# ASC 150 Solar

4189341342B

## Designer's handbook

DEIF Improve Tomorrow


# 1. Introduction

## 1.1 About

The ASC 150 Solar controller is a fully flexible controller to control and protect a photovoltaic (PV) system with up to 32 inverters. Use ASC 150 Solar to add PV to an existing or new site. You can have up to 16 ASC Solar controllers working together.

Use ASC 150 Solar as a single controller to add PV power and a mains connection (optional) to an existing site.

In a power management system (PMS), use ASC 150 Solar for seamless integration of PV power with other power sources (including storage, gensets and/or mains). To save fuel, the PMS maximises PV penetration, while making sure that the gensets meet their minimum load requirements. The PMS also makes sure that spinning reserve requirements are met, and responds quickly to load and weather changes.

For sites with genset and/or mains controllers from other suppliers, use ASC 150 Solar with open PMS to add solar, storage and/or mains controllers.

The controller has built-in AC measurements. There are two sets of voltage measurements (three phases, and (optional) the neutral phase), and one set of current measurements (three phases). There is also a 4th current measurement that can be used to measure mains power. The controller can receive power measurements from power meters, genset communication, and/or transducers.

Operators can easily control the system from the display unit. Alternatively, use the communication options to connect to an HMI/SCADA system.

### 1.1.1 Controller types

If the AGC 150 or ASC 150 has an extended or premium software package, you can change it to any AGC 150 or ASC 150* controller type. Select the controller type under `Basic settings > Controller settings > Type`.

| Parameter | Setting | Controller type |
|---|---|---|
| 9101 | DG unit | Genset (Generator or Stand-alone) controller |
| | Mains unit | Mains controller |
| | BTB unit | BTB controller |
| | DG HYBRID unit | Genset-Solar hybrid controller |
| | ENGINE DRIVE unit | Engine drive controller |
| | Remote unit | Remote display |
| | ENGINE DRIVE MARINE unit | Engine drive controller for marine use |
| | DG MARINE unit | Stand-alone genset controller for marine use |
| | ASC 150 Storage* | Battery storage controller |
| | ASC 150 Solar* | Solar controller |
| | ATS unit | Automatic transfer switch |
| | DG PMS Lite | PMS Lite controller |

**NOTE** * To change to these controller types, the controllers must have the sustainability option (S10).

## 1.2 Terms and abbreviations

| Term | Abbreviation | Explanation |
|---|---|---|
| Alternating current | AC | An electric current which periodically reverses direction. An inverter is used to convert direct current from solar panels to alternating current. |
| Apparent power | S | A combination of active power (P) and reactive power (Q). |
| Automatic Sustainable Controller | ASC 150 Storage<br>ASC-4 Battery | DEIF's controller to integrate an energy storage system in an application with other power sources. |
| | ASC 150 Solar<br>ASC-4 Solar | DEIF's controller to integrate photovoltaic in an application with other power sources. |
| AGC | AGC 150<br>AGC-4 Mk II<br>AGC-4 | DEIF controllers to control a genset (DG), bus tie breaker (BTB), or a mains (grid) connection. |
| Back of module temperature | BOM | The temperature measured at the back of the PV panel. The BOM affects the PV panel efficiency and output. |
| Brownfield | | An installation that already has power generating equipment and controllers. The controllers may be from other suppliers. Therefore the system cannot be fully controlled by DEIF.<br><br>For ASC Solar, you can add single controllers or open PMS controllers to a brownfield site. |
| Busbar | BB | The equipment for the electrical connection of all the sources and the loads. The busbar can also be connected to the mains (grid). |
| Curtailment | | The power from the PV system is reduced, so that it produces less power than it could. |
| Direct current | DC | A flow of electric charge in one direction. Solar panels produce direct current. The inverter converts the direct current to alternating current. |
| Energy management | EM | The ASC and AGC controllers work together to follow the energy management rules. They work together to run at the configured set point. In this way, the PV, ESS, mains connection(s), and/or genset(s) run optimally. |
| Energy management system | EMS | The ASC controllers work with each other, as well as with AGC Genset and Mains controllers. The ASC Solar controllers make sure that there is as much PV power as possible. The ASC Storage/Battery controllers charge and discharge according to the energy management rules. The AGC Genset controllers start, stop and run at the load required by energy management. The AGC Mains controllers connect and disconnect the mains as required. AGC Bus tie breaker controllers and ALC automatic load controllers can also be used.<br><br>Together, the controllers form an energy management system. This can also be called an integrated system. |
| Frequency response | FR | Some inverters (the primary regulator) respond immediately to a frequency change. |
| Global horizontal irradiation | GHI | The irradiation from the sky, as measured on the horizontal. |
| Greenfield | | A new installation. Since there are no pre-existing controllers, the owner can choose to only use DEIF controllers. The new control system can then consist of ASC and AGC controllers working together for power/energy management. |
| Grid | | National or local electricity grid. Also known as mains. |
| Grid-tied | | The PV system is connected to grid/mains power. |
| Inverter | | Equipment that changes direct current to alternating current. |

| Term | Abbreviation | Explanation |
|---|---|---|
| Load-dependent start or stop | LDSS | Controller settings that use the system load to determine when to start and stop gensets. |
| Mains breaker | MB | The breaker between the PV system and the grid/mains power. |
| M-Logic | | DEIF's PLC-like configurable logic tool. |
| Multi-line 150 | ML 150 | One of DEIF's controller series. This includes AGC 150, ASC 150 Storage, and ASC 150 Solar. The controllers work together to provide energy management. ML-2 controllers can also be used with these controllers. |
| Multi-line 2 | ML-2 | One of DEIF's controller series. This includes AGC-4, ASC-4 Battery, and ASC-4 Solar. The controllers work together to provide energy management. ML 150 controllers can also be used with these controllers. |
| Off-grid | | The PV system is not connected to grid/mains power. |
| Open PMS | | For brownfield energy management applications. Open PMS has ASC Solar and/or Battery/Storage controllers along with other controllers from other vendors. The ASC controllers get power measurements (required for energy management) from the other controllers and/or power meters. |
| Photovoltaic | PV | A system that converts sunlight to electrical power. The system may consist of several solar panels and an inverter. |
| Photovoltaic breaker | PVB | The breaker between the PV system and the conventional power system. The ASC Solar can control this breaker. |
| Plane of array | POA | The angle of the PV panels. |
| Power management | PM | DEIF's name for energy management. |
| Radio Ripple Control Receiver | RRCR | Binary inputs are used for external set point control. |
| Single controller | | The single controller operates based on its own measurements and inputs. The single controller can also use power measurements from other power sources. However, single controllers are used in applications without power management. |
| Source | BA | A power source. This can be a PV system, an ESS, a mains connection, another busbar section, or a genset. |
| Spinning reserve | | Partially loaded and synchronised power sources that can quickly respond to load changes. |
| Utility software | USW | DEIF's software to configure the application and controllers. The USW can also be used to monitor the application, as well as to configure M-Logic. |
| Watts (peak) | Wp | Solar panel rating unit. |

## 1.3 About the Designer's handbook

### General purpose

This document gives information about the controller's functionality and its applications, and for configuring the controller.

**CAUTION**

**Installation errors**

Read this document before working with the controller. Failure to do this may result in human injury or damage to the equipment.

## Intended users of the Designer's handbook

This Designer's handbook is primarily intended for the panel designer in charge. Based on this document, the panel designer can give the electrician the necessary information to install the controller, for example detailed electrical drawings.

The Designer's handbook can also be used during commissioning to check the parameters, and operators may find it useful for understanding the system and for troubleshooting.

## List of technical documentation

| Document | Contents |
|---|---|
| Product sheet | • Short description<br>• Controller applications<br>• Main features and functions<br>• Technical data<br>• Protections<br>• Dimensions |
| Data sheet | • General description<br>• Functions and features<br>• Controller applications<br>• Software variants<br>• Protections<br>• Inputs and outputs<br>• Technical specifications |
| Designer's handbook | • Principles<br>• Communication<br>• Applications<br>• Controller sequences and functions<br>• Protections and alarms<br>• Regulation<br>• Examples |
| Installation instructions | • Tools and materials<br>• Mounting<br>• Minimum wiring for the controller<br>• Wiring information and examples |
| Operator's manual | • Controller equipment (buttons and LEDs)<br>• Operating the system<br>• Alarms and log |
| Communication | **ASC 150 Modbus server tables**<br>• Modbus address list<br>  ◦ PLC addresses<br>  ◦ Corresponding controller functions<br>• Descriptions for function codes, function groups<br>**ASC Solar Modbus client tables**<br>• Modbus address list for *PV monitoring*<br>• Descriptions for function codes, function groups |
| Application notes | **DEIF Hybrid controller compatibility**<br>• PV systems<br>• Weather stations and forecast* systems |

| Document | Contents |
|---|---|
| | • Energy storage systems<br>• Power measurements<br>  ◦ Power meters<br>  ◦ Genset controllers |

**NOTE** * The ASC 150 Solar does not support forecasting. To use forecasting, use ASC-4 Solar.

### 1.3.1 Software version

This document is based on the AGC 150 software version 1.17.

## 1.4 Warnings and safety

### Safety during installation and operation

Installing and operating the equipment may require work with dangerous currents and voltages. The installation must only be carried out by authorised personnel who understand the risks involved in working with electrical equipment.

**DANGER!**

**Hazardous live currents and voltages**

Do not touch any terminals, especially the AC measurement inputs and the relay terminals. Touching the terminals could lead to injury or death.

### Current transformer danger

**DANGER!**

**Electrical shock and arc flash**

Risk of burns and electrical shock from high voltage.

Short all current transformer secondaries before breaking any current transformer connections to the controller.

### Factory settings

The controller is delivered pre-programmed from the factory with a set of default settings. These settings are based on typical values and may not be correct for your system. You must therefore check all parameters before using the controller.

### Electrostatic discharge

Electrostatic discharge can damage the controller terminals. You must protect the terminals from electrostatic discharge during the installation. When the controller is installed and connected, these precautions are no longer necessary.

### Data security

To minimise the risk of data security breaches:

- As far as possible, avoid exposing controllers and controller networks to public networks and the Internet.
- Use additional security layers like a VPN for remote access, and install firewall mechanisms.
- Restrict access to authorised persons.

## 1.5 Legal information

### Third party equipment

DEIF takes no responsibility for the installation or operation of any third party equipment, including the **genset**.

### Warranty

**NOTICE**

**Warranty**

The controller is not to be opened by unauthorised personnel. If opened anyway, the warranty will be lost.

### Disclaimer

DEIF A/S reserves the right to change any of the contents of this document without prior notice.

The English version of this document always contains the most recent and up-to-date information about the product. DEIF does not take responsibility for the accuracy of translations, and translations might not be updated at the same time as the English document. If there is a discrepancy, the English version prevails.

### Copyright

# 2. Utility software

## 2.1 Download the utility software

The **Multi-line 2 Utility Software v.3.x** is the software interface between a PC and the controller. The software is free of charge. Download it from www.deif.com

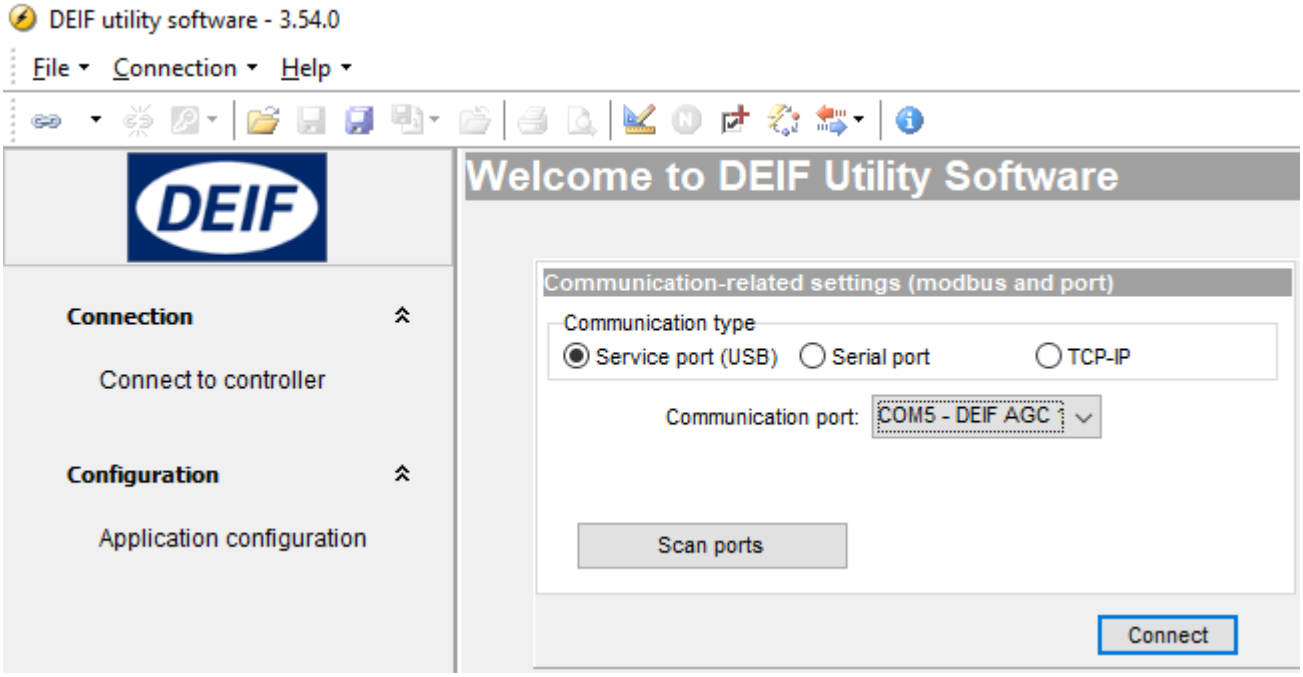
## 2.2 Connection

You can use a USB connection or TCP/IP to connect to the controller.

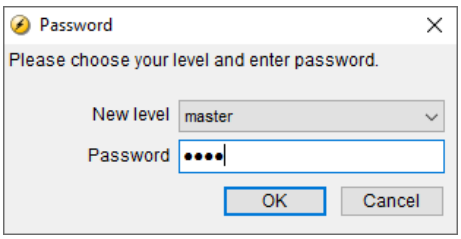
### 2.2.1 USB connection

You need a USB cable (USB A to B) to connect the controller to a PC.

1. Install the utility software on a PC.
2. Use the USB cable to connect the controller service port to the PC.
3. Start the utility software.




4. Select a service port option.
5. When prompted, select the access level, enter the password, and select OK.




**More information**
See **General functions, Password** for the default passwords.

## 2.2.2 TCP connection

You can use TCP/IP communication to connect to the controller. This requires an Ethernet cable, or a connection to the network that includes the controller.

### Default controller network address

- IP: 192.168.2.2
- Gateway: 192.168.2.1
- Subnet mask: 255.255.255.0

### Configuring the controller IP address using the display unit or a USB connection

When connecting to a controller using TCP/IP, you must know the controller's IP address. Find the IP address on the display under: `Communication > Ethernet setup`.

**You can use the display to change the controller's IP address.**

Alternatively, you can use a USB connection or an Ethernet connection and the utility software to change the controller IP address.

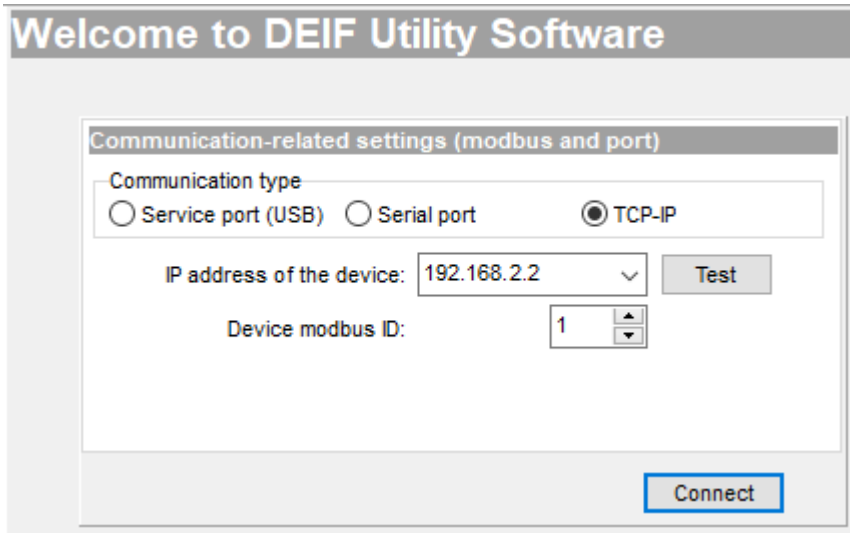
### Point-to-point Ethernet connection to the controller

If you do not want to use the display unit or a USB connection to change the IP address, you can use a point-to-point Ethernet connection. The PC must have a static IP address. For the default controller network address, the PC static IP address must be 192.168.2.xxx, where xxx is a free IP-address in the network (note: xxx cannot be 2 (the controller IP address) or 1 (the gateway)).

If you change the controller address (for example, from 192.168.**2**.yyy to 192.168.**47**.yyy) the connection is lost. A new static IP for the PC is needed. In this case, 192.168.47.zzz, where zzz is a free IP-address in the network. The PC address, IP address, and gateway must be in the same subnet.

When the PC has the correct static IP address:

1. Use an Ethernet cable to connect the PC to the controller.
2. Start the utility software.
3. Select *TCP-IP*, and enter the controller IP address.

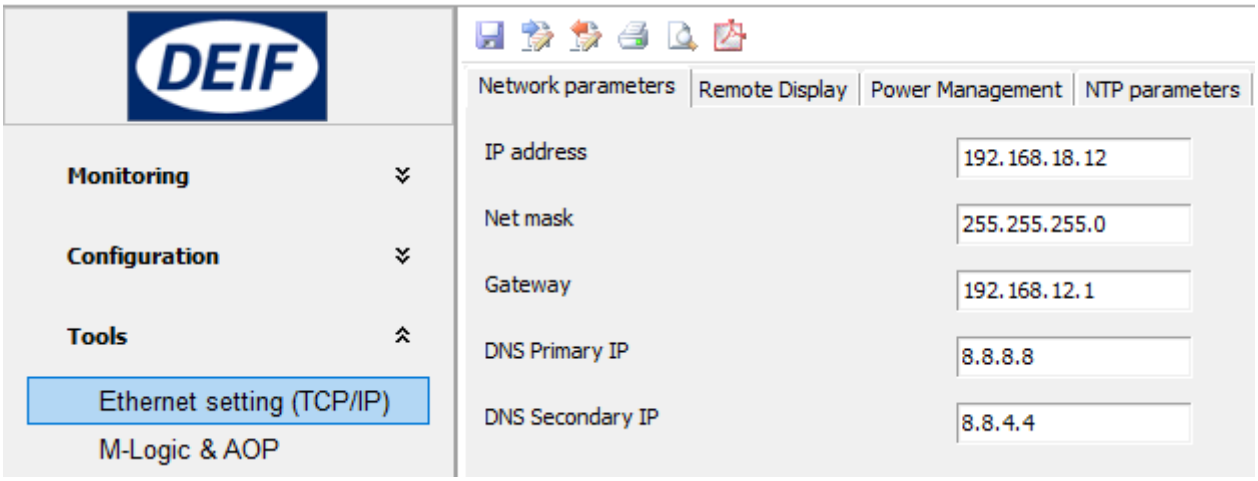



4. You can use the *Test* button to check if the connection is successful.
5. Select *Connect* to connect to the controller using TCP-IP.

### Configuring the controller IP address using the utility software

1. Select *Connect* to connect to the controller using TCP-IP.
2. Select *Ethernet setting (TCP/IP)*.

The *Network Parameters* window opens:




When the controller network parameters have been changed, press the *Write to device* button.

The controller receives the new network parameters and reboots the network hardware.

To connect to the controller again, use the new controller IP address (and a correct PC static IP address).

### Using a switch

For a system with multiple controllers, all controllers can be connected to a switch. Create a unique IP address for each controller in the network before connecting the controllers to a switch.

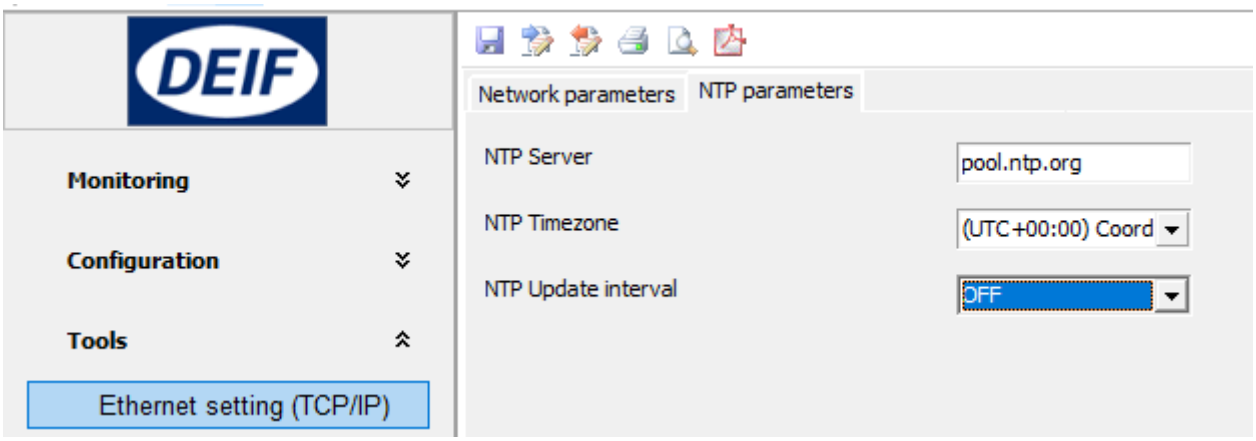
The PC can then be connected to the switch, and the Ethernet cable can be in the same port of the switch at all times. You can enter the controller IP address in the utility software.

The TCP-IP connection is faster than other connections. It also allows the user to shift between controllers in the application supervision window in the utility software.

## 2.3 Using NTP

To ensure that the controller always has the right time, you can use the network time protocol (NTP) function.

Select *Ethernet setting (TCP/IP)* in the Utility software, then select the *NTP parameters* tab in the *Network Parameters* window:



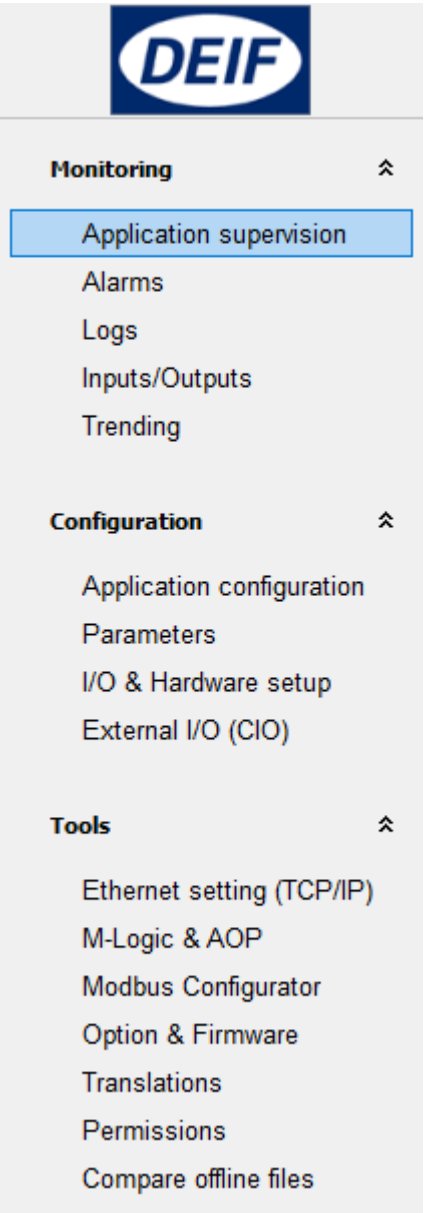

You can select an NTP server, a time zone and an update interval. Write the changes to the controller to activate the NTP function.

## 2.4 Utility software interface

### 2.4.1 Top toolbar

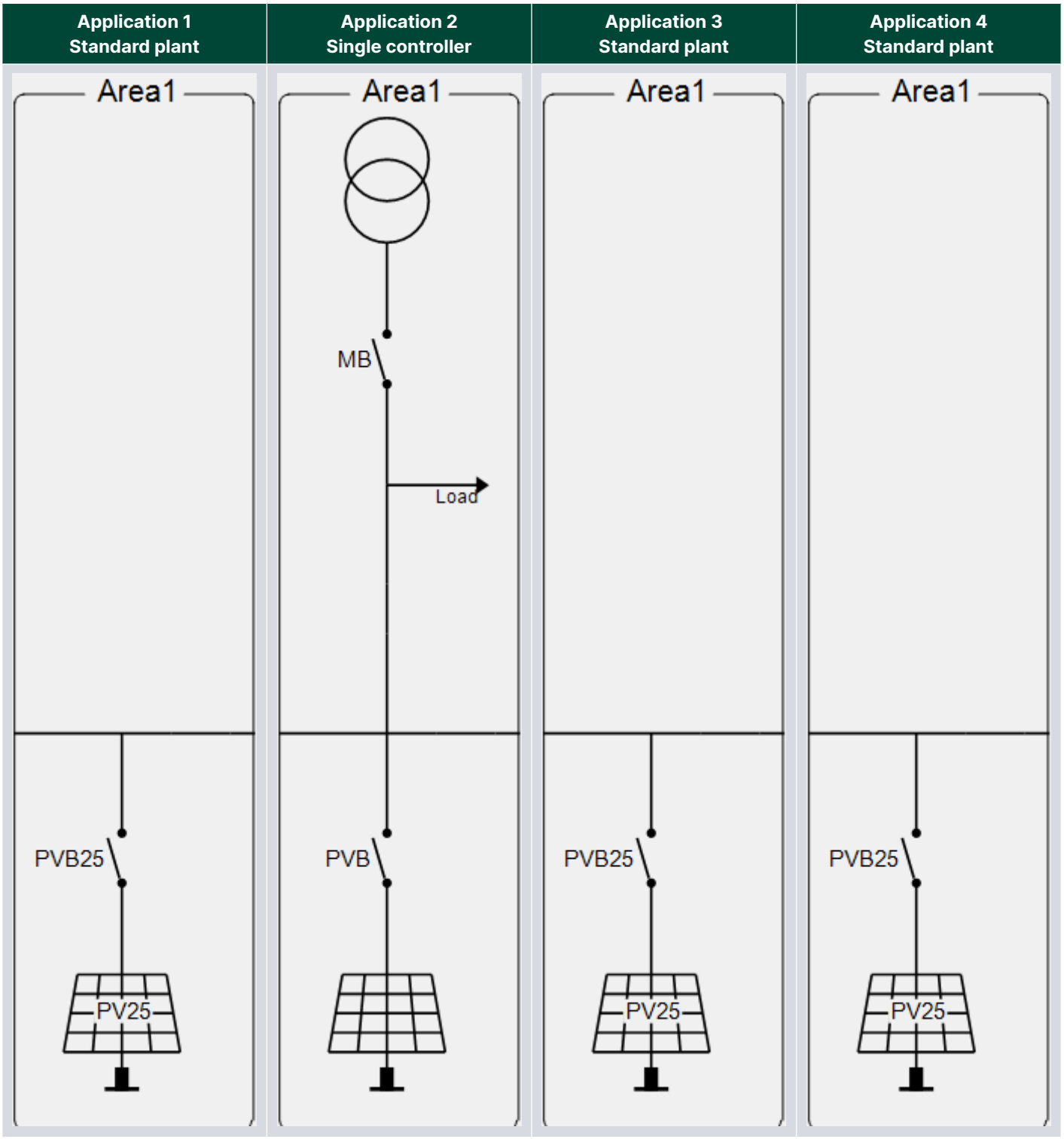

1. Connect to a controller.
2. Disconnect from a controller.
3. Permission level.
4. Application settings.
5. Add options (create an option code and send it to support@deif.com).
6. Enter an upgrade code (received from DEIF support).
7. Update the controller firmware.
8. Configure the display views.
9. Not used for the controller.
10. Configure the AOP-2 buttons and LEDs (Additional Operator Panel).
11. RRCR.
12. Read the controller counters.
13. Information on the controller and the software.
14. Read, write, backup, and restore the device.
15. Data tracing (shows the max./min. of a value, as long as the data tracer window is open).
16. Send commands to the controller.
17. Synchronise the controller clock with the connected PC.

### 2.4.2 Left menu




- **DEIF**
  - Link to www.deif.com
- **Monitoring**
  - Application supervision
    - See the plant operation, including how much power each genset produces.
  - Alarms
    - An overview of the active alarms.
    - See the history for the alarms that are activated while the PC is connected.
  - Logs
    - See the alarms and events logs from the controller.
  - Inputs/outputs
    - The controller input and output status.
  - Trending
    - See real-time operation.
    - Trending is possible when a PC is connected and the trending window is open. The controller cannot save the data.
- **Configuration**
  - Application configuration
    - Create the application single-line drawing(s).
  - Parameters
    - Configure and view parameters.
  - I/O & Hardware setup
    - Configure the inputs and outputs.
  - External I/O (CIO)
    - Detect and configure the external inputs and outputs.
- **Tools**
  - Ethernet setting (TCP/IP)
    - Configure Ethernet settings and communication.
  - M-Logic & AOP
    - Configure M-Logic and additional operator panels.
  - Modbus Configurator
    - Configure the configurable Modbus addresses.
  - Options & Firmware
    - See the available options.
  - Translations
    - Customise or translate (almost all of) the text in the controller.
  - Permissions
    - See and change the user permissions.
- Compare offline files
  - Compare utility software project files.

## 2.5 Set up applications




Select *Application configuration* in the left menu. The controller comes with four pre-configured standard applications. Standard applications 1, 3 and 4 are identical.

The applications can be changed with the utility software.

## 2.6 Emulation

You can use the utility software to emulate the application.

Requirements:

- One or more controllers, each with its own power supply.
- For multiple controllers, connect their power management CAN bus terminals.
- A USB or TCP/IP connection from one of the controllers to your PC.
- For each controller, disable the *Emergency STOP* alarm (menu 3490). Alternatively, activate digital input 4 (the emergency stop).

The operation and other inputs can be emulated.

**NOTE** During emulation, if the controller detects AC voltage, it activates the *Live voltage detected* alarm.

**CAUTION**

**Emulation can start the PV system**

During emulation, the controller uses the communication connection to the PV system. The controller can therefore send commands to the PV system. Be very careful about using emulation if the controller is mounted in a real installation.

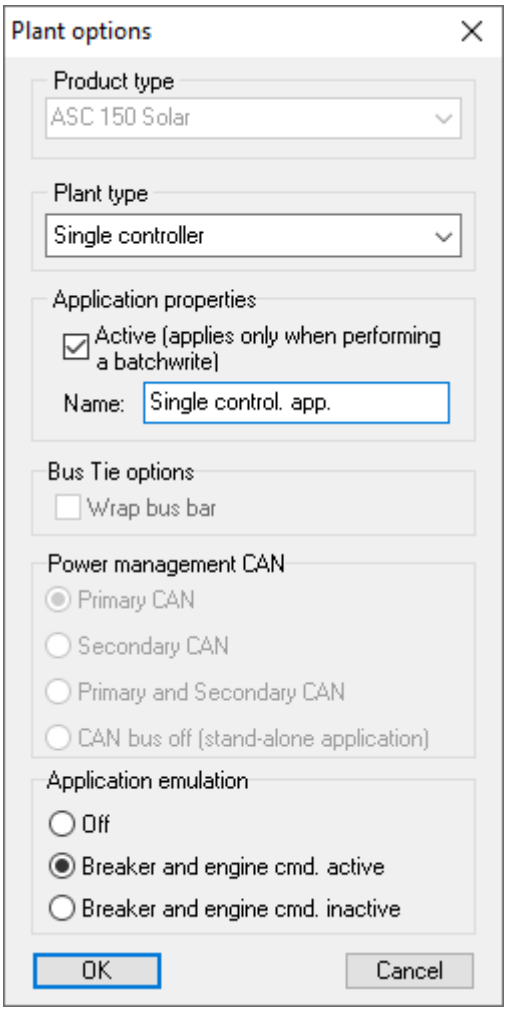
**CAUTION**

**Emulation can activate relays**

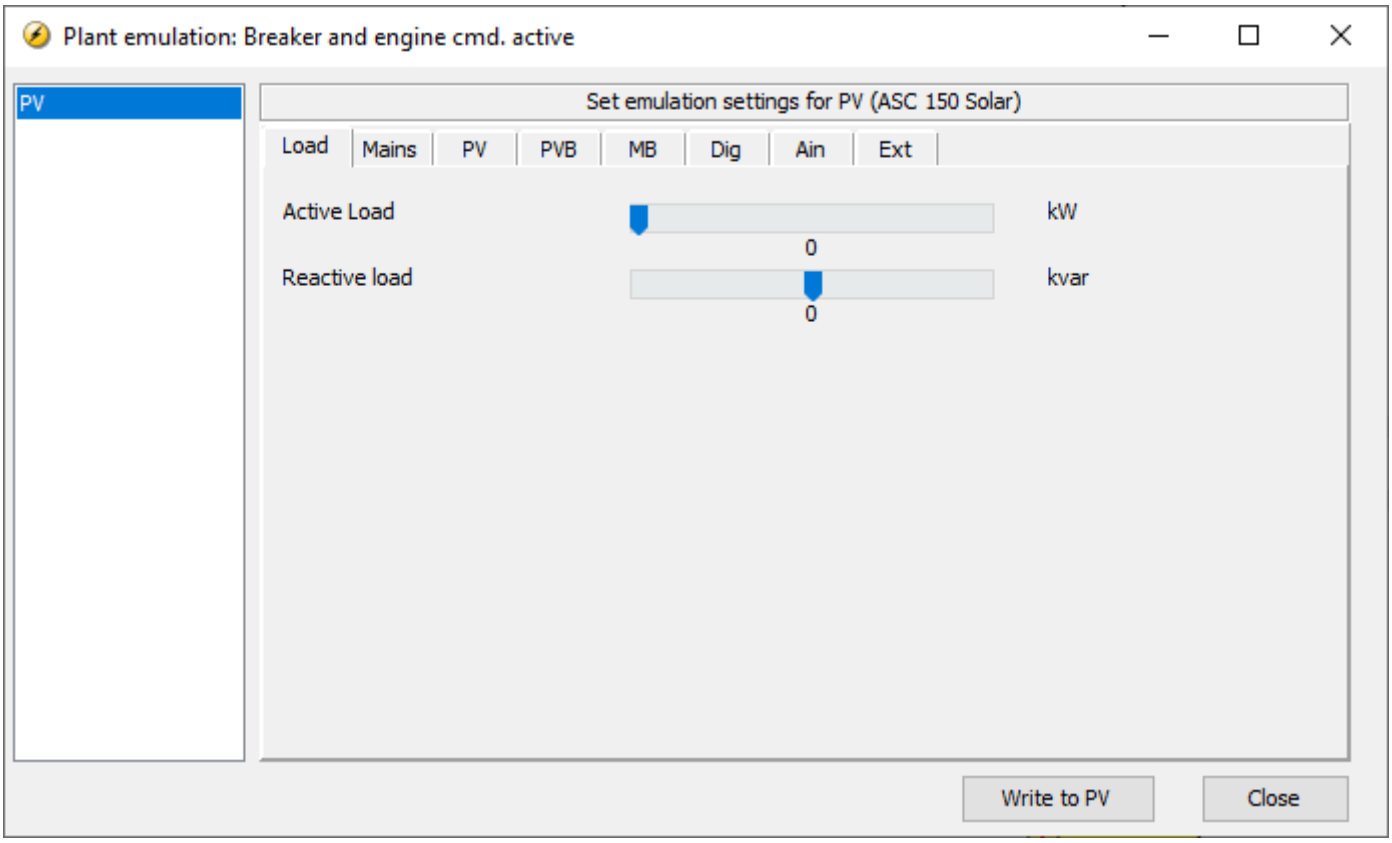
If you select *Breaker and engine cmd. active*, the controller activates its relays (for example, the relay to close a breaker). Be very careful about selecting this if the controllers are mounted in a real installation.

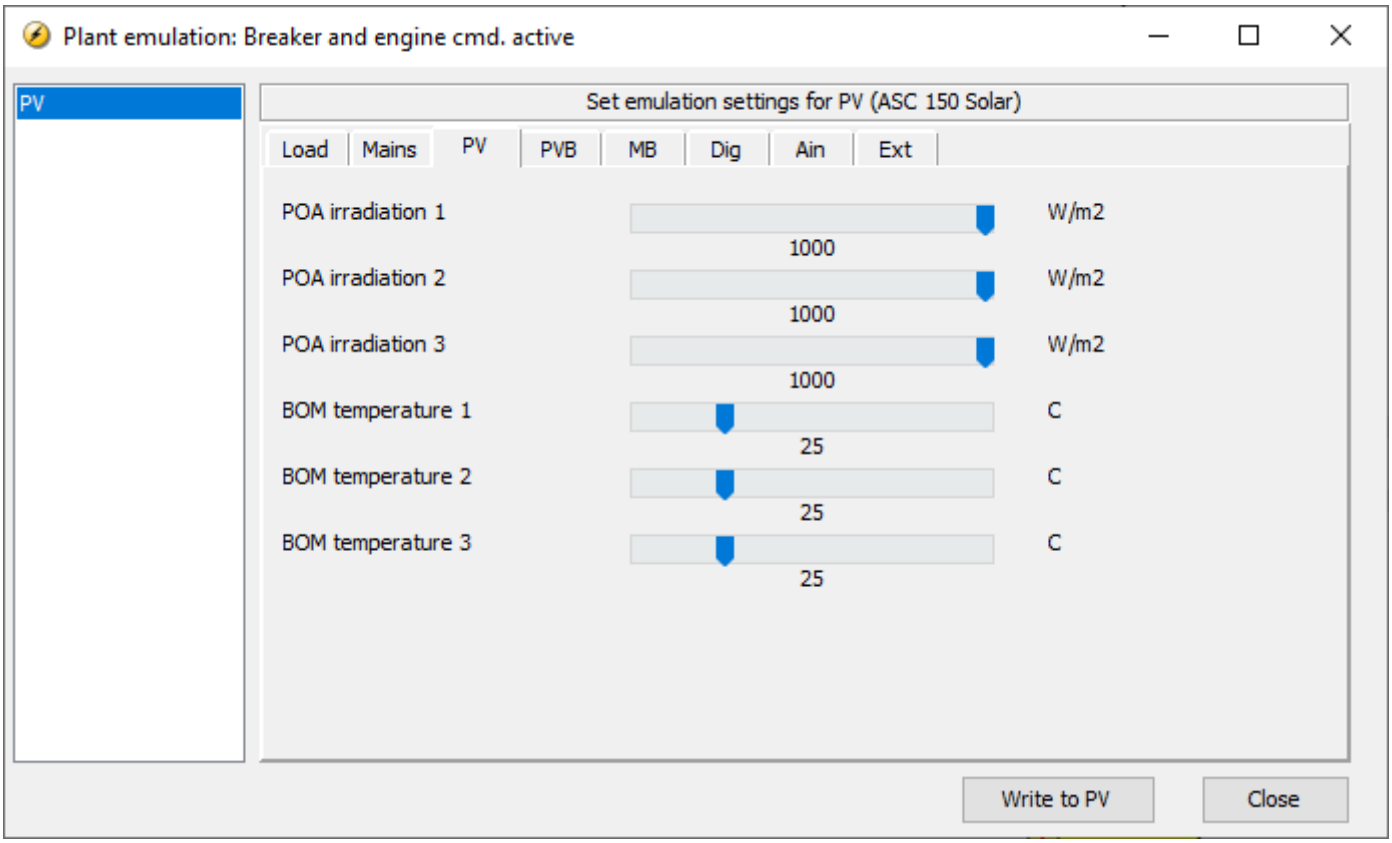
1. Under *Application configuration*, in *Plant options*, select *Breaker and engine cmd. active* or *Breaker and engine cmd. inactive*.
   - For *Breaker and engine cmd. active*, the controllers activate the relays and try to communicate with the PV. If the controllers are mounted in a real installation, the breakers will open/close and the PV start/stop.
   - The real installation is not affected if *Breaker and engine cmd. inactive* is selected.

   In real installations, emulation can be used during the commissioning. When the commissioning is done, select *Off* for *Application emulation*.




2. Under *Application supervision*, select *Emulation stimuli* to open the *Plant emulation* box. You can adjust a wide range of plant and input settings.



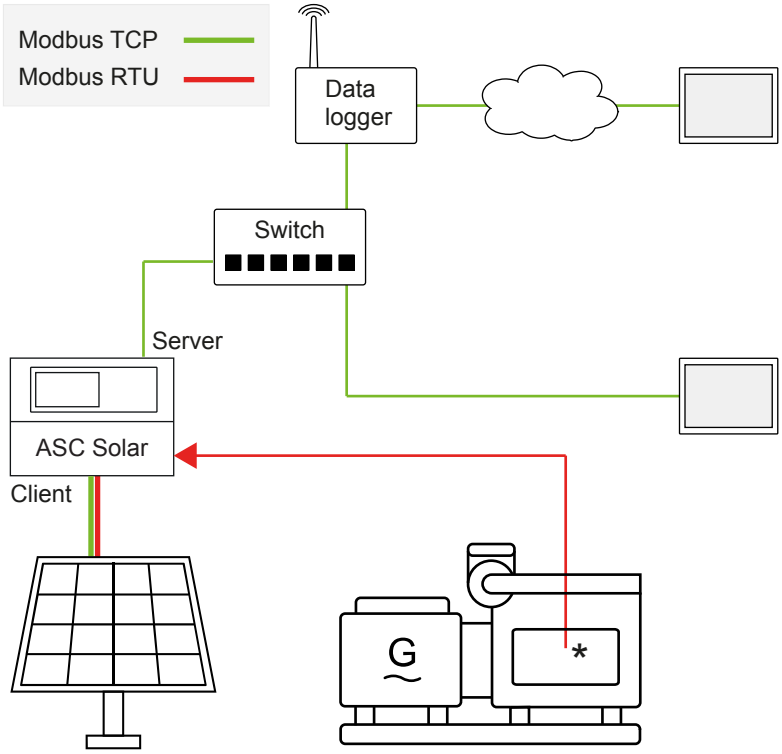



3. You can see the emulated effect on the plant diagram on the *Application supervision* page.

# 3. Communication

## 3.1 ASC Solar communication

**Example of ASC Solar communication for a single controller application**




The ASC can communicate over Modbus as the client and/or server device. The ASC can communicate with the PV system using Modbus TCP or Modbus RTU. The ASC reads from power meters or genset controllers using Modbus RTU.

### 3.1.1 Modbus client and Modbus server

#### ASC as Modbus client

The ASC can communicate with the PV system directly, or through a gateway device. The ASC is the Modbus client and the PV system is the Modbus server. The ASC transmits the references to the PV system using Ethernet (Modbus TCP/IP) or RS-485 (Modbus RTU).

#### ASC as Modbus server

The DEIF Open protocol uses Ethernet (Modbus TCP/IP) or RS-485 (Modbus RTU). The PLC or the Fuel save controller of the PV system is the Modbus client. Using this protocol, the PV system can read the references from the ASC, which is the Modbus server.

Other equipment, for example, a SCADA system or a PLC, can also be the Modbus client and use the ASC Modbus server to read operating data and adjust set points.

**More information**
See **ASC 150 Modbus server tables**, **ASC-4 and ASC 150 Solar Modbus client tables**, and **DEIF hybrid controller compatibility**.

## 3.2 Hardware settings

### 3.2.1 RS-485

**`Communication > RS485`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7553 | Broadcast ID | 0 to 255<br>Not enabled, Enabled | 0<br>Not enabled | **Enabled**: This ID is used as the broadcast ID for write telegrams.<br>**Not enabled**: The controller uses ID 0. |

**`Communication > RS485 > RS485 [1 or 2] > Settings`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7511 or 7521 | Ext. comm. ID [1 or 2] | 1 to 247 | 3 | External communication ID for the Modbus server |
| 7512 or 7522 | Ext. comm.speed[1 or 2] | 9600 Baud<br>19200 Baud<br>38400 Baud<br>115200 Baud | 9600 Baud | Communication speed for RS-485 [1 or 2] |

**`Communication > RS485 > RS485 [1 or 2] > Communication error`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7513 or 7523 | Timer | 1 to 100 s | 10 s | Communication error for RS-485 [1 or 2] |
| 7516 or 7526 | Enable | OFF<br>ON | OFF | |
| 7517 or 7527 | Fail class | Fail classes | Warning | |

### 3.2.2 CAN bus

**`Communication > CAN protocols`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7841 | CAN A protocol | OFF<br>AOP2<br>Ext. Modules DEIF | OFF | **AOP2**: CAN [A or B] is connected to an AOP.<br>**Ext. Module DEIF**: CAN [A or B] is connected to a CIO. |
| 7842 | CAN B protocol | OFF<br>PMS Primary<br>AOP2<br>PMS Secondary<br>Ext. Modules DEIF | PMS Primary | |
| 7843 | VCAN C protocol | OFF<br>PMS Primary<br>PMS Secondary | OFF | See Using Ethernet for power management. |

### 3.2.3 PV - Modbus TCP/IP settings

You can use Ethernet connections for Modbus communication to the PV system. For each ASC, you can configure communication to up to 32 PV inverters.

#### Configure using the display

Configure the PV Modbus TCP/IP settings under `Settings > Modbus TCP/IP setup > PV Modbus TCP/IP`. The settings are explained below.

### Configure using the utility software

On the *Ethernet setting (TCP/IP)* page in the utility software, select *PV - Modbus TCP/IP*, then configure the settings.


### General settings

| Setting | Details |
|---|---|
| Use basic/extended TCP/IP setup | **Basic setup**: The controller uses the settings under *Basic TCP/IP setup*.<br>**Extended setup**: The controller uses the settings under *Extended TCP/IP setup*. |
| Use Tx min. interval | **True**: The controller uses the value in parameter 7563 as the minimum delay between telegrams to the inverters.<br>**False**: The communication is as fast as possible. |

### Basic setup

If the PV inverters have sequential IP addresses and the same Modbus IDs, you can use the basic TCP/IP setup to quickly set up the communication. You only need to configure the first IP address, the number of PV inverters. Configure the Modbus IDs for control and monitoring in parameters 7545 and 7551 respectively.

### Extended setup

There can be up to 32 PV nodes, each with their own IP address. You can configure each node separately. The nodes are independent. You can continue to communicate with the enabled nodes even though some nodes are not enabled.

| Setting | Details |
|---|---|
| Enable | **Enable**: Enable communication with the PV node.<br>**Not enabled**: The controller does not communicate with the PV node. |
| IP address of node | The node IP address. It must be in the same network range as the controller IP. |
| Control type | **TCP**: Slower, but has more error control.<br>**UDP**: Faster, not supported by all inverters. |
| Monitoring | **Enable**: Enable monitoring of all the inverters in the PV node. This is required when power and/or voltage measurements come from the PV inverter(s).<br>**Not enabled**: Faster. |
| Monitor type | **TCP**: Slower, but has more error control.<br>**UDP**: Faster, not supported by all inverters.<br>This does not have to be the same as the control type. |
| Number of PV inverters at node | Use this if there are multiple PV inverters on the same IP address. The PV inverters must have sequential Modbus IDs. |
| Static ctrl. ID | **Enabled** (Static): Telegrams are only written to the control start ID of node.<br>**Not enabled** (Dynamic): Telegrams are written to all the Modbus IDs of node. |

| Setting | Details |
|---|---|
| Control start ID | The control Modbus ID for the first PV inverter in the node. The range is **0 to 247**. |
| Control end ID | Read only. If *Static ctrl. ID* is *Enabled*, then this is the same as the *Control start ID*. |
| Monitor start ID | The monitoring Modbus ID for the first PV inverter in the node. The range is **1 to 247**. |
| Monitor end ID | Read only. This is based on the number of PV inverters at the node plus the monitor start ID. |

### Modbus IP conflict alarm

When the configuration is saved, the controller checks that it is valid. If the configuration is not valid, the controller activates the **MODBUS IP CONFLICT** alarm.

| Alarm value | Details |
|---|---|
| 1 | An IP address conflicts with another address. For example, the same address is used for inverter communication and the weather station. |
| 2 | **Basic setup**: The number of PV nodes makes the last byte of the IP address exceed 255. |
| 3 | An IP address (that is set to use UDP) is the same as the UDP broadcast address on the network. |
| 5 | **Extended setup**: The number of PV inverters connected to the node makes the control ID exceed 247. |
| 6 | **Extended setup**: The number of PV inverters connected to the node makes the monitor ID exceed 247. |
| 7 | **Extended setup** is selected, but no nodes are enabled. |
| 8 | More than the maximum PV inverters (32 or 16) are enabled. |

## 3.2.4 Weather station - Modbus TCP/IP settings

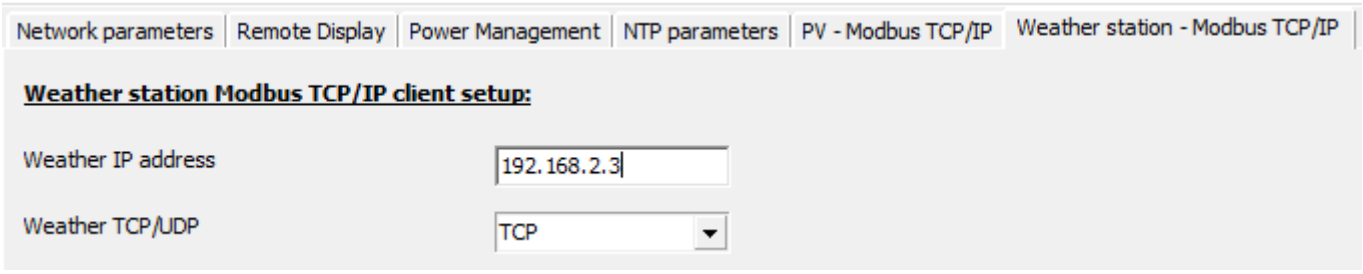
You can use Ethernet connections for Modbus communication to the weather station.

### Configure using the display

Configure the weather station modbus TCP/IP settings under `Settings > Modbus TCP/IP setup > Weath. Modbus TCP/IP`.

### Configure using the utility software

On the *Ethernet setting (TCP/IP)* page in the Utility software, select *Weather station - Modbus TCP/IP*, then configure the settings.




## 3.2.5 Ethernet

**`Communication > Ethernet comm. error`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7901 | Timer | 1 to 100 s | 10 s | Communication error for the Ethernet port. |
| 7904 | Enable | OFF<br>ON | OFF | |
| 7905 | Fail class | Fail classes | Warning | |

## 3.3 Protocol parameters

### 3.3.1 PV parameters

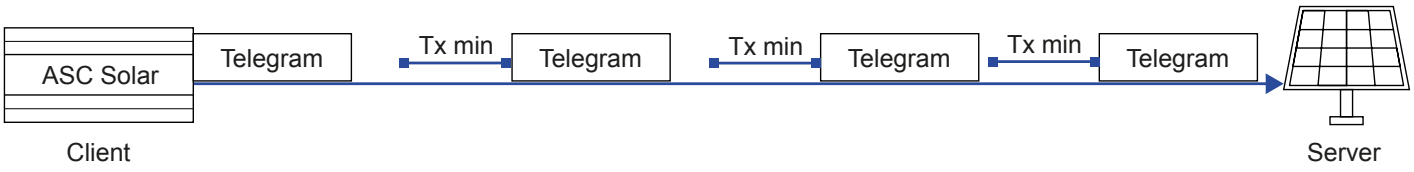
**Communication > PV**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7541 | PV comm. intf. | Modbus RTU client 1<br>Modbus RTU client 2<br>Modbus TCP/IP client | Modbus RTU client 1 | Select the PV communication interface. |
| 7545 | PV comm. ID | 0 to 247 | 3 | The ID given to the PV system to receive and transmit data. |
| 7551 | Mon. comm. ID | 1 to 247 | 3 | The lowest ID of the inverters with PV monitoring. |
| 7561 | PV protocol | **See DEIF Hybrid controller compatibility** | Off | Select the protocol that matches your PV system. If the PV system is not in the list, select Off. Additional protocols may be available. Contact DEIF for details. |
| 7562 | Tx write type | Unicast<br>Broadcast | Unicast | Only affects protocols where the ASC is the Modbus client. |
| 7563 | Tx min. interval | 0.1 to 10 s | 0.5 s | The time that the controller waits (after receiving a telegram) before it sends the next telegram. See the diagram below. This only affects protocols where the ASC is the Modbus client. |
| 7564 | Tx write fnc. | Single register 0×06<br>Multiple register 0×10 | Multiple register 0×10 | Select whether write commands use single register write (0×06) or multiple register write (0×10). Depending on the protocol, using multiple register write (0×10) may be faster (fewer telegrams needed). However, some inverters only support 0×06. This only affects protocols where the ASC is the Modbus client. |
| 7565 | PV monitoring | 1 to 32 | 1 | Enable PV monitoring for RTU communication, and select the number of inverters to monitor.<br><br>For TCP/IP communication, enable PV monitoring from the utility software, *Ethernet setting (TCP/IP) > PV - Modbus TCP/IP*. |
| 7570 | PV comm. error | 0 to 100 s | 3 s, Warning | If enabled, this alarm activates when there is no communication from the PV. |
| 7580 | PV warning | 0 to 100 s | 0 s, Warning | If enabled, this alarm activates when a warning alarm is present on the PV. |
| 7590 | PV shutdown | 0 to 100 s | 0 s, Shutdown | If enabled, this alarm activates when there is a shutdown alarm present on the PV. |
| 7600 | PV monitoring err. | 0 to 100 s | 3 s, Warning | If enabled, this alarm activates when there is no communication with one or more of the monitored inverters. |

**NOTE** The ASC detects communication failure if the PV does not respond to telegrams. The ASC does not use a heartbeat.

#### Tx min interval

Some inverters cannot receive information fast enough. For example, some inverters can accept telegrams every 100 ms, while others need 500 ms.




You can also configure these settings from the display, under `Settings > Communication > PV`

### 3.3.2 Weather parameters

**`Communication > Weather station`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7542 | Weather intf. | Modbus RTU client 1<br>Modbus RTU client 2<br>Modbus TCP/IP client | Modbus RTU client 1 | Select the weather communication interface. |
| 7660 | Weatherstation comm | 1 to 247 | 3 | The ID given to the weather station to transmit data. |
| 7661 | Weather protocol | **See DEIF Hybrid controller compatibility** | Off | Select the protocol that matches your weather station. If the weather station is not in the list, select Off. Additional protocols may be available. Contact DEIF for details. |
| 7670 | Weather comm.err | 0 to 100 s | 3 s, Warning | If enabled, this alarm activates when there is no communication from the weather station. |

You can also configure these settings from the display, under `Settings > Communication > Weather station`

### 3.3.3 Power meter parameters

**`Communication > Power meter`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7544 | Meter comm. intf. | Modbus RTU client 1<br>Modbus RTU client 2 | Modbus RTU client 1 | Select the power meter communication interface. |
| 7761 | Pow. met. Tx min int | 0.1 to 10 s | 0.5 s | Minimum time between ASC telegrams to the power meters. |

These parameters are used for all the power meters connected to the controller.

**More information**
See **Power measurements and connection status** for the genset meter and mains meter parameters.

**More information**
See **Solar controller functions** for the PV meter parameters.

## 3.4 Troubleshooting

You can use the display to check whether the communication is connected for each external device. You can also see communication details from the display.

Under `Service view > Communication analysis`, you can see:

- Modbus client RTU port 1

- Modbus client RTU port 2
- Modbus client TCP/IP
- TCP/UDP multi node status

For each selection, you can see configuration and operating details. For example, for *Modbus client TCP/IP*, you can see:

- Details for each connected device (use *<Prev.* and *Next>* to navigate)
  - IDs, Rx and Tx info, IP address, connected (true or false), and so on.

### 3.4.1 TCP/UDP multi node status

On the display, you can see the status under `Service view > Communication analysis > TCP/UDP multi node status`.

As the example shows, you can see the status and IP address for each of the PV inverters (up to 32) connected to the controller using TCP/IP. You can also see the status and IP address of the weather station.

**Example of multi node status**

```
PV NOT READY
Multi node status
Node  1: NOT CONNECTED
          192.168.2.75
Weather: NOT CONNECTED
           192.168.2.7
```

## 3.5 Remote monitoring

### 3.5.1 Monitoring solutions

A range of remote monitoring solutions is possible.

For an existing system, you can use the Ethernet TCP/IP connection or one of the RS-485 ports of the ASC. All data in the Modbus protocol can then be polled from the device. The ASC acts as a server device in the system. For example, this solution can be used in HMI or SCADA systems.

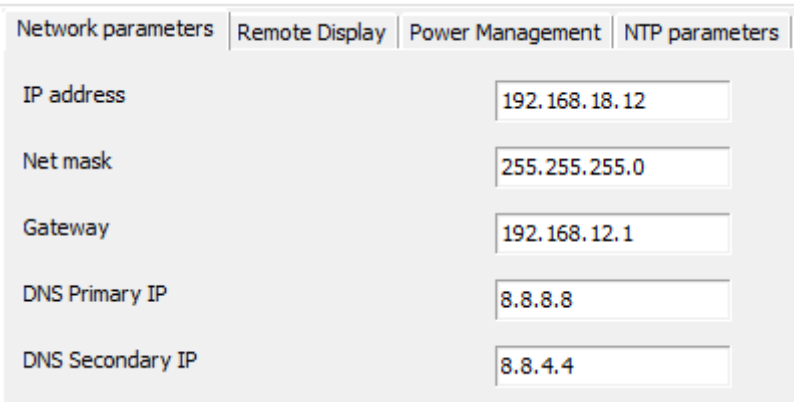
Another solution is to install a gateway, giving access to a cloud-based database. This gives an accessible front portal. Live data and log data are sent to a server (depending on the solution). **Insight** is DEIF's ready-made solution for remote monitoring.

Alternatively, the gateway can work as an actual remote gateway. In this solution, the DEIF PC utility software can be accessed with all the control and monitoring functions needed (control can be switched off, or made user level-dependent).

### 3.5.2 DEIF Modbus server connection

The controller's Ethernet connection is used for remote or local monitoring.

You can use the utility software to see (or set up) the controller. On *the Ethernet setting (TCP/IP)* page, open *Network parameters*.




Alternatively, use the display: `Settings > Communication > Ethernet setup`

### 3.5.3 DEIF remote monitoring

The DEIF remote monitoring system is a hybrid monitoring system that provides PV values and other relevant plant values. Values, alarms and logs can be seen from both the ASC and the PV system. Alternatively, all the values, alarms and logs can be seen from the ASC.

### 3.5.4 PV values

The controller includes a generic Modbus client that can access various values from the supported PV system. The available values depend on the PV system. For compatible systems, see **DEIF hybrid controller compatibility**.

The **ASC Modbus client tables** show which values are supported. Available PV data can be read from the ASC Modbus server using the TCP/IP port.

# 4. Single-controller applications

## 4.1 Single controller

The ASC can operate as a single controller, that is, without power management communication to other DEIF controllers. Single controllers are particularly useful for brownfield applications (the ASC is installed in an existing plant). Single controllers can also be used in greenfield applications.

In a single-controller application, the ASC Solar controller operates as the only DEIF controller in the system. The ASC is the link to the inverter.

To control the PV power set point (optional), the single controller must get the power measurements and breaker positions for the power sources in the rest of the application. You can use transducers, or the ASC can read Modbus values from power meters, external genset controllers, or a PLC.

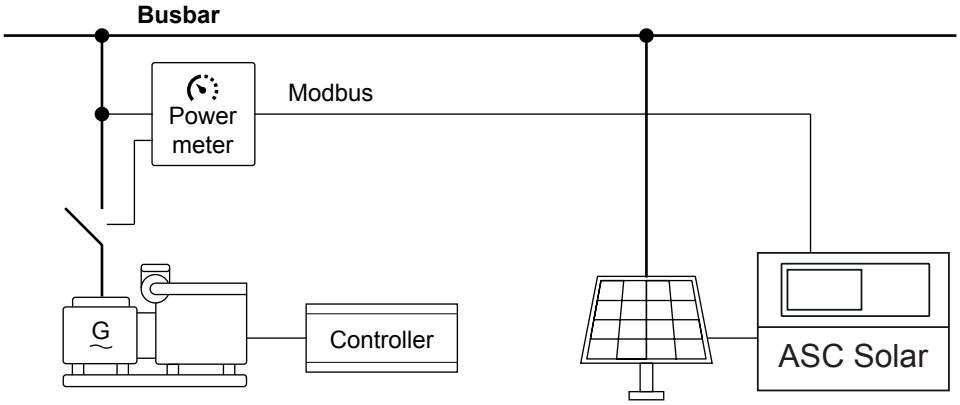
The ASC can be used in single controller applications that are off-grid, grid-tied, or a combination. There is a maximum of 16 grid connections, and there can be up to 16 gensets. If there is more than 1 grid connection, the ASC interacts with the grid connections as if there was only 1 grid connection.

## 4.2 Modes of operation

### Off-grid applications

In a single controller off-grid application, the ASC can only use island operation.

### Single controller off-grid PV application

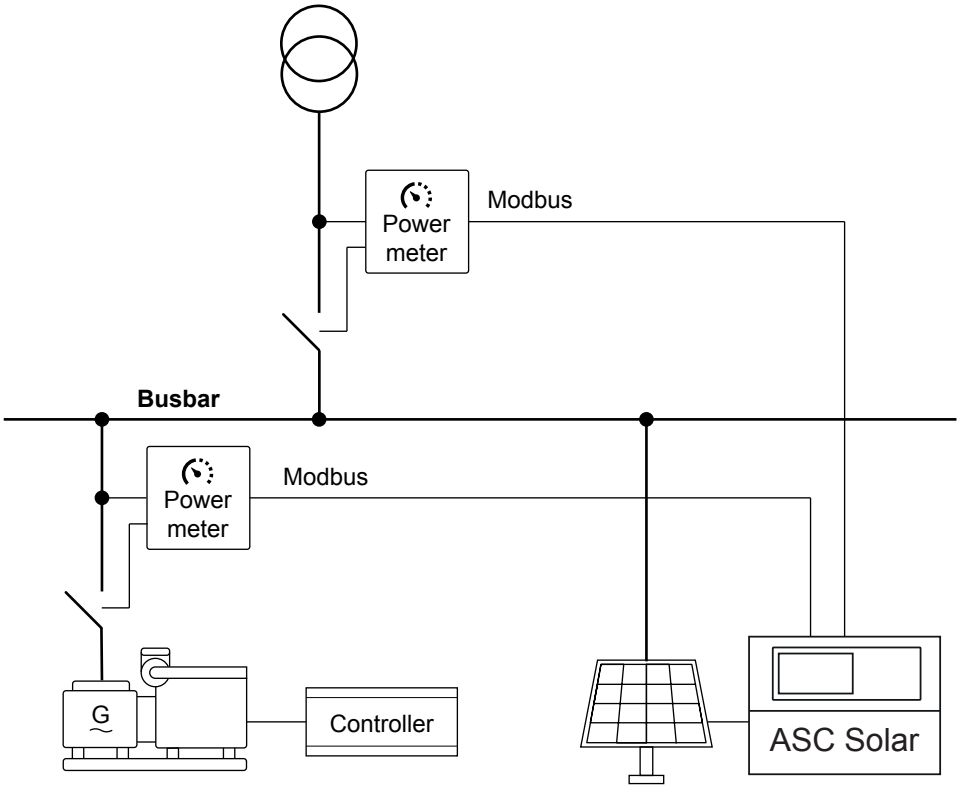



### Grid-tied applications

In a single-controller grid-tied application, the ASC can have the following modes of operation:

- MPE (Mains Power Export)
- Peak shaving
- Fixed power

**Single-controller grid-tied PV application**




**NOTE** Gensets are not required in a grid-tied application.

### Combination applications

In a single-controller combination application, the ASC can have the following modes of operation:

- Mains breaker open (that is, off-grid):
  - Island operation
- Mains breaker closed (that is, grid-tied):
  - MPE (Mains Power Export)
  - Peak shaving
  - Fixed power

## 4.3 Setup of a single controller application

In a single controller application, the ASC 150 Solar can control a system of PV inverters, one PV breaker (PVB), and one mains breaker (MB).

You can use the display or the utility software to set up a single controller application.

### 4.3.1 Application setup using the display

**`Parameters > Functions > Quick setup`**

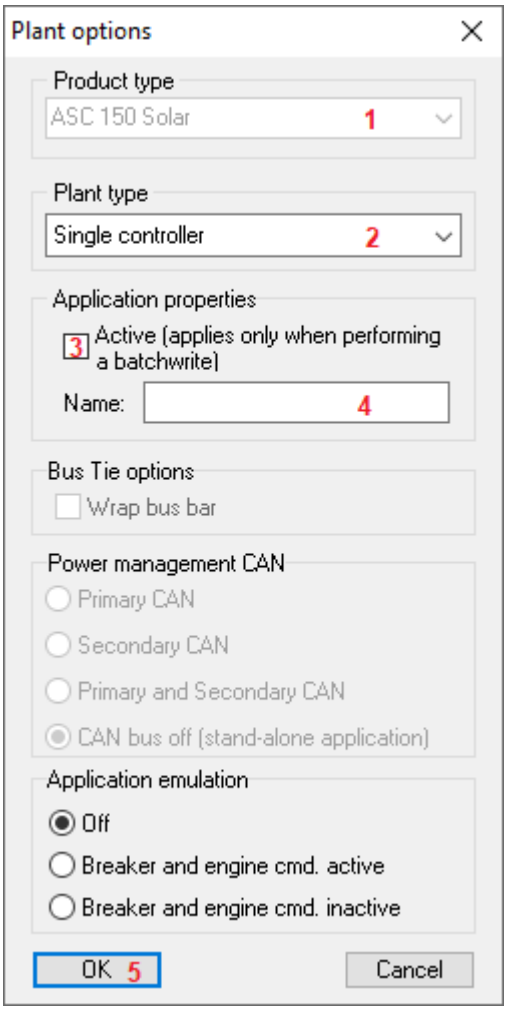
| Name | Range | Default | Details |
|---|---|---|---|
| Mode | Off<br>Setup stand alone<br>Setup plant<br>Adapt plant | Off | Select **Setup stand alone**. |
| CAN line | Off<br>CAN PM Primary<br>CAN PM Secondary | Off | Select **Off**. |

| Name | Range | Default | Details |
|---|---|---|---|
| MB | Pulse<br>No breaker<br>EXT/ATS<br>Continuous<br>Compact | Pulse | Select the mains breaker type. |
| PVB | Pulse<br>No breaker<br>External<br>Continuous<br>Compact | Pulse | Select the PV breaker type. |
| Mains | Mains present<br>No mains present | Mains present | Select whether there is a mains connection. |
| PV | Single controller<br>Standard | Standard | Select **Single controller**. |

### 4.3.2 Application setup using the utility software

When connected to the controller with the utility software:

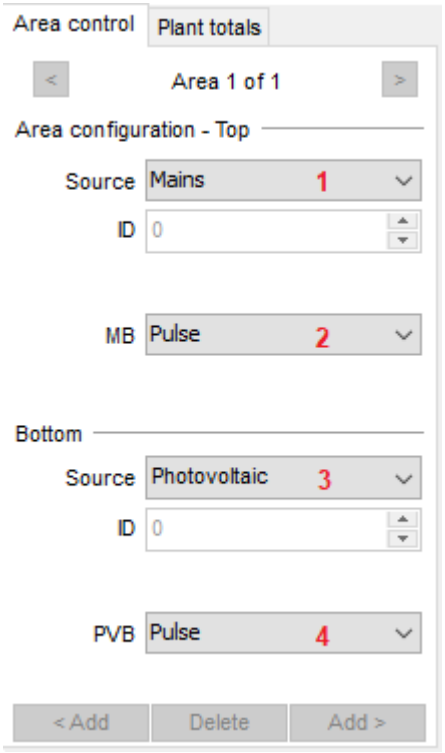
1. Select *Application configuration*
2. Select *New plant configuration*
3. The *Plant options* window opens.




Select the plant options:

1. Select the *Product (controller) type*
   - Greyed out when already connected to a controller.
2. Select the *Plant type*: *Single controller*
3. Select to activate the application when it is written to the controller.
4. Write a name for the application.
5. Select OK to save the application.

**Example**




1. Select one of these types of power source to show in the top area:
   - None
   - Mains
   - Photovoltaic
2. Select the breaker type for the mains breaker:
   - Pulse
   - Continuous NE
   - Compact
   - Ext
   - None
   - Continuous ND
3. Select the power source to show in the bottom area:
   - None
   - Mains
   - Photovoltaic
4. Select the breaker type for the PV breaker:
   - Pulse
   - Ext/ATS no control
   - Continuous NE
   - None

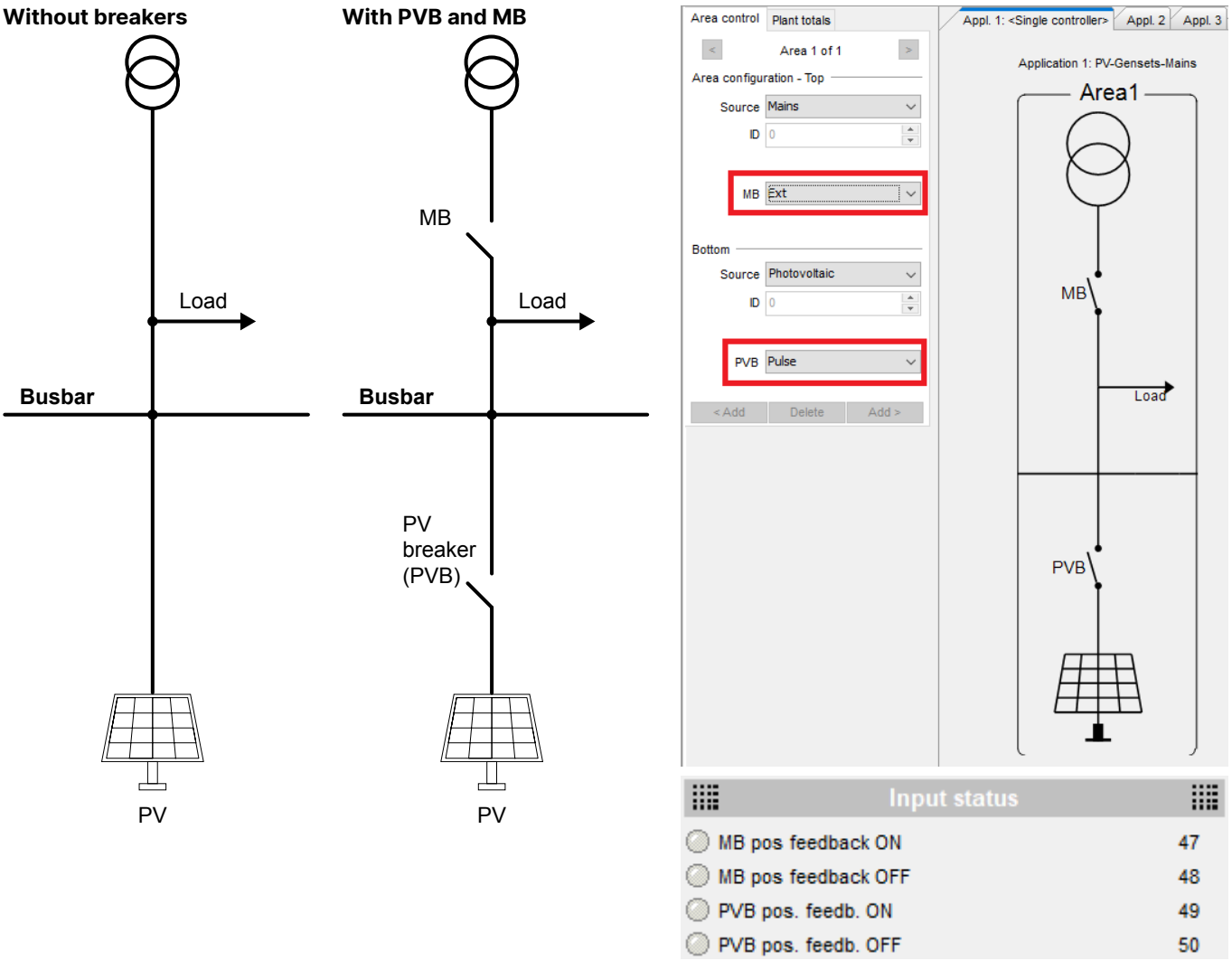
After the application drawing is created, press *Write plant configuration to device* to send the configuration to the connected controller.

## 4.4 Breaker control

In a single controller application, the ASC Solar controller can control a PV breaker and/or mains breaker (optional). If the ASC controls the PVB, it can, for example, protect the generator(s) from reverse power by tripping the PVB.

Use the *Application configuration* page in the utility software to add or remove the breakers to match the application. The controller automatically assigns digital inputs* for the breaker feedbacks.

**NOTE** * To use breaker feedbacks from a mains power meter, you must configure these in M-Logic. See Mains power measurement from power meter communication.




## 4.5 Power measurements and connection status

For a single controller application, the ASC needs the active power from all the other power sources in the system. The reactive power is optional. The ASC also needs the connection status of the other power sources.

There is a range of ways to get this information, using Modbus or analogue transducer signals.

| | Active power (P) | Reactive power (Q) | Connection status |
|---|---|---|---|
| Power meter* | ● | ● | ● |
| External genset controller* | ● | ● | ● |
| DEIF open communication | ● | ● | ● |
| Transducer (Modbus or analogue)* | ● | ● | - |
| ASC 4th current transformer** | ● | ● | - |
| Digital input | - | - | ● |

**NOTE** * Check the compatibility list to make sure that the power meter, external genset controller, or transducer supports all these measurements.

**NOTE** ** Only for a mains connection. The controller uses the single-phase current measurement to calculate the mains power.

## 4.5.1 Power meters and genset controllers

The ASC supports a wide range of power meters, as well as communication with genset controllers from other manufacturers.

**More information**
See the **DEIF hybrid controller compatibility** documents for a list of compatible power meters and genset controllers.

### Connection status

If the power meter/genset controller does not include the connection status, you must configure a digital input.

## 4.5.2 Genset power measurement from power meter communication

For a single controller application, the genset active power and breaker positions must be monitored. Genset reactive power is optional, and is only required if the ASC must control reactive power. The application can include up to 16 gensets. There are a number of ways for the ASC to get the genset power measurements.

Genset power measurement from power meter communication is described here. Note that genset controllers are also used for power meter communication.

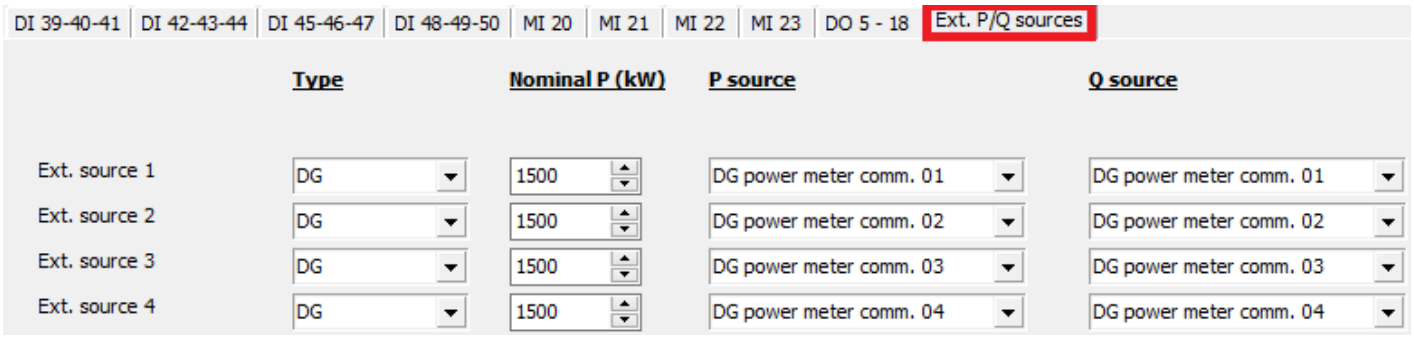
**`Communication > Power meter > DG meter`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7701 | DG meter ID | 1 to 247 | 3 | Select the genset power meter ID. |
| 7721 | DG meter protocol | **See DEIF Hybrid controller compatibility** | Off | Select the protocol that matches your power meter. Additional protocols may be available. Contact DEIF for details. |
| 7722 | DG nbr. nodes | 1 to 16 | 1 | Number of nodes. |
| 7730 | DG meter err. | Fail classes | Warning | If enabled, this alarm activates when there is no communication from the genset power meter. |

You can also configure these settings from the display, under `Settings > Communication > Power meter > DG meter settings`

### Power measurement

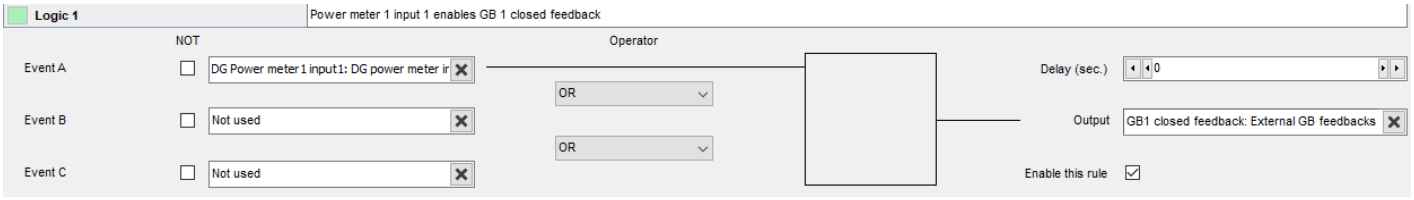
In the utility software, on the *I/O & Hardware* page, select *Ext. P/Q sources*. For up to 16 sources, select the type and nominal power. For each *P source* and *Q source*, select *DG power meter comm. xx*.




### Gensets connected

The ASC also needs to know which gensets are connected. For some power meter protocols, this is included. See the **DEIF hybrid controller compatibility** document.

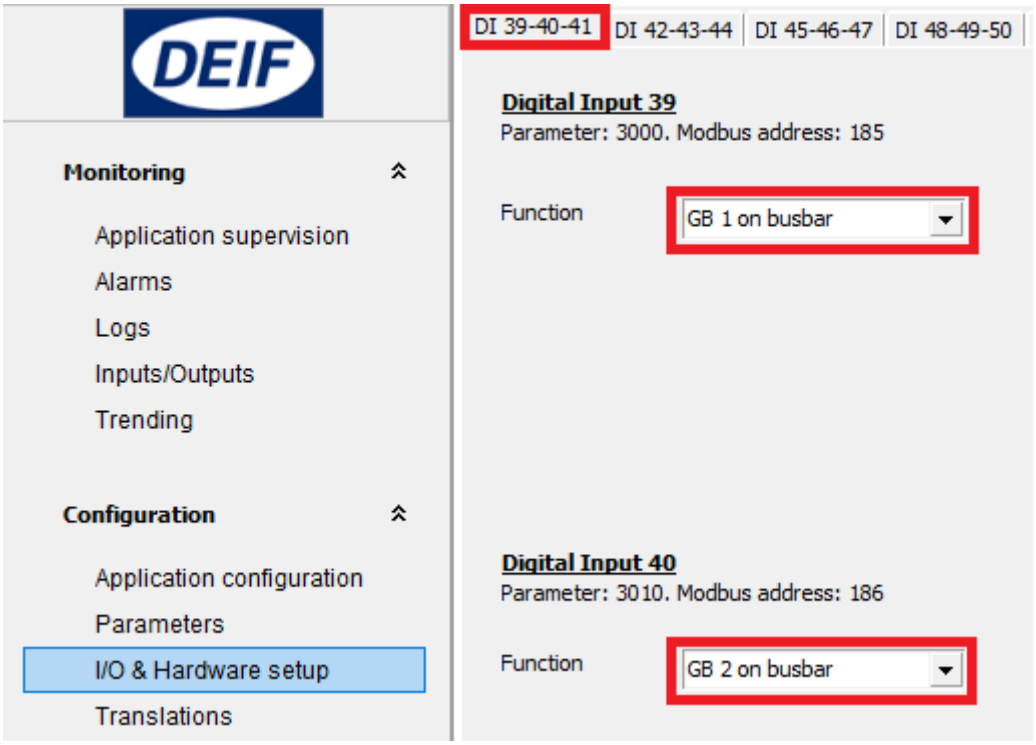
### Genset breaker status from the power meter protocol




If the genset breaker status is included in the power meter protocol, configure M-Logic to connect the output from the power meter to enable the corresponding genset.

For DEIF genset controllers, Input 1 is always for GB closed. Input 3 is always for GB open.

### Genset breaker status from digital inputs




If the genset breaker status is not included in the power meter protocol, configure a digital input for each breaker.

## 4.5.3 Mains power measurement from power meter communication

For a single controller application, the mains active power is needed. Mains reactive power is optional. There are a number of ways for the ASC to get the mains power measurements. Mains power measurement from power meter communication is described here.

If a mains breaker is included in the application drawing, the mains breaker position must be monitored. A single controller can control the breaker for one mains connection. Alternatively, the single controller can be used with up to 16 mains connections (no breaker control).

### Operating modes and power measurement

For mains power export (MPE) and peak shaving operation, the mains power must be measured.

For fixed power operation, you must configure the mains power measurement. However, the actual mains power measurement is not required. If the mains power measurement is not connected, the ASC shows 0 kW for the mains power.

**Communication > Power meter > Mains meter**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7703 | Mains meter ID | 1 to 247 | 3 | Select the mains power meter ID. |
| 7725 | Mains meter protocol | **See DEIF Hybrid controller compatibility** | Off | Select the protocol that matches your power meter. Additional protocols may be available. Contact DEIF for details. |
| 7726 | Mains nbr. nodes | 1 to 16* | 1 | Number of nodes. |
| 7750 | Mains meter err. | Fail classes | Warning | If enabled, this alarm activates when there is no communication from the mains power meter. |

**NOTE** * If there is more than one mains node, you must have *Premium* software.

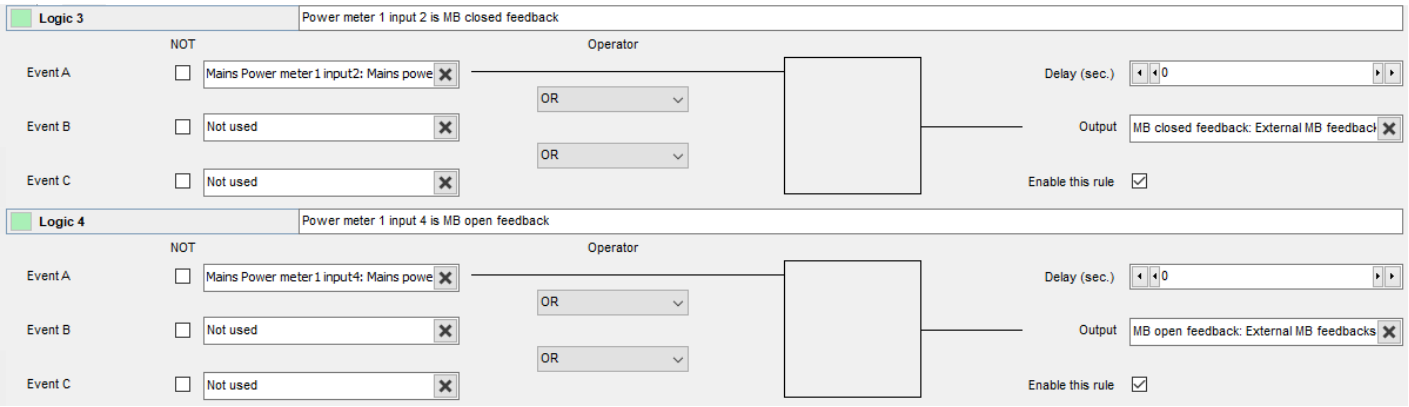
You can also configure these settings from the display, under `Settings > Communication > Power meter > Mains meter settings`

**NOTE** To use a mains meter for active power, select *Power meter comm.* in parameter 7005. For reactive power, select *Power meter comm.* in parameter 7009.

### Mains connection

If a mains breaker is included in the application drawing, the mains breaker position must be monitored. For some power meter protocols, this is included. See the **DEIF hybrid controller compatibility** document.

### Mains breaker status from the power meter protocol




If the mains breaker status is included in the power meter protocol, configure M-Logic to connect the output from the power meter to mains breaker feedbacks.

For DEIF mains controllers, Power meter input 2 is always used for MB closed. Power meter input 4 is always used for MB open.

### Mains breaker status from digital inputs

If the mains breaker status is not included in the power meter protocol, you can configure a digital input for each breaker feedback. Configure the inputs in the utility software, under *I/O & Hardware setup*.

You must use digital input 47 for *MB position on* and digital input 48 for *MB position off*.

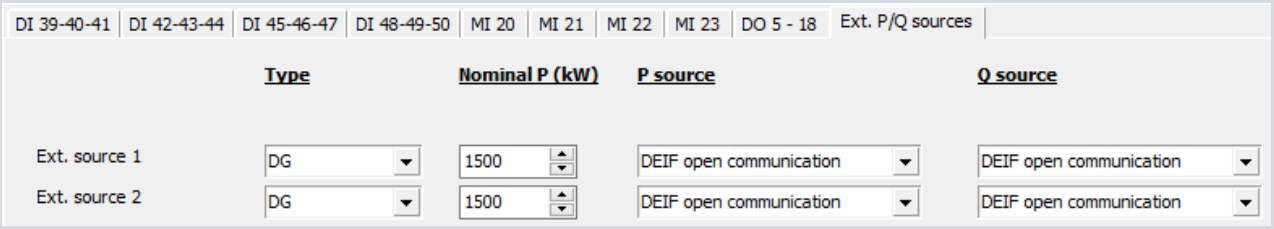
## 4.5.4 DEIF open communication

An external system (for example, a PLC) can use the ASC Modbus server to send the ASC the power measurements and connection status.

**Example for two gensets**

The application consists of two gensets (controlled by a PLC) and a PV system (controlled by a single ASC Solar controller).

1. In the utility software, on the *I/O & Hardware setup* page, under *Ext. P&Q sources*, configure two external sources. For *P source* and *Q source*, select *DEIF open communication*.




2. Configure the PLC to connect to the ASC Modbus server.
3. Configure the PLC to use the following:
   - *Genset 1 Active power*: PLC address 446151 (Modbus address 46150, function code 03)
   - *Genset 2 Active power*: PLC address 446152 (Modbus address 46151, function code 03)
   - *Genset 1 Reactive power*: PLC address 446167 (Modbus address 46166, function code 03)
   - *Genset 2 Reactive power*: PLC address 446168 (Modbus address 46167, function code 03)
   - *Genset breaker 1 Closed*: PLC address 446185, bit 0 (Modbus address 46184, bit 0, function code 03)
   - *Genset breaker 2 Closed*: PLC address 446185, bit 1 (Modbus address 46184, bit 1, function code 03)

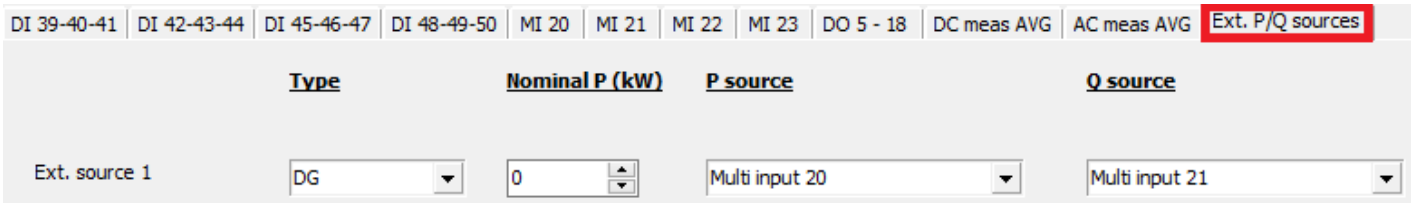
## 4.5.5 Measurement transducers for genset power

The genset power (active and reactive) can be measured with transducers, and received by ASC analogue inputs, multi inputs, or a CIO 308.

### Selecting the measurement transducers

In the utility software, under *I/O & Hardware setup*, *Ext. P/Q sources*, select the inputs that the transducers are connected to.

In the following example, the *DG 1* power transducer is connected to Multi input 20. The reactive power transducer is connected to Multi input 21.




### Configuring the multi-input

For a multi-input, under *I/O & Hardware setup*, select the multi-input. Select the input type and scaling (for example, for active power, this can be *kW 1/1* or *kW 1/10*). Configure the curve.

### Connection status

Transducers always also need a digital input for connection status. If the power meter/genset controller does not include the connection status, you must configure a digital input.

## 4.5.6 Measurement transducers for mains power

The mains power (active and reactive) can be measured with transducers, and received by ASC analogue inputs, multi inputs, or a CIO 308.

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7003 | Transducer range max | 0 to 20000 kW | 0 kW | If used, configure the mains power transducer range. |
| 7004 | Transducer range min | -20000 to 0 kW | 0 kW | If used, configure the mains power transducer range. |
| 7005 | Mains power measure | Multi input 20 (transducer)<br>4th CT power meas (internal)<br>DEIF open communication<br>Power meter comm. | 4th CT power meas (internal) | Select the mains power measurement. |
| 7007 | Transd. range max Q | -20000 to 20000 kvar | 0 kvar | If used, configure the mains reactive power transducer range. |
| 7008 | Transd. range min Q | -20000 to 20000 kvar | 0 kvar | If used, configure the mains reactive power transducer range. |
| 7009 | Mains Q measure | Multi input 22 (transducer)<br>4th CT power meas (internal)<br>DEIF open communication<br>Power meter comm. | 4th CT power meas (internal) | Select the mains reactive power measurement. |

#### Configuring the multi-input

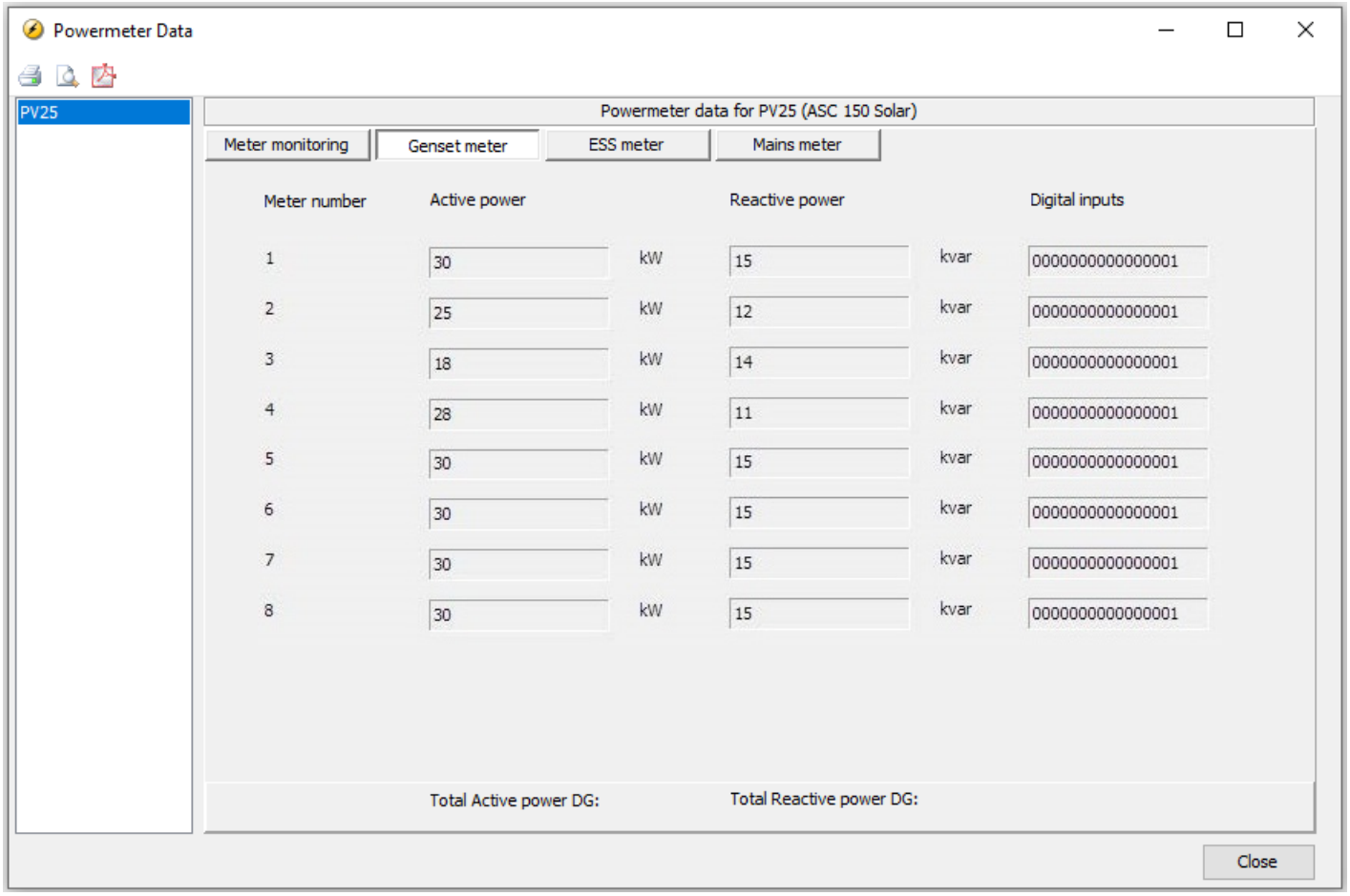
For a multi-input, under *I/O & Hardware setup*, select the multi-input. Select the input type and scaling (for example, for active power, this can be *kW 1/1* or *kW 1/10*). Configure the curve.

#### Connection status

When using transducers, you always also need a digital input for the connection status.

### 4.5.7 Power meter monitoring

In the utility software, under *Application supervision*, select *Power meter data*  to open the *Power meter data* window.




*Digital inputs* shows the breaker status.

For the *DEIF Genset Control* protocol, for genset breakers:

- **...0001**: The breaker is closed.
- **...0100**: The breaker is open.

For mains breakers (*AGC Genset single controller*, or *AGC Mains*):

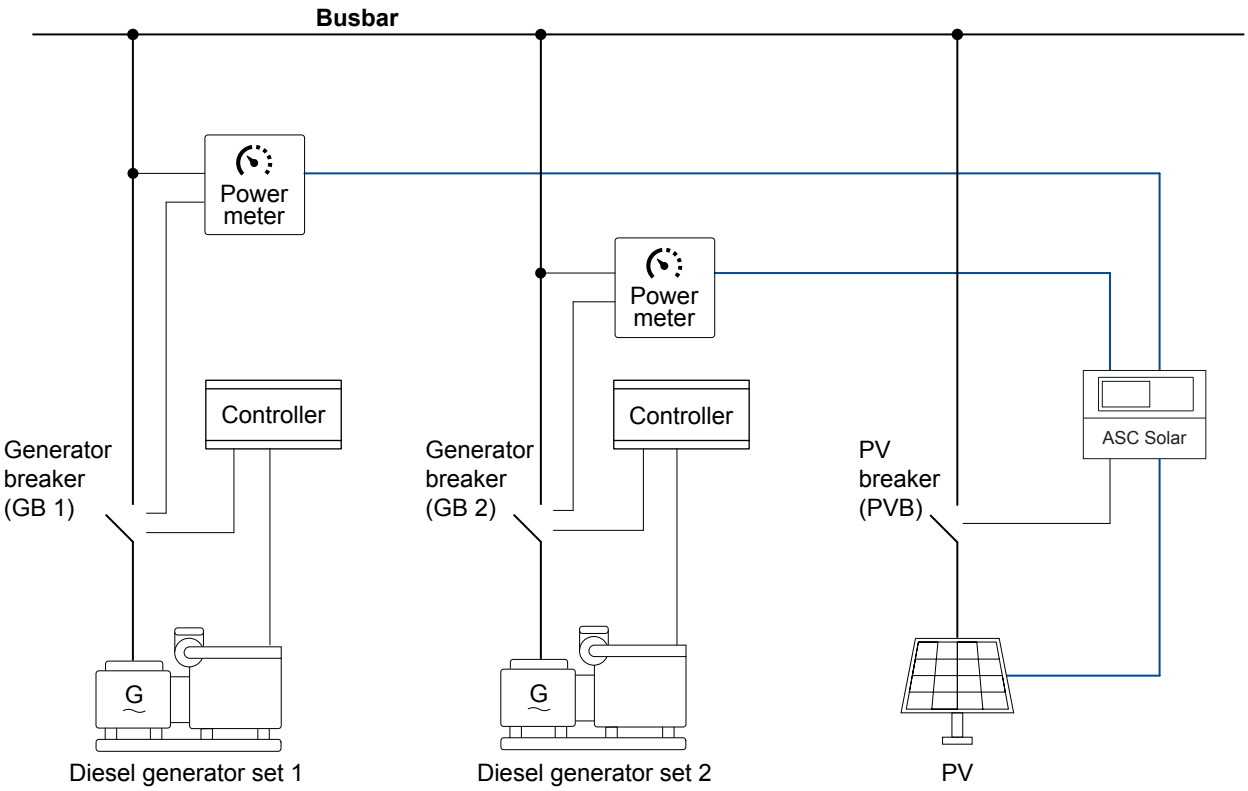
- **...0010**: The breaker is closed.
- **...1000**: The breaker is open.

## 4.6 Genset applications

### 4.6.1 Gensets and single solar controller (off-grid)

A single controller application is used if the gensets already have a control system (shown by *Controller* in the example).

The ASC requires the GB breaker feedbacks (open or closed), and the active power from the gensets. The reactive power is optional. See **Power measurements and connection status** for the range of ways to get this information.

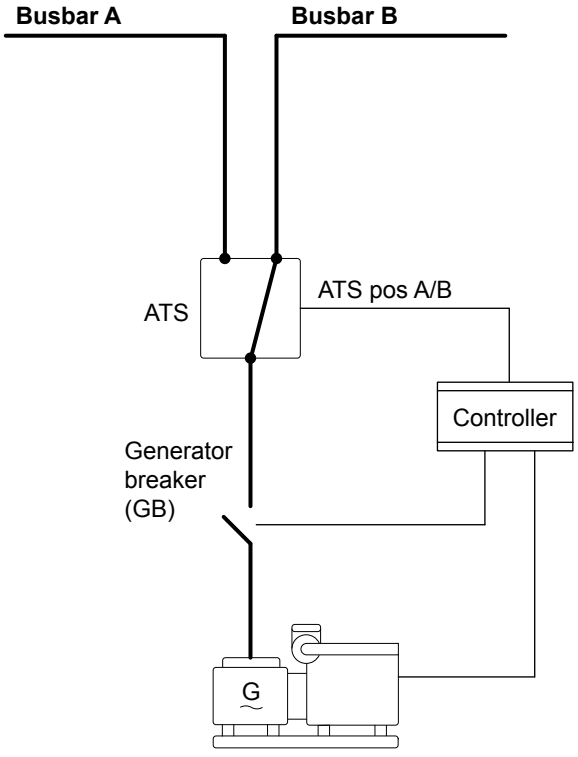



**Setting in ASC**

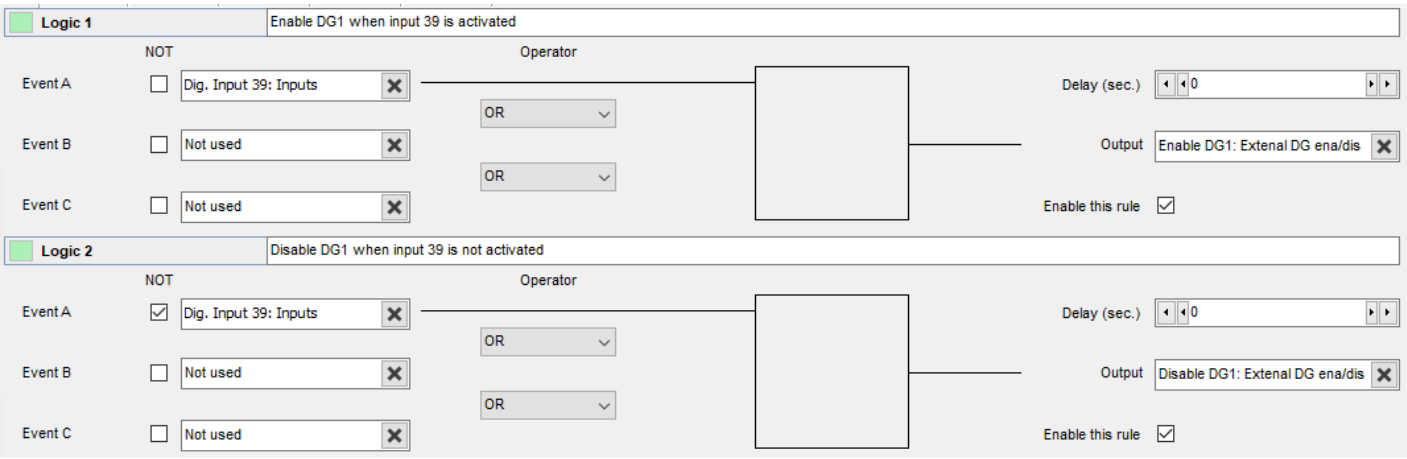
| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Island operation |

## 4.6.2 Split busbar

In a single controller application, the generators can be enabled and disabled. This is useful if the generators can connect to two busbars.



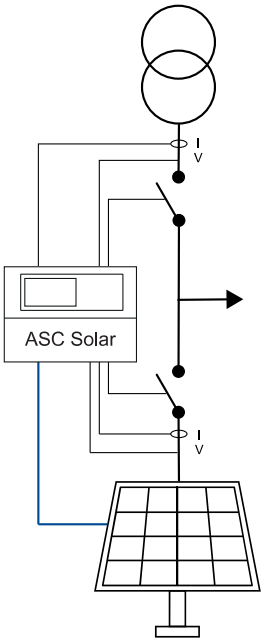
In the ASC in M-Logic, you can program whether the genset is connected to the PV side (enabled) or connected to the side without the PV (disabled):




## 4.7 Mains applications

### 4.7.1 Mains and single solar controller (grid-tied)

This application is used to operate parallel to mains when no AGC mains is installed. The ASC needs inputs from the MB feedback (open/closed) and the active power from the mains (export or import). The reactive power is optional. See **Power measurements and connection status** for the range of ways to get this information.




#### Setting in ASC

**`Basic settings > Application type > Plant type > Plant mode`**

| Parameter | Name | Range |
|---|---|---|
| 6071 | Operating mode | Fixed power<br>Peak shaving<br>Main power export |

### 4.7.2 Mains power measurement

For a single controller application, the mains active power (imported or exported) and breaker position must be measured. The reactive power is optional.

**`Basic settings > Measurement setup > Wiring connection > Mains power measure`**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7005 | Mains power measure | Multi input 20 (transducer)<br>4th CT power meas (internal)<br>DEIF open communication<br>Power meter communication | 4th CT power meas (internal) | Select the measurement for the mains active power. |
| 7009 | Mains Q measure | Multi input 22 (transducer)<br>4th CT power meas (internal)<br>DEIF open communication<br>Power meter communication | 4th CT power meas (internal) | Select the measurement for the mains reactive power. |

**More information**
See **Power measurements and connection status** for the range of ways to get this information.

### 4.7.3 Mains breaker handling

The ASC can control one mains breaker in a single controller application. However, if there is more than one mains connection, the ASC cannot control a mains breaker.

#### Mains breaker rule

In a single controller application, the ASC does not synchronise the mains breaker.

The controller can only close the mains breaker when there is no voltage or frequency on the busbar.

- For safety, the ASC checks that there is no voltage or frequency on the busbar. For example, voltage could come from externally controlled gensets.
- To confirm that there is no voltage, the ASC closes the PVB. The ASC can then use its AC measurements to check the busbar voltage and frequency.
- Once the ASC has confirmed that there is no voltage or frequency on the busbar, it can close the mains breaker.

#### Mains failure

You can configure the mains failure detection voltages (parameter 7063, 7064), frequencies (parameter 7073, 7074) and hysteresis (parameters 7091, 7092, 7093, 7094).

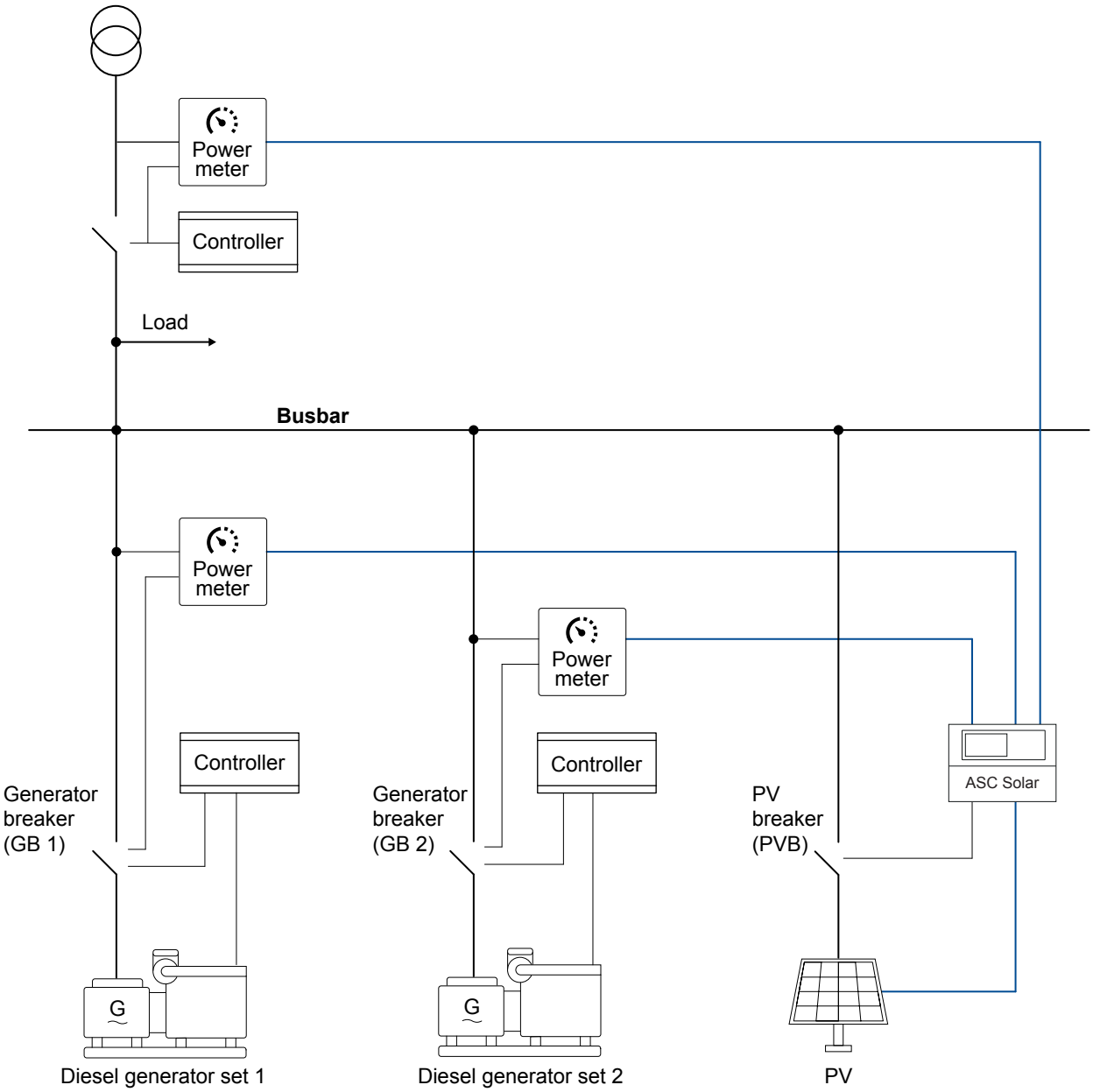
There are mains failure voltage (parameter 7061) and frequency (parameter 7071) alarms.

If the ASC 150 Solar must automatically open the mains breaker during a mains failure, you must enable mode shift (parameter 7081).

## 4.8 Combination (off-grid + grid-tied)

This application is used when a single controller application is used in both grid-tied and off-grid (islanded) modes. In this example, third party controllers are installed (shown by *Controller* in the diagram).

The ASC needs the mains power and reactive power, and the gensets power and reactive power. The ASC also needs feedback from the breakers (GBs and MB). See **Power measurements and connection status** for the range of ways to get this information.




### Setting in ASC

**`Basic settings > Application type > Plant type > Plant mode`**

| Parameter | Name | Range |
|---|---|---|
| 6071 | Operating mode | Island operation<br>Fixed power<br>Peak shaving<br>Mains power export |

### From grid-tied to off-grid

If *Mode shift on* is selected (*Modeshift*, parameter 7081), then the controller automatically changes the operating mode. When the mains breaker is opened, the mode changes to *Island operation*.

**NOTE** You can use M-Logic to set parameter 7081.

# 5. Energy management systems

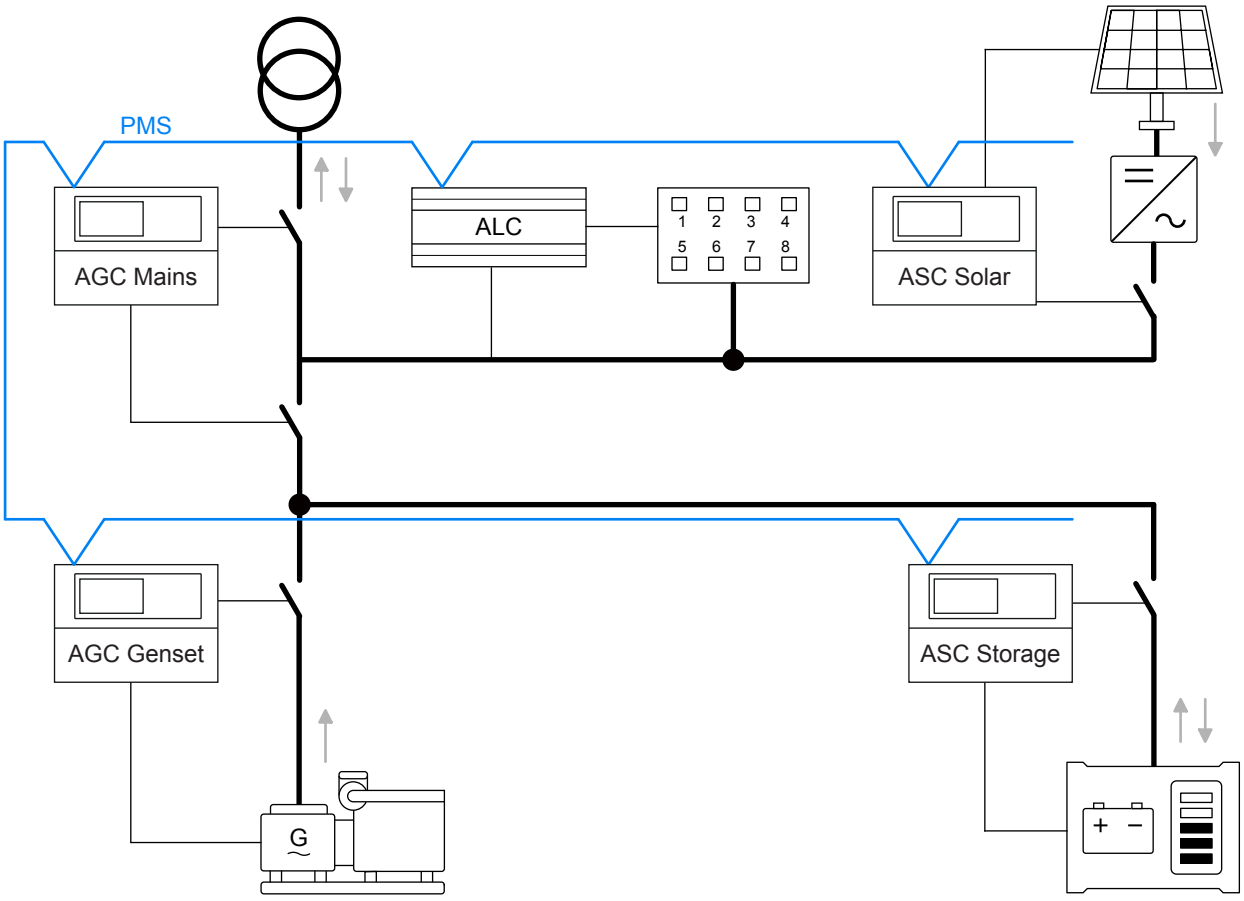
## 5.1 Overview

ASC Solar, ASC Storage, ASC Battery, AGC Genset, AGC Mains and ALC-4 can work together as an energy management system. The application configuration and controller parameters allow a wide range of applications.

The controllers use CAN bus to share the information needed for energy management. In AGC-4 Mk II and AGC-4, option G5 is required for energy management.

**Quick overview**
See DEIF - Hybrid Solutions for a quick introduction to energy management systems.

**Example of energy management system**




**Controller functions**

| Controller | Controls | Functions |
|---|---|---|
| ASC Solar | PV | • P and Q control<br>• Control photovoltaic (PV) breaker*<br>• Inverter communication |
| ASC Storage/Battery | ESS | • P-Q control, V-f control, and droop (VSG)<br>• Energy storage system charging and discharging<br>• Control energy storage system (ESS) breaker*<br>• Energy storage system communication |
| AGC Genset | Genset | • Governor control |

| Controller | Controls | Functions |
|---|---|---|
| | | • AVR control<br>• Control genset breaker<br>• ECU communication |
| AGC Mains | Mains connection | • Power import or export<br>• Control mains breaker*, tie breaker*<br>• Synchronise the plant to the mains |
| ALC | Load groups | • Connect and disconnect load groups<br>• Manage heavy consumer requests |

**NOTE** * Optional.

## 5.2 Power management applications

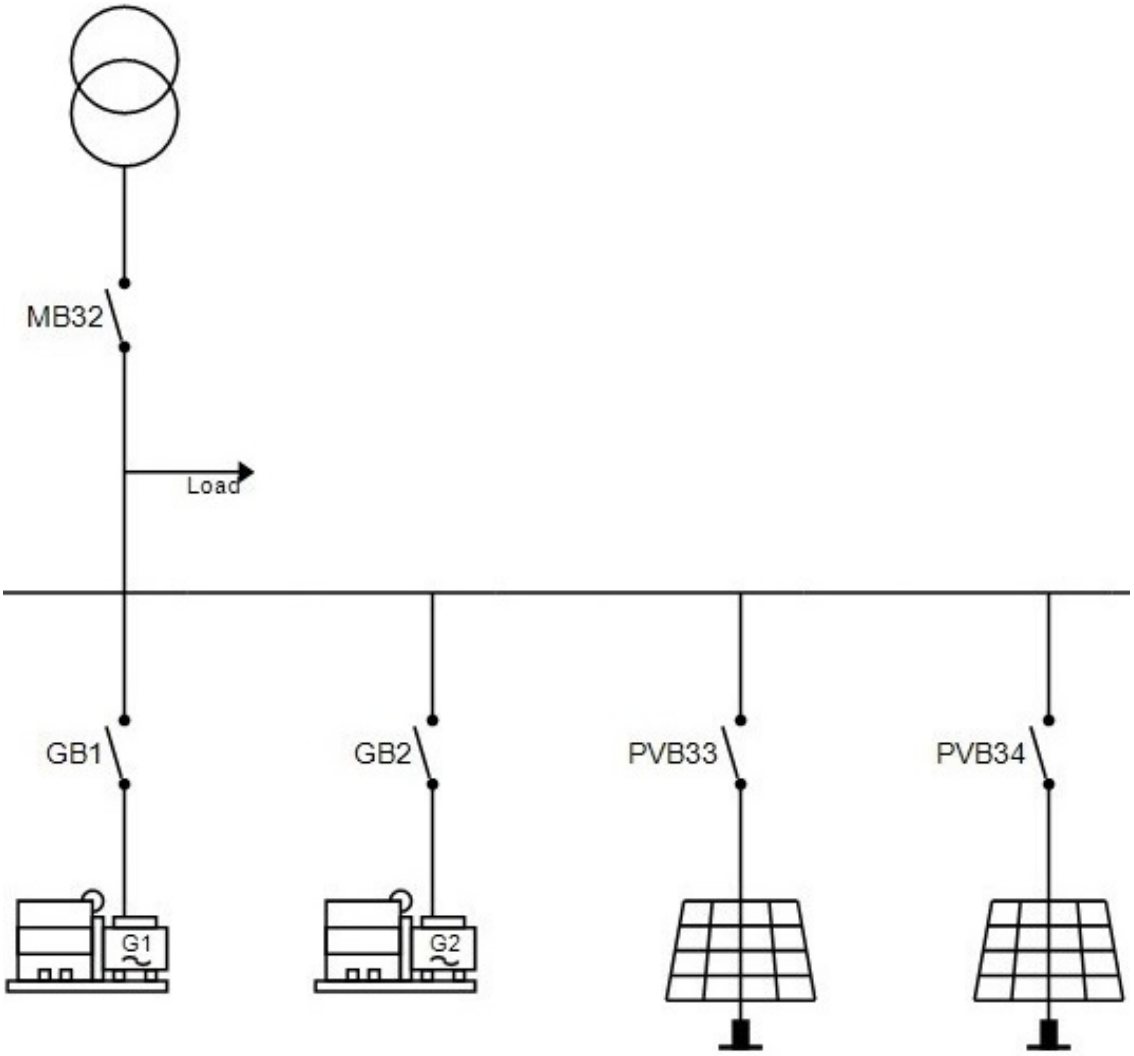
The ASC can be included in power management (also known as energy management). This allows PV, mains, gensets, and/or ESS to work together in an integrated system. Power management can include:

- Automatic rotation of genset priority.
- Fuel-optimised genset priority.
- Control of plant spinning reserve.
- Flexible application support with common grid-tied, combination, and off-grid applications.

### ASC and PV on the utility software application drawing

The ASC controls and monitors the inverters(s) of the PV plant. In the application single line drawing, the ASC is shown as a PV module. Each PV module represents either an inverter, or a string of inverters. There can be up to 16 ASC Solar controllers.

**Breaker control**




The ASC can control a PV breaker. For PV, this can be useful if there is a breaker in front of the string of inverters. The breaker can close when the busbar is live and Hz/voltage is normal. If the busbar is outside its limits, the ASC can open the PV breaker but not close it.

One ASC can control one PV breaker. For PV, the breaker can disconnect the PV if a sudden drop in the load forces reverse power to the gensets (risking a generator trip).

If the ASC is in AUTO mode, the ASC closes the breaker when the busbar is live (and then the inverter starts). The ASC does not require a manual start signal if AUTO is selected.

If SEMI is selected, an operator needs to push the breaker close and start buttons on the display unit. Alternatively, this signal can be sent by Modbus, digital input and so on.

## 5.3 Power management operation

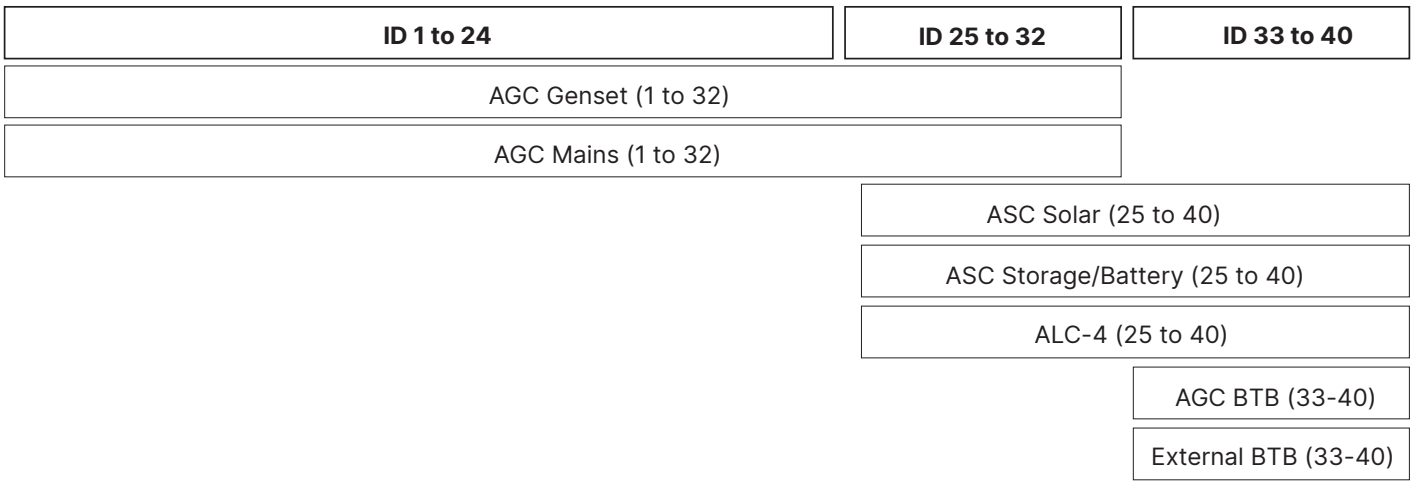
The ASC follows the operation of the AGC mains: Island, fixed power, mains power export, peak shaving, or load take-over (grid-tied or off-grid). If there is no mains controller (AGC mains) in the application, the plant uses island operation (off-grid).

## 5.4 System limitations

When the ASC is used for power management, the number of controllers is limited.

| | Maximum number |
|---|---|
| AGC Genset | 32 |
| AGC Mains | 32 |
| ASC Solar | 16 |
| ASC Storage/Battery | 16 |
| ALC-4 | 8 |
| AGC BTB/Externally-controlled BTB | 8 |

### Controller ID allocation and sharing



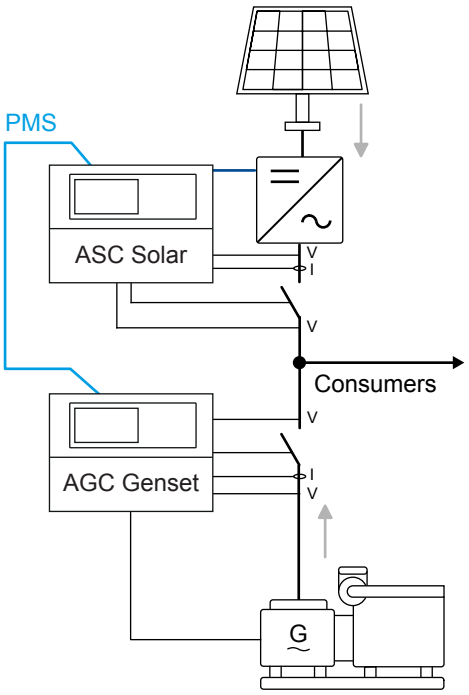

**Example**

If you have a system with one mains feeder, then you have (32 - 1) = 31 IDs left for the gensets. If you have two mains feeders, you have (32 - 2) = 30 IDs left for the gensets.

If you have a system with 14 ASC controllers, you can have (16 - 14) = 2 bus tie breakers.

## 5.5 Off-grid applications

### 5.5.1 Off-grid with genset(s) and solar



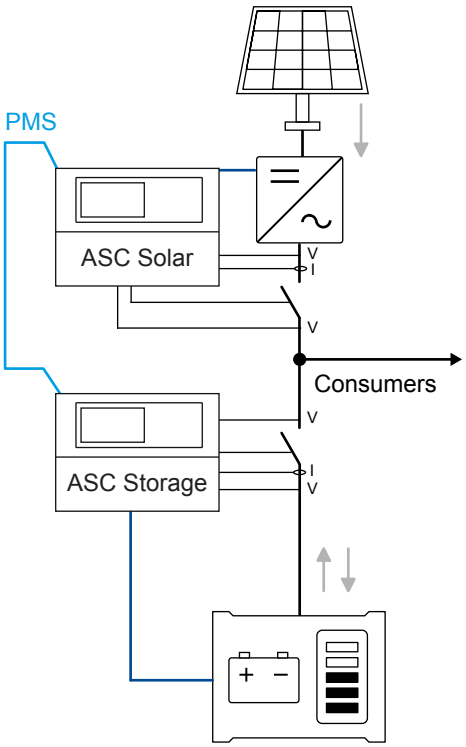

**AGC Genset configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

**ASC Solar configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

### 5.5.2 Off-grid with solar and battery



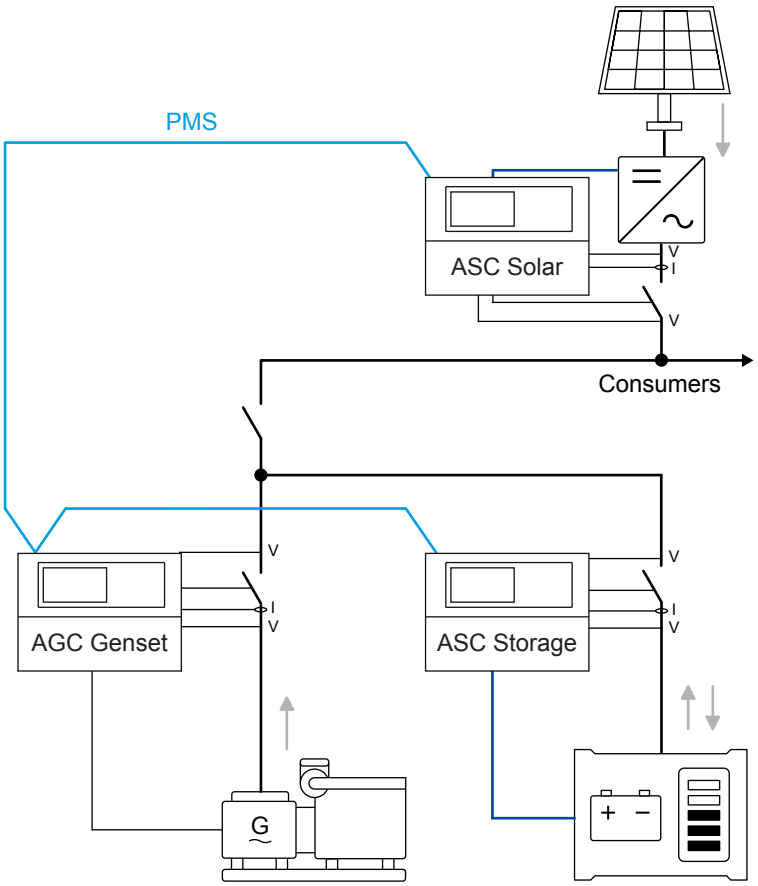

**ASC Battery configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

**ASC Solar configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

### 5.5.3 Off-grid with genset(s), solar and battery




**ASC Battery configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

**ASC Solar configuration**

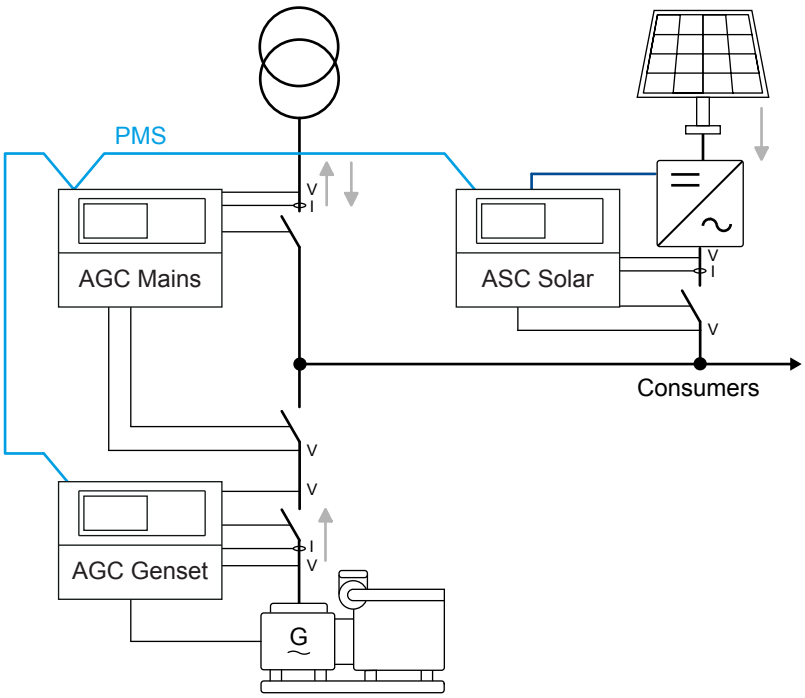
| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

**AGC Genset configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

## 5.6 Grid-tied applications

### 5.6.1 Grid-tied hybrid genset solar




**ASC solar configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

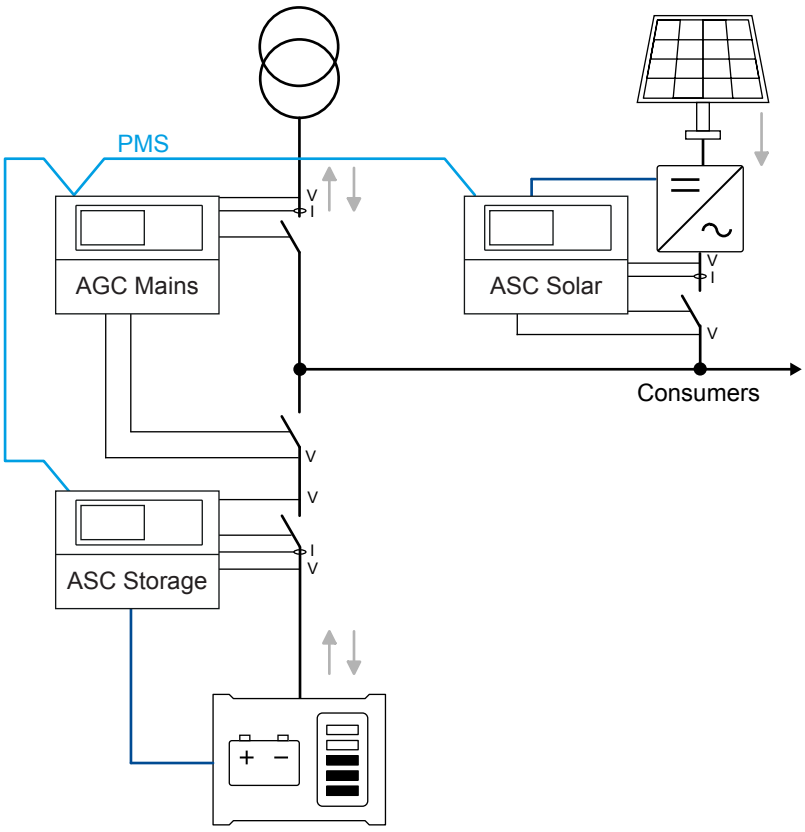
**AGC genset configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

**AGC mains configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6070 | Plant mode | Select a plant mode (in the AGC mains controller). For example, Mains Power Export. |

## 5.6.2 Grid-tied hybrid solar-battery




### ASC Battery configuration

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

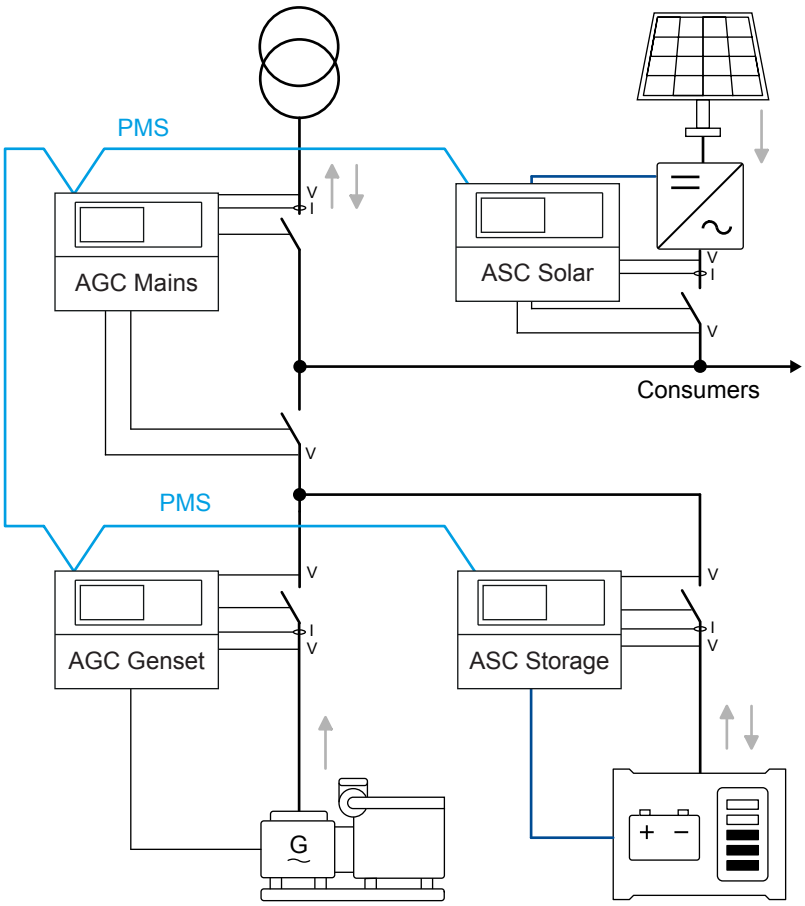
### ASC Solar configuration

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

### AGC mains configuration

| Parameter | Name | Setting |
|---|---|---|
| 6070 | Plant mode | Select a plant mode (in the AGC mains controller). For example, Mains Power Export. |

### 5.6.3 Grid-tied hybrid solar-genset-battery




**ASC Battery, ASC Solar, and AGC Genset configuration**

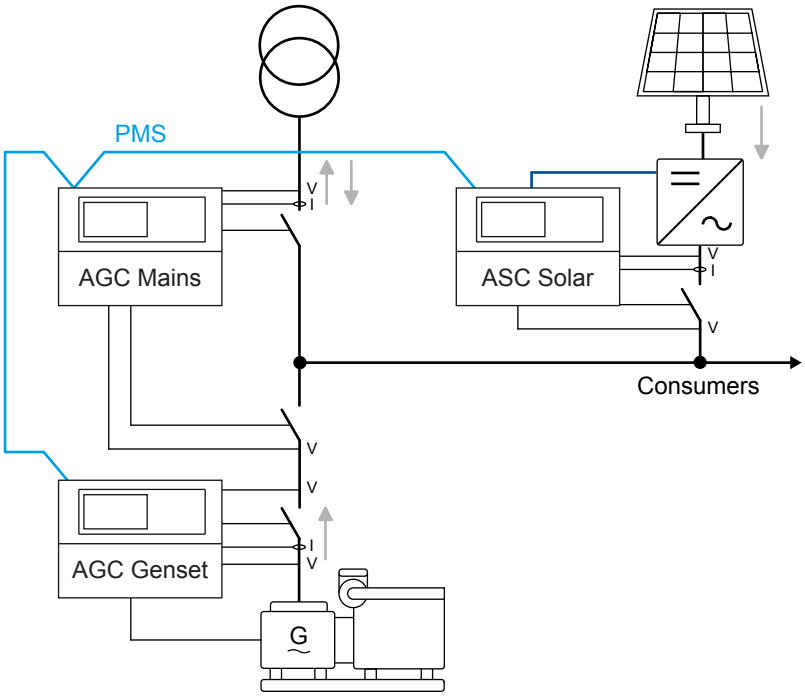
| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

**AGC Mains configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6070 | Plant mode | Select a plant mode (in the AGC mains controller). For example, Mains Power Export. |

## 5.7 Combination (off-grid + grid-tied)

This application is used for grid-tied and off-grid (islanded) modes.




In a power management combination application, the ASC can have the following modes of operation:

- Mains breaker open (that is, off-grid):
  - Island operation
- Mains breaker closed (that is, grid-tied):
  - MPE (Mains Power Export)
  - Peak shaving
  - Fixed power

**ASC Solar and AGC Genset configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Operating mode | Power management |

**AGC Mains configuration**

| Parameter | Name | Setting |
|---|---|---|
| 6071 | Plant mode | Select a plant mode (in the AGC mains controller). For example, Mains Power Export. |

## 5.8 Power management communication

### 5.8.1 CAN connections

The CAN line wiring between controllers must be a daisy chain connection. The line must be a continuous communication bus, and it cannot be mixed with the other communication.

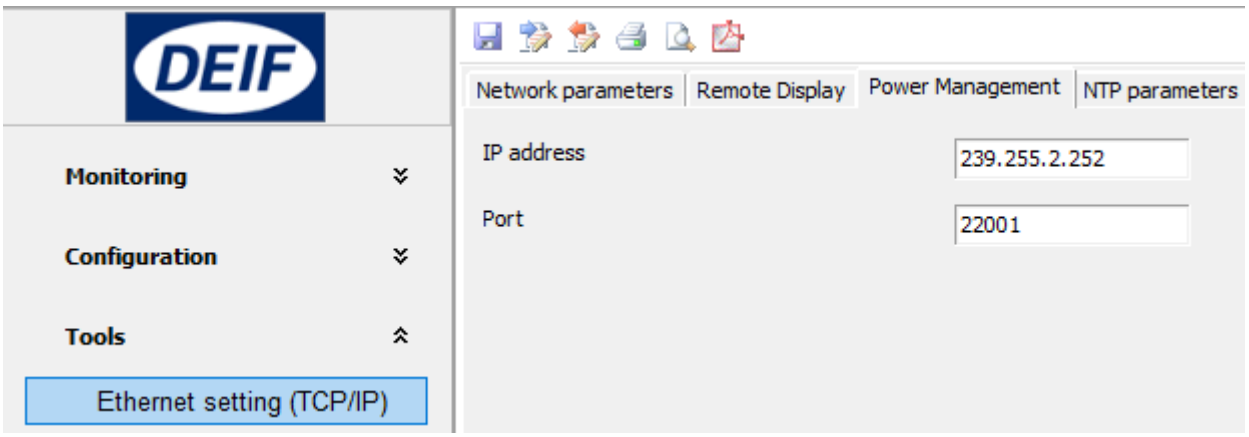
**More information**
See **CAN bus power management system** in the **Installation instructions** for wiring recommendations.

For *CAN B protocol* (parameter 7842) (under `Communication > CAN protocols`), select either *PM Primary* or *PM Secondary*. The *CAN B protocol* selection must be the same in all controllers. The power management functions are the same for *PM Primary* and *PM Secondary*.

### 5.8.2 Using Ethernet for power management

You can use Ethernet connections for power management communication redundancy.

In the utility software, on the *Ethernet setting (TCP/IP)* page, select *Power management*.




For each controller in the power management system:

1. Select the same IP address for the controllers to broadcast to, and the port.
   - The IP address must be in the range 239.255.xxx.xxx.
2. In parameter 7843 (*VCAN C Protocol*), select *PMS Primary* or *PMS Secondary*.

## 5.9 Easy connect

If the application consists of only genset, storage and/or solar controllers, Easy connect is a fast and easy way to add more controllers to a new or existing application. Easy connect commands normally come from the display, but they can also be sent from M-Logic and Modbus. You can also use Easy connect to remove genset, storage and/or solar controllers.

#### Preconditions

- All controllers in the application have the same software version.
  - You can use Easy connect for an application with a mix of AGC-4 Mk II, AGC-4, AGC 150, and ASC 150. All the controllers must support the same Easy connect functions.
- Easy connect is enabled in all controllers in parameter 8023, or *M-Logic Output, Easy connect, Enable Easy connect*.
- For genset controllers, in *Quick setup mode* (parameter 9186), select *Setup plant*.
- For storage and solar controllers, in *Quick setup mode* (parameter 9181), select *Setup plant*.
- The genset, ESS or PV to be added or removed is not running.

#### Activate Easy connect

If the preconditions are met, the Easy connect sequence is activated whenever:

- Easy connect is enabled in parameter 8023.
- A controller powers up.
- The CAN conditions change (that is, if a controller is added or removed).

**`Power management > Easy connect`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 8023 | Easy connect | OFF<br>ON | OFF |

### Using Easy connect

Once the Easy connect sequence starts, the operator cannot use the display unit to change parameters. Configure the parameters as required before the sequence starts, or use the utility software.

If a controller must be removed and another controller must be added to the plant, always first remove the controller then add the new controller.

**NOTICE**

**Give the controllers enough time to make changes**

When a controller is added or removed, the controllers use approx. one minute time to apply the change. When *Receiving application* is shown, do not add or remove more controllers. Making multiple simultaneous changes can reset the application.

### M-Logic commands and events

As an alternative to using the display for Easy connect, the following commands are available under *M-Logic, Output, Easy connect*:

| Controller | Command | Description |
|---|---|---|
| Genset only | Add DG | The user can connect multiple genset controllers to the CAN bus, then use this command to add each genset controller to the application. |
| Genset only | Remove DG | The user can use this command to remove a genset controller from the application, without the need to disconnect the CAN bus. |
| Storage only | Add ESS | The user can connect multiple storage controllers to the CAN bus, then use this command to add each storage controller to the application. |
| Storage only | Remove ESS | The user can use this command to remove a storage controller from the application, without the need to disconnect the CAN bus. |
| Solar only | Add PV | The user can connect multiple solar controllers to the CAN bus, then use this command to add each solar controller to the application. |
| Solar only | Remove PV | The user can use this command to remove a solar controller from the application, without the need to disconnect the CAN bus. |
| All | Select yes on display | This command selects YES if there is a "YES/NO" prompt on the display. |
| All | Select no on display | This command selects NO if there is a "YES/NO" prompt on the display. |
| All | Enable Easy connect | The user can activate the Easy connect function with this command. |
| All | Disable Easy connect | The user can deactivate the Easy connect function with this command. |

The following events are available under *M-Logic, Events, Easy connect*:

| Event | Description |
|---|---|
| Plant active | Activated for an Easy connect plant. |
| Stand alone | Activated for a stand-alone (single controller) application. |

### Setting up the controller for a single controller application

You can also use Easy Connect to set up the controller for a single controller application.

- For genset controllers, in *Quick setup mode* (parameter 9186), select *Setup stand alone*.

- For storage and solar controllers, in *Quick setup mode* (parameter 9181), select *Setup stand alone*.

## 5.10 Using utility software to create the application

### 5.10.1 Controller IDs

After connecting the CAN bus communication, each controller must have a unique internal communication ID. With Easy Connect, the controllers set the IDs automatically.

For manual setup, you must set the controller ID in each controller.

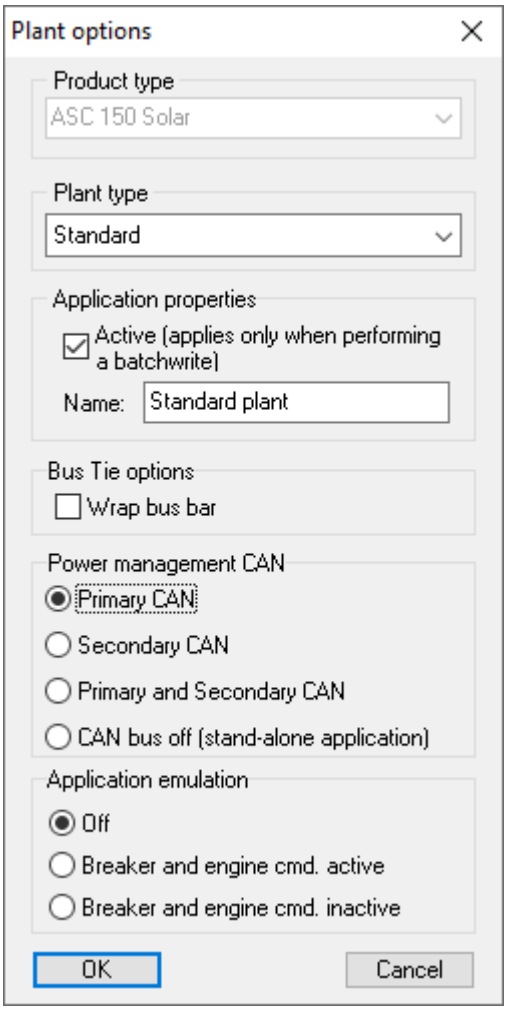
**`Communication > Power management ID`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 7531 | Int. comm. ID | 25 to 40 | 25 |

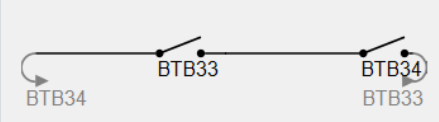
### 5.10.2 Application configuration

When the IDs are configured, you can configure the application with the utility software.

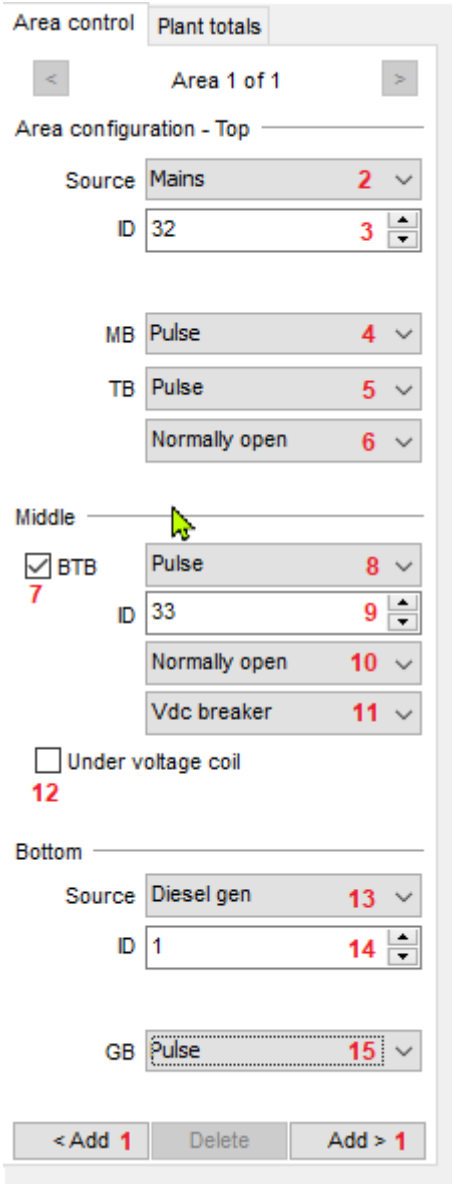
Connect to a controller with the PC utility software, then select *Application configuration*. In the top taskbar, select *New plant configuration*  . The *Plant options* window opens.



### Plant options

| | Description | Comments |
|---|---|---|
| **Product type** | The controller type is selected here. | This function is greyed out if a controller is already connected. |
| **Plant type** | • Single controller<br>• Standard | Select *Standard* for power management systems.<br>If *Single controller* is selected, the CAN ports for power management communication are turned off. |
| **Application properties** | The application is activated when it is written to the controller.<br>Name the application. | Naming the application can be helpful, if the controller is in a plant where the controller will switch between applications. The controllers can switch between four different applications. Controllers connected to each other by CAN bus communication cannot have different applications or numbers. |
| **Bus tie options** | Select the *Wrap bus bar* option. | Activate this option if the busbar is connected as a ring connection in the application. When the wrap busbar is selected, it is shown like this:<br>  |
| **Power management CAN** | Primary CAN<br>Secondary CAN<br>Primary and secondary CAN<br>CAN bus off | *Primary CAN* must be used, if the Power Management CAN bus is wired to CAN port B on each controller.<br>*Primary and secondary CAN* is only used for redundant CAN bus communication lines for power management. If this setting is selected and only one line is present, an alarm is activated. This alarm cannot be cleared.<br>Note: Select *Primary and secondary CAN* if you are using Ethernet for power management communication redundancy.<br>*CAN bus off* should only be used if the controller is in a single controller application. |
| **Application emulation** | Off<br>Breaker and engine cmd. active<br>Breaker and engine cmd. inactive | Turn on emulation here. |

You can now create the application drawing in the controllers. From the left side of the page, you can add controllers to the configuration. You can also select the type of breakers in the application.

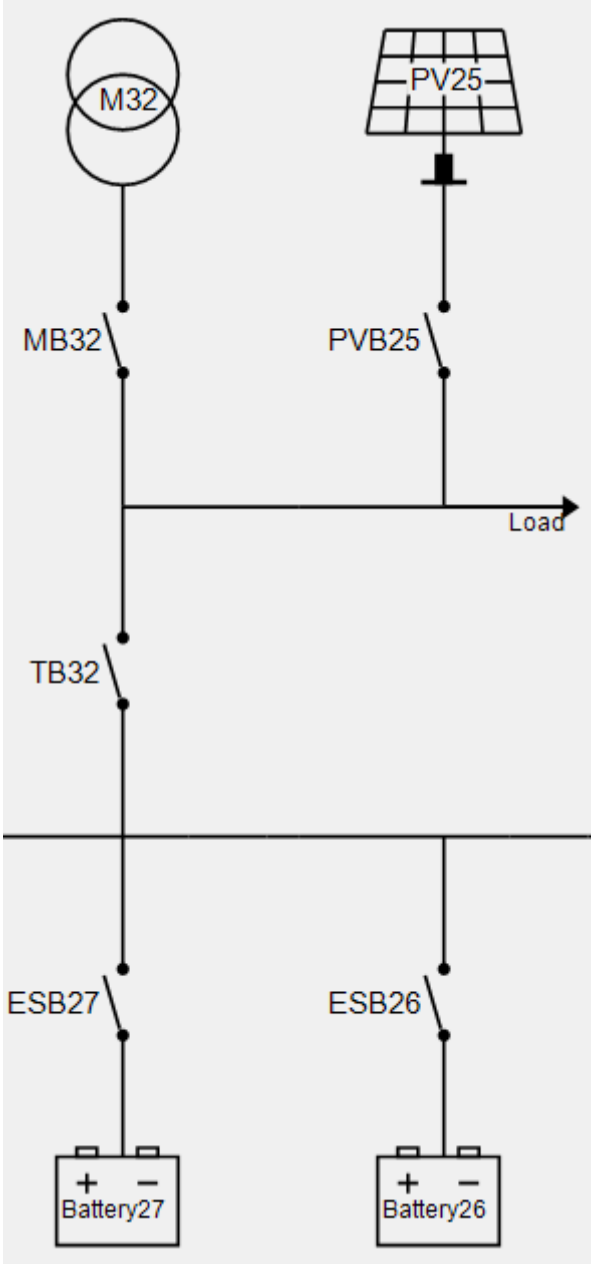



### Plant configuration options

| No. | Name | Description |
|---|---|---|
| 1 | Add/Delete | Add and delete areas. Adding areas makes the application configuration/plant bigger. |
| 2 | Source | Select the type of power source for the top area (None, Mains, Diesel gen, Photovoltaic, LG or Battery). |
| 3 | ID | Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller. |
| 4 | MB | Mains is selected as the source (no. 2), so it is possible to select the type of breaker for the mains breaker (Pulse, Ext/ATS no control, Continuous NE, Compact, None, Continuous ND). |
| 5 | TB | Mains is selected as the source (no. 2), so it is possible to select the type of breaker for the tie breaker (Pulse, Continuous NE, Compact, None). |
| 6 | - | Select whether the tie breaker is *Normally open* or *Normally closed*. |
| 7 | BTB | Select to add a BTB controller. |
| 8 | - | The type of bus tie breaker (Pulse, Ext, Continuous NE, Compact).<br><br>Select *Ext* for an externally controlled BTB, that is, there is no AGC BTB controller. The bus tie breaker position feedbacks must be connected to any controller in the power management system. |

| No. | Name | Description |
|---|---|---|
| 9 | ID | Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller. |
| 10 | - | Select whether the BTB is *Normally open* or *Normally closed*. |
| 11 | - | If *Vdc breaker* is selected, the breaker can open and close when there is no voltage on the busbar. If *Vac breaker* is selected, voltage must be present on the busbar before the breaker can be handled. |
| 12 | Under voltage coil | Select this if the BTB has an under-voltage coil. |
| 13 | Source | Select the type of power source for the bottom area (None, Mains, Diesel gen, Photovoltaic, LG or Battery). |
| 14 | ID | Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller. |
| 15 | GB | In this example, diesel genset is selected as the source (no. 13), so it is possible to select the type of breaker for the genset breaker (Pulse, Continuous NE, Compact). |

**Application configuration example**




After you have created the application, send it to the controllers. Select *Write plant configuration to the device*  . After this, only the controller connected to the PC utility software has the application configuration.

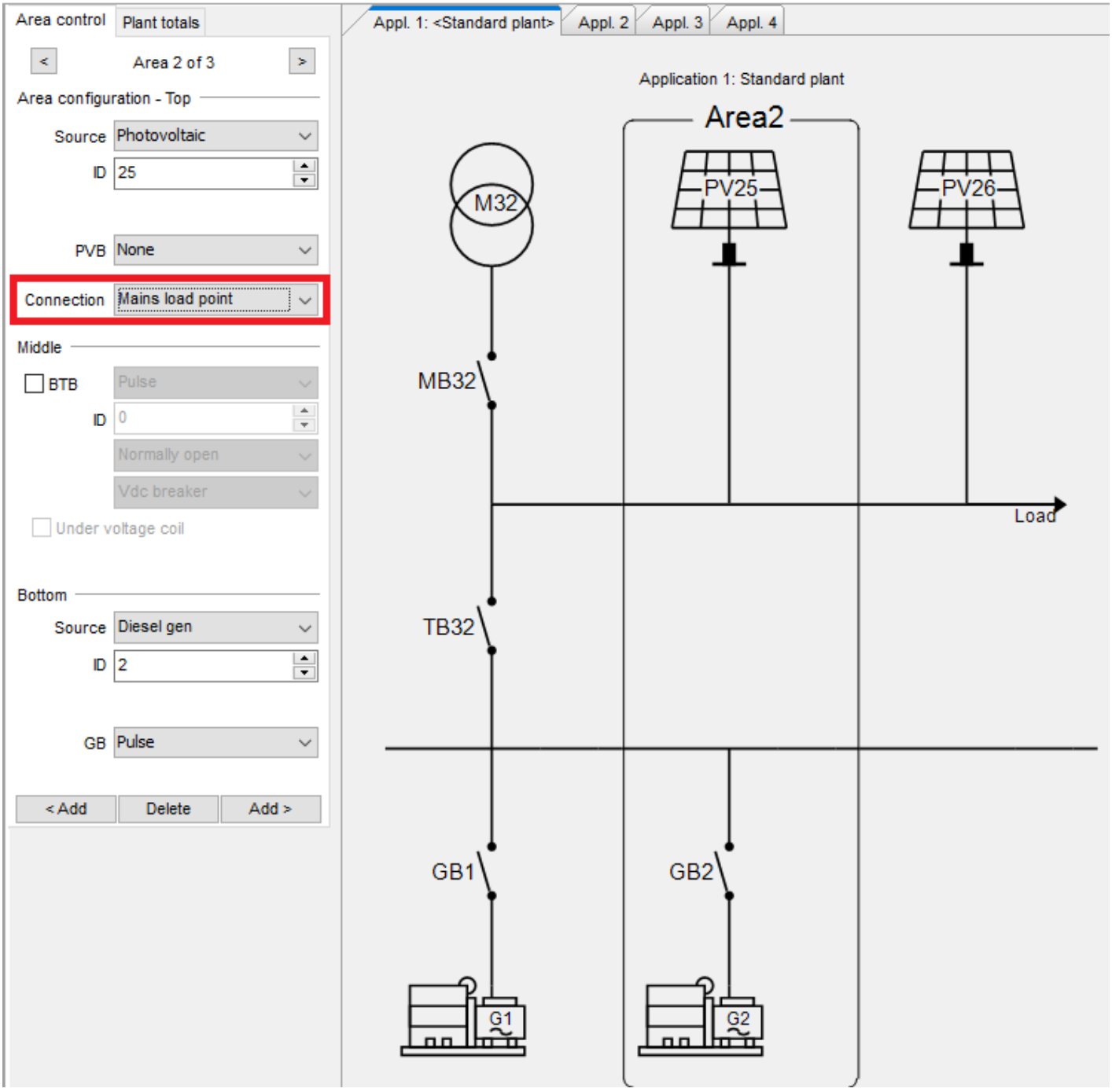
The application configuration can then be sent from this controller to all the other controllers. Select *Broadcast plant application* 

## 5.10.3 PV connected to load point or busbar

The ASC Solar controller allows inverters to be connected to the load point and/or the busbar.

For inverters connected to the load point, in the utility software, on the *Application configuration* page, for *Connection*, select *Mains load point*.

**Example with PV connected to the load point**




**NOTE** For ASC 150 Solar, PV can only be connected to the load point if the ASC does not control the PVB.

## 5.11 Genset management

### 5.11.1 Genset load-dependent start and stop

The genset load-dependent start and stop (LDSS) parameters are configured in the AGC Genset controllers. You can configure two sets of LDSS parameters in each AGC Genset controller.

If the available PV is reduced (for example, due to clouds), the energy management system can be configured to tell the AGC Genset to use the second set of LDSS parameters. Set these LDSS parameters lower, to make sure that there is enough spinning reserve.

**More information**
See **Genset functions, Load-dependent start and stop** in the **Option G5 Power management AGC-4 Mk II** for more information and examples.

### 5.11.2 Genset set points (kW)

In power management mode, the controllers force the gensets that are connected to the busbar to operate at or above a minimum load. This is to reduce the risk of engine problems, for example wet-stacking, fouling, or other issues caused by idling at low loads.

#### Island operation

During island operation the connected genset load can be between -50 and 100 % of engine nominal power. The *Min DG load 01/02* parameters (15011 to 15013) on the ASC ensure that all engines connected to the busbar do not go below the minimum load.

If there are multiple ASC controllers in the application, the set point for these parameters must be the same in each controller.

#### Parallel to grid operation

Gensets that operate in parallel to the PV plant are always loaded to at least their *Minimum Load* setting to prevent engine fouling. This is true even if the PV plant can supply more power to the grid than the set point allows.

The power management system uses PV production as much as possible to supply the load demand, and starts and stops gensets as required while taking minimum genset load into account.

## 5.12 Spinning reserve

You can configure the spinning reserve on the busbar in the ASC controller.

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 8001 | Spin. res. grid-tie | 0 to 100 % | 0 % | Spinning reserve in mains parallel operation. |
| 8002 | Spin. res. off-grid | 0 to 100 % | 10 % | Spinning reserve in island operation. |
| 8003 | Spin. res. origin | ASC settings<br>PV communication | ASC settings | • *ASC settings*: The spinning reserve is calculated as an adjusted percentage of the currently produced power.<br>• *PV communication*: This can only be used with the *DEIF open protocol*. |

#### Example

| | Capacity [kW] | Actual dispatch [kW] |
|---|---|---|
| Gensets | 400 each | 100 |
| PVs total | 500 | 500 |
| Load | - | 600 |
| Penetration ratio (PV:Diesel) | 500:400 (~ 56 %) | 500:100 (~ 83 %) |
| Spinning reserve | - | 300 |

If the spinning reserve set point is 50 % of the PV dispatch, for this example, the spinning reserve is 250 kW. If only one genset is running, the genset cannot be loaded more than $P_{NOMINAL} – P_{SPINNING\ RESERVE}$: 400 – 250 = 150 kW.

When the genset load exceeds 150 kW, to meet the spinning reserve requirement, the power management system requests another genset to start.

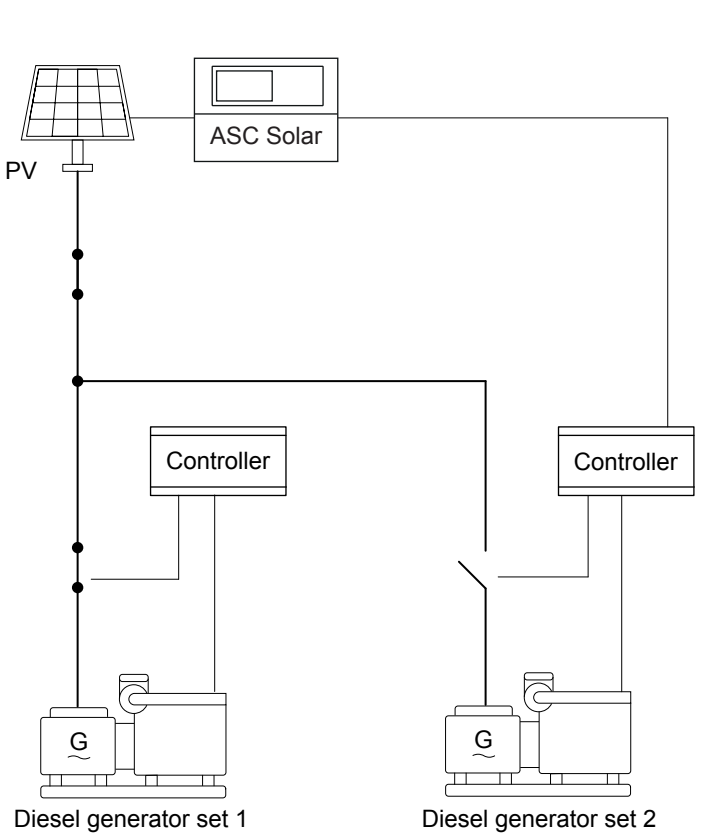
### 5.12.1 Alarms for spinning reserve

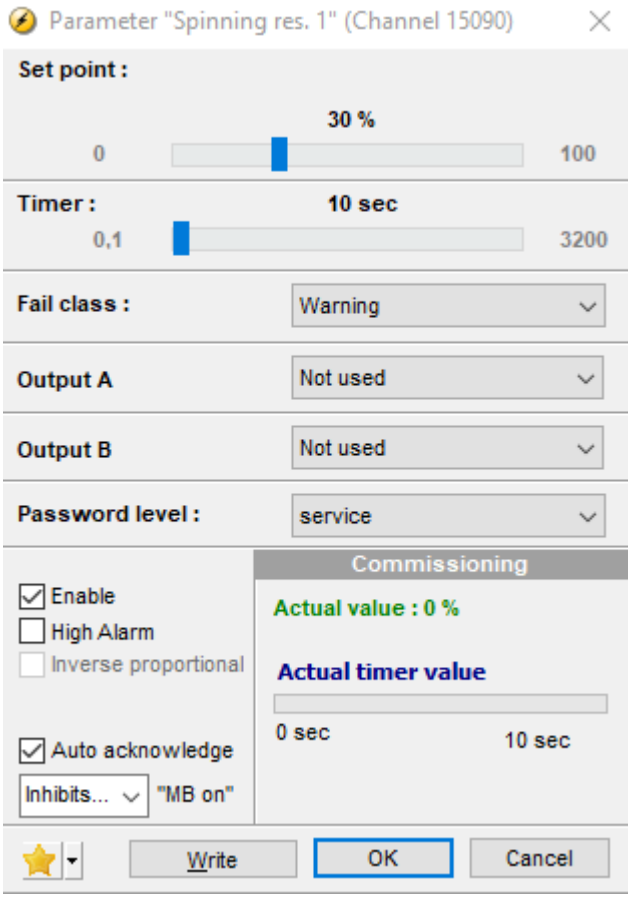
Two alarms are available for the spinning reserve function (menus 15090 and 15100). These alarms can be used in power management applications or single controller applications.

The alarms can be configured to activate above or below the set point, along with a set point, timer, and fail class.

#### Using the spinning reserve alarm to start the next genset

If there is no power management system, you can configure one of the spinning reserve alarm's outputs to send a start command to the next genset. This is shown in the diagram and screenshot below. The digital output on terminal 5 of the ASC is configured to activate if the spinning reserve is too low. ASC terminal 5 is wired as a start input to the genset controller.




**NOTE** Select *Auto acknowledge* to automatically deactivate the output when the spinning reserve required is available again. Select *Enable* to enable the alarm.

#### Using the spinning reserve alarm for load management

You can configure the spinning reserve alarm to send a signal to disconnect load groups.

## 5.13 Set points in multi-ASC applications

If more than one ASC is present, they will share the load equally if they are running or ready to start. This means that the ASCs ensure that the production is balanced between the running inverters.

## 5.14 Dynamic frequency response

The AGC-4 Mk II can use the dynamic frequency response (DFR) function to automatically adjust the genset frequency set point, based on the genset load. DFR is designed for systems where photovoltaic (PV) power and a genset are connected. Without DFR, when the PV conditions are good, the PV can produce too much power.

**More information**
See **Dynamic frequency response** in the **AGC-4 Mk II Designer's handbook**.

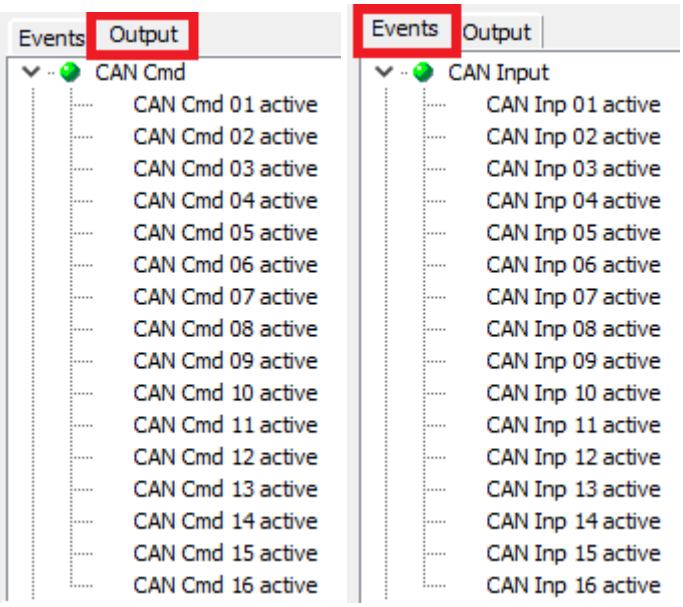
## 5.15 More power management communication

### 5.15.1 CAN flags (M-Logic)

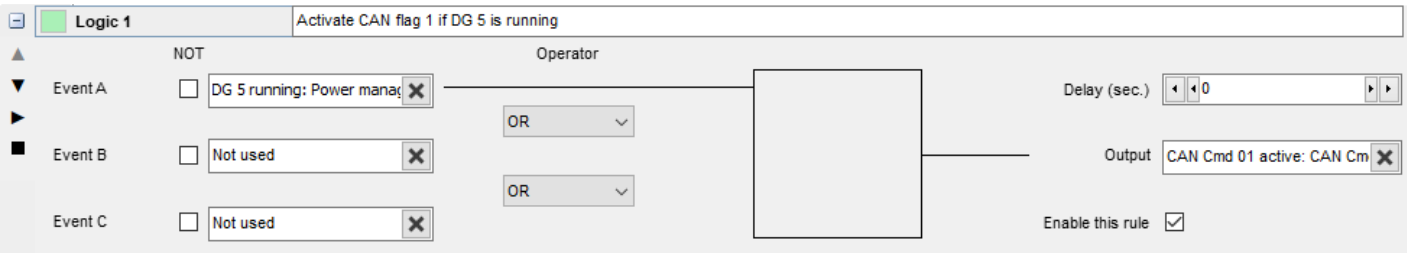
M-Logic has 16 CAN flags for CAN commands. They are like digital inputs. When a CAN command is sent from one controller, the corresponding CAN flag is activated in all the controllers. No wire is needed, as the CAN flags are communicated over the power management CAN bus.

**NOTE** Only use continuous signals from digital inputs or AOP buttons to activate the CAN inputs. AOP buttons are pulse inputs, so a latch function must be used to create a continuous signal.

#### M-Logic CAN flag outputs and events




#### M-Logic CAN command example




*CAN Cmd 01* is activated when DG 5 is running. *CAN Inp 01 active* is then activated in all controllers in the power management system.

### 5.15.2 CAN bus setup

If it is critical for the application to have the fastest possible inter-controller communication, configure parameters 9171 and 9172 from the controller display.

Press *Shortcut menu*, select Jump and enter the parameter number:

| Parameter | Text | Range | Default |
|---|---|---|---|
| 9171 | Int CAN units * | ≤ 15 units<br>≤ 20 units | ≤ 20 units |

| Parameter | Text | Range | Default |
|---|---|---|---|
| | | ≤25 units<br>≤ 30 units<br>≤ 35 units<br>≤ 40 units | |
| 9172 | Int CAN baud ** | 125k<br>250k | 125k |

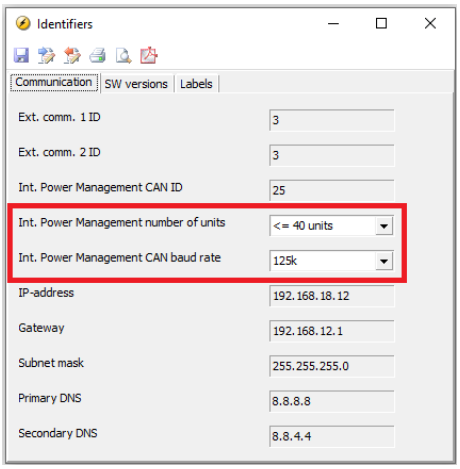
**NOTE** * The lower the number of units, the faster the power management.

** 125 kbit baud allows cable length up to 300 m, 250 kbit baud allows cable length up to 150 m.

All controllers in the system must have the same settings in parameters 9171 and 9172, otherwise an *Appl. hazard* alarm is displayed. A *Unit number Error* entry is created in the event log, and the controller with the different baud rate is tagged with the alarm value 100 in the alarm log.

The parameters can also be configured with the utility software:

1. In the task bar, select *Identifiers*
2. In the pop-up window, change *Int. Power Management number of units* and *Int. Power Management CAN BAUD rate*.




## 5.15.3 CAN failure mode

If there is a failure on the CAN controlling the power management, the system can be set up to respond in a variety of ways.

**`Power management > Communication failures`**

| Parameter | Text | Range | Default | Details |
|---|---|---|---|---|
| 7532 | CAN fail mode | Manual<br>Semi-auto<br>No mode change | Semi-auto | The controller mode if there is a CAN failure. See below. |
| 7533 | Miss. all units | Fail classes | Warning | The controller cannot detect any other controllers. |
| 7534 | Fatal CAN error | Fail classes | Warning | More controllers are missing than configured in parameter 8800. |
| 7535 | Any DG missing | Fail classes | Warning | The controller cannot detect at least one genset controller. |
| 7536 | Any mains missing | Fail classes | Warning | The controller cannot detect at least one mains controller. |
| 7871 | Any BTB miss. | Fail classes | Warning | The controller cannot detect at least one BTB controller. |

| Parameter | Text | Range | Default | Details |
|---|---|---|---|---|
| 7874 | Any LG miss. | Fail classes | Warning | The controller cannot detect at least one load group controller. |
| 7875 | Any PV miss. | Fail classes | Warning | The controller cannot detect at least one solar controller. |
| 7876 | Any Bat miss. | Fail classes | Warning | The controller cannot detect at least one storage/battery controller. |
| 8800 | CAN miss amount | 2 to 32 | 2 | The setting for the fatal CAN error. |

#### SEMI-AUTO mode

If *SEMI-AUTO* mode is selected, the controllers change to SEMI-AUTO mode when a fatal CAN error occurs. The regulators in the controllers are still active. This means that load sharing is possible.

#### No mode change

If *No mode change* is selected, the controllers are kept in the mode they were in before the fatal CAN error occurred. In an application with several mains, BTBs and gensets, if one genset is not visible anymore, the rest of the system can still behave almost like normal and continue in AUTO mode.

### 5.15.4 CAN bus alarms

| Alarm | Description |
|---|---|
| Any DG missing | Activated when one or more genset controllers are missing. Activates the fail class in parameter 7535. |
| Any mains missing | Activated when one or more mains controllers are missing. Activates the fail class in parameter 7536 (also used when a BTB controller is missing). |
| Appl. Hazard | The application configuration is not the same in all the controllers in the system. The power management system cannot operate correctly. If enabled, this alarm activates the fail class in parameter 7872. |
| Duplicate CAN ID | Activated when two or more controllers have the same internal communication ID. The power management system cannot operate. |
| Missing all units | Activated only when a controller cannot "see" any other controllers on the CAN bus line. Activates the fail class in parameter 7533. |
| CAN bus communication failures | The *XXX missing* alarms, the alarm is activated on all other controllers in the application. |
| CAN ID X P missing | The controller has lost CAN bus communication to CAN ID on *PM Primary*. |
| CAN MAINS X P missing | The controller has lost CAN bus communication to a mains controller with ID X on *PM Primary*. |
| CAN BTB X P missing | The controller has lost CAN bus communication to a BTB controller with ID X on *PM Primary*. |
| CAN ID X S missing | The controller has lost CAN bus communication to CAN ID on *PM Secondary*. |
| CAN MAINS X S missing | The controller has lost CAN bus communication to a mains controller with ID X on *PM Secondary*. |
| CAN BTB X S missing | The controller has lost CAN bus communication to a BTB controller with ID X on *PM Secondary*. |
| CAN setup CH: 784x | The controller can detect power management communication on a CAN port, but the correct protocol is not set. For a genset controller, this alarm also monitors the CAN setup between the engine communication protocol and CAN port. |

# 6. Open PMS applications

## 6.1 Open PMS

Open PMS is a power management system that consists of solar and/or storage controllers. Open PMS can also include a mains controller. The ASC controller(s) get power measurements from the externally controlled power source(s). You can therefore use open PMS to add power management to a brownfield application.

Open PMS automatically supplies the power that is necessary for the load efficiently, safely and reliably:

- Automatically maximises PV power
- Automatically closes and opens breakers
- Balances the loads in the system
- Deploys logic

The open PMS operating data can be shown graphically on the controller display. You can also monitor open PMS from a graphical supervision page in the utility software.

**Open PMS features**

| Open PMS features | Extended | Premium |
|---|---|---|
| Power management operation limits:<br>• External generator controllers per solar/storage controller<br>• Mains controllers*<br>• External mains connections<br>• Solar controllers*<br>• Storage (BESS) controllers* | <br>4<br>32<br>1<br>16<br>16 | <br>16<br>32<br>1<br>16<br>16 |
| EasyConnect | ● | ● |
| External sources included in the available power:<br>• Supply the busbar load<br>• Charge batteries<br>• Minimum and optimal genset load | ●<br>●<br>●<br>● | ●<br>●<br>●<br>● |

***Restrictions on controllers**

| ID 1 to 24 | ID 25 to 32 | ID 33 to 40 |
|---|---|---|
| AGC Mains (1 to 32) | | |
| | ASC Solar (25 to 40) | |
| | ASC Storage/Battery (25 to 40) | |

**Plant modes with a mains controller**

With a mains controller, open PMS supports:

- Configurable mains power set point
- Configurable mains operating mode
- Auto-start signal for the application to the mains controller
- Standard AGC mains PMS features, including cos phi set points, and mains breaker control

| Standard plant modes | Applications |
|---|---|
| Island mode | Power plant with synchronising generators. |
| Automatic Mains Failure | Critical power/emergency standby plants, black start generator. |
| Fixed power | Power plant with fixed kW set point (including building load). |

| Standard plant modes | Applications |
|---|---|
| Peak shaving | Power plant where generator supplies peak load demand paralleled to the mains. |
| Load take-over | Plant mode where the load is moved from mains to generator. For example, peak demand periods, or periods with a risk of power outages. |
| Mains power export | Power plant with fixed kW set point (excluding building load). |

### Plant modes with an external mains

The ASC 150 that is connected to the external mains operates as an *AGC mains lite* and controls the mains mode.

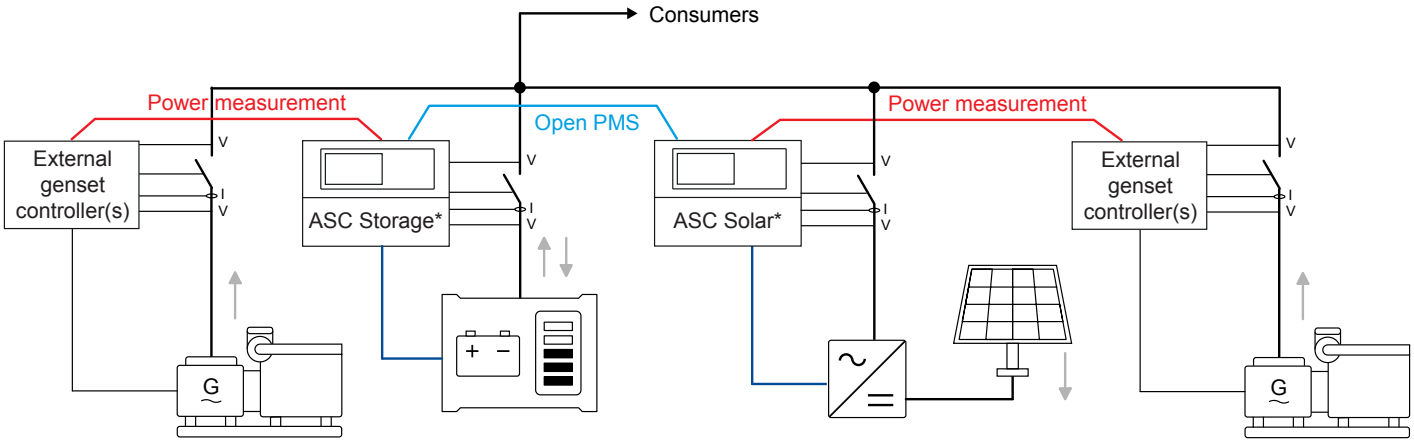
| Standard plant modes | Applications |
|---|---|
| Fixed power | Power plant with fixed kW set point (including building load). |
| Peak shaving | Power plant where generator supplies peak load demand paralleled to the mains. |
| Mains power export | Power plant with fixed kW set point (excluding building load). |

**NOTE** For an open external mains breaker, open PMS cannot synchronise so that the mains breaker can close. That is, open PMS runs in island mode and cannot back sync.

## 6.2 Single-line application diagrams for open PMS

### 6.2.1 Off-grid open PMS

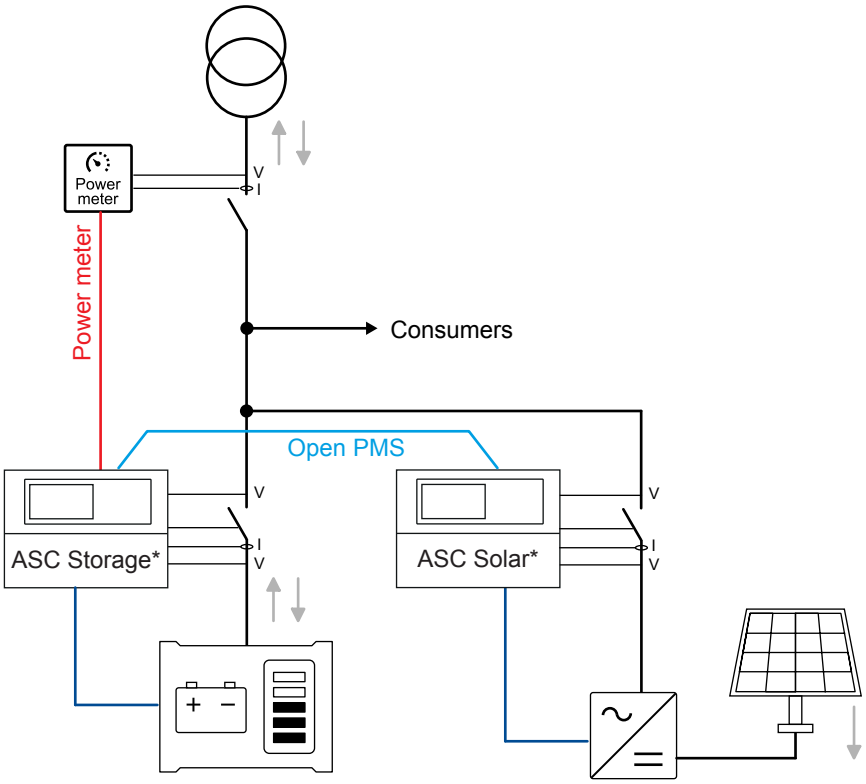
#### Off-grid solar, storage and external genset(s)



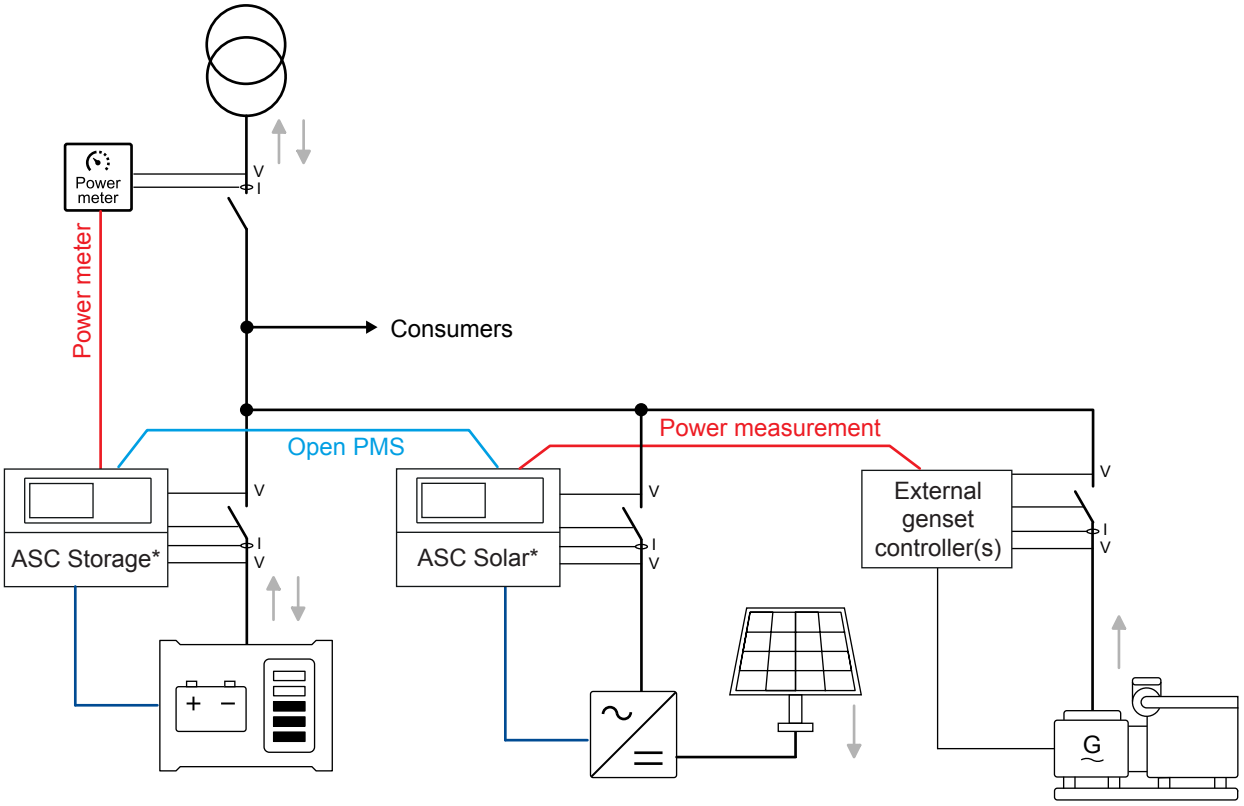

**NOTE** * You can use multiple controllers in the application. Power measurements can be connected to the closest ASC controller.

## 6.2.2 Grid-tied open PMS

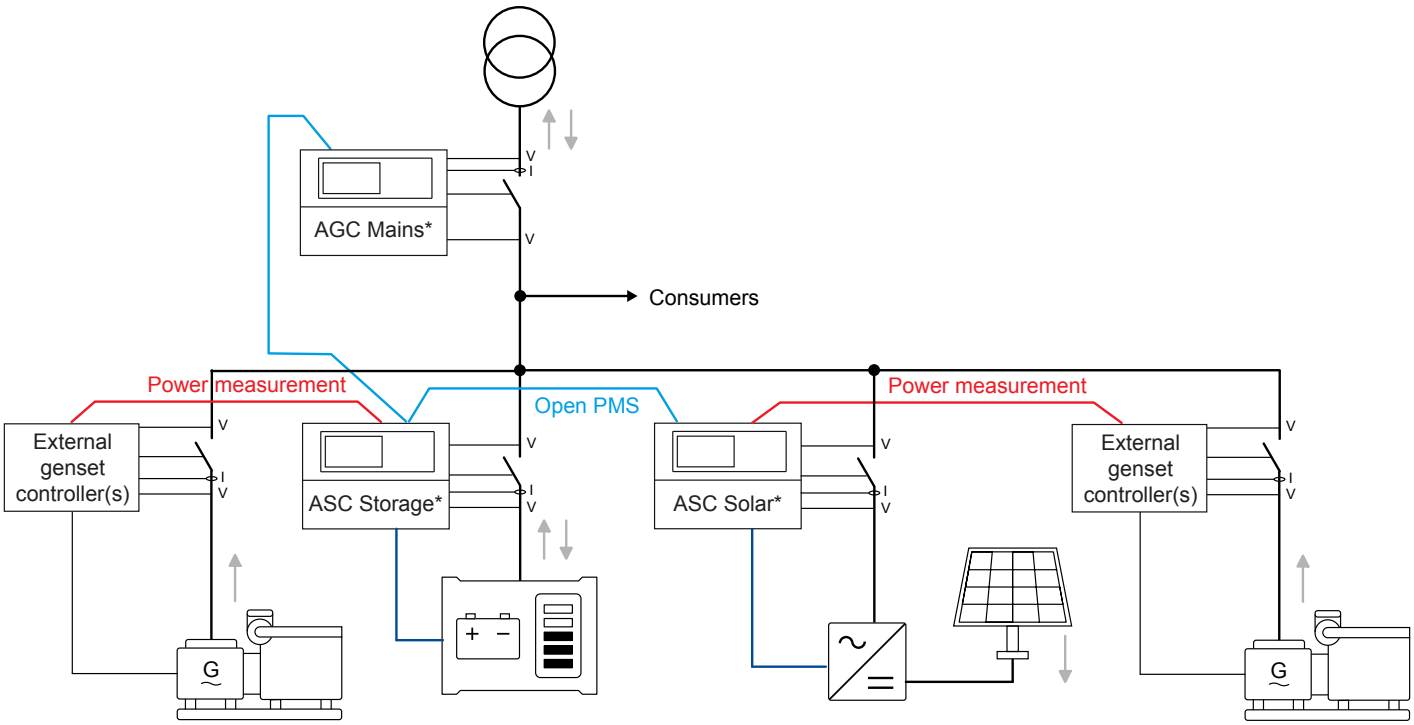
### Grid-tied solar, storage and external mains




### Grid-tied solar, storage, external genset(s) and external mains



**Grid-tied solar, storage, mains and external genset(s)**




**NOTE** * You can use multiple controllers in the application. Power measurements can be connected to the closest ASC controller.

## 6.3 Setup of an open PMS application

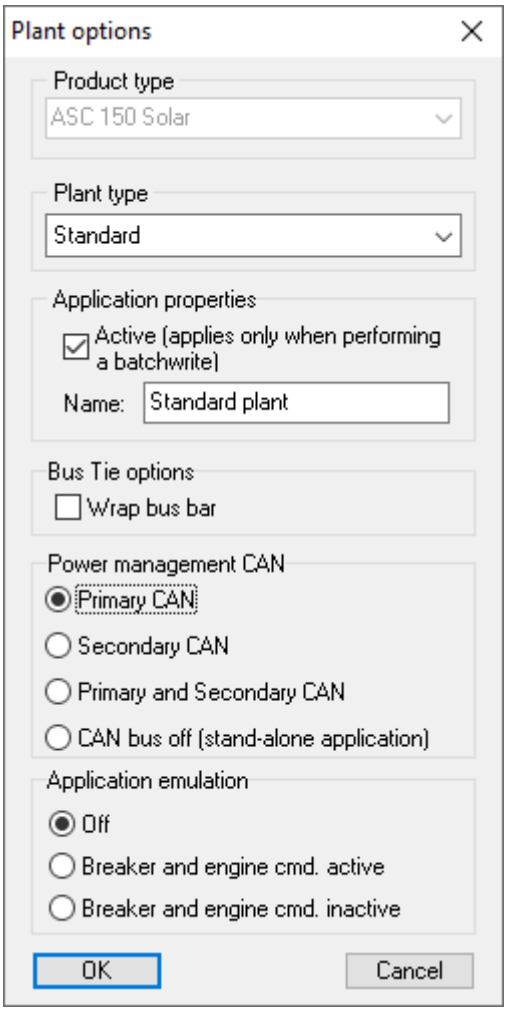
You must set the controller ID in each open PMS controller.

**`Communication > Power management ID`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 7531 | Int. comm. ID | 25 to 40 | 25 |

When the IDs are configured, you can configure the application with the utility software.

Connect to a controller with the PC utility software, then select *Application configuration*. In the top taskbar, select *New plant configuration* . The *Plant options* window opens.

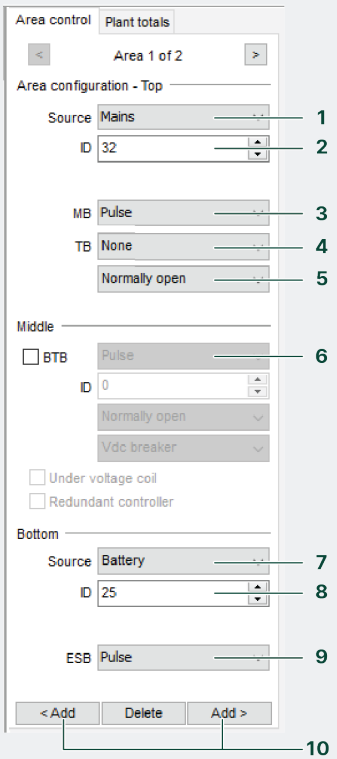



### Plant options

| | Description | Comments |
|---|---|---|
| **Product type** | The controller type is selected here. | This function is greyed out when a controller is connected. |
| **Plant type** | • Single controller<br>• Standard | Select *Standard* for open PMS. |
| **Application properties** | The application is activated when it is written to the controller.<br>Name the application. | Naming the application can be helpful, if the controller is in a plant where the controller will switch between applications. The controllers can switch between four different applications. Controllers that are connected to each other cannot have different applications or numbers. |
| **Bus tie options** | Not relevant. | You cannot use this for open PMS. |
| **Power management CAN** | Primary CAN<br>Secondary CAN<br>Primary and secondary CAN<br>CAN bus off | Use *Primary CAN* if the Power Management CAN bus is wired to CAN port B on each controller.<br>Only use *Primary and secondary CAN* if there is redundant CAN bus communication for power management. If this setting is selected and only one communication line is present, an alarm is activated. This alarm cannot be cleared. |
| **Application emulation** | Off<br>Breaker and engine cmd. active<br>Breaker and engine cmd. inactive | You can turn on emulation here, for testing the system or training operators.<br>**NOTE** Do not use emulation when the controller is connected to power generating equipment. |

You can now create the application drawing in the controllers. From the left side of the page, you can add the ASC controllers and/or the mains controller to the configuration. You can also select the type of breakers in the application.

### Plant configuration options

| No. | | Name | Description |
|---|---|---|---|
|  | 1 | Source | Select the type of power source for the top area (None, Mains, Photovoltaic, or Battery). |
| | 2 | ID | Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller. |
| | 3 | MB | Mains is selected as the source (no. 2), so it is possible to select the type of breaker for the mains breaker (Pulse, Ext/ATS no control, Continuous NE, Compact, None, Continuous ND). |
| | 4 | TB | Open PMS does not support TB. You must therefore select *None*. |
| | 5 | - | Select whether the tie breaker is *Normally open* or *Normally closed*. |
| | 6 | BTB | You cannot select a BTB in open PMS. |
| | 7 | Source | Select the type of power source for the bottom area (None, Mains, Photovoltaic, or Battery). |
| | 8 | ID | Set the ID. This ID should correspond to the internal communication ID (parameter 7531) in the controller. |
| | 9 | ESB | In this example, battery is selected as the source (no. 13), so it is possible to select the type of breaker (Pulse, Ext/ATS no control, Continuous NE, None). |
| | 10 | Add/Delete | Add and delete areas. Adding areas makes the application configuration/ plant bigger. |

### Restrictions

**Do not include the external genset(s) or an external mains in the open PMS application.** These are configured separately as external P/Q sources.

**Do not include genset(s) with AGC controllers in the open PMS application.** If present, these are also configured separately as external P/Q sources.

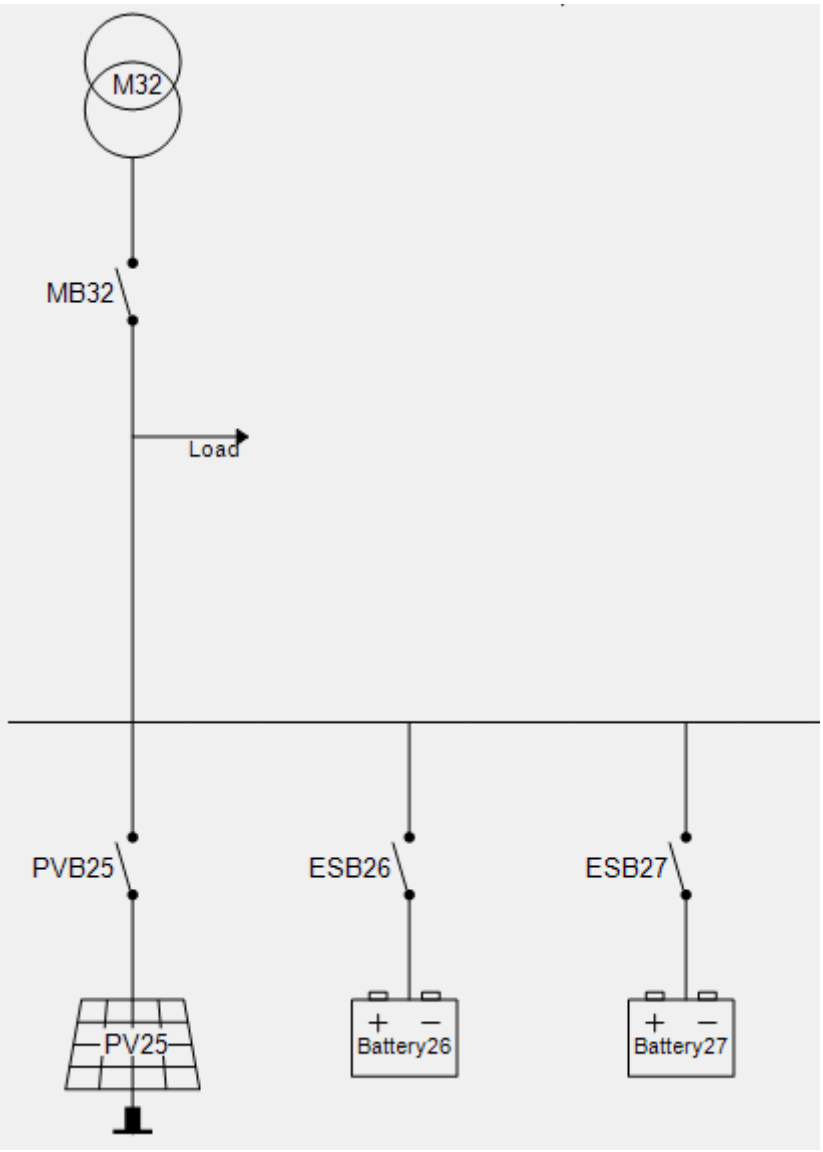
**Mains controller(s) cannot have tie breakers** in an open PMS application.

**Do not include bus tie breakers (BTB) or load groups (LG)** in the open PMS application. These are not supported by open PMS.

The **ASC solar controller cannot be in the mains load point.**

**NOTE** Use an **Energy management system** if the application cannot comply with these restrictions.

**Application configuration example**




After you have created the application, send it to the controllers. Select *Write plant configuration to the device* . After this, only the controller connected to the PC utility software has the application configuration.

The application configuration can then be sent from this controller to all the other controllers. Select *Broadcast plant application*

### 6.3.1 ASC open PMS parameters

You can use open PMS with ASC 150 Solar, ASC 150 Storage, ASC-4 Solar and/or ASC-4 Battery.

To use open PMS, you must configure these parameters in each ASC (especially parameter 8351).

**ASC parameters**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 6071 | Operation mode | (See the software - only *Power* | Power management | This parameter must be **Power management**. |

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| | | *management* is relevant) | | |
| 8022 | Mode update | Update local<br>Update all | Update all | **Update all**: When the mode is changed in the controller, the mode is changed in all open PMS controllers.<br>**Update local**: When the mode is changed in the controller, the other open PMS controllers are not affected. |
| 8351 | **Open PMS** | Not enabled, Enabled | Not enabled | To use open PMS, this parameter must be **Enabled**. |
| 8352 | Open PMS mode | Peak shaving<br>Fixed power<br>Mains Power Export | Mains Power Export | If this controller is connected to an external mains measurement, use this parameter to set the open PMS mode.<br><br>If this controller is not connected to an external mains measurement, this parameter is ignored.<br><br>If the application does not include any mains, the controller with the lowest ID is the plant controller. |

## 6.3.2 Using external gensets

You can use open PMS with external gensets. For each ASC controller, you can configure and connect up to 16 external genset power measurements and breaker feedbacks.

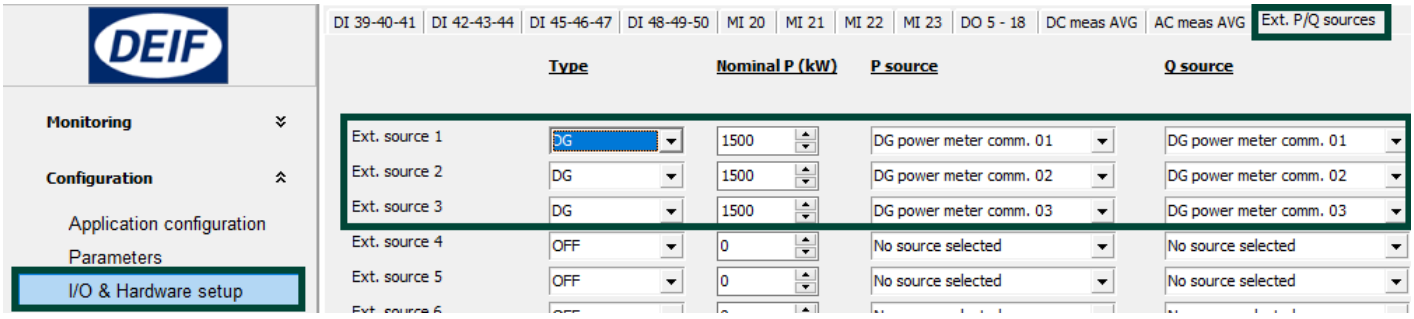
### Application configuration

The application configuration must not include a *Genset* source. Open PMS detects that external genset(s) are present when:

- *Open PMS* (parameter 8351) is *Enabled* in the ASC.
- In the utility software, under *I/O & Hardware setup* > *Ext. P/Q sources*, *Ext. source [1 to 16]*:
  - *Type* is *DG*
  - The nominal power is configured
  - The *P source* (required) is selected
  - The *Q source* (optional) is selected.

If you need to use AGC genset controllers in open PMS, select *DG power comm [1 to 16]*. In *DG meter prot.* (parameter 7721), select *DEIF genset control*.

### Example of external genset configuration




### Genset power measurements

The setup of the genset power measurements and breaker feedbacks for open PMS is the same as the setup for single-controller applications.

**More information**
See Power measurements and connection status for how to set up the genset power measurements and breaker feedback.

### Different types of gensets or power meters

For each ASC controller, you can only have one genset meter protocol (parameter 7721). If the application has more than one set of genset and/or power meter types, connect each set to separate ASC controllers.

Alternatively, if you have a PLC, you can use the DEIF open protocol. The PLC can read the genset power from the different genset and/or power meter types, then write it to the ASC.

## 6.3.3 Using an external mains

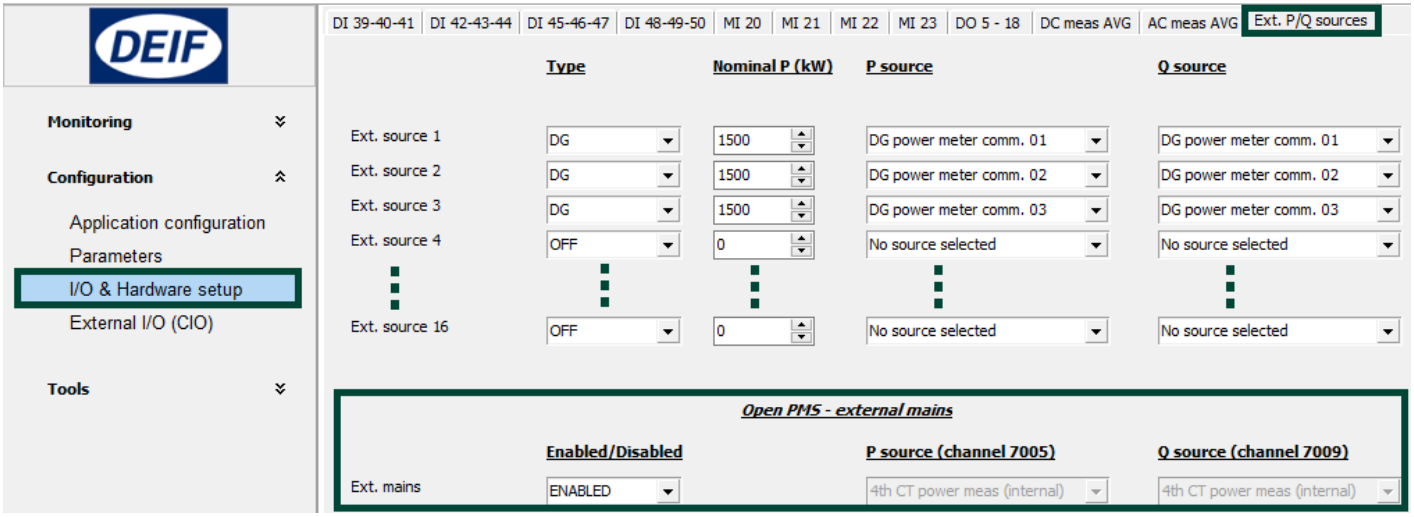
You can use open PMS with an external mains. Configure and connect the external mains power measurement and breaker feedback to one ASC controller. The set points in this ASC controller are used as the open PMS plant set points.

### Application configuration

The application configuration must not include a *Mains* source. Open PMS detects that an external mains is present when:

- *Open PMS* (parameter 8351) is *Enabled* in the ASC.
- *Mains power measure* (parameter 7005): A mains power measurement is selected.
- *Mains Q measure* (parameter 7009) (optional): A mains reactive measurement is selected.
- In the utility software, under *I/O & Hardware setup* > *Ext. P/Q sources* > *Open PMS - external mains*, *Ext. mains* is *ENABLED*.

### Example of external main configuration




### Auto start/stop

To start the application automatically, the ASC with the external mains power measurement must get an *Auto start/stop* signal. This can be from a digital input, M-Logic (*Output* > *Command*), or Modbus communication.

### Operation

For an external mains, the open PMS operating mode is configured in the connected ASC controller. This ASC operates as an *AGC mains lite* controller. The open PMS application uses the ASC set point. The ASC controller sends power references to the other open PMS controllers.

Open PMS supports three power management modes.

For an external mains, it is not possible for the open PMS to synchronise the mains breaker. That is, back sync is not possible.

**Parameters for the ASC with an external mains**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 6071 | Operation mode | See the software. | Power management | This parameter must be **Power management**. |
| 7001, 7002, 7006, 7011-7014 | Peak shaving and mains power export parameters | - | - | If *Peak shaving* or *Mains power export* is selected in parameter 8352, open PMS uses these set points for the plant. |
| 7051 | Fixed power | 0 to 20000 kW | 500 kW | If *Fixed power* is selected in parameter 8352, open PMS uses this set point for the plant. |
| 8022 | Mode update | Update local<br>Update all | Update all | **Update all**: When the mode is changed in the controller, the mode is changed in all open PMS controllers.<br>**Update local**: When the mode is changed in the controller, the other open PMS controllers are not affected. |
| 8351 | **Open PMS** | Not enabled, Enabled | Not enabled | To use open PMS, this parameter must be **Enabled**. |
| 8352 | Open PMS mode | Peak shaving<br>Fixed power<br>Mains Power Export | Mains Power Export | Use this parameter to set the open PMS mode.<br><br>If the controller is not connected to an external mains measurement, this parameter is ignored. |

### Mains power measurements

The setup of the mains power measurements and breaker feedbacks for open PMS is the same as the setup for single-controller applications.

**More information**
See Power measurements and connection status for how to set up the mains power measurements and breaker feedback.

**NOTE** For power meter communication, there can be up to 16 mains nodes (parameter 7726).
**NOTE** If digital inputs are used for the external mains breaker feedback, you must use digital input 47 for *MB position on* and digital input 48 for *MB position off*.
**NOTE** For external mains, the mains breaker position feedbacks do not activate the position failure alarm.

## 6.3.4 Using an AGC mains

You can use open PMS with an AGC 150 mains or AGC-4 Mk II mains controller.

### Application configuration

For open PMS, the configuration of the AGC mains is the same as for standard power management. No additional configuration is needed.

The AGC mains must have a controller ID and be included in the application configuration.

### Auto start/stop

To start the application automatically, the AGC mains must get an *Auto start/stop* signal. This can be from a digital input, M-Logic (*Output > Command Power management*), or Modbus communication.

### Operation

The open PMS operating mode is configured in the AGC mains controller. The open PMS application uses the AGC mains set point.

Open PMS supports the standard AGC mains power management functions, including cos phi set points and mains breaker control.

### AGC mains parameters

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 6070 | Plant mode | Auto mains failure<br>Peak shaving<br>Fixed power<br>Mains power export<br>Load take over | Auto mains failure | Use this parameter to set the plant mode. |
| 7001 to 7253 | Mains parameters | - | - | Configure these parameters as required for the application and plant mode. |
| 7842 | CAN B Protocol | OFF<br>PMS Primary<br>AOP2<br>PMS Secondary<br>Ext. Modules DEIF | PMS Primary | Select **PMS Primary** or **PMS Secondary**. Select the same protocol in the ASC controllers. |
| 8021 | Start/stop | Remote, Local | Remote | **Remote**: For a Modbus auto start/stop signal.<br>**Local**: For a digital input or M-Logic auto start/stop signal. |

## 6.4 Open PMS in operation

When the application is running, open PMS automatically supplies the power that is necessary. This includes active (required) and reactive (optional) power. As a power management system, open PMS supplies power efficiently, safely and reliably.

Power from the external power sources (gensets and/or mains) is included in the available power. Open PMS uses the available power to supply the load.

For maximum efficiency, open PMS automatically maximises the PV power. Open PMS charges and uses the batteries according to the configured settings. As far as possible, open PMS makes sure that the gensets are not run below the minimum load. Rather, open PMS tries to use the mains, solar and storage power so that the gensets run at the optimal genset load.

Open PMS balances the load between the open PMS controllers.

In AUTO mode, open PMS controllers automatically close and open their breakers.

Finally, if there is M-Logic, open PMS deploys the M-Logic in the controller(s).

**NOTE** Open PMS does not control the load sharing, or the connection of the external gensets. Open PMS indirectly controls the power of the external gensets by adjusting the solar, storage and mains set points.

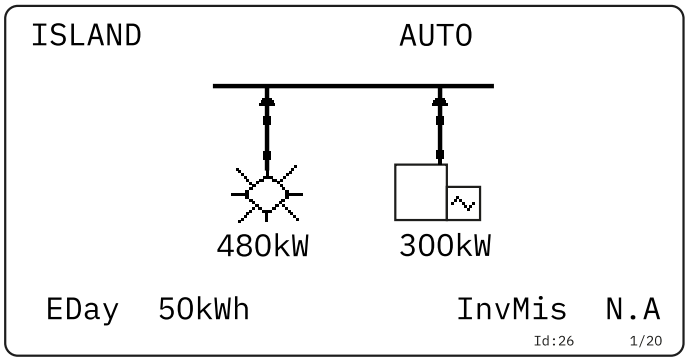
### Examples of ASC 150 displays for open PMS

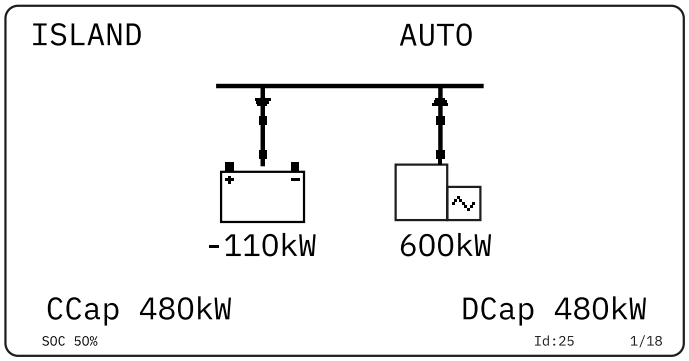
**Island**

ASC 150 Solar
(connected to genset(s))

ASC 150 Storage
(connected to genset(s))

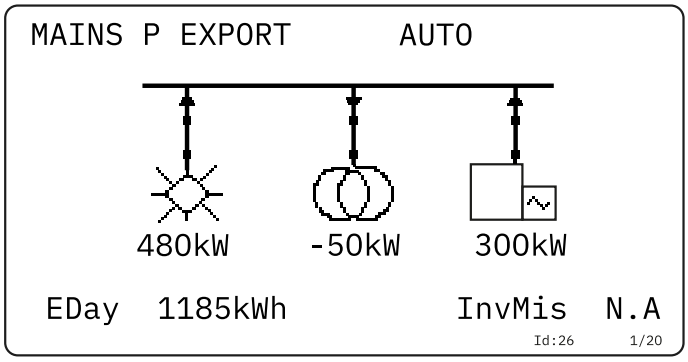
**Island**



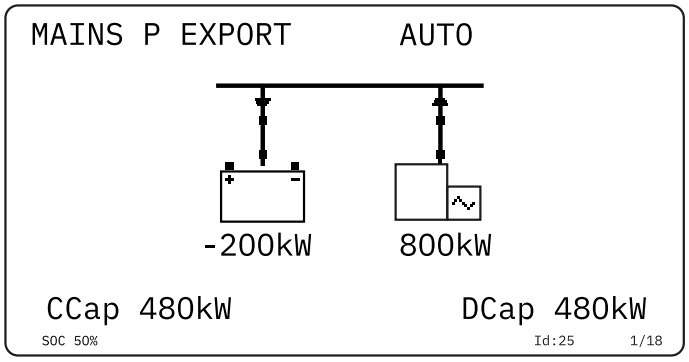




**Grid-tied with external mains**

ASC 150 Solar
(connected to mains and genset(s))

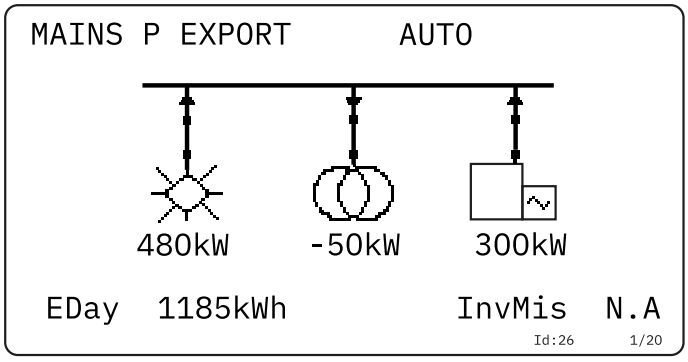



ASC 150 Storage
(connected to genset(s))

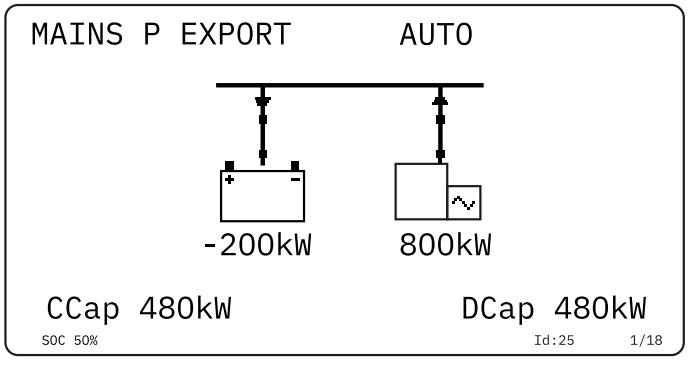



**Grid-tied with AGC mains**

ASC 150 Solar




ASC 150 Storage
(connected to gensets)



# 7. Solar controller functions

## 7.1 Inverter set points

The inverters get a set point from the ASC controller. The ASC can transmit or broadcast the set point to the inverters (for example, SunSpec). Alternatively, if there is a PLC controlling the inverters, the PLC can read the set point from the ASC (DEIF Open).

The set point is calculated so that the inverters always produce as much as possible. The PV penetration will cover the load demand apart from the genset minimum load (island operation).

In grid-tied modes (for example, peak shaving or fixed power), the plant can be set up to stop all engines. This is done by adjusting the minimum number of gensets to run (multi-start) to **0** (the default is **1**) for the AGC Genset controllers.

**More information**
See the **AGC Parameter list** for more information about the genset multi-start parameters.

### 7.1.1 Inverter connection limitations

If the system consists of an inverter type where only a limited number can be connected, additional ASC Solar controllers can be needed.

For ASC 150, the maximum number of inverters is 32 for *Premium* software (16 for *Extended* software).

### 7.1.2 Reactive set points (kvar)

You can use a variety of reactive power regulation methods to regulate the reactive power from the inverters. Reactive power control is supported by most inverters.

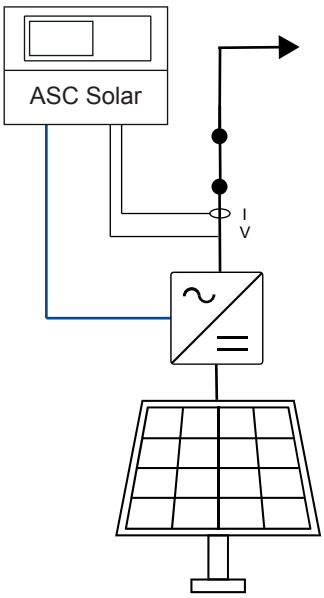
There are parameters for grid-tied and off-grid modes:

| Parameter | Name | Default | Grid-tied | Off-grid | Details |
|---|---|---|---|---|---|
| 7052 | Cosphi ref | 0.9 | ● | | Use this parameter to configure the fixed power cos phi set point. When the PV is running in parallel to the utility with fixed cos phi reference, it follows this set point. |
| 7053 | Cosphi ref | Inductive | ● | | This parameter makes it possible to select inductive or capacitive reference from the cos phi dispatch. |
| 7054 | Contr. sett. Q | 500 kvar | ● | | For a fixed Q [kvar], the inverters use the set point in this parameter. The inverters each supply an equal share of the set point. For example, if the set point is 105 kvar and the application contains 15 inverters, then each inverter will supply 7 kvar. |
| 7055 | Q type grid-tie | Cosphi superior | ● | | See the section below. |
| 7031 | DG cosphi lim I | 0.8 | | ● | The limit of the genset cos phi on the inductive side. For example, if set to 0.95, the genset will only deliver reactive load up to a maximum of 0.95 inductive. If the actual load has characteristic of 0.9, the inverters will carry the remainder from 0.95 to 0.9.<br><br>If there are multiple ASC controllers in the application, the set point for this parameter must be the same in each controller. |
| 7032 | DG cosphi lim C | 1.0 | | ● | The limit of the genset cos phi on the capacitive side. If set to for example 1.00, the genset will not be able to operate with the |

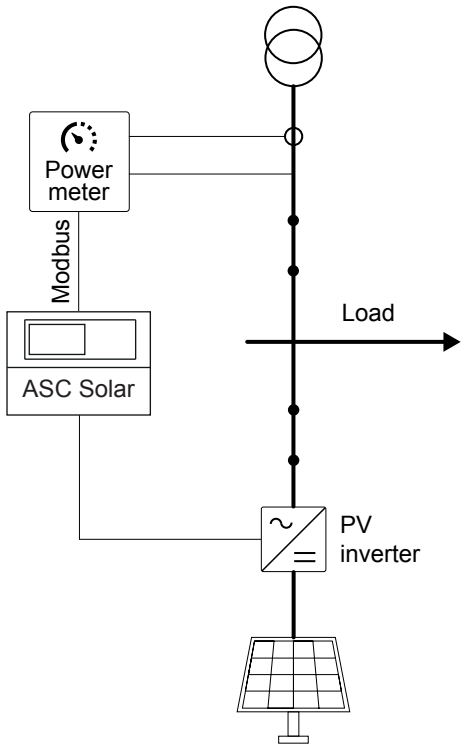
| Parameter | Name | Default | Grid-tied | Off-grid | Details |
|---|---|---|---|---|---|
| | | | | | capacitive power factor (under-excited). If the menu 7031 is set to 1.00 and 7032 is set to 1.00, the genset will not carry any Q at all. The inverters will supply all Q (under the assumption they support it).<br><br>If there are multiple ASC controllers in the application, the set point for this parameter must be the same in each controller. |
| 7033 | Q type off-grid | Off | | ● | If equal var sharing (in percent) is requested between the gensets and the inverters, equal kvar sharing can be enabled in this parameter. If var sharing is switched off, the settings in parameters 7031 or 7032 will be used. |

### 7055, Method of var regulation

- **Off**: No Q control when the MB is closed or when fixed power mode is selected.
- **Cosphi fixed**: The inverters maintain a fixed cos phi (set in parameter 7052).




- **Cosphi imp/exp**: The inverters are regulated against a cos phi set point in parameter 7052.
  - **Measured at the point of connection**: A power meter or measurement transducers are needed to measure the reactive power imported to or exported from the plant. The inverters are regulated accordingly.




- **Cosphi superior**: This is used if the application is a power management application and the cos phi set point is controlled at the AGC mains controller. If one or several ASC controllers are used, it is often more convenient to adjust the cos phi set point from a central point. That is, the AGC mains adjusts the set point, and then transmits the set point to the ASC(s). All ASCs with this setting will follow the AGC mains. If one or several ASCs do not use this setting, they may, for example, use a fixed cos phi set point.
- **Q fixed**: The ASC uses the setting in parameter 7054.
- **Q imp/exp**: This requires a power meter/transducer (see **Cosphi imp/exp**) and the Q ref will maintain measure at the point of connection.

### 7.1.3 Set point communication

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7501 | Comm. bus control P | Enabled<br>Not enabled | Not enabled | **Enabled**: Allows the **P reference** value to be changed over Modbus or Profibus.<br><br>**Not enabled**: The **P reference** value cannot be changed over Modbus or Profibus. |
| 7502 | Comm. bus ctrl cosphi | Enabled<br>Not enabled | Not enabled | **Enabled**: Allows the **cosphi reference** value to be changed over Modbus or Profibus.<br><br>**Not enabled**: The **cosphi reference** value cannot be changed over Modbus or Profibus. |
| 7503 | Comm. bus control Q | Enabled<br>Not enabled | Not enabled | **Enabled**: Allows the **Q reference** value to be changed over Modbus or Profibus.<br><br>**Not enabled**: The **Q reference** value cannot be changed over Modbus or Profibus. |
| 7504 | Comm. bus P Q scale | 1%, 0.1%, or 0.01% | 1% | |

## 7.2 Using nominal settings

The controller uses the nominal settings as the basis for control (including power management) and protection. That is, set points are configured as a percentage of the nominal setting.

You can have more than one set of nominal settings. Using sets of nominal settings allow users to quickly move equipment to new applications.

**More information**
See Nominal settings for general nominal settings information.

### 7.2.1 Setting the nominal apparent power (S)

The nominal apparent power (S) is the basis of all the PMS calculations. The nominal apparent power is the AC capacity of the system. The controller calculates the inverter set point from the nominal apparent power. The maximum inverter set point is the nominal apparent power. This is also true even if the *Instant P max* is more than the nominal apparent power.

For parameter set 1, configure *Nom. S 1* (parameter 6006). Add up the inverter nameplate apparent power (S) for each inverter that the controller controls, and use this value.

**Example of nominal apparent power**

The ASC is connected to **10 identical inverters**. The inverters each have nameplate apparent power of **48 kVA**. The nominal apparent power is therefore 10 x 48 kVA = **480 kVA**.

### 7.2.2 Setting the nominal reactive power (Q)

The nominal reactive power (Q) limits the reactive power that the PV system generates.

For parameter set 1, configure *Nom. Q 1* (parameter 6005). Add up the inverter nameplate reactive power (Q) for each inverter that the controller controls, and use this value.

**Example of nominal reactive power**

The ASC is connected to **12 identical inverters**. The inverters each have nameplate reactive power of **30 kvar**. The nominal reactive power is therefore 12 x 30 kvar = **360 kvar**.

### 7.2.3 Setting the nominal power (P)

The nominal power (P) is the total installed DC capacity of the PV plant in full sunlight. The nominal power is used to calculate the maximum available solar power (*Instant P max*). *Instant P max* is the nominal power derated by actual measurements, for example, POA, BOM, and/or GHI.

For parameter set 1, configure *Nom. P 1* (parameter 6002). Add up the solar panel nameplate power (P) [unit = Wp, or watt peak] for each solar panel that the controller controls, and use this value.

**Example of nominal power**

The ASC is connected to **700** solar panels. The solar panels each have nameplate power of **420 Wp**. The nominal power is therefore 700 x 420 W x 1 kW / 1000 W = **294 kWp**.

# 7.3 Penetration ratio

## 7.3.1 Optimal stability

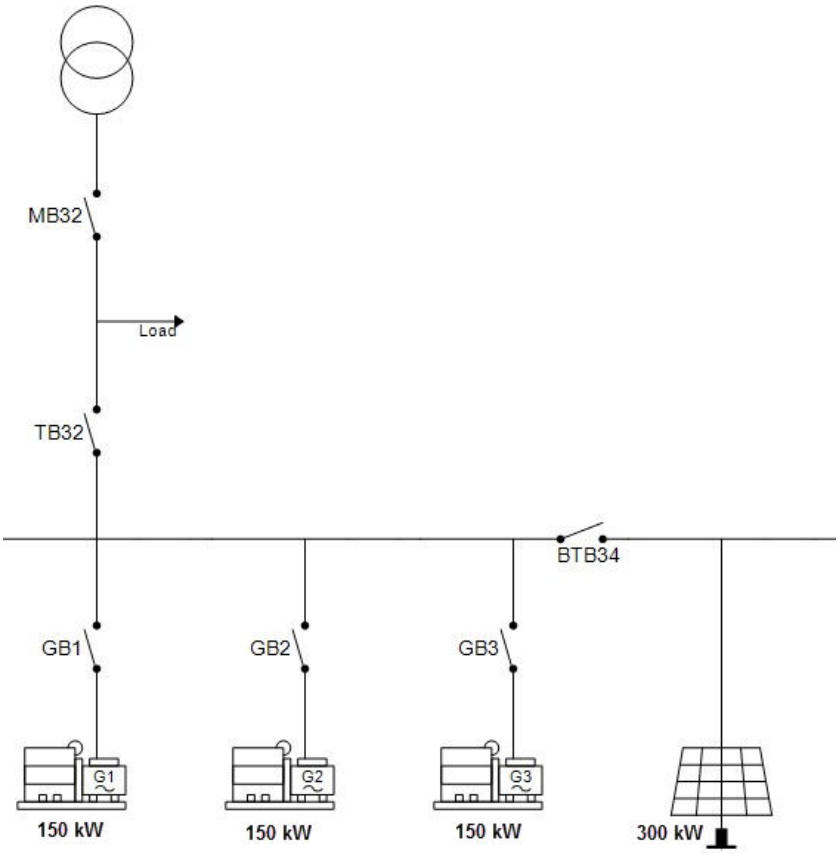
The inverter manufacturers describe a certain penetration rate. Different manufacturers could have different ratios. This could be (example in percent) 25:75, 40:60, 50:50 or 60:40 (PV:Diesel).

It relates to the gensets and inverters connected to the busbar in order to get optimal stability. So for a 400 kW PV plant connected to the busbar, you need to design the system with at least 600 kW diesel machinery for a 40:60 ratio.

There is no setting for this since it is part of the design phase. However, with the DEIF Power management system, a minimum number of gensets connected to the busbar can be adjusted.

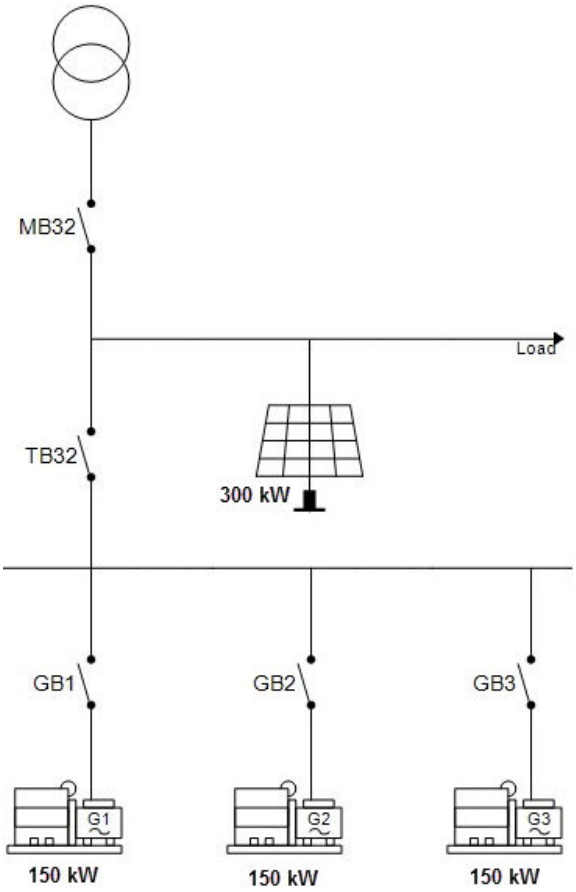
If one genset is too small compared to the PV facility and more than one genset is needed to achieve the correct penetration ratio then a BTB can be used.

**Application example with PV plant and a bus tie breaker**




Keep BTB34 open unless grid-tied or if MB32 is open, then close BTB34 only if more than one (two or three) gensets are connected.

**Application example with PV plant in the load point**




Alternatively, use the mains controller tie breaker to separate the gensets from the PV plant.

## 7.4 Production curtailment

The ASC has a counter that measures the curtailment of the PV penetration.

### 7.4.1 Curtailment definition

The PV system can sometimes produce more power than the application needs. To prevent damage, instability, and/or exceeding a power export set point, the ASC reduces the PV set point.

*Curtailment* is the reduction of the PV power from what could be produced. Curtailment reduces the PV power penetration.

The ASC monitors curtailment, since curtailment shows when the energy production from the PV system is underused.

### 7.4.2 PV capacity

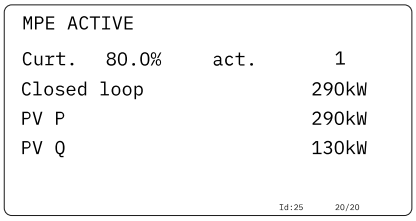
The PV capacity is the maximum PV power that the PV system can produce at a specific time. It is also called *Instant P max*.

The PV capacity calculation is based on the installed number of panels, and their back of module temperatures, as well as the irradiation.

### 7.4.3 Curtailment example

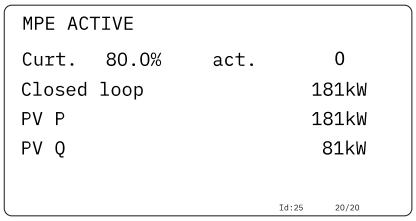
If the PV capacity is 363 kW and the set point requires 363 kW, the PV inverters are not curtailed. If the set point requires 290 kW and the ASC regulates the inverters to run at 290 kW and measures 290 kW, the curtailment is recorded in the curtailment counters. In this example, the curtailment is 73 kW.

You can see in the display unit whether the curtailment counter is operating. When there is curtailment, “act” is 1. The value shown on the display (80 %) is the curtailment threshold set point.




## 7.4.4 Irradiation

If there is a change in the irradiation, the penetration changes. For example, during dusk hours, the capacity decreases. If the ASC measures less power than required from the PV side, the curtailment counter is switched off because it is no longer possible for the PV plant to dispatch the requested power.




In this example, the curtailment threshold set point is 80 %. The curtailment is not active, and so "act" is 0.

## 7.4.5 Curtailment threshold

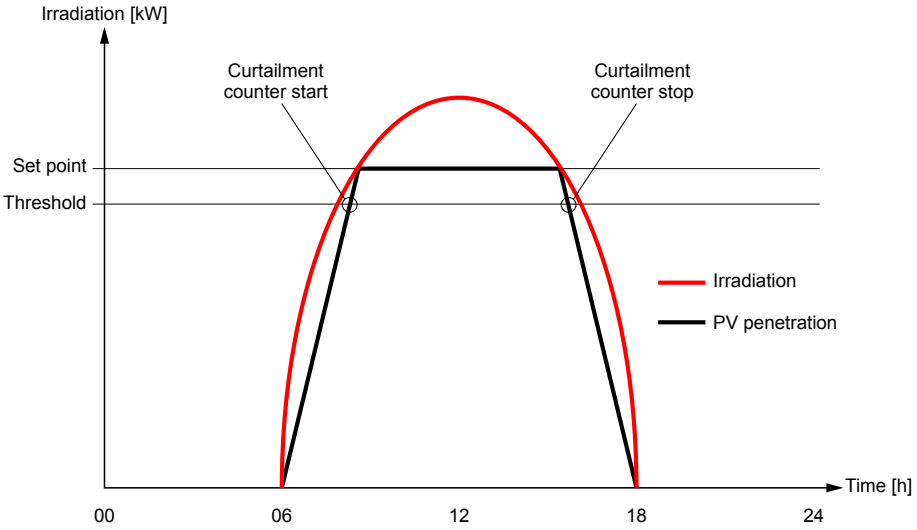
The PV penetration is measured by the ASC. If there are variations from the output of the PV panels compared to the power measured by the ASC, there can be false or missing increments of the curtailment counter.

As an example, the ASC transmits a request to the inverters to deliver 363 kW using the SunSpec Modbus communication. When the ASC measures less than 363 kW, the curtailment counters are off. When the power reaches 363 kW, the curtailment counters are turned on, since it is assumed that more than 363 kW could be available.

The inverters produce the power requested by the ASC. Note that a set point is transmitted, not a regulation signal. Therefore the ASC measurement can differ from the PV measurement, for example, 362.5 instead of 363 kW (depending on CT classes and so on). This can still be considered within the expected range.

The threshold can be adjusted to match the expected deviation between the two systems, so that the curtailment counter starts at the correct level. The curtailment threshold can be up to 100 % (parameter 17341).

**Simplified curtailment threshold diagram**




# 7.5 Weather data

## 7.5.1 Connection to weather data

The ASC has various inputs available. Each input can be used for connection to weather data using an analogue input, PV communication, DEIF open communication, or weather station communication.

| Sensor | Abbreviation | Function |
|---|---|---|
| Plane of array irradiance | POA | POA is used to calculate the maximum active P that the PV plant can produce. There are three POA sensors (parameters 17271, 17273 and 17275). The irradiance can therefore be measured at up to three locations.<br><br>The POA sensors can be weighted against each other (parameters 17291, 17292 and 17293), based on the PV capacity at each location. |
| Back of module temperature | BOM | BOM measurements are used to calculate the maximum active P that the PV plant can produce. There are three BOM sensors (parameters 17281, 17283 and 17285). The back of module temperature can therefore be measured at up to three locations.<br><br>The BOM sensors can be weighted against each other (parameters 17294, 17295 and 17296), based on the PV capacity at each location. |
| Global horizontal irradiation | GHI irr. | For Instant P max. calculation, GHI irr. can be used instead of a POA sensor (parameter 17311) |
| Ambient temperature | Ambient temp. | Readings only (parameter 17313) |
| Relative humidity | Rel. humidity | Readings only (parameter 17315) |
| Barometric pressure | Barometric pres | Readings only (parameter 17321) |
| Wind speed | | Readings only (parameter 17323) |
| Wind direction | | Readings only (parameter 17325) |
| Rain fall | | Readings only (parameter 17331) |
| Snow depth | | Readings only (parameter 17333) |

### 7.5.2 Connection to POA and BOM sensors

Three POA and three BOM sensor inputs can be configured. The controller uses the measurements from these sensors to calculate the available PV power (*Instant P max*). The controller needs to know how much PV power is available for power management.

The setup of these sensors depends on the site.

If sensors are missing, a standard value is used for the missing sensors (1000 W/m$^2$ for POA, and 25 °C for BOM).

#### POA and BOM sensor weighting example

The PV installation has the following locations:

- Area A: 500 panels, 250 Wp each
- Area B: 450 panels, 250 Wp each
- Area C: 600 panels, 265 Wp each

Total installation = 500 x 250 + 450 x 250 + 600 x 265 = 396.5 kWp

- POA and BOM weighting for Area A = 500 x 250 / 396500 = 32 %
- POA and BOM weighting for Area B = 450 x 250 / 396500 = 28 %
- POA and BOM weighting for Area C = 600 x 265 / 396500 = 40 %

The following table shows an example of how the sensor weights can be used during operation.

| Area | POA measurement | BOM measurement | Weight | POA contribution | BOM contribution |
|---|---|---|---|---|---|
| **A** | 1000 W/m$^2$ | 40 °C | 32 % | 320 | 12.8 |
| **B** | 1000 W/m$^2$ | 30 °C | 28 % | 280 | 8.4 |
| **C** | 800 W/m$^2$ | 20 °C | 40 % | 320 | 8.0 |
| **Total** | | | | **920 W/m$^2$** | **29.2 °C** |

## 7.6 Derate inverter

The inverters have an apparent power rating, so the derate is based on S [kvar]. The inverters can be derated, for example, based on the ambient temperature.

**More information**
See **Weather data** for Instant P max derating based on BOM and POA readings. P max relates to the Wp of the installed panels.

**More information**
See **Derate inverter instant Q-Max (capability curve)** for derating of the Q [kvar] production.

| Derate function | Unit | Term used |
|---|---|---|
| S | kVA | Instant S-max |
| P | kW | Instant P-max |
| Q | kvar | Instant Q-max |

The derate function allows the controller to reduce the maximum output power of the inverter as required. Up to three derate curves can be used to derate the inverter independently of each other. The first curve active derates the inverter to the adjusted set point.

## 7.6.1 Derate inputs

The derate function can be configured to one of the following inputs:

| Input |
|---|
| Multi-input [20 to 23] |
| M-Logic |

Select the needed inputs in **6240-6250-6260 Instant S-max.**

## 7.6.2 Derate parameters

The parameters that define the derate characteristics are the following:

### Start derate point (6240/6250/6260 Instant S max derate)

This is the setting where the derating must start. The setting can be in mA (max. 20 mA) or in Celcius °C (max. 200°C).

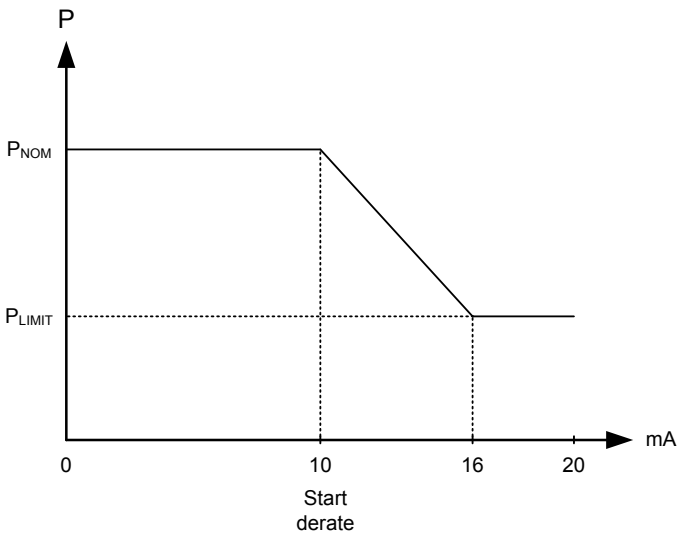
### Slope (6243/6253/6263 Instant S max derate)

Adjust the derating speed. The adjustment is in percent per unit. If the 4 to 20 mA input is used, the derating is in %/mA. If the Pt100/Pt1000/RMI input is used, the derating is in %/C.

**NOTE** For the 4 to 20 mA input, the minimum and maximum settings can be configured. The *Start derate point* and *Slope* settings use these new settings.

### Derate limit (6246/6256/6266 Instant S max derate)

This is the lowest derate level:

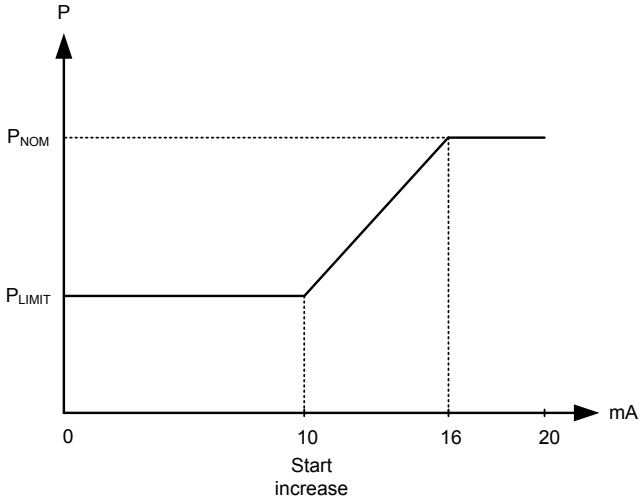



## 7.6.3 Derate characteristic

It can be selected whether the derating should be proportional or inverse proportional. The drawing above shows inverse proportional derating.

Select the derate characteristic in *6241/6251/6261 Instant S max derate*. *Enabled*: Proportional derating. *Not enabled*: Inverse proportional derating.

### Proportional derating




The inverter is derated when the control value is lower than the set point. In the example above, the control value is a mA signal.

## 7.7 Derate inverter instant P-max

Three POA (Plane Of Array) sensors and three BOM (Back Of Module) sensors can be connected. In addition, one GHI sensor can be connected. See Connection to weather data.

The POA/GHI and BOM are weighed together (parameter 17301) to calculate an instant P-Max of the inverters (panels). For example, if the module temperature increases, the capacity of the modules decreases. In general, the instant P-max derate follows a power temperature coefficient model (parameter 17303). The default is -0.38 %/°C.

### Parameters

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 17301 | Instant P max. | POA + BOM<br>GHI + BOM<br>No sensors | POA + BOM | Select the basis for the instant P max calculation. See below. |
| 17303 | P temp. coeff. | -0.99 to 0 %/°C | -0.38 %/°C | Select the power derating coefficient. |
| 17305 | Irradia. sensor | 50 to 200 % | 100 % | Multiplier for the POA/GHI irradiance sensor input.<br>• Use > 100 % for reduced sensor output (for example, dirt or shadow on the sensor).<br>• Use < 100 % for sensor output too high (for example, dirt or shadow on the panels). |

### POA + BOM

The ASC uses the back of module temperature with the plane of array to derate the maximum PV power.

### GHI + BOM

The ASC uses the back of module temperature with the global horizontal irradiation to derate the maximum PV power.

### No sensors

The ASC requests the maximum PV power allowed by the power management system (PMS). This is to make sure that the system uses as much PV power as possible.

Without sensors, the PMS cannot know whether more PV power is available. For power management calculations, the ASC therefore uses the actual PV power.

**NOTE** When the controller is connected to a system with no sensors, there is a slower power ramp-up.

# 7.8 Flowcharts

## 7.8.1 Functions

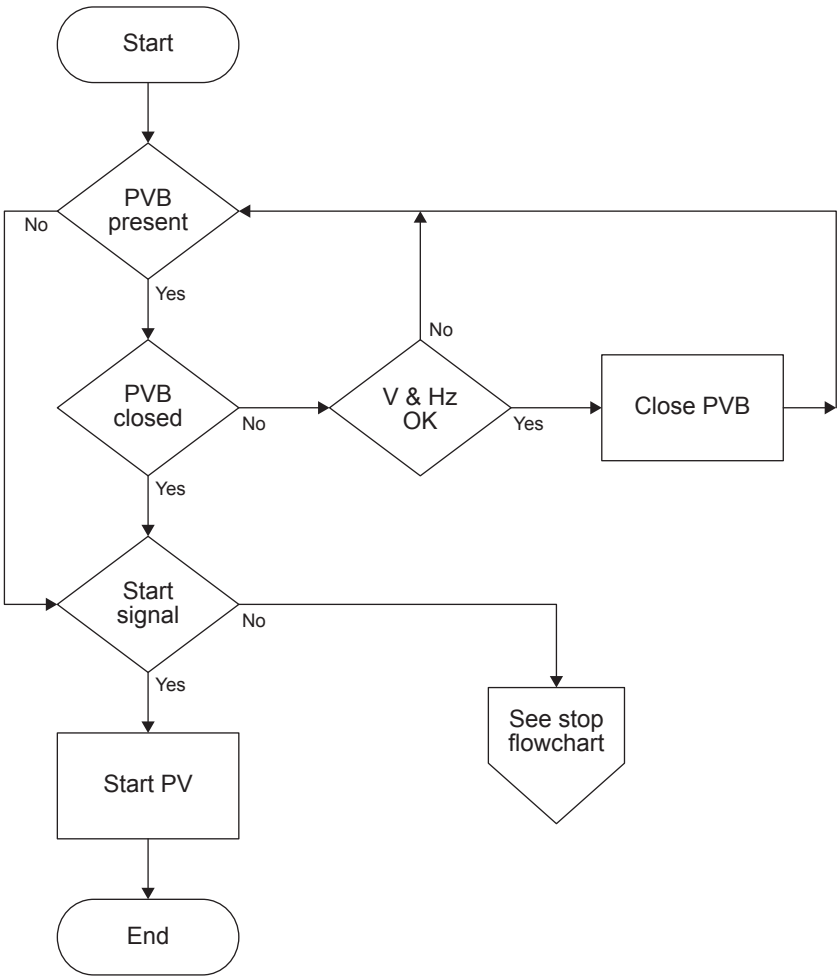
The following flowcharts show the most important function principles. The functions included are:

- Start sequence
- Stop sequence

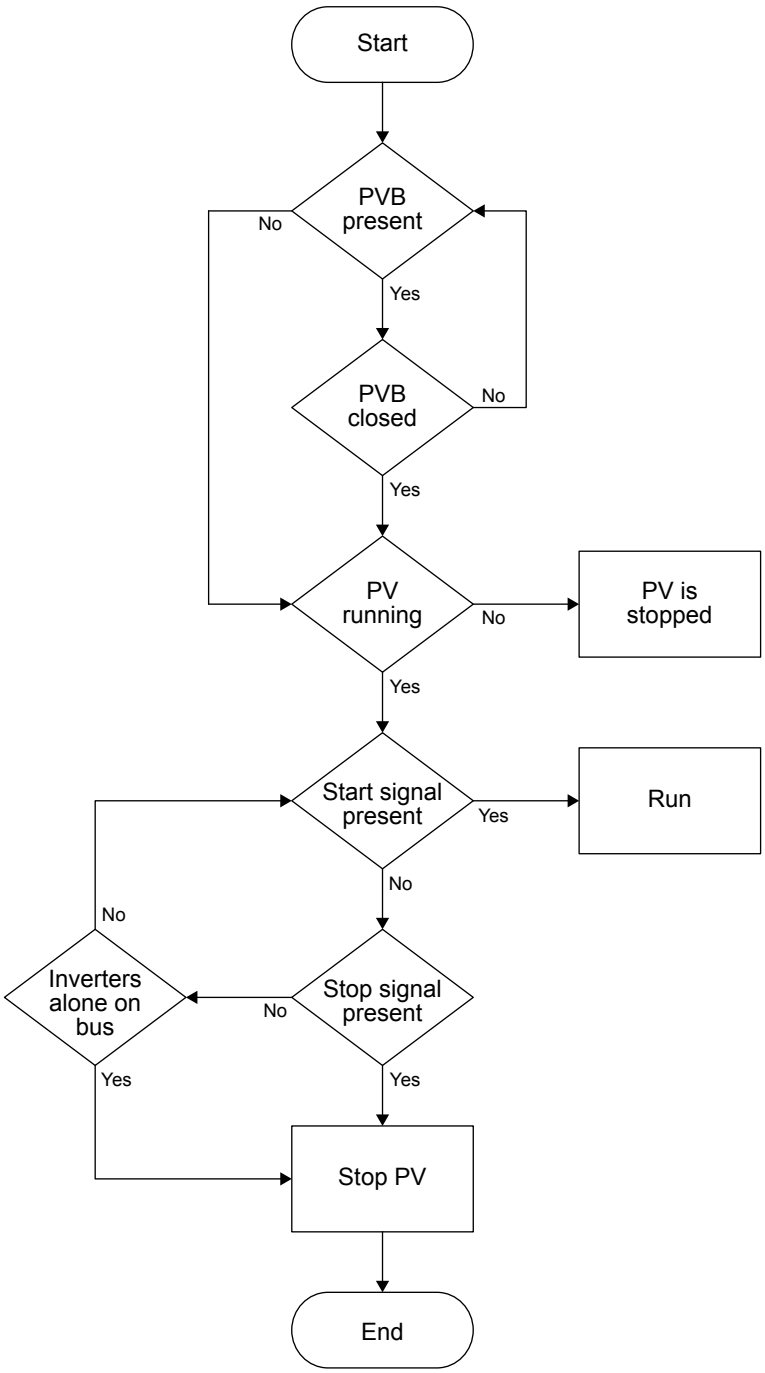
Flowcharts for the mode descriptions are in the **AGC Designer's handbook**.

**NOTE** These simplified flowcharts are only for guidance.

## 7.8.2 Start sequence



### 7.8.3 Stop sequence




## 7.9 Modes of operation

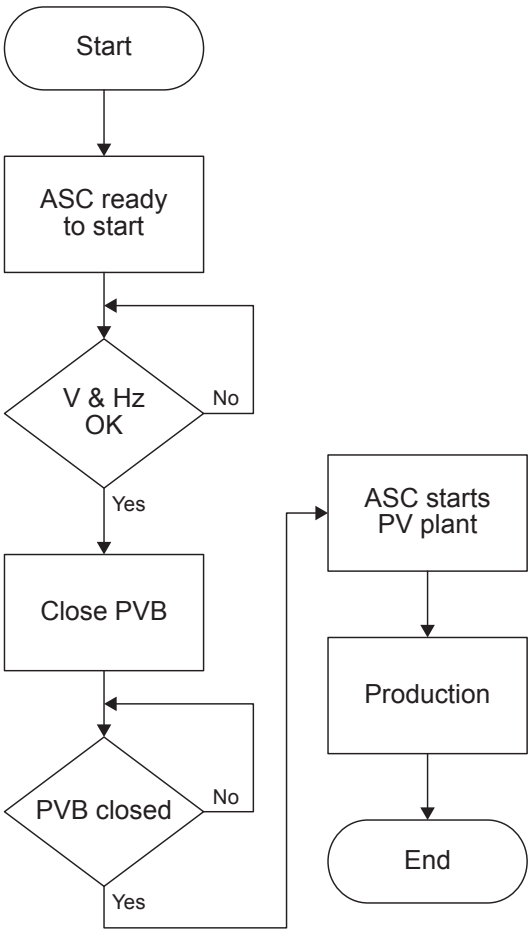
### 7.9.1 Operation mode

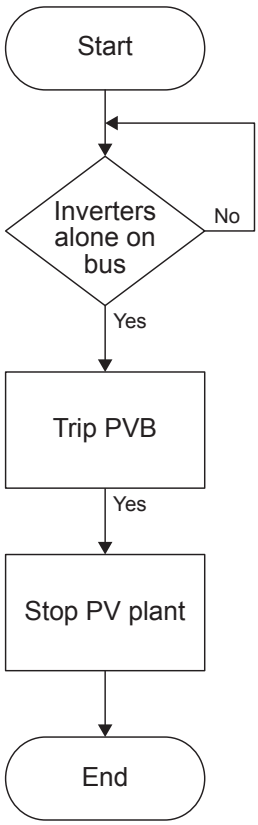
The ASC can be operated in semi mode (local) or in automatic mode (remote). In automatic, the system will close the PV breaker (if present) and start PV penetration if the plant has a start signal.

Rules for PV operation:

- The PV plant can only be started if the PVB (if present) is closed.
- The PVB can only be closed if the busbar voltage and frequency are inside the defined window.
- The PV plant can only be started if the PV voltage and frequency are inside the defined window.
- If neither a DG nor mains is connected to the busbar, the PVB is opened.

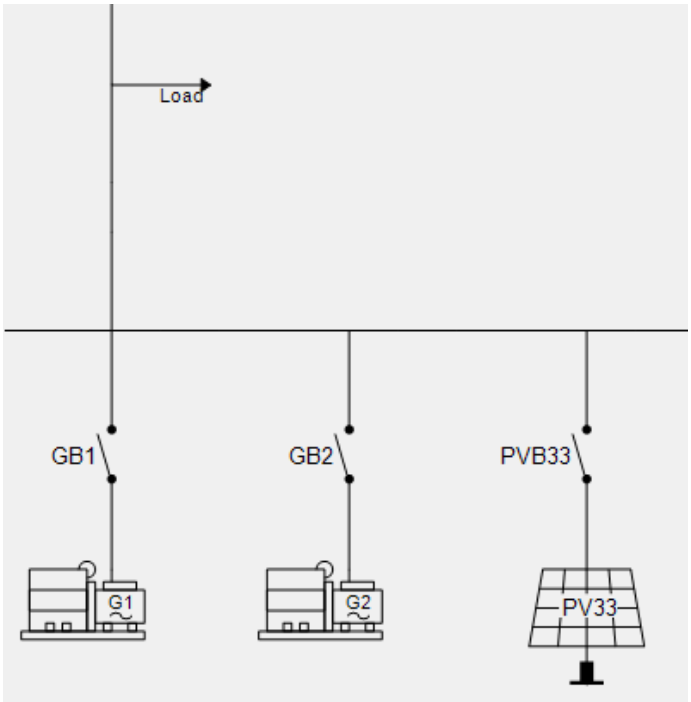
- If the PVB is open, the PV plant is stopped.




## 7.9.2 Island start

This is how the plant starts in island operation (with the controllers in AUTO and power management on).




1. Activate the start signal on the AGC DG.

2. The genset(s) start and connect to the busbar.
3. When the busbar is energised, the ASC starts and connects the inverters.
4. The inverters follow the ASC ramp up curves. The inverters ramp up until the genset minimum load is reached.

### 7.9.3 Island operation

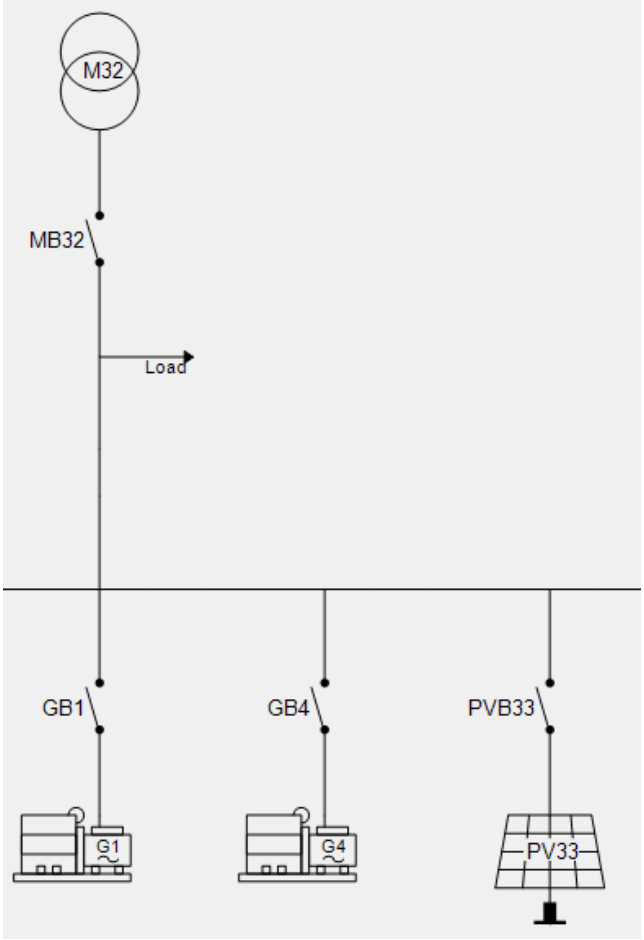
During island operation the connected genset load can be between -50 and 100 % of engine nominal power. The *Min DG load 01/02* parameters on the ASC are shared parameters that ensure all engines connected to the busbar are loaded to the same level. Since the gensets are in frequency control mode, the inverters regulate the power. If the gensets are loaded more than the parameter set point, then the inverters are regulated up to take over load from the gensets and vice versa.

**Minimum generator load parameters**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 15011 | Min DG load 01 | -50 to 100 % | 30 % | Sets the minimum load level for all gensets connected to the busbar. |
| 15012 | Min DG load 02 | -50 to 100 % | 30 % | Sets the minimum load level for all gensets connected to the busbar. |
| 15013 | Min DG load set | Min. DG load set 1<br>Min. DG load set 2 | Min. DG load set 1 | Selects the active minimum genset load setting. |

### 7.9.4 Parallel mains start

This is how the plant starts when there is a mains connection (with the controllers in AUTO and power management on).

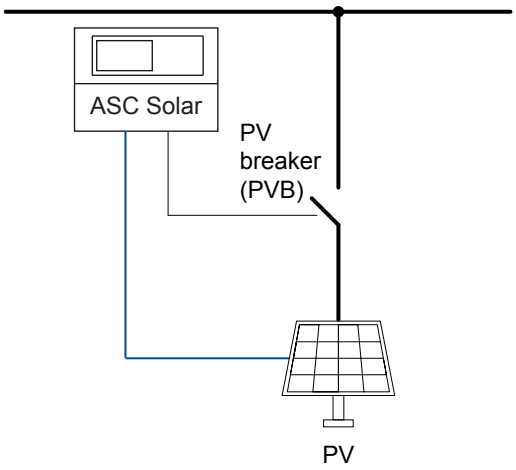



1. Activate the start signal on the AGC Mains.
2. When the mains breaker is closed and the busbar is energised, PV penetration starts.

3. The required number of gensets start (minimum zero, one or two in this example).
4. When the plant is operational and the requested set point is reached, the minimum number of gensets run, according to the run settings and load demand.

## 7.9.5 Fixed power

### Single-line diagram




### AUTO mode

When the controller is in AUTO mode, it automatically starts the PV system and connects to the busbar. The fixed power is sent to the PV system as the set point. If the PV system can produce more power than required, it is curtailed.

For fixed power, the controller does not need power measurements from other power sources, for example, the mains power measurement.

### SEMI AUTO mode

If the PV system is already connected to the busbar, as required, the PV is curtailed so that it does not exceed the fixed power set point.

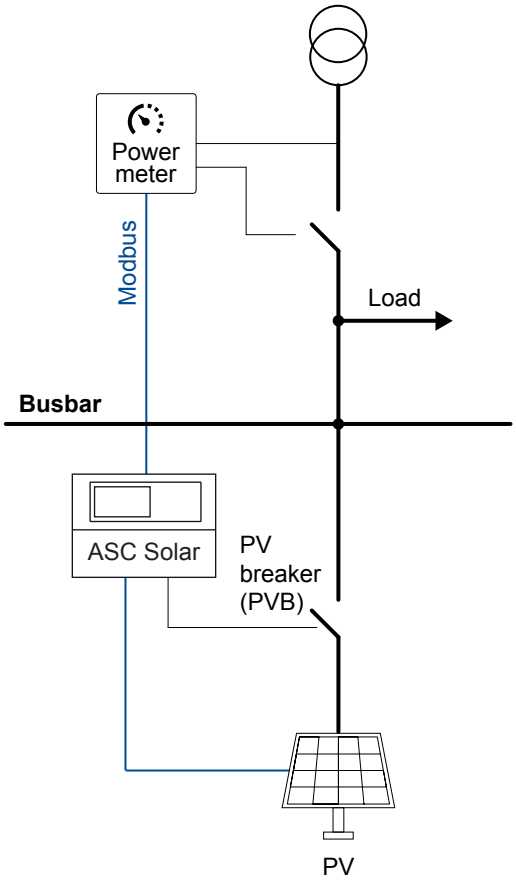
If the PV system is not connected to the busbar, the operator has to start the PV system and close the PV breaker.

### Parameters

| Parameter | Text | Range | Default |
|---|---|---|---|
| 7051 | Fixed power | 0 to 20000kW | 500 kW |
| 7056 | FP scale | 1kW:1kW<br>1kW:10kW<br>1kW:100kW<br>1kW:1000kW | 1kW:1kW |

## 7.9.6 Mains power export

### Single-line diagram



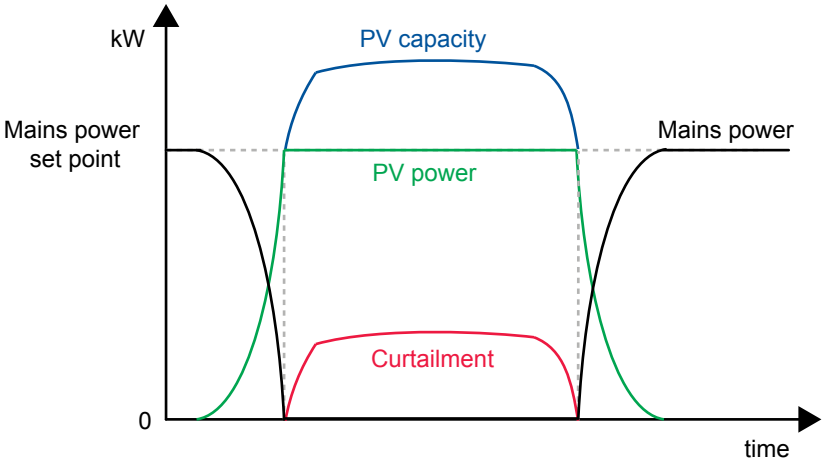

### AUTO mode

The mains power export mode can be used to maintain a constant level of exported or imported power through the mains breaker.

The mains power measurement is required. See **Mains power measurement**.

The ASC monitors the mains power. As required, the ASC curtails the PV power, so that the mains power export set point is not exceeded.

### Mains power export example




### SEMI-AUTO mode

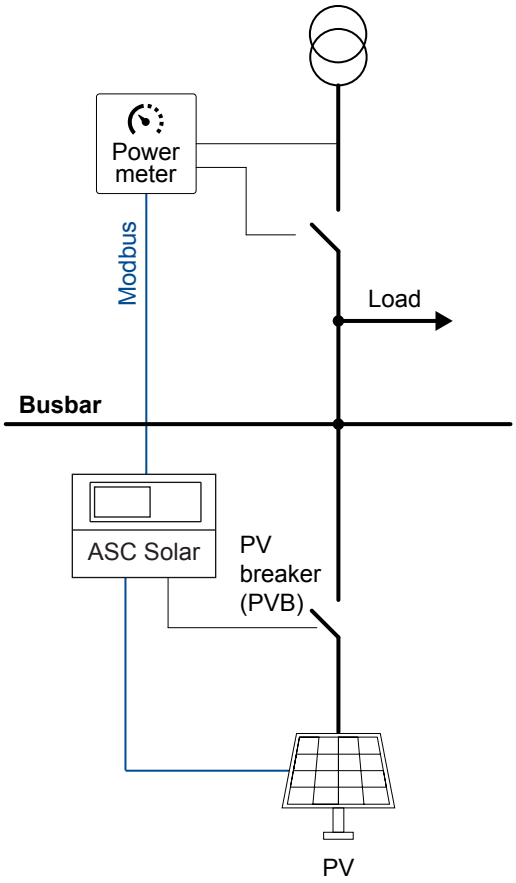
When the PV is paralleled to the mains, as required, it is curtailed to meet the mains power export set point.

**Parameters**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 7001 | Day setting | -20000 to 20000kW | 750 kW |
| 7002 | Night setting | -20000 to 20000kW | 1000 kW |
| 7006 | MPE/PS scale | 1kW:1kW<br>1kW:10kW<br>1kW:100kW<br>1kW:1000kW | 1kW:1kW |
| 7011 | Start Hour | 0 to 23 | 8 |
| 7012 | Start Minute | 0 to 59 | 0 |
| 7013 | Stop Hour | 0 to 23 | 16 |
| 7014 | Stop Minute | 0 to 59 | 0 |

## 7.9.7 Peak shaving

**Single-line diagram**

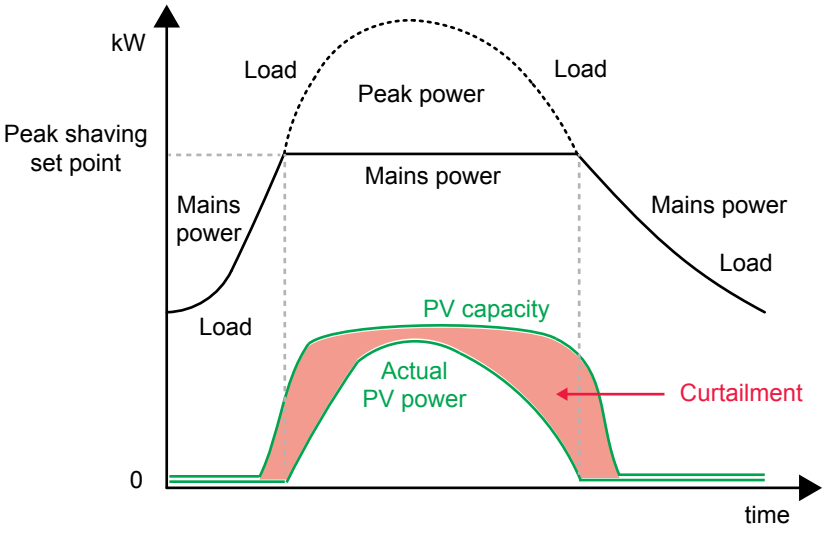



**AUTO mode**

When the mains import increases above the maximum mains import set point, the PV system supplies the extra load, to keep the mains import at the maximum import level.

The mains power measurement is required. See **Mains power measurement**.

**Peak shaving example**




**SEMI AUTO mode**

When the PV system is parallel to the mains, as required, the PV is curtailed according to the peak shaving set point. The maximum mains import is not exceeded in spite of the SEMI AUTO mode.

**Parameters**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 7001 | Day setting | -20000 to 20000kW | 750 kW |
| 7002 | Night setting | -20000 to 20000kW | 1000 kW |
| 7006 | MPE/PS scale | 1kW:1kW<br>1kW:10kW<br>1kW:100kW<br>1kW:1000kW | 1kW:1kW |
| 7011 | Start Hour | 0 to 23 | 8 |
| 7012 | Start Minute | 0 to 59 | 0 |
| 7013 | Stop Hour | 0 to 23 | 16 |
| 7014 | Stop Minute | 0 to 59 | 0 |

# 7.10 Regulation

## 7.10.1 Load ramps

To avoid oscillations, load ramps (up and down) can be configured for both power and reactive power.

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 2611 | P ramp up | 0.1 to 20 %/s | 2 %/s | Limits the rate of power increase from the PV system. |
| 2621 | P ramp down | 0.1 to 20 %/s | 2 %/s | Limits the rate of power decrease from the PV system. |
| 2622 | Ramp open point | 1 to 20 % | 5 % | The breaker cannot open during the ramp down until the load is below this point. |
| 2641 | Q ramp up | 0.1 to 100 %/s | 2 %/s | Limits the rate of reactive power increase from the PV system. |
| 2642 | Q ramp lim. max | 1 to 110 % | 90 % | The controller ignores the Q ramp if the reactive power is below this value. |

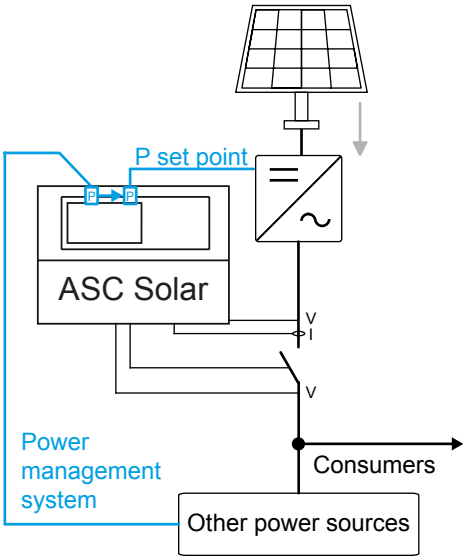
| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 2651 | Q ramp down | 0.1 to 100 %/s | 2 %/s | Limits the rate of reactive power decrease from the PV system. |
| 2652 | Q ramp lim. min | -20 to 50 % | -10 % | The controller ignores the Q ramp if the reactive power exceeds this value. |

The reactive power ramp rates are adjusted according to the nominal rating of the inverters (S=[kVA]).

If the genset has reverse power, the ramps are ignored.

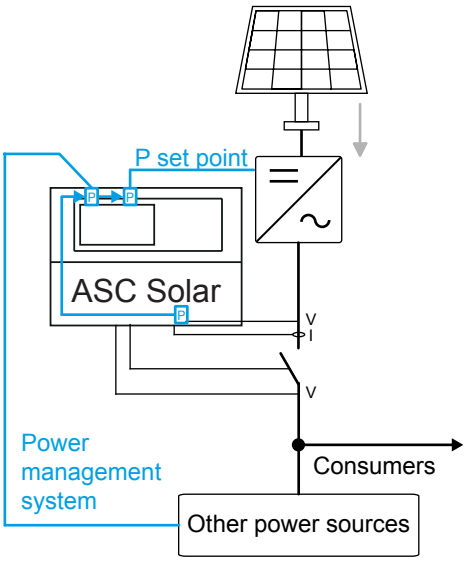
## 7.10.2 Closed loop

### Open loop




By default, *Closed loop* (parameter 2631) is **Not enabled**. The ASC sends the power set point from the power management system to the PV system.

### Closed loop




To use the closed loop function, select **Enable** for *Closed loop* (parameter 2631).

The closed loop function is useful if:

- One or more PV inverters do not produce the expected power. This may be due to different PV panel angles. PV failures and/or manual stops can also cause lower than expected power.
- The inverters are very far from the ASC.

To compensate, the ASC can use its AC measurements to adjust the power set point to the PV system.

### 7.10.3 Continuous writing of P/Q

In general, you can enable writing the **P ref** to the inverter(s) in *P reference* (parameter 2781). Similarly, you can enable writing the **Q ref** to the inverter(s) in *Q reference* (parameter 2782).

Some inverters cannot process a lot of data from the ASC. For these inverters, use *P ref. enable* (parameters 2783) and *Q ref. enable* (parameter 2784) to disable continuous writing of **P ref** and **Q ref**.

Note: This feature is only available when using the **SunSpec Generic** PV protocol.

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 2783 | P ref. Enable | Enabled<br>Not enabled | Enabled | **Enabled**: The controller continuously sends the state of the **P reference** parameter (2781) to the inverter.<br><br>**Not enabled**: The controller only sends the state of the **P reference** parameter (2781) to the inverter when the state changes. |
| 2784 | Q ref. Enable | Enabled<br>Not enabled | Enabled | **Enabled**: The controller continuously sends the state of the **Q reference** parameter (2782) to the inverter.<br><br>**Not enabled**: The controller only sends the state of the **Q reference** parameter (2782) to the inverter when the state changes. |

### 7.10.4 RRCR external set point control

The grid can use a Radio Ripple Control Receiver (RRCR) for load management. The ASC can use the RRCR signals for power and reactive power regulation.

You can use four binary inputs (from an external RRCR) to configure 16 signal combinations. Each of the 16 signal combinations can used for a set point for *Power*, and a set point for *Reactive Power* or *cos phi*.

You can also make combined set points, for example, *Power* and *Reactive Power*, using the same inputs.

For feedback to the RRCR, you can use four relay outputs to configure 16 signal combinations. This feedback can only be used to represent the *Power* set point.

**More information**
See **RRCR configuration** in the **AGC-4 Mk II Designer's handbook** for how to use the utility software to configure RRCR.

## 7.11 Fail class

All activated alarms must be configured with a fail class. The fail classes define the category of the alarms and the subsequent alarm action. You can use the display or the utility software to select the fail class for each alarm.

These fail classes have different actions that depend on the running status of the inverter.

### 7.11.1 Inverter running

| Fail class/action | Alarm horn relay | Alarm display | Trip PV breaker | Stop inverter | Trip mains breaker |
|---|---|---|---|---|---|
| Warning | ● | ● | | | |
| Trip PVB | ● | ● | ● | | |
| Shutdown | ● | ● | ● | ● | |
| Trip MB | ● | ● | | | ● |

Example: An alarm with the fail class *Shutdown* is activated:

- The ASC activates the alarm horn relay.
- The ASC displays the alarm on the alarm info screen.
- The ASC opens the inverter breaker immediately.
- The ASC stops the inverter immediately.
- The inverter cannot be started from the ASC (see next table).

### 7.11.2 Inverter stopped

| Fail class/action | Alarm horn relay | Alarm display | Block inverter start | Block PVB sequence | Trip mains breaker |
|---|---|---|---|---|---|
| Warning | ● | ● | | | |
| Trip PVB | ● | ● | | ● | |
| Shutdown | ● | ● | ● | ● | |
| Trip MB | ● | ● | | | ● |

## 7.12 Alarm inhibit

To limit when the alarms are active, each alarm has configurable inhibit settings. The inhibits are only available in the utility software.

Each alarm has a drop-down window where you can select which conditions have to be present to inhibit the alarm. You can select more than one inhibit. The alarm is inhibited as long as at least one of the selected inhibits is active.

| Inhibit | Description |
|---|---|
| Inhibit 1 | M-Logic outputs: The conditions are programmed in M-Logic. |
| Inhibit 2 | |
| Inhibit 3 | |
| PVB on | The PV breaker is closed. |
| PVB off | The PV breaker is open. |
| Run status | The PV voltage and frequency is okay, and the timer in parameter 6160 has expired. |
| Not run status | The PV is off, or the timer in parameter 6160 has not expired. |
| PV voltage > 30 % | The PV voltage is above 30 % of the nominal voltage. |
| PV voltage < 30 % | The PV voltage is below 30 % of the nominal voltage. |
| MB on | The mains breaker is closed (single controller application). |
| MB off | The mains breaker is open (single controller application). |
| Parallel | Both the PVB and MB are closed. |
| Not parallel | Either the PVB or MB can be closed, but not both. |

**NOTE** Function inputs, such as remote start or access lock, are never inhibited. Only alarm inputs can be inhibited.

## 7.13 Mode overview

**AUTO**: The controller operates automatically, and the operator cannot initiate any sequences manually.

**SEMI-AUTO**: The operator has to initiate all sequences. This can be done using the buttons, Modbus commands, or digital inputs. When started, the PV runs at the nominal values.

### 7.13.1 SEMI-AUTO mode

The controller can be operated in SEMI-AUTO mode. This means that the controller does not initiate any sequences automatically. It only initiates sequences if external signals are given.

An external signal may be given by:

1. Buttons on the display
2. Digital inputs*
3. Modbus commands

**NOTE** * The controller has a limited number of digital inputs. See **Digital inputs** for availability.

**SEMI-AUTO mode commands**

| Command | Description |
|---|---|
| Start | The PV start sequence is initiated |
| Stop | The PV is stopped. |
| Close PVB | The controller closes the photovoltaic breaker if the mains breaker is open, or synchronise and close the photovoltaic breaker if the mains breaker is closed. |
| Open PVB | The controller ramps down and opens the photovoltaic breaker at the breaker open point if the mains breaker is closed. The controller opens the photovoltaic breaker instantly if the mains breaker is open or the ASC is in island mode. |
| Close MB | In a single controller application, to be certain that there is no voltage on the busbar, the controller closes the photovoltaic breaker. If there is no voltage, the controller closes the mains breaker. |
| Open MB | In a single controller application, the controller opens the mains breaker instantly. |

### 7.13.2 Not in AUTO mode

This function activates an alarm if the system is not in AUTO mode.

**`Functions > Not in Auto`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6541 | Timer | 10.0 to 900.0 s | 300.0 s |
| 6544 | Enable | OFF<br>ON | OFF |
| 6545 | Fail class | Fail classes | Warning |

## 7.14 PV power measurements

By default, the ASC calculates the PV power from the ASC AC measurements. However, you can select another source for the PV power measurements.

**Basic settings > Measurement setup > Wiring connection > Power measure origin**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7021 | PV power | ASC measurements<br>PV communication<br>DEIF open communication<br>Power meter comm. | ASC measurements | Select the measurement for the PV power. |

### 7.14.1 PV meter

To use a PV meter, select *Power meter comm.* in parameter 7021.

**Communication > Power meter > PV meter**

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7702 | PV meter ID | 1 to 247 | 3 | Select the PV power meter ID. |
| 7723 | PV meter prot. | **See DEIF Hybrid controller compatibility** | Off | Select the protocol that matches your power meter. Additional protocols may be available. Contact DEIF for details. |
| 7724 | PV nbr. nodes | 1 to 16 | 1 | Select the number of external PV meters. |
| 7740 | PV meter err. | Fail classes | Warning | If enabled, this alarm activates when there is no communication from the PV power meter. |

You can also configure these settings from the display, under `Settings > Communication > Power meter > PV meter settings`

**NOTE** You can only use a PV meter if you have *Premium* software.

## 7.15 Additional power measurements

### 7.15.1 Busbar AC measurements

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 7022 | BB PV V/f meas | ASC measurements<br>PV communication | ASC measurements | **ASC measurements**: The ASC uses its own measurements for the busbar voltage and frequency.<br><br>**PV communication**: The ASC uses the measurements from the PV communication for the busbar voltage and frequency. See the requirements below. |

#### Requirements for measurements from PV communication

- **Externally controlled PV breaker, or no PV breaker**: If the application is changed so that the ASC controls the PV breaker, the ASC activates the *Unsupported application* alarm.
- **Voltage and frequency values must be available from the inverter(s)**: The inverter protocol must include the voltage and frequency values (at least one phase-phase or phase-neutral voltage measurement).
- **Communication with the inverter(s)**: If the ASC cannot communicate with the inverter(s), it activates the *PV comm. error* alarm (menu 7570).
- **Default scaling**: *Scaling* (parameter 9031) must be *100 to 25000 V*.

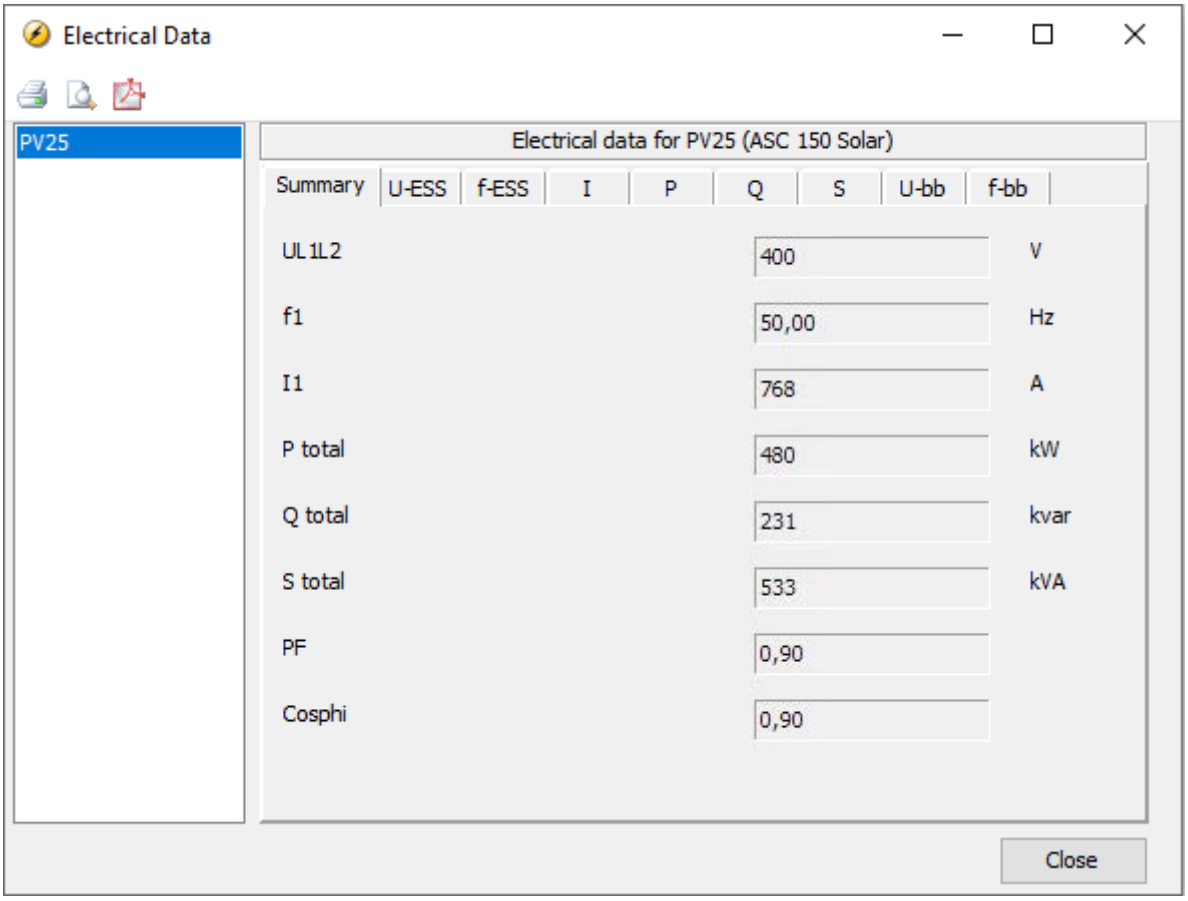
#### V/f from communication failure

If the PV communication fails, the controller activates the *V/f from com. fail* (menu 7023) alarm. To avoid dangerous situations, the default alarm action is *Shutdown*.

When this alarm is activated, on the display, the PV icon, mains icon, and load lines turn yellow and flash.

## 7.15.2 Electrical data monitoring

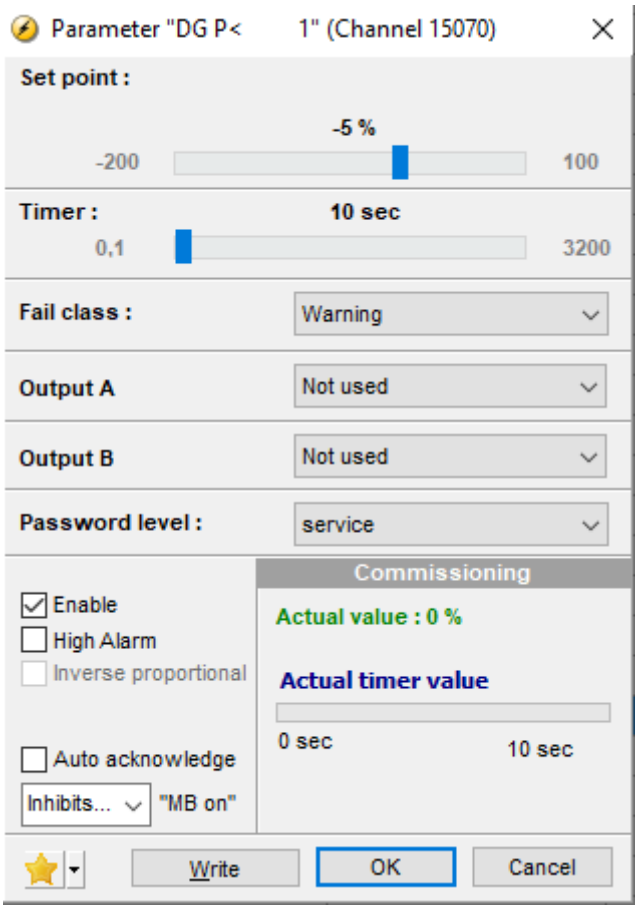
In the utility software, under *Application supervision*, select *Electrical Data* to open the *Electrical Data* window.




## 7.15.3 Genset reverse power

The ASC monitors the genset production using the measurements from the power meter (over Modbus) (or, alternatively, input from transducers). The ASC can activate an alarm if the genset has reverse power (menu 15070 or 15080). The alarm is typically used in ASC stand-alone mode (fuel saving, without power management). In the full power management solution, the power management system is automatically given the state via the PMS data from the gensets.

By default, the alarm is not enabled. The alarm action can be selected in the fail class menu. For example, a shutdown stops the PV and thereby pushes load onto the diesel engine.




The alarm has a wide range. You can combine this with the high alarm selection for *DG reverse power* or *DG positive power*.

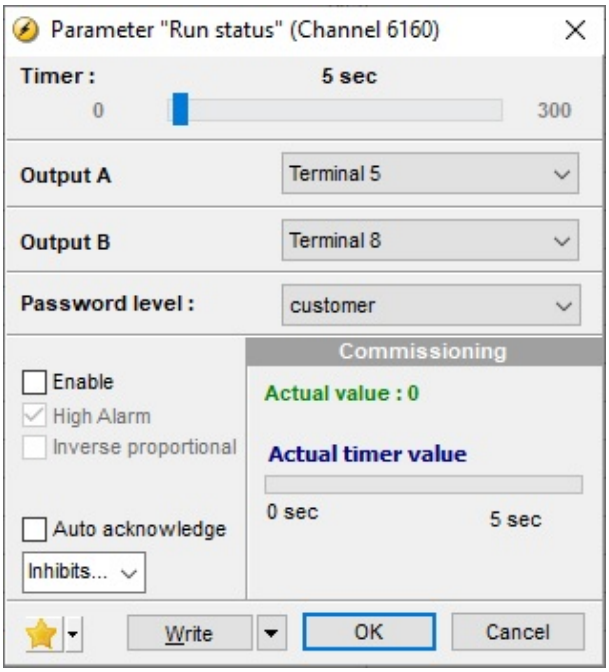
## 7.16 Other functions

### 7.16.1 Run status for the PV system

The ASC can activate an alarm and/or digital outputs when the PV system is running.

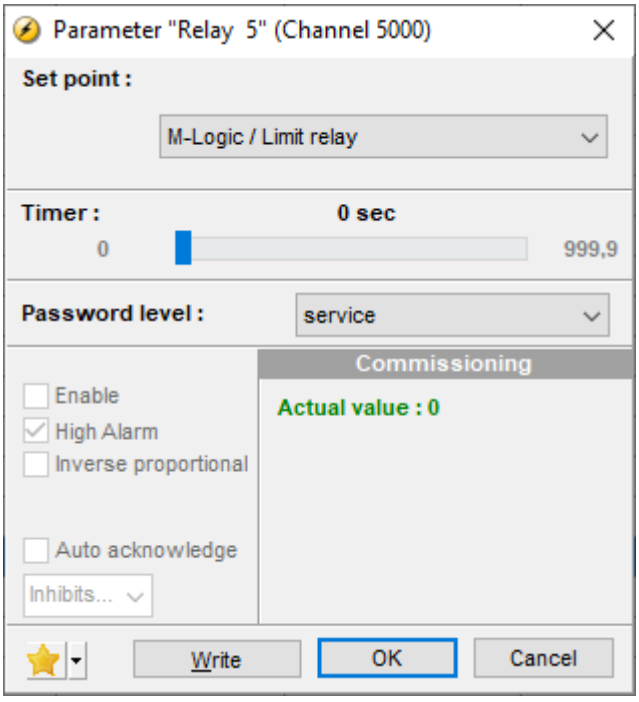
When the controller gets feedback from the PV system that it is running, the run status timer starts. When the timer expires, the alarm and/or digital outputs are activated.

The function is configured in the **6160 Run status** menu.




Select the relays in output A and/or output B, and enable the function. If the timer setting is 0 s, the function is activated as soon as the controller gets running feedback from the PV system.

If you do not want an a run status alarm, you can change the relay function to *M-Logic / Limit relay* in the relay configuration. The controller then activates the relay, but not the alarm.



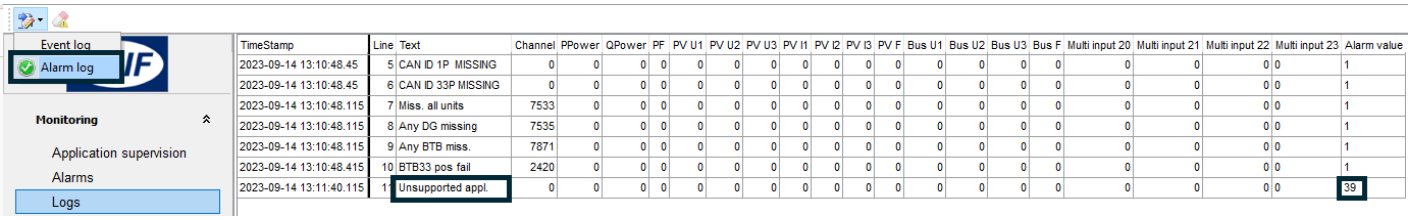

**NOTE** If the relay function is not *M-Logic / Limit relay*, the controller activates an alarm every time that the PV system is running.

## 7.16.2 Unsupported application alarm

The ASC 150 Solar controller has configuration limitations. If a configuration rule is broken, the controller activates the *Unsupported application* alarm. The alarm value shows which rule was broken. You can see the alarm value in the alarm log in the utility software.

| Alarm value | Configuration rule |
|---|---|
| 22 | To control a mains breaker, the ASC 150 controller must have option S4. |
| 23 | If the busbar AC measurements are from inverter communication (parameter 7022), PV breaker control is not allowed. |
| 32 | For a single controller application, the ASC cannot control a mains breaker if more than one mains is connected. |
| 33 | All ASC 150 controllers must have option S10. |
| 34 | If the busbar AC measurements are from inverter communication (parameter 7022), the *Scaling* (parameter 9031) must be *100 to 25000 V*. |
| 38 | For open PMS, the plant can only have one mains connection (external mains or AGC mains). |
| 39 | For open PMS, only one controller can be connected to an external mains. |
| 40 | For an open PMS application, *Diesel gen* cannot be included as a power source. |
| 41 | For an open PMS application, bus tie breakers are not allowed. |

### Alarm log example




| TimeStamp | Line | Text | Channel | PPower | QPower | PF | PV U1 | PV U2 | PV U3 | PV I1 | PV I2 | PV I3 | PV F | Bus U1 | Bus U2 | Bus U3 | Bus F | Multi input 20 | Multi input 21 | Multi input 22 | Multi input 23 | Alarm value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2023-09-14 13:10:48.45 | 5 | CAN ID 1P MISSING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2023-09-14 13:10:48.45 | 6 | CAN ID 33P MISSING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2023-09-14 13:10:48.115 | 7 | Miss. all units | 7533 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2023-09-14 13:10:48.115 | 8 | Any DG missing | 7535 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2023-09-14 13:10:48.115 | 9 | Any BTB miss. | 7871 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2023-09-14 13:10:48.415 | 10 | BTB33 pos fail | 2420 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2023-09-14 13:11:40.115 | 11 | Unsupported appl. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 39 |

## 7.16.3 Other parameters

| Parameter | Name | Range | Default | Details |
|---|---|---|---|---|
| 17181 | PV prepare | 0 to 9900 s | 0 s | You can configure a timer that starts after the start command is given, so that the PV inverter can start its reconnection process. After this timer runs out, the controller starts sending (and ramping up) the power set points. |
| 17304 | Inv. efficiency | 80 to 100 % | 100 % | You can define the inverter efficiency. |

# 8. General functions

## 8.1 Introduction

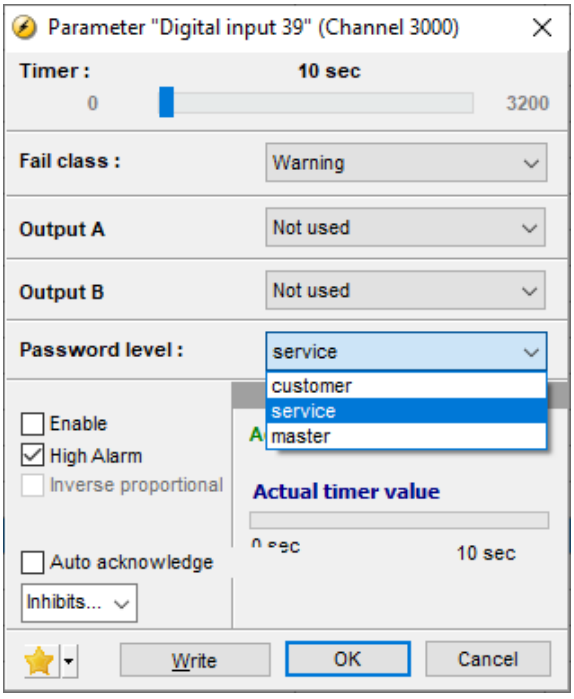
This chapter describes the general functions for AGC 150 and ASC 150.

## 8.2 Password

The controller has three password levels that can be configured on the controller or from the utility software. Parameter settings cannot be changed with a lower ranking password, but are shown on the display.

| Password level | Default password | Customer access | Service access | Master access |
|---|---|---|---|---|
| Customer | 2000 | ● | | |
| Service | 2001 | ● | ● | |
| Master | 2002 | ● | ● | ● |

With the utility software it is possible to protect each parameter with a specific password level. Enter the parameter and select the correct password level.




The password level can also be changed from the parameter view in the Level column:

1. Right-click the appropriate field in the Level column.
2. Select *Change access level*.
3. Select the required access level.
   - *Customer*
   - *Service*
   - *Master*

You can see and edit permissions in the utility software on the *Tools > Permissions* page.

## 8.3 AC measurement systems

The controller is designed for measurement of voltages in systems with nominal voltages between 100 and 690 V AC. The AC system can be three-phase, single-phase, or split phase.

**More information**
See the **Installation instructions** for how to wire the different systems.

**CAUTION**

**Incorrect configuration is dangerous**

Configure the correct AC configuration. If in doubt, contact the switchboard manufacturer for information.

**Basic settings > Measurement setup > Wiring connection > AC configuration**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 9131 | AC configuration | 3 phase 3W4<br>3 phase 3W3<br>2 phase L1/L3*<br>2 phase L1/L2*<br>1 phase L1* | 3 phase 3W4 |
| 9132 | AC configuration BB | 3 phase 3W4<br>3 phase 3W3 | 3 phase 3W4 |

**NOTE** * If this is selected, the same system is used for the busbar, and parameter 9132 is disabled.

### 8.3.1 Three-phase system

The three-phase system is the default setting for the controller. When this is used, all three phases must be connected to the controller.

The following configuration is required for three-phase measuring.

**Basic settings > Nominal settings > Voltage > PV nominal U**

| Parameter | Text | Range | Default | Adjust to value |
|---|---|---|---|---|
| 6004 | Nom. U 1 | 100 to 25000 V | 400 V | $U_{NOM}$. Phase-phase voltage of the source For example, for a 400/230 V AC system, use 400 V AC. |

**Basic settings > Measurement setup > Voltage transformer > PV VT**

| Parameter | Text | Range | Default | Adjust to value |
|---|---|---|---|---|
| 6041 | PV primary U | 100 to 25000 V | 400 V | Primary VT |
| 6042 | PV secondary U | 100 to 690 V | 400 V | Secondary VT |

**Basic settings > Nominal settings > Voltage > Busbar nominal U**

| Parameter | Text | Range | Default | Adjust to value |
|---|---|---|---|---|
| 6053 | BB nominal U 1 | 100 to 25000 V | 400 V | $U_{NOM}$ |

**Basic settings > Measurement setup > Voltage transformer > Busbar VT**

| Parameter | Text | Range | Default | Adjust to value |
|---|---|---|---|---|
| 6051 | BB primary U 1 | 100 to 25000 V | 400 V | Primary VT |
| 6052 | BB secondary U 1 | 100 to 690 V | 400 V | Secondary VT |

**NOTE** The controller has two sets of busbar transformer settings, which can be enabled individually in this measurement system.

## 8.3.2 Split-phase system

The split-phase system is a special application, where two phases and neutral are connected to the controller. The controller shows phases L1 and L2/L3 in the display. The phase angle between L1 and L3 is 180 °. Split-phase is possible between L1-L2 or L1-L3.

The following configuration is required for the split phase measuring (example 240/120 V AC).

**Basic settings > Nominal settings > Voltage > PV nominal U**

| Parameter | Text | Range | Adjust to value |
|---|---|---|---|
| 6004 | Nom. U 1 | 100 to 25000 V | $U_{NOM}$ (120 V AC) |

**Basic settings > Measurement setup > Voltage transformer > PV VT**

| Parameter | Text | Range | Adjust to value |
|---|---|---|---|
| 6041 | PV primary U | 100 to 25000 V | $U_{NOM}$ |
| 6042 | PV secondary U | 100 to 690 V | $U_{NOM}$ |

**Basic settings > Nominal settings > Voltage > Busbar nominal U**

| Parameter | Text | Range | Adjust to value |
|---|---|---|---|
| 6053 | BB nominal U 1 | 100 to 25000 V | $U_{NOM}$ |

**Basic settings > Measurement setup > Voltage transformer > Busbar VT**

| Parameter | Text | Range | Adjust to value |
|---|---|---|---|
| 6051 | BB primary U 1 | 100 to 25000 V | $U_{NOM}$ |
| 6052 | BB secondary U 1 | 100 to 690 V | $U_{NOM}$ |

The measurement $U_{L3L1}$ shows 240 V AC. The voltage alarm set points refer to the nominal voltage 120 V AC, and $U_{L3L1}$ does not activate any alarm.

**NOTE** The controller has two sets of busbar transformer settings, which can be enabled individually in this measurement system.

## 8.3.3 Single-phase system

The single-phase system consists of one phase and the neutral.

The following configuration is required for the single-phase measuring.

**Basic settings > Nominal settings > Voltage > PV nominal U**

| Parameter | Text | Range | Adjust to value |
|---|---|---|---|
| 6004 | Nom. U 1 | 100 to 25000 V | Phase-neutral voltage of the source For example, for a 230 V AC system, use 230 V AC. |

**Basic settings > Measurement setup > Voltage transformer > PV VT**

| Parameter | Text | Range | Adjust to value |
|---|---|---|---|
| 6041 | PV primary U | 100 to 25000 V | $U_{NOM} \times \sqrt{3}$ |
| 6042 | PV secondary U | 100 to 690 V | $U_{NOM} \times \sqrt{3}$ |

**Basic settings > Nominal settings > Voltage > Busbar nominal U**

| Parameter | Text | Range | Adjust to value |
|---|---|---|---|
| 6053 | BB nominal U 1 | 100 to 25000 V | $U_{NOM} \times \sqrt{3}$ |

**Basic settings > Measurement setup > Voltage transformer > Busbar VT**

| Parameter | Text | Range | Adjust to value |
|---|---|---|---|
| 6051 | BB primary U 1 | 100 to 25000 V | $U_{NOM} \times \sqrt{3}$ |
| 6052 | BB second. U 1 | 100 to 690 V | $U_{NOM} \times \sqrt{3}$ |

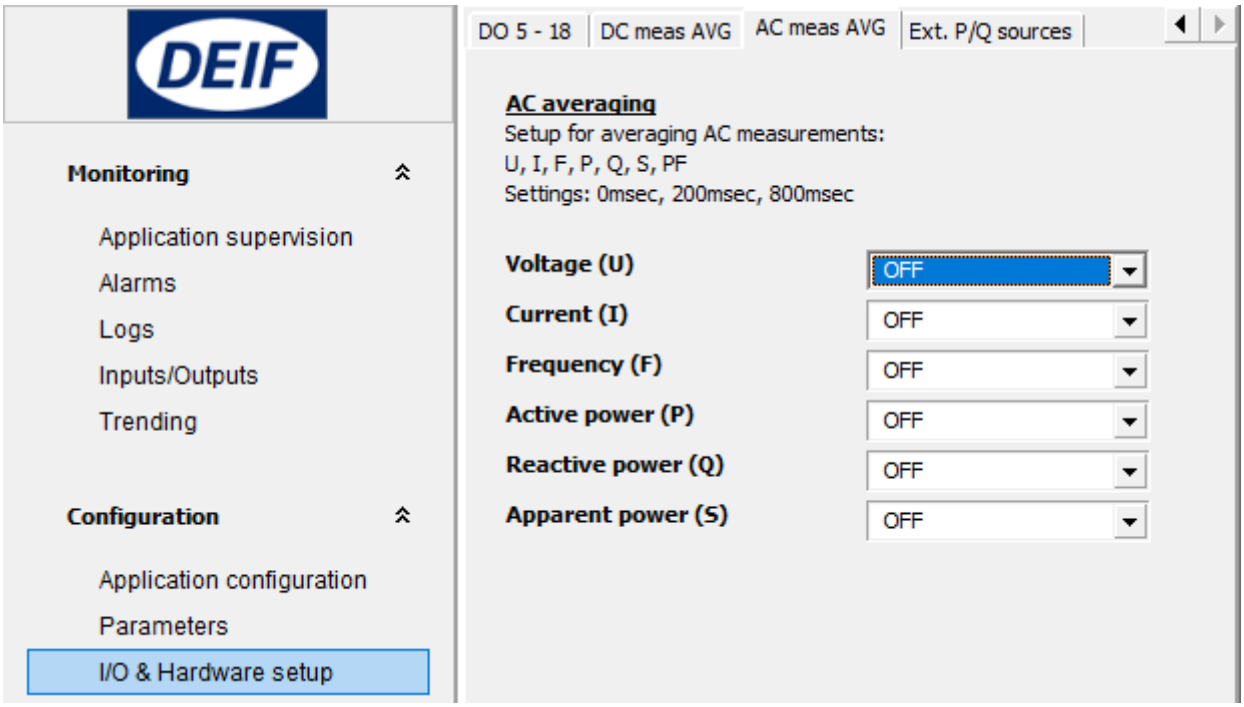
**NOTE** The voltage alarms refer to $U_{NOM}$ (for example, 230 V AC).

The controller has two sets of busbar transformer settings, which can be enabled individually in this measurement system.

### 8.3.4 AC measurement averaging

You can use the utility software to set up averaging for a number of AC measurements. The averaged values are then shown on the display unit and in the Modbus values. However, the controller continues to use real-time measurements.

In the utility software, under *I/O & Hardware setup*, select the *AC meas AVG* tab. For each measurement, you can select no averaging (0 ms), averages calculated over 200 ms, or averages calculated over 800 ms.




## 8.4 Nominal settings

The controller has four sets of nominal settings for the PV and two sets for the busbar. The four sets of nominal PV settings can be individually configured.

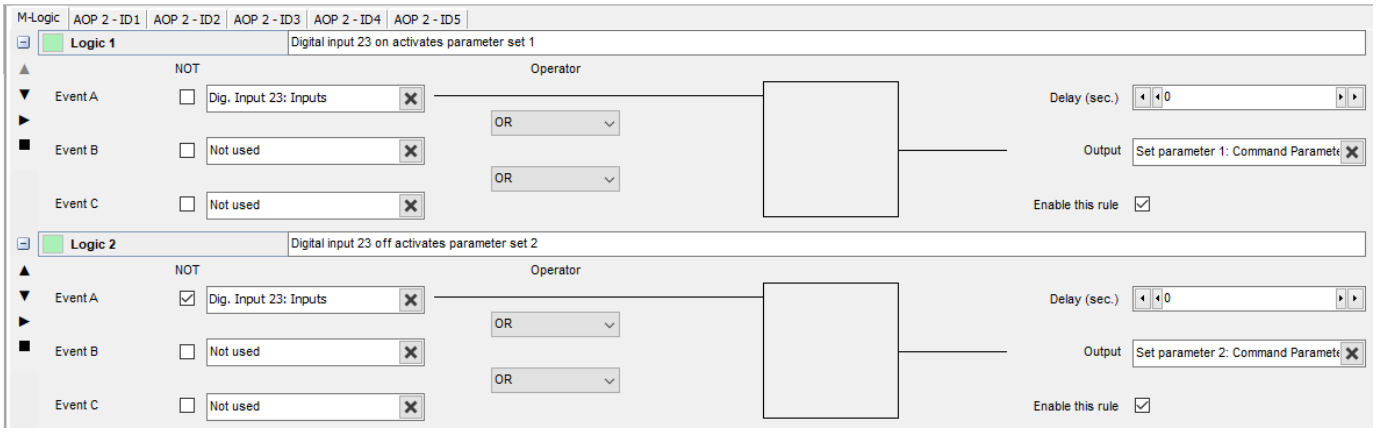
**`Alternative configuration > PV nominal settings`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6007 | Enable nom. set | Nominal setting [1 to 4] | Nominal setting 1 |

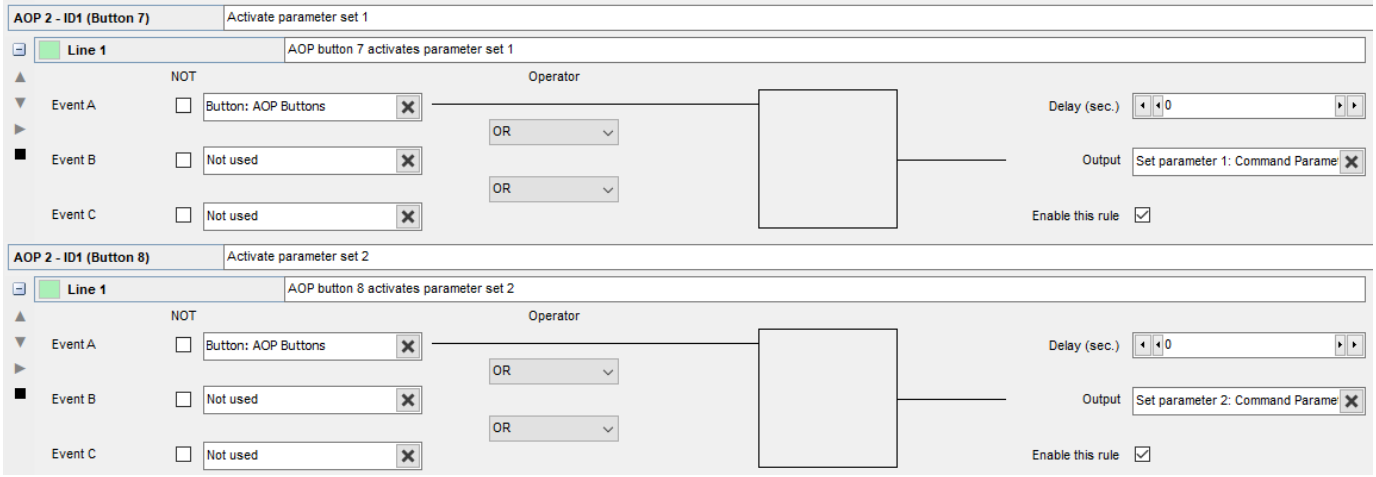
### Switch between the nominal settings

You can use the following to switch between the four sets of nominal settings:

1. **Digital input**: M-Logic is used when a digital input is needed to switch between the four sets of nominal settings. Select the required input among the input events, and select the nominal settings in the outputs. For example:



2. **AOP**: M-Logic is used when the AOP is used to switch between the four sets of nominal settings. Select the required AOP button among the input events, and select the nominal settings in the outputs. For example:




3. **Menu settings**: On the controller or with the utility software.

### 8.4.1 Default nominal settings

The default nominal settings are settings 1. To use another set of nominal settings, use the parameters under `Alternative configuration`.

**Basic settings > Nominal settings > Voltage > PV nominal U**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6004 | Nom. U 1 | 100 to 25000 V | 400 V |

**Basic settings > Nominal settings > Voltage > Busbar nominal U**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6053 | BB nominal U 1 | 100 to 25000 V | 400 V |

**Basic settings > Nominal settings > Current > 3 phase nominal**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6003 | Nom. I 1 | 0 to 9000 A | 867 A |

**Basic settings > Nominal settings > Current > 4th CT nominal**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6007 | Nom. I E/N/M 1 | 0 to 9000 A | 867 A |

**Basic settings > Nominal settings > Frequency**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6001 | Nom. f 1 | 48.0 to 62.0 Hz | 50 Hz |

**Basic settings > Nominal settings > Power > 3 phase nominal**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6002 | Nom. P 1 | 10 to 20000 kW | 480 kW |
| 6005 | Nom. Q 1 | 10 to 20000 kvar | 480 kvar |
| 6006 | Nom. S 1 | 10 to 20000 kVA | 480 kVA |

**Basic settings > Nominal settings > Power > 4th**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6055 | 4th CT nom. P 1 | 10 to 9000 kW | 480 kW |

### 8.4.2 Scaling

For applications above 25000 V and below 100 V, adjust the input range to match the actual value of the primary voltage transformer.

Changing the voltage scaling also affects the nominal power scaling.

**Basic settings > Measurement setup > Scaling**

| Parameter | Text | Range | Default | Notes |
|---|---|---|---|---|
| 9031 | Scaling | 10 to 2500 V<br>100 to 25000 V<br>10 to 160000 V<br>0.4 to 75000 V | 100 to 25000 V | **10 to 2500 V**: This is recommended for generators up to 150 kVA. The nominal power must be less than 900 kW.<br>**100 to 25000 V**: This is recommended for generators over 150 kVA. |

**NOTICE**

**Incorrect configuration is dangerous**

Correct all nominal values and the primary VT settings after the scaling (parameter 9030) is changed.

## 8.5 Breakers

### 8.5.1 Breaker types

There are five breaker type settings. Set the breaker type with the utility software under *Application configuration*.

**More information**
See **Utility software** for how to set up applications.

#### Continuous NE and Continuous ND

*Continuous NE* is a normally energised signal, and *Continuous ND* is a normally de-energised signal. These settings are usually used in combination with a contactor.

The controller only uses the *Close breaker* output:

- Closed: This closes the contactor.
- Open: This opens the contactor.

The *Open breaker* output can be configured for another function.

#### Pulse

This setting is usually used in combination with a circuit breaker. The controller uses these outputs:

- To close the circuit breaker, the *Close breaker* output is activated (until there is breaker close feedback).
- To open the circuit breaker, the *Open breaker* output is activated (until there is breaker open feedback).

#### External/ATS no control

This setting is used to show the position of the breaker, but the breaker is not controlled by the controller.

### Compact

This setting is usually used in combination with a direct controlled motor driven breaker. The controller uses these outputs:

- The *Close breaker* output closes briefly to close the compact breaker.
- The *Open breaker* output closes to open the compact breaker. The output stays closed long enough to recharge the breaker.

If the compact breaker is tripped externally, it is recharged automatically before next closing.

## 8.5.2 Breaker spring load time

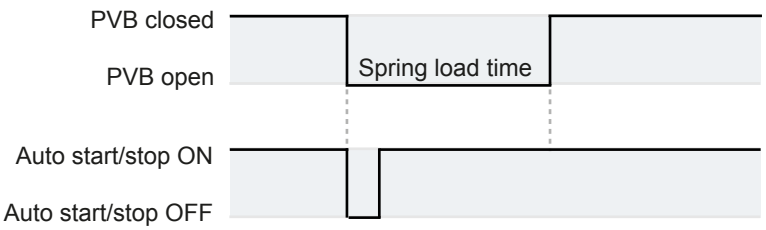
To avoid breaker close failures in situations where the breaker close command is given before the breaker spring has been loaded, the spring load time can be adjusted.

### Principle

You could have a close failure if:

1. A PV system is in AUTO mode, the Auto start/stop input is active, the PV is running, and the PVB is closed.
2. The Auto start/stop input is deactivated, the stop sequence is executed, and the PVB is opened.
3. If the Auto start/stop input is activated again before the stop sequence is finished, the controller activates a PVB close failure, since the PVB needs time to load the spring before it is ready to close.

The diagram shows an example where a single PV system in island mode is controlled by the Auto start/stop input.




- When the Auto start/stop input deactivates, the PVB opens.
- The Auto start/stop is re-activated immediately after the PVB has opened, for example by the operator using a switch in the switchboard.
- The controller waits a while before sending the close signal again, because the spring load time must expire.

### Ensuring time to reload

If the breaker needs time to reload the spring after it has opened, the controller can take this delay into account. This can be controlled through timers in the controller or through digital feedbacks from the breaker, depending on the breaker type:

1. **Timer-controlled.** A load time set point for the PVB and MB control for breakers with no feedback indicating that the spring is loaded. After the breaker has been opened it will not be allowed to close again before the delay has expired. When the timer is running, the remaining time is shown in the display.
2. **Digital input.** Two configurable inputs are used for feedbacks from the breakers: One for PVB spring loaded and one for MB spring loaded. After the breaker has been opened it cannot close before the configured inputs are active.

If both a timer and breaker feedbacks are used, both requirements must be met before the breaker is allowed to close.

## 8.5.3 Breaker position failure

The breaker position failure alarm is activated if a controller has no breaker position feedback, or if both feedbacks from the breaker are high.

When a controller has a breaker position failure, it informs the other controllers in the application. The system then blocks the section with the breaker position failure. Sections that are not affected by the breaker position failure can continue to operate.

You can assign a fail class to try to trip the faulty breaker when the controller discovers a breaker position failure.

## 8.6 M-Logic

The main purpose of M-Logic is to give the operator/designer more flexibility.

M-Logic is used to execute different commands at predefined conditions. M-Logic is not a PLC but substitutes one, if only very simple commands are needed.

M-Logic is a simple tool based on logic events. One or more input conditions are defined, and at the activation of those inputs, the defined output will occur. A great variety of inputs can be selected, such as digital inputs, alarm conditions and running conditions. A variety of the outputs can also be selected, such as relay outputs, change of modes.

You can configure M-Logic in the utility software.

### 8.6.1 General shortcuts

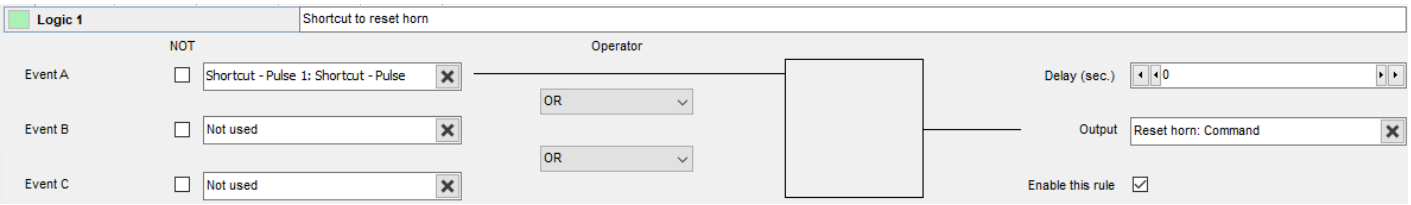
You can configure your own shortcuts with M-Logic in the utility software. You can see the configured shortcuts when you push the *Shortcut* button and select *General shortcuts*. If you have not configured a shortcut, then the *General shortcuts* menu is empty.

For a pulse shortcut, the command is sent each time you select the shortcut and press OK in the display menu.

For a switch shortcut, the switch is toggled (on/off) each time you select the shortcut.

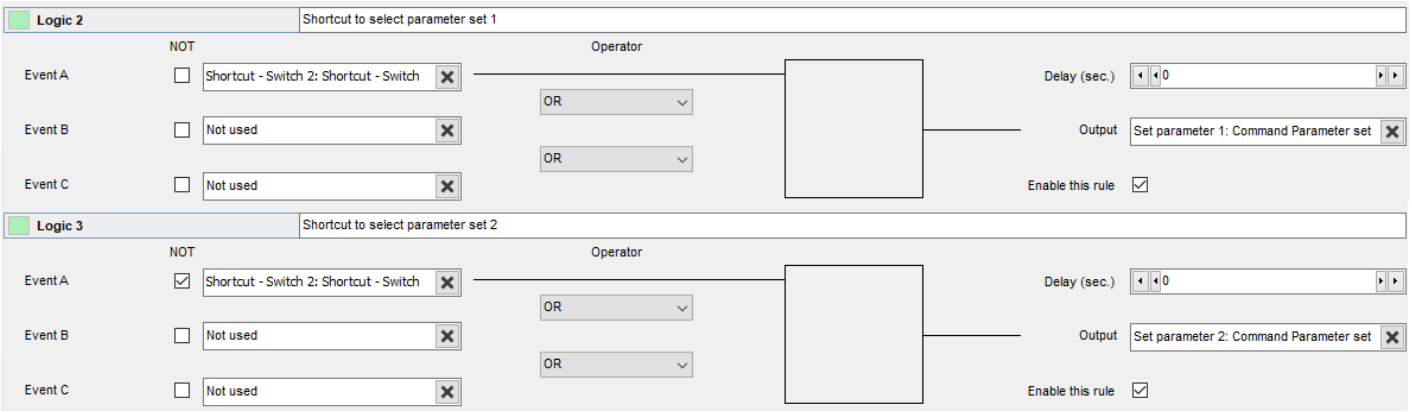
Use the *Translations* interface to rename the shortcut.

#### Example of shortcut pulse




Rename *SC Pulse 1* to *Reset horn*.

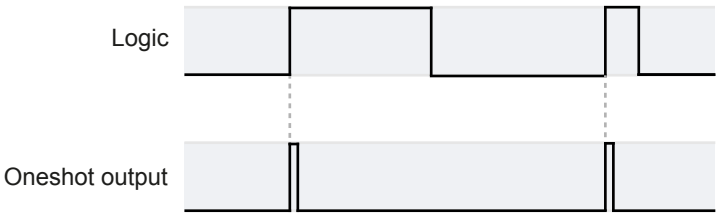
#### Example of shortcut switch




Rename *SC Switch 2 on* to *Use parameter set 1*. Rename *SC Switch 2 off* to *Use parameter set 2*.

### 8.6.2 Oneshots

| Description | Notes |
|---|---|
| Oneshot set [1-16] | The oneshot is activated for a short time (about 100 ms) when the logic is true. If the logic remains true, the oneshot is not activated again. When the logic is false, the function is reset. |




### Oneshots

| Description | Notes |
|---|---|
| Oneshot output [1-16] | The event is active when the oneshot output is activated. |

## 8.7 Timers and counters

### 8.7.1 Command timers

Command timers are used to execute a command at a specific time. For example, to start and stop the genset automatically at specific times on certain weekdays. In AUTO mode, this function is available in island operation, load take-over, mains power export, and fixed power operation.

Up to four command timers can be configured with M-Logic. Each command timer can be set for the following time periods:

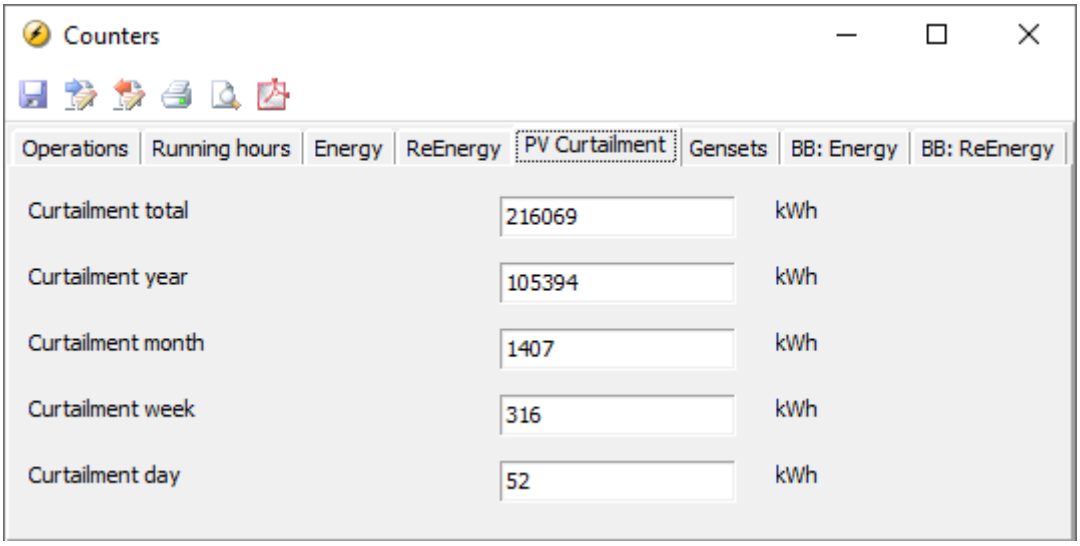
- Individual days (MO, TU, WE, TH, FR, SA, SU)
- MO, TU, WE, TH
- MO, TU, WE, TH, FR
- MO, TU, WE, TH, FR, SA, SU
- SA, SU

To start in AUTO mode, the Auto start/stop command can be programmed in M-Logic or in the input settings. The time-dependent commands are flags that are activated when the command timer is in the active period.

### 8.7.2 USW counters

You can view and adjust a number of counters using the USW. Click the **Σ** icon to open the counters window.

**ASC counters example**

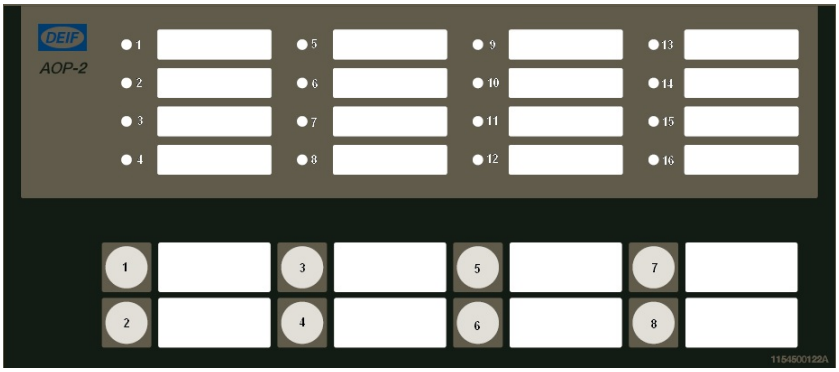



| Counters | Details |
|---|---|
| Operations | Breaker operations |
| Running hours | PV running hours |
| Energy | Energy from the PV |
| ReEnergy | Reactive energy from the PV |
| Curtailment | Curtailment of energy from the PV |
| Gensets | Energy from the gensets |
| BB: Energy | Energy to/from the mains |
| BB: ReEnergy | Reactive energy to/from the mains |

## 8.8 Interfaces

### 8.8.1 Additional operator panel, AOP-2

The AOP-2 is an additional operator panel that can be connected to the controller using a CAN bus communication port. It can be used as an interface to the controller for indication of status and alarms together, and with buttons for, for example, alarm acknowledge and mode selection.




The configurable LEDs are named 1 to 16, and the buttons are named 1 to 8.

**CAN Node ID configuration**

The CAN Node ID for the AOP-2 can be set to 1-9:

1. Press buttons 7 and 8 simultaneously to activate the CAN ID change menu. The LED for the present CAN ID number is ON, and LED 16 is flashing.
2. Use button 7 (increase) and button 8 (decrease) to change the CAN ID according to the table below.
3. Press button 6 to save the CAN ID and return to normal operation.

| CAN ID | Indication of CAN ID selection |
|---|---|
| 0 | LED 16 flashes (CAN bus OFF) |
| 1 | LED 1 ON.<br>LED 16 flashes (default value). |
| 2 | LED 2 ON.<br>LED 16 flashes. |
| 3 | LED 3 ON.<br>LED 16 flashes. |
| 4 | LED 4 ON.<br>LED 16 flashes. |
| 5 | LED 5 ON.<br>LED 16 flashes. |

**Programming**

Use the utility software to program the AOP-2. See the **Help** in the utility software.

## 8.8.2 Access lock

With the access lock on, the operator cannot change controller parameters or running modes. The input to be used for the access lock function is defined in the utility software.

Access lock is typically activated from a key switch installed behind the door of the switchboard cabinet. As soon as access lock is activated, changes from the display cannot be made.

Access lock only locks the display and does not lock any AOP or digital input. AOP can be locked by using M-Logic. It is still possible to read all parameters, timers and the state of inputs in the service menu.

You can read alarms, but not acknowledge them when access lock is activated. Nothing can be changed from the display.

This function is ideal for rental or critical equipment. The operator cannot change anything. If there is an AOP-2, the operator is still able to change up to 8 different predefined things.

**NOTE** The *Stop* button is not active in SEMI-AUTO mode when the access lock is activated. For safety reasons, an emergency stop switch is recommended.

## 8.8.3 Language selection

The controller can show several languages. The default master language is English, which cannot be changed. Different languages can be configured with the utility software.

**`Basic settings > Controller settings > Language`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 6081 | Language selection | English<br>Language [1 to 8] | English |

# 9. AC protections

## 9.1 About protections

### 9.1.1 Protections in general

All protection set points are a percentage of the nominal values.

For most of the protections a set point and time delay is selected. When the timer runs out, the output is activated. The operate time is the delay setting + the reaction time.

When setting up the controller, the measuring class of the controller and an adequate safety margin has to be taken into consideration, for example:

- A power generation system must not reconnect to a network when the voltage is < 85 % of $U_{NOM}$ ±0 % or > 110 % ±0 %. To ensure reconnection within this interval, the controller's tolerance/accuracy has to be taken into consideration. If the reconnection tolerance is ±0 %, set a controller's set points 1-2 % higher/lower than the actual set point.

**General parameter ranges for protections**

| Setting | Range |
|---|---|
| Output A | Not used<br>12 relays: 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18<br>External I/O: Relays available in the connected CIO(s)<br>Limits |
| Output B | |
| Enable | OFF<br>ON |
| Fail class | See the controller type |

**Inhibits**

You can only select inhibits using the utility software. Each alarm has a selection list for the inhibit conditions. Inhibit of the alarm is active as long as one of the selected inhibit functions are active.

### 9.1.2 Phase-neutral voltage trip

If the voltage alarms are to work based on phase-neutral measurements, the voltage detection type for both generator and busbar must be set to phase neutral.

**AC configuration and protections > Voltage protections > Voltage detect. type**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1201 | PV U detection type | Ph-Ph<br>Ph-N | Ph-Ph |

**Busbar > Voltage protections > Voltage detect. type**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1202 | BB U detection type | Ph-Ph<br>Ph-N | Ph-Ph |

As shown in the vector diagram below, there is a difference in voltage values at an error situation for the phase-neutral voltage and the phase-phase voltage.

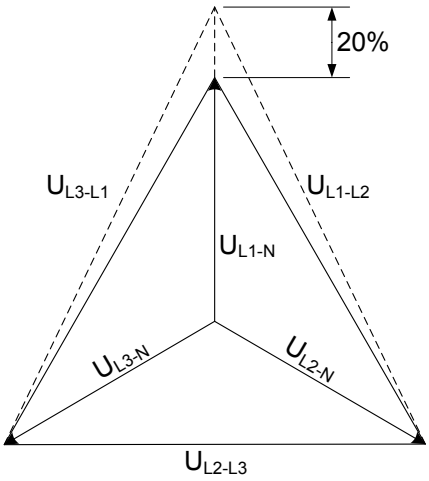
**Example: Actual measurements at a 10 % under-voltage situation in a 400/230 volt system**

| | Phase-neutral | Phase-phase |
|---|---|---|
| Nominal voltage | 400/230 | 400/230 |
| Voltage, 10 % error | 380/207 | 360/185 |

The alarm will occur at two different voltage levels, even though the alarm set point is 10 % in both cases.

The 400 V AC system below shows that the phase-neutral voltage must change 20 %, when the phase-phase voltage changes 40 volts (10 %).

**Example**




$U_{NOM}$ = 400/230 V AC
**Error measurements**

- $U_{L1L2}$ = 360 V AC
- $U_{L3L1}$ = 360 V AC
- $U_{L1-N}$ = 185 V AC
- $\Delta U_{PH-N}$ = 20 %

### 9.1.3 Phase sequence error and phase rotation

The controller monitors the rotation of the voltage, and activates an alarm if the voltage is rotating in the wrong direction. The controller can monitor the rotation in both directions.

**AC configuration and protections > AC configuration > Phase sequence error PV**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 2153 | Fail class | Fail classes | Warning |

**AC configuration and protections > AC configuration > Phase rotation**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 2154 | Set point | L1L2L3<br>L1L3L2 | L1L2L3 |

**Busbar > AC configuration > Phase sequence error BB**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 2156 | Fail class | Fail classes | Warning |

## 9.2 PV protections

The *operate time* is defined in IEV 447-05-05 (from the instant when the need for protection arises, to when the controller output has responded). For each protection, the *operate time* is given for the minimum user-defined time delay.

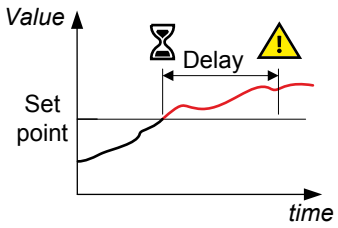
| Protection | IEC symbol (IEC 60617) | ANSI (IEEE C37.2) | Operate time | Alarms |
|---|---|---|---|---|
| Over-voltage | U>, U>> | 59 | < 200 ms | 2 |
| Under-voltage | U<, U<< | 27 | < 200 ms | 3 |
| Voltage unbalance | UUB> | 47 | < 200 ms* | 1 |
| Negative sequence voltage | | 47 | < 200 ms* | 1 |
| Zero sequence voltage | | 59Uo | < 200 ms* | 1 |
| Over-current | 3I>, 3I>> | 50TD | < 100 ms | 4 |
| Fast over-current (short circuit) | 3I>>> | 50/50TD | < 50 ms | 2 |
| Unbalance current | IUB> | 46 | < 200 ms* | 2 |
| Directional over-current | | 67 | < 100 ms | 2 |
| Inverse time over-current | It> | 51 | - | 1 |
| Neutral inverse time over-current | | 51N | - | 1 |
| Earth fault inverse time-over current | | 51G | - | 1 |
| Negative sequence current | | 46 | < 200 ms* | 1 |
| Zero sequence current | | 51Io | < 200 ms* | 1 |
| Over-frequency | f>, f>> | 81O | < 200 ms | 3 |
| Under-frequency | f<, f<< | 81U | < 200 ms | 3 |
| Overload** | P>, P>> | 32 | < 200 ms | 4 |
| Low power** | | | | 1 |
| Reverse power | P<, P<< | 32R | < 200 ms | 2 |
| Reactive power export (Over-excitation) | Q>, Q>> | 40O | < 200 ms | 1 |
| Reactive power import/loss of excitation (under-excitation) | Q<, Q<< | 40U | < 200 ms | 1 |

**NOTE** * These operate times include the minimum user-defined delay of 100 ms.
**NOTE** ** You can configure these protections for overload or reverse power.

### 9.2.1 Over-voltage (ANSI 59)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Over-voltage | U>, U>> | 59 | < 100 ms |

The alarm response is based on the highest phase-to-phase voltage, or the highest phase-to-neutral voltage, from the source, as measured by the controller. The phase-to-phase voltage is the default.




**AC configuration and protections > Voltage protections > Over-voltage > PV U> [1 or 2]**

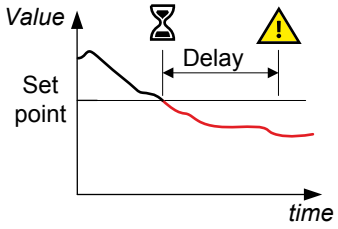
| Parameter | Text | Range | PV U> 1 | PV U> 2 |
|---|---|---|---|---|
| 1151 or 1161 | Set point | 100 to 130 % | 103 % | 105 % |
| 1152 or 1162 | Timer | 0.1 to 100 s | 10 s | 5 s |

| Parameter | Text | Range | PV U> 1 | PV U> 2 |
|---|---|---|---|---|
| 1155 or 1165 | Enable | OFF<br>ON | OFF | OFF |
| 1156 or 1166 | Fail class | Fail classes | Warning | Warning |

### 9.2.2 Under-voltage (ANSI 27)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Under-voltage | U<, U<< | 27 | < 100 ms |

The alarm response is based on the lowest phase-to-phase voltage, or the lowest phase-to-neutral voltage, from the source, as measured by the controller. The phase-to-phase voltage is the default.




**AC configuration and protections > Voltage protections > Under-voltage > PV U< [1 to 3]**

| Parameter | Text | Range | PV U< 1 | PV U< 2 | PV U< 3 |
|---|---|---|---|---|---|
| 1171, 1181 or 1191 | Set point | 40 to 100 % | 97 % | 95 % | 95 % |
| 1172, 1182 or 1192 | Timer | 0.1 to 100 s | 10 s | 5 s | 5 s |
| 1175, 1185 or 1195 | Enable | OFF<br>ON | OFF | OFF | OFF |
| 1176, 1186 or 1196 | Fail class | Fail classes | Warning | Warning | Warning |

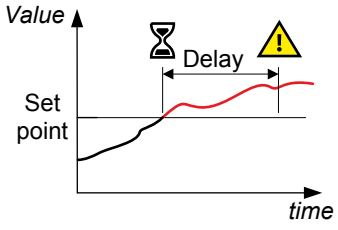
### 9.2.3 Voltage unbalance (ANSI 47)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Voltage unbalance (voltage asymmetry) | UUB> | 47 | < 200 ms* |

**NOTE** * The operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the highest difference between any of the three phase-to-phase voltage or phase-to-neutral true RMS values and the average voltage, as measured by the controller. The phase-to-phase voltage is the default.

If phase-to-phase voltages are used, the controller calculates the average phase-to-phase voltage. The controller then calculates the difference between each phase-to-phase voltage and the average voltage. Finally, the controller divides the maximum difference by the average voltage to get the voltage unbalance.




**AC configuration and parameters > Voltage protections > Voltage unbalance > PV Unbalance U**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1511 | Set point | 0 to 50 % | 10 % |
| 1512 | Timer | 0.1 to 100 s | 10 s |
| 1515 | Enable | OFF | OFF |

| Parameter | Text | Range | Default |
|---|---|---|---|
| | | ON | |
| 1516 | Fail class | Fail classes | Trip PVB |

## 9.2.4 Negative sequence voltage (ANSI 47)

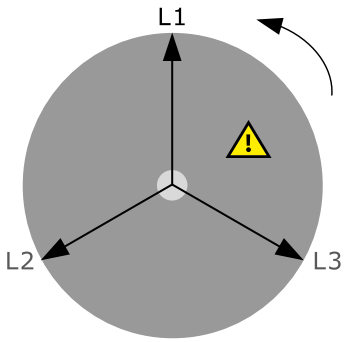
| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Negative sequence voltage | | 47 | < 200 ms* |

**NOTE** * The operate time includes the minimum user-defined delay of 100 ms.

Negative sequence voltages arise when the virtual representation of the phase rotation for an unbalanced system appears negative.

Negative sequence voltages can occur where there are single phase loads, unbalanced line short circuits and open conductors, and/or unbalanced phase-to-phase or phase-to-neutral loads.

The alarm response is based on the estimated phase-to-neutral voltage phasors, as measured from the source.




**AC configuration and protections > Voltage protections > Negative seq. voltage > PV neg. seq. U**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1551 | Set point | 1 to 100 % | 5 % |
| 1552 | Timer | 0.2 to 100 s | 0.5 s |
| 1555 | Enable | OFF<br>ON | OFF |
| 1556 | Fail class | Fail classes | Trip MB |

**AC configuration and protections > Voltage protections > Negative seq. voltage > Neg. seq select**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1561 | Set point | PV measurement<br>BB measurement | PV measurement |

## 9.2.5 Zero sequence voltage (ANSI 59Uo)

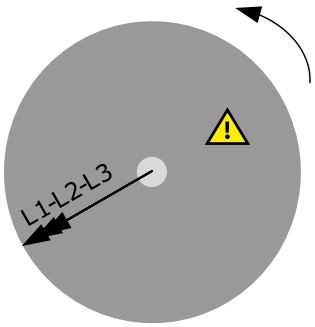
| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Zero sequence voltage | | 59Uo | < 200 ms* |

**NOTE** * The operate time includes the minimum user-defined delay of 100 ms.

Zero sequence voltages arise when the phases rotation is positive, but the vector zero value (star point) is displaced. This zero sequence voltage protection can be used instead of using zero voltage measurement or summation transformers (zero sequence transformers).

This protection is used for detecting earth faults.

The alarm response is based on the estimated phase-to-neutral voltage phasors, as measured from the source.




**AC configuration and protections > Voltage protections > Zero sequence voltage > PV zero seq. U**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1581 | Set point | 0 to 100 % | 5 % |
| 1582 | Timer | 0.2 to 100 s | 0.5 s |
| 1585 | Enable | OFF<br>ON | OFF |
| 1586 | Fail class | Fail classes | Trip MB |

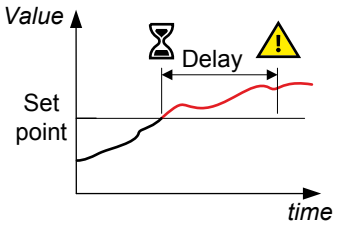
**AC configuration and protections > Voltage protections > Zero sequence voltage > Zero seq select**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1591 | Type | PV measurement<br>BB measurement | PV measurement |

## 9.2.6 Over-current (ANSI 50TD)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Over-current | 3I>, 3I>> | 50TD | < 100 ms |

The alarm response is based on the highest phase current true RMS value from the source, as measured by the controller.




**AC configuration and protections > Current protections > Over-current > I> [1 to 4]**

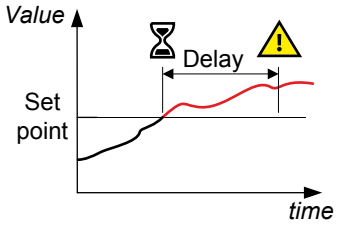
| Parameter | Text | Range | I> 1 | I> 2 | I> 3 | I> 4 |
|---|---|---|---|---|---|---|
| 1031, 1041, 1051 or 1061 | Set point | 50 to 200 % | 115 % | 120 % | 115 % | 120 % |
| 1032, 1042, 1052 or 1062 | Timer | 0.1 to 3200 s | 10 s | 5 s | 10 s | 5 s |
| 1035, 1045, 1055 or 1065 | Enable | OFF<br>ON | ON | ON | ON | ON |
| 1036, 1046, 1056 or 1066 | Fail class | Fail classes | Warning | Trip PVB | Trip PVB | Trip PVB |

## 9.2.7 Fast over-current (ANSI 50/50TD)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Fast over-current | 3I>>> | 50/50TD* | < 50 ms |

**NOTE** * ANSI 50 applies when the Delay parameter is 0 s.

The alarm response is based on the highest phase current true RMS values from the source, as measured by the controller.




**AC configuration and protections > Current protections > Fast over-current > I>> [1 or 2]**

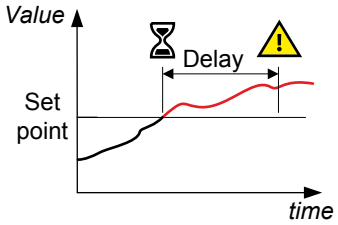
| Parameter | Text | Range | I>> 1 | I>> 2 |
|---|---|---|---|---|
| 1131 or 1141 | Set point | 150 to 300 % | 150 % | 200 % |
| 1132 or 1142 | Timer | 0 to 3200 s | 2 s | 0.5 s |
| 1135 or 1145 | Enable | OFF<br>ON | OFF | OFF |
| 1136 or 1146 | Fail class | Fail classes | Trip PVB | Trip PVB |

## 9.2.8 Unbalance current (ANSI 46)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Unbalance current | IUB> | 46 | < 200 ms* |

**NOTE** * The operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the highest difference between any of the three phase current true RMS values, as measured by the controller. You can choose either the *Average* method (ANSI) or the *Nominal* method to calculate the current unbalance.




**AC configuration and protections > Current protections > Unbalance current > Unbalance I [1 or 2]**

| Parameter | Text | Range | Unbalance I 1 | Unbalance I 2 |
|---|---|---|---|---|
| 1501 or 1711 | Set point | 0 to 100 % | 30 % | 40 % |
| 1502 or 1712 | Timer | 0.1 to 100 s | 10 s | 10 s |
| 1505 or 1715 | Enable | OFF<br>ON | OFF | OFF |
| 1506 or 1716 | Fail class | Fail classes | Trip PVB | Trip PVB |

**AC configuration and protections > Current protections > Unbalance current > Type**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1203 | Type | Ref. to nominal<br>Ref. to average | Ref. to nominal |

**NOTE** The *Average method* is very sensitive at low loads.

The average method uses the ANSI standard calculation method to determine current unbalance. The controller calculates the average current for the three phases. The controller then calculates the difference between each phase current and the average current. Finally, the controller divides the maximum difference by the average current to get the current unbalance.

**Average method example**

The controller controls a PV system with a nominal current of 100 A. The L1 current is 80 A, the L2 current is 90 A, and the L3 current is 60 A.

The average current is 76.7 A. The difference between the phase current and the average is 3.3 A for L1, 13.3 A for L2 and 16.7 A for L3.

The current unbalance is therefore 16.7 A / 76.7 A = 0.22 = 22 %.

With the nominal method the controller calculates the difference between the phase with the highest current, and the phase with the lowest current. Finally, the controller divides the difference by the nominal current to get the current unbalance.

**Nominal method example**

The controller controls a PV system with a nominal current of 100 A. The L1 current is 80 A, the L2 current is 90 A, and the L3 current is 60 A.

The current unbalance is (90 A - 60 A) / 100 A = 0.3 = 30 %.

## 9.2.9 Voltage-dependent over-current (ANSI 51V)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Voltage-dependent over-current | Iv> | 51V | - |

This protection is activated when a short circuit is present and the voltage drops. The current rises briefly, before it falling to a lower level.

The short circuit current level can drop below the rated current of the PV system, and thus the short circuit will not be tripped, if a standard ANSI 50/50TD is used. When the short circuit is present, the voltage will be low. This can be used for tripping at a lower current, when the voltage is low.

**AC configuration and protections > Current protections > Voltage dependent over-current**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1101 | ES Iv> (50 %) | 50 to 200 % | 110 % |
| 1102 | ES Iv> (60 %) | 50 to 200 % | 125 % |
| 1103 | ES Iv> (70 %) | 50 to 200 % | 140 % |
| 1104 | ES Iv> (80 %) | 50 to 200 % | 155 % |
| 1105 | ES Iv> (90 %) | 50 to 200 % | 170 % |

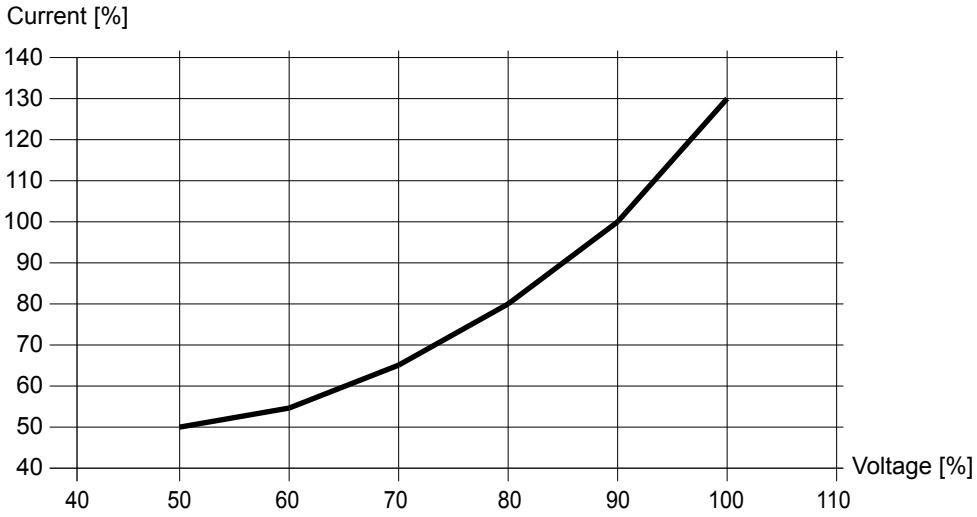
| Parameter | Text | Range | Default |
|---|---|---|---|
| 1106 | ES Iv> (100 %) | 50 to 200 % | 200 % |
| 1110 | Fail class | Fail classes | Trip PVB |

**Example**

There are six current and voltage level set points. The voltage levels are pre-set, so only the current levels must be set. All values are in percentage of the nominal settings. The default values are shown in the table below.

| Parameter | Voltage level (not adjustable) | Current level (adjustable) |
|---|---|---|
| 1101 | 50 % | 50 % |
| 1102 | 60 % | 55 % |
| 1103 | 70 % | 65 % |
| 1104 | 80 % | 80 % |
| 1105 | 90 % | 100 % |
| 1106 | 100 % | 130 % |

The set points can be shown on a curve:

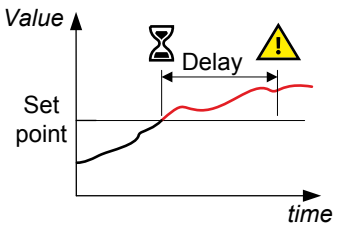



When the operating values are above the curve, the breaker is tripped. The PVB also trips when the PV voltage is below 50 % of rated, and the current is above 50 % of rated.

## 9.2.10 Directional over-current (ANSI 67)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Directional over-current | | 67 | < 100 ms |

The alarm response is based on the highest phase current true RMS value, with the direction from the active power from the source, as measured by the controller.



**AC configuration and protections > Current protections > Directional over-current > I>direct. [1 or 2]**

| Parameter | Text | Range | I> direct. 1 | I> direct. 2 |
|---|---|---|---|---|
| 1601 or 1611 | Set point | -200 to 200 % | 120 % | 130 % |
| 1602 or 1612 | Timer | 0 to 3200 s | 0.1 s | 0.1 s |
| 1605 or 1615 | Enable | OFF<br>ON | OFF | OFF |
| 1606 or 1616 | Fail class | Fail classes | Trip MB | Trip MB |

**NOTE** For a positive set point, the alarm trigger level is *High*. When a negative set point is written to the controller, then the controller automatically changes the alarm trigger level to *Low*.

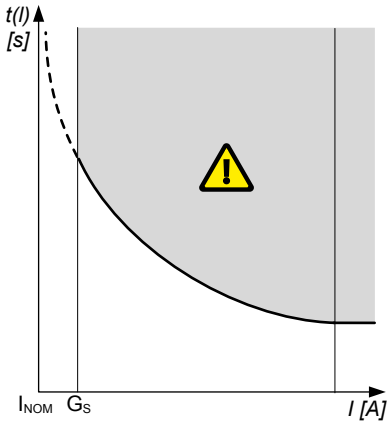
## 9.2.11 Inverse time over-current (ANSI 51)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Inverse time over-current | It> | 51 | - |

The alarm response is based on the highest phase current true RMS values, as measured by the controller.

The alarm response time depends on an approximated integral of the current measurement over time. The integral is only updated when the measurement is above the activation threshold (dotted curve on the diagram). See the description below for more details.

**NOTE** The diagram on the right is a simplified representation of this alarm. The diagram does not show the integral over time.




### Inverse time over-current calculation method

The controller uses this equation from IEC 60255-151 to calculate the time that the current measurement may be over the set point before the inverse time over-current alarm is activated:

$$t(G) = TMS \left( \frac{k}{\left(\frac{G}{G_s}\right)^{\alpha} - 1} + c \right)$$

where:

- t(G) = Theoretical operating time value at G, in seconds
- k, c and α = Constants for the selected curve (*k* and *c* in seconds, *α* (alpha) has no unit)
- G = Measured value, that is, $I_{phase}$
- $G_S$ = Alarm set point ($G_S = I_{nom}$ • Limit / 100 %)
- TMS = Time multiplier setting

**AC configuration and protections > Current protections > Inverse time over-current**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1081 | I> inverse type | IEC Inverse<br>IEC Very Inverse<br>IEC Extremely inverse<br>IEEE Moderately Inv. | IEC Inverse |

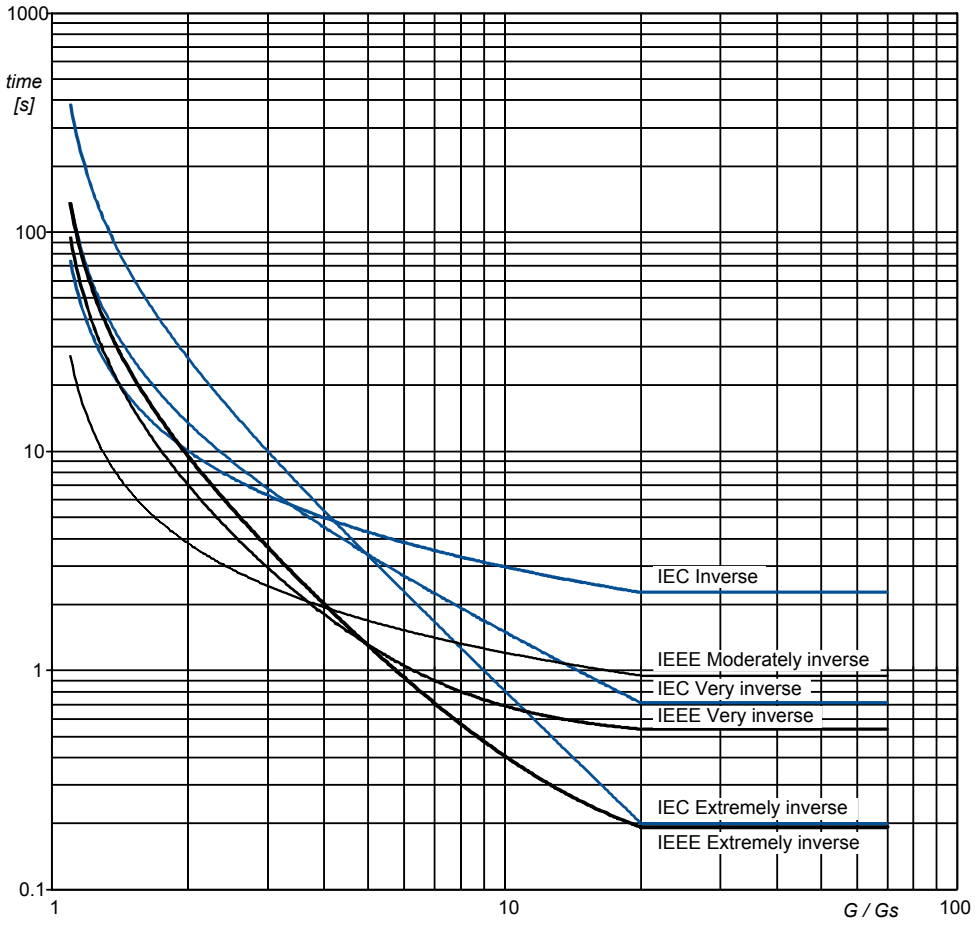
| Parameter | Text | Range | Default |
|---|---|---|---|
| | | IEEE Very Inverse<br>IEEE Extremely Inv.<br>Custom | |
| 1082 | I> inverse Limit | 50 to 200 % | 110 % |
| 1083 | I> inverse TMS | 0.01 to 100.00 | 1.00 |
| 1084 | I> inverse k | 0.001 to 32.000 s | 0.140 s |
| 1085 | I> inverse c | 0.000 to 32.000 s | 0.000 s |
| 1086 | I> inverse a | 0.001 to 32.000 s | 0.020 s |
| 1088 | Enable | OFF<br>ON | ON |
| 1089 | Fail class | Fail classes | Trip PVB |

### Standard inverse time over-current curves

The controller includes these standard inverse time over-current curves, in accordance with IEC 60255-151.

| Curve name | k | c | alpha (α, or a) |
|---|---|---|---|
| IEC inverse | 0.14 s | 0 s | 0.02 |
| IEC very inverse | 13.5 s | 0 s | 1 |
| IEC extremely inverse | 80 s | 0 s | 2 |
| IEEE moderately inverse | 0.0515 s | 0.114 s | 0.02 |
| IEEE very inverse | 19.61 s | 0.491 s | 2 |
| IEEE extremely inverse | 28.2 s | 0.1217 s | 2 |

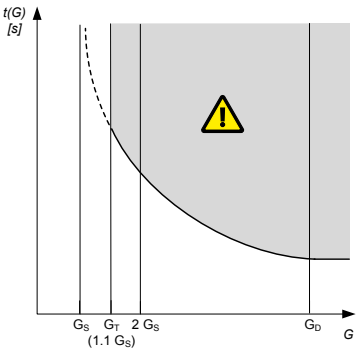
### Standard curve shapes for inverse time over-current, with time multiplier setting (TMS) = 1




### Definite time characteristic

$G_D$ is the point where the alarm shifts from an inverse curve to a definite time characteristic, as the following graph shows. That is, after this point, the curve is flat, and a current increase does not have any effect on the alarm response time. In IEC60255, this point is defined as $G_D = 20 \times G_S$.

### Inverse time over-current time characteristic graph




**Influence of the CT primary current rating on $G_D$ example**

A current transformer has a primary rating of 500 A and a secondary rating of 5 A. The nominal current of the system is 350 A, and the three-phase inverse time over-current alarm *Limit* is 100 %.

$G_D$ of the inverse time over-current characteristic graph according to IEC60255 is 7000 A.

- $G_D = 20 \times G_S = 20 \times (I_{nom} \times (\text{Limit} / 100)) = 20 \times (350 \times (1 / 1)) = 7000$ A

However, the highest $G_D$ value where measurements can be made is 1500 A.

- Because the secondary current rating is 5 A, the formula to calculate the measurable $G_D$ is $G_D = 3 \times I_{CT\ primary}$.

- $G_D = 3 \times I_{CT\ primary} = 3 \times 500 = 1500$ A

**NOTE** If the performance of the inverse time over-current protection is important, use a current transformer that is rated for a 1 A secondary current (that is, -/1 A).

## 9.2.12 Neutral inverse time over-current (ANSI 51N)

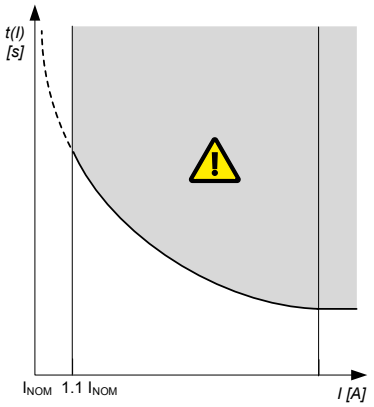
| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Neutral inverse time over-current | | 51N | - |

This is the inverse time over-current alarm for the neutral current measurement.

The alarm response is based on the unfiltered (except for anti-aliasing) neutral current, as measured by the 4th current measurement.

The alarm response time depends on an approximated integral of the current measurement over time. The integral is only updated when the measurement is above the activation threshold.

**NOTE** The diagram on the right is a simplified representation of this alarm. The diagram does not show the integral over time.




**AC configuration and protections > Current protections > Neutral inverse time over-current**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1721 | In> inverse Type | IEC Inverse<br>IEC Very Inverse<br>IEC Extremely inverse<br>IEEE Moderately Inv.<br>IEEE Very Inverse<br>IEEE Extremely Inv.<br>Custom | IEC Inverse |
| 1722 | In> inverse Limit | 2. to 120 % | 30 % |
| 1723 | In> inverse TMS | 0.01 to 100.00 | 1.00 |
| 1724 | In> inverse k | 0.001 to 32.000 s | 0.140 s |
| 1725 | In> inverse c | 0.000 to 32.000 s | 0.000 s |
| 1726 | In> inverse a | 0.001 to 32.000 s | 0.020 s |
| 1728 | Enable | OFF<br>ON | OFF |
| 1729 | Fail class | Fail classes | Trip PVB |

**More information**
See **Inverse time over-current (ANSI 51)** for the calculation method, the standard curves, and information about the definite time characteristic.

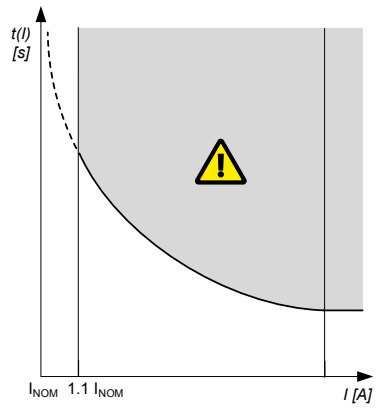
## 9.2.13 Earth fault inverse time over-current (ANSI 51G)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Earth fault inverse time over-current | | 51G | - |

This is the inverse time over-current alarm for the ground current measurement.

The alarm response is based on the ground current, as measured by the 4th current measurement filtered to attenuate the third harmonic (at least 18 dB).

**NOTE** The diagram on the right is a simplified representation of this alarm. The diagram does not show the integral over time.




**AC configuration and protections > Current protections > Earth fault inverse time over-current**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1731 | Ie> inverse Type | IEC Inverse<br>IEC Very Inverse<br>IEC Extremely inverse<br>IEEE Moderately Inv.<br>IEEE Very Inverse<br>IEEE Extremely Inv.<br>Custom | - |
| 1732 | Ie> inverse Limit | 2 to 120 % | 10 % |
| 1733 | Ie> inverse TMS | 0.01 to 100.00 | 1.00 |
| 1734 | Ie> inverse k | 0.001 to 32.000 s | 0.140 s |
| 1735 | Ie> inverse c | 0.000 to 32.000 s | 0.000 s |
| 1736 | Ie> inverse a | 0.001 to 32.000 s | 0.020 s |
| 1738 | Enable | OFF<br>ON | OFF |
| 1739 | Fail class | Fail classes | Trip PVB |

**More information**
See **Inverse time over-current (ANSI 51)** for the calculation method, the standard curves, and information about the definite time characteristic.

## 9.2.14 Negative sequence current (ANSI 46)

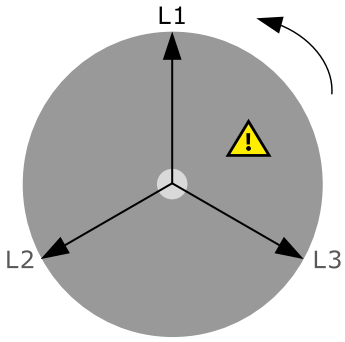
| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Negative sequence current | | 46 | < 200 ms* |

**NOTE** * The operate time includes the minimum user-defined delay of 100 ms.

Negative sequence currents arise when the virtual representation of the phase rotation for an unbalanced system appears negative.

Negative sequence currents can occur where there are single phase loads, unbalanced line short circuits and open conductors, and/or unbalanced phase-phase or phase-neutral loads.

The alarm response is based on the estimated phase-to-neutral current phasors, from the source, as measured by the controller.




**AC configuration and protections > Current protections > Negative sequence current > Negative. seq. I.**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1541 | Set point | 1 to 100 % | 20 % |
| 1542 | Timer | 0.2 to 100 s | 0.5 s |
| 1545 | Enable | OFF<br>ON | OFF |
| 1546 | Fail class | Fail classes | Trip MB |

## 9.2.15 Zero sequence current (ANSI 51Io)

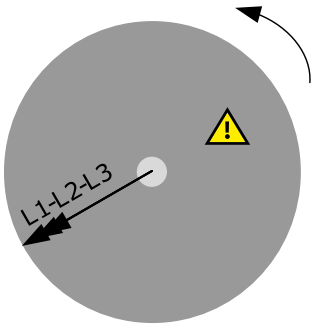
| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Zero sequence current | | 51Io | < 200 ms* |

**NOTE** * The operate time includes the minimum user-defined delay of 100 ms.

Zero sequence currents arise when the phases rotation is positive, but the vector zero value is displaced.

This protection is used for detecting earth faults.

The alarm response is based on the estimated current phasors from the source, as measured by the controller.



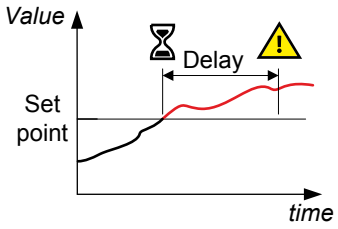

**AC configuration and protections > Current protections > Zero sequence current > Zero seq. I**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1571 | Set point | 0 to 100 % | 20 % |
| 1572 | Timer | 0.2 to 100 s | 0.5 s |
| 1575 | Enable | OFF<br>ON | OFF |
| 1576 | Fail class | Fail classes | Trip MB |

## 9.2.16 Over-frequency (ANSI 81O)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Over-frequency | f>, f>> | 81O | < 100 ms |

The alarm response is based on the fundamental frequency (based on phase voltage), due to the selection made in parameter 1204.




**AC configuration and protections > Frequency protections > Over-frequency > PV f> [1 to 3]**

| Parameter | Text | Range | PV f> 1 | PV f> 2 | PV f> 3 |
|---|---|---|---|---|---|
| 1211, 1221 or 1231 | Set point | 100 to 120 % | 103 % | 105 % | 105 % |
| 1212, 1222 or 1232 | Timer | 0.2 to 100 s | 10 s | 5 s | 5 s |
| 1215, 1225 or 1235 | Enable | OFF<br>ON | OFF | OFF | OFF |
| 1216, 1226 or 1236 | Fail class | Fail classes | Warning | Warning | Warning |

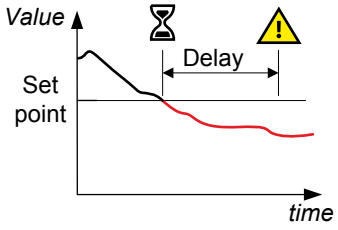
**AC configuration and protections > Frequency protections > Frequency detection type**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1204 | Type | L1<br>L2<br>L3<br>L1 or L2 or L3<br>L1 and L2 and L3 | L1 or L2 or L3 |

## 9.2.17 Under-frequency (ANSI 81U)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Under-frequency | f<, f<< | 81U | < 100 ms |

The alarm response is based on the highest fundamental frequency (based on phase voltage), from the source. This ensures that the alarm only activates when all of the phase frequencies are below the set point.




**AC configuration and protections > Frequency protections > Under-frequency > PV f< [1 to 3]**

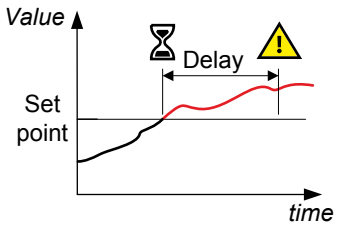
| Parameter | Text | Range | PV f< 1 | PV f< 2 | PV f< 3 |
|---|---|---|---|---|---|
| 1241, 1251 or 1261 | Set point | 80 to 100 % | 97 % | 95 % | 95 % |
| 1242, 1252 or 1262 | Timer | 0.2 to 100 s | 10 s | 5 s | 5 s |

| Parameter | Text | Range | PV f< 1 | PV f< 2 | PV f< 3 |
|---|---|---|---|---|---|
| 1245, 1255 or 1265 | Enable | OFF<br>ON | OFF | OFF | OFF |
| 1246, 1256 or 1266 | Fail class | Fail classes | Warning | Warning | Warning |

## 9.2.18 Overload (ANSI 32)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Overload | P>, P>> | 32 | < 100 ms |

The alarm response is based on the active power (all phases), from the source, as measured by the controller.



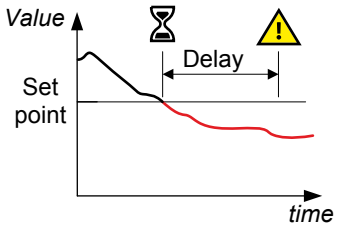

**AC configuration and protections > Power protections > Overload > P> [1 to 4]**

| Parameter | Text | Range | P> 1 | P> 2 | P> 3 | P> 4 |
|---|---|---|---|---|---|---|
| 1451, 1461, 1471 or 1481 | Set point | -200 to 200 % | 100 % | 110 % | 100 % | 110 % |
| 1452, 1462, 1472 or 1482 | Timer | 0.1 to 3200 s | 10 s | 5 s | 10 s | 5 s |
| 1455, 1465, 1475 or 1485 | Enable | OFF<br>ON | OFF | OFF | OFF | OFF |
| 1456, 1466, 1476 or 1486 | Fail class | Fail classes | Warning | Trip PVB | Trip PVB | Trip PVB |

## 9.2.19 Low power

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Low power | - | - | < 100 ms |

The alarm response is based on the active power (all phases), from the source, as measured by the controller.



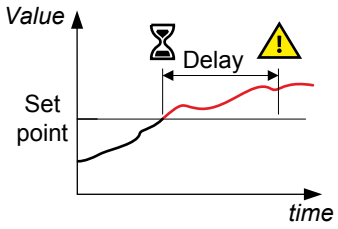

**AC configuration and protections > Power protections > Overload > P<**

| Parameter | Text | Range | P< |
|---|---|---|---|
| 1491 | Set point | -200 to 200 % | 30 % |
| 1492 | Timer | 0.1 to 3200 s | 3200 s |
| 1495 | Enable | OFF<br>ON | OFF |
| 1496 | Fail class | Fail classes | Trip PVB |

## 9.2.20 Reverse power (ANSI 32R)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Reverse power | P<, P<< | 32R | < 100 ms |

The alarm response is based on the active power (all phases), to the source, as measured by the controller.



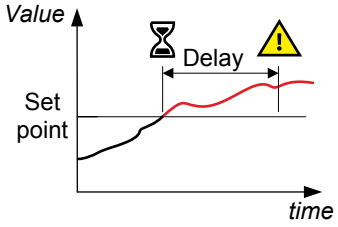

**AC configuration and protections > Power protections > Reverse power > -P> [1 to 3]**

| Parameter | Text | Range | -P> 1 | -P> 2 | -P > 3 |
|---|---|---|---|---|---|
| 1001, 1011 or 1071 | Set point | -200 to 0 % | -5 % | -5 % | -5 % |
| 1002, 1012 or 1072 | Timer | 0.1 to 100 s | 10 s | 10 s | 10 s |
| 1005, 1015 or 1075 | Enable | OFF<br>ON | ON | ON | OFF |
| 1006, 1016 or 1076 | Fail class | Fail classes | Trip PVB | Trip PVB | Trip PVB |

## 9.2.21 Reactive power export (ANSI 40O)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Reactive power export (over-excitation) | Q>, Q>> | 40O | < 100 ms |

The alarm response is based on the reactive power (Q) from the source, as measured and calculated by the controller. Reactive power export is when the PV is feeding an inductive load.



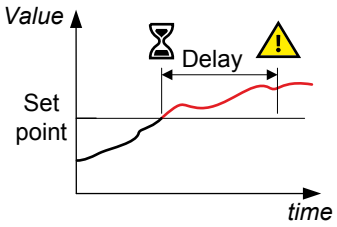

**AC configuration and protections > Reactive power protect. > Overexcitation > Q>**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1531 | Set point | 0 to 100 % | 60 % |
| 1532 | Timer | 0.1 to 100 s | 10 s |
| 1535 | Enable | OFF<br>ON | OFF |
| 1536 | Fail class | Fail classes | Warning |

## 9.2.22 Reactive power import (ANSI 40U)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Reactive power import (loss of excitation/under-excitation) | Q<, Q<< | 40U | < 100 ms |

The alarm response is based on the reactive power (Q) to the source, as measured and calculated by the controller. Reactive power import is when the PV is feeding a capacitive load.




**AC configuration and protections > Reactive power protect. > Underexcitation > -Q>**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1521 | Set point | 0 to 150 % | 50 % |
| 1522 | Timer | 0.1 to 100 s | 10 s |
| 1525 | Enable | OFF<br>ON | OFF |
| 1526 | Fail class | Fail classes | Warning |

## 9.3 Busbar standard protections

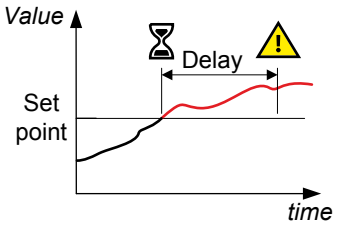
| Protection | IEC symbol (IEC 60617) | ANSI (IEEE C37.2) | Operate time | Alarms |
|---|---|---|---|---|
| Over-voltage | U>, U>> | 59 | < 50 ms | 3 |
| Under-voltage | U<, U<< | 27 | < 50 ms | 4 |
| Voltage unbalance | UUB> | 47 | < 200 ms* | 1 |
| Positive sequence under-voltage | $U_1$< | 27D | < 40 ms | 1 |
| Over-frequency | f>, f>> | 81O | < 50 ms | 3 |
| Under-frequency | f<, f<< | 81U | < 50 ms | 4 |
| Vector shift | dφ/dt | 78 | < 40 ms | 1 |
| Rate of change of frequency ROCOF (df/dt) | (df/dt) | 81R | < 120 ms | 1 |

**NOTE** * The operate time includes the minimum user-defined delay of 100 ms.

### 9.3.1 Busbar over-voltage (ANSI 59)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Over-voltage | U>, U>> | 59 | < 50 ms |

The alarm response is based on the highest phase-to-phase voltage, or the highest phase-to-neutral voltage, from the busbar, as measured by the controller.



**Busbar > Voltage protections > Over-voltage > BB U> [1 to 3]**

| Parameter | Text | Range | BB U> 1 | BB U> 2 | BB U> 3 |
|---|---|---|---|---|---|
| 1271, 1281 or 1291 | Set point | 100 to 120 % | 103 % | 105 % | 105 % |
| 1272, 1282 or 1292 | Timer | 0.04 to 99.99 s | 10 s | 5 s | 5 s |
| 1275, 1285 or 1295 | Enable | OFF<br>ON | OFF | OFF | OFF |
| 1276, 1286 or 1296 | Fail class | Fail classes | Warning | Warning | Warning |

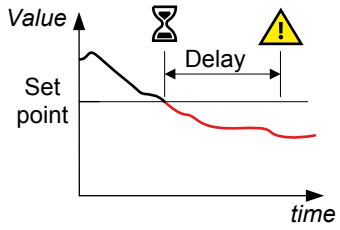
**Busbar > Voltage protections > Voltage detect. type**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1202 | Type | Phase-Phase<br>Phase-Neutral | Phase-Phase |

## 9.3.2 Busbar under-voltage (ANSI 27)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Under-voltage | U<, U<< | 27 | < 50 ms |

The alarm response is based on the lowest phase-to-phase voltage, or the lowest phase-to-neutral voltage, from the busbar, as measured by the controller.




**Busbar > Voltage protections > Under-voltage > BB U< [1 to 4]**

| Parameter | Text | Range | BB U< 1 | BB U< 2 | BB U< 3 | BB U< 4 |
|---|---|---|---|---|---|---|
| 1301, 1311, 1321 or 1331 | Set point | 40 to 100 % | 97 % | 95 % | 97 % | 95 % |
| 1302, 1312, 1322 or 1332 | Timer | 0.04 to 99.99 s | 10 s | 5 s | 10 s | 5 s |
| 1305, 1315, 1325 or 1335 | Enable | OFF<br>ON | OFF | OFF | OFF | OFF |
| 1306, 1316, 1326 or 1336 | Fail class | Fail classes | Warning | Warning | Warning | Warning |

**Busbar > Voltage protections > Voltage detect. type**

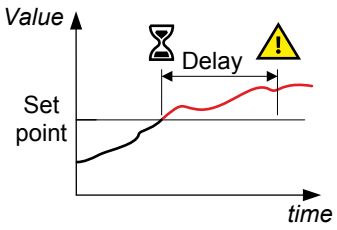
| Parameter | Text | Range | Default |
|---|---|---|---|
| 1202 | Type | Phase-Phase<br>Phase-Neutral | Phase-Phase |

## 9.3.3 Busbar voltage unbalance (ANSI 47)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Voltage unbalance (voltage asymmetry) | UUB> | 47 | < 200 ms* |

**NOTE** * The operate time includes the minimum user-defined delay of 100 ms.

The alarm response is based on the highest difference between any of the three busbar phase-to-phase voltage or phase-to-neutral true RMS values and the average voltage, as measured by the controller. The phase-to-phase voltage is the default.




If phase-to-phase voltages are used, the controller calculates the average phase-to-phase voltage. The controller then calculates the difference between each phase-to-phase voltage and the average voltage. Finally, the controller divides the maximum difference by the average voltage to get the voltage unbalance. See the example.

**Busbar > Voltage protections > Voltage unbalance > BB Unbalance U**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1621 | Set point | 0 to 50 % | 6 % |
| 1622 | Timer | 0.1 to 100 s | 10 s |
| 1625 | Enable | OFF<br>ON | OFF |
| 1626 | Fail class | Fail classes | Warning |

**Busbar voltage unbalance example**

The busbar has a nominal voltage of 230 V. The L1-L2 voltage is 235 V, the L2-L3 voltage is 225 V, and the L3-L1 voltage is 210 V.

The average voltage is 223.3 V. The difference between the phase-to-phase voltage and the average is 12.7 V for L1-L2, 2.7 V for L2-L3 and 13.3 V for L3-L1.

The busbar voltage unbalance is 13.3 V / 223.3 V = 0.06 = 6 %

## 9.3.4 Positive sequence under-voltage (ANSI 27d)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Positive sequence under-voltage | $U_2<$ | 27d | < 40 ms |

As a result of the generator's power production to the consumers, the positive sequence system represents the fault-free part of the voltages.

The controller measures the voltage state on the positive sequence voltage part of the voltage phasors of the busbar or mains. The alarm response is based on the lowest positive voltage value measured at the zero crossing point of each phase.

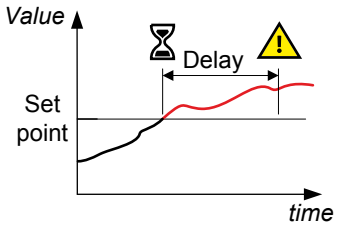
**Busbar > Voltage protections > Pos. seq. under-volt. > BB Pos seq volt**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1441 | Set point | 10 to 110 % | 70 % |
| 1442 | Timer | 1 to 9 Periods | 2 Periods |
| 1445 | Enable | OFF<br>ON | OFF |
| 1446 | Fail class | Fail classes | Trip MB |

## 9.3.5 Busbar over-frequency (ANSI 81O)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Over-frequency | f>, f>> | 81O | < 50 ms |

The alarm response is based on the lowest fundamental frequency (based on phase voltage), from the busbar. This ensures that the alarm only activates when all of the phase frequencies are above the set point.




**Busbar > Frequency protections > Over-frequency > BB f> [1 to 4]**

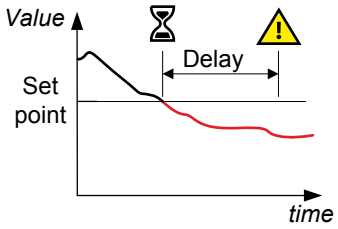
| Parameter | Text | Range | BB f> 1 | BB f> 2 | BB f> 3 | BB f> 4 |
|---|---|---|---|---|---|---|
| 1351, 1361, 1371 or 1921 | Set point | 100 to 120 % | 103 % | 105 % | 105 % | 102 % |
| 1352, 1362, 1372 or 1922 | Timer | 0.04 to 99.99 s | 10 s | 5 s | 5 s | 5600 s* |
| 1355, 1365, 1375 or 1925 | Enable | OFF<br>ON | OFF | OFF | OFF | OFF |
| 1356, 1366, 1376 or 1926 | Fail class | Fail classes | Warning | Warning | Warning | Warning |

**NOTE** * The range for this alarm is 1500 to 6000 s.

## 9.3.6 Busbar under-frequency (ANSI 81U)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Under-frequency | f<, f<< | 81U | < 50 ms |

The alarm response is based on the highest fundamental frequency (based on phase voltage), from the busbar. This ensures that the alarm only activates when all of the phase frequencies are below the set point.




**Busbar > Frequency protections > Under-frequency > BB f< [1 to 5]**

| Parameter | Text | Range | BB f< 1 | BB f< 2 | BB f< 3 | BB f< 4 | BB f< 5 |
|---|---|---|---|---|---|---|---|
| 1381, 1391, 1401, 1411 or 1931 | Set point | 80 to 100 % | 97 % | 95 % | 97 % | 95 % | 95 % |
| 1382, 1392, 1402, 1412 or 1932 | Timer | 0.04 to 99.99 s | 10 s | 5 s | 10 s | 5 s | 5600 s* |
| 1385, 1395, 1405, 1415 or 1935 | Enable | OFF<br>ON | OFF | OFF | OFF | OFF | OFF |
| 1386, 1396, 1406, 1416 or 1936 | Fail class | Fail classes | Warning | Warning | Warning | Warning | Warning |

**NOTE** * The range for this alarm is 1500 to 6000 s.

## 9.3.7 Vector shift (ANSI 78)

| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| Vector shift | dφ/dt | 78 | < 40 ms |

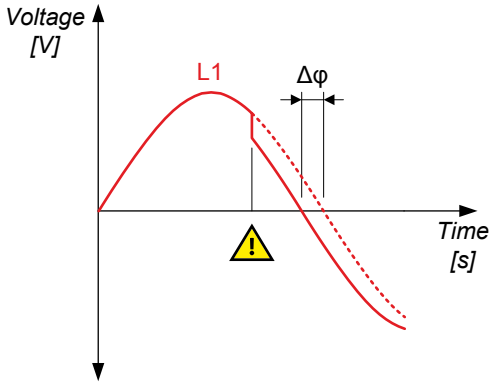
Vector shifts can arise when a mains failure occurs while a generator is running parallel with the mains.

Vector shifts can occur because the stator magnetic field lags behind the rotor magnetic field. When a mains failure occurs, the phase angle between the stator and rotor magnetic fields changes. This change in the phase angle, is also known as a vector shift.

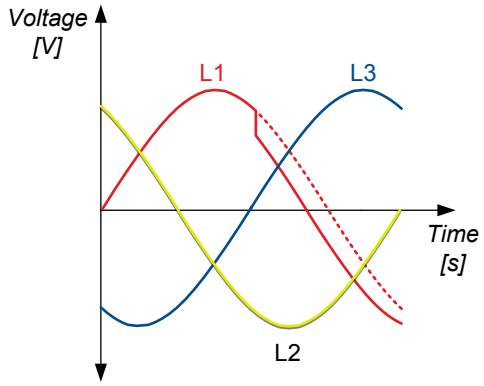
The alarm response is based on the change in the phase angle that occurred due to the mains failure. The alarm response can be based on the change in an individual phase, or on the change in all the phases.

In grids where fast automatic reconnection attempts are expected, this protection opens the breaker to prevent damaging failures. Fast changes in frequency can also activate this alarm. Too sensitive configuration can lead to too many unwanted detections of vector shift.

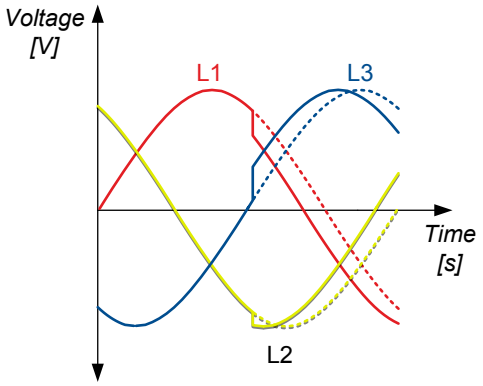
**Vector shift causes the instantaneous phase angle change (Δφ)**




**Vector shift in phase L1 only**




**Vector shift in all phases**




**Busbar > Additional protections > Vector shift**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1431 | Set point | 1 to 90 ° | 10 ° |
| 1434 | Enable | OFF<br>ON | OFF |
| 1435 | Fail class | Fail classes | Trip MB |
| 1436 | Type | Individual phases<br>All phases | All phases |

## 9.3.8 Rate of change of frequency (ANSI 81R)

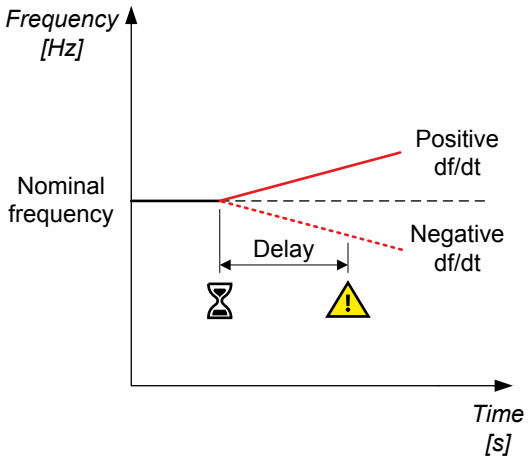
| Protection | IEC symbol (IEC60617) | ANSI (IEEE C37.2) | Operate time |
|---|---|---|---|
| ROCOF (df/dt) | df/dt | ANSI 81R | Standard: < 120 ms |

When a mains failure occurs, the measured frequency might change within a short period of time, if the generators are either instantly overloaded or instantly deloaded.

If the generator overloads instantly, it slows down, and the generator frequency might decrease shortly. Similarly, if the generator deloads instantly, it speeds up, and the generator frequency might increase shortly.

The alarm response is based on the rate of change of the measured frequency, within a specified time period.

In grids where fast automatic reconnection attempts are expected, this protection opens the breaker to prevent damaging failures.




**Busbar > Additional protections > df/dt (ROCOF)**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 1421 | Set point | 0.200 to 10.000 Hz/s | 5.000 Hz/s |
| 1422 | Periods | 3 to 20 Periods | 6 Periods |
| 1423 | Timer | 0.00 to 3.00 s | 0.00 s |
| 1426 | Enable | OFF<br>ON | OFF |
| 1427 | Fail class | Fail classes | Trip MB |

# 10. Inputs and outputs

## 10.1 Digital inputs

### 10.1.1 Standard digital inputs

The controller has as standard 12 digital inputs, located on the terminals 39 to 50. All inputs are configurable.

**Digital inputs**

| Input | Text | Function | Technical data |
|---|---|---|---|
| 39 | In | Configurable | Negative switching only, < 100 Ω |
| 40 | In | Configurable | Negative switching only, < 100 Ω |
| 41 | In | Configurable | Negative switching only, < 100 Ω |
| 42 | In | Configurable | Negative switching only, < 100 Ω |
| 43 | In | Configurable | Negative switching only, < 100 Ω |
| 44 | In | Configurable | Negative switching only, < 100 Ω |
| 45 | In | Configurable | Negative switching only, < 100 Ω |
| 46 | In | Configurable | Negative switching only, < 100 Ω |
| 47 | MB position on* | Configurable (application dependent) | Negative switching only, < 100 Ω |
| 48 | MB position off* | Configurable (application dependent) | Negative switching only, < 100 Ω |
| 49 | PVB position on | Configurable (application dependent) | Negative switching only, < 100 Ω |
| 50 | PVB position off | Configurable (application dependent) | Negative switching only, < 100 Ω |

**NOTE** * For a single controller application with a mains breaker.

### 10.1.2 Configuring digital inputs

The digital inputs can be configured from the controller or with the utility software (some parameters can only be accessed with the utility software).

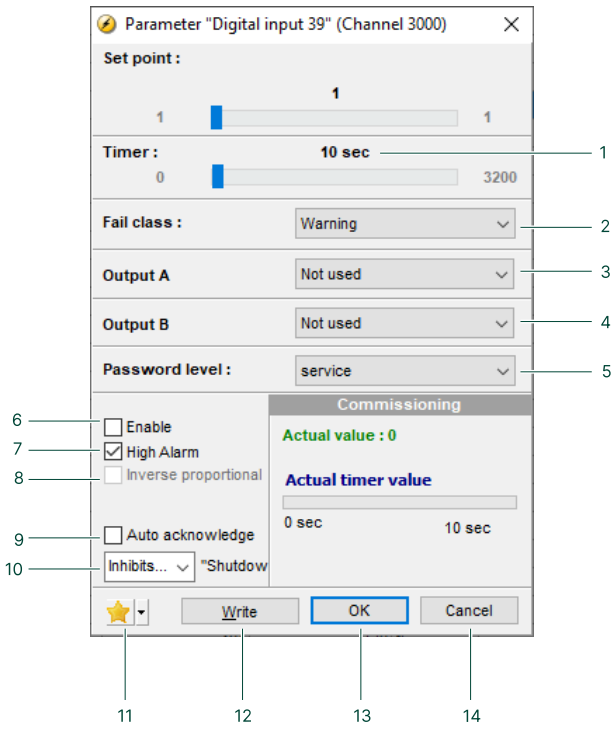
**`I/O settings > Inputs > Digital input > Digital input [39 to 50]`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 3001, 3011, 3021, 3031, 3041, 3051, 3061, 3071, 3081, 3091, 3101 or 3111 | Delay | 0.0 to 3200 s | 10.0 s |
| 3002, 3012, 3022, 3032, 3042, 3052, 3062, 3072, 3082, 3092, 3102 or 3112 | Output A | Relays and M-Logic | Not used |
| 3003, 3013, 3023, 3033, 3043, 3053, 3063, 3073, 3083, 3093, 3103 or 3113 | Output B | Relays and M-Logic | Not used |
| 3004, 3014, 3024, 3034, 3044, 3054, 3064, 3074, 3084, 3094, 3104 or 3114 | Alarm | Disable<br>Enable | Disable |
| 3005, 3015, 3025, 3035, 3045, 3055, 3065, 3075, 3085, 3095, 3105 or 3115 | Fail class | Fail classes | Warning |
| 3006, 3016, 3026, 3036, 3046, 3056, 3066, 3076, 3086, 3096, 3106 or 3116 | Type | High<br>Low | High |

**Configure a digital input with the utility software**

In the utility software, in *Parameters*, select the digital input to configure.

A window opens with the following parameter settings:




| No. | Text | Description |
|---|---|---|
| 1 | Timer | The timer setting is the time from the alarm level is reached until the alarm occurs. |
| 2 | Fail class | Select the required fail class from the list. When the alarm occurs, the controller reacts according to the selected fail class. |
| 3 | Output A | Select the terminal (or the limit option) to be activated by an alarm. Limit makes the alarm useable as an input event in M-Logic. |
| 4 | Output B | Select the terminal (or the limit option) to be activated by an alarm. Limit makes the alarm useable as an input event in M-Logic. |
| 5 | Password level | Select the password level that is needed to modify this parameter (cannot be edited by a user with lower privileges). |
| 6 | Enable | Activates/deactivates the alarm function. |
| 7 | High alarm | The alarm is activated when the signal is high. |
| 8 | Inverse proportional | Not used for digital inputs. |
| 9 | Auto acknowledge | If this option is set, the alarm is automatically acknowledged if the signal related to the alarm disappears. |
| 10 | Inhibits | Select the exceptions to when an alarm must be activated. To select when the alarms are to be active, each alarm has a configurable inhibit setting. |
| 11 | Favourite | Mark the parameter as a favourite parameter. You can choose to view only favourite parameters. |
| 12 | Write | Select to write the changes to the controller. |
| 13 | OK | Select to confirm after each writing to the controller. |
| 14 | Cancel | Quit without writing to the controller. |

## 10.2 DC relay outputs

The controller has 12 x DC relay outputs as standard. The outputs are divided in two groups with different electrical characteristics.

All outputs are configurable, unless other stated.

**Relay outputs, group 1**

Electrical characteristics

- Voltage: 0 to 36 V DC
- Current: 15 A DC inrush, 3 A DC continuous

| Relay | Default setting |
|---|---|
| Relay 05 | No default |
| Relay 06 | No default |

**Relay outputs, group 2**

Electrical characteristics

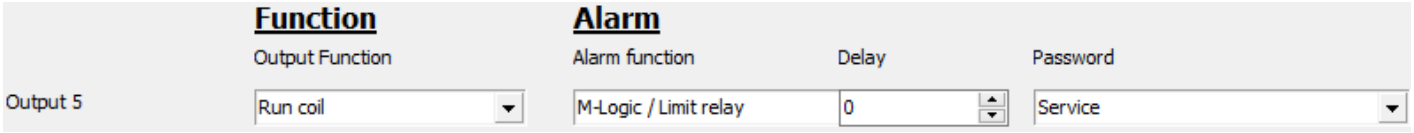
- Voltage: 4.5 to 36 V DC
- Current: 2 A DC inrush, 0.5 A DC continuous

| Relay | Default setting |
|---|---|
| Relay 09 | No default |
| Relay 10 | No default |
| Relay 11 | Status OK |
| Relay 12 | No default |
| Relay 13 | No default |
| Relay 14 | No default |
| Relay 15 | MB ON relay* |
| Relay 16 | MB OFF relay* |
| Relay 17 | PVB ON relay** |
| Relay 18 | PVB OFF relay** |

**NOTE** * For a single controller application with a mains breaker. If there is no breaker, these outputs are configurable.
**NOTE** ** If there is no breaker, these outputs are configurable.

## 10.2.1 Configure a relay output

Use the utility software, under *I/O setup, DO 5 - 18* to configure the relay outputs.




| Setting | Description |
|---|---|
| Output function | Select an output function. |
| Alarm function | Alarm relay NE<br>M-Logic / Limit relay<br>Alarm relay ND |
| Delay | The alarm timer. |
| Password | Select the password level to modify this configuration (cannot be edited by a user with lower privileges). |

# 10.3 Analogue inputs

## 10.3.1 Introduction

The controller has four analogue inputs (also known as multi-inputs): Multi-input 20, multi-input 21, multi-input 22, and multi-input 23. Terminal 19 is the common ground for the multi-inputs.

The multi-inputs can be configured as:

- 4-20 mA
- 0-10 V DC
- Pt100
- RMI oil pressure
- RMI water temperature
- RMI fuel level
- RMI Custom
- Binary/digital input

The function of the multi-inputs can only be configured with the utility software.

### Wiring

The wiring depends on the measurement type (current, voltage, or resistance).

**More information**
See **Wiring** in the **Installation instructions** for examples of wiring.

## 10.3.2 Application description

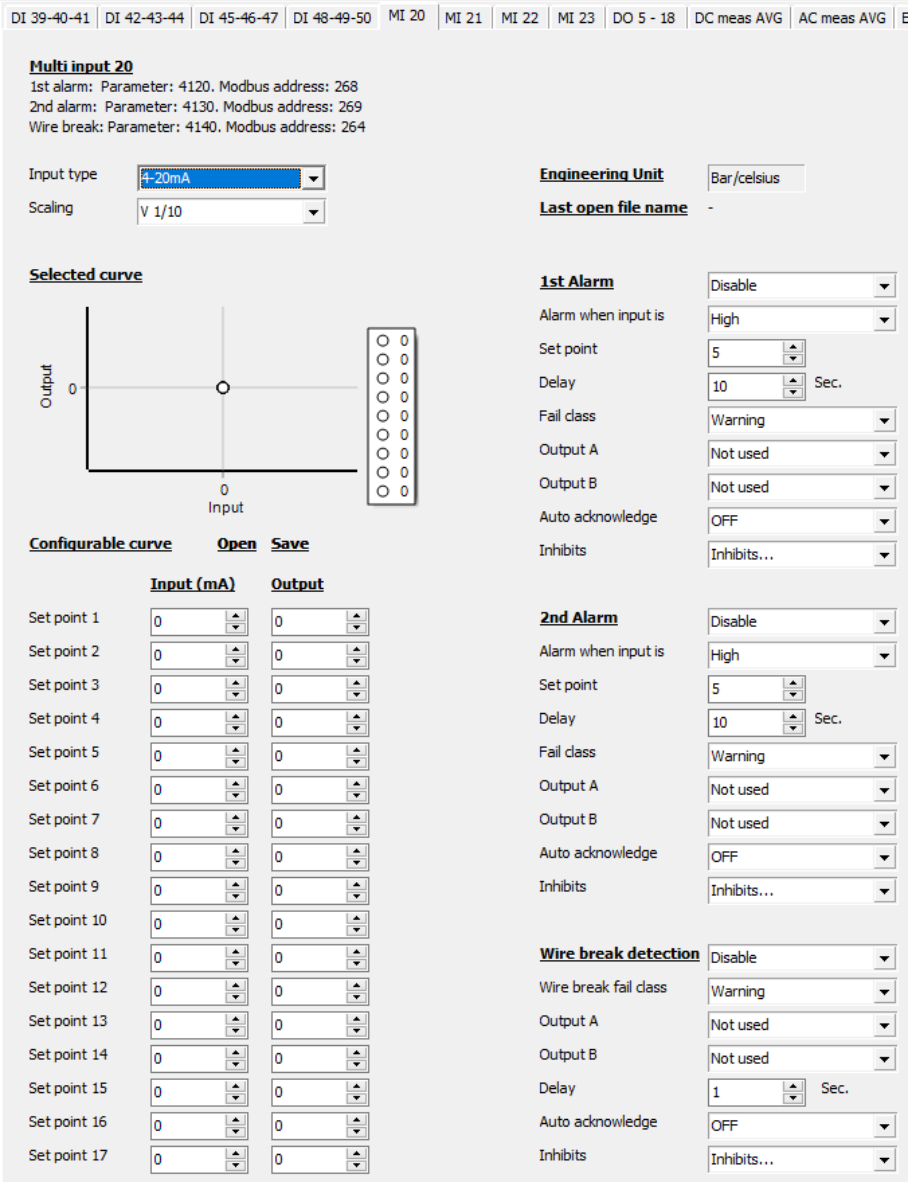
The multi-inputs can be used in different applications. For example:

- Power transducer. If you want to measure the power from another power source, a power transducer sending a 4-20 mA signal could be connected to multi-input 20.
- Temperature sensor. Pt100 resistors are often used to measure temperature. In the utility software, you can choose whether the temperature should be shown as Celsius or Fahrenheit.
- RMI inputs. The controller has three RMI types; oil, water and fuel. It is possible to choose different types within each RMI type. There is also a configurable type. For more information, see the **AGC 150 Genset Mains BTB Designer's handbook**.
- An extra button. If the input is configured as digital, it works like an extra digital input.
- Differential measurement can be used to activate an alarm when two values are too far apart.

## 10.3.3 Configuring multi-inputs

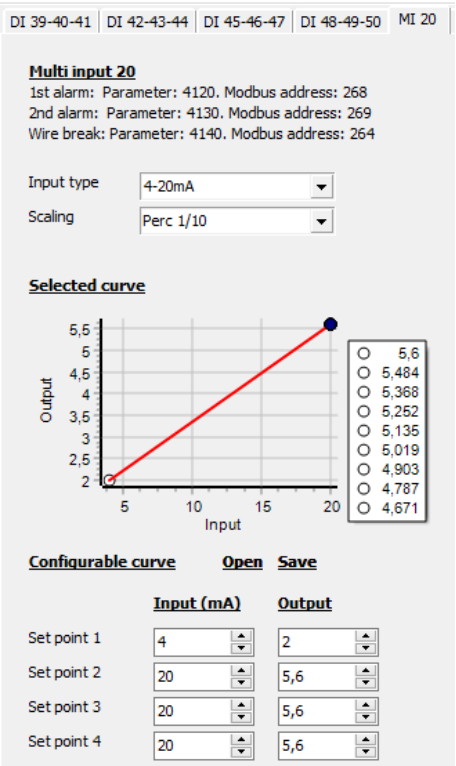
Configure each multi-input to match the connected sensor.

1. In the utility software, select *I/O & Hardware setup*, then select *MI 20 / 21 / 22 / 23*.

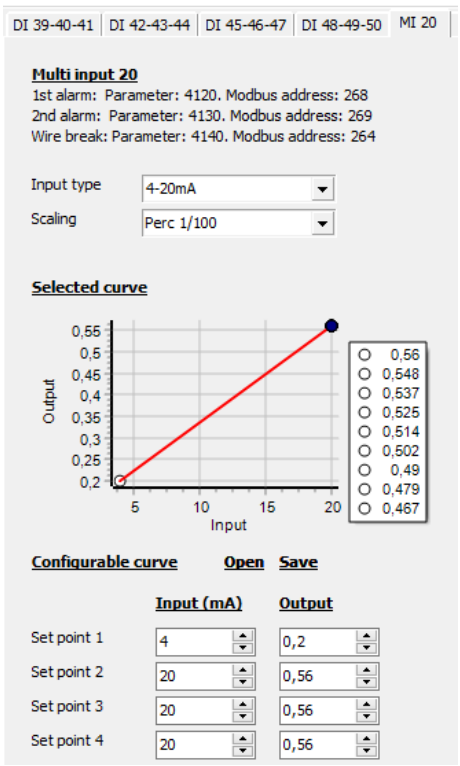



2. Select the appropriate *Scaling*.

**Examples**




**Scaling 1/10**

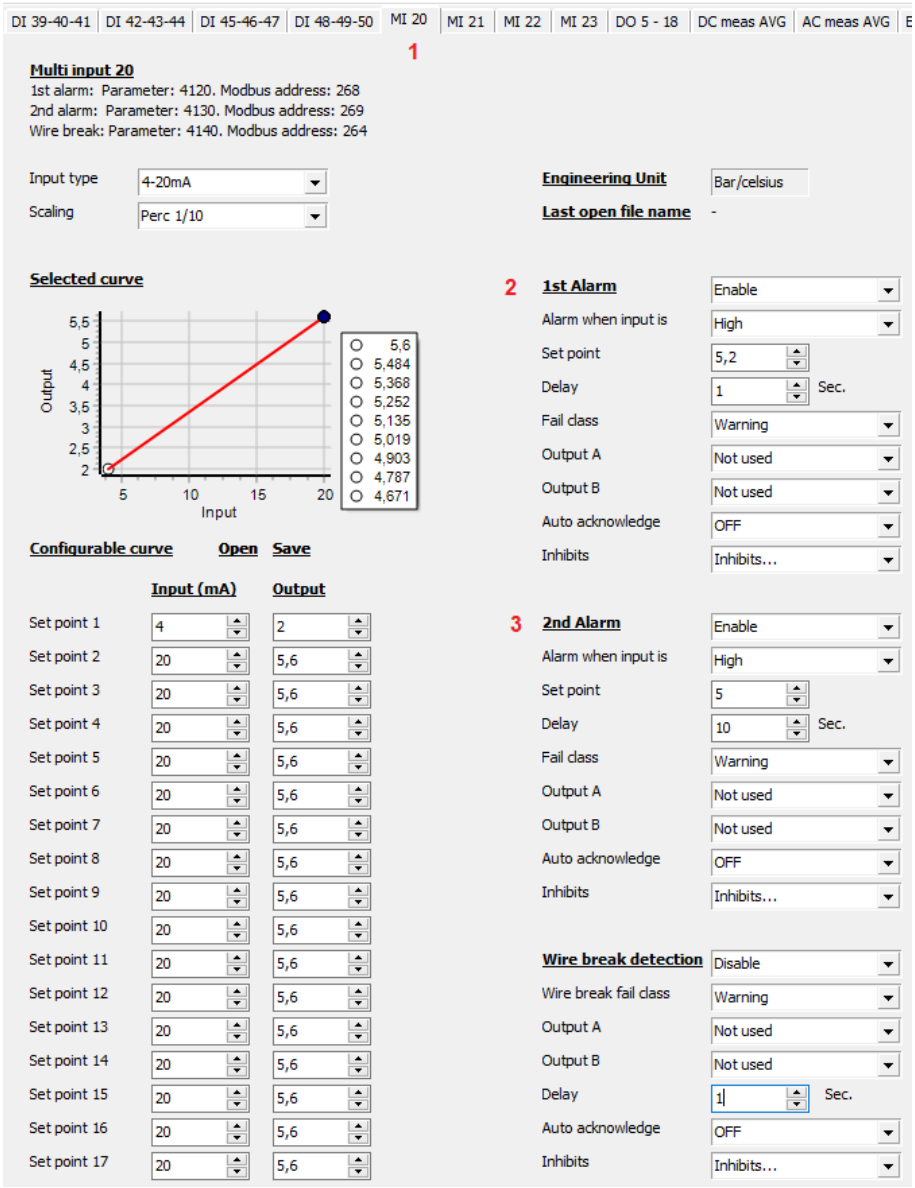



**Scaling 1/100**

## 10.3.4 Alarms

For each multi-input, two alarm levels are available. With two alarms it is possible to have the first alarm reacting slow, while the second alarm can react faster. For example, if the sensor measures generator current as protection against overload, a small overload is acceptable for a shorter period, but in case of a large overload, the alarm should activate quickly.

Use the utility software to configure the multi-input alarms. Select *I/O & Hardware setup*, then select *MI 20 / 21 / 22 /23*.




1. Select the desired multi-input tab.
2. Configure the parameters for 1st alarm.
3. Configure the parameters for 2nd alarm.

### Sensors with max. output less than 20 mA

If a sensor has a maximum output less than 20 mA, it is necessary to calculate what a 20 mA signal would indicate.

**Example**: A pressure sensor gives 4 mA at 0 bars and 12 mA at 5 bar.

- (12 - 4) mA = 8 mA = 5 bar
- 1 mA = 5 bar/8 = 0.625 bar
- 20 - 4 mA = 16 × 0.625 bar = 10 bar

### Configuring multi-input alarms from the display

Alternatively, you can use the display to configure the multi-input alarms: `I/O settings > Inputs > Multi input > Multi input [20 to 23].1 / 2`

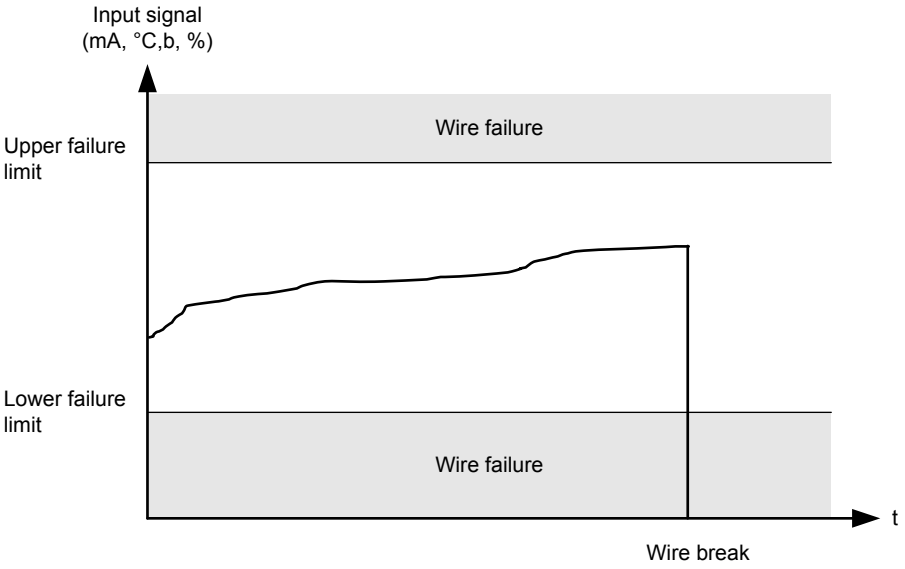
## 10.3.5 Wire break

To supervise the sensors/wires connected to the multi-inputs and analogue inputs, you can enable the wire break function for each input. If the measured value on the input is outside the normal dynamic area of the input, it is detected as a short circuit or a break. An alarm with a configurable fail class is activated.

| Input | Wire failure area | Normal range | Wire failure area |
|---|---|---|---|
| 4-20 mA | <3 mA | 4-20 mA | >21 mA |
| 0-10 V DC | ≤0 V DC | - | N/A |
| RMI Oil, type 1 | <10.0 Ω | - | >184.0 Ω |
| RMI Oil, type 2 | <10.0 Ω | - | >184.0 Ω |
| RMI Oil, type 4 | <33.0 Ω | - | 240.0 Ω |
| RMI Temp, type 1 | <10.0 Ω | - | >1350.0 Ω |
| RMI Temp, type 2 | <18.2 Ω | - | >2400.0 Ω |
| RMI Temp, type 3 | <3.6 Ω | - | >250.0 Ω |
| RMI Temp, type 4 | <32.0 Ω | - | >2500.0 Ω |
| RMI Fuel, Type 1 | <1.6 Ω | - | >78.8 Ω |
| RMI Fuel, Type 2 | <3.0 Ω | - | >180.0 Ω |
| RMI Fuel, type 4 | <33.0 Ω | - | >240.0 Ω |
| RMI configurable | <lowest resistance | - | >highest resistance |
| RMI Custom | <lowest resistance | - | >highest resistance |
| Pt100 | <82.3 Ω | - | >194.1 Ω |
| Level switch | Only active if the switch is open | | |

### Principle

The diagram shows that when the wire of the input breaks, the measured value drops to zero, and the alarm is activated.



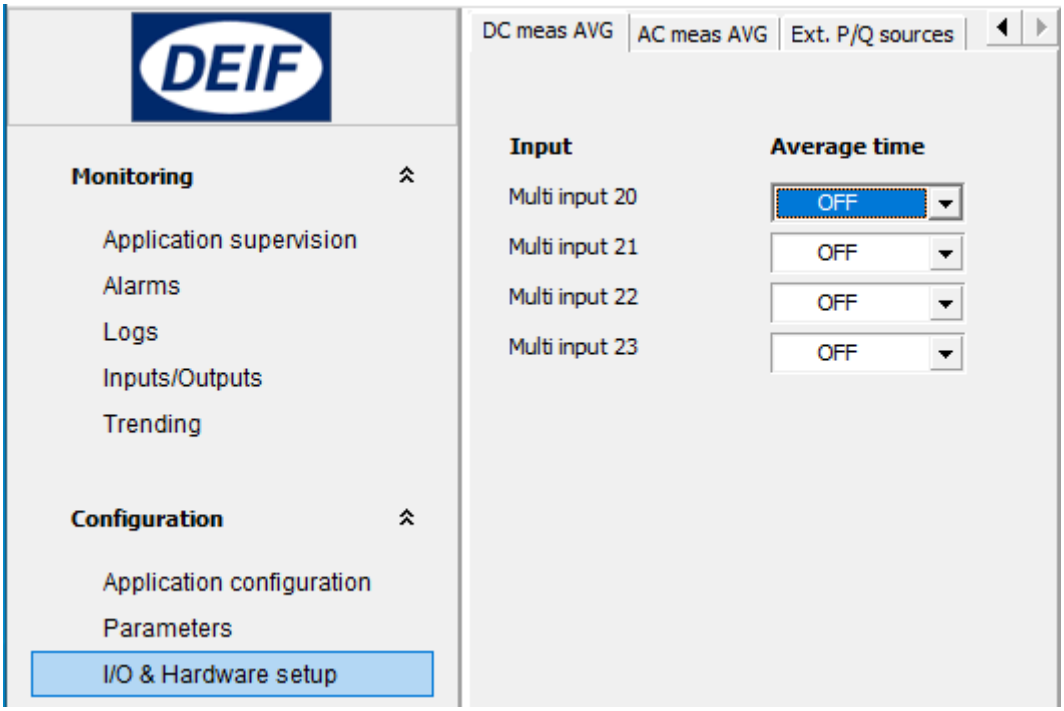

### Configuring wire break alarms from the utility software or display

You can use the utility software to configure wire break alarms. Alternatively, you can use the display to configure wire break alarms: `I/O settings > Inputs > Multi input > Wire fail [20 to 23]`

## 10.3.6 DC measurement averaging

You can use the utility software to set up averaging for the DC measurements (Multi input 20 to 23). The averaged values are then shown on the display unit and in the Modbus values. However, the controller continues to use real-time measurements.

In the utility software, under *I/O & Hardware setup*, select the *DC meas AVG* tab. For each measurement, you can select OFF, or averages calculated over 100 ms to 10 s.




## 10.3.7 Differential measurement

Differential measurement compares two measurements, and gives an alarm or trip if the difference between two measurements become too large (or too small). To have the alarm activate if the difference between the two inputs is lower than the alarm's set point, remove the check mark from *High Alarm* in the alarm configuration.

It is possible to have up to six comparisons. Two alarms can be configured for each comparison.

### Using differential measurement to create an extra analogue alarm

If the same measurement is selected for input A and input B, the controller uses the value of the input for the differential measurement alarm.

**`Functions > Delta alarms > Set [1 to 6]`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 4601, 4603, 4605, 4671, 4673 or 4675 | Input A for comparison set [1 to 6] | See the controller | Multi-input 20 |
| 4602, 4604, 4606, 4672, 4674 or 4676 | Input B for comparison set [1 to 6] | | |

**`Functions > Delta alarms > Set [1 to 6] > Delta ana[1 to 6] [1 or 2]`**

| Parameter | Text | Range | Default |
|---|---|---|---|
| 4611, 4631, 4651, 4681, 4701 or 4721 | Set point 1 | -999.9 to 999.9 | 1.0 |
| 4621, 4641, 4661, 4691, 4711 or 4731 | Set point 2 | -999.9 to 999.9 | 1.0 |
| 4612, 4632, 4652, 4682, 4702 or 4722 | Timer 1 | 0.0 to 999.0 s | 5.0 s |
| 4622, 4642, 4662, 4692, 4712 or 4732 | Timer 2 | 0.0 to 999.0 s | 5.0 s |

| Parameter | Text | Range | Default |
|---|---|---|---|
| 4613, 4633, 4653, 4683, 4703 or 4723 | Output A set 1 | Relays and M-Logic | - |
| 4623, 4643, 4663, 4693, 4713 or 4733 | Output A set 2 | | |
| 4614, 4634, 4654, 4684, 4704 or 4724 | Output B set 1 | | |
| 4624, 4644, 4664, 4694, 4714 or 4734 | Output B set 2 | | |
| 4615, 4635, 4655, 4685, 4705 or 4725 | Enable set 1 | OFF<br>ON | OFF |
| 4625, 4645, 4665, 4695, 4715 or 4735 | Enable set 2 | | |
| 4616, 4636, 4656, 4686, 4706 or 4726 | Fail class set 1 | Fail classes | Warning |
| 4626, 4646, 4666, 4696, 4716 or 4736 | Fail class set 2 | | |

## 10.4 Analogue outputs

The controller has two analogue outputs that are active and galvanically separated. No external supply can be connected.

### 10.4.1 Using an analogue output as a transducer

You can configure transducers 52 and/or 55 to transmit values to an external system. The values include the controller's set points, and AC measurements.

You can select a scale for some of the values. For example, for the busbar voltage (parameter 5913), select the minimum in 5915, and select the maximum in 5914.

**NOTE** These values are also available using Modbus.

#### Transducer range

**`I/O settings > Outputs > Transducer > Output [52 or 55] limits`**

| Parameter | Name | Range | Details |
|---|---|---|---|
| 5802 or 5812 | AOUT [52 or 55] limits | -10.5 to 5 V | The transducer minimum limit. |
| 5803 or 5813 | AOUT [52 or 55] limits | -5 to 10.5 V | The transducer maximum limit. |

#### Transducer configuration example: Power output

**`I/O settings > Outputs > Transducer > kW > P output actual`**

| Parameter | Name | Range | Details |
|---|---|---|---|
| 5823 | P1 output type | **Set point**<br>Disabled<br>-10 to 10 V | Select the output. |
| | | **Transducer A**<br>Disabled<br>Transducer 52<br>Transducer 55 | |
| 5824 | P1 output max | 0 to 20000 kW | PV active power maximum for the transducer |
| 5825 | P1 output min | -9999 to 20000 kW | PV active power minimum for the transducer |

**Other transducer values**

| Parameter | Name | Details |
|---|---|---|
| 5693, 5694, 5695 | P ref | The controller's power set point. |
| 5853, 5854, 5855 | S | PV apparent power |
| 5863, 5864, 5865 | Q | PV reactive power |
| 5873, 5874, 5875 | PF | Power factor of the power from the PV |
| 5883, 5884, 5885 | f (PV) | PV frequency |
| 5893, 5894, 5895 | U (PV) | PV L1-L2 voltage |
| 5903, 5904, 5905 | I | PV L1 current |
| 5913, 5914, 5915 | U BB | Busbar/mains L1-L2 voltage |
| 5923, 5924, 5925 | f BB | Busbar/mains frequency |
| 5933, 5934, 5935 | Input 20 | The value received by analogue input 20. |
| 5943, 5944, 5945 | Input 21 | The value received by analogue input 21. |
| 5953, 5954, 5955 | Input 22 | The value received by analogue input 22. |

## 10.5 Additional inputs and outputs

If more inputs and/or outputs (IOs) are needed, you can use CIO modules with the ASC 150. When the CIOs are installed and the IOs are configured, the CIO IOs act like IOs on the ASC 150.

To use CIOs, in *CIO Enable* (parameter 7891) select *ON*.

**More information**
See the **CIO 116 Installation and Commissioning guide** under www.deif.com/products/cio-116.

See the **CIO 208 Installation and Commissioning guide** under www.deif.com/products/cio-208.

See the **CIO 308 Installation and Commissioning guide** under www.deif.com/products/cio-308.

# 11. Small Solar-Gensets-Mains example

## 11.1 Introduction

As this handbook shows, you can use the application drawing, inputs and outputs, parameters and M-Logic to use the ASC 150 Solar controller in a wide variety of applications. To help you to set up a single ASC 150 Solar controller quickly, this chapter has an example of a specific, simple, single controller application.

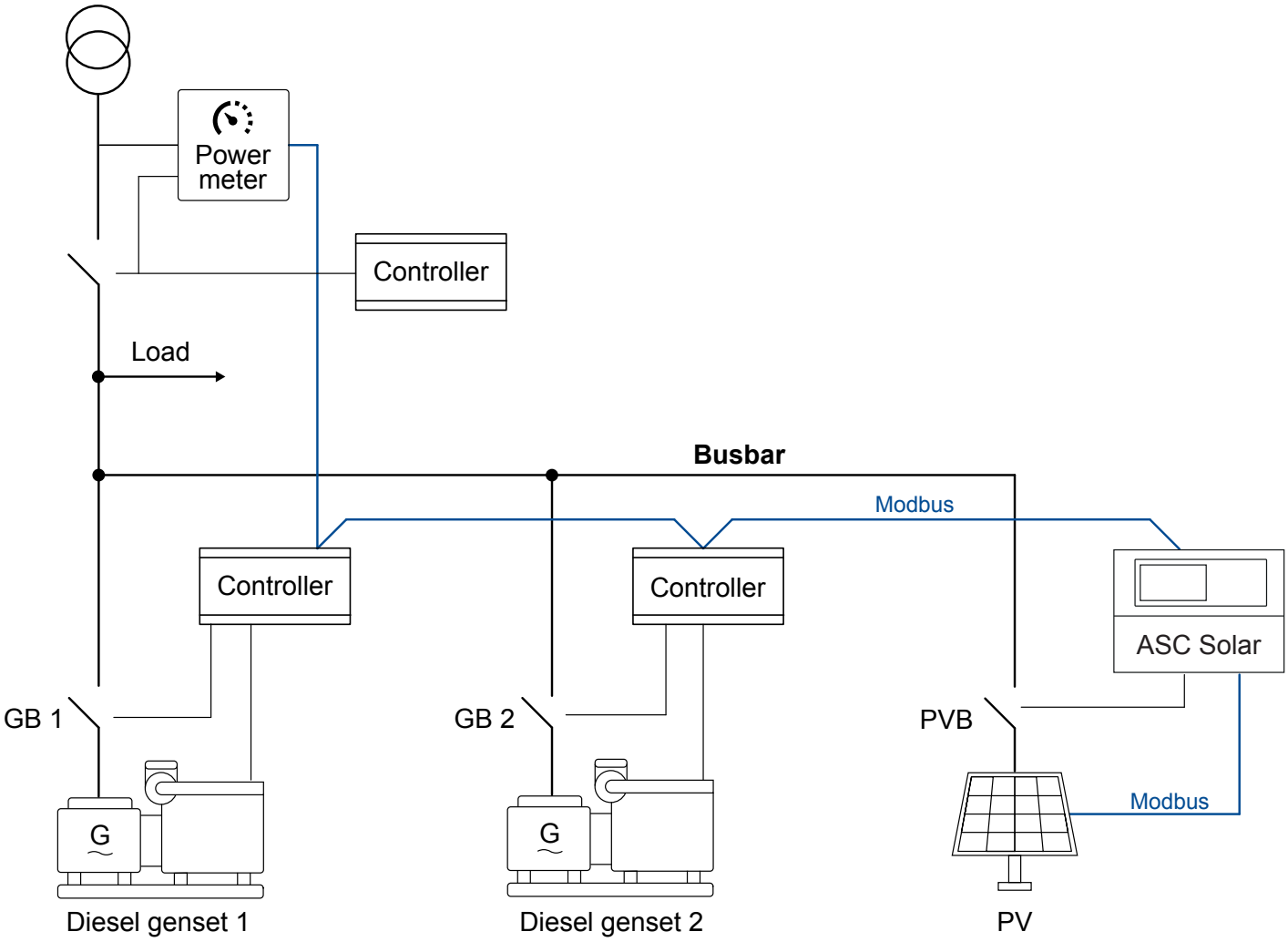
**DANGER!**

**Incorrect configuration is dangerous**

Only allow authorised personnel, who understand the risks involved in working with electrical systems, to do the installation and configuration. The configuration given here is an example. Do not blindly follow this example. Be careful to create a configuration that is suitable for your electrical system instead.

## 11.2 Application setup

**Single-line diagram for the application example**




**System information**

- PV power and the ASC 150 Solar are added to an existing application.
  - The application already had controllers for the gensets and the mains.
- Three-phase system, 50 Hz, 400 V phase-phase

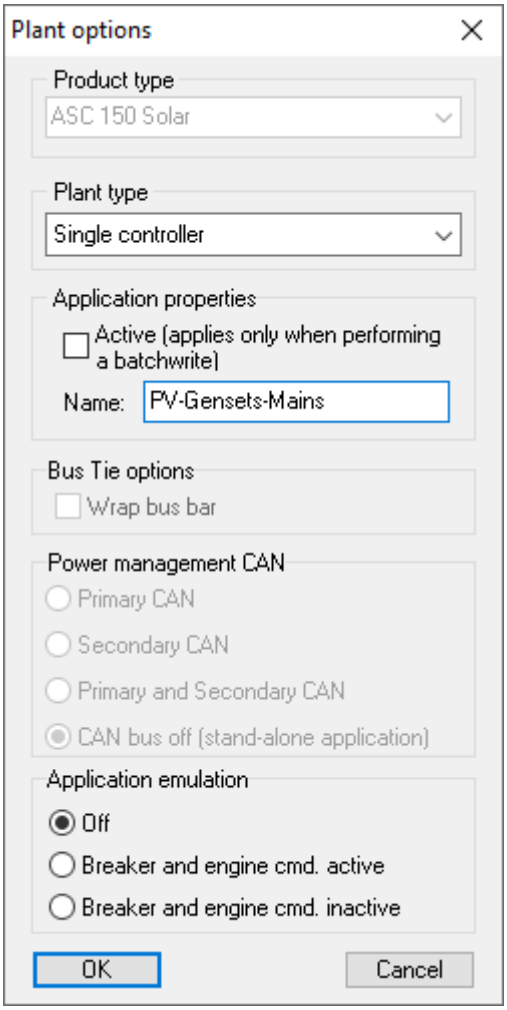
- PV system:
  - PV panels: 700 x 420 W panels
  - Inverters: 12 x Fronius Eco 25.0-3-S, each rated for 25 kVA (25 kW)
  - Total inverter nominal power = 300 kW
  - RS-485 Modbus RTU communication
  - Protocol = SunSpec Generic
- Genset 1 and Genset 2: 480 kW (600 kVA), with a DSE 8xxx controller each
  - Minimum genset load: 30 %
- Mains power meter: ABB SACE Emax 2
- Operation strategy:
  - Maximise the power from the PV system.
  - Protect the gensets from low load.
  - Prevent power export to the mains.

### ASC 150 Solar software variant

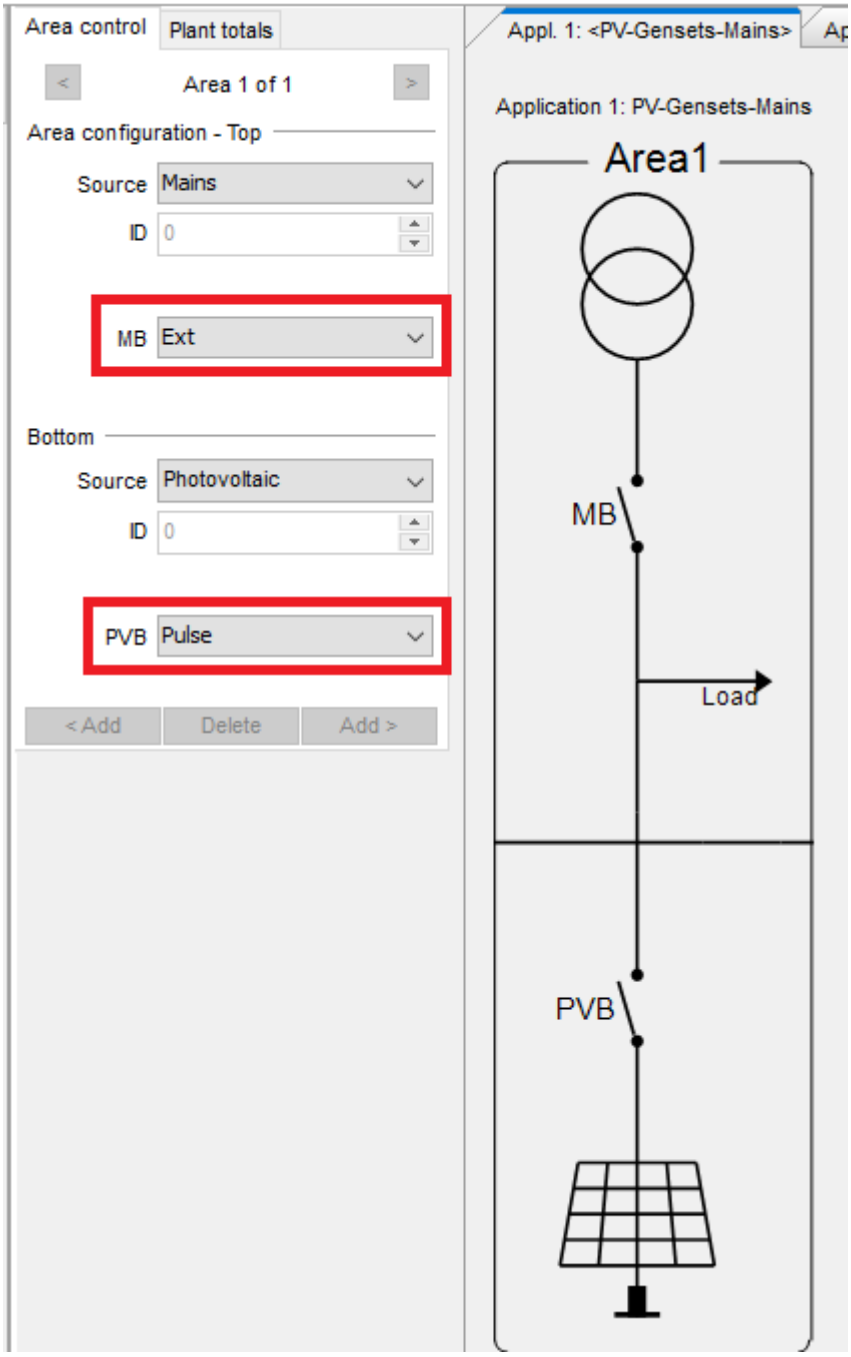
To allow parallel operation with the mains, the ASC 150 must have *Premium* software.

### Creating the application drawing in the USW

1. On the *Application configuration* page, use *New plant configuration* to open a *Plant options* window to create a new application. The *Plant type* must be *Single controller*.



2. Under *Area control*, select *Ext* for the mains breaker. If the ASC 150 controls the PV breaker, select the breaker type. If not, select *Ext/ATS no control*.




3. Use *Write plant configuration to the device* to write the configuration to the controller.

## 11.3 Inputs/Outputs

The ASC 150 Solar automatically configures the PVB relays (outputs 17 and 18) and inputs (inputs 49 and 50) based on the plant configuration.

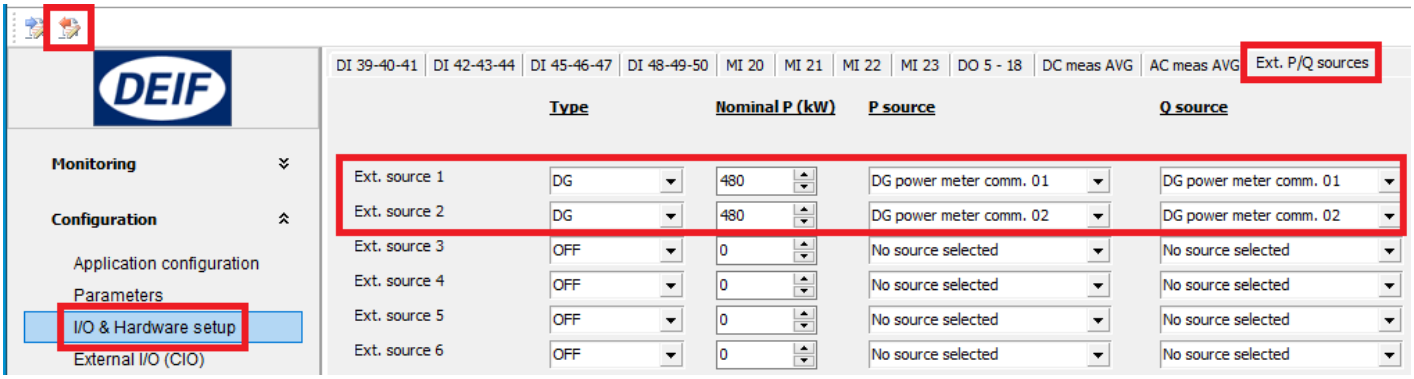
**Set up the measurements from the genset controllers**

On the *I/O & Hardware setup* page, select *Ext. P/Q sources*.

For *Ext. source 1*, select *DG*, *480*, *DG power meter comm. 01* and *DG power meter comm. 01*.

For *Ext. source 2*, select *DG*, *480*, *DG power meter comm. 02* and *DG power meter comm. 02*.

Write the configuration to the controller.




## 11.4 Wiring

The minimum required wiring is listed in the following table.

**More information**
See the **Installation instructions** for complete wiring information.

| Terminal(s) | Function | Details |
|---|---|---|
| 1-2 | Power supply | 6.5 to 36 V DC, power for the controller |
| 1-4 | Emergency stop | Digital input |
| 8-17 | Close PV breaker | Maximum 36 V DC/0.5 A relay |
| 8-18 | Open PV breaker | Maximum 36 V DC/0.5 A relay |
| 33 | Data + (A) | Connect these terminals to the Modbus RTU terminals of the two genset controllers and mains power meter (daisy chained). |
| 34 | GND | |
| 35 | Data - (B) | |
| 36 | Data + (A) | Connect these terminals to the RTU connection of the inverters (daisy chained). |
| 37 | GND | |
| 38 | Data - (B) | |
| 47 | Mains breaker closed | +36 V DC with respect to plant supply negative<br>-24 V DC with respect to plant supply negative |
| 48 | Mains breaker open | |
| | Common | |
| 49 | PV breaker closed | +36 V DC with respect to plant supply negative<br>-24 V DC with respect to plant supply negative |
| 50 | PV breaker open | |
| | Common | |
| 56 | S1 (k) L1 AC current | Connect to the PV 3-phase power. Use x/1 A or x/5 A current transformers. |
| 57 | S1 (k) L2 AC current | |
| 58 | S1 (k) L3 AC current | |
| 59 | S2 (l) L1, L2, and L3 AC current | |
| 63 | L1 PV voltage | Maximum 690 V AC phase-phase |
| 64 | L2 PV voltage | Maximum 690 V AC phase-phase |

| Terminal(s) | Function | Details |
|---|---|---|
| 65 | L3 PV voltage | Maximum 690 V AC phase-phase |
| 67 | L1 Busbar voltage | Maximum 690 V AC phase-phase |
| 68 | L2 Busbar voltage | Maximum 690 V AC phase-phase |
| 69 | L3 Busbar voltage | Maximum 690 V AC phase-phase |

## 11.5 Parameters

For this example, set the following parameters. Select *Write parameters to the device* when you have finished.

**NOTE** Not all parameters are shown in the list below. Parameters with factory defaults that are suitable for this example are not included.

| Parameter | Name | Description |
|---|---|---|
| 6001 | Nom. f 1 | For this example, select *50 Hz*. |
| 6002 | Nom. P 1 | Use the PV information to configure the nominal power. For example, if this plant consists of 700 x 420 W solar panels, the nominal power is 294 kW. |
| 6003 | Nom. I 1 | Use the inverter information to configure the nominal current. For this example, **434 A** ((12 x 25)/(1.73 x 0.4)). |
| 6004 | Nom. U 1 | Use the inverter information to configure the nominal voltage. For this example, select **400 V**. |
| 6005 | Nom. Q 1 | Use the inverter information to configure the nominal reactive power. For this example, select **300 kvar**. |
| 6006 | Nom. S 1 | Use the inverter information to configure the nominal apparent power. For this example, select **300 kVA** (12 x 25 kVA). |
| 6041 | PV primary U | The PV primary voltage. For this example, select **400 V**. |
| 6042 | PV secondary U | The PV secondary voltage. For this example, select **400 V**. |
| 6043 | PV Primary I | The PV primary current. If necessary, adjust this set point. |
| 6044 | PV Secondary I | The PV secondary current. If necessary, adjust this set point. |
| 6051 | BB Primary U 1 | The busbar primary voltage. For this example, select **400 V**. |
| 6052 | BB second. U 1 | The busbar secondary voltage. For this example, select **400 V**. |
| 6053 | BB Nominal U 1 | The busbar nominal voltage. For this example, select **400 V**. |
| 6071 | Operation mode | For this example, select **Mains power export**. |
| 7001 | Day setting | Select **0 kW** to prevent mains power export. |
| 7002 | Night setting | Select **0 kW** to prevent mains power export. |
| 7005 | Mains power measure | For this example, select *Power meter communication*. |
| 7009 | Mains Q measure | For this example, select *Power meter communication*. |
| 7511 | Ext. comm. ID 1 | Select an ID for the ASC 150 Solar for communication with the PV system. Use the lowest communication ID of the inverters. |
| 7551 | Mon. comm ID | Select the lowest communication ID of the inverters. |
| 7561 | PV protocol | For this example, select *SunSpec Generic*. |
| 7565 | PV Monitoring | For this example, select **12** (inverters) and **Enable**. |
| 7701 | DG meter ID | Select the DG meter communication ID. |
| 7703 | Mains meter ID | Select the mains meter communication ID. |

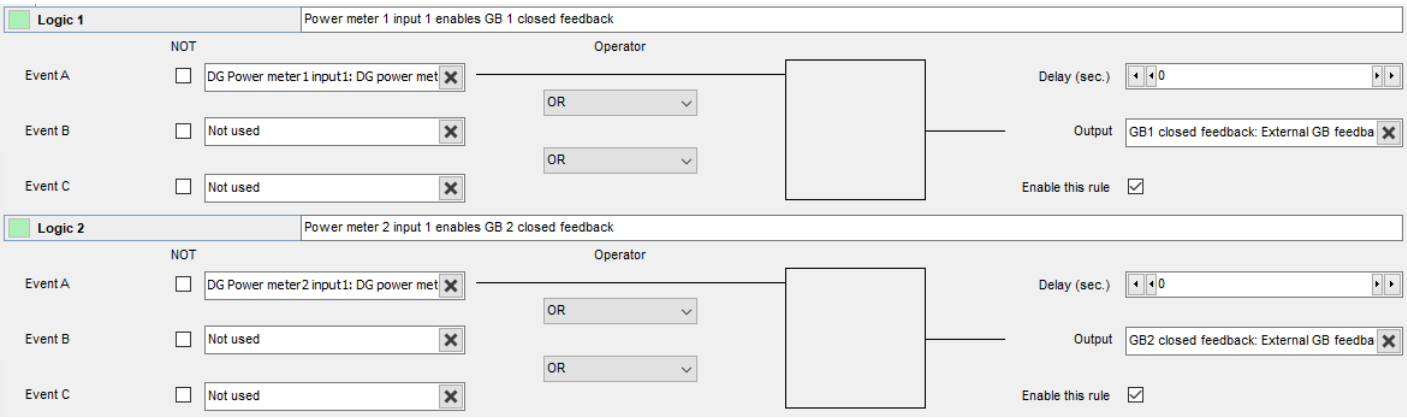
| Parameter | Name | Description |
|---|---|---|
| 7721 | DG meter prot. | For this example, select *DSE 8xxx, 7xxx, 6xxx and 4xxx*. |
| 7722 | DG nbr. nodes | For this example, select **2**. |
| 7725 | Mains met. prot | For this example, select *ABB SACE Emax 2*. |
| 15011 | Min DG load 1 | If necessary, adjust this set point. For this example, select **30 %**. |

**NOTE** You can configure additional parameters for additional functions. For example, to track curtailment, configure POA irradiation (17271) and BOM temperature (17281).

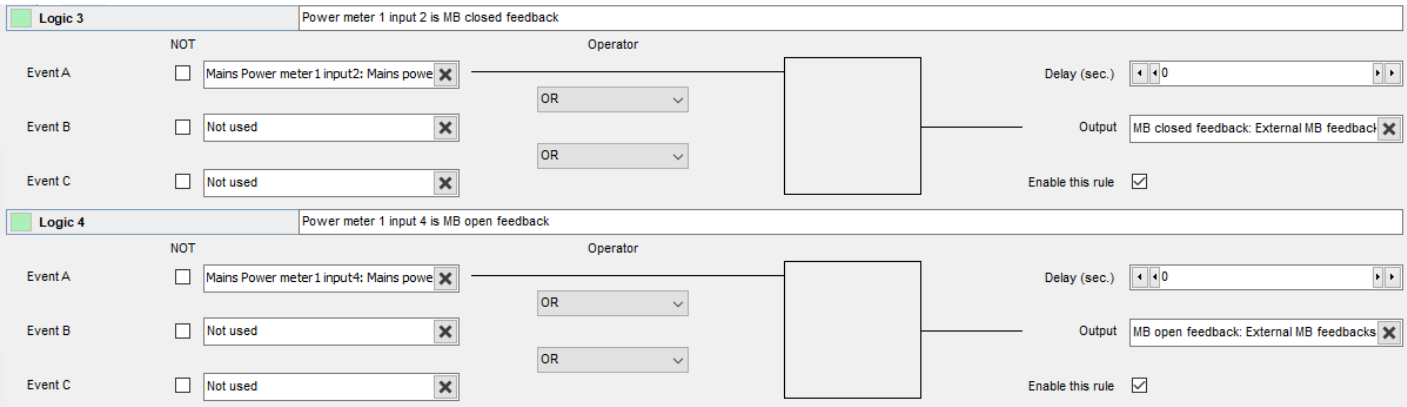
## 11.6 Configure logic

For this example, you must configure the following M-Logic in the utility software. You can also configure other M-Logic, as required.

### Genset controllers breaker status inputs




### Mains breaker status from the power meter protocol




## 11.7 Commissioning

**DANGER!**

**Incorrect wiring and configuration are dangerous**

Before using the system, check that the wiring and parameters are correct for the application.

Before starting operation, check that all the wiring is correct.

Check that the parameters are correct for the application.

Check that the controller can communicate with the PV system, the genset controller, and the power meters.

## 11.8 Operation

Push MODE on the display unit, then select AUTO.

The ASC 150 Solar receives breaker states for the mains and gensets, along with the power measurements.

The ASC 150 Solar automatically controls the PV system to:

- Maximise the power from the PV system.
- If necessary, curtail the PV production to:
  1. Protect the gensets from low load.
  2. Prevent power export to the mains.