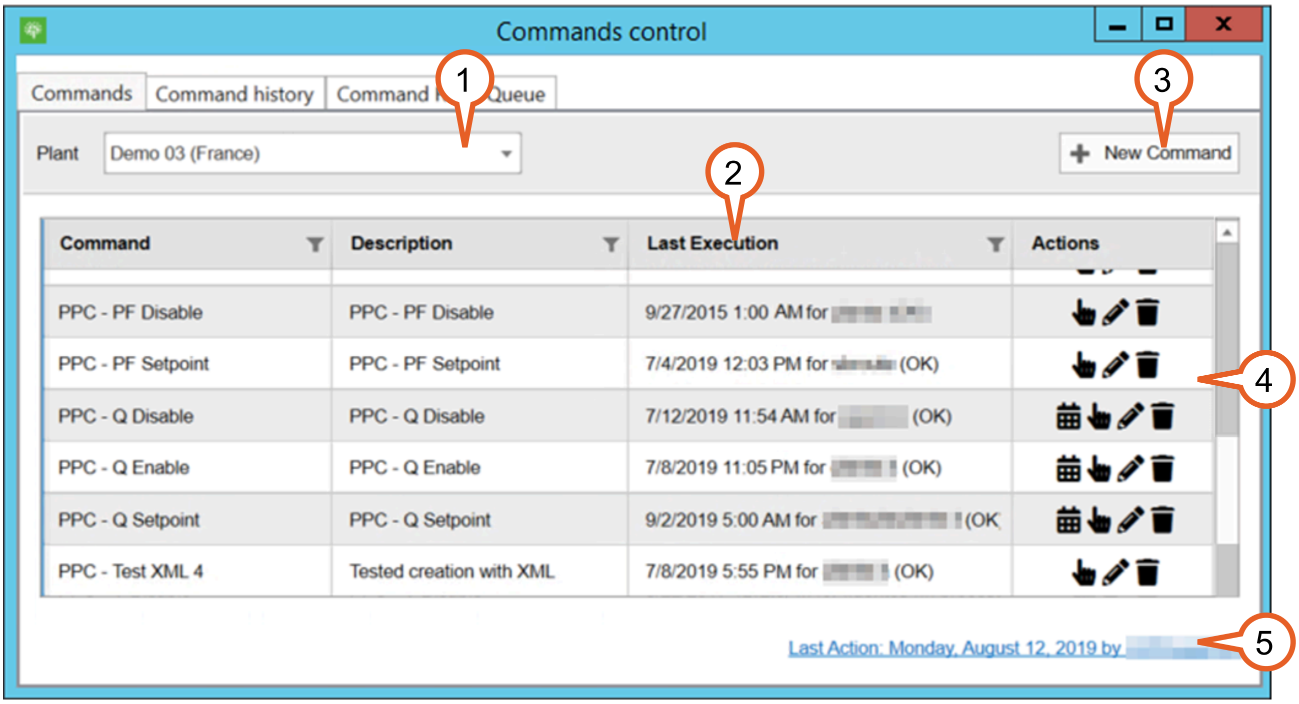


> ⚠ CAUTION: Follow all the safety procedures before performing any action from this module. These actions directly impact the plant.

> ⚠ CAUTION: For security reasons, actions taken in the Commands Control module are protected by a password and stored in the application log.

Command tab

Commands tab



1. **Plant selection**: click to select a plant from the drop-down list to display the available commands.
2. Commands list: displays the available commands for the selected plant.

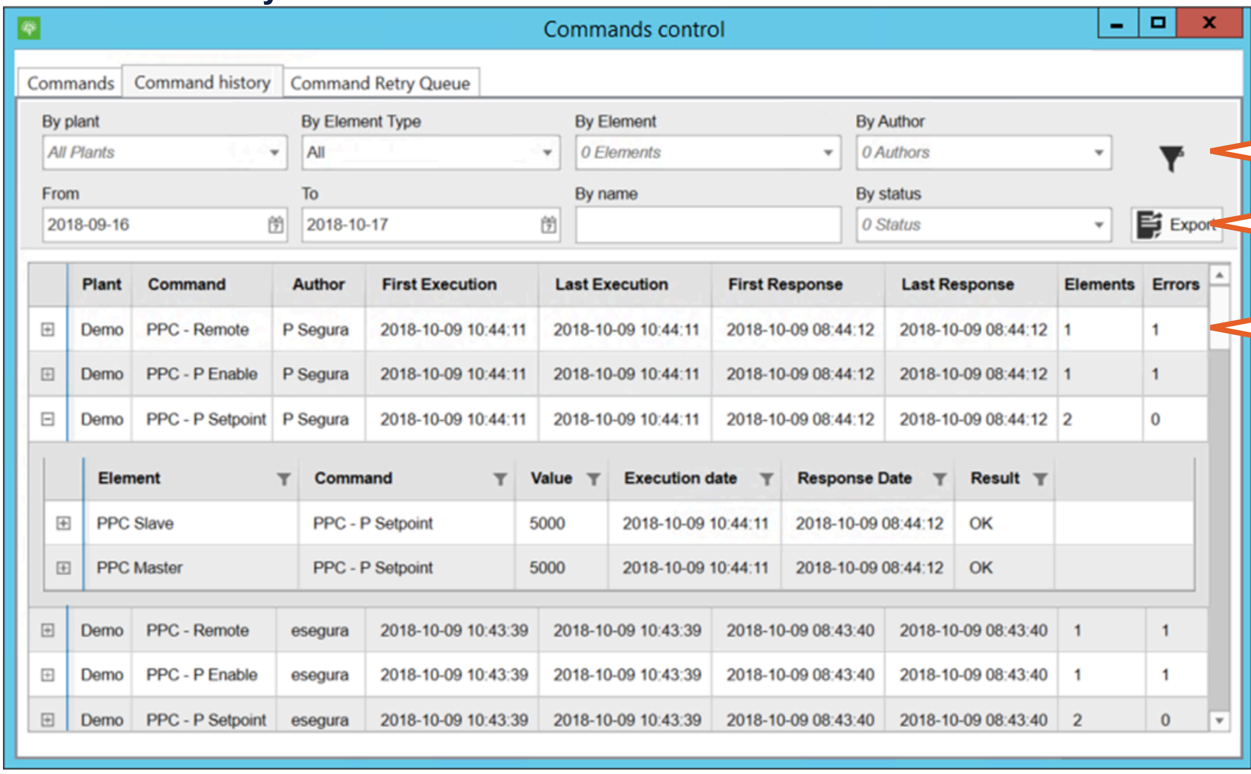
   Click a column header to sort the table by the values of that column. Rearrange columns by dragging and dropping the headers. Click the icon on any column header for advanced filtering.
3. **New command**: click to create a new command sequence. For further information, contact your GPM representative.
4. **Action buttons**:
   - **Execute** the command.
   - **Edit** the command sequence.
   - **Delete** the command.
   - **View or edit** the scheduled command.
5. **Last action**: displays the date and the user who made the last changes to the Command Controls view.

   Clicking the hyperlink takes you to the Action Log.

Command history tab

The Command History tab allows you to see the history of the commands that have been executed and export this information.

Commands History tab



1. **Filter**: select the filtering criteria and click to display commands that match the criteria on the list.
2. **Export**: click to export the list to a Microsoft Excel format.
3. Commands list: click a column header to sort the table by the values of that column. You can rearrange columns by dragging and dropping the headers.

Command retry queue tab

The system can be configured to resend a command when it is not possible to communicate with the device.

The Command Retry Queue tab displays the commands that are queued for a retry when they fail to be sent. If you do not want the system to retry sending a command, you can delete it from the retry queue.

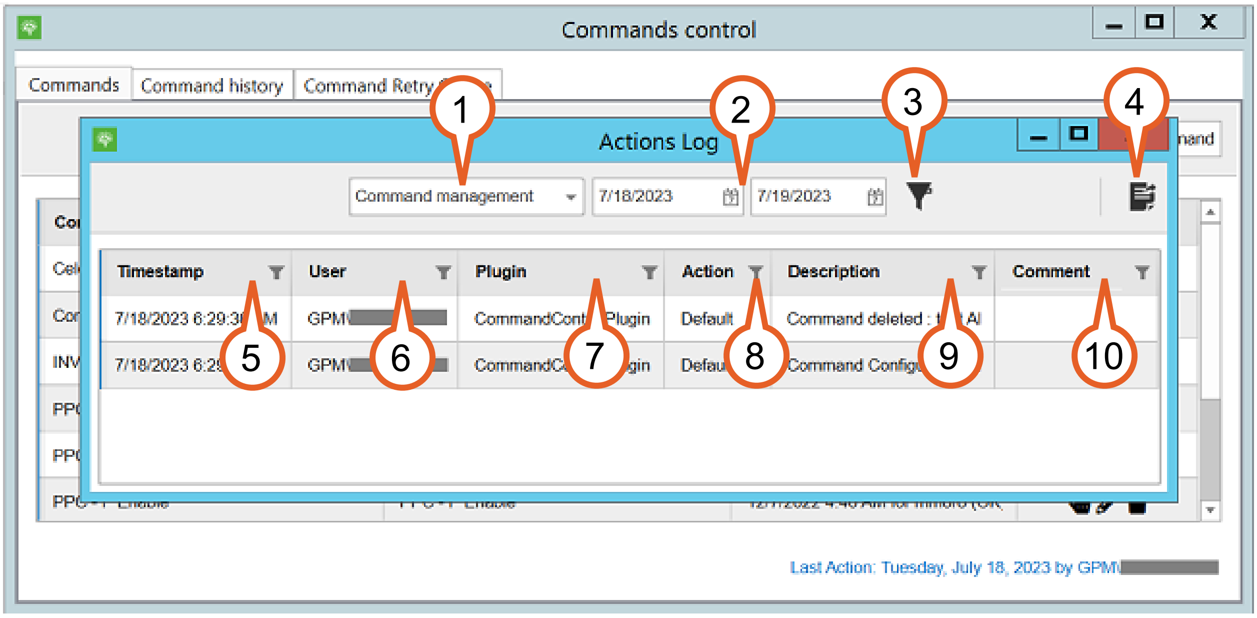
> ⓘ NOTE: The Command Retry Queue tab is only available for plants with multiple PPCs.

Clicking the hyperlink takes you to the Actions log.

Actions Log

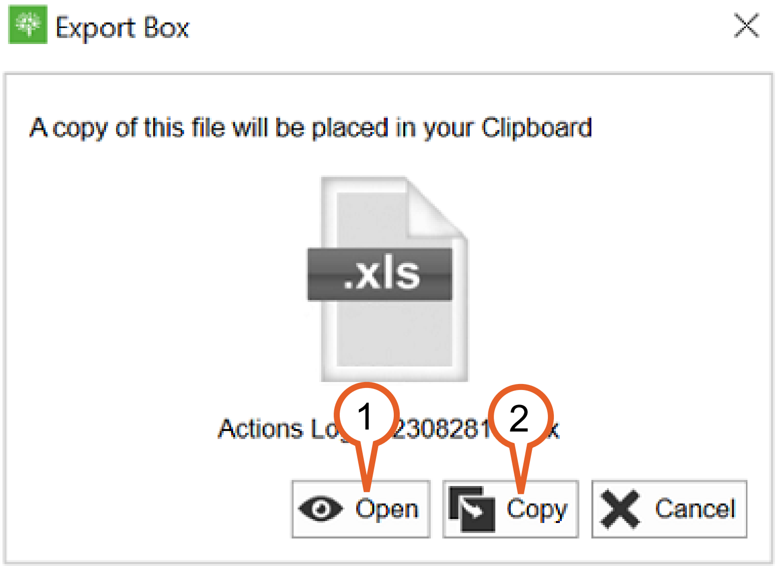
The Actions log records all users activities in the system. It includes action timestamps, user identification, action descriptions and classification by modules.

Actions log



1. Module: filter the actions by module.
2. Calendar:filter by the dates selected in the calendar.
3. Filter: apply the module and calendar filters.
4. Export: access the Export Box to view or download the Actions log.
5. Timestamp: date and time when the action was performed.
6. User: user that performed the action.
7. Plugin: plugin related to the action.
8. Action: type of action.
9. Description: brief description of the action.
10. Comment: comments related to the action.

Actions log export



1. Open: see the Actions Log in XLS format.
2. Copy: download an XLS copy of the Actions log onto your Clipboard.

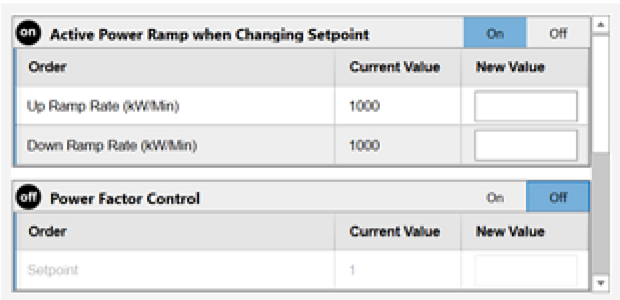
Send Setpoints Values from Power Plant Control View

To send a set point value to a plant, follow these steps:

⚠ CAUTION: Use extreme caution and follow all the safety procedures before performing any action from the PPC module. These actions directly impact the plant.

1. On the **Set Point Controls** panel of the Power Plant Control module, identify the set point that you want to control and click **On** to enable it.

Set Point Controls panel



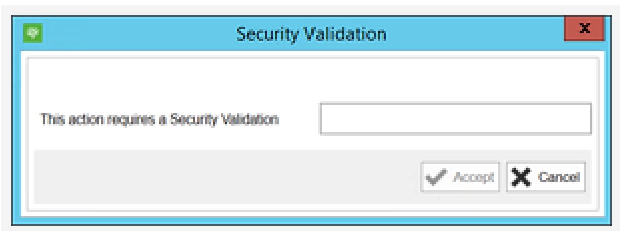
2. In the *New Value* field, enter the new value.

ⓘ NOTE: The application automatically suggests the last value entered.

3. Click **APPLY CHANGES**.

Result: The **Security Validation** dialog appears:

Security Validation dialog



4. On the **Security Validation** dialog, enter the administrator password and click **Accept**.

ⓘ NOTE: If you do not have the administrator password, contact your GPM representative

Result

The set point value is sent to the plant.

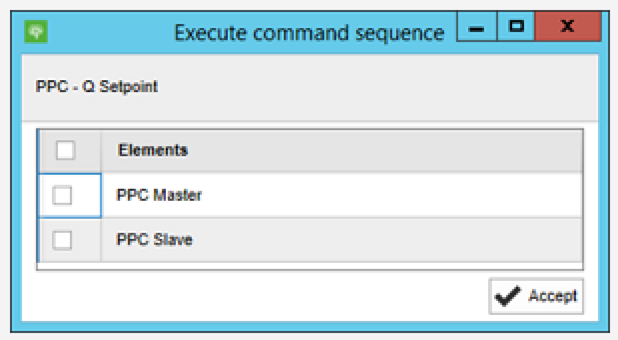
Send command sequences

To send a command sequence from the Commands Control view, follow these steps:

⚠ CAUTION: Follow all the safety procedures before performing any action from this module. These actions directly impact the plant.

1. In the **Actions** column of the command sequence, click the icon.
2. (Optional)) If your command affects multiple devices, on the **Execute Command Sequence** dialog, select the devices to which you want to send the command sequence and click **Accept**:

Execute Command Sequence dialog

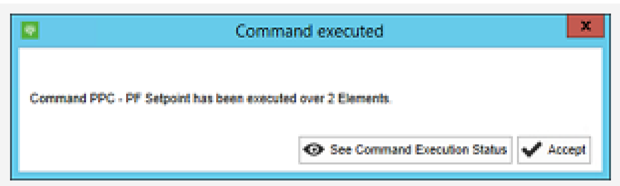


3. On the **COMMAND EXECUTION** dialog, enter the administrator password and click **Accept**.

Result

The command sequence is sent to the selected elements and a confirmation message appears:

Command execution confirmation



To check if the command sequence is successfully sent, click **See Command Execution Status**. This takes you to the Command History tab of the Commands Control module and displays the history of the related command. If you want to close the dialog, click **Accept**.

GPM HMI PPC

The GPM HMI PPC is a stand-alone web application that runs through the embedded service of the controller. This service allows you to control your plant by sending commands to physical devices.

The user interface of the GPM PPC contains tools to monitor your plant's performance without navigating away from the interface, providing you with all necessary tools to take quick decisions and to act accordingly.

About GPM Power Plant Controller and RTUSmartBridge2

The GPM Power Plant Controller is a secondary power plant control. With the RTUSmartBridge2 service, the GPM PPC manages the power flow determined by the external operators and how to divide the total active and reactive power by each element. These services use the different RTUs distributed by the plant to communicate with each active or reactive devices (power inverters or capacitors banks).

Power plant control types	
Primary	Regulates individual inverters to work as a source of current or voltage.
Secondary	Manages the energy quality of the plant in reference to the point of common connection (PCC), also known as point of interconnection (POI).
Tertiary	Eetermines how much energy must be provided to the grid, taking in account the state of the grid. It is usually managed by the national grid operator, which can also consider the options of connection or disconnection of the plant.

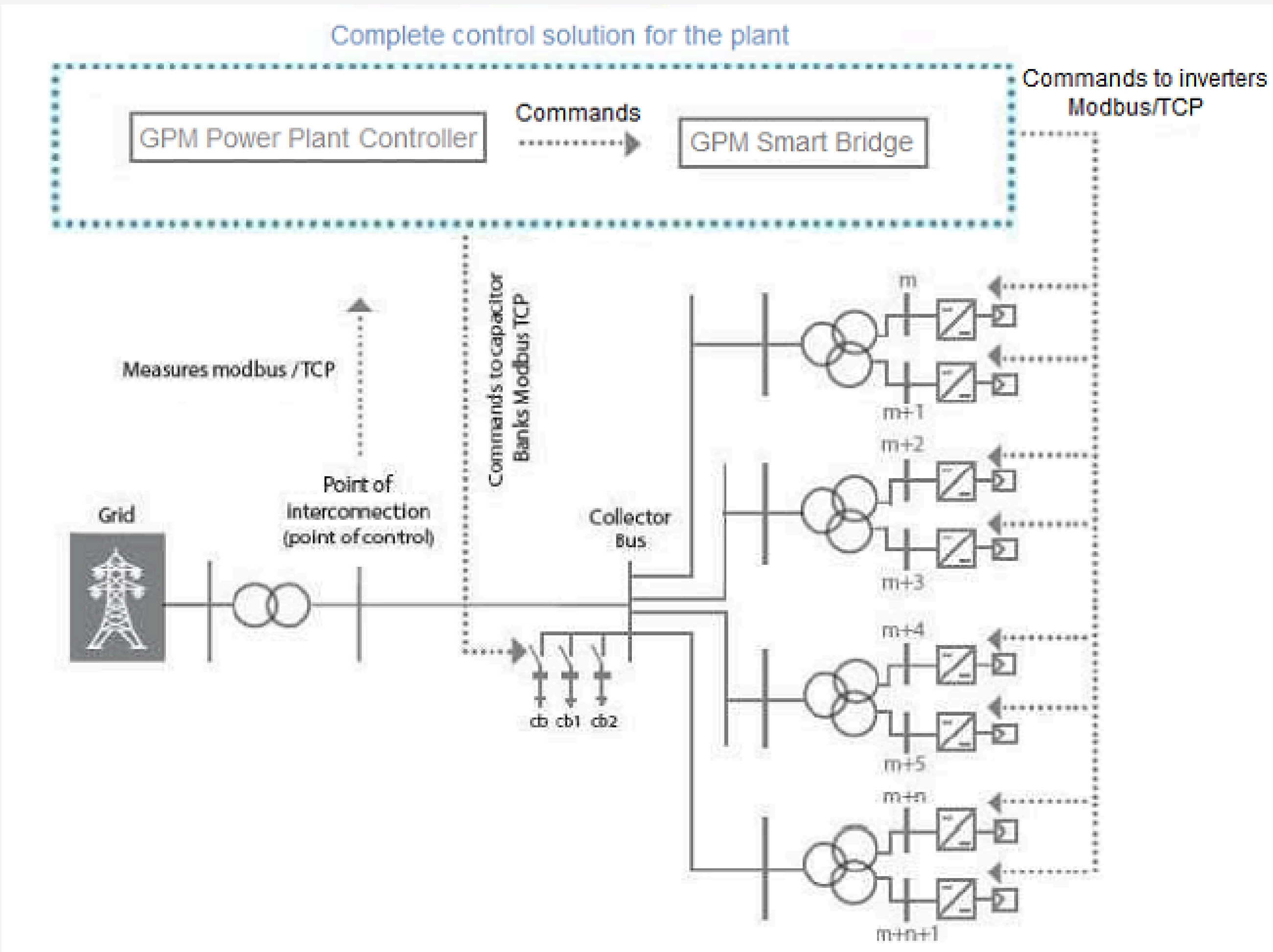
Functional overview

In general terms, the external operator sends a setpoint as an input to the PPC service. Based on control laws (PI), it evaluates how much power must be delivered at the POI. This power setpoint is the output of the service. It is sent to the RTUSmartBridge2 service, which understands the layout of the RPC and distributes the setpoint to each device.

This web application enables final users to interact with the plant through different interfaces, thanks to the Modbus map of the PPC. This allows testing the communications with the meter, and managing the different controls to enable and send different setpoints.

The GPM PPC and the RTUSmartBridge2 services can be installed without entering the Linux terminal. All the configuration files can be set within the web interface, avoiding human error. This procedure and other features are accessible through a single web interface with a tab navigator.

General scheme

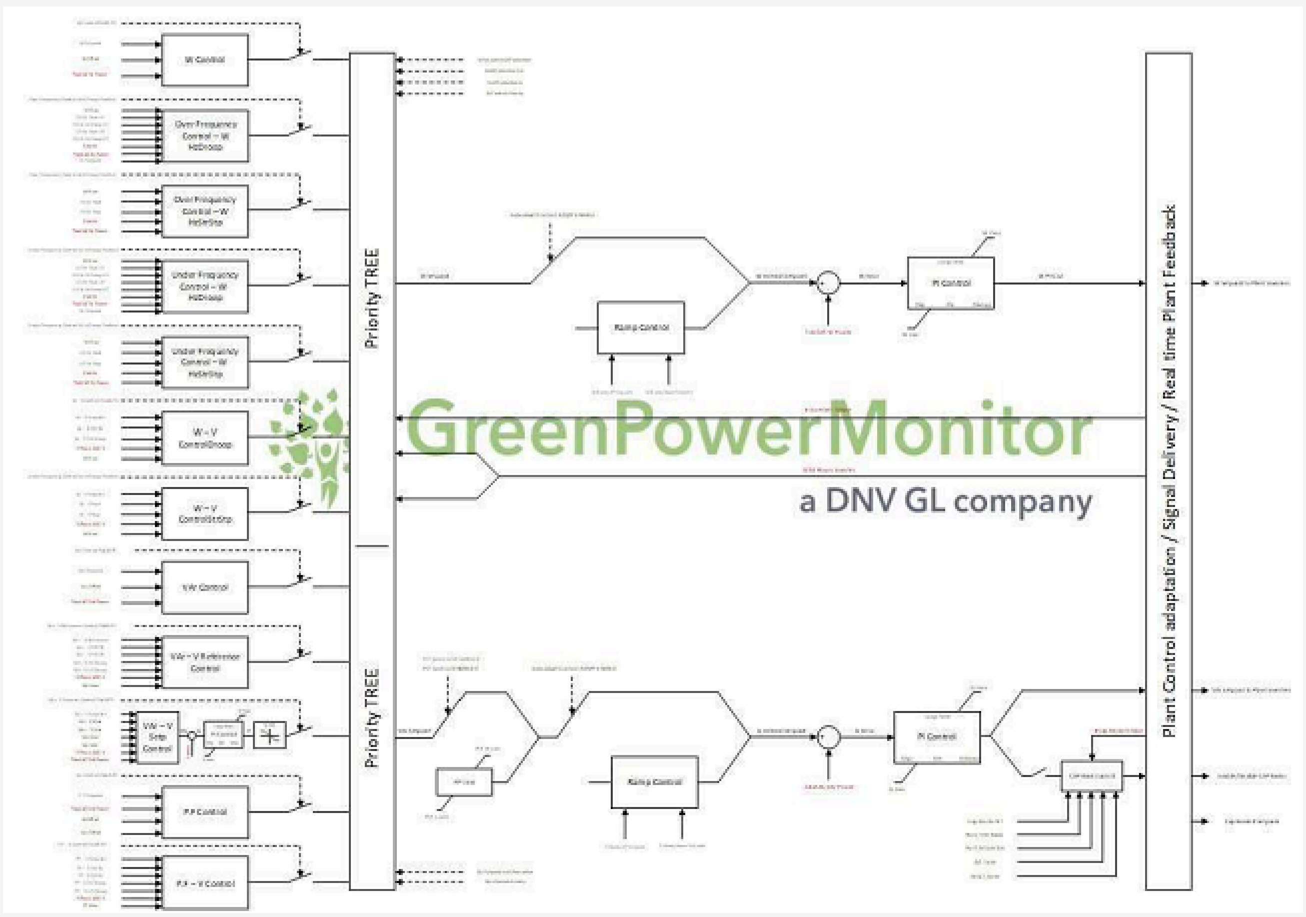


Structure

The structure of the GPM PPC is based on two layers of control loops:

1. Inner loops: active and reactive power PI which receive the setpoint through the outer loops.
2. Outer loops: divided into:
   a. Terms of active power with or without ramps:
      - Curtailment.
      - Under/Over frequency control droop.
      - Under/Over frequency control STR-STP.
   b. Terms of reactive power with or without ramps:
      - Curtailment
      - Voltage setpoint control PI.
      - Power Factor (PF) .
      - Over/Under voltage control droop.

GPM PPC controls block diagram



Setup

When the members of a project management team must set up a new PPC, they must define the entire architecture of the services and their configuration, taking into account that the controls must be set up. A good calibration can sometimes require several modifications in real time, to reach a high-quality response performance.

Based on the needs of the DAPM department, the GPM HMI PPC was developed to set all the required services and their appliance, users to interact to the PPC Modbus map in real time, to improve the performance of the services.

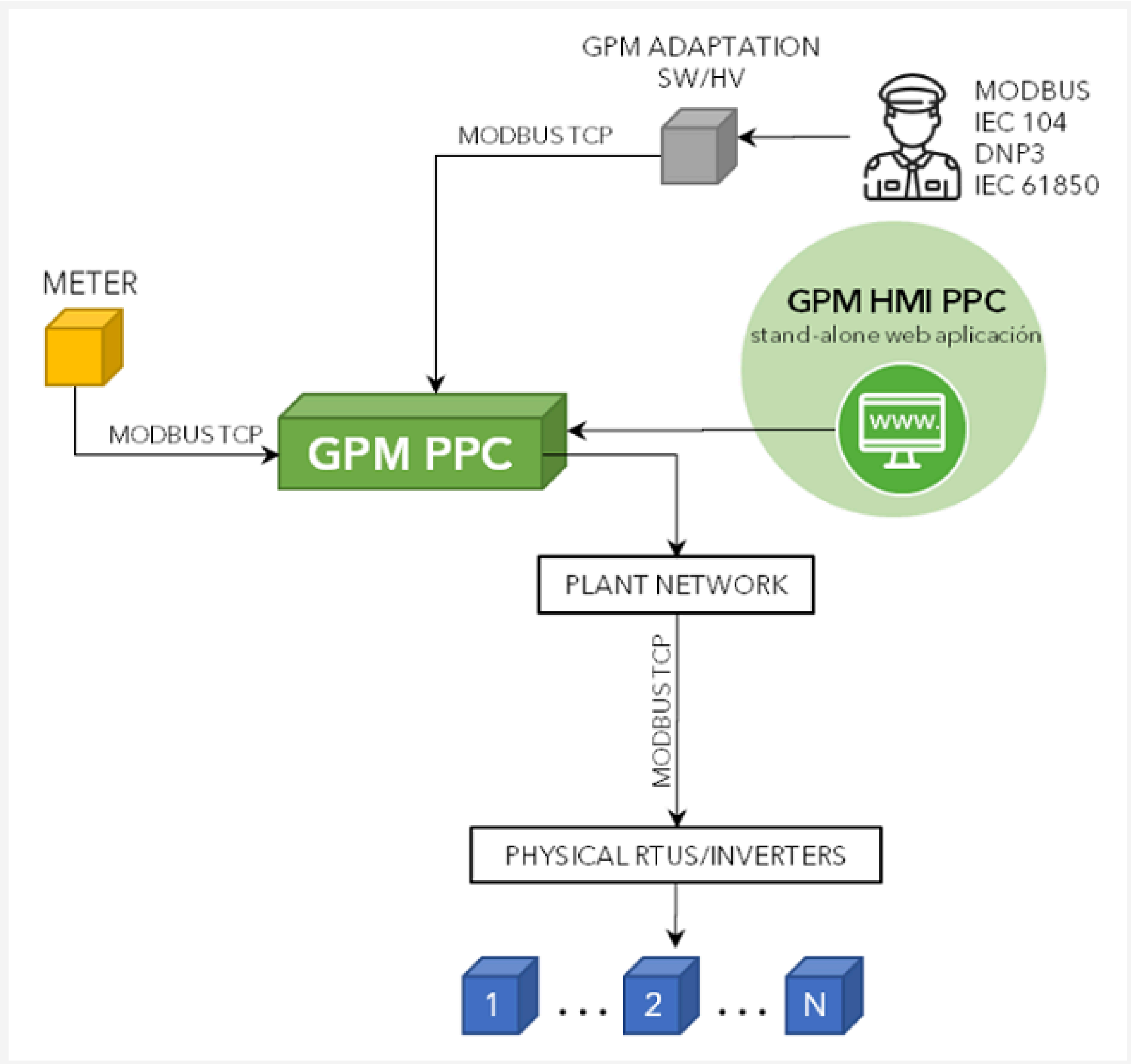
HMI requirements

The current version of the web application can be installed in:

- Moxa UC8112: Linux Debian OS Jessie (v8.x) & Stretch (v9.x).
- Server: Linux Debian OS Jessie (v8.x), Stretch (v9.x) & Bullseye (v11.x)

In terms of web development, the front-end is supported by Google Chrome.

Example of the field configuration when the GPM **HMI PPC is used**

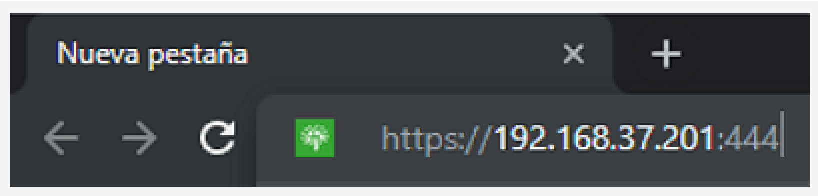


Access the GPM HMI PPC

To access the GPM HMI PPC, follow these steps:

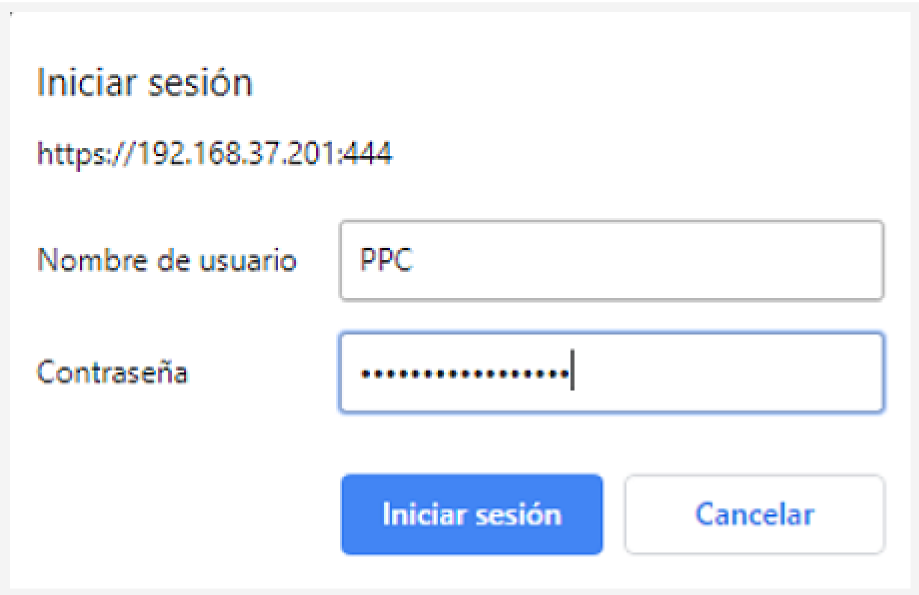
1. Open a new Google Chrome tab and search the IP of the GPM PPC's controller through the HTTPS protocol and the port 444. For example:

Google Chrome tab



2. The navigator shows a dialog view. Set the user credentials of the HMI.

Login



3. Click on **Log in** to launch the HMI Application.

Result

The application opens.

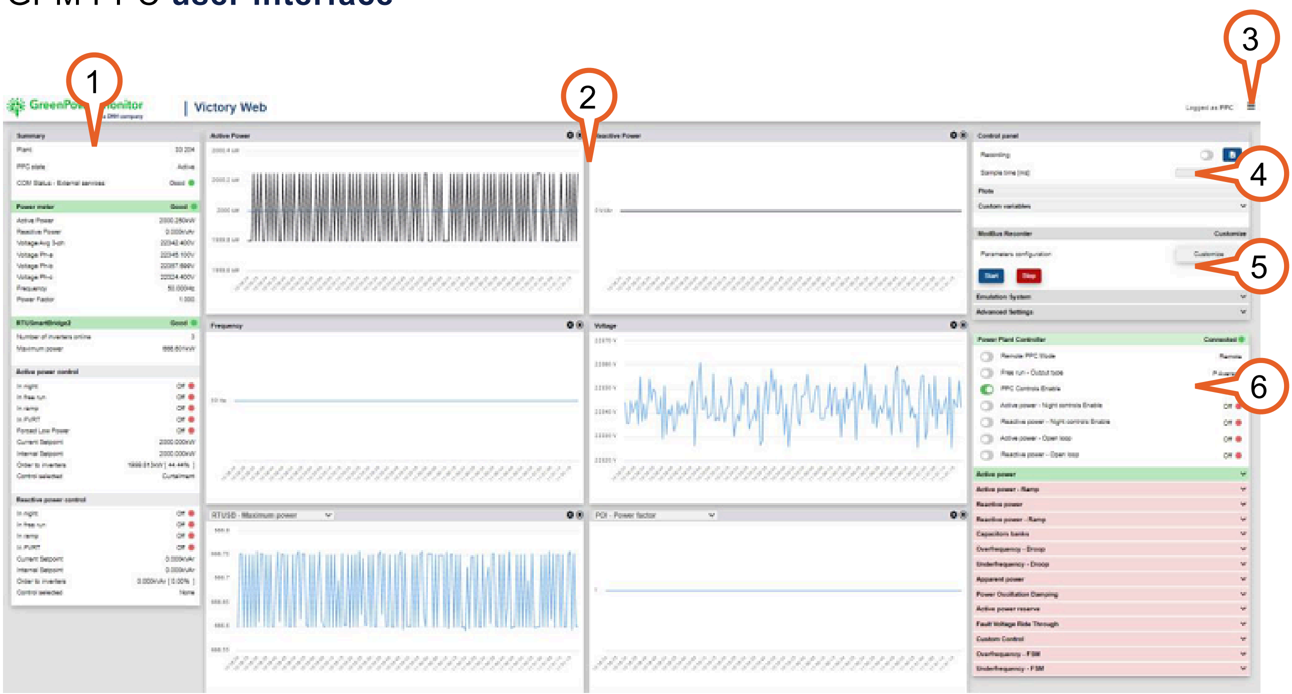
User interface

The user interface (UI) of the GPM HMI PPC allows you to see how the GPM PPC is working through the meter values and operational data (RTUSmartBridge2 and CAPBANKSGpm services).

The UI displays the main features of the active and reactive power controls values, and provides the necessary information to assess and diagnose all the activity at the plant: power measurements, GPM services and active/reactive power controls feedback.

⚠ CAUTION: Actions taken in this UI have a direct impact on the plant. Please follow all the safety procedures before performing any action.

GPM PPC **user interface**



ⓘ NOTE: For detailed information, click on each element in the list to navigate to its corresponding section.

1. **Summary panel**: displays how the PPC is working through the meter values and operational data (RTUSmartBridge2 and CAPBANKSGpm services).
2. **Charts**: low sampling time trending data with customizable axis with the power measurements values.

3. **Menu**: click the ☰ icon to go to the GPM PPC map view or to see the versions of the services installed.
4. **Chart data selection**: select a summary parameter from the selection list to be displayed at a single plot (only available for the two bottom plots).
5. **Control panel**: contains the features of recorded data, monitoring display settings, and a list of customized parameters.
6. GPM PPC panel: allows interactions between the user and service's controllers.

User roles

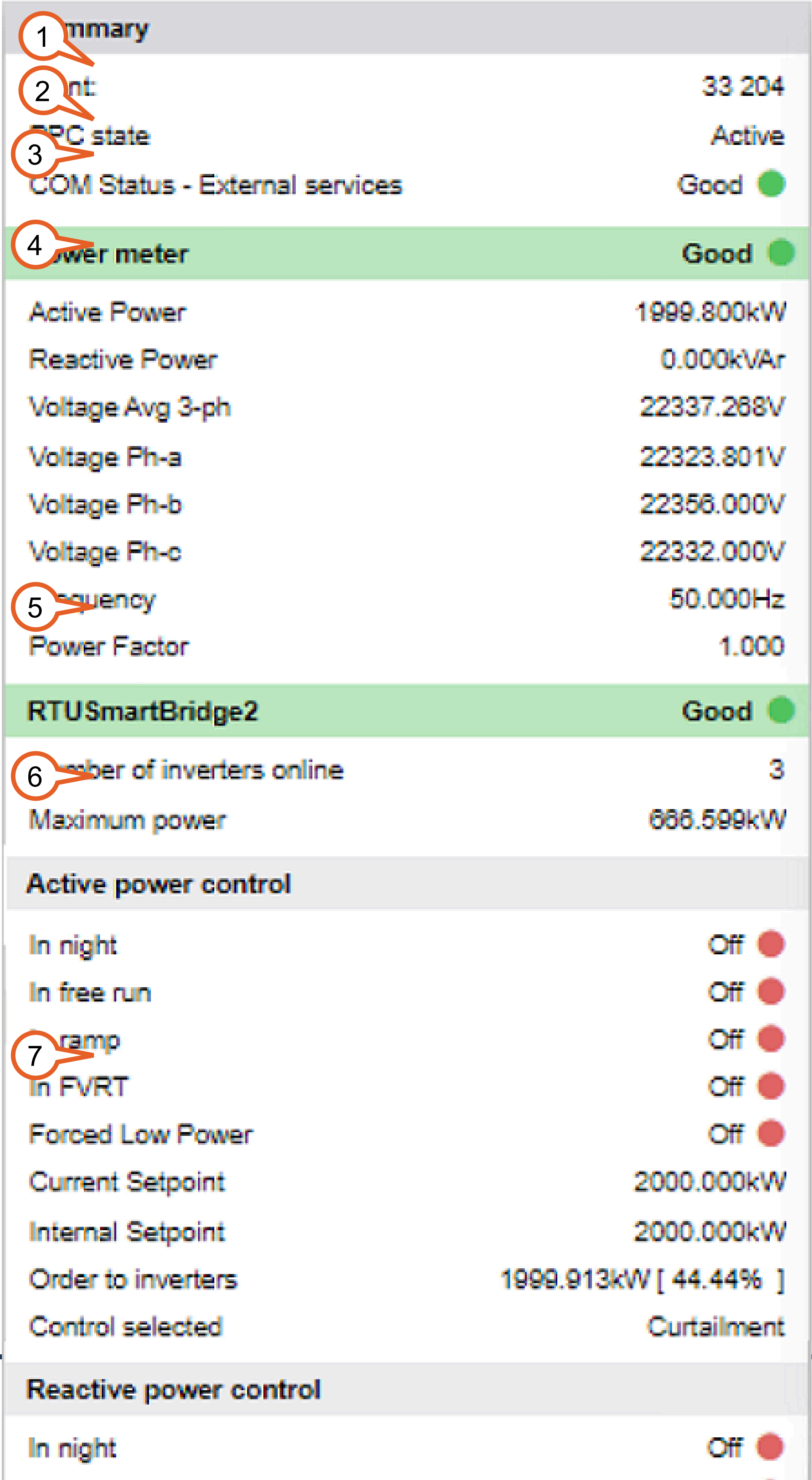
The GPM HMI PPC has three different user modes: GPM, PPC or Guest. The (UI) changes based on the mode, allowing different levels of action:

Actions and users	GPM	GPM PPC	Guest
Interaction with the PPC mode changing setpoints and operation modes	Yes	Yes	No
Feedback of the PPC map through inputs and canvas	Yes	Yes	Yes
Access to the rest of displays of the HMI application	Yes	No	No

Summary panel overview

The summary panel allows you to see how the PPC is working through the meter values and operational data (RTUSmartBridge2 and CAPBANKSGpm services). In addition, this main block shows the main features of the active and reactive power controls values.

Summary panel



1. **Plant name**: configured name of the plant in GPM PPC.
2. **GPM PPC State**: shows if the current monitored GPM PPC is active or in stand-by mode.
3. **External services indicator**: shows if the connection between the GPM PPC and the rest of Modbus devices is good or bad.
4. **Power meter feedback**: displays all the information necessary for a good GPM PPC's performance, regarding the power meter connected at the POI, including the communication status.
5. **RTUSmartBridge2 service feedback**: displays the information required by the GPM PPC from the RTUSmartBridge2 service, including the communication status.
6. **CAPBANKS service feedback**: displays the information required by the GPM PPC from the CAPBANKS service, including the communication status.
7. **Active/Reactive power control feedback**: displays the information published by the GPM PPC about the inner control loops.

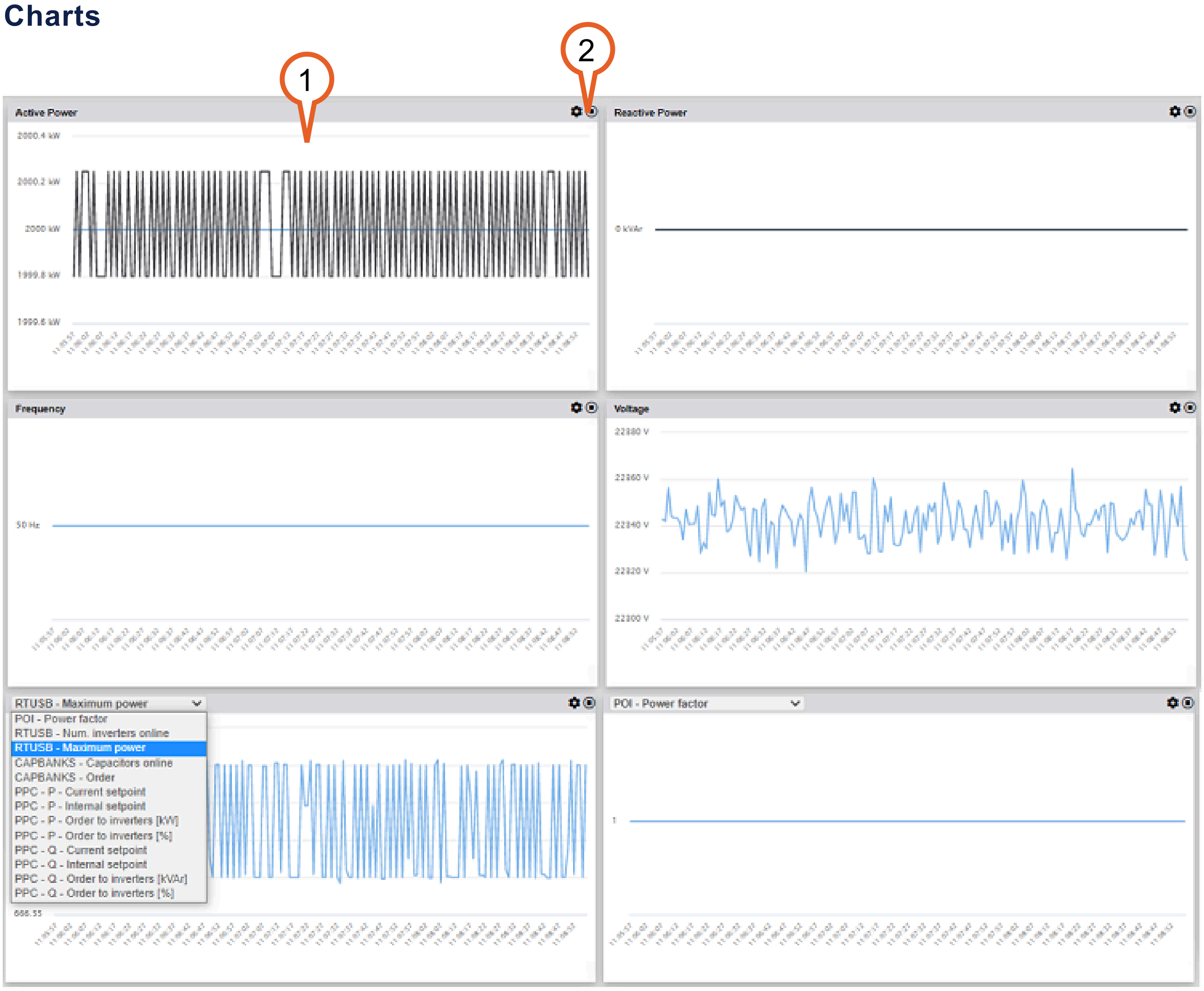
Charts

The Monitoring view displays a total of six charts with data for different plant variables. The first four are fixed:

- Active power
- Reactive power
- Frequency
- Voltage

The last two charts are customizable. You can define them in the Chart settings.

Charts



1. **Chart canvas**: displays six charts.
2. Action buttons:
   a. **Chart settings**: click the ⚙ icon to display a modal where you can modify the minimum and maximum values of the Y-axis.
   b. **Freezing trigger**: click the ⦿ icon to stop updating the values on the Y-axis

and the time on the X-axis. Click the ▶ icon to resume displaying the latest data.

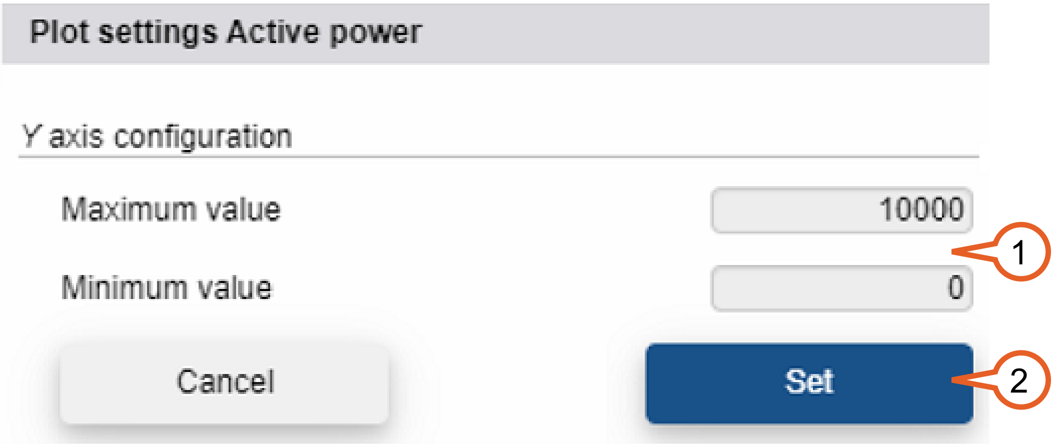
Axes

- **Y-axis**: displays values for the variable on display. The axis behaves automatically or manually, depending on the toggled settings in the control panel.
- **X-axis**: displays time as a constant variable. The number of ticks depends on the number of samples set in the Chart settings.

Simple chart settings

The simple chart settings allow you to enter maximum and minimum values for the parameters displayed on the chart.

Chart settings



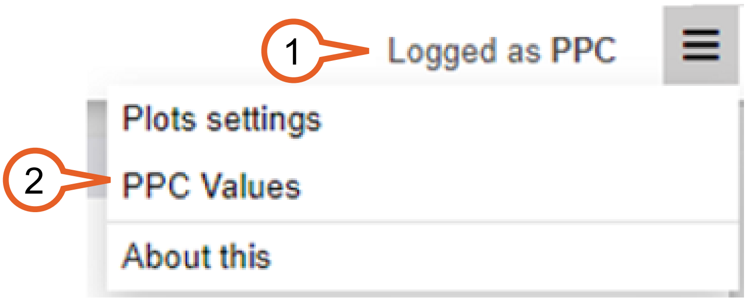
1. *Value fields*: enter the maximum and minimum value of the chart's Y-axis.
2. Action buttons:
   a. **Cancel**: close without saving the changes.
   b. **Save**: save the current settings and close the view. You must apply the changes by toggling off the auto-scaling switch in the Monitoring view.

Top menu

At the right corner of the web display, there is a label which says the current user logged at the web and a drop-down menu with different options depending on the role of the user. Considering the PPC or Guest user, only the option of the PPC Values and About this are shown.

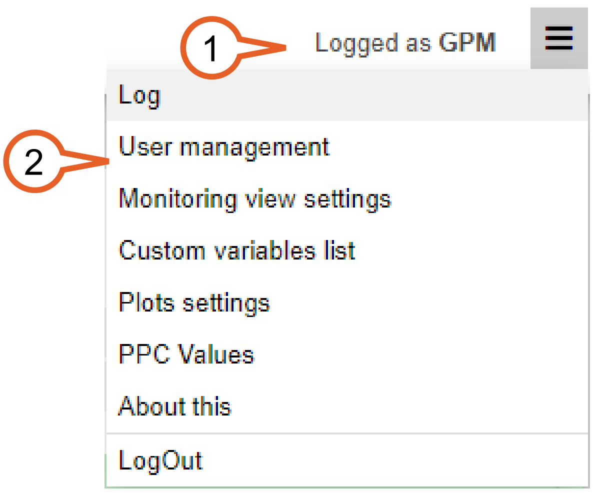
Access to the PPC Setup and Testbench is limited to the GPM user.

Top menu



1. User information: shows who is currently logged into the application service.
2. **Menu**: hover over to display the menu options. Click on an option to show the corresponding modal view:
   - **Chart settings**: configure the Y-axis and the number of samples per X-axis for all the charts.
   - **PPC values**: display the real-time values of the PPC's Modbus map.
   - **About**: see the current installed version of the services.

Top menu



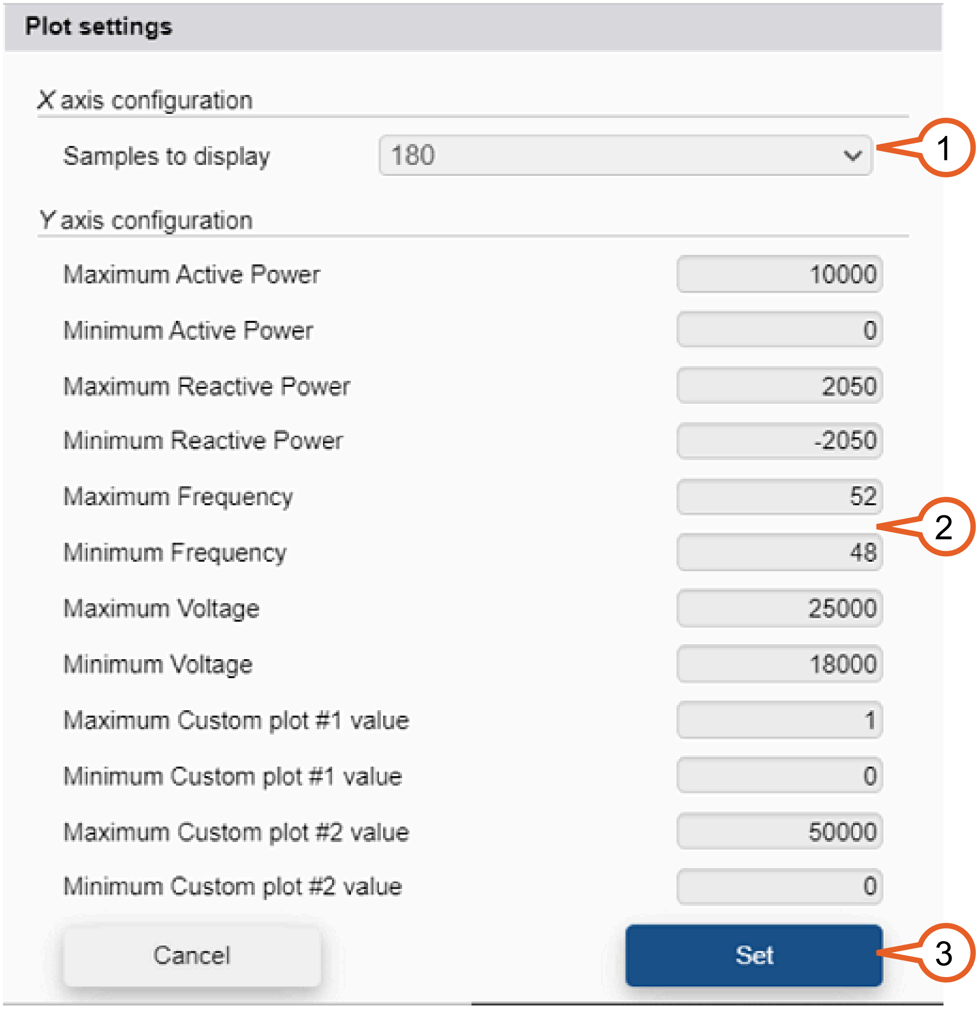
1. User information: shows who is currently logged into the application service.

2. **Menu**: hover over to display the menu options. Click on an option to show the corresponding modal view:
   - **Log**: click to open the modal to download a record of all user interactions that affect local or remote configuration files and services.
   - **User management**: click to make changes to the credentials of users for the "PPC" and "Guest" profiles.
   - **Monitoring view settings**: click to customize the controls that appear in the PPC panel.
   - **Custom variables list**: click to edit the list of custom variables.
   - **Chart settings**: configure the Y-axis and the number of samples per X-axis for all the charts.
   - **PPC values**: display the real-time values of the PPC's Modbus map.
   - **About**: see the current installed version of the services.

Chart settings

The Chart settings allow you to configure the minimum and maximum values for each parameter displayed on the charts of the monitoring view, as well as the number of samples to display.

Plot settings



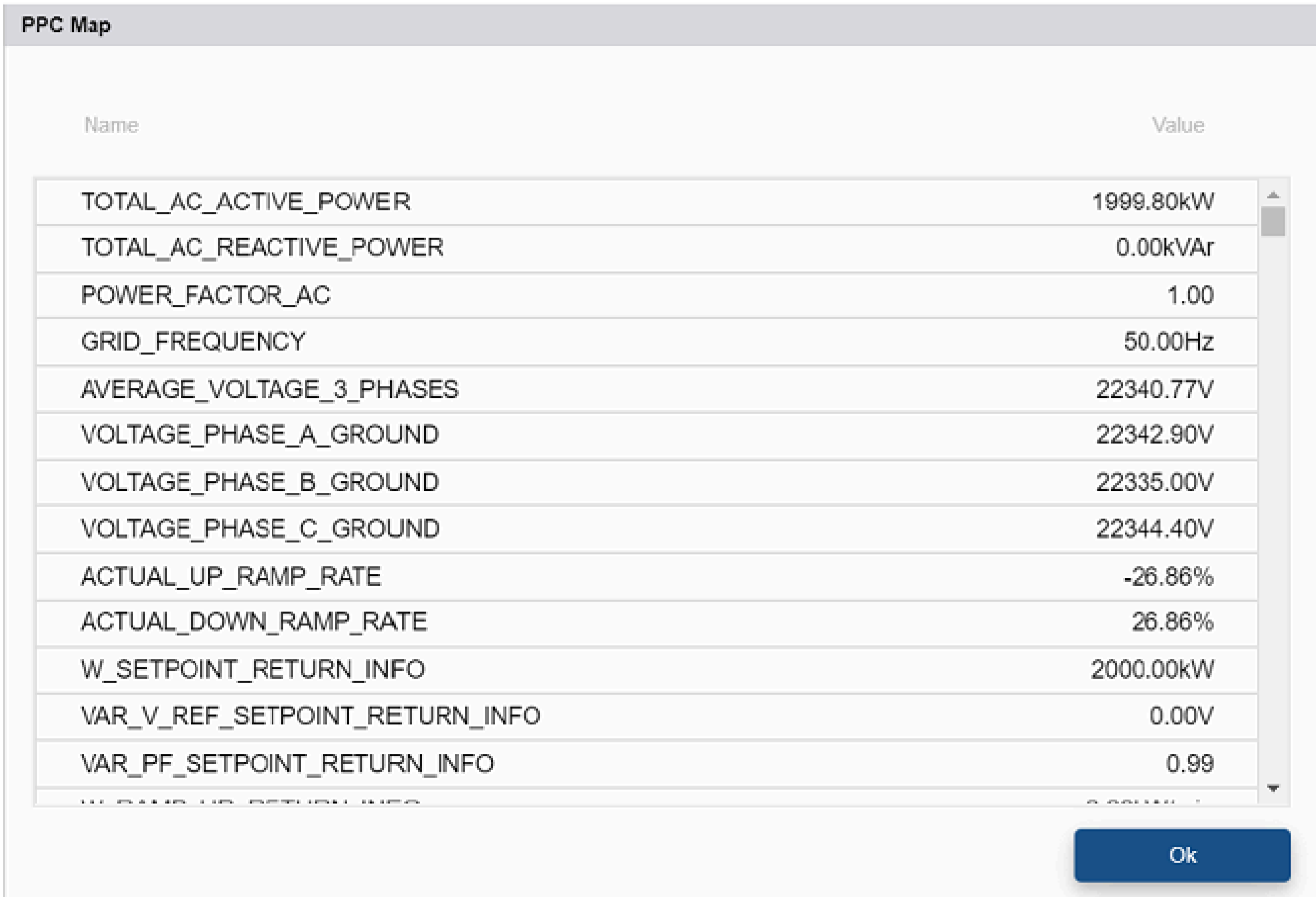
1. **Samples to display**: open the menu to select the number of samples (for example, **180**) to show in all the graphs.
2. *Value fields*: enter the maximum and minimum values for the Y-axes of the graphs.
3. Action buttons:
   a. **Cancel**: close without saving the changes.
   b. **Save**: save the current settings and close the view. You must apply the changes by toggling off the auto-scaling switch in the Monitoring view.

PPC values

The PPC values modal allows you to see the entire Modbus Map of the PPC in real time.

ⓘ NOTE: You can search for a tag by pressing **CTRL+F** and typing the name of the tag.

PPC map



Name	Value
TOTAL_AC_ACTIVE_POWER	1999.80kW
TOTAL_AC_REACTIVE_POWER	0.00kVAr
POWER_FACTOR_AC	1.00
GRID_FREQUENCY	50.00Hz
AVERAGE_VOLTAGE_3_PHASES	22340.77V
VOLTAGE_PHASE_A_GROUND	22342.90V
VOLTAGE_PHASE_B_GROUND	22335.00V
VOLTAGE_PHASE_C_GROUND	22344.40V
ACTUAL_UP_RAMP_RATE	-26.86%
ACTUAL_DOWN_RAMP_RATE	26.86%
W_SETPOINT_RETURN_INFO	2000.00kW
VAR_V_REF_SETPOINT_RETURN_INFO	0.00V
VAR_PF_SETPOINT_RETURN_INFO	0.99

1. Parameter names: displays Modbus tag names.
2. Parameter values: latest value, followed by the units of the Modbus tag.
3. **Exit button**: click to close the modal.

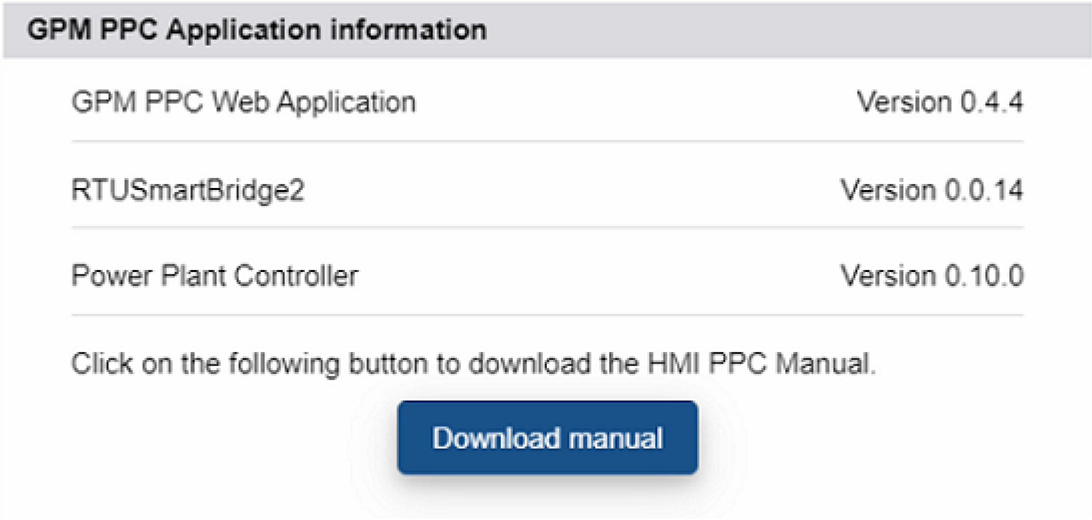
About

The About modal displays the version of the HMI PPC you are working with. It also displays the versions of the PPC and RTUSmartBridge services.

To close the modal, click anywhere outside it.

> ⓘ NOTE: If a service is failing or is not installed, an error message appears.

GPM PPC application information

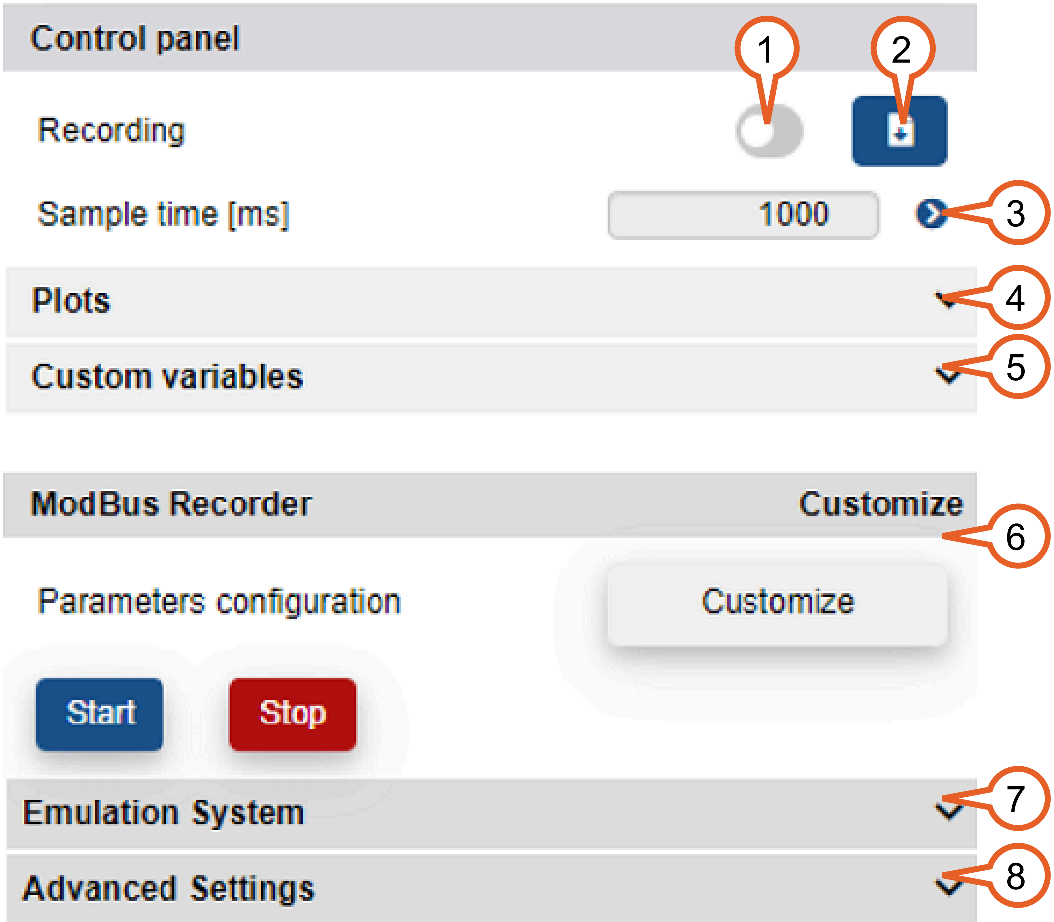


1. Application service: current service installed.
2. Version: number of the version of the application service installed at the embedded controller.
3. **User guide**: link to the GPM PPC user guide.

Control panel

The control panel allows you to interact with the GPM HMI PPC. It is divided into six panels that include different features that allow you to manage data, configure displays, run simulations, and define parameters for specific controls.

Control panel



ⓘ NOTE: For more information, click on the link in the list to navigate to the section for each panel.

1. **Recording toggle**: allows to start or stop the application to record the data measurement into a .csv file.
2. **Recording files manager** click the icon to download or delete the .csv files stored at the controller's device.
3. *Sample time*: time in ms between monitoring requests to the PPC Modbus map. Click the ▶ icon to apply the current sample time.

4. Plots: click the ⌄ icon to display the settings regarding the plots.
5. Custom variables: click the ⌄ icon to display the list of parameters monitored from external services or extra features.
6. Modbus recorder: allows you to record main parameters of PPC with a granularity of up to 1 ms.
7. Emulation system: allows you to simulate frequency and voltage values separately that are feed into PPC.
8. Advanced settings: allows you to set parameters regarding the night and Capbank controls.

Recording service

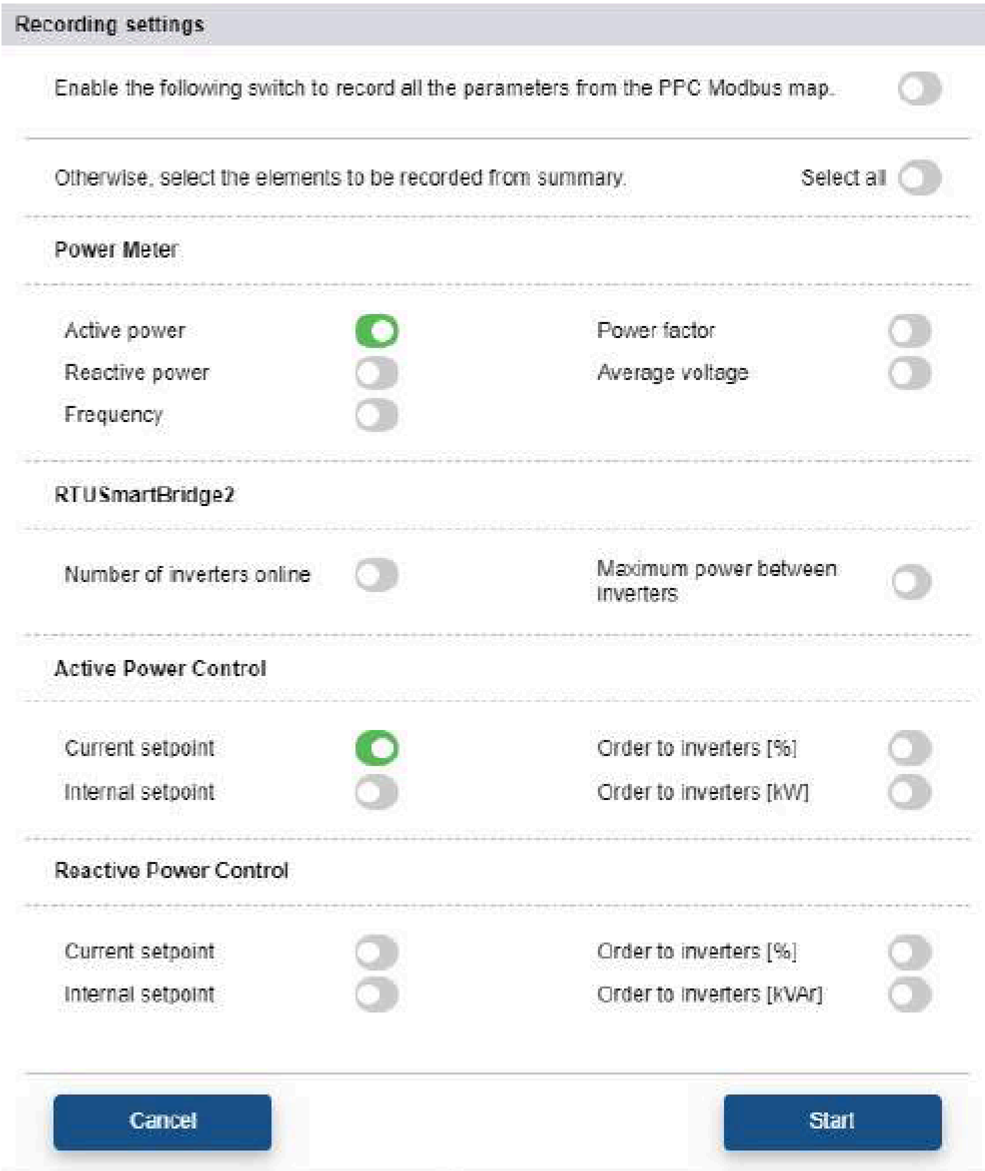
The HMI allows you to save data for current measurements to CSV files. When you click on the recording switch, a modal view opens to select data for recordings.

There are two different options to record data:

- Entire PPC Modbus map.
- Selected parameters from the summary block.

When you have recorded the desired data, you must stop the recording and download the CSV files.

Recording settings



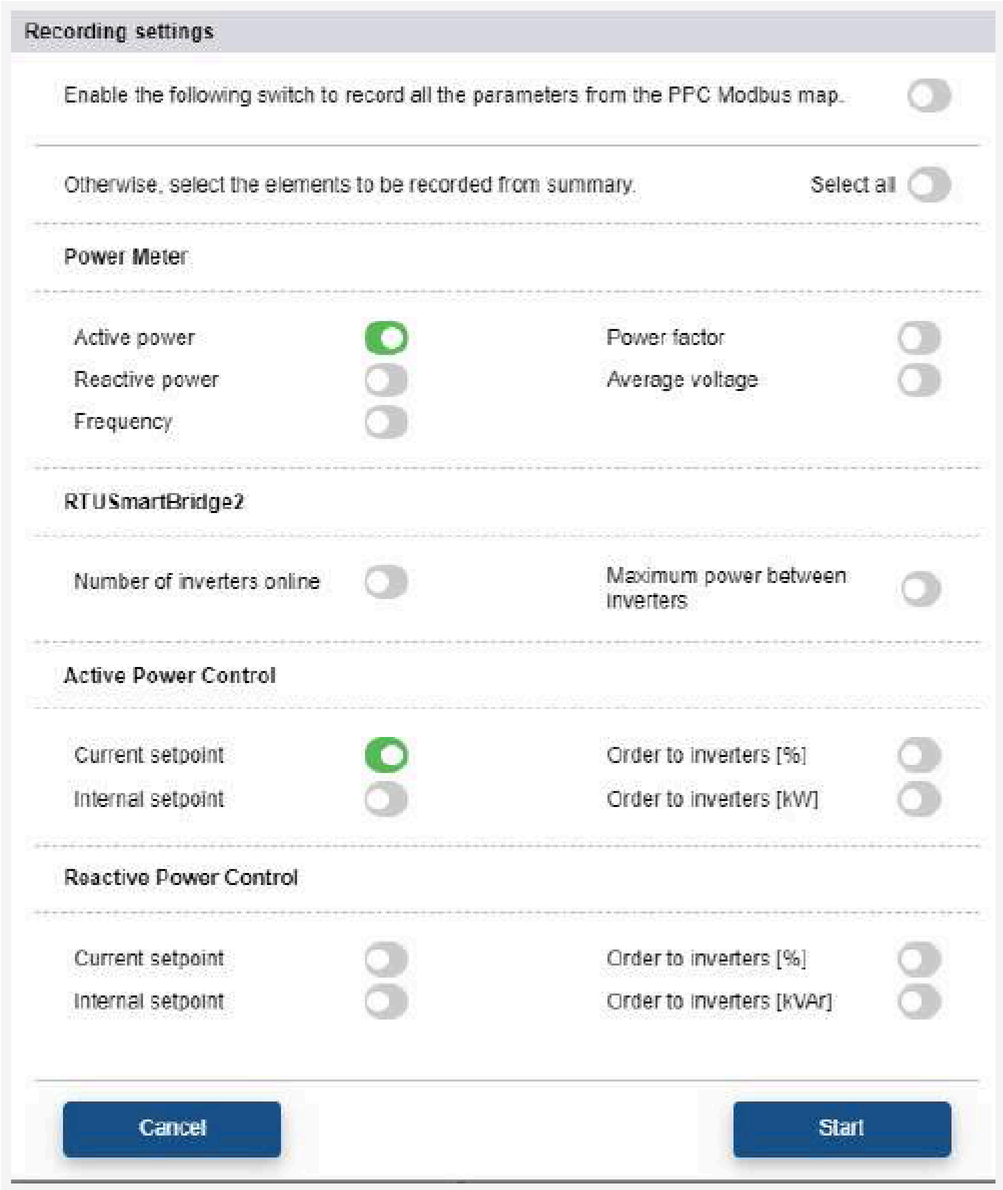
Record Modbus map

To record the entire Modbus map, follow these steps:

1. In the Control Panel, toggle on the **Recording toggle**.

   Result: The Recording settings appear:

   Recording settings



2. Enable the toggle on the first line to record all the parameters from the PPC Modbus map.
3. Click **Start**.

Result

The system begins to record data from the entire Modbus map.

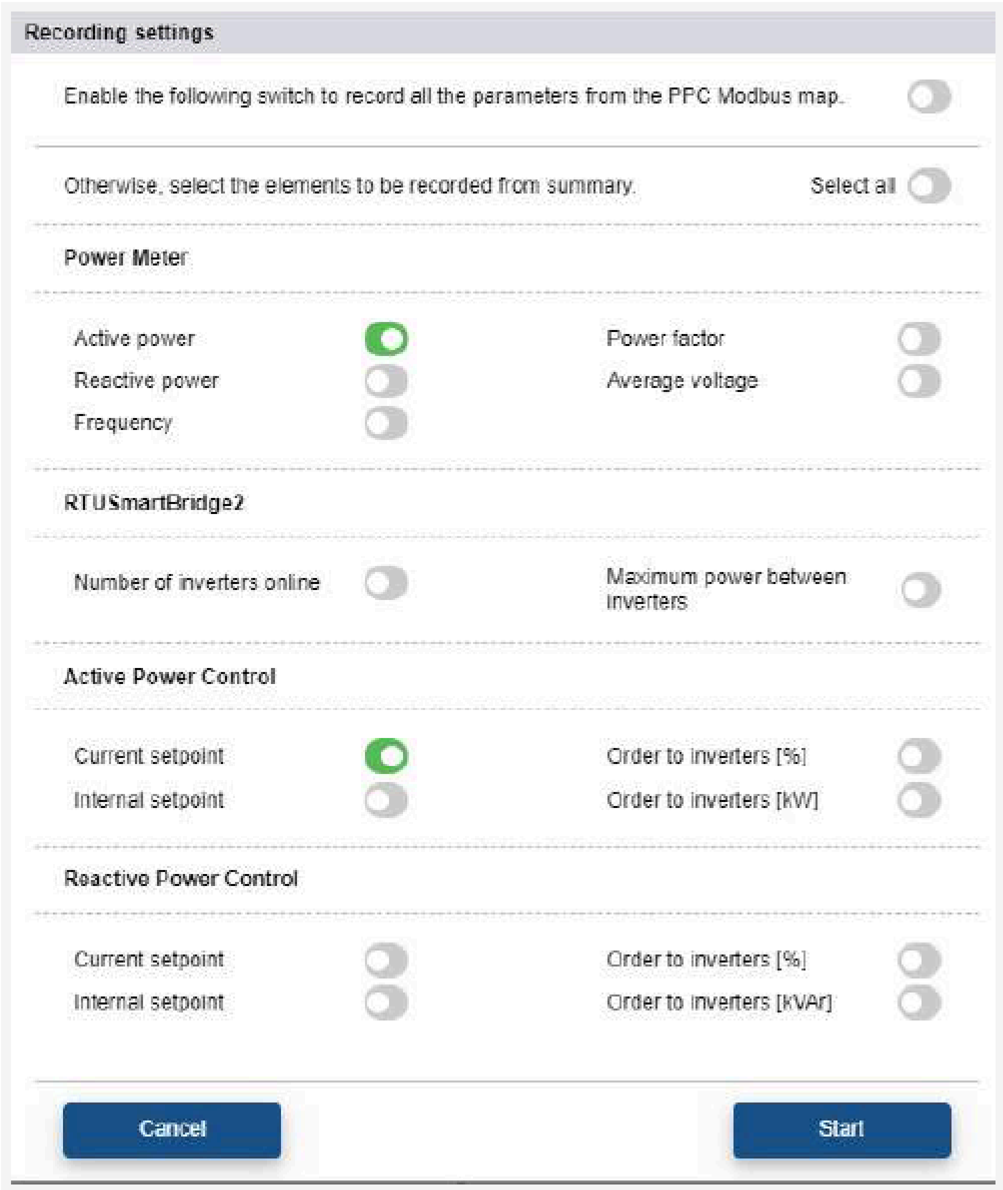
Record selected parameters

To record a selection of parameters, follow these steps:

1. In the <u>Control Panel</u>, toggle on the **Recording toggle**.

   Result: The Recording settings appear:

   Recording settings



2. Toggle on the parameters you want to select.

   OR: Toggle on **Select all** to record data for every parameter.

3. Click **Start**.

Result

The system begins to record data for the selected parameters.

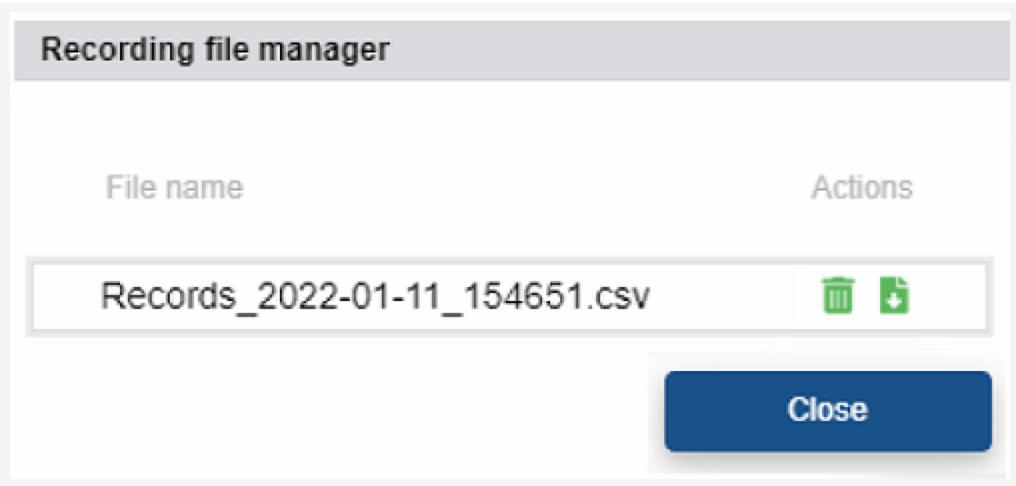
Save recordings

To stop the recording and save the CSV files, follow these steps:

1. In the Control Panel, toggle off the **Recording toggle**.

   Result: The Recording file manager appears:

   Recording file manager



   ⚠ CAUTION: If a file is currently recording, this modal will not open and an alert will appear.

2. Enter a *File name*.

   By default, files are named using the following format: Records_yyyy-mm-dd_hh-ii-ss.csv.

3. Click the the icon to download the current record file.

4. Click **Close**.

Result

The system stops recording and the CSV files begin to download.

ⓘ NOTE: If you do not want to keep the current files,
click the icon to delete the recording.

Modbus recorder

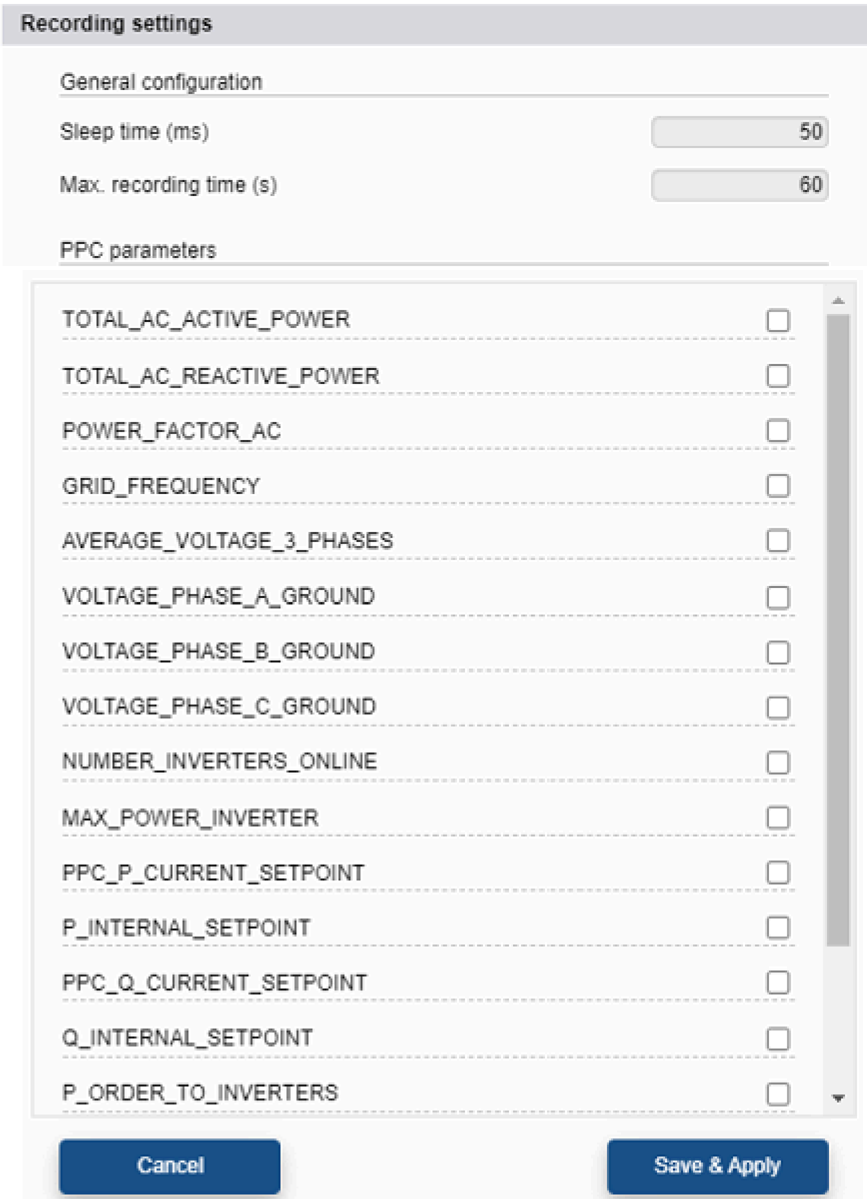
In terms of charts interaction, users may auto scale or freeze all the trending plots interacting with the switching buttons.

On the other hand, there is a list of custom variables which are explained forward, and it is displayed when the button with the same tag label is clicked. Also, this button will change its color when a custom variable is in alarm state or disconnection.

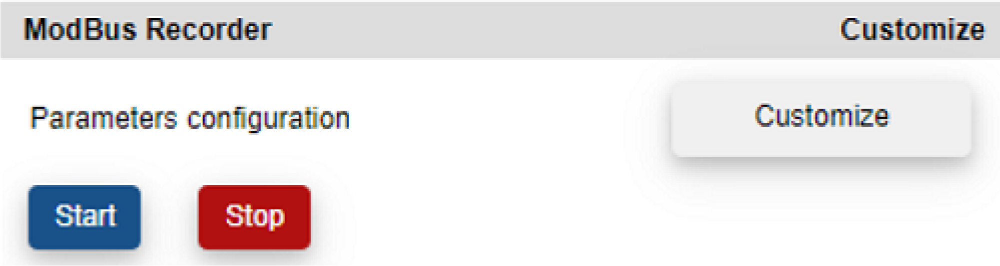
Modbus recorder

The Modbus recorder feature allows users to save the desired PPC parameters with a quicker sample time compared to the previous recording service. In order to make the configuration, the user should open the Customize modal view. The Start and Stop buttons will be used to control the recording, after the configuration is completed and saved. Once we stop the recording, a record.csv fill be downloaded automatically.

Modbus recorder settings



Modbus recorder - parameters configuration

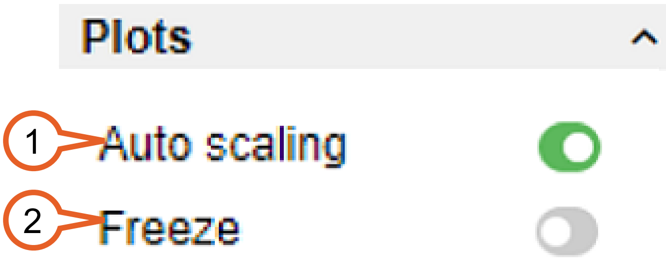


1. **Customize**: click to configure sleep time and maximum recording time and to select the variables to be recorded.
2. **Start/Stop**: once the recorder has been customized, the start button will start recording that can be stopped anytime with the stop button. The recoding will stop automatically if it is not stopped via Stop button.

Charts settings panel

The Charts settings panel allows you to configure the display and the behavior of the charts displayed on the user interface.

Plots settings



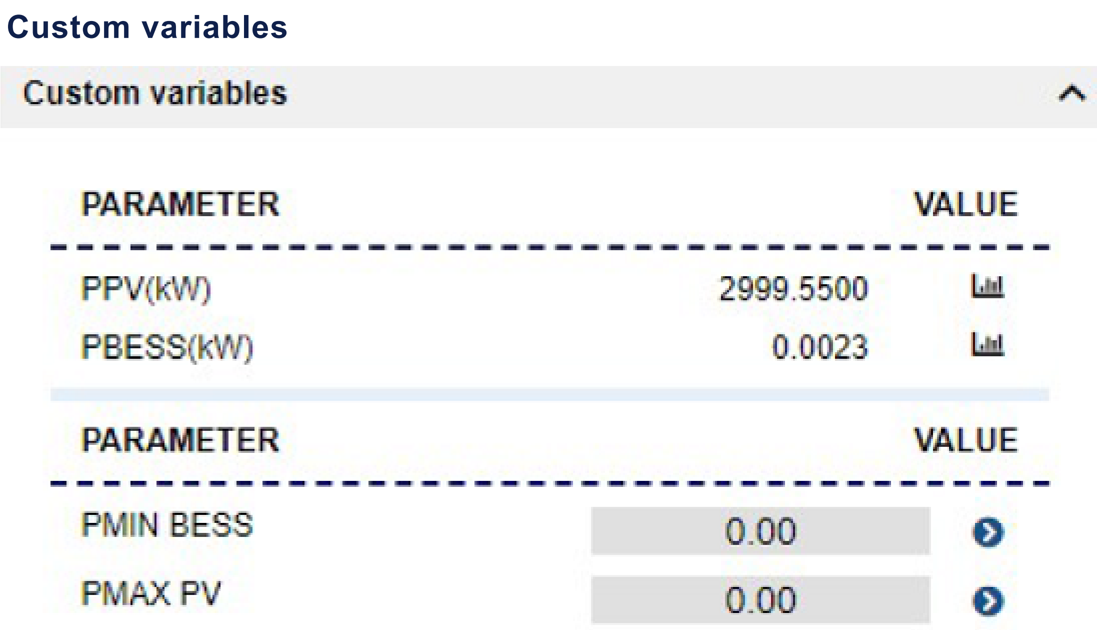
1. **Auto-scaling**: enable the toggle to set the the Y-axis of the charts automatically. If it is disabled, the Y-axis takes the values from the configuration.
2. **Freeze**: enabled the toggle to stop updating values for all the trends.

Custom variables panel

You to display the data for specific parameters on a chart. You can also overwrite values for parameters.

ⓘ NOTE: To create custom variables, contact your GPM representative.

You can create custom variables in the Custom Variables Editor.



1. **Tag**: custom variable name. The list of variables is customizable, and the number of variables may be different between setups.
2. **Value**: value associated to the custom variable. The value may be a string or numerical and may have an alarm attached to certain values which could be resumed at the control panel's button with tag Custom variables.

Display parameter variables in charts

To display variables for parameters on charts, follow these steps:

1. In the Custom Variables panel, click the icon in the row of the variable you want to display on a chart:

   Plotting the parameters

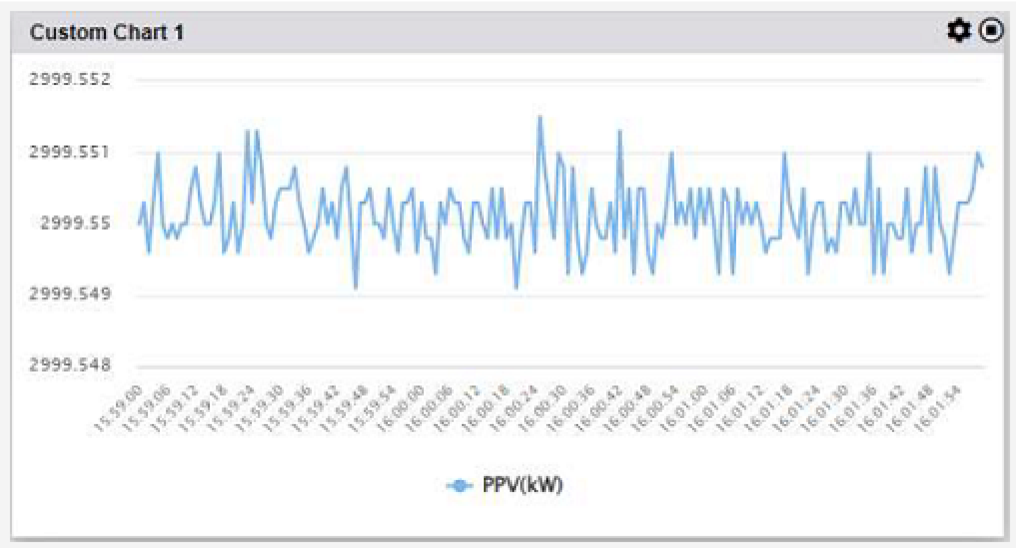
2. Click the icon.

   > ⓘ NOTE: You can display graphs for up to four parameters at a time. You can remove a graph by clicking the icon for its parameter.

Result

A custom chart appears in the monitoring view:

Custom chart



Parameters displayed on graphs display the icon in green:

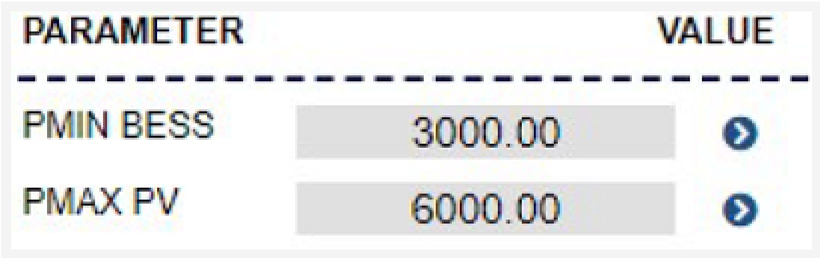
PARAMETER	VALUE			
PPV(kW)	2999.5505			
PBESS(kW)	0.0013			

Overwrite values for parameters

To overwrite the value of a parameter, follow these steps:

1. Enter the value for the desired parameter in the *Value* field.

   Overwriting a parameter

2. Click the ▶ icon.

Result

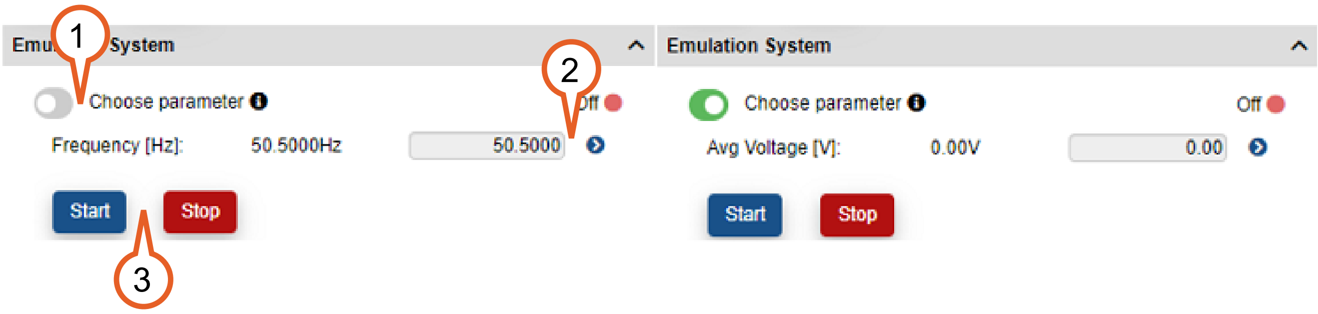
The new value is saved.

Emulation system

The emulation system allows you to emulate the frequency and the average voltage of the PPC. You can then use the results to manually edit the values of parameters.

⚠ CAUTION: If a file is being recorded, this modal view will not open, and an alert will appear.

Emulation system configuration



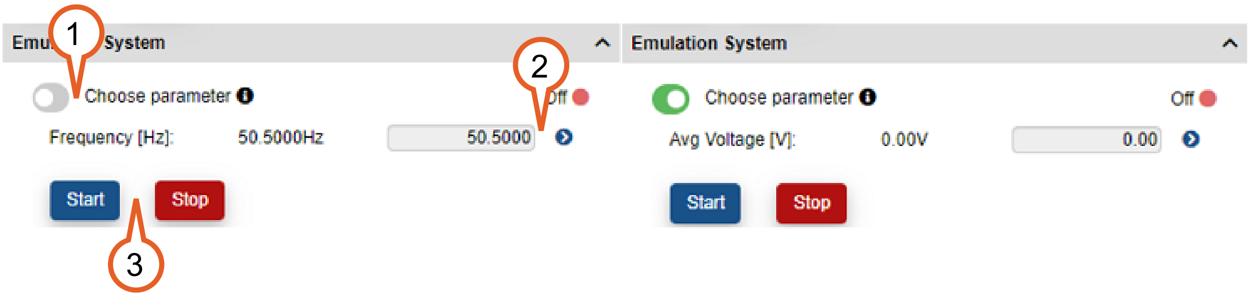
1. **Trigger**: toggle to select between frequency and voltage.
2. **Actions**: enter values in the *Value* field and confirm them by clicking on the ▶ icon.
3. **Start/Stop**: start and stop the emulation separately.

Emulate frequencies and average voltages

To emulate a frequency and an average voltage, follow these steps:

1. In the Emulation system panel, enable the toggle to select **Average Voltage [V]**.
   OR: Disable the toggle to select **Frequency [Hz]**.

   ### Emulation system configuration

2. Enter a *Value* (for example, 50.5000).
3. Click the ▶ icon.
4. Click **Start**.

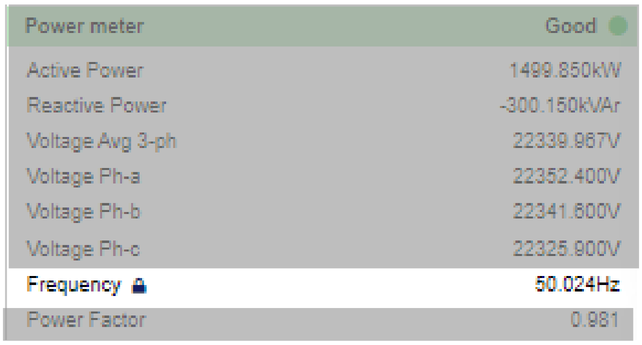
Result

The system runs the emulation. When the emulation is running, the status changes to "On".

Emulation status: On

The  icon indicates that the value is being emulated and is not a real measurement from the plant.

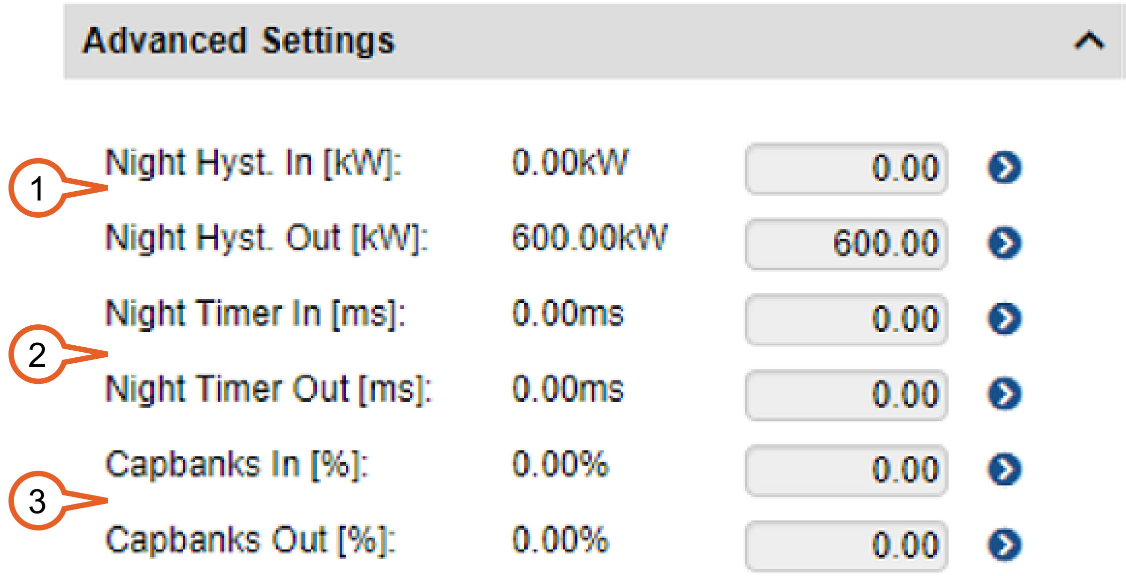
Emulated value



Advanced settings

This panel allows you to change the value of different configuration parameters. Applying these changes does not require stopping the PPC.

Advanced settings



1. *Nigh Hysteresis In/Out*: define the thresholds to enter and exit the night mode.
2. *Nigh Timer In/Out*: determines the time to wait before entering and exiting night mode when the thresholds are reached.
3. *Capbank In/Out*: define the thresholds to switch Capbanks on and off.

Power Plant Controller

The Power Plant Controller panel allows you to interact with the GPM PPC by enabling controls and sending setpoint commands.

The panel is divided into two sections:

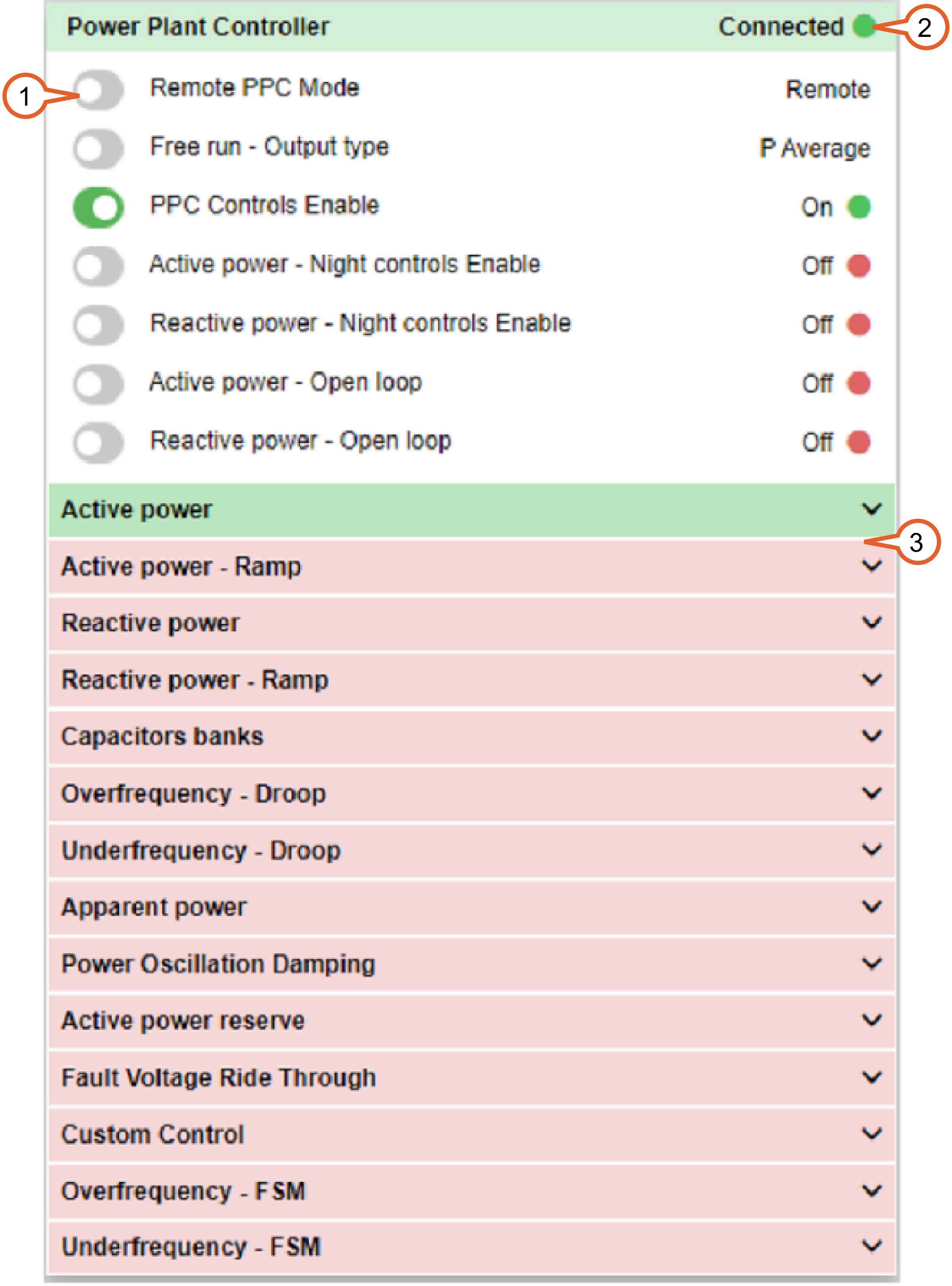
- Power Plant Controller: shows the communication status between the PPC and the HMI, followed by the communication status between this service and the RTUSmartBridge2.

  Action toggles allow you to enable or disable specific control modes.

  > ⓘ NOTE: The available toggles may vary depending on your configuration.

- Control panels: detailed controls with different levels of configuration. For more information about each control, see the Control panels section.

Power Plant Controller panel



1. **Action toggles**: toggle on to enable each control mode:

ⓘ NOTE: Toggles interact directly with the Modbus Map of the PPC service.

a. Remote PPC Mode: allows the GPM PPC accepts external setpoints. When disabled, the PPC mode is in local mode.

   Internally, the PPC has a list of configured IPs. These are classified as "remote", "local" and "always allowed". This makes it possible to configure the PPC in real time, either in local mode, or remotely from the monitoring page.

b. Free run - Output type: use the toggle to select between two output modes:

   - **P Average** (toggle off – 0 reg value): the PPC uses the RTUSB feedback to calculate the order sent to inverters based on the number of inverters online and the maximum active power registered between the inverters.
   - **P Max Reg.** (toggle on – 1 reg. value). the PPC evaluates the order sent to inverters based on the maximum active power registered between the inverters, multiplied by the number of inverters configured at the plant.

   ⓘ TIP: If the production is commonly unbalanced, and the Free-run power average mode causes abrupt drops in production, select **P Max. Reg.** mode.

c. PPC Controls Enable: determines if the GPM PPC is regulating (ON) or not (OFF).

   When the toggle is enabled, the PPC automatically operates in Free run, with the active power setpoint equaling 100%, and the reactive power equaling 0%.

d. Active power - Night controls Enable: toggle on to enable night controls for active power.

e. Reactive power - Night controls Enable: toggle on to enable night controls for reactive power.

   ⓘ NOTE: You can only enable one mode for night control at a time.

f. Active power - Open loop: allows the GPM PPC to disable the PI of active inner control, to work in open loop. This can disable the operating PI, and each input setpoint at the inner control will be sent directly to the RTUSmartBridge2 service

g. Reactive power - Open loop: allows the GPM PPC to disable the PI of reactive inner control, to work in open loop. This can disable the operating PI, and each input setpoint at the inner control will be sent directly to the RTUSmartBridge2 service.

> ⓘ NOTE: Depending on the layout of the plant and its rated power, setting a reactive power setpoint of 0% does not mean that the plant will have a 0MVAr at the point of interconnection. In most cases, a self-inductive reactive power will appear.

2. Communication status: displays the connection status between the GPM service PPC and the HMI Application
3. **Control panels**: active controls appear in green; inactive controls appear in red.

   Click the ⌄ icon for each control to expand it and see the available options.

   > ⓘ NOTE: You can only expand one control panel at a time.

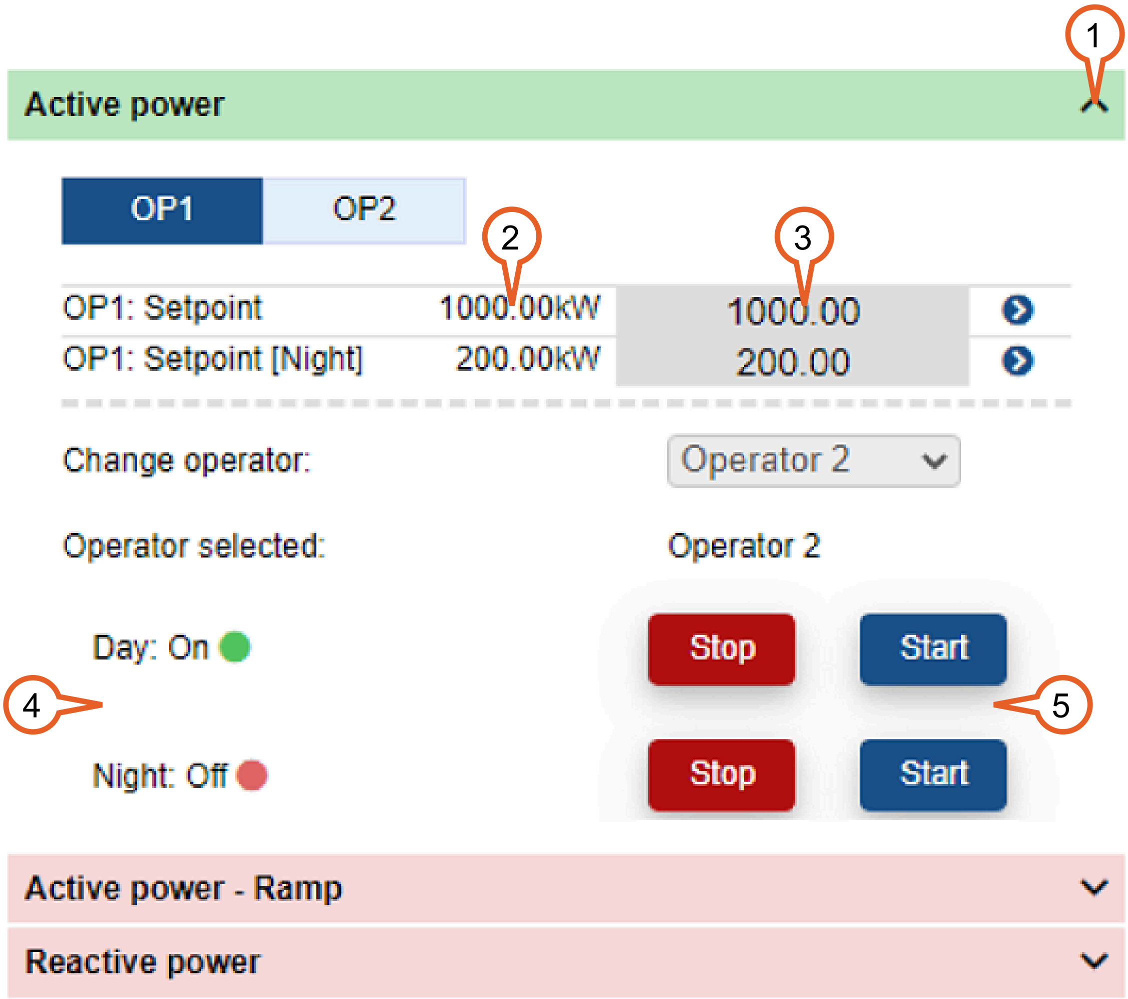
Control panels

The control panels allow you to send setpoint commands to devices directly from the user interface.

The available control panels are:

- Active power
- Reactive power
- Overfrequency and undefrequency
- Active power ramp and Reactive power ramp
- Capacitor banks
- Apparent power
- Power oscillation damping
- Active power reserve
- Fault voltage ride-through
- Hybrid PPC

Power Plant Controller control panels



1. **Expand/Collapse**: click to display or hide each control.

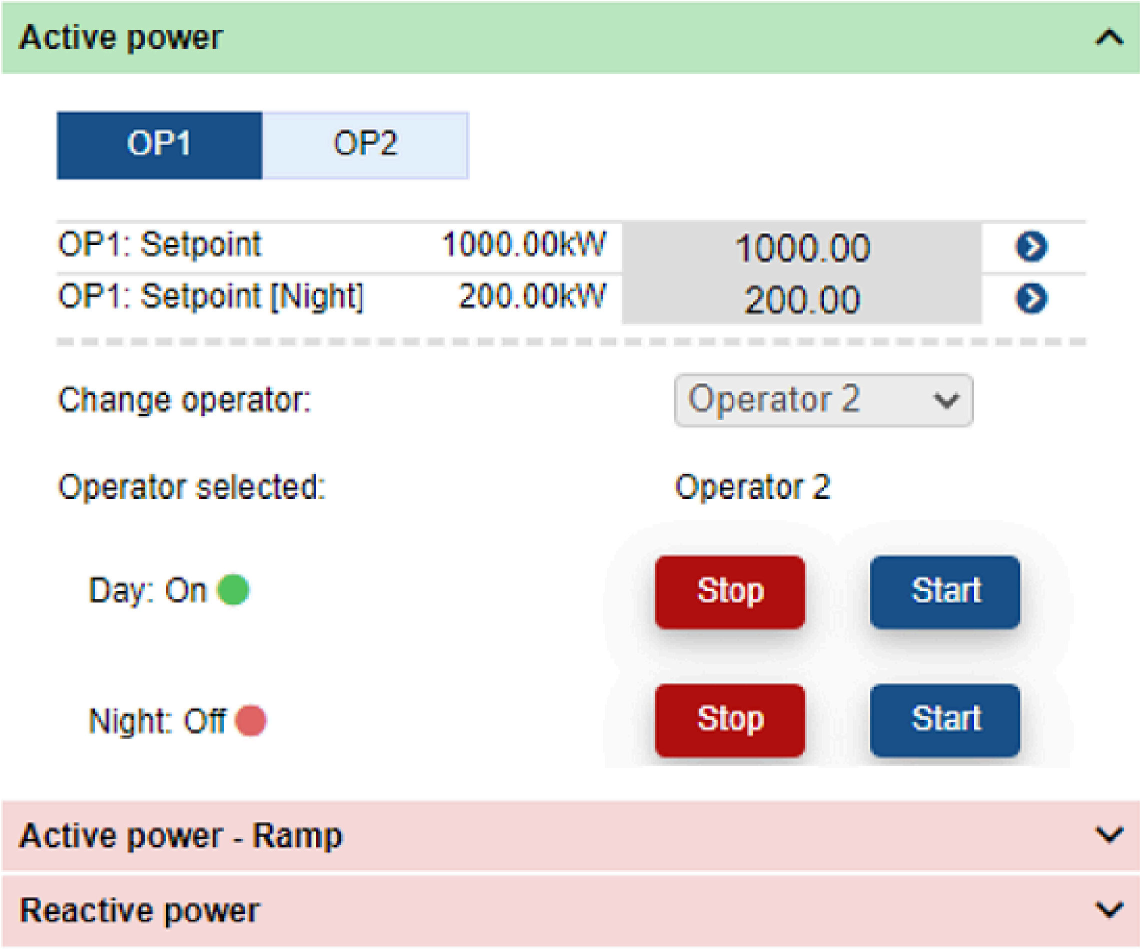
   ⓘ NOTE: You can only expand one control panel at a time.

2. Feedback value: white background label indicates the current value at the PPC Modbus Map, displaying the units of the parameter. This field is not editable.
3. *Setpoint command value*: grey field where the orders must be written.
4. Day/Night status: feedback of the enabled control. If this control has sub-controls configured, it also displays the enabled current sub-control.
5. **Start/Stop**: To apply the current values at the input fields and the switch status button, click on the Start button to overwrite the PPC's Modbus Map.

Active Power Control

Active power control is a curtailment that the system treats as a step, unless the active power ramp is enabled. The GPM HMI PPC allows you to define the setpoints through two different operators. Once you have defined the setpoints, you choose which one to use.

Active Power control panel



You can also set the active power setpoint reference for night mode control. This comes into effect when:

- the system is in night mode.
- the power controls for night mode are enabled.
- the night mode for active power curtailments is configured in the power controls list from the PPC configuration tab (Setup).

Reactive power control

The Reactive control loop has four main external inputs, considered as external loops (see Figure 2. GPM PPC Controls block diagram). The control panel for Reactive power has one tab for each loop.

The main control panel displays a status bar, with an indicator followed by the current reactive power mode (for example, Power Factor).

Reactive power setpoint mode

This mode follows two different setpoints given by the external user. The night setpoint is active when:

- the system is In night mode.
- the Q controls for night mode are enabled.
- the night mode for active power curtailments active power curtailments is configured in the Q controls list from the PPC configuration tab (Setup).

Reactive power control panel in setpoint mode

Power Factor mode

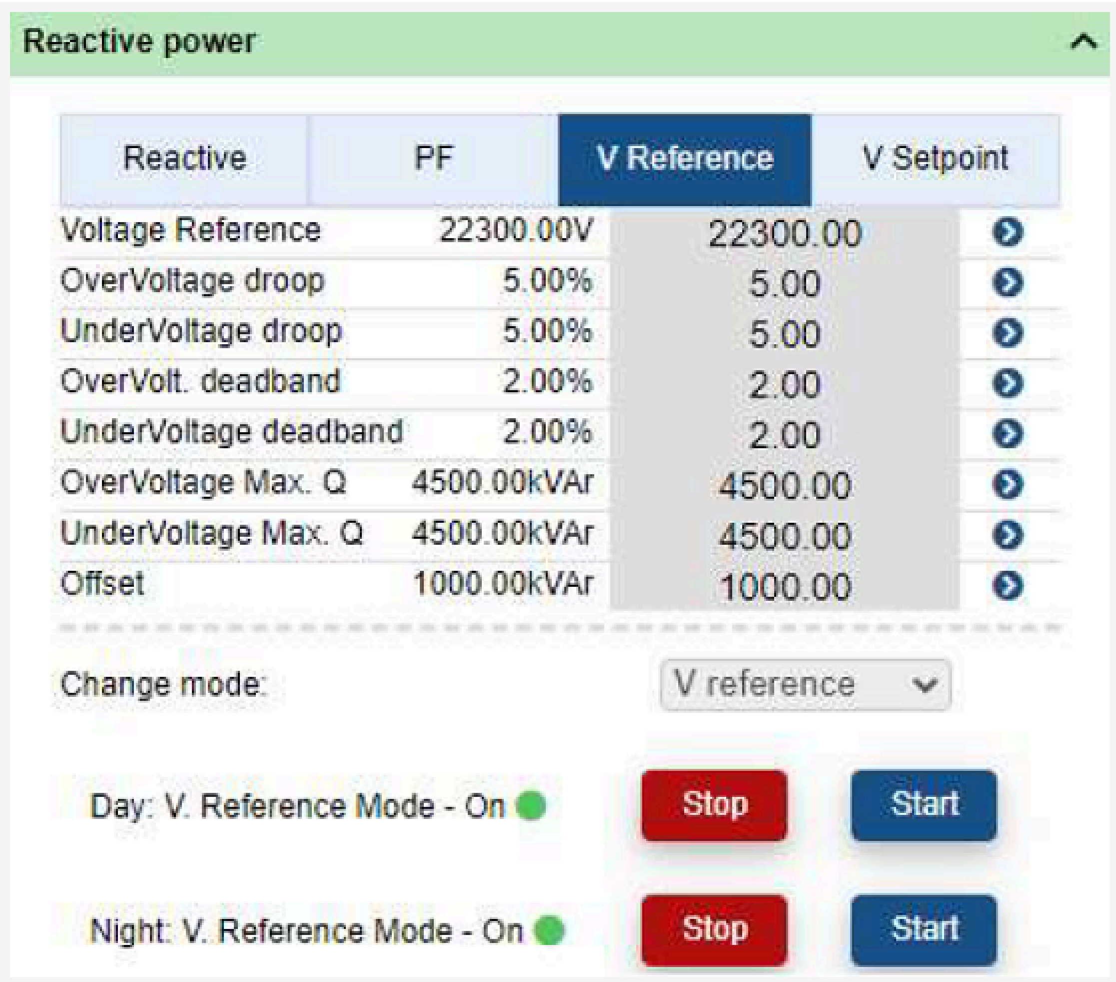
When you set a Power Factor (PF) setpoint, the PPC internally evaluates the reactive power required to accomplish it.

Reactive power control panel in Power Factor mode

Voltage reference mode

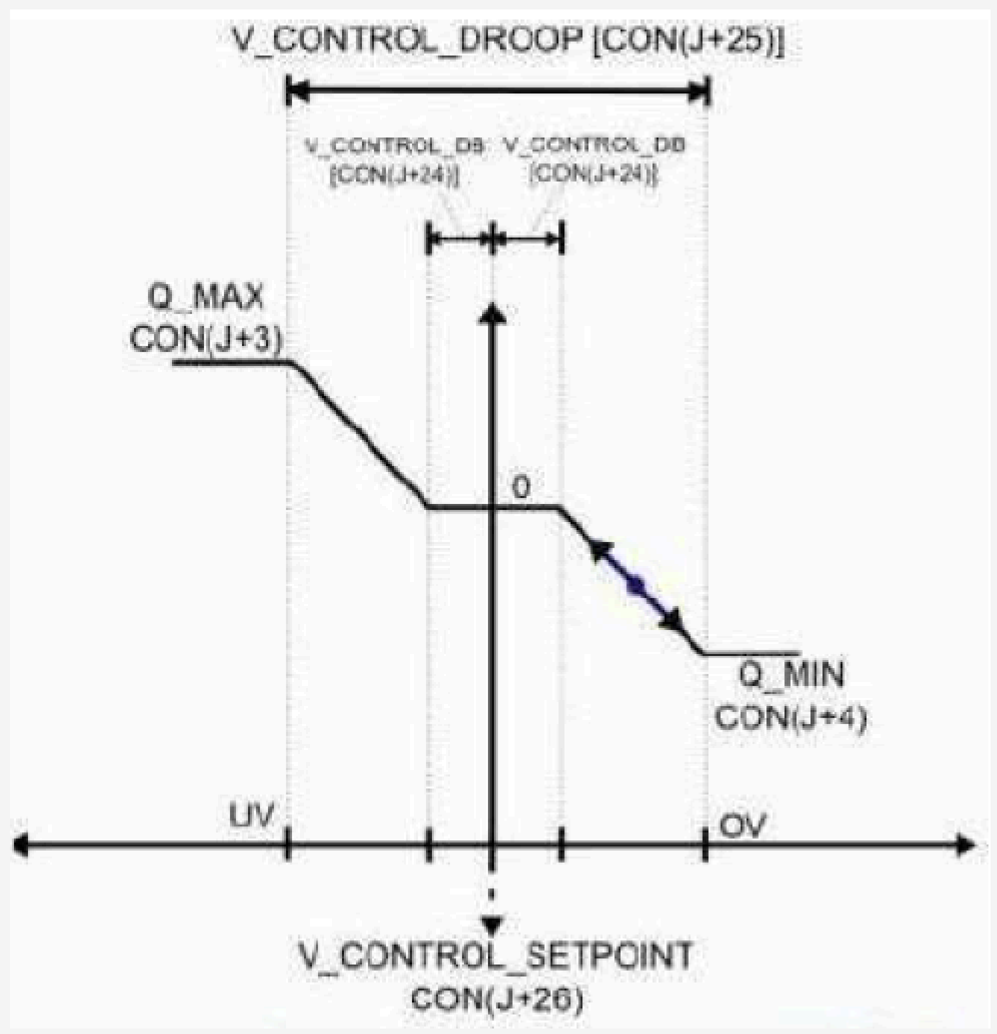
In Voltage reference mode, you must set the parameters to define a droop control for over- and undervoltage controls.

Reactive power control panel in Voltage reference mode



Voltage reference control is a reactive control that requires different parameters for each side of the plot. This means that the system can treat under- and overvoltage reaction differently or equally:

Voltage reference control: expected reaction



- **Voltage setpoint**: voltage reference at the point of interconnection (POI). The PPC does not require any modification of the reactive power internal curtailment.
- **Deadband**: voltage interval defined around the voltage setpoint in terms of %, to avoid oscillations of the reactive power control. This ensures that the reactive power setpoint remains constant. This parameter can be set asymmetric for under- and overvoltage behaviour.
- **Droop**: the slope (in terms of %/V) that the controls must follow to reach the voltage reference whenever the PCC is in under or over the voltage level.

> ⓘ NOTE: The terms of Q_MAX and Q_MIN are defined during the configuration of the PPC service.

Voltage setpoint mode

The Voltage setpoint represents the input of an external proportional-integral (PI) control that evaluates the required reactive power to reach the desired voltage level.

Reactive power control panel in Voltage setpoint mode

ⓘ NOTE: This control is not related to the Voltage reference which has a different behavior.

Overfrequency and underfrequency controls

Under- and overfrequency controls allow you to define the way in which the active power behaves in two ways:

- Droop-control technique.
- Fast frequency regulation (FFR) in non-dynamic terms.

Overfrequency control panel in Droop mode

Droop control

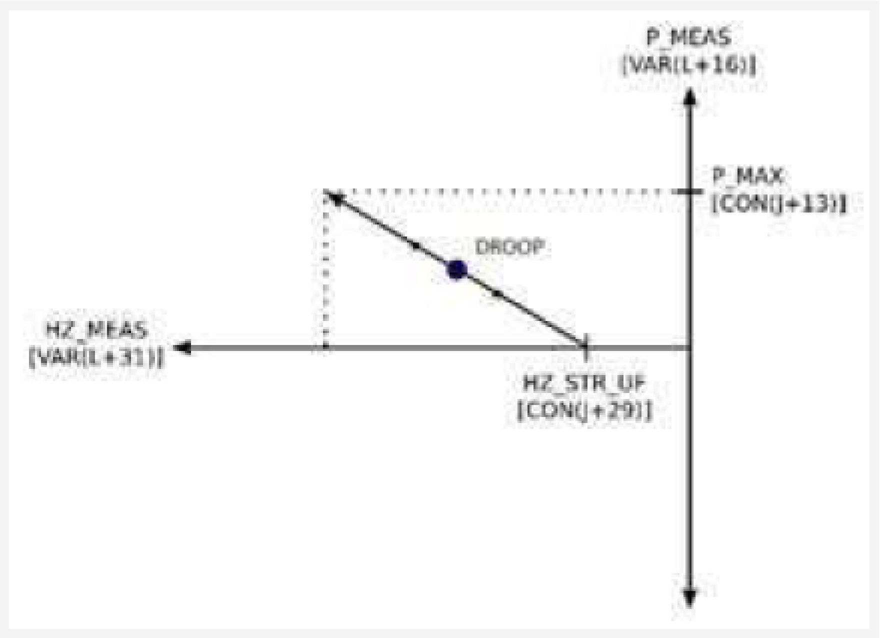
In Droop control, the frequency could drop or increase until it reaches an STR point. This means that it could leave a deadband bound. Then, the active power increases or decreases following a fixed slope, until it reaches the maximum or minimum value at the PCC.

Droop control allows you to modify the behaviour of the regulation, changing the power reference to a certain limit instead of the maximum active power. To enable this feature, toggle on Relative P mode:

- Disabled: the system considers the maximum power as the active power in the droop equation.
- Enabled: the system considers the instantaneous active power measured at the PPC, when the frequency reaches out the deadband, as the active power at the droop slope.

> ⓘ NOTE: The Droop control has the option to enable two different droops at two different starting points. The first droop triggers the under- or over-frequency control, and it keeps working until the second STR point is reached, where the second droop takes its place.

Active power reactions at underfrequency states in a droop control



Active and reactive power ramp

Depending on the country or the final client, it may be mandatory to reach certain active or reactive power steady point within certain slopes (for example, kW/min or MW/min). In such a case, the ramp must be configured internally at the PPC service, and then the slopes must be defined in the Modbus map at the Monitoring view, and then activated.

Active power ramp control panel

These controls are considered external setpoints, delivered by an external user or operator to the PPC, and can be considered as steps or ramp inputs to the inner control loop:

- Active power.
- Reactive power.
- Overfrequency and underfrequency.

Different slopes can be considered for the cases of increasing or decreasing.

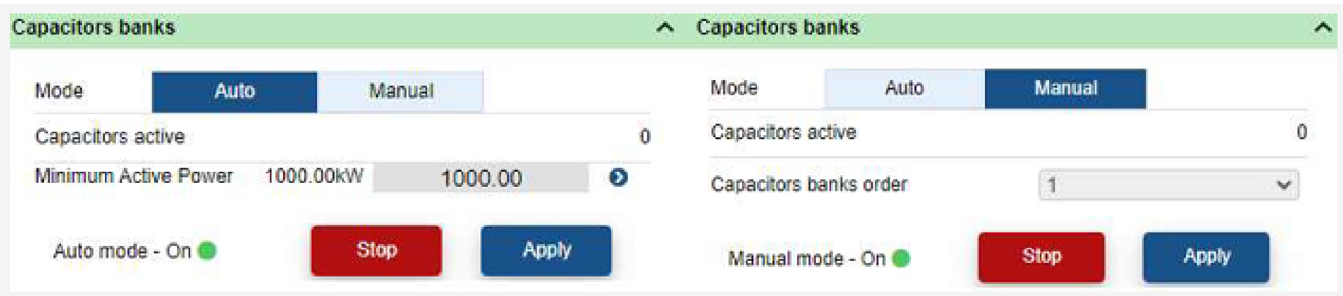
Capacitor banks

The Capacitor banks control allows you to enable the PPC's capacitors banks (CAPBANKS) control. This control has two modes:

- **Auto**: the GPM PPC service manages the number of capacitor banks to enable. You can configure a minimum active power criterion to activate the CAPBANKS in real time. This parameter establishes the starting point of production at which to enable the CAPBANKS. The CAPBANKS do not activate if production is below this limit, even if the Q conditions are reached.
- **Manual**: you manage the number of capacitor banks to enable from the selector list of the HMI user interfaces.

In terms of feedback, this block shows the current status of the control and how many banks are currently active.

Capacitor banks block in auto (left) and manual (right) modes



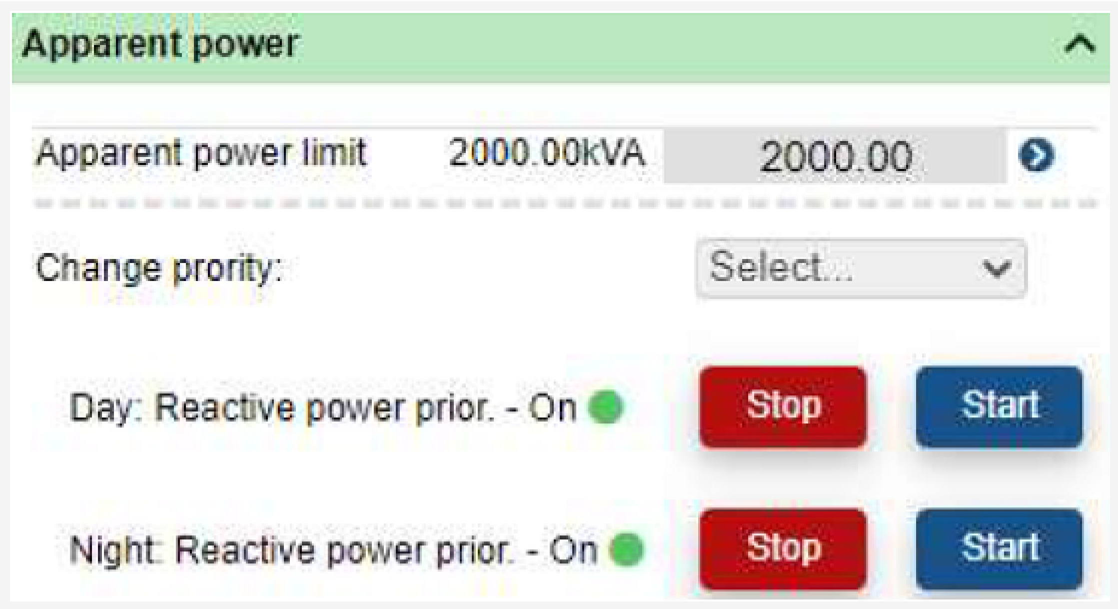
Apparent power control

Apparent power control defines the maximum apparent power that the plant can produce. This is done by prioritizing either the active or the reactive power, and computing a limit for the non-prioritized power setpoint.

Before sending commands from this control, you must define a priority:

- **Active power**
- **Reactive power**

Apparent power control panel



Power Oscillation Damping control

The Power Oscillation Damping (POD) control acts against inter-area power oscillation. When it is active, the GPM PPC analyzes the measurements at the point of interconnection (POI) and detects whether there is an oscillation within the desired frequency limits.

POD control panel

The GPM PPC can act both on the active power and the reactive power output of the plant for the POD control:

- **Active** (toggle on): the GPM PPC performs the signal analysis and detection on the frequency measurements at the POI.
- **Reactive** (toggle of): the GPM PPC uses the voltage measurement.

Active power reserve control

Active power reserve mode produces a suitable active setpoint by reading an available power input value and a configured reserve percentage value. The reserved power (%) is the reserve percentage of the plant's maximum power.

Active power reserve control panel

Fault voltage ride-through

The Fault voltage ride-through (FVRT) control prevents new sentpoints from being sent to the system during fault events. To do this, you must define an upper and a lower voltage limit. The "Freeze time" parameter determines when the GPM PPC starts sending new setpoints to the inverters after the voltage re-enters normal operation.

FVRT control panel

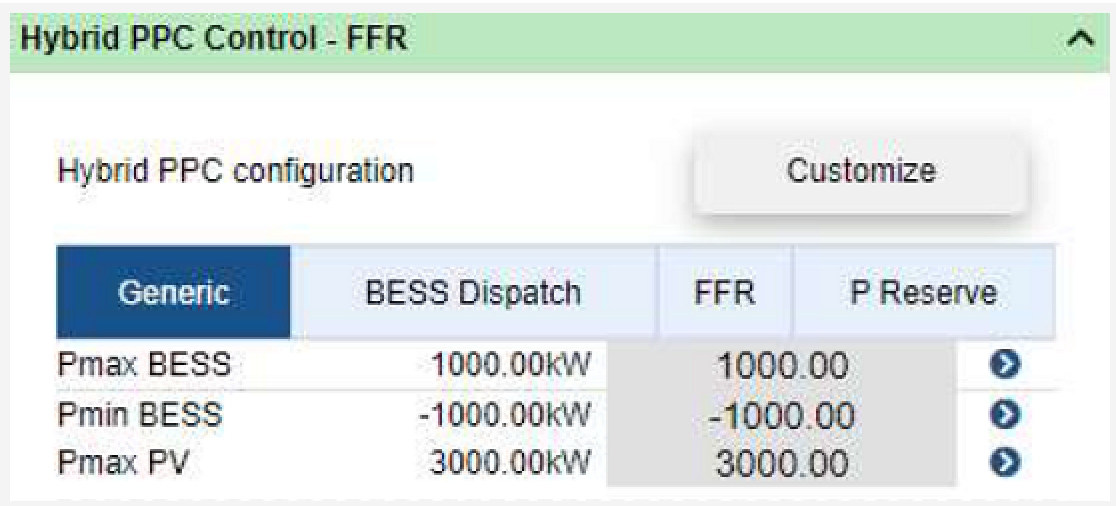
Hybrid PPC Control

The Hybrid PPC (HPPC) control allows you to customize all the required parameters for the correct functionality of the HPPC.

The HPPC has seven modes:

- Full shutdown
- Battery Energy Storage Station (BESS) system off
- Battery Negery Storage Station (BESS) dispatch
- Fault frequency ride-through (FFR)
- Active power reserve
- Peak-shaving
- Arbitrage

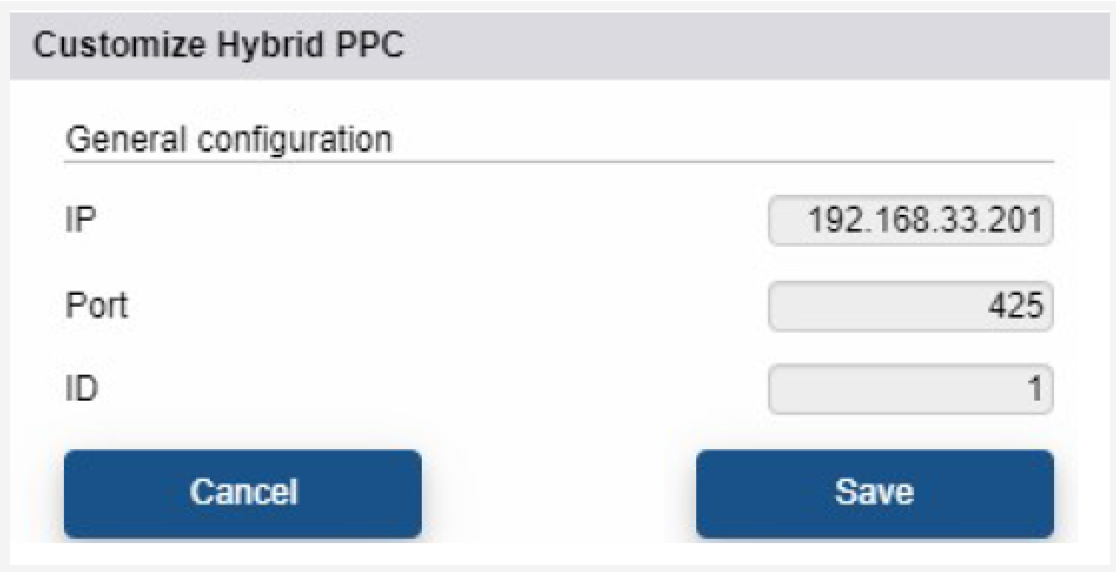
HPPC control panel



To connect the HMI with the HPPC, you must first click the **Customize** button to configure the general parameters and establish communication:

- IP
- Port
- ID

HPPC customization control panel



Full Shutdown mode

Full Shutdown mode allows you to shut down the plant and send setpoints of "0" to both the PV and the Battery Energy Storage Station (BESS). To enable this mode, you must simply select in in the drop-down menu.

> ⓘ NOTE: You do not need to configure any parameters in this mode.

Full Shutdown control panel

BESS System OFF mode

The Battery Energy Storage Station (BESS) System OFF mode allows you to define a setpoint that is followed exclusively by the PV, working as a regular PV plant.

> ⓘ NOTE: You do not need to configure any parameters in this mode.

BESS System OFF control panel

BESS Dispatch mode

BESS Dispatch mode allows you to maintain a determined active power setpoint at the point of interconnection (POI), defined by the control of the regular PPC, while at the same time enabling the site operator to independently control the behavior of the BESS. This lets the operator manage the BESS output power using three different sub-modes:

- Regular dispatch
- State of Charge (Soc) Droop
- SoC Target

Regular Dispatch

In Regular Dispatch sub-mode, you can determine a BESS dispatch value in [kW] for the system to follow. It is also possible to configure a BESS ramp rate in [kW/min], to achieve a smooth active power change at the POI.

SoC Droop

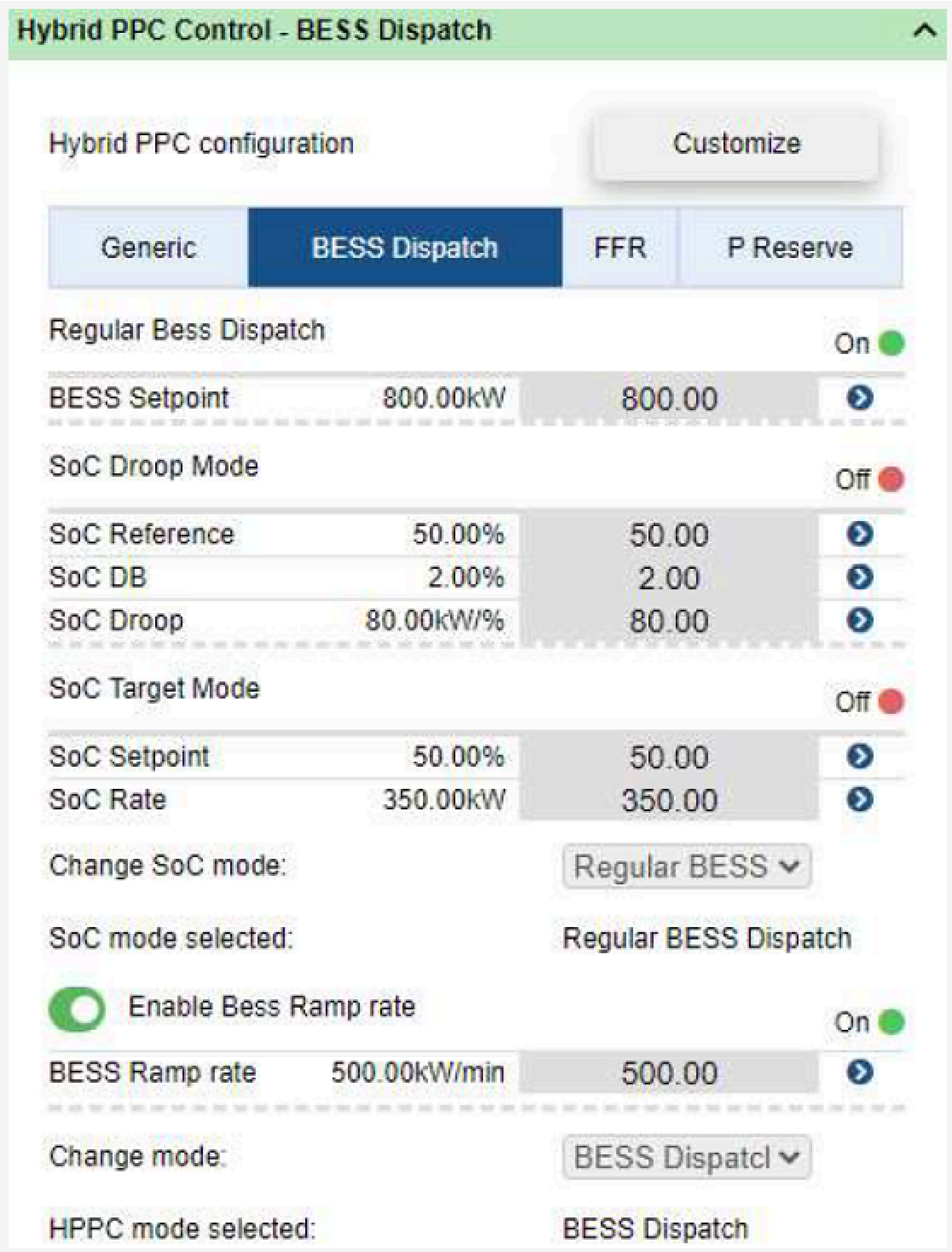
The SoC Droop sub-mode ensures that the average SoC of the BESS remains equal to a reference value determined by the site operator. This allows the Hybrid PPC to regulate the rates of charge or discharge at which the BESS operates, depending the deviation of the instantaneous SoC is from the reference value.

The droop parameters (for exmaple, the SoC reference value [%] or the SoC droop rate [kW/%]) are fully configurable, as well as a certain death-band [%], in which the BESS active power setpoint is null.

SoC Target

In SoC Target sub-mode, you can define an average SoC target [%] for the BESS system and the amount of time [h] that the charging or discharging process of the BESS must take to achieve the desired SoC value. This allows the hybrid PPC to determine the active power setpoint required for the BESS to fulfill the site operator's command, which remains constant until the target is reached. Once the instantaneous SoC is equal to the target value, the BESS system shuts down, maintaining the pre-defined SoC value.

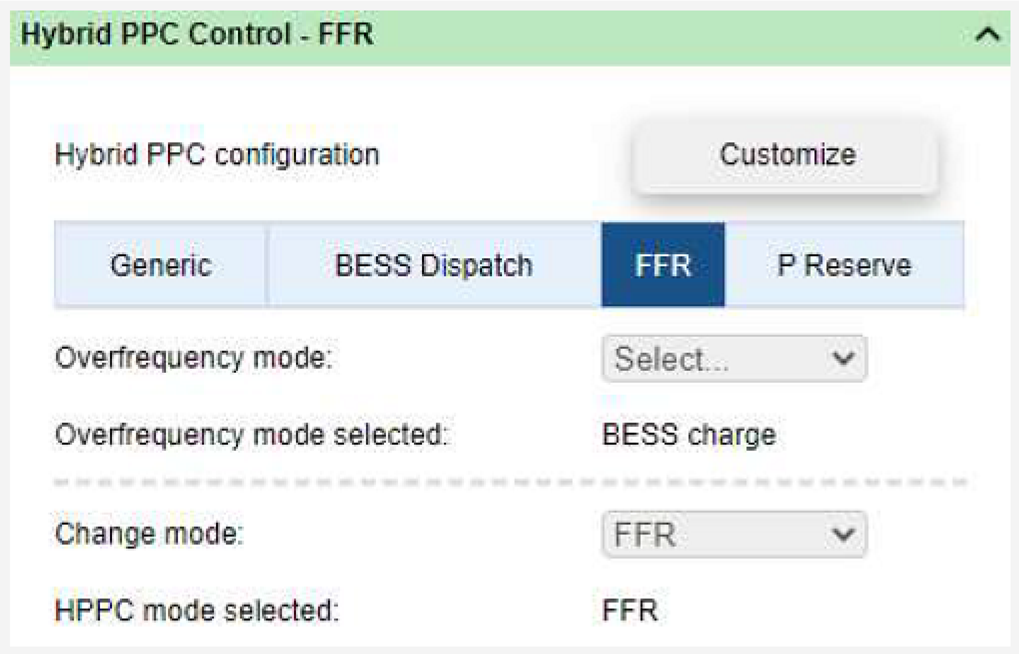
BESS Dispatch control panel



Fault Frequency Ride-through mode

In Fault Frequency Ride-through (FFR) mode, the PV generation follows the setpoint of the PPC. The BESS only triggers when a frequency event occurs, providing a very fast increase (in case of underfrequency) or decrease (in case of overfrequency). You must choose if the power decrease is performed through a PV curtailment or through a BESS charge.

FFR control panel



Active Power Reserve mode

Active Power Reserve mode sets the BESS to reserve a portion of the generated active power. The system reserves active power for as long as the frequency remains within the deadband. If the frequency deviates from the deadband, the system fulfills the power setpoint through a coordinated strategy minimizing PV curtailment.

Active power reserve control panel

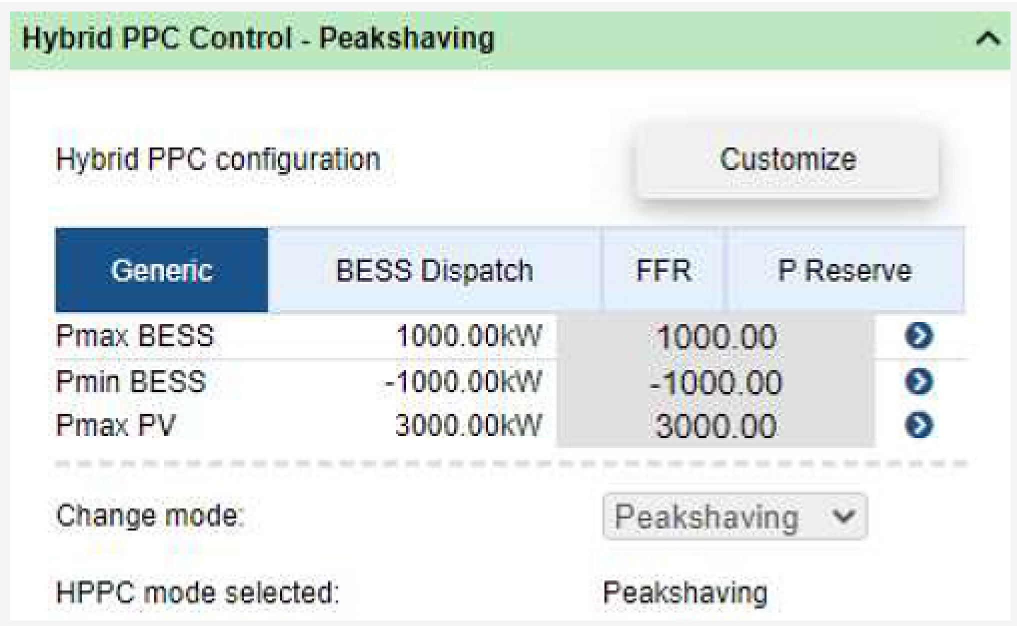
Peak-shaving mode

In Peak-shaving mode, the hybrid site is controlled by using the BESS to comply with the PPC setpoints, while minimizing the curtailment of PV.

If the setpoint is lower than the available PV power, the BESS will tend to always be charging (when possible).

> ⓘ NOTE: You do not need to configure any parameters in this mode.

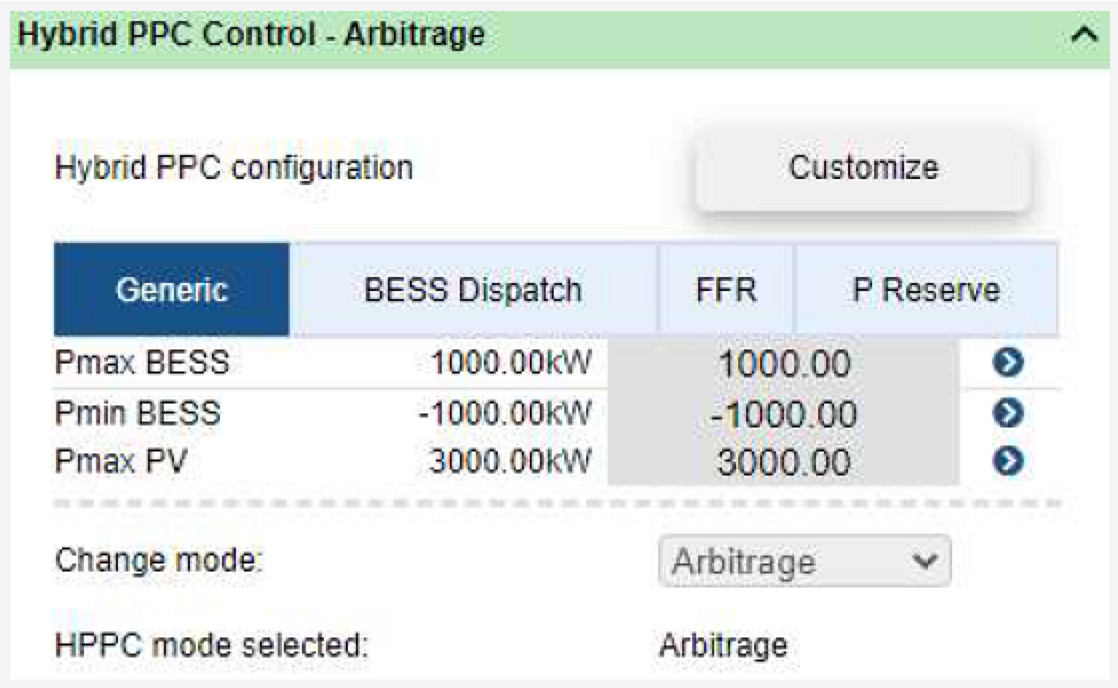
Peak-shaving control panel



Arbitrage mode

Arbitrage mode freezes the PV setpoint and uses the BESS exclusively to quickly fulfil the required setpoint. You can use this mode to quickly activate the BESS to follow a bidding request for a short period of time without any unwanted dynamics.

Arbitrage control panel

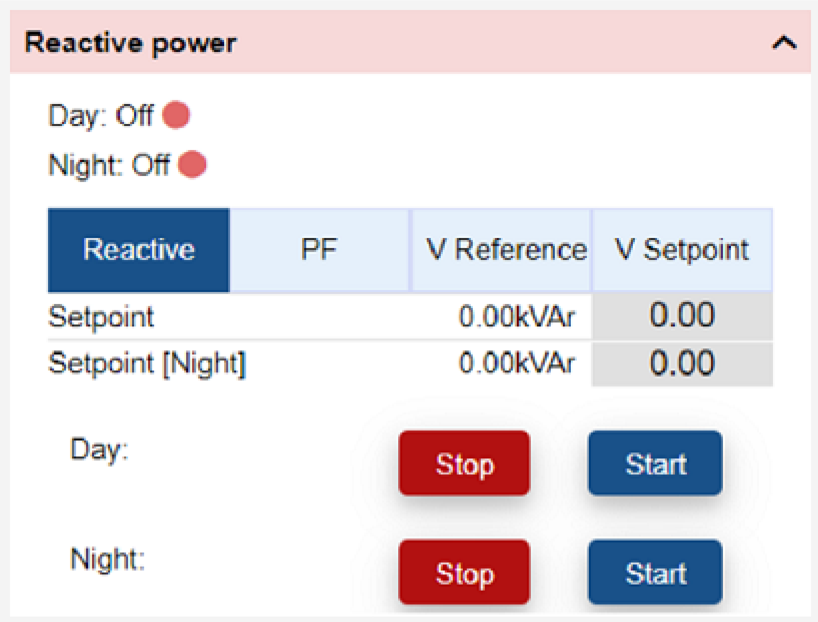


Send setpoint commands

To send a setpoint command, follow these steps:

1 In the Power Plant controller panel, click the icon to expand the control for which you want to send a command.

Reactive power control



2 If there is a sub-control, select the one you want to activate in the corresponding tab:

Subcontrol: PF

3 Enter values for the setpoints in the input fields, taking in account the units shown in the feedback field.

Setpoint values

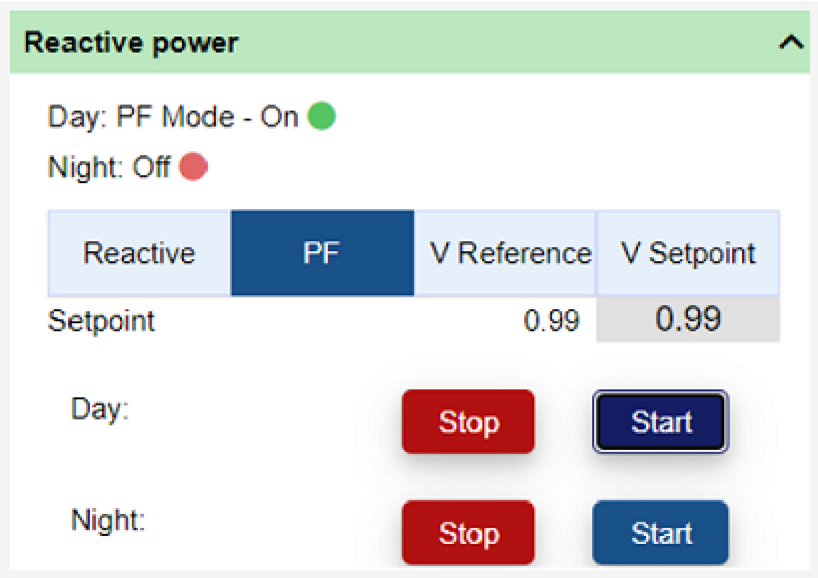
4 Click **Start** to confirm the value and enable the command control.

> ☆ IMPORTANT: This asynchronous action interacts directly with the Modbus Map of the PPC and directly affects the plant.

Result

The system accepts the request and the values for the parameter are updated when the next reading request is resolved.

Updated parameter



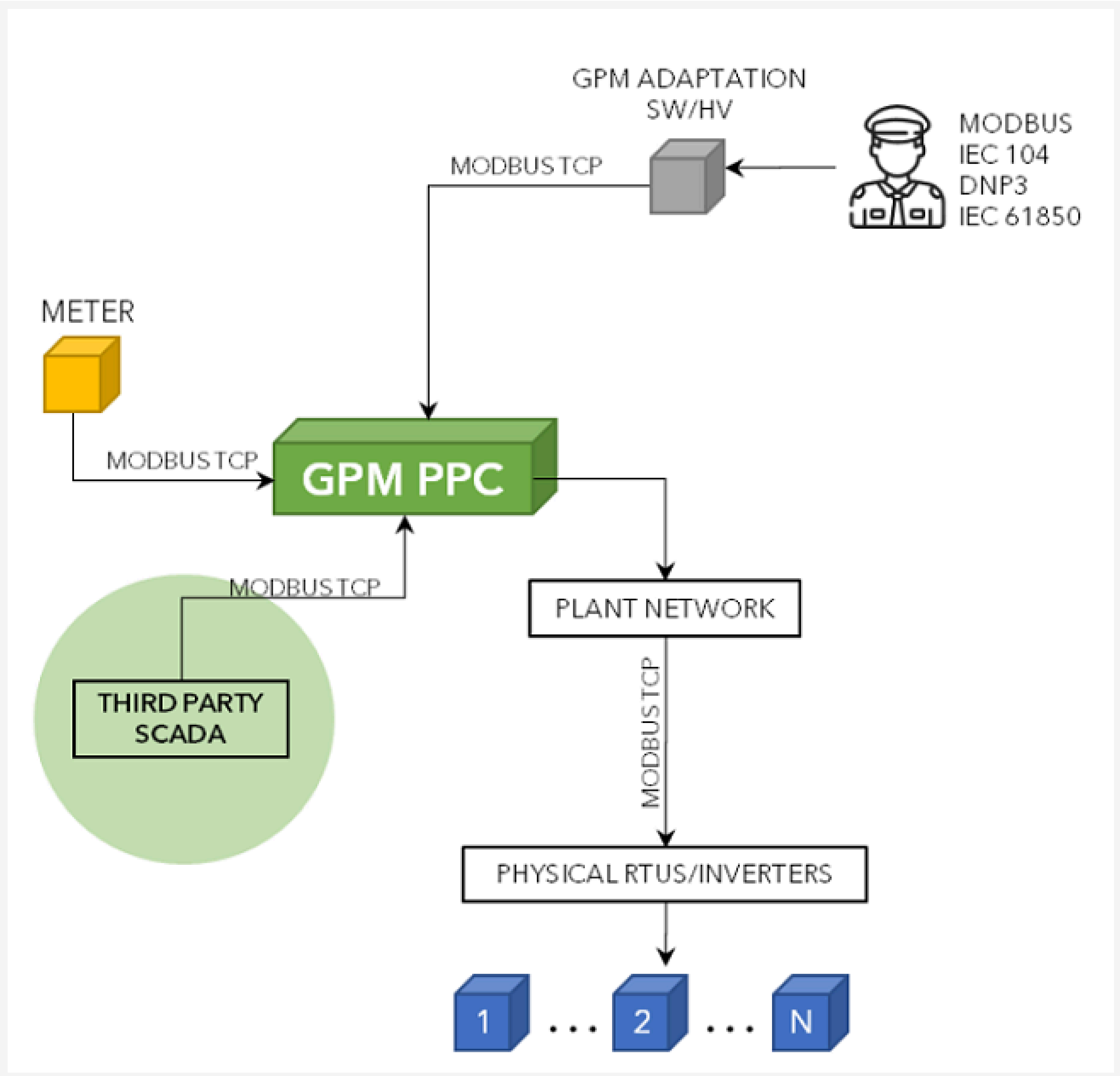
Other configuration interfaces

The GPM PPC also offers the possibility to interact with a third-party SCADA through the PPC Modbus map.

Third-party SCADA

The following image shows a general scheme for the third-party SCADA configuration:

Third-party SCADA configuration



Interaction with the GPM PPC

This section includes detailed information and codes for the following interactions:

Remote Control. The SB Role

- The GPM PPC can accept commands using Modbus TCP
- The commands must be adapted using the SMB

Principle of Communication Network

The GPM PPC communicates with the connected devices, with the power analyzer, the grid operator, and the SCADA system via Modbus protocol.

> ⓘ NOTE: For a more detailed description of the Modbus protocol, please see the latest versions of document available on the Modbus website.

Modbus TCP communications

The GPM PPC has an interface programmed for communications with the exterior based on Modbus protocol.

Communication parameters

Parameter	Default Value	Allowed Values
IP Address	PPC's LAN IP address	Any IP address
TCP Port	Not a default value	N/A

TCP Master/Client

The PPC Modbus TCP client supports multiple simultaneous connections by different Modbus TCP masters. In addition, the GPM PPC supports simultaneous connections by Modbus TCP. A list of multiple IPs is defined, in order to control which client, have access to the GPM PPC. This list is defined for gave access to the configuration of the GPM PPC.

Modbus application protocol

The Modbus application protocol

Supported functions

Code	Name	Description
3 (0x03)	Read Holding Registers	Reads the contents of a block of consecutive registers from the GPM PPC.
16 (0x10)	Write Multiple Holding Registers	Writes the value of a block of consecutive registers to the GPM PPC.

Exception response

If the GPM PPC receives a Modbus request that it cannot handle, it returns an exception response informing the Modbus master of the nature of the exception. The exception response data field may contain one of the exception codes listed in the next table:

Code	Name	Meaning
1	Illegal Function	The GPM PPC does not support the function code specified in the Modbus Request Packet.
2	Illegal Address	The address range specified in the Modbus Request Packet contains an illegal register address.
3	Illegal Data Value	▪ A value contained in the Modbus request is not allowed. ▪ Per the Modbus standard, this exception validates that the request is well-formed, but does not validate the contents of the registers.
4	Slave Device Failure	The PPC's Modbus client has detected an unrecoverable error.

Data-type mapping on Modbus

Measurement	Description
▪ int16 ▪ uint16	▪ Signed/unsigned 16-bit integer. ▪ Single-word (16 bit) values are transmitted in little endian order, according to the Modbus standard. Example: a parameter with value 0x1234 will be mapped on Modbus as: ▪ Address n: 0x3412
▪ int32 ▪ uint32	▪ Signed/unsigned 32-bit integer. ▪ Double-word (32 bit) values are transmitted in little endian order. Example: a parameter with value 0x12345678 will be mapped on Modbus as: ▪ Address n: 0x7856 ▪ Address n+1: 0x3412
▪ int64 ▪ uint64	▪ Signed/unsigned 64-bit integer. ▪ Four-word (64 bit) values are transmitted in little endian order. Example: a parameter with value 0x123456789ABCDEF0 will be mapped to Modbus as: ▪ Address n: 0X F0DE ▪ Address n+1: 0xBC9A ▪ Address: n+2: 0x7856 ▪ Address: n+3: 0x3412
▪ float32	▪ IEEE 754 Single Precision Floating Point (32-bit). ▪ Floating point values are converter to IEEE 754 format and transmitted in little endian order. Example: the floating-point value 123.4567 converts to the 32-bit hexadecimal value 0x42f6e9d5. This value will be mapped to Modbus as: ▪ Address n: 0x d5e9

- Address n+1: 0x f642

Floating points: special values

Special values for floating points.

Special Value	Description
+0	Positive zero (normal zero).
▪ -0	▪ Negative zero. ▪ When reading, -0 must be tolerated. ▪ This value may be written to any writable parameter. In most cases, -0 is treated identically to +0 by the inverter. The exception is PF commands, where +0 and -0 cause the inverter to produce maximum reactive power with opposite signs.
▪ +inf ▪ -inf	▪ Positive and negative infinity. ▪ When reading, +inf and -inf values must be tolerated. ▪ These values may not be written to any writable register.
▪ NaN	▪ Not a number. ▪ In the IEEE754 standard, these are many possible NaN values. ▪ When reading, NaN must be tolerated. Typically, NaN means that the value is a measurement that is unavailable or unreadable. ▪ Some writable parameters will accept a NaN value.

Parameter data model

Communication parameters

The access field (R/W) defines whether the parameter is readable or writable.

Code	Descripition
R	Parameter is read-only.
R*	Parameter is read-only on Modbus. Some classes of user are to write this.
R/W	Parameter is readable and writable.

Units

Measurable parameters are given a unit of measure by combining a scaling prefix and SI unit according to the following tables:

ⓘ NOTE: Units followed by "(pu)" are per-unit quantities. For example, "V (pu)" indicated that the parameter is a per-unit voltage where a value of 1.0 represents a full-scale reading.

Prefixes

Prefix	Meaning	Prefix	Meaning
(none)	No scaling		
d	deci $x10^{-1}$	da	deca x10
c	centi $x10^{-2}$	h	hecta x100
m	milli $x10^{-3}$	k	kilo x1000
μ	micro $x10^{-6}$	M	mega $x10^{6}$
n	nano $x10^{-9}$	G	giga $x10^{9}$
p	pico $x10^{-12}$	T	tera $x10^{12}$

Units

Unit	Meaning	Unit	Meaning
(none)	Unitless quantity	1/s	per second
A	amperes	V	volts
Ah	ampere hours	VA	volt-amperes
A/s	amperes per second	VAh	volt-amperes hours
ºC	degrees Celsius	var	vars
cos(θ)	power factor	varh	vars hours
f	farad	var/s	vars per second
h	hours	W	watts
Hz	hertz	Wh	watt hours
Hz/s	hertz per second	W/m^2	watts per square second
Pa	pascal	W/s	watts per second
rpm	revolutions per minute	Ω	ohms
s	seconds	%	unitless percentage where a value of 1.0 means 100%

Communication parameters reference

Code	Descripition
R	Parameter is read-only.
R*	Parameter is read-only on Modbus. Some classes of user are to write this.
R/W	Parameter is readable and writable.

Parameter data model - units reference

Prefix	Meaning	Prefix	Meaning
(none)	No scaling		
d	deci $x10^{-1}$	da	deca x10
c	centi $x10^{-2}$	h	hecta x100
m	milli $x10^{-3}$	k	kilo x1000
µ	micro $x10^{-6}$	M	mega $x10^{6}$
n	nano $x10^{-9}$	G	giga $x10^{9}$
p	pico $x10^{-12}$	T	tera $x10^{12}$

Unit	Meaning	Unit	Meaning
(none)	Unitless quantity	1/s	per second
A	amperes	V	volts
Ah	ampere hours	VA	volt-amperes
A/s	amperes per second	VAh	volt-amperes hours
ºC	degrees Celsius	var	vars
cos(θ)	power factor	varh	vars hours
f	farad	var/s	vars per second
h	hours	W	watts
Hz	hertz	Wh	watt hours

Hz/s	hertz per second	W/m^2	watts per square second
Pa	pascal	W/s	watts per second
rpm	revolutions per minute	Ω	ohms
s	seconds	%	unitless percentage where a value of 1.0 means 100%

Operation mode commands and feedback

This section provides detailed lists of the different Modbus addresses required for the activation/deactivation of all the PPC operation modes.

Input measurements

Meter POI

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
20	TOTAL AC ACTIVE POWER	kW	Read	1792	float32	2	3
21	TOTAL AC REACTIVE POWER	kVAr	Read	1794	float32	2	3
23	AC POWER FACTOR	-	Read	1798	float32	2	3
24	GRID FREQUENCY	Hz	Read	1800	float32	2	3
27	VOLTAGE PHASE A-GROUND	kV	Read	1806	float32	2	3
28	VOLTAGE PHASE B-GROUND	kV	Read	1808	float32	2	3
29	VOLTAGE PHASE C-GROUND	kV	Read	1810	float32	2	3
291	AVAILABLE ACTIVE POWER	kW	Read	9992	float32	2	3

GPM RTUSB2

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
77	NUMBER OF INVERTERS ONLINE	-	Read	9728	unit32	2	3
124	MAX POWER OF PV INVERTER	kW	Read	9984	float32	2	3

GPM capacitor banks

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
79	NUMBER CAPACITOR BANKS ONLINE	-	Read	9730	uint32	2	3

Output GPMRTUSB2

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
175	ACTIVE POWER ORDER TO INVERTERS	kW	Read	18180	float32	2	3
176	REACTIVE POWER ORDER TO INVERTERS	KVAr	Read	18186	float32	2	3
177	RELATIVE ACTIVE POWER ORDER TO INVERTERS	%	Read	18190	float32	2	3
178	RELATIVE REACTIVE POWER ORDER TO INVERTERS	%	Read	18192	float32	2	3

Internally computed parameters

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
25	AVERAGE VOLTAGE 3 PHASES	kV	Read	1802	float32	2	3
33	ACTUAL UP RAMP RATE	%	Read	1818	float32	2	3
34	ACTUAL DOWN RAMP RATE	%	Read	1820	float32	2	3
153	ACTIVE POWER INTERNAL SETPOINT	kW	Read	18178	float32	2	3
154	REACTIVE POWER INTERNAL SETPOINT	kVAr	Read	18184	float32	2	3

System commands

	Name	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
47	PPC OPERATING MODE	-	Read	13312	uint16	1	3
48	CONTROLS ENABLED	-	Read	13313	uint16	1	3
110	OPERATION MODE CONTROLS ON/ OFF	-	Read and write	54273	uint16	1	3
125	COMS STATUS SMARTBRIDGE	-	Read	13339	uint16	1	3
168	PPC CONTROLS OPERATION MODE	-	Read and write	54272	uint16	1	3
169	PPC STATE	-	Read	13330	uint16	1	3
170	PPC ERRORS 1	-	Read	13331	uint16	1	3
171	PPC ALARMS 1	-	Read	13335	uint16	1	3
187	ACTIVE CONTROL KP	-	Read and write	59160	float32	2	3
188	ACTIVE CONTROL KI	-	Read and write	59162	float32	2	3
189	ACTIVE	-	Read	59164	float32	2	3

	CONTROL AWUP		and write				
190	REACTIVE CONTROL KP	-	Read and write	59166	float32	2	3
191	REACTIVE CONTROL KI	-	Read and write	59168	float32	2	3
192	REACTIVE CONTROL AWUP	-	Read and write	59170	float32	2	3
225	PPC LOOP TIME	ms	Read	17920	uint32	2	3
226	SET PPC LOOP TIME	ms	Read and write	58880	uint32	2	3
227	FREE RUN	-	Read	17410	float32	2	3
228	FREE RUN NEGATIVE	-	Read	17413	float32	2	3
257	ACTIVE POWER OPENLOOP PI CONTROLLER DISABLED	-	Read and write	58369	uint16	1	3
258	REACTIVE POWER OPENLOOP PI CONTROLLER DISABLED	-	Read and write	58370	uint16	1	3
231	ACTIVE POWER CONTROL	-	Read	17414	uint16	1	3

	SELECTED						
232	REACTIVE POWER CONTROL SELECTED	-	Read	17415	uint16	1	3
234	REACTIVE POWER IN FREE RUN	-	Read	17416	uint16	1	3
235	NEGATIVE REACTIVE POWER FREE RUN	-	Read	17417	uint16	1	3
236	ACTIVE POWER IN NIGHT MODE	-	Read	17408	uint16	1	3
237	ACTIVE POWER IN RAMP	-	Read	17409	uint16	1	3
238	REACTIVE POWER IN NIGHT MODE	-	Read	17411	uint16	1	3
239	REACTIVE POWER IN RAMP	-	Read	17412	uint16	1	3
240	ACTIVE POWER CURRENT SETPOINT	kW	Read and write	18176	float32	2	3
241	REACTIVE POWER CURRENT SETPOINT	kWAr	Read and write	18182	float32	2	3
242	POWER FACTOR	-	Read	18188	float32	2	3

	CURRENT SETPOINT		and write				
243	PPC ERRORS 2	-	Read	13332	uint16	1	3
265	ACTIVE POWER EXIT FREE RUN OPERATION MODE	-	Read and write	54304	uint16	1	3
267	MIN POWER OF PV INVERTER	kW	Read	9990	float32	2	3
268	REACTIVE POWER EXIT FREE RUN OPERATION MODE	-	Read and write	54305	uint16	1	3
470	FIRMWARE VERSION 0	-	Read	13359	uint16	1	3
471	FIRMWARE VERSION 1	-	Read	13360	uint16	1	3
472	FIRMWARE VERSION 2	-	Read	13361	uint16	1	3
517	NIGHT DETECTION HYSTERESY STEP IN	kW	Read and write	55190	float32	2	3
518	NIGHT DETECTION HYSTERESY STEP OUT	kW	Read and write	55192	float32	2	3
519	NIGHT	ms	Read	55194	float32	2	3

	DETECTION TIMER STEP IN		and write				
520	NIGHT DETECTION TIMER STEP OUT	ms	Read and write	55196	float32	2	3
650	ACTIVE POWER SETPOINT IN USE	kW	Read	9994	float32	2	3

ⓘ NOTE: Depending on the value of parameter 231 - ACTIVE POWER CONTROL SELECTED, the user can know which control is activated at the moment taking into account the following table:

Value	Description
0	None
1	Active power setpoint always active
2	Over-frequency control mode 1 (STR-STP)
3	Over-frequency control mode 2 (Droop control)
4	Under-frequency control mode 1 (STR-STP)
5	Under-frequency control mode 2 (Droop control)
6	Active power – Over-voltage (Droop control)
7	Active power – Under-voltage (Droop control)
8	Active power – Over-voltage (STR-STP)
9	Active power – Under-voltage (STR-STP)
10	Active Power – Free Run Actual Up Ramp Rate

11	Nondynamic Over-frequency control
12	Nondynamic Under-frequency control

ⓘ NOTE: The same will be appreciated in the parameter 232 - REACTIVE POWER CONTROL SELECTED, where the following list should be considered:

Value	Description
0	None
101	Reactive power setpoint always active
102	Power Factor control always active
103	Reactive power – Voltage Control Droop Q(V)
104	Power Factor – Voltage control droop PF(V)
105	Power Factor – Voltage control (STR-STP)
106	Reactive power – Voltage setpoint

Name
PPCGpm.xAlgorithmParameters.uiEvaluationTime
PPCGpm.xAlgorithmParameters.ulNumberOfinverters
PPCGpm.xAlgorithmParameters.dWmax
PPCGpm.xAlgorithmParameters.dWOffset
ExecutionOrder - uiRampEnable
PPCGpm.xAlgorithmParameters.uiEnableNegativeActivePowerControl
PPCGpm.xAlgorithmParameters.dPKp

PPCGpm.xAlgorithmParameters.dPKi
PPCGpm.xAlgorithmParameters.dPKiAwup
PPCGpm.xAlgorithmParameters.dVARmax
PPCGpm.xAlgorithmParameters.dVAROffset
ExecutionOrder - uiRampEnable
PPCGpm.xAlgorithmParameters.dQKp
PPCGpm.xAlgorithmParameters.dQKi
PPCGpm.xAlgorithmParameters.dQKiAwup
PPCGpm.xAlgorithmParameters.dNullProductionIn
PPCGpm.xAlgorithmParameters.dNullProductionOut
PPCGpm.xAlgorithmParameters.dVARNullProductionSetpoint
PPCGpm.xAlgorithmParameters.dWNullProductionSetpoint

Active power control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
35	ACTIVE POWER SETPOINT RETURN INFO	kW	Read	5888	float32	2	3
43	ERROR TERM FOR ACTIVE POWER	kW	Read	5904	float32	2	3
49	ACTIVE POWER CURTAILMENT ENABLED	-	Read	13314	uint16	1	3
96	ACTIVE POWER CURTAILMENT CONTROL OPERATION MODE	-	Read and write	54274	uint16	1	3
112	ACTIVE POWER SETPOINT	kW	Read and write	59136	float32	2	3
681	ACTIVE POWER SETPOINT 2	kW	Read and write	59182	float32	2	3

Active power ramp control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
38	ACTIVE UP RAMP RATE RETURN INFO	kW/ min	Read	5896	float32	2	3
39	ACTIVE DOWN RAMP RATE RETURN INFO	kW/ min	Read	5898	float32	2	3
53	ACTIVE POWER RAMP CONTROL ENABLED	-	Read	13318	uint16	1	3
99	ACTIVE POWER RAMP CONTROL OPERATION MODE	-	Read and write	54278	uint16	1	3
115	ACTIVE POWER RAMP UP	kW/ min	Read and write	59144	float32	2	3
116	ACTIVE POWER RAMP DOWN	kW/ min	Read and write	59146	float32	2	3
179	FREERUN ACTIVE ACTUAL UP RAMP RATE CONTROL ENABLED	-	Read	13346	uint16	1	3
180	FREERUN	-	Read	54297	uint16	1	3

ACTIVE ACTUAL UP RAMP RATE CONTROL OPERATION MODE	and write

Active power reserve mode

	Name	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
292	ACTIVE POWER RESERVE CONTROL ENABLE	-	Read	13357	uint16	1	3
293	ACTIVE POWER IN RESERVE POWER	-	Read	17419	uint16	1	3
294	ACTIVE POWER RESERVE CONTROL OPERATION MODE	-	Read and write	54310	uint16	1	3
296	ACTIVE POWER CONTROL RESERVED POWER	%	Read and write	55156	float32	2	3

Frequency control

Over-frequency control mode 0 (STR-STP)

	Name	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
65	OVER FREQUENCY START STOP CONTROL ENABLED	-	Read	13328	uint16	1	3
81	START FREQUENCY FOR ACTIVE POWER-OVER FREQUENCY START-STOP CONTROL	Hz	Read and write	55042	float32	2	3
82	STOP FREQUENCY FOR ACTIVE POWER-OVER FREQUENCY START-STOP CONTROL	Hz	Read and write	55044	float32	2	3
111	ACTIVE POWER - OVER FREQUENCY START- STOP CONTROL OPERATION MODE	-	Read and write	54290	uint16	1	3
233	RELATIVE ACTIVE POWER	%	Read and	55166	float32	2	3

	LIMIT FOR FREQUENCY CONTROL		write				
269	HIGH LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55136	float32	2	3
270	LOW LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55138	float32	2	3
295	ACTIVE POWER-FREQUENCY DROOP BASE POWER TYPE	-	Read and write	54311	uint16	1	3
453	ACTIVE POWER-FREQUENCY DROOP MAX POWER	-	Read and write	55164	float32	2	3

Over-frequency control mode 1 (Droop control)

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
40	W FREQ SETPOINT RETURN INFO	Hz	Read	5900	float32	2	3
46	ERROR TERM FOR FREQUENCY (ACTIVE POWER CONTROL)	Hz	Read	5912	float32	2	3
80	ACTIVE POWER - OVER FREQUENCY DROOP	%/Hz	Read and write	55040	float32	2	3
92	ACTIVE POWER CONTROL FREQUENCY SETPOINT	Hz	Read and write	59148	float32	2	3
143	ACTIVE POWER - OVER FREQUENCY DROOP CONTROL ENABLED	-	Read	13341	uint16	1	3
145	ACTIVE POWER - OVER FREQUENCY DROOP CONTROL	-	Read and write	54292	uint16	1	3

	OPERATION MODE						
147	START FREQUENCY FOR ACTIVE POWER-OVER FREQUENCY DROOP CONTROL	Hz	Read and write	55080	float32	2	3
195	ACTIVE POWER - OVER FREQUENCY DROOP 2	%/Hz	Read and write	55108	float32	2	3
196	START FREQUENCY 2 FOR ACTIVE POWER-OVER FREQUENCY DROOP CONTROL	Hz	Read and write	55110	float32	2	3
233	RELATIVE ACTIVE POWER LIMIT FOR FREQUENCY CONTROL	%	Read and write	55166	float32	2	3
269	HIGH LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55136	float32	2	3
270	LOW LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55138	float32	2	3

295	ACTIVE POWER-FREQUENCY DROOP BASE POWER TYPE	-	Read and write	54311	uint16	1	3

Non-dynamic Over-frequency control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
244	NONDYNAMIC OVER FREQUENCY CONTROL SETTING MODE	-	Read and write	54301	uint16	1	3
246	NONDYNAMIC OVER FREQUENCY CONTROL ENABLED	-	Read	13350	uint16	1	3
248	NONDYNAMIC OVER FREQUENCY CONTROL TRIGGER FREQUENCY	Hz	Read and write	55118	float32	2	3
250	NONDYNAMIC OVER FREQUENCY CONTROL ACTIVE POWER SETPOINT	kW	Read and write	55122	float32	2	3
252	NONDYNAMIC OVER FREQUENCY CONTROL DURATION TIME	s	Read and write	55126	float32	2	3

254	NONDYNAMIC OVER FREQUENCY CONTROL IDLE TIME	s	Read and write	55130	float32	2	3
233	RELATIVE ACTIVE POWER LIMIT FOR FREQUENCY CONTROL	%	Read and write	55166	float32	2	3
269	HIGH LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55136	float32	2	3
270	LOW LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55138	float32	2	3

Over-Frequency Control - FSM

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
651	ACTIVE POWER - OVER FREQUENCY DROOP FSM CONTROL ENABLED	-	Read	13382	uint16	1	3
652	ACTIVE POWER - OVER FREQUENCY DROOP FSM NIGHT CONTROL ENABLED	-	Read	13383	uint16	1	3
656	ACTIVE POWER - OVER FREQUENCY DROOP FSM CONTROL OPERATION MODE	-	Read and write	54334	uint16	1	3
658	ACTIVE POWER - OVER FREQUENCY DROOP FSM NIGHT CONTROL OPERATION MODE	-	Read and write	54336	uint16	1	3
660	ACTIVE POWER - OVER	-	Read and	54338	uint16	1	3

	FREQUENCY DROOP FSM HYSTERESIS ENABLE		write				
664	START FREQUENCY FOR ACTIVE POWER-OVER FREQUENCY DROOP FSM CONTROL	Hz	Read and write	55198	float32	2	3
665	START FREQUENCY 2 FOR ACTIVE POWER-OVER FREQUENCY DROOP FSM CONTROL	Hz	Read and write	55200	float32	2	3
666	ACTIVE POWER - OVER FREQUENCY DROOP FSM HYSTERESIS WAIT STOP FREQUENCY	Hz	Read and write	55202	float32	2	3
667	ACTIVE POWER - OVER FREQUENCY DROOP FSM HYSTERESIS WAIT STOP FREQUENCY 2	Hz	Read and write	55204	float32	2	3
668	ACTIVE POWER - OVER	%	Read and	55206	float32	2	3

	FREQUENCY DROOP FSM		write				
669	ACTIVE POWER - OVER FREQUENCY DROOP FSM 2	%	Read and write	55208	float32	2	3

Under-frequency control mode 0 (STR-STP)

	Name	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
138	START FREQUENCY FOR ACTIVE POWER-UNDER FREQUENCY START-STOP CONTROL	Hz	Read and write	55052	float32	2	3
139	STOP FREQUENCY FOR ACTIVE POWER-UNDER FREQUENCY START-STOP CONTROL	Hz	Read and write	55054	float32	2	3
140	ACTIVE POWER - UNDER FREQUENCY START- STOP CONTROL OPERATION MODE	-	Read and write	54291	uint16	1	3
141	ACTIVE POWER-UNDER FREQUENCY START-STOP CONTROL ENABLED	-	Read	13340	uint16	1	3
233	RELATIVE	%	Read	55166	float32	2	3

	ACTIVE POWER LIMIT FOR FREQUENCY CONTROL		and write				
269	HIGH LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55136	float32	2	3
270	LOW LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55138	float32	2	3
295	ACTIVE POWER-FREQUENCY DROOP BASE POWER TYPE	-	Read and write	54311	uint16	1	3
453	ACTIVE POWER-FREQUENCY DROOP MAX POWER	-	Read and write	55164	float32	2	3

Under-frequency control mode 1 (Droop control)

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
40	W FREQ SETPOINT RETURN INFO	Hz	Read	5900	float32	2	3
46	ERROR TERM FOR FREQUENCY (ACTIVE POWER CONTROL)	Hz	Read	5912	float32	2	3
86	ACTIVE POWER - UNDER FREQUENCY DROOP	%/Hz	Read and write	55050	float32	2	3
92	ACTIVE POWER CONTROL FREQUENCY SETPOINT	Hz	Read and write	59148	float32	2	3
144	ACTIVE POWER - UNDER FREQUENCY DROOP CONTROL ENABLED	-	Read	13342	uint16	1	3
146	ACTIVE POWER - UNDER FREQUENCY DROOP CONTROL	-	Read and write	54293	uint16	1	3

	OPERATION MODE						
148	START FREQUENCY FOR ACTIVE POWER-UNDER FREQUENCY DROOP CONTROL	Hz	Read and write	55082	float32	2	3
197	ACTIVE POWER - UNDER FREQUENCY DROOP 2	%/Hz	Read and write	55112	float32	2	3
198	START FREQUENCY 2 FOR ACTIVE POWER-UNDER FREQUENCY DROOP CONTROL	Hz	Read and write	55114	float32	2	3
233	RELATIVE ACTIVE POWER LIMIT FOR FREQUENCY CONTROL	%	Read and write	55166	float32	2	3
269	HIGH LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55136	float32	2	3
270	LOW LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55138	float32	2	3

295	ACTIVE POWER-FREQUENCY DROOP BASE POWER TYPE	-	Read and write	54311	uint16	1	3

Non-dynamic Under-frequency control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
171	NONDYNAMIC UNDER FREQUENCY CONTROL SETTING MODE	-	Read and write	54302	uint16	1	3
173	NONDYNAMIC UNDER FREQUENCY CONTROL ENABLED	-	Read	13351	uint16	1	3
175	NONDYNAMIC UNDER FREQUENCY CONTROL TRIGGER FREQUENCY	Hz	Read and write	55120	float32	2	3
177	NONDYNAMIC UNDER FREQUENCY CONTROL ACTIVE POWER SETPOINT	kW	Read and write	55124	float32	2	3
179	NONDYNAMIC UNDER FREQUENCY CONTROL DURATION TIME	s	Read and write	55128	float32	2	3

181	NONDYNAMIC UNDER FREQUENCY CONTROL IDLE TIME	s	Read and write	55132	float32	2	3
233	RELATIVE ACTIVE POWER LIMIT FOR FREQUENCY CONTROL	%	Read and write	55166	float32	2	3
269	HIGH LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55136	float32	2	3
270	LOW LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	kW	Read and write	55138	float32	2	3

Under-frequency control - FSM

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
653	ACTIVE POWER - UNDER FREQUENCY DROOP FSM CONTROL ENABLED	-	Read	13384	uint16	1	3
654	ACTIVE POWER - UNDER FREQUENCY DROOP FSM NIGHT CONTROL ENABLED	-	Read	13385	uint16	1	3
657	ACTIVE POWER - UNDER FREQUENCY DROOP FSM CONTROL OPERATION MODE	-	Read and write	54335	uint16	1	3
659	ACTIVE POWER - UNDER FREQUENCY DROOP FSM NIGHT CONTROL OPERATION MODE	-	Read and write	54337	uint16	1	3
661	ACTIVE POWER - UNDER	-	Read and	54339	uint16	1	3

	FREQUENCY DROOP FSM HYSTERESIS ENABLE		write				
670	START FREQUENCY FOR ACTIVE POWER-UNDER FREQUENCY DROOP FSM CONTROL	Hz	Read and write	55210	float32	2	3
671	START FREQUENCY 2 FOR ACTIVE POWER-UNDER FREQUENCY DROOP FSM CONTROL	Hz	Read and write	55212	float32	2	3
672	ACTIVE POWER - UNDER FREQUENCY DROOP FSM HYSTERESIS WAIT STOP FREQUENCY	Hz	Read and write	55214	float32	2	3
673	ACTIVE POWER - UNDER FREQUENCY DROOP FSM HYSTERESIS WAIT STOP FREQUENCY 2	Hz	Read and write	55216	float32	2	3
674	ACTIVE POWER - UNDER	%	Read and	55218	float32	2	3

	FREQUENCY DROOP FSM		write				
675	ACTIVE POWER - UNDER FREQUENCY DROOP FSM 2	%	Read and write	55220	float32	2	3

Active Power – Over-voltage (Droop control)

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
149	ACTIVE POWER - OVER VOLTAGE DROOP	%/kV	Read and write	55084	float32	2	3
150	START VOLTAGE FOR ACTIVE POWER-OVER VOLTAGE DROOP CONTROL	kV	Read and write	55086	float32	2	3
151	ACTIVE POWER - OVER VOLTAGE DROOP CONTROL ENABLED	-	Read	13343	uint16	1	3
152	ACTIVE POWER - OVER VOLTAGE DROOP CONTROL OPERATION MODE	-	Read and write	54294	uint16	1	3
161	VOLTAGE REFERENCE SETPOINT RETURN INFO (ACTIVE POWER CONTROL)	kV	Read	5916	uint16	2	3

162	ERROR TERM FOR VOLTAGE REFERENCE CONTROL (ACTIVE POWER CONTROL)	kV	Read	5918	float32	2	3
167	ACTIVE POWER CONTROL VOLTAGE REFERENCE SETPOINT	kV	Read and write	59154	float32	2	3

Active Power – Over-voltage (STR-STP)

	Name	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
163	ACTIVE POWER- OVER VOLTAGE START-STOP CONTROL ENABLED	-	Read	13345	uint16	1	3
164	ACTIVE POWER - OVER VOLTAGE START- STOP CONTROL OPERATION MODE	-	Read and write	54296	uint16	1	3
165	START FREQUENCY FOR ACTIVE POWER-OVER VOLTAGE START-STOP CONTROL	kV	Read and write	55096	float32	2	3
166	STOP FREQUENCY FOR ACTIVE POWER-OVER VOLTAGE START- STOP CONTROL	kV	Read and write	55098	float32	2	3

Reactive absolute power control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
41	REACTIVE POWER RETURN INFO	kVAr	Read	5890	float32	2	3
52	REACTIVE POWER CURTAILMENT ENABLED	-	Read	13315	uint16	1	3
123	ERROR TERM FOR REACTIVE	kVAr	Read	5906	float32	2	3
126	REACTIVE POWER CURTAILMENT CONTROL OPERATION MODE	-	Read and write	54275	uint16	1	3
127	REACTIVE POWER SETPOINT	kVAr	Read and write	59142	float32	2	3

Reactive power ramp control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
54	REACTIVE POWER RAMP CONTROL ENABLED	-	Read	13347	uint16	1	3
100	REACTIVE POWER RAMP CONTROL OPERATION MODE	-	Read and write	54298	uint16	1	3
117	REACTIVE POWER RAMP UP	kVAr/ min	Read and write	59156	float32	2	3
118	REACTIVE POWER RAMP DOWN	kVAr/ min	Read and write	59158	float32	2	3
172	REACTIVE UP RAMP RATE RETURN INFO	kVAr/ min	Read	5922	float32	2	3
173	REACTIVE DOWN RAMP RATE RETURN INFO	kVAr/ min	Read	5924	float32	2	3

Power factor control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
37	POWER FACTOR SETPOINT RETURN INFO (REACTIVE POWER CONTROL)	-	Read	5894	float32	2	3
45	ERROR TERM FOR POWER FACTOR (REACTIVE POWER CONTROL)	-	Read	5910	float32	2	3
51	REACTIVE POWER - POWER FACTOR CONTROL ENABLED	-	Read	13317	uint16	1	3
98	REACTIVE POWER - POWER FACTOR CONTROL OPERATION MODE	-	Read and write	54277	uint16	1	3
114	REACTIVE POWER CONTROL POWER FACTOR SETPOINT	-	Read and write	59140	float32	2	3

Power factor limit in control (with the PF control disabled)

	Parameter	Parameter	Register type	Address	Format	Num Regs/ Bits	Function Code Read
136	REACTIVE POWER FACTOR LIMIT LOW	-	Read and write	55076	float32	2	3
137	REACTIVE POWER FACTOR LIMIT HIGH	-	Read and write	55078	float32	2	3

Name
PPCGpm.xAlgorithmParameters.uiEnableQPowerFactorLimit

Reactive power – voltage control droop Q(V)

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
36	REFERENCE VOLTAGE SETPOINT RETURN INFO (REACTIVE POWER CONTROL)	kV	Read	5892	float32	2	3
44	ERROR TERM FOR VOLTAGE REFERENCE CONTROL (REACTIVE POWER CONTROL)	kV	Read	5908	float32	2	3
50	REACTIVE POWER - VOLTAGE REFERENCE CONTROL ENABLED	-	Read	13316	uint16	1	3
97	REACTIVE POWER - VOLTAGE REFERENCE CONTROL OPERATION MODE	-	Read and write	54276	uint16	1	3

113	REACTIVE POWER CONTROL VOLTAGE REFERENCE SETPOINT	kV	Read and write	59138	float32	2	3
129	REACTIVE POWER - OVER VOLTAGE DEAD BAND	%	Read and write	55060	float32	2	3
130	REACTIVE POWER - UNDER VOLTAGE DEAD BAND	%	Read and write	55062	float32	2	3
131	REACTIVE POWER - OVER VOLTAGE DROOP	%/kV	Read and write	55066	float32	2	3
133	REACTIVE POWER - UNDER VOLTAGE DROOP	%/kV	Read and write	55072	float32	2	3
193	REACTIVE POWER - OVER VOLTAGE MAX REACTIVE POWER	kVAr	Read and write	55064	float32	2	3
194	REACTIVE POWER - UNDER VOLTAGE MAX REACTIVE POWER	kVAr	Read and write	55070	float32	2	3

Reactive power – voltage setpoint

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
217	VOLTAGE SETPOINT RETURN INFO (REACTIVE POWER CONTROL)	kV	Read	5926	float32	2	3
218	ERROR TERM FOR VOLTAGE CONTROL (REACTIVE POWER CONTROL)	kV	Read	5928	float32	2	3
219	REACTIVE POWER - VOLTAGE CONTROL ENABLED	-	Read	13349	uint16	1	3
220	REACTIVE POWER - VOLTAGE CONTROL OPERATION MODE	-	Read and write	54300	uint16	1	3
221	REACTIVE POWER CONTROL VOLTAGE SETPOINT	kV	Read and write	59172	float32	2	3

222	REACTIVE VOLTAGE CONTROL KP	-	Read and write	59174	float32	2	3
223	REACTIVE VOLTAGE CONTROL KI	-	Read and write	59176	float32	2	3
224	REACTIVE VOLTAGE CONTROL AWUP	-	Read and write	59178	float32	2	3

Name
PPCGpm.xAlgorithmParameters.dQVKp
PPCGpm.xAlgorithmParameters.dQVKi
PPCGpm.xAlgorithmParameters.dQVKiAwup
PPCGpm.xAlgorithmParameters.dVARVmax
PPCGpm.xAlgorithmParameters.dVARVmin

Power factor - voltage control droop PF(V)

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
155	REACTIVE POWER - POWER FACTOR-VOLTAGE CONTROL ENABLED	-	Read	13344	uint16	1	3
156	REACTIVE POWER - POWER FACTOR-VOLTAGE CONTROL OPERATION MODE	-	Read and write	54295	uint16	1	3
157	REACTIVE POWER - POWER FACTOR-OVER VOLTAGE DEAD BAND	%	Read and write	55088	float32	2	3
158	REACTIVE POWER - POWER FACTOR-UNDER VOLTAGE DEAD BAND	%	Read and write	55090	float32	2	3
159	REACTIVE POWER - POWER FACTOR-VOLTAGE OVER VOLTAGE	%/kV	Read and write	55092	float32	2	3

	DROOP						
160	REACTIVE POWER - POWER FACTOR-VOLTAGE UNDER VOLTAGE DROOP	%/kV	Read and write	55094	float32	2	3

Name
PPCGpm.xAlgorithmParameters.dPFmax

Power factor – voltage control (STR-STP)

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
181	REACTIVE POWER - POWER FACTOR-ACTIVE POWER START - STOP CONTROL ENABLED	-	Read	13348	uint16	1	3
182	REACTIVE POWER - POWER FACTOR-ACTIVE POWER START - STOP CONTROL OPERATION MODE	-	Read and write	54299	uint16	1	3
183	START POWER FACTOR FOR REACTIVE POWER - POWER FACTOR-ACTIVE POWER START-STOP	-	Read and write	55100	float32	2	3
184	STOP POWER FACTOR FOR REACTIVE POWER - POWER FACTOR-ACTIVE POWER START-STOP	-	Read and write	55102	float32	2	3
185	START ACTIVE	kW	Read	55104	float32	2	3

	POWER FOR REACTIVE POWER - POWER FACTOR-ACTIVE POWER START-STOP		and write				
186	STOP ACTIVE POWER FOR REACTIVE POWER - POWER FACTOR-ACTIVE POWER START-STOP	kW	Read and write	55106	float32	2	3

Control over capacitor banks

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
55	CAPBANKS CONTROL ENABLED	-	Read	13319	uint16	1	3
101	SET MOD CAPBANKS CONTROL	-	Read and write	54279	uint16	1	3
230	ORDER TO CAPBANKS	-	Read	17922	uint32	2	3
266	MINIMUM ACTIVE POWER TO ACTIVATE CAPBANK	kW	Read and write	55134	float32	2	3

Name
PPCGpm.xAlgorithmParameters.uiNumberCapBanks
PPCGpm.xAlgorithmParameters.dNominalReactivePowerPerCapBankReactivePower
PPCGpm.xAlgorithmParameters.dFilterActivationTime
PPCGpm.xAlgorithmParameters.dCapBanksActivationTim
PPCGpm.xAlgorithmParameters.dCapBanksDesactivationTime
PPCGpm.xAlgorithmParameters.dCapBankHysteresyActuation

Active power night control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
259	ACTIVE POWER NIGHT CONTROLS ENABLED	-	Read	13320	uint16	1	3
260	ACTIVE POWER NIGHT CONTROLS OPERATION MODE	-	Read and write	13352	uint16	1	3
263	NIGHT ACTIVE POWER SETPOINT	kW	Read and write	59150	float32	2	3
481	ACTIVE POWER NIGHT CURTAILMENT ENABLED	-	Read	13370	uint16	1	3
482	ACTIVE POWER - OVER FREQUENCY START-STOP NIGHT CONTROL ENABLED	-	Read	13371	uint16	1	3
483	ACTIVE POWER - UNDER FREQUENCY START-STOP NIGHT CONTROL	-	Read	13372	uint16	1	3

	ENABLED						
484	ACTIVE POWER - OVER FREQUENCY DROOP NIGHT CONTROL ENABLED	-	Read	13373	uint16	1	3
485	ACTIVE POWER - UNDER FREQUENCY DROOP NIGHT CONTROL ENABLED	-	Read	13374	uint16	1	3
486	ACTIVE POWER - OVER VOLTAGE DROOP NIGHT CONTROL ENABLED	-	Read	13375	uint16	1	3
487	ACTIVE POWER - OVER VOLTAGE START-STOP NIGHT CONTROL ENABLED	-	Read	13376	uint16	1	3
488	FREERUN ACTIVE ACTUAL UP RAMP RATE NIGHT CONTROL ENABLED	-	Read	13377	uint16	1	3
489	ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC NIGHT CONTROL	-	Read	13378	uint16	1	3

	ENABLED						
490	ACTIVE POWER - UNDER FREQUENCY NON-DYNAMIC NIGHT CONTROL ENABLED	-	Read	13379	uint16	1	3
501	ACTIVE POWER NIGHT CURTAILMENT OPERATION MODE	-	Read and write	54321	uint16	1	3
502	ACTIVE POWER - OVER FREQUENCY START-STOP NIGHT CONTROL OPERATION MODE	-	Read and write	54322	uint16	1	3
503	ACTIVE POWER - UNDER FREQUENCY START-STOP NIGHT CONTROL OPERATION MODE	-	Read and write	54323	uint16	1	3
504	ACTIVE POWER - OVER FREQUENCY DROOP NIGHT CONTROL OPERATION MODE	-	Read and write	54324	uint16	1	3

505	ACTIVE POWER - UNDER FREQUENCY DROOP NIGHT CONTROL OPERATION MODE	-	Read and write	54325	uint16	1	3
506	ACTIVE POWER - OVER VOLTAGE DROOP NIGHT CONTROL OPERATION MODE	-	Read and write	54326	uint16	1	3
507	ACTIVE POWER - OVER VOLTAGE START-STOP NIGHT CONTROL OPERATION MODE	-	Read and write	54327	uint16	1	3
508	FREERUN ACTIVE ACTUAL UP RAMP RATE NIGHT CONTROL OPERATION MODE	-	Read and write	54328	uint16	1	3
509	ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC NIGHT CONTROL OPERATION MODE	-	Read and write	54329	uint16	1	3
510	ACTIVE POWER - UNDER	-	Read and	54330	uint16	1	3

	FREQUENCY NON-DYNAMIC NIGHT CONTROL OPERATION MODE		write				
652	ACTIVE POWER - OVER FREQUENCY DROOP FSM NIGHT CONTROL ENABLED	-	Read	13383	uint16	1	3
654	ACTIVE POWER - UNDER FREQUENCY DROOP FSM NIGHT CONTROL ENABLED	-	Read	13385	uint16	1	3
658	ACTIVE POWER - OVER FREQUENCY DROOP FSM NIGHT CONTROL OPERATION MODE	-	Read and write	54336	uint16	1	3
659	ACTIVE POWER - UNDER FREQUENCY DROOP FSM NIGHT CONTROL OPERATION MODE	-	Read and write	54337	uint16	1	3
682	NIGHT ACTIVE POWER SETPOINT 2	kW	Read and write	59184	float32	2	3

Reactive power night control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
261	REACTIVE POWER NIGHT CONTROLS ENABLED	-	Read	54280	uint16	1	3
262	REACTIVE POWER NIGHT CONTROLS OPERATION MODE	-	Read and write	54303	uint16	1	3
264	NIGHT REACTIVE POWER SETPOINT	kVAr	Read and write	59180	float32	2	3
473	REACTIVE POWER NIGHT CURTAILMENT ENABLED	-	Read	13362	uint16	1	3
474	REACTIVE POWER - POWER FACTOR NIGHT CONTROL ENABLED	-	Read	13363	uint16	1	3
475	REACTIVE POWER - VOLTAGE REFERENCE NIGHT CONTROL ENABLED	-	Read	13364	uint16	1	3

476	REACTIVE POWER - POWER FACTOR-VOLTAGE NIGHT CONTROL ENABLED	-	Read	13365	uint16	1	3
477	REACTIVE POWER - POWER FACTOR-ACTIVE POWER START - STOP NIGHT CONTROL ENABLED	-	Read	13366	uint16	1	3
478	REACTIVE POWER - VOLTAGE NIGHT CONTROL ENABLED	-	Read	13367	uint16	1	3
493	REACTIVE POWER NIGHT CURTAILMENT OPERATION MODE	-	Read and write	54313	float32	2	3
494	REACTIVE POWER - VOLTAGE REFERENCE NIGHT CONTROL OPERATION MODE	-	Read and write	54314	float32	2	3
495	REACTIVE POWER - POWER FACTOR NIGHT CONTROL	-	Read and write	54315	float32	2	3

	OPERATION MODE						
496	REACTIVE POWER - POWER FACTOR-VOLTAGE NIGHT CONTROL OPERATION MODE	-	Read and write	54316	float32	2	3
497	REACTIVE POWER - POWER FACTOR-ACTIVE POWER START - STOP NIGHT CONTROL OPERATION MODE	-	Read and write	54317	float32	2	3
498	REACTIVE POWER - VOLTAGE NIGHT CONTROL OPERATION MODE	-	Read and write	54318	float32	2	3
680	REACTIVE POWER - VOLTAGE REFERENCE REACTIVE POWER OFFSET	kVAr	Read and write	55230	float32	2	3

Forced low power mode

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
290	ACTIVE POWER IN FORCED LOW POWER MODE	-	Read	17418	uint16	1	3

Maximum apparent power mode

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
285	ACTIVE POWER SMAX CONTROL OPERATION MODE	-	Read and write	54309	uint16	1	3
286	ACTIVE POWER SMAX CONTROL ENABLED	-	Read	13356	uint16	1	3
287	REACTIVE POWER SMAX OPERATION MODE	-	Read and write	54308	uint16	1	3
288	REACTIVE POWER SMAX CONTROL ENABLED	-	Read	13355	uint16	1	3
289	MAX APPARENT POWER CONTROL LIMIT	kVA	Read and write	55154	float32	2	3
480	REACTIVE POWER SMAX NIGHT CONTROL ENABLED	-	Read	13369	uint16	1	3
492	ACTIVE POWER SMAX NIGHT CONTROL ENABLED	-	Read	13381	uint16	1	3

500	REACTIVE POWER SMAX NIGHT CONTROL OPERATION MODE	-	Read and write	54320	uint16	1	3
512	ACTIVE POWER SMAX NIGHT CONTROL OPERATION MODE	-	Read and write	54332	uint16	1	3

Fault ride-through

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
297	FVRT CONTROL ENABLE	-	Read	13358	uint16	1	3
298	FVRT CONTROL OPERATION MODE	-	Read and write	54312	uint16	1	3
299	FVRT HIGH VOLTAGE LIMIT	kV	Read and write	55158	float32	2	3
450	FVRT LOW VOLTAGE LIMIT	kV	Read and write	55160	float32	2	3
451	FVRT FREEZE TIME	ms	Read and write	55162	float32	2	3
452	IN FVRT	-	Read	17420	uint16	1	3

Power oscillation damping control

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
272	REACTIVE POWER POD CONTROL OPERATION MODE	-	Read and write	54306	uint16	1	3
273	REACTIVE POWER POD CONTROL ENABLED	-	Read	13353	uint16	1	3
283	ACTIVE POWER POD CONTROL OPERATION MODE	-	Read and write	54307	uint16	1	3
284	ACTIVE POWER POD CONTROL ENABLED	-	Read	13354	uint16	1	3
479	REACTIVE POWER POD NIGHT CONTROL ENABLED	-	Read	13368	uint16	1	3
491	ACTIVE POWER POD NIGHT CONTROL ENABLED	-	Read	13380	uint16	1	3
499	REACTIVE POWER POD	-	Read and	54319	uint16	1	3

	NIGHT CONTROL OPERATION MODE		write				
511	ACTIVE POWER POD NIGHT CONTROL OPERATION MODE	-	Read and write	54331	uint16	1	3

Emulation system

	Parameter	Units	Register type	Address	Format	Num Regs/ Bits	Function Code Read
513	EMULATED FREQUENCY	Hz	Read and write	55182	float32	2	3
514	EMULATED VOLTAGE	kV	Read and write	55184	float32	2	3
521	EMULATED FREQUENCY ENABLE	-	Read	58371	uint16	1	3
522	EMULATED VOLTAGE ENABLE	-	Read	58372	uint16	1	3

Parameters tags

	Parameter Name	Generic Configuration Parameter Tag	Description
1	TOTAL AC ACTIVE POWER	TOTAL_AC_ACTIVE_POWER	Register returning active power measurement from the POI meter.
2	TOTAL AC REACTIVE POWER	TOTAL_AC_REACTIVE_POWER	Register returning reactive power measurement from the POI meter.
3	AC POWER FACTOR	POWER_FACTOR_AC	Register returning power factor measurement from the POI meter.
4	GRID FREQUENCY	GRID_FREQUENCY	Register returning grid frequency measurement from the POI meter.
5	AVERAGE VOLTAGE 3 PHASES	AVERAGE_VOLTAGE_3_PHASES	Register returning phase to ground voltage measurement from the POI meter.
6	VOLTAGE PHASE A-GROUND	VOLTAGE_PHASE_A_GROUND	Register returning phase A to ground voltage measurement from the POI meter.
7	VOLTAGE PHASE B-GROUND	VOLTAGE_PHASE_B_GROUND	Register returning phase B to ground voltage measurement from the POI meter.
8	VOLTAGE PHASE C-GROUND	VOLTAGE_PHASE_C_GROUND	Register returning phase C to ground voltage measurement from the POI meter.

9	ACTUAL UP RAMP RATE	ACTUAL_UP_RAMP_RATE	Register returning internally calculated actual upwards ramp rate.
10	ACTUAL DOWN RAMP RATE	ACTUAL_DOWN_RAMP_RATE	Register returning internally calculated actual downwards ramp rate.
11	ACTIVE POWER SETPOINT RETURN INFO	W_SETPOINT_RETURN_INFO	Register returning active power setpoint externally received by the PPC.
12	REFERENCE VOLTAGE SETPOINT RETURN INFO (REACTIVE POWER CONTROL)	VAR_V_REF_SETPOINT_RETURN_INFO	Register returning voltage reference externally received by the PPC for voltage droop control.
13	POWER FACTOR SETPOINT RETURN INFO (REACTIVE POWER CONTROL)	VAR_PF_SETPOINT_RETURN_INFO	Register returning power factor setpoint externally received by the PPC for voltage droop control.
14	ACTIVE UP RAMP RATE RETURN INFO	W_RAMP_UP_RETURN_INFO	Register returning configured limit ramp up rate for active power variation.
15	ACTIVE DOWN RAMP RATE RETURN INFO	W_RAMP_DOWN_RETURN_INFO	Register returning configured limit ramp down rate for active power variation.

16	FREQUENCY SETPOINT RETURN INFO (ACTIVE POWER CONTROL)	`W_FREQ_SETPOINT_RETURN_INFO`	Register returning nominal frequency for active power droop control.
17	REACTIVE POWER RETURN INFO	VAR_SETPOINT_RETURN_INFO	Register returning reactive power setpoint externally received by the PPC.
18	ERROR TERM FOR ACTIVE POWER	`ERROR_TERM_W`	Register returning error between internal active power setpoint and total AC active power measured at POI.
19	ERROR TERM FOR VOLTAGE REFERENCE CONTROL (REACTIVE POWER CONTROL)	ERROR_TERM_VAR_V_REF	Register returning error between voltage reference setpoint (reactive power droop control) and average voltage measured at POI.
20	ERROR TERM FOR POWER FACTOR (REACTIVE POWER CONTROL)	`ERROR_TERM_VAR_PF`	Register returning error between power factor setpoint and power factor measured at POI.
21	ERROR TERM FOR FREQUENCY (ACTIVE POWER CONTROL)	ERROR_TERM_W_FREQ	Register returning error between nominal frequency and frequency measured at POI.

22	REMOTE-LOCAL MODE	`REMOTE_LOCAL_MODE`	Register returning: 0 if set to be controlled in remote control mode or 1 if set to be controlled in local mode.
23	GENERAL CONTROLS ENABLED	`GENERAL_CONTROLS_ENABLED`	Register returning: 0 if PPC control action disabled 1 enabled.
24	ACTIVE POWER CURTAILMENT ENABLED	`W_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
25	REACTIVE POWER - VOLTAGE REFERENCE CONTROL ENABLED	`AR_V_REF_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
26	REACTIVE POWER - POWER FACTOR CONTROL ENABLED	`VAR_PF_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
27	ACTIVE POWER RAMP CONTROL ENABLED	`W_RAMP_CONTROL_ENABLED`	Register returning: 0 if ramp rate limitation applies to such control, otherwise 1.
28	ACTIVE POWER - OVER FREQUENCY START-STOP CONTROL ENABLED	`W_OV_FREQ_STR_STP_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.

29	PPC STATE	`PPC_STATE`	Internal parameter not used in any control or monitoring function.
30	PPC ERRORS 1	`PPC_ERRORS_1`	Internal parameter not used in any control or monitoring function.
31	PPC ALARMS 1	`PPC_ALARMS_1`	Internal parameter not used in any control or monitoring function.
32	NUMBER OF INVERTERS ONLINE	`NUMBER_INVERTERS_ONLINE`	Register returning number of inverters operating.
33	REACTIVE POWER CURTAILMENT ENABLED	`VAR_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
34	ERROR TERM FOR REACTIVE	`ERROR_TERM_VAR`	Register returning error between internal reactive power setpoint and reactive power measured at POI.
35	MAX POWER OF PV INVERTER	`MAX_ACTIVE_POWER_INVERTER`	Register returning the active power production of the inverter that is generating the highest value of active power among all inverters.
36	START FREQUENCY FOR ACTIVE POWER-OVER FREQUENCY START-STOP CONTROL	`W_OV_FREQ_STR_STP_STR`	Register returning parameter's value and allowing its modification.
37	STOP FREQUENCY FOR ACTIVE POWER-OVER	`W_OV_FREQ_STR_STP_STP`	Register returning parameter’s value and allowing its modification.

	FREQUENCY START-STOP CONTROL		
38	REMOTE-LOCAL MODE SETTING	`SET_REMOTE_LOCAL_MODE`	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling.
39	GENERAL CONTROLS ENABLE SETTING	`SET_GENERAL_CONTROLS_ENABLE`	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling.
40	ACTIVE POWER CURTAILMENT CONTROL OPERATION MODE	`SET_MOD_W_CONTROL`	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling.
41	REACTIVE POWER - VOLTAGE REFERENCE CONTROL OPERATION MODE	`SET_MOD_VAR_V_REF_CONTROL`	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling. (Voltage Droop Control)
42	REACTIVE POWER - POWER FACTOR CONTROL OPERATION MODE	`SET_MOD_VAR_PF_CONTROL`	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling.
43	ACTIVE POWER RAMP CONTROL	`SET_MOD_W_RAMP_CONTROL`	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling.

	OPERATION MODE		
44	ACTIVE POWER - OVER FREQUENCY START- STOP CONTROL OPERATION MODE	`SET_MOD_W_OV_FREQ_STR_STP_CONTROL`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
45	ACTIVE POWER SETPOINT	`W_SETPOINT`	Register returning parameter’s value and allowing its modification.
46	REACTIVE POWER CONTROL VOLTAGE REFERENCE SETPOINT	`VAR_V_REF_SETPOINT`	Register returning parameter’s value and allowing its modification. (Voltage droop control)
47	REACTIVE POWER CONTROL POWER FACTOR SETPOINT	`VAR_PF_SETPOINT`	Register returning parameter’s value and allowing its modification.
48	ACTIVE POWER RAMP UP	`W_RAMP_UP`	Register returning parameter’s value and allowing its modification.
49	ACTIVE POWER RAMP DOWN	`W_RAMP_DOWN`	Register returning parameter’s value and allowing its modification.

50	ACTIVE POWER CONTROL FREQUENCY SETPOINT	`W_FREQ_SETPOINT`	Register returning nominal frequency and allowing its modification.
51	REACTIVE POWER CURTAILMENT CONTROL OPERATION MODE	`SET_MOD_VAR_CONTROL`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
52	REACTIVE POWER SETPOINT	`VAR_SETPOINT`	Register returning parameter's value and allowing its modification.
53	REACTIVE POWER - OVER VOLTAGE DROOP	`VAR_OV_V_DROOP`	Register returning parameter's value and allowing its modification.
54	REACTIVE POWER - UNDER VOLTAGE DROOP	`VAR_UN_V_DROOP`	Register returning parameter's value and allowing its modification.
55	NUMBER OF CAPACITOR BANKS ONLINE	`NUMBER_CAPACITOR_BANKS_ONLINE`	Register returning parameter's value.
56	CAPACITOR BANK CONTROL OPERATION MODE	`SET_MOD_CAPBANKS_CONTROL`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.

57	CAPACITOR BANK CONTROL ENABLED	CAPBANKS_CONTROL_ENABLED	Register returning parameter's value.
58	REACTIVE POWER FACTOR LIMIT LOW	VAR_PF_LIMIT_LOW	Register returning parameter's value and allowing its modification. Maximum Power Factor limiting minimum (negative, inductive) reactive power setpoints.
59	REACTIVE POWER FACTOR LIMIT HIGH	VAR_PF_LIMIT_HIGH	Register returning parameter's value and allowing its modification. Maximum Power Factor limiting maximum (positive, capacitive) reactive power setpoints.
60	START FREQUENCY FOR ACTIVE POWER-UNDER FREQUENCY START-STOP CONTROL	W_UN_FREQ_STR_STP_STR	Register returning parameter's value and allowing its modification.
61	STOP FREQUENCY FOR ACTIVE POWER-UNDER FREQUENCY START-STOP CONTROL	W_UN_FREQ_STR_STP_STP	Register returning parameter's value and allowing its modification.
62	REACTIVE POWER - OVER VOLTAGE DEAD BAND	VAR_OV_V_DB	Register returning parameter's value and allowing its modification.

63	REACTIVE POWER - UNDER VOLTAGE DEAD BAND	VAR_UN_V_DB	Register returning parameter's value and allowing its modification.
64	ACTIVE POWER- UNDER FREQUENCY START-STOP CONTROL ENABLED	W_UN_FREQ_STR_STP_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled.
65	ACTIVE POWER - UNDER FREQUENCY START-STOP CONTROL OPERATION MODE	SET_MOD_W_UN_FREQ_STR_STP_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
66	ACTIVE POWER - FREQUENCY DROOP REFERENCE TYPE	SET_MOD_W_FREQ_DROOP_REFERENCE_TYPE	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
67	ACTIVE POWER - OVER FREQUENCY DROOP	W_OV_FREQ_DROOP	Register returning parameter's value and allowing its modification.
68	ACTIVE POWER - UNDER	W_UN_FREQ_DROOP	Register returning parameter's value and allowing its modification.

	FREQUENCY DROOP		
69	ACTIVE POWER - OVER FREQUENCY DROOP CONTROL ENABLED	W_OV_FREQ_DROOP_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled.
70	ACTIVE POWER - UNDER FREQUENCY DROOP CONTROL ENABLED	W_UN_FREQ_DROOP_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled.
71	ACTIVE POWER - OVER FREQUENCY DROOP CONTROL OPERATION MODE	SET_MOD_W_OV_FREQ_DROOP_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
72	ACTIVE POWER - UNDER FREQUENCY DROOP CONTROL OPERATION MODE	SET_MOD_W_UN_FREQ_DROOP_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.

73	START FREQUENCY FOR ACTIVE POWER-OVER FREQUENCY DROOP CONTROL	`W_OV_FREQ_DROOP_STR`	Register returning parameter’s value and allowing its modification.
74	START FREQUENCY FOR ACTIVE POWER-UNDER FREQUENCY DROOP CONTROL	`W_UN_FREQ_DROOP_STR`	Register returning parameter’s value and allowing its modification.
75	ACTIVE POWER - OVER VOLTAGE DROOP	`W_OV_V_DROOP`	Register returning parameter’s value and allowing its modification.
76	START VOLTAGE FOR ACTIVE POWER-OVER VOLTAGE DROOP CONTROL	`W_OV_V_DROOP_STR`	Register returning parameter’s value and allowing its modification.
77	ACTIVE POWER - OVER VOLTAGE DROOP CONTROL ENABLED	`W_OV_V_DROOP_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.

78	ACTIVE POWER - OVER VOLTAGE DROOP CONTROL OPERATION MODE	SET_MOD_W_OV_V_DROOP_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
79	ACTIVE POWER INTERNAL SETPOINT	P_INTERNAL_SETPOINT	Register returning the setpoint input at PI control level after all control configurations (including ramp rate control) have been assessed.
80	REACTIVE POWER INTERNAL SETPOINT	Q_INTERNAL_SETPOINT	Register returning the setpoint input at PI control level after all control configurations (including ramp rate control) have been assessed.
81	REACTIVE POWER - POWER FACTOR-VOLTAGE CONTROL ENABLED	VAR_PF_V_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled.
82	REACTIVE POWER - POWER FACTOR-VOLTAGE CONTROL OPERATION MODE	SET_MOD_VAR_PF_V_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
83	REACTIVE POWER - POWER	VAR_PF_OV_V_DB	Register returning parameter's value and allowing its modification.

	FACTOR- OVER VOLTAGE DEAD BAND		
84	REACTIVE POWER - POWER FACTOR- UNDER VOLTAGE DEAD BAND	`VAR_PF_UN_V_DB`	Register returning parameter's value and allowing its modification.
85	REACTIVE POWER - POWER FACTOR- VOLTAGE OVER VOLTAGE DROOP	`VAR_PF_OV_V_DROOP`	Register returning parameter's value and allowing its modification.
86	REACTIVE POWER - POWER FACTOR- VOLTAGE UNDER VOLTAGE DROOP	`VAR_PF_UN_V_DROOP`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
87	VOLTAGE REFERENCE SETPOINT RETURN INFO (ACTIVE POWER CONTROL)	`W_V_REF_SETPOINT_RETURN_INFO`	Register returning parameter's value and allowing its modification.

88	ERROR TERM FOR VOLTAGE REFERENCE CONTROL (ACTIVE POWER CONTROL)	`ERROR_TERM_W_V_REF`	Register returning error between voltage reference and voltage measured at POI.
89	ACTIVE POWER-OVER VOLTAGE START-STOP CONTROL ENABLED	`W_OV_V_STR_STP_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
90	ACTIVE POWER - OVER VOLTAGE START- STOP CONTROL OPERATION MODE	`SET_MOD_W_OV_V_STR_STP_CONTROL`	Register returning parameter’s value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
91	START FREQUENCY FOR ACTIVE POWER-OVER VOLTAGE START-STOP CONTROL	`W_OV_V_STR_STP_STR`	Register returning parameter’s value and allowing its modification.
92	STOP FREQUENCY FOR ACTIVE POWER-OVER VOLTAGE	`W_OV_V_STR_STP_STP`	Register returning parameter’s value and allowing its modification.

	START-STOP CONTROL		
93	ACTIVE POWER CONTROL VOLTAGE REFERENCE SETPOINT	W_V_REF_SETPOINT	Register returning parameter's value and allowing its modification.
94	REACTIVE POWER RAMP UP	VAR_RAMP_UP	Register returning parameter's value and allowing its modification.
95	REACTIVE POWER RAMP DOWN	VAR_RAMP_DOWN	Register returning parameter's value and allowing its modification.
96	REACTIVE UP RAMP RATE RETURN INFO	VAR_RAMP_UP_RETURN_INFO	Register returning the parameter's value.
97	REACTIVE DOWN RAMP RATE RETURN INFO	VAR_RAMP_DOWN_RETURN_INFO	Register returning the parameter's value.
98	ACTIVE POWER ORDER TO INVERTERS	P_ORDER_TO_INVERTERS	Register returning the value of active power order to inverters.
99	REACTIVE POWER ORDER TO INVERTERS	Q_ORDER_TO_INVERTERS	Register returning the value of reactive power order to inverters.

100	RELATIVE ACTIVE POWER ORDER TO INVERTERS	`P_RELATIVE_ORDER_TO_INVERTER`	Register returning the value of active power order to inverters referenced to the maximum active power capacity of all inverters.
101	RELATIVE REACTIVE POWER ORDER TO INVERTERS	Q_RELATIVE_ORDER_TO_INVERTER	Register returning the value of reactive power order to inverters referenced to the maximum reactive power capacity of all inverters.
102	FREERUN ACTIVE ACTUAL UP RAMP RATE CONTROL ENABLED	`W_ACTUAL_UP_RAMP_RATE_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
103	FREERUN ACTIVE ACTUAL UP RAMP RATE CONTROL OPERATION MODE	SET_MOD_W_ACTUAL_UP_RAMP_RATE_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
104	REACTIVE POWER RAMP CONTROL ENABLED	`VAR_RAMP_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
105	REACTIVE POWER RAMP CONTROL OPERATION MODE	SET_MOD_VAR_RAMP_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.

106	REACTIVE POWER - POWER FACTOR-ACTIVE POWER START - STOP CONTROL ENABLED	`VAR_PF_W_STR_STP_CONTROL_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
107	REACTIVE POWER - POWER FACTOR-ACTIVE POWER START - STOP CONTROL OPERATION MODE	`SET_MOD_VAR_PF_W_STR_STP_CONTROL`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
108	START POWER FACTOR FOR REACTIVE POWER - POWER FACTOR-ACTIVE POWER START-STOP	`VAR_PF_W_STR_STP_PF_STR`	Register returning parameter's value and allowing its modification.
109	STOP POWER FACTOR FOR REACTIVE POWER - POWER FACTOR-	`VAR_PF_W_STR_STP_PF_STP`	Register returning parameter's value and allowing its modification.

	ACTIVE POWER START-STOP		
110	START ACTIVE POWER FOR REACTIVE POWER - POWER FACTOR-ACTIVE POWER START-STOP	`VAR_PF_W_STR_STP_W_STR`	Register returning parameter's value and allowing its modification.
111	STOP ACTIVE POWER FOR REACTIVE POWER - POWER FACTOR-ACTIVE POWER START-STOP	`VAR_PF_W_STR_STP_W_STP`	Register returning parameter's value and allowing its modification.
112	ACTIVE CONTROL KP	`W_KP`	Register returning parameter's value and allowing its modification.
113	ACTIVE CONTROL KI	`W_KI`	Register returning parameter's value and allowing its modification.
114	ACTIVE CONTROL AWUP	`W_AWUP`	Register returning anti wind-up PI's gain value and allowing its modification.
115	REACTIVE CONTROL KP	`VAR_KP`	Register returning parameter's value and allowing its modification.
116	REACTIVE	`VAR_KI`	Register returning parameter's value and

	CONTROL KI		allowing its modification.
117	REACTIVE CONTROL AWUP	`VAR_AWUP`	Register returning anti wind-up PI's gain value and allowing its modification.
118	REACTIVE POWER - OVER VOLTAGE MAX REACTIVE POWER	`OV_V_MAX_VAR`	Register returning parameter's value and allowing its modification.
119	REACTIVE POWER - UNDER VOLTAGE MAX REACTIVE POWER	`UN_V_MAX_VAR`	Register returning parameter's value and allowing its modification.
120	ACTIVE POWER - OVER FREQUENCY DROOP 2	`W_OV_FREQ_DROOP_2`	Register returning parameter's value and allowing its modification.
121	START FREQUENCY 2 FOR ACTIVE POWER-OVER FREQUENCY DROOP CONTROL	`W_OV_FREQ_DROOP_STR_2`	Register returning parameter's value and allowing its modification.
122	ACTIVE POWER - UNDER	`W_UN_FREQ_DROOP_2`	Register returning parameter's value and allowing its modification.

	FREQUENCY DROOP 2		
123	START FREQUENCY 2 FOR ACTIVE POWER-UNDER FREQUENCY DROOP CONTROL	W_UN_FREQ_DROOP_STR_2	Register returning parameter's value and allowing its modification.
124	VOLTAGE SETPOINT RETURN INFO (REACTIVE POWER CONTROL)	VAR_V_SETPOINT_RETURN_INFO	Register returning parameter's value and allowing its modification. (voltage PI control).
125	ERROR TERM FOR VOLTAGE CONTROL (REACTIVE POWER CONTROL)	ERROR_TERM_VAR_V	Register returning error between voltage setpoint (voltage PI control) and average voltage measured at POI.
126	REACTIVE POWER - VOLTAGE CONTROL ENABLED	VAR_V_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled. (voltage PI control)
127	REACTIVE POWER - VOLTAGE CONTROL OPERATION MODE	SET_MOD_VAR_V_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling. (voltage PI control).

128	REACTIVE POWER CONTROL VOLTAGE SETPOINT	VAR_V_SETPOINT	Register returning parameter's value and allowing its modification. (voltage PI control).
129	REACTIVE VOLTAGE CONTROL KP	VAR_V_KP	Register returning parameter's value and allowing its modification.
130	REACTIVE VOLTAGE CONTROL KI	VAR_V_KI	Register returning parameter's value and allowing its modification.
131	REACTIVE VOLTAGE CONTROL AWUP	VAR_V_AWUP	Register returning anti wind-up PI's gain value and allowing its modification.
132	PPC LOOP TIME	PPC LOOP TIME	Register returning parameter's value (in milliseconds).
133	SET PPC LOOP TIME	SET PPC LOOP TIME	Register returning parameter's value (in milliseconds) and allowing its modification.
134	ACTIVE POWER IN FREE RUN	P_IN_FREE_RUN	Register returning parameter's value: 1 Free run active, (Maximum active power command sent to inverters). 0 Free run inactive.
135	ACTIVE POWER IN FREE RUN NEGATIVE	P_IN_FREE_RUN_NEGATIVE	Register returning parameter's value: 1 Free run active, (Minimum active power command sent to inverters). 0 Free run inactive.
136	ORDER TO CAPBANKS	ORDER_TO_CAPBANKS	Register returning number of Capbanks connected.
137	ACTIVE POWER	P_CONTROL_SELECTED	Register returning the active power selected control code number:1 for Setpoint control, 2

	CONTROL SELECTED		Overfrequency Start-Stop,3 Overfrequency droop, 4 Underfreqeuncy Start-Stop, 5 Underfrequency droop, 6 Ovevoltage droop, 7 Undervoltage Droop, 8 Overvoltage Start-Sop, 9 Undervotlage Start-Stop,10 Free Run Actual Up Ramp Rate,11 NonDynamic Overfrequency,12 NonDynamic Underfrequency ,13 POD, 14 Max Apparent Power.
138	REACTIVE POWER CONTROL SELECTED	`Q_CONTROL_SELECTED`	Register returning the reactive power selected control code number:101 for Setpoint control, 102 PF, 103 Voltage Droop, 104 PF voltage control, 105 PF active power control, 106 Voltage PI, 107 POD, 108 Max Apparent Power.
139	RELATIVE LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	`W_FREQ_RELATIVE_ACTIVE_POWER_LIMIT`	Register returning parameter’s value (%) and allowing its modification.
140	REACTIVE POWER IN FREE RUN	`Q_IN_FREE_RUN`	Register returning parameter’s value: 1 Free run active, Maximum reactive power command sent to inverters. 0 Free run inactive.
141	REACTIVE POWER IN FREE RUN NEGATIVE	`Q_IN_FREE_RUN_NEGATIVE`	Register returning parameter’s value: 1 Free run active, (Minimum reactive power command sent to inverters). 0 Free run inactive.
142	ACTIVE POWER CONTROL IN NIGHT	`P_IN_NIGHT`	Register returning: 0 if such control is disabled or 1 enabled.

143	ACTIVE POWER CONTROL IN RAMP	`P_IN_RAMP`	Register returning: 0 if such control is disabled or 1 enabled.
144	REACTIVE POWER CONTROL IN NIGHT	`Q_IN_NIGHT`	Register returning: 0 if such control is disabled or 1 enabled.
145	REACTIVE POWER CONTROL IN RAMP	`Q_IN_RAMP`	Register returning: 0 if such control is disabled or 1 enabled.
146	ACTIVE POWER CURRENT SETPOINT	`P_CURRENT_SETPOINT`	Register returning parameter's value and allowing its modification. Signal prior ramp rate limitation, whose value is taken after evaluating all controls activated.
147	REACTIVE POWER CURRENT SETPOINT	`Q_CURRENT_SETPOINT`	Register returning parameter's value and allowing its modification. Signal prior ramp rate limitation, whose value is taken after evaluating all controls activated.
148	POWER FACTOR CURRENT SETPOINT	`PF_CURRENT_SETPOINT`	Register returning parameter's value and allowing its modification. Signal prior ramp rate limitation, whose value is taken after evaluating all controls activated.
149	PPC ERRORS 2	`PPC_ERRORS_2`	Register returning parameter's value. Its value is associated with a number of bits, being each of them related to a single data source the PPC reads from. Each bit becomes 1 in case the connection to a data source is lost and thus modifying the value of PPC_ERRORS_2.

150	ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC CONTROL OPERATION MODE	SET_MOD_W_OV_FREQ_NONDYNAMIC_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
151	ACTIVE POWER - UNDER FREQUENCY NON-DYNAMIC CONTROL OPERATION MODE	SET_MOD_W_UN_FREQ_NONDYNAMIC_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
152	ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC CONTROL ENABLED	W_OV_FREQ_NONDYNAMIC_CONTROL_ENABLE	Register returning: 0 if such control is disabled or 1 enabled.
153	ACTIVE POWER - UNDER FREQUENCY NON-DYNAMIC CONTROL ENABLED	W_UN_FREQ_NONDYNAMIC_CONTROL_ENABLE	Register returning: 0 if such control is disabled or 1 enabled.

154	TRIGGER FREQUENCY FOR ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC CONTROL	`W_OV_FREQ_NONDYNAMIC_TRIGGER_FREQ`	Register returning parameter's value and allowing its modification.
155	TRIGGER FREQUENCY FOR ACTIVE POWER - UNDER FREQUENCY NON-DYNAMIC CONTROL	`W_UN_FREQ_NONDYNAMIC_TRIGGER_FREQ`	Register returning parameter's value and allowing its modification.
156	POWER SETPOINT FOR ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC CONTROL	`W_OV_FREQ_NONDYNAMIC_W_SETPOINT`	Register returning parameter's value and allowing its modification.
157	POWER SETPOINT FOR ACTIVE POWER - UNDER FREQUENCY NON-DYNAMIC	`W_UN_FREQ_NONDYNAMIC_W_SETPOINT`	Register returning parameter's value and allowing its modification.

	CONTROL		
158	DURATION TIME FOR ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC CONTROL	`W_OV_FREQ_NONDYNAMIC_DURATION_TIME`	Register returning parameter's value and allowing its modification.
159	DURATION TIME FOR ACTIVE POWER - UNDER FREQUENCY NON-DYNAMIC CONTROL	`W_UN_FREQ_NONDYNAMIC_DURATION_TIME`	Register returning parameter's value and allowing its modification.
160	IDLE TIME FOR ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC CONTROL	`W_OV_FREQ_NONDYNAMIC_IDLE_TIME`	Register returning parameter's value and allowing its modification.
161	IDLE TIME FOR ACTIVE POWER - UNDER FREQUENCY NON-DYNAMIC	`W_UN_FREQ_NONDYNAMIC_IDLE_TIME`	Register returning parameter's value and allowing its modification.

	CONTROL		
162	ACTIVE POWER CONTROL IN OPENLOOP - PI_DISABLED	`W_OPENLOOP_PI_DISABLE`	Register returning: 0 if such control is disabled or 1 enabled.
163	REACTIVE POWER CONTROL IN OPENLOOP - PI DISABLED	`VAR_OPENLOOP_PI_DISABLE`	Register returning parameter's value and allowing its configuration. 1 for enabling 0 for disabling.
164	ACTIVE POWER NIGHT CONTROLS ENABLED	`W_NIGHT_CONTROLS_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
165	ACTIVE POWER NIGHT CONTROLS OPERATION MODE	`SET_MOD_W_NIGHT_CONTROLS`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
166	REACTIVE POWER NIGHT CONTROLS ENABLED	`VAR_NIGHT_CONTROLS_ENABLED`	Register returning: 0 if such control is disabled or 1 enabled.
167	REACTIVE POWER NIGHT CONTROLS OPERATION MODE	`SET_MOD_VAR_NIGHT_CONTROLS`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.

168	NIGHT ACTIVE POWER SETPOINT	`W_NIGHT_SETPOINT`	Register returning parameter's value and allowing its modification.
169	NIGHT REACTIVE POWER SETPOINT	VAR_NIGHT_SETPOINT	Register returning parameter's value and allowing its modification.
170	ACTIVE POWER EXIT FREE RUN OPERATION MODE	`SET_MOD_W_EXIT_FREE_RUN`	Register returning parameter's value and allowing its configuration/modification. Allowed values 0, 1, 2.
171	MINIMUM ACTIVE POWER TO ACTIVATE CAPBANK	CAPBANKS_MIN_AC_POWER	Register returning parameter's value and allowing its modification. Minimum active power measured at POI to allow capacitor banks connection.
172	MIN POWER OF PV INVERTER	`MIN_ACTIVE_POWER_INVERTER`	Register returning parameter's value. Minimum active power produced among all inverters.
173	REACTIVE POWER EXIT FREE RUN OPERATION MODE	SET_MOD_VAR_EXIT_FREE_RUN	Register returning parameter's value and allowing its configuration/modification. Allowed values 0 and 2.
174	HIGH LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	`W_FREQ_ACTIVE_POWER_LIMIT_HIGH`	Register returning parameter's value and allowing its modification.

175	LOW LIMIT FOR ACTIVE POWER IN FREQUENCY CONTROL	W_FREQ_ACTIVE_POWER_LIMIT_LOW	Register returning parameter's value and allowing its modification.
176	ACTIVE POWER FREE RUN TENDENCY	P_FREE_RUN_TENDENCY	Register returning parameter's value and allowing its modification. Provides information about positive or negative variation of active power during free run.
177	REACTIVE POWER POD CONTROL OPERATION MODE	SET_MOD_VAR_POD_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
178	REACTIVE POWER POD CONTROL ENABLED	VAR_POD_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled.
179	ACTIVE POWER POD CONTROL OPERATION MODE	SET_MOD_W_POD_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
180	ACTIVE POWER POD CONTROL ENABLED	W_POD_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled.
181	ACTIVE POWER SMAX CONTROL OPERATION MODE	SET_MOD_W_SMAX_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.

182	ACTIVE POWER SMAX CONTROL ENABLED	W_SMAX_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled.
183	REACTIVE POWER SMAX CONTROL OPERATION MODE	SET_MOD_VAR_SMAX_CONTROL	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
184	REACTIVE POWER SMAX CONTROL ENABLED	VAR_SMAX_CONTROL_ENABLED	Register returning: 0 if such control is disabled or 1 enabled.
185	MAX APPARENT POWER CONTROL LIMIT	SMAX_CONTROL_LIMIT	Register returning parameter's value and allowing its modification. Reactive and Active power setpoint generation will be limited and conditioned to SMAX_CONTROL_LIMIT's value.
186	ACTIVE POWER CONTROL IN FORCED LOW POWER	P_IN_FORCED_LOW_POWER	Register returning: 0 if such mode is inactive or 1 active. External P setpoint of 0 kW.
187	AVAILABLE ACTIVE POWER	AVAILABLE_ACTIVE_POWER	Register returning parameter's value. Total estimated active power that could be produced (kW).
188	ACTIVE POWER RESERVE CONTROL ENABLE	W_RESERVE_CONTROL_ENABLE	Register returning: 0 if such control is disabled or 1 enabled.

189	ACTIVE POWER IN RESERVE POWER	P_IN_RESERVE_POWER	Register returning: 0 if such control is disabled or 1 enabled.
190	ACTIVE POWER RESERVE CONTROL OPERATION MODE	SET_MOD_W_RESERVE_CONTROL	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling.
191	ACTIVE POWER - FREQUENCY DROOP BASE POWER TYPE	SET_MOD_W_FREQ_DROOP_BASEPOWER_TYPE	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling.
192	ACTIVE POWER CONTROL RESERVED POWER	W_CONTROL_RESERVED_POWER	Register returning parameter's value and allowing its modification (%). Amount of available power reserved at any time.
193	FVRT CONTROL ENABLE	FVRT_CONTROL_ENABLE	Register returning: 0 if such feature is inactive or 1 active.
194	FVRT CONTROL OPERATION MODE	SET_MOD_FVRT	Register returning parameter's value and allowing its configuration: activation/deactivation. 1 for enabling 0 for disabling.
195	FVRT HIGH VOLTAGE LIMIT	FVRT_VOLTAGE_LIMIT_HIGH	Register returning parameter's value and allowing its modification (kV).

196	FVRT LOW VOLTAGE LIMIT	`FVRT_VOLTAGE_LIMIT_LOW`	Register returning parameter's value and allowing its modification (kV).
197	FVRT FREEZE TIME	`FVRT_FREEZE_TIME`	Register returning parameter's value and allowing its modification (ms).
198	IN FVRT	`IN_FVRT`	Register returning: 1 in case of FVRT event 0 in normal operation.
199	ACTIVE POWER - FREQUENCY DROOP REFERENCE MAX POWER	`W_FREQ_DROOP_REFERENCE_MAX_POWER`	Register returning parameter's value and allowing its modification. Used in case the active power's droop reference has to be different to the maximum active power of the plant.
200	ACTIVE POWER - OVER FREQUENCY DROOP HYSTERESIS ENABLE	`SET_MOD_W_OV_FREQ_HYST`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
201	ACTIVE POWER - UNDER FREQUENCY DROOP HYSTERESIS ENABLE	`SET_MOD_W_UN_FREQ_HYST`	Register returning parameter's value and allowing its configuration: activation/ deactivation. 1 for enabling 0 for disabling.
202	ACTIVE POWER - OVER FREQUENCY DROOP HYSTERESIS	`W_OV_FREQ_HYST_WAIT_STOP`	Register returning parameter's value and allowing its modification.

	WAIT STOP FREQUENCY		
203	ACTIVE POWER - UNDER FREQUENCY DROOP HYSTERESIS WAIT STOP FREQUENCY	`W_UN_FREQ_HYST_WAIT_STOP`	Register returning parameter's value and allowing its modification.
204	ACTIVE POWER - OVER FREQUENCY DROOP HYSTERESIS WAIT STOP FREQUENCY 2	`W_OV_FREQ_HYST_WAIT_STOP_2`	Register returning parameter's value and allowing its modification.
205	ACTIVE POWER - UNDER FREQUENCY DROOP HYSTERESIS WAIT STOP FREQUENCY 2	`W_UN_FREQ_HYST_WAIT_STOP_2`	Register returning parameter's value and allowing its modification.
206	OPERATION TIME	`OPERATION_TIME`	Register returning PPC's time in operation in seconds from the last reboot.
207	GET TIME	`GET_TIME`	Register returning amount of time needed by the PPC to get all data sources during the previous execution loop.

208	COMPUTING TIME	`COMP_TIME`	Register returning the time it took the PPC to perform all control calculations during the last execution loop.
209	SET TIME	`SET_TIME`	Register returning the time it took the PPC to broadcast the P&Q command to the inverters during the last execution loop.
210	MAX ACTIVE POWER	`W_MAX`	Register returning parameter's value and allowing its modification. This parameter is used for limiting active power references that get in the PI controller.
211	NOMINAL ACTIVE POWER	`W_NOM`	Register returning parameter's value and allowing its modification. This parameter should be equal to the maximum active power that all inverters could deliver in P priority mode. Unless specific cases W_NOM= VAR_NOM
212	SATURATION ACTIVE POWER	`W_SAT`	Register returning parameter's value and allowing its modification. This parameter is used for limiting the active power PI controller output.
213	MAX REACTIVE POWER	`VAR_MAX`	Register returning parameter's value and allowing its modification. This parameter is used for limiting reactive power references that get in the PI controller.
214	NOMINAL REACTIVE POWER	`VAR_NOM`	Register returning parameter's value and allowing its modification. This parameter should be equal to the maximum reactive power that all inverters could deliver in Q priority mode. Unless specific cases W_NOM= VAR_NOM
215	SATURATION REACTIVE	`VAR_SAT`	Register returning parameter's value and allowing its modification. This parameter is

	POWER		used for limiting the reactive power PI controller output.
216	FIRMWARE VERSION 0	`FW_V0`	
217	FIRMWARE VERSION 1	`FW_V1`	
218	FIRMWARE VERSION 2	`FW_V2`	
219	REACTIVE POWER NIGHT CURTAILMENT ENABLED	`VAR_CONTROL_NIGHT_ENABLED`	
220	REACTIVE POWER - POWER FACTOR NIGHT CONTROL ENABLED	`VAR_PF_CONTROL_NIGHT_ENABLED`	
221	REACTIVE POWER - VOLTAGE REFERENCE NIGHT CONTROL ENABLED	`VAR_V_REF_CONTROL_NIGHT_ENABLED`	
222	REACTIVE POWER - POWER FACTOR-VOLTAGE	`VAR_PF_V_CONTROL_NIGHT_ENABLED`	

	NIGHT CONTROL ENABLED	
223	REACTIVE POWER - POWER FACTOR-ACTIVE POWER START - STOP NIGHT CONTROL ENABLED	VAR_PF_W_STR_STP_CONTROL_NIGHT_ENABLED
224	REACTIVE POWER - VOLTAGE NIGHT CONTROL ENABLED	VAR_V_CONTROL_NIGHT_ENABLED
225	REACTIVE POWER POD NIGHT CONTROL ENABLED	VAR_POD_CONTROL_NIGHT_ENABLED
226	REACTIVE POWER SMAX NIGHT CONTROL ENABLED	VAR_SMAX_CONTROL_NIGHT_ENABLED
227	ACTIVE POWER NIGHT CURTAILMENT ENABLED	W_CONTROL_NIGHT_ENABLED

228	ACTIVE POWER - OVER FREQUENCY START-STOP NIGHT CONTROL ENABLED	W_OV_FREQ_STR_STP_CONTROL_NIGHT_ENABLED
229	ACTIVE POWER - UNDER FREQUENCY START-STOP NIGHT CONTROL ENABLED	W_UN_FREQ_STR_STP_CONTROL_NIGHT_ENABLED
230	ACTIVE POWER - OVER FREQUENCY DROOP NIGHT CONTROL ENABLED	W_OV_FREQ_DROOP_CONTROL_NIGHT_ENABLED
231	ACTIVE POWER - UNDER FREQUENCY DROOP NIGHT CONTROL ENABLED	W_UN_FREQ_DROOP_CONTROL_NIGHT_ENABLED
232	ACTIVE POWER - OVER VOLTAGE	W_OV_V_DROOP_CONTROL_NIGHT_ENABLED

	DROOP NIGHT CONTROL ENABLED	
233	ACTIVE POWER - OVER VOLTAGE START-STOP NIGHT CONTROL ENABLED	`W_OV_V_STR_STP_CONTROL_NIGHT_ENABLED`
234	FREERUN ACTIVE ACTUAL UP RAMP RATE NIGHT CONTROL ENABLED	`W_ACTUAL_UP_RAMP_RATE_CONTROL_NIGHT_ENABLED`
235	ACTIVE POWER - OVER FREQUENCY NON-DYNAMIC NIGHT CONTROL ENABLED	`W_OV_FREQ_NONDYNAMIC_CONTROL_NIGHT_ENABLED`
236	ACTIVE POWER - UNDER FREQUENCY NON-DYNAMIC NIGHT	`W_UN_FREQ_NONDYNAMIC_CONTROL_NIGHT_ENABLED`

	CONTROL ENABLED	
237	ACTIVE POWER POD NIGHT CONTROL ENABLED	W_POD_CONTROL_NIGHT_ENABLED
238	ACTIVE POWER SMAX NIGHT CONTROL ENABLED	W_SMAX_CONTROL_NIGHT_ENABLED
239	REACTIVE POWER NIGHT CURTAILMENT OPERATION MODE	SET_MOD_VAR_CONTROL_NIGHT
240	REACTIVE POWER - VOLTAGE REFERENCE NIGHT CONTROL OPERATION MODE	SET_MOD_VAR_V_REF_CONTROL_NIGHT
241	REACTIVE POWER - POWER FACTOR NIGHT CONTROL OPERATION MODE	SET_MOD_VAR_PF_CONTROL_NIGHT

242	REACTIVE POWER - POWER FACTOR-VOLTAGE NIGHT CONTROL OPERATION MODE	`SET_MOD_VAR_PF_V_CONTROL_NIGHT`
243	REACTIVE POWER - POWER FACTOR-ACTIVE POWER START - STOP NIGHT CONTROL OPERATION MODE	`SET_MOD_VAR_PF_W_STR_STP_CONTROL_NIGHT`