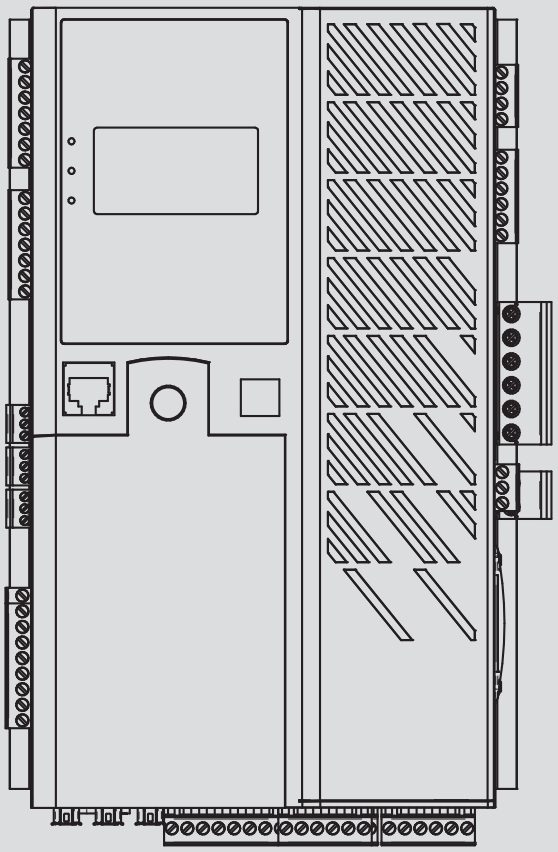

D700

Digital voltage regulator

Installation and maintenance

LEROY-SOMER™
KATO ENGINEERING™

Nidec
All for dreams

D700 digital voltage regulator

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0. TERMS AND EXPRESSIONS

VT — Power transformer, in this manual a voltage transformer used both for the power supply and for measuring the voltage.

CT — Current transformer, used for measuring the current.

PMG — Permanent Magnet Generator.

AREP — Auxiliary windings installed in the machine which are used to supply the AVR with power. They often consist of 2 windings: the first “H1” which is affected by voltage variations, the second “H3” which is affected by current variations.

Booster — All current transformers used as a source of power for the AVR.

1. General Instructions

1.1. Identity sheet

The D700 AVR has been manufactured by

MOTEURS LEROY SOMER
Boulevard Marcellin Leroy, CS 10015
16915 ANGOULEME Cedex 9
France
Tel: +33 2 38 62 40 00

LEROY SOMER reference: 5067495
KATO ENGINEERING reference: 5089419
Optional mounting plate kit: 40036453

1.2. General overview of the product

This manual describes how to install, use, set up and maintain the D700 AVR.

The purpose of this AVR is to regulate alternators with a field current of less than 25 A in continuous operations, and 50 A maximum in the event of short-circuit for 10 seconds maximum.[1]

Its design is in accordance with mounting in a generator terminal box or a control cabinet. It is required, at a minimum, to follow the local protection and safety standards, especially those specific to electrical installations for voltages of 300 VAC phase/neutral maximum. [2]

It takes the form of a compact unit with a set of connectors on 3 of its sides, a heatsink on its rear panel and a graphic LCD display unit with interface buttons, and USB/Ethernet connectors on the front.

[1] These values are given for a temperature of 25°C. See the detailed technical specification for the full range of values.
[2] A set of mounting brackets supplied with the AVR, is required to mount the AVR to the back of the cabinet or in the terminal box.

The D700 AVR consists of a number of function blocks:

- A power bridge (this supplies a field current)
- A measuring circuit for the various measuring signals such as voltage, current
- A set of digital and analog I/O: for control of regulation modes, operating information, correcting references
- A set of connectors
- A set of communication modes for dialogue and remote parameter-setting
- A display unit and interface buttons for dialogue and local parameter-setting

Various additional features can be combined with the D700:

- 6 Pt100 temperature sensors
- 1 incremental encoder input for the rotor angular position
- 1 slot for inserting a HMS fieldbus communication card (optional, if requested by the customer)
- 1 dedicated serial port for a remote HMI if applicable (optional, in development)
- 1 dedicated serial port for an external power bridge (optional, with MENTOR MP drive LEROY SOMER)
- 1 dedicated serial port for redundancy between two D700s (optional, in development)
- 1 optional port for a dedicated D700 module (option in development)

1.3. Technical characteristics

1.3.1. Components

The D700 AVR is a digital voltage regulator used to control the alternator field current using separate control loops. The regulation mode is managed either by parameter-setting, or via the D700 digital inputs, or via the various communication modes.

These regulation modes are:

- Voltage regulation
  - With or without quadrature droop to allow parallel machine operation (1F)
  - With or without cross-current compensation
  - With or without load compensation[3]
- Matching of the machine voltage and grid voltage prior to connection to a grid (called “3F” or “U=U”)
- Power factor regulation, only when the alternator is connected to a grid (2F)
- kVAr regulation, only when the alternator is connected to a grid
- Regulation of cos phi at the installation delivery point (as much as the drive system capacity allows), from an analog input (remote measurement mode by a converter supplied by the customer) or by directly calculating the power factor at the delivery point.[4]
- Regulation of the field current, or manual mode, which allows direct control of the field current value

[3] Quadrature droop, cross-current and load compensation cannot be enabled at the same time and require the use of an optional current transformer.

[4] Obligation to have the Grid code VTs and Grid code current measurement CT placed at the delivery point and wired on the D700.

The D700 can also be used to:

- Adjust the reference for the regulation mode in progress, using:
  - up/down volt-free contacts
  - an analog input (4-20 mA, 0-10 V, ±10 V, Potentiometer)
- Monitor 6 Pt100 temperature sensors
- Limit the minimum field current delivered to the exciter field
- Limit the maximum field current delivered to the exciter field
- Limit the maximum stator current limit
- Detect loss of phase
- Withstand a sudden short-circuit for 10 seconds maximum in AREP, PMG or Shunt + booster
- Protect the alternator in the event of a rotating diode trip
- Monitor trips and support electrical networks (Grid Code)
- Monitor signals (data logger, event logger)

The various trip, regulation mode and measurement data items can be delivered to the 12 digital outputs and/or 4 analog outputs (4-20 mA, 0-10 V, ±10 V).

In order to simplify wiring operations and exchanges with a higher-level control system, a 100baseT Ethernet link is available. A communication module can be added as an option.

1.3.2. Operating values

- **Alternator voltage sensing:**
  - 3 phases without neutral, 3 phases with neutral, 2 phases or 1 phase with neutral
  - Three-phase range 0-230 VAC or 0-530 VAC (120% max. 2 minutes)
  - Consumption < 2 VA
- **Grid code voltage sensing:**
  - 3 phases without neutral, 3 phases with neutral, 2 phases or 1 phase with neutral
  - Three-phase range 0-230 VAC or 0-530 VAC (120% max. 2 minutes)
  - Consumption < 2 VA
- **Stator current measurement by CT:**
  - 1 or 3 phases
  - Range 0-1 A or 0-5 A (300% max. 30s)
  - Consumption < 2 VA
- **Grid code voltage measurement:**
  - 1 phase
  - Range 0-1 A or 0-5 A (300% max. 30s)
  - Consumption < 2 VA
- **Cross-current measurement**
  - 1 phase
  - Range 0-1 A or 0-5 A (300% max. 30s)
  - Consumption < 2 VA
- **Power supply:**
  - **AC:**
    - 4 terminals for PMG, AREP, SHUNT
    - 2 independent circuits
    - Range 50-277 VAC (115% max. 2 minutes)
    - Consumption max < 3000VA

- **DC (preloading not managed):**
  - Range 50-400 VDC (110% max. 2 minutes)
  - Consumption max < 3000VA
- **Booster**
  - Managed by an external module (optional), connected to the DC power supply.
  - Rated 0-25 A (< 400 VDC)
  - Short-circuit 50A max. at 25°C (< 400 VDC)
- **Field excitation**
  - Rated 0-25 A
  - Short-circuit 50A max. at 25°C
  - Field winding resistance > 4 ohms
- **Auxiliary supply:**
  - Range 18-35 VDC
  - Consumption < 1 A
- **Frequency measurement**
  - Range 30-400 Hz

- Regulation accuracy
  - +/-0.25% of the average of the three phases with harmonic distortion less than 20%
  - +/-0.5% of the average of the three phases with harmonic distortion from 20% up to 40% (harmonics associated to six-thyristors load type)

- Voltage adjustment range: 0 to 150% of the rated voltage by means of volt-free contacts or an analog input
- Quadrature droop adjustment range: -20% to 20%
- Under frequency protection: integrated, adjustable threshold, slope adjustable from 0.5 to 3 x V/Hz in steps of 0.1 V/Hz
- Excitation ceiling: adjustable by configuration at 3 points
- Environment: ambient temperature from -40°C to +65°C, relative humidity of less than 95%, non-condensing, mounted in a cabinet or in a terminal box without excessive vibration

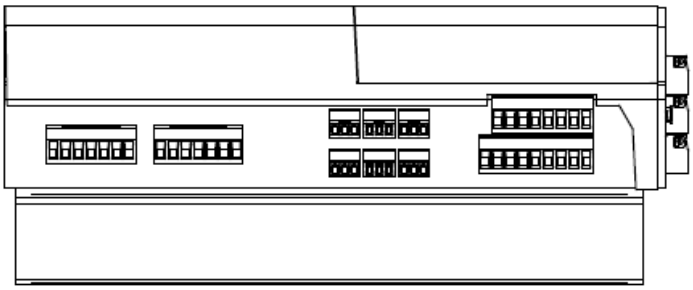
- AVR parameters set using software xxx supplied with the product or via communication interfaces.

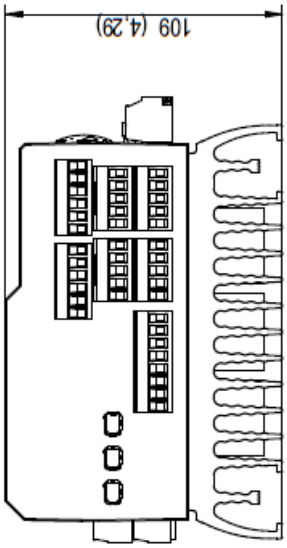
- Dimensions (excluding connectors)
  - Height: 258 mm (10.15")
  - Width: 162.5 mm (6.38")
  - Depth: 109 mm (4.29")
- Mounting: ***Diagram on next page excluding mounting terminals***

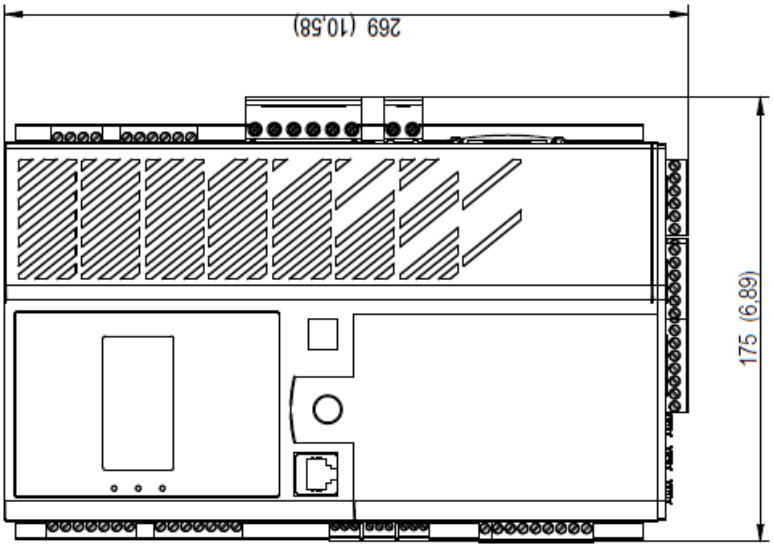
- Weight: 3.09 kg

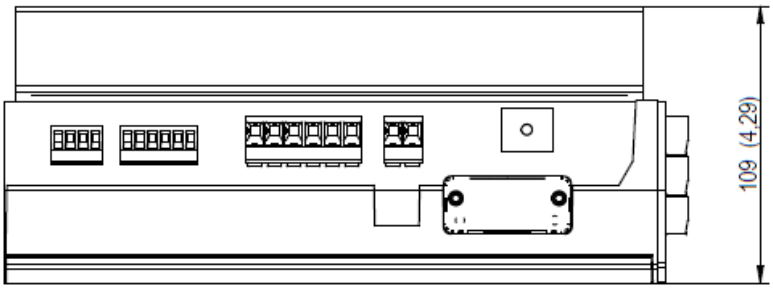
- Conformity to standards
  - EMC: IEC 61000-6-2, IEC 61000-6-4 and IEC 60255-26
  - Protection relay safety: IEC 60255-27
  - Humidity: IEC 60068-1 and test in accordance with IEC 60068-2-14
  - Dry heat: IEC 60068-2-2
  - Damp heat: IEC 60028-2-30
  - Cold: IEC 600068-2-1

D700 digital voltage regulator



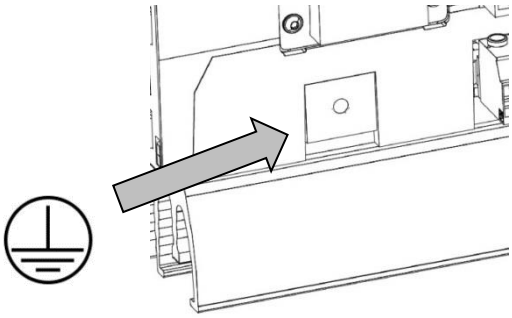






1.4. Safety devices and general warning symbols

For the user's own safety, the D700 must be connected to an approved earth using the earth terminal shown below. The tooling for this connection is not included with the D700. A tightening torque of 2.5Nm +/- 0.5Nm must be applied to the screw.



Note: All 0V of electronic boards are connected to the earth

It is essential to comply with the power connection diagrams recommended in this manual.

The D700 includes devices which, in the event of problems, can de-energize or over excite the generator. The generator itself can also become jammed for mechanical reasons. Finally, voltage fluctuations or power cuts may also cause the unit to stop.

The D700 which is the subject of this manual is designed to be integrated in an installation or electrical machine, and can under no circumstances be considered to be a safety device. It is therefore the responsibility of the machine manufacturer, the designer of the installation or the user to take all necessary precautions to ensure that the system complies with current standards, and to provide any devices required to ensure the safety of equipment and personnel (especially direct contact with connectors when the AVR is running).

LEROY-SOMER declines all responsibility in the event of the above recommendations not being observed.

The various interventions described in this manual are accompanied by recommendations or symbols to alert the user to potential risks of accidents. It is vital that you understand and comply with the various warning symbols below.

- Throughout the manual, this symbol warns of consequences which may arise from inappropriate use of the AVR, since electrical risks may lead to material or physical damage as well as constituting a fire hazard.

- This symbol warns of electrical danger to personnel:

1.4.1. General information

The D700 AVR may contain unprotected live parts, as well as hot surfaces, during operation. Unjustified removal of protection devices, incorrect use, faulty installation or inappropriate operation could represent a serious risk to personnel and equipment.
For further information, consult the documentation.
All work relating to transportation, installation, commissioning and maintenance must be performed by experienced, qualified personnel (see IEC 364, CENELEC HD 384 or DIN VDE 0100, as well as national specifications for installation and accident prevention).
In these basic safety instructions, qualified personnel means persons competent to install, mount, commission and operate the product and possessing the relevant qualifications.

1.4.2. Use

D700 voltage regulators are components designed for integration in installations or electrical machines.
When integrated in a machine, commissioning must not take place until it has been verified that the machine comply with directive 2006/42/EC (Machinery Directive). It is also necessary to comply with standard EN 60204, which stipulates in particular that electrical actuators (which include voltage regulators) cannot be considered as circuit-breaking devices and certainly not as isolating switches.
Commissioning can take place only if the requirements of the Electromagnetic Compatibility Directive (EMC 2014/30/EU) are met.
The voltage regulators meet the requirements of the Low Voltage Directive 2014/35/EU. The harmonized standards of the DIN VDE 0160 series in connection with standard VDE 0660, part 500 and EN 60146/VDE 0558 are also applicable.
The technical characteristics and instructions concerning the connection conditions specified on the nameplate and in the documentation provided must be observed without fail.

1.4.3. Transportation, storage

All instructions concerning transportation, storage and correct handling must be observed.
The climatic conditions specified in this manual must be observed.

1.4.4. Installation

The installation and cooling of equipment must comply with the specifications in the documentation supplied with the product.
The D700 must be protected against excessive stress. In particular, there must be no damage to parts and/or modification of the clearance between components during transportation and handling. Avoid touching the electronic components and any live parts.
The D700 contains parts which are sensitive to electrostatic stress and may be easily damaged if handled incorrectly. Electrical components must not be exposed to mechanical damage or destruction (risks to health!).

1.4.5. Electrical connection

When work is performed on D700s which are powered up, national accident prevention specifications must be respected.

The electrical installation must comply with the relevant specifications (for example conductor cross-sections, protection via fused circuit-breaker, or/and connection of protective conductor). More detailed information is given in this manual.

Instructions for an installation which meets the requirements for electromagnetic compatibility, such as screening, earthing, presence of filters and correct insertion of cables and conductors, are also given in this manual. These instructions must be followed in all cases, even if the AVR carries the CE mark. Adherence to the limits given in the EMC legislation is the responsibility of the manufacturer of the installation or the machine.

For EU application : Instrument transformers shall provide basic insulation according to the requirements of IEC 61869-1, " Instrument transformers – Part 1: General requirements " and IEC 61869-2, " Additional requirements for current transformers"
For US application: Instrument transformers shall provide basic insulation according to the requirements of IEEE C57.13, "Requirements for Instrument Transformers," and IEEE C57.13.2, "Conformance Test Procedure for Instrument Transformers."

1.4.6. Operation

Installations incorporating D700s must be fitted with additional protection and monitoring devices as laid down in the current relevant safety regulations: law on technical equipment, accident prevention regulations, etc. Modifications to the D700 parameters using control software or the HMI are permitted.
Active parts of the device and live power connections must not be touched immediately after the D700 is powered down, as the capacitors may still be charged. In view of this, the warnings fixed to the voltage regulators must be observed.
During operation, all doors and protective covers must be kept closed.

1.4.7. Service and maintenance

Refer to the manufacturer's documentation.
Our technical support service will be pleased to provide you with any additional information you may require.

This manual is to be given to the end user.

1.4.8. Protection of components

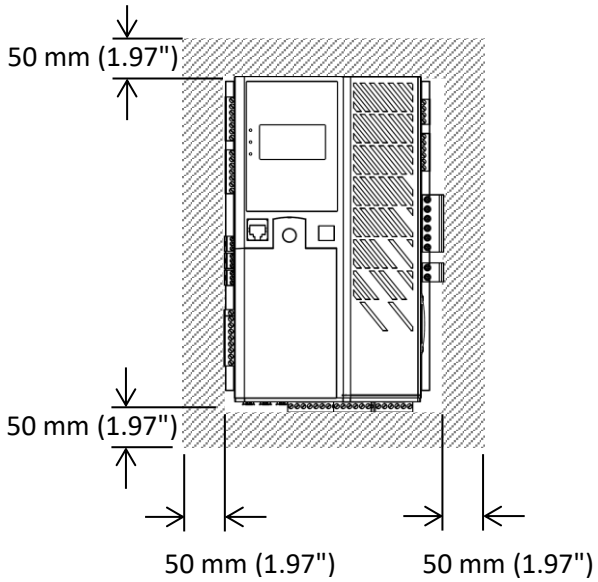
The AVR auxiliary power supply, which sources the product's internal power supplies, is essential for AVR operation. It should therefore be connected permanently and should be protected by 1 A slow-blow fuses.

Similarly, both the AC and DC AVR power supplies, which are used to create the field current, should be protected by fast-blow fuses or circuit-breakers.

2. Installation instructions

2.1. Layout of the space housing the AVR

It should always be fitted vertically, and 50 mm minimum clearance must be provided around the AVR so as to allow air to flow around the back of it.



Ventilation, cooling or even heating system may be needed to keep the AVR within the environmental limits described earlier.

NOTE: If you wish to integrate components which do not comply with the above minimum prerequisites, please consult technical support.

2.2. Mounting

The D700 does not have integrated mounts. A set of feet needs to be added for the AVR to be attached at the back of the cabinet. These feet are inserted on each side in the heatsink slide rails, at the top and bottom of the D700.

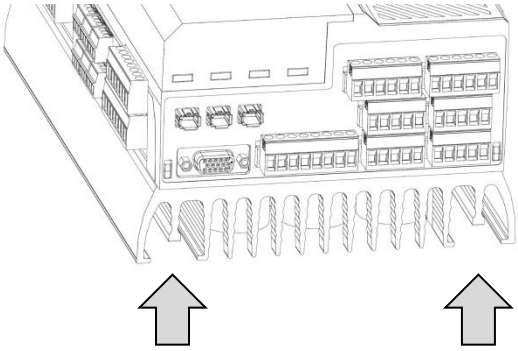
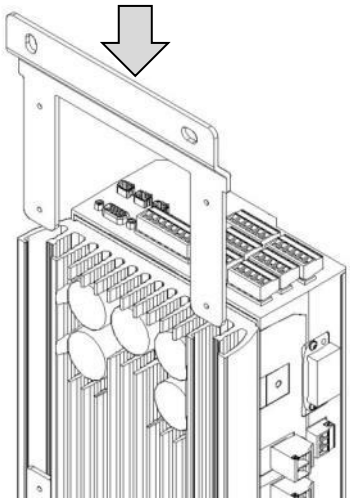
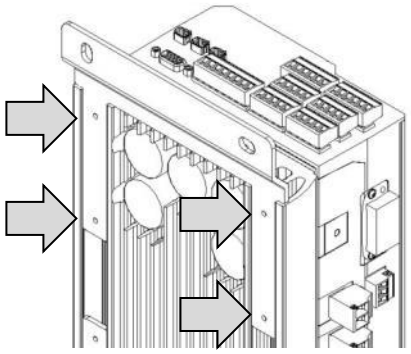


Figure 1: Location of heatsink slide rails

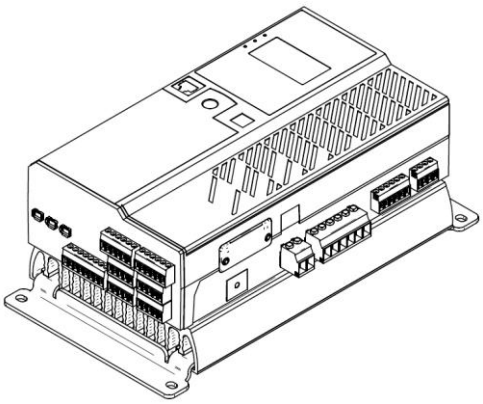


Step 1: Insert the foot in the slides

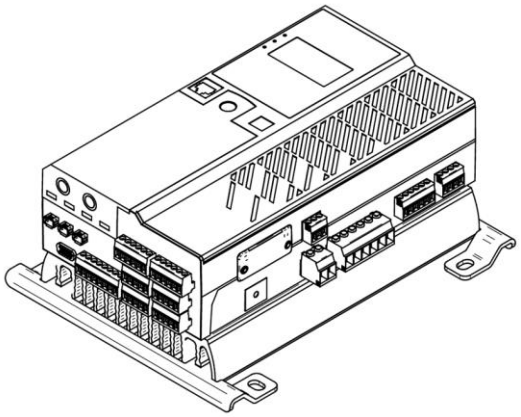


Step 2: Fit the retaining screws

Two foot part numbers are available. The diagrams are available in the appendix.



Standard feet



Variant feet

Note: Don't hesitate to contact technical support to have additional mounting feet made.

2.3. Connections

The D700 must be connected to the various measurement, power and control signals to be able to perform its regulation functions:

- **Grid code voltage measurement[5]:**

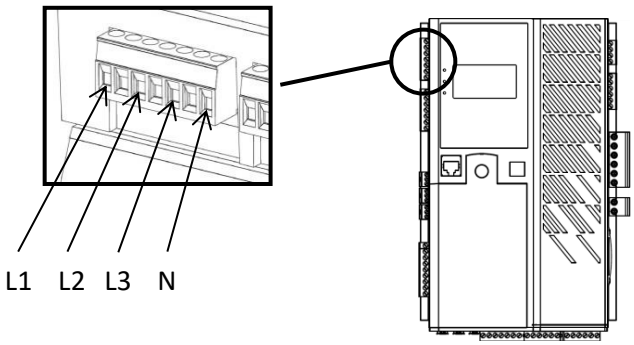
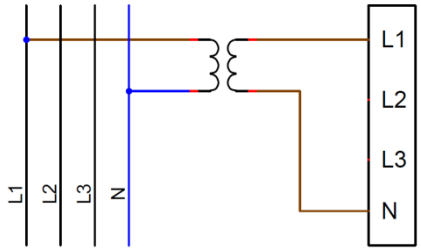
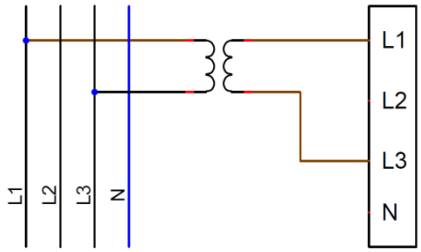
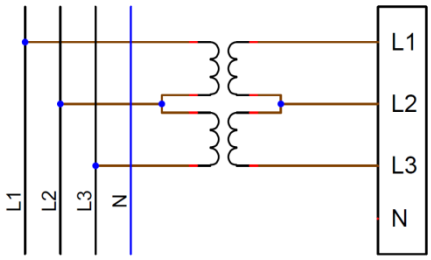
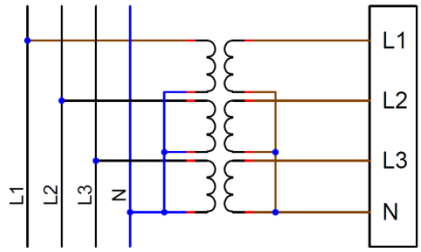


Figure 2: Grid voltage sensing connection

Voltage transformers are mandatory if the alternator voltage measurement is higher than 480 VAC rms phase-to-phase (686 VAC rms maximum for 10 seconds), or 277 VAC rms between phase and neutral.

Connection	Electrical schematic
Phase/Neutral	
Phase/Phase	
3-Phase	

[5] The connector intermediate contacts are not connected.

Connection	Electrical schematic
3-Phase/Neutral	

NOTE: The grid code voltage measurement connection must match the grid code current measurement transformer mounting phase which is mounted on phase L2. If this wiring is not complied with, the resulting power and power factor calculations will be incorrect. The CT phase angle can however be used to correct them if measurement is not possible on the same phase as the CT. It also depends on the phase direction of rotation.

For greater accuracy, there are 2 possible measurement ranges:

Alternator voltage measurement		Measurement range
Phase/Neutral	Phase/Phase	
115 VAC rms max.	200 VAC rms max.	200 V
346 VAC rms max.	530 VAC rms max.	600 V

- **Alternator voltage measurement[6]:**

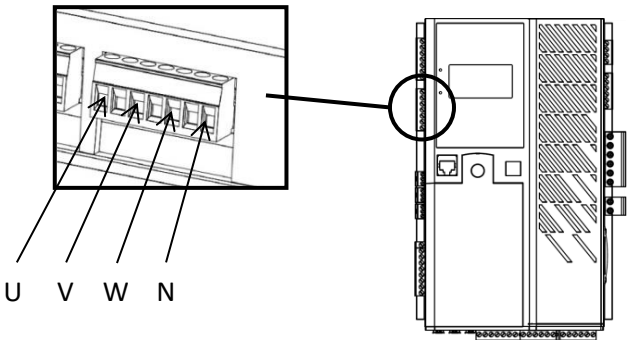
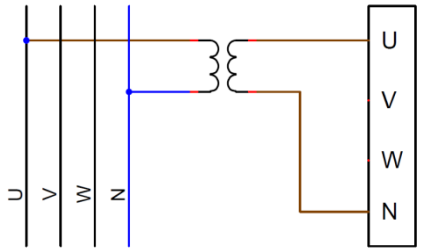
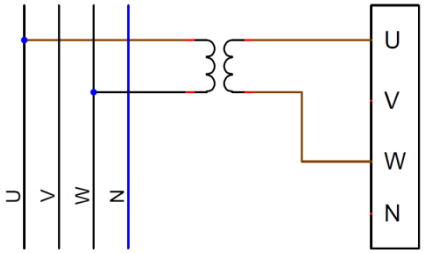
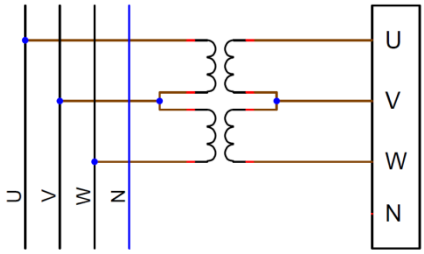
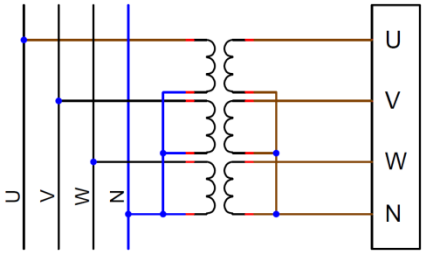


Figure 3: Grid code voltage sensing connection

Voltage transformers are mandatory if the alternator voltage measurement is higher than 480 VAC rms phase-to-phase (686 VAC rms maximum for 10 seconds), or 277 VAC rms between phase and neutral.

[6] The connector intermediate contacts are not connected.

Connection	Electrical schematic
Phase/Neutral	
Phase/Phase	
3-Phase	
3-Phase/Neutral	

NOTE: The alternator voltage measurement connection must match the alternator current measurement transformer mounting phase(s). If there is only one current transformer, it should be mounted on phase V. If this wiring is not complied with, the resulting power and power factor calculations will be incorrect. It also depends on the direction of rotation.

NOTE 2: If necessary, see the appendix for examples of vector permutations.

For greater accuracy, there are 2 possible measurement ranges:

Alternator voltage measurement		Measurement range
Phase/Neutral	Phase/Phase	
115 VAC rms max.	200 VAC rms max.	200 V
346 VAC rms max.	530 VAC rms max.	600 V

- **Temperature measurement inputs**

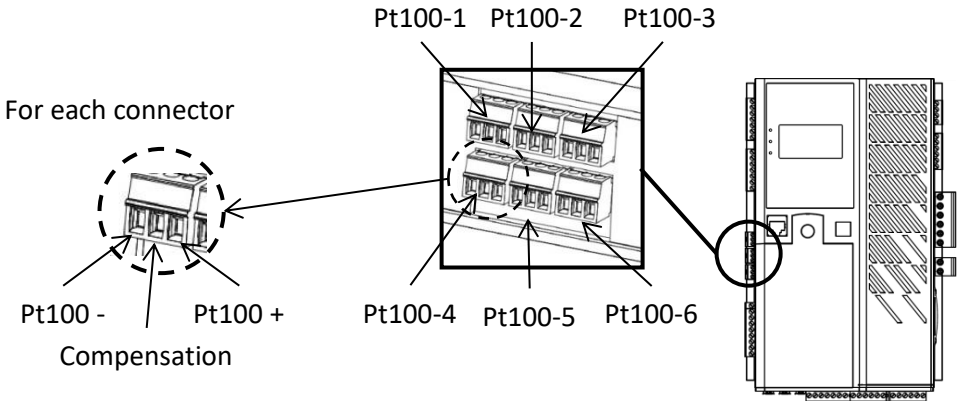
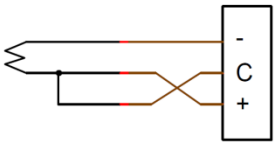
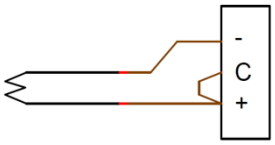


Figure 4: Temperature sensor connections

2-wire and 3-wire Pt100 temperature sensors can be connected:

Connection	Electrical schematic
With compensation	
Without compensation	

The measurement range for these temperature sensor inputs is between -50°C and 250°C. For each connected sensor, two thresholds can be defined: the alarm threshold and the trip threshold.

CAUTION: The PT100 inputs are non-isolated and referenced to the product earth.

- **Analog inputs:**

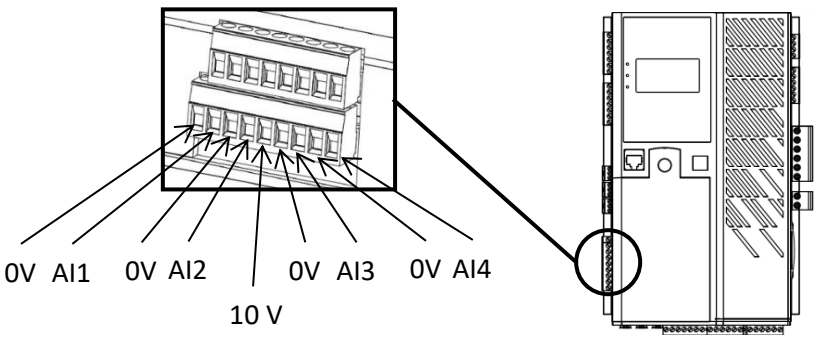
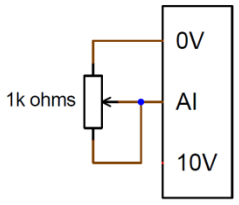
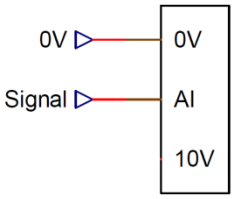


Figure 5: Analog input connection

Each analog input can be configured with several modes:

Connection	Electrical schematic
Potentiometer	
4-20 mA +/-10 V 0/+10 V	

Each input is defined by a destination parameter and its signal type (potentiometer, 4-20 mA, ±10 V, 0/10 V) and by its minimum and maximum limits. The 10 V is only present on the terminal block to create a voltage reference or to use potentiometers with a value > 1 k ohms configured in 0-10 V mode.

CAUTION: The analog inputs are non-isolated. The 0 V is referenced to the product earth.

- **Analog outputs:**

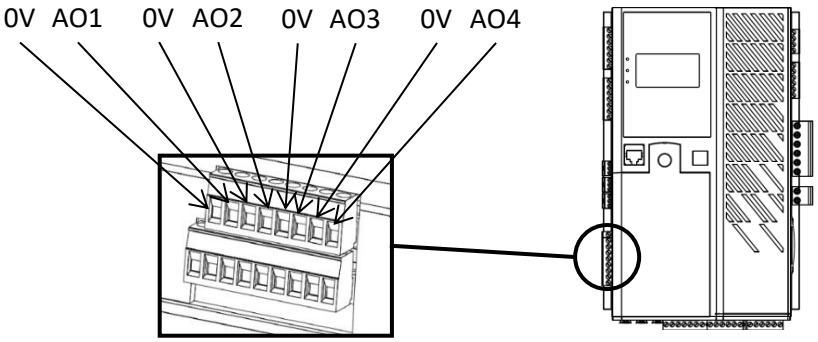
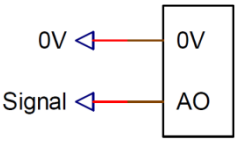


Figure 6: Analog output connections

Each analog output can be configured with several modes:

Connection	Electrical schematic
4-20 mA +/-10 V 0/+10 V	

Each output is defined by a source parameter and its signal type (4-20 mA, ±10 V, 0/10 V) and by its minimum and maximum limits.

CAUTION: The analog inputs are non-isolated. The 0 V is referenced to the product earth.

- **Digital outputs:**

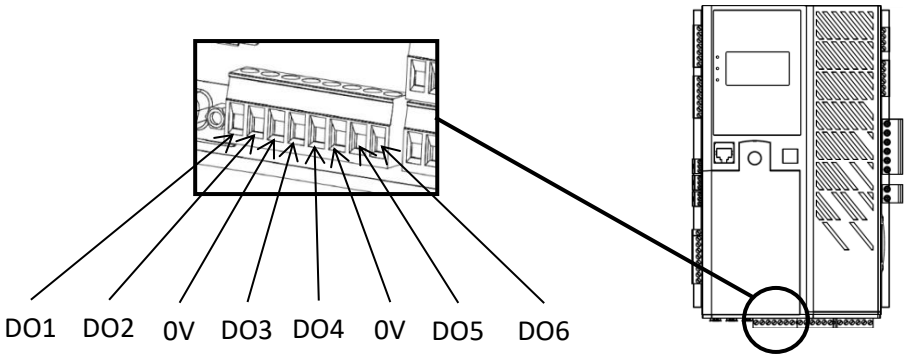
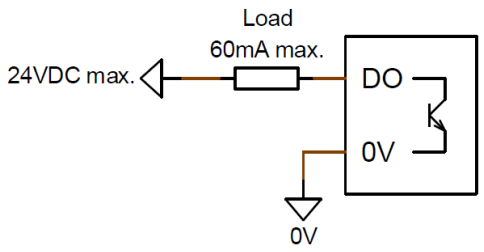


Figure 7: Digital output connections

Each digital output is open collector transistor type. They can each withstand a maximum voltage of 24 VDC and 60 mA maximum.

Connection	Electrical schematic
Digital output	

They are configured by a source parameter (alarm, regulation mode in progress, etc.) and their activation mode: normally open (active low) or normally closed (active high).

CAUTION: The digital outputs are non-isolated. The 0 V is referenced to the product earth. Watch out for the risk of reversed polarity on the voltage which could cause the output to break.

- **Digital inputs:**

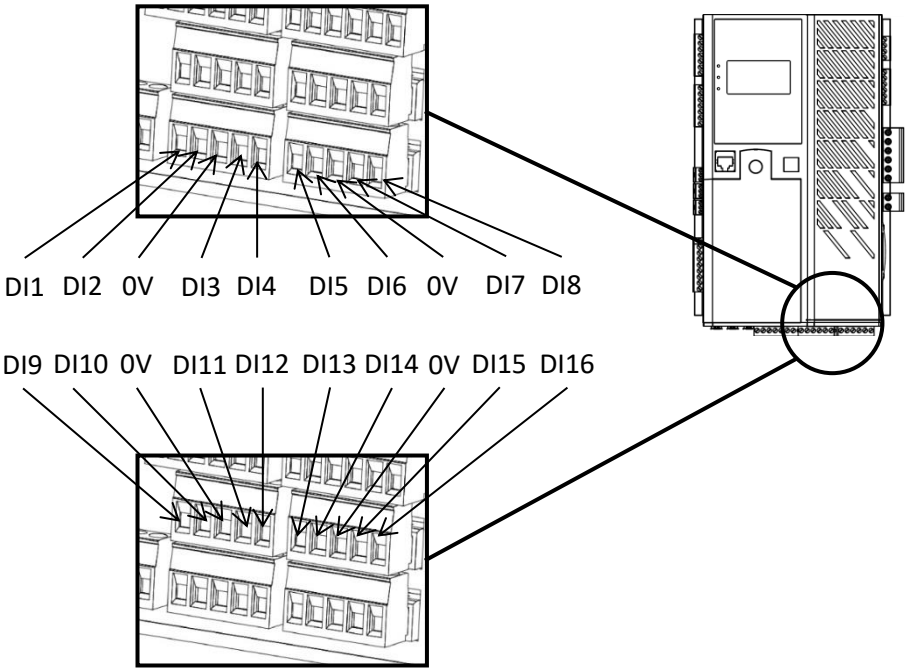
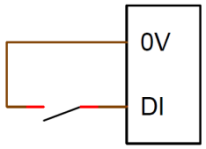


Figure 8: Digital input connections

Each digital input should be controlled by a volt-free contact.

Connection	Electrical schematic
Digital input	

They are configured by a destination parameter (control of a regulation mode, starting, etc.) and their activation mode: normally open (active low) or normally closed (active high).

CAUTION: The digital inputs are non-isolated. The 0 V is referenced to the product earth.

- **Relay outputs:**

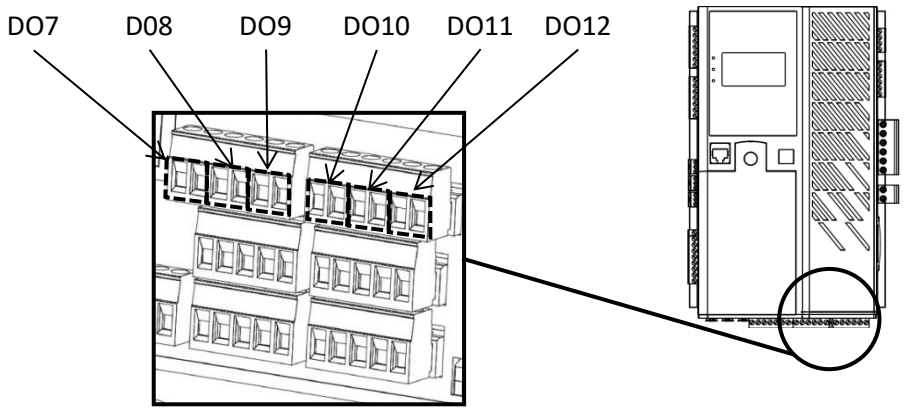
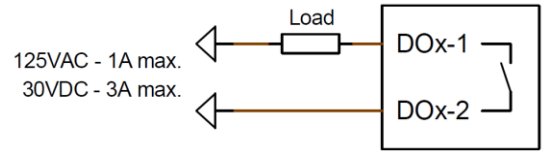


Figure 9: Relay output connections

The relay outputs are volt-free contacts, isolated from the product earth. They can withstand a maximum voltage of 125 VAC-1 A or 30 VDC-3 A maximum.
The relay switching maximum power is 90 W/1290 VA.

Connection	Electrical schematic
Relay output	

They are configured by a source parameter (alarm, regulation mode in progress, etc.) and their activation mode: normally open (active low) or normally closed (active high).

- **DC voltage power supply:**

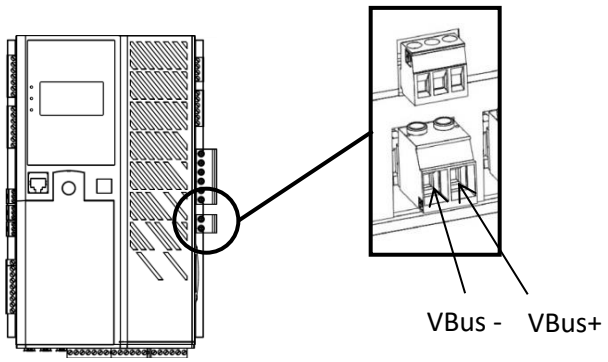
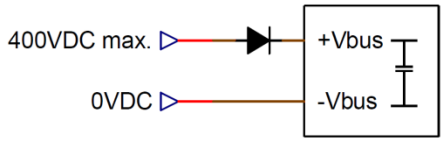


Figure 10: DC voltage power supply connection

The power stage can be supplied with DC voltage, with a maximum voltage of 400 VDC.

Connection	Electrical schematic
DC voltage power supply	

CAUTION: This power supply is directly linked to the power unit capacitor voltage. This voltage feed should therefore be protected by a diode and a suitable capacitor preloading system so as to avoid damaging them. Total capacitor value is 1650 µF. Maximum preloading current must not be more than 2A.

- **Auxiliary power supply[7]:**

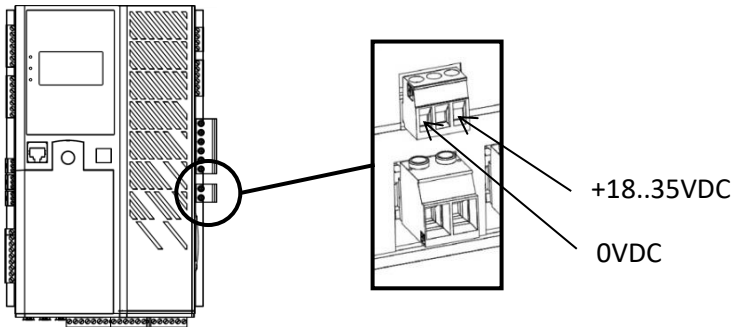
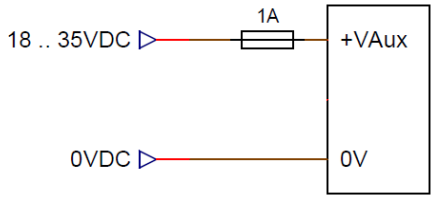


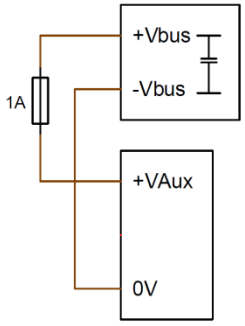
Figure 11: Auxiliary power supply connection

The auxiliary power supply can be used to produce the voltages needed for the AVR measurement, control and monitoring circuits. The minimum voltage value is 18 VDC and maximum is 35 VDC.

Connection	Electrical schematic
Auxiliary power supply	

[7] The connector middle contact is not connected.

In the event of a “black start” (without auxiliary power supply), and only in this specific instance, the auxiliary voltage input can be supplied from the power unit DC voltage (VBus). The D700 is then able to manage this voltage which can reach 400 VDC maximum.

Connection	Electrical schematic
Auxiliary power supply from the power bus DC voltage	

NOTE: This power supply input must be protected by a 1 A fast-blow fuse. (For US applications, reference MERSEN 250 FA 1A - E76491- or the equivalent)

- **Field**:

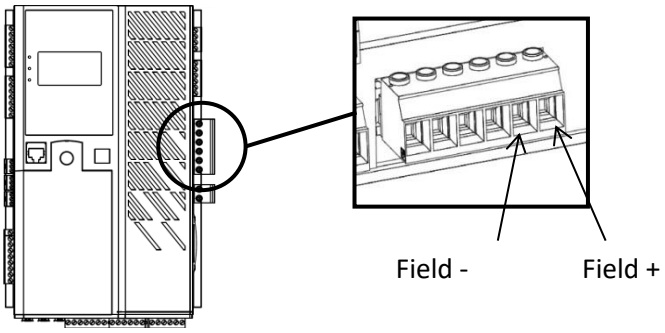
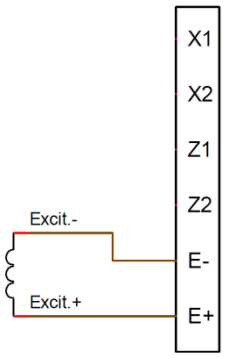


Figure 12: Field connection

Connection	Electrical schematic
Field	

- **Power supply**:

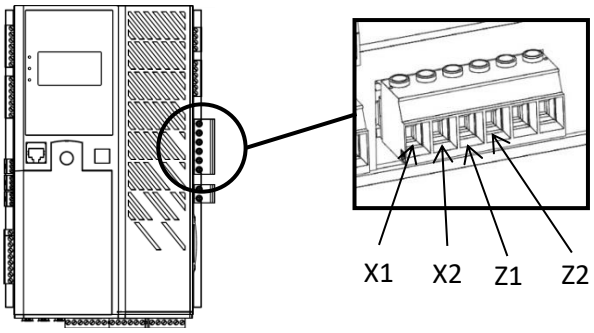
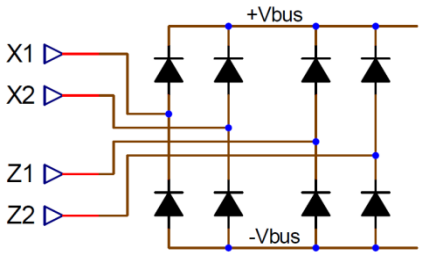


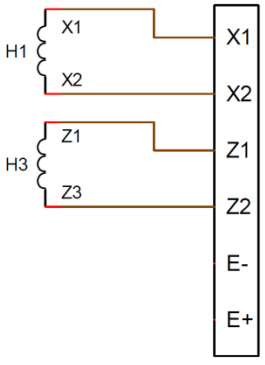
Figure 13: AC auxiliary power supply connection

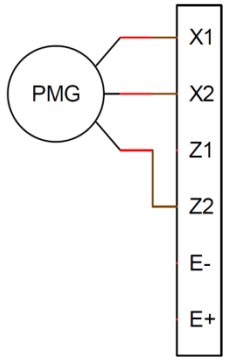
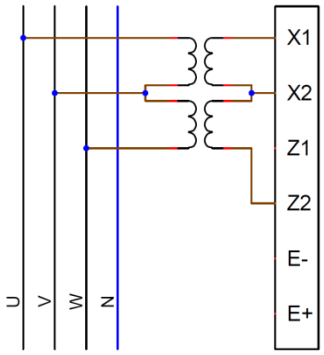
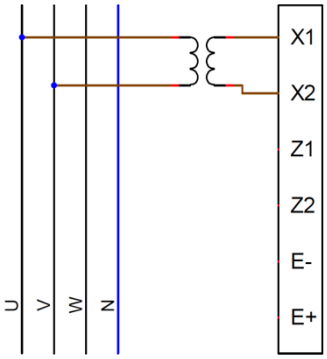
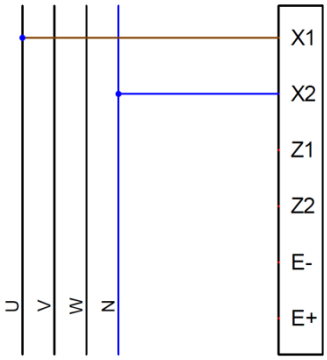
The D700 power stage can take several different source types: shunt, PMG, AREP, or external power supply. This stage consists of rectifier diodes as in the electrical schematic below.



NOTE: According power supply, a suitable capacitor preloading system will be implemented so as to avoid damaging them. Total capacitor value: 1650 µF. Maximum preloading current 2 A

The maximum power supply voltage is 300 VAC between each of the connection points X1, X2, Z1, Z2. For US applications, this supply input must be protected by fuses from listed Class CC Fuse (25A max) or listed inverse time circuit breaker (20A max).

Connection	Electrical schematic
AREP	

Connection	Electrical schematic
PMG	
3-phase SHUNT	
2-phase SHUNT	
Phase/neutral SHUNT (low voltage)	

- **Alternator current measurement (parallel operation CT):**

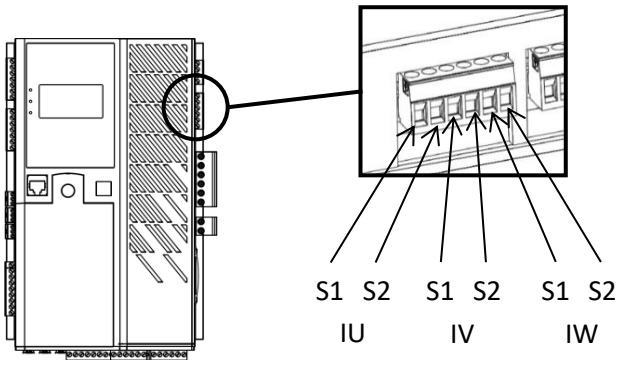
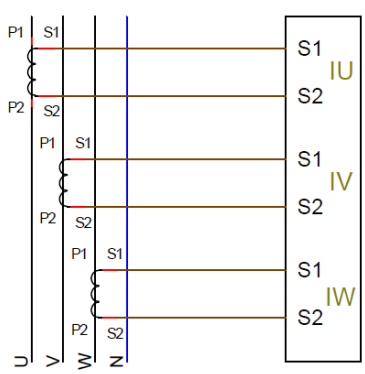
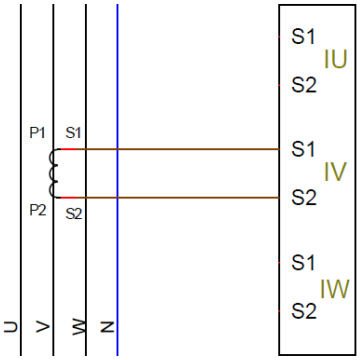


Figure 14: Alternator current measurement connection

The alternator current can be measured on 1 phase or 3 phases. If there is only one CT, it should always be mounted on phase V.

Connection	Electrical schematic
With one CT per phase	
With only one CT	

- **Grid code current measurement**:

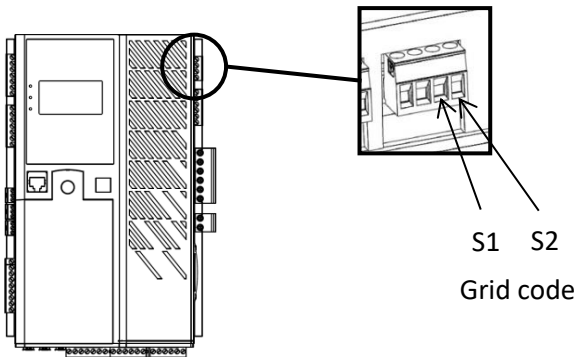
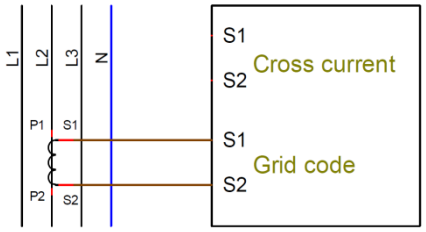


Figure 15: Grid code current measurement connection

The grid current is measured by a single CT. It should always be mounted on phase L2.

Connection	Electrical schematic
Grid code current measurement CT	

- **Cross-current measurement**:

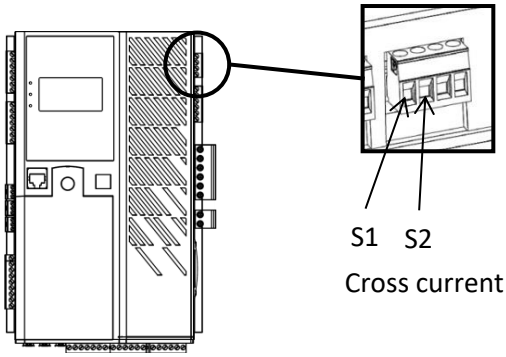
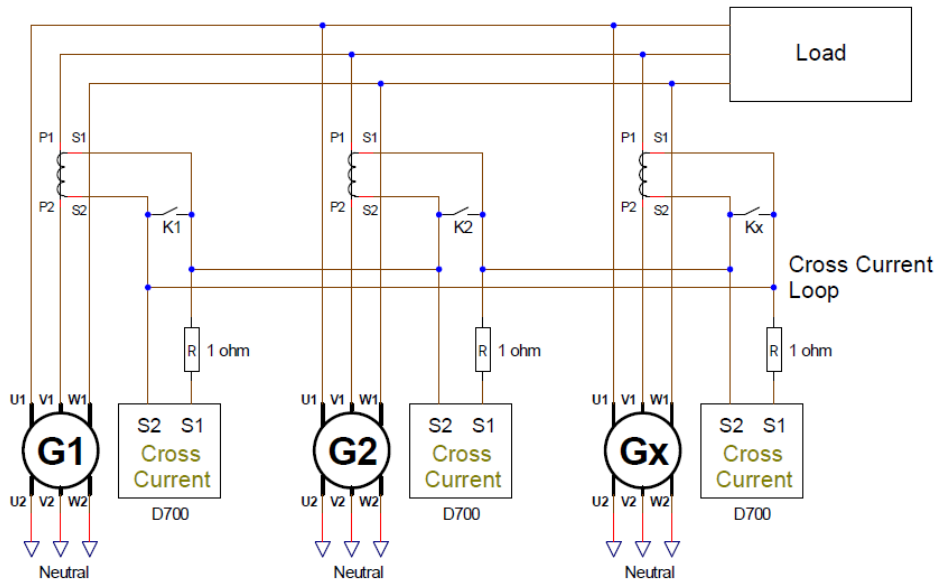


Figure 16: Cross-current measurement connection

The cross current is measured by a single CT with the loop wiring as drawn on the schematic below (example for x alternators equipped with D700).[8] [9] [10]

[8] If the machine is taken offline, the K contact must be closed. It must be open if the machine is running.
[9] The cross-current loop cannot be used to calculate power ratings on the D700. If this type of measurement is essential for the application to work properly, an extra CT must be connected to the alternator current measurement input.
[10] 1 ohm resistors must be connected to the cross-current input on each AVR.

Connection	Electrical schematic
Cross-current measurement CT	

2.4. Wiring precautions

Cables must never exceed 100 m in length.
To ensure respect of standards IEC 61000-6-2, IEC 61000-6-4, IEC 60255-26, shielded cables are imperative in case of a D700 installed outside of the terminal box.

The total ohmic value of the exciter loop (out and back) must not exceed 5% of the exciter resistance, regardless of the cable length.
The total ohmic value of the power system cables must not exceed 5% of the exciter resistance, regardless of the cable length.

For information, the resistance at 20°C in mΩ/m for copper cables is approximately:

Cross-section (mm²)	Resistance (mΩ/m)
1.5	13.3
2.5	7.98
4	4.95
6	3.3
10	1.91

Calculation example:

For a 10 ohm exciter

- Maximum cable resistance = 0.5 ohms (2 x 0.25 ohms)
- Cross-section as a function of the distance between the AVR and the alternator:

Distance (m)	Cross-section (mm²)
30	2.5
50	4
75	6
100	10

2.5. Handling

This AVR weighs 3.09 kg (6.823 lbs), with its center of gravity at the back, around the power bridge. Appropriate precautions should therefore be taken when installing it at the back of the cabinet.

3. Installation instructions

3.1. Warning symbols

See section "*1.4. Safety devices and general warning symbols* ".

While the AVR is running, do not unplug any connectors or make any wiring modifications, as this may lead to electric shock and/or destruction of the AVR and/or damage to the alternator.

The same goes for modifications to the main alternator settings, such as: machine data, voltage and current measurement transformer wiring, upper or lower reference limits, starting control, etc. which must be made with the alternator stopped.

The D700 operating ranges must always be adhered to. Changing the settings to inappropriate voltages or currents may cause partial or total destruction of the AVR and/or alternator.

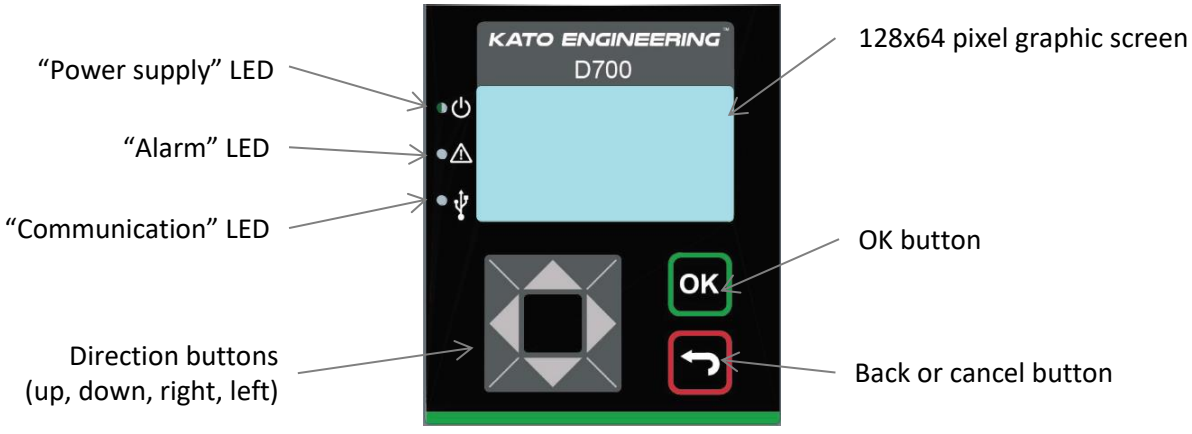
The power input must be protected by a circuit-breaker or fuses in order to avoid irreparable damage to the AVR in the event of short-circuit or voltage surge.

3.2. Description of manual controls and signalling

3.2.1. Overview of the HMI

The D700 HMI interface consists of:

- 1 black and white backlit display
- 6 pushbuttons, for navigating menus and settings, confirming and cancelling
- 3 multicolor LEDs



Two modes are available:

- **User**: used to view predefined menus giving the main performance parameters measured by the D700
- **Super User**: used to view and modify all the D700 settings (except for the calibration settings)

3.2.2. LED behaviour

"Power supply" LED:
- **Green** if the auxiliary power supply is present and all the internal power supplies are working
- **Red** if one of the power supplies is faulty or if the auxiliary power supply is missing

"Alarm" LED:
- **Red** if a fault is present
- **Green** if there are no faults

"Communication" LED:
- **Blue** if only the USB is connected
- **Yellow and red** if the Ethernet is connected
- **White and purple** if both the USB and the Ethernet are connected

On starting the D700, the screen below appears, indicating your AVR firmware version (at the bottom).

3.2.3. "User" mode

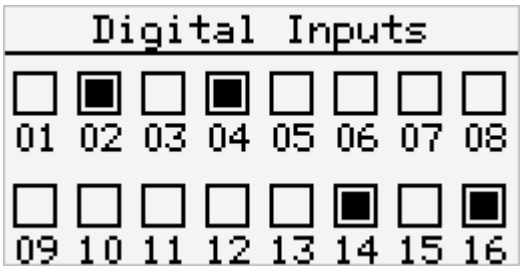
"User" mode only allows viewing of menu "0" whose pages are defined in your AVR. In factory configuration, the default pages are as follows:

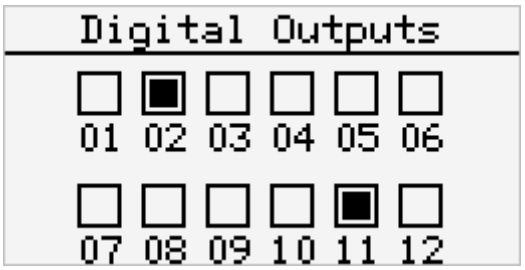
- Page 1: alternator average voltage, alternator average current, alternator frequency
- Page 2: alternator voltages between phases U-V, V-W, W-U
- Page 3: alternator phase currents Iu, Iv, Iw
- Page 4: active power, reactive power, apparent power, power factor
- Page 5: average field current, average field voltage, Vbus power unit voltage
- Page 6: alternator average voltage, alternator average current, active power

NOTE: The information on these pages can be changed in User mode. See section *4.2.1. Set the menu "0" page parameters*".

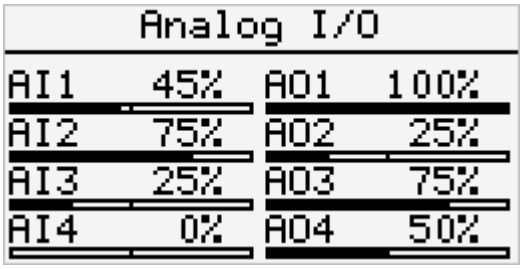
The “up” (next page) and “down” (previous page) buttons are used to move between pages.

As well as these pages, the inputs and outputs can be displayed. A white square corresponds to a disabled input or output, a black square corresponds to an enabled input or output.

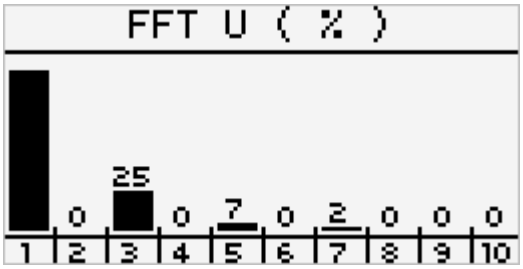




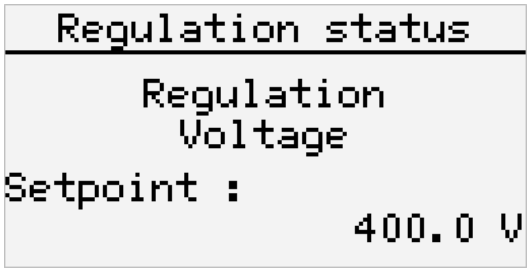
The analog I/O levels are available.



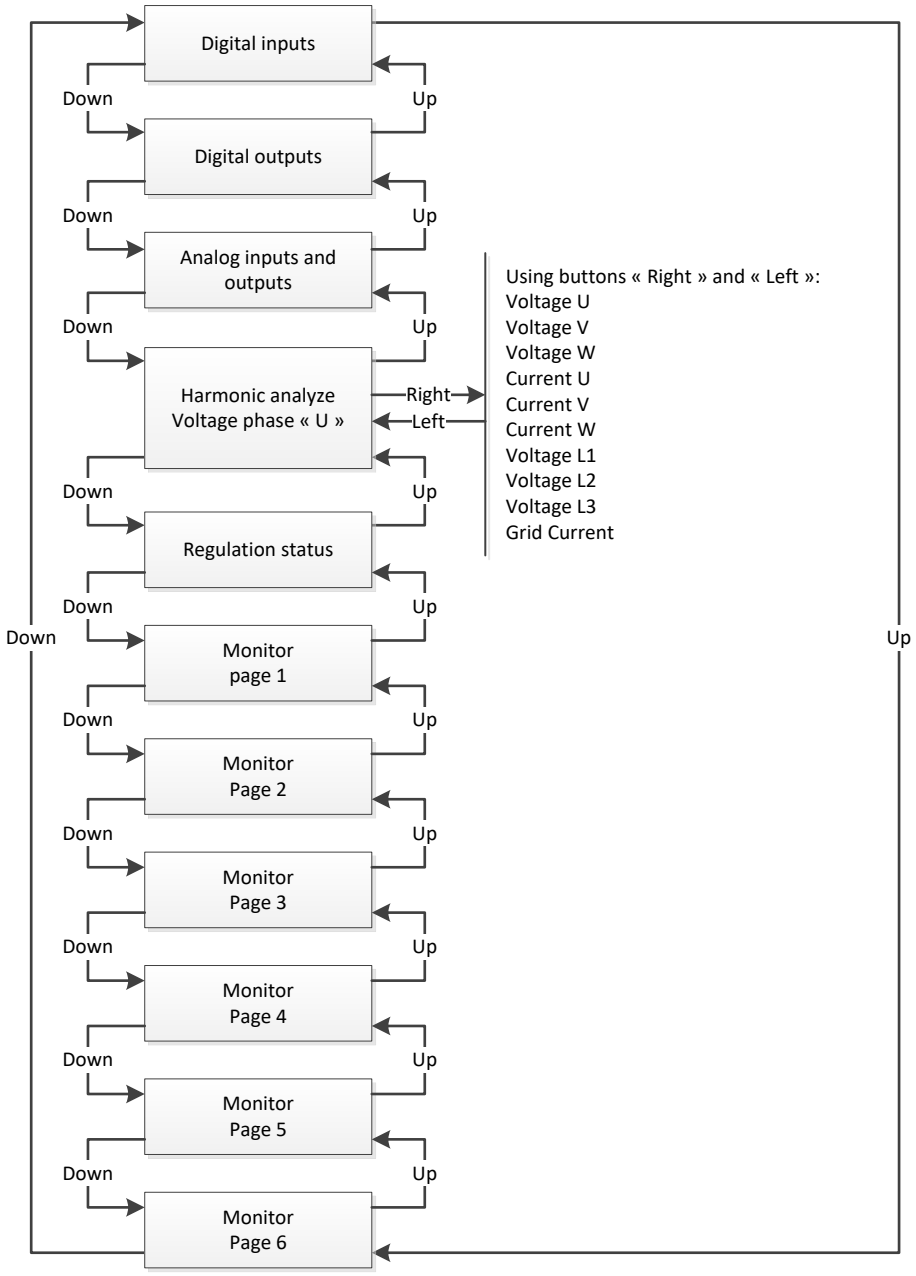
The following pages can be used to view the harmonic analyses. With the “left” and “right” buttons, the harmonics on voltages U, V, W, currents Iu, Iv, Iw, grid phases L1, L2, L3, and the grid code CT current can be viewed in succession.



In the next page regulation status is displayed:

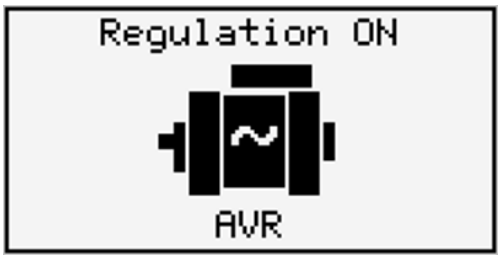


Synoptic view of moving between pages:



3.2.4. Messages

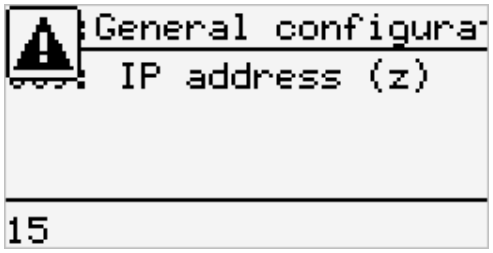
When changing regulation mode, a pop-up window displays the information. In the example below: regulation is switched on in voltage regulation mode.



3.2.5. Alarms

When alarms appear, a pop-up window displays the fault (this pop-up window remains displayed for 2 seconds if no action is taken and the “Alarm” LED is lit up red.

These pop-up windows can be acknowledged by pressing “OK”. As long as this alarm is present, an icon is displayed in the top left-hand corner of the screen.

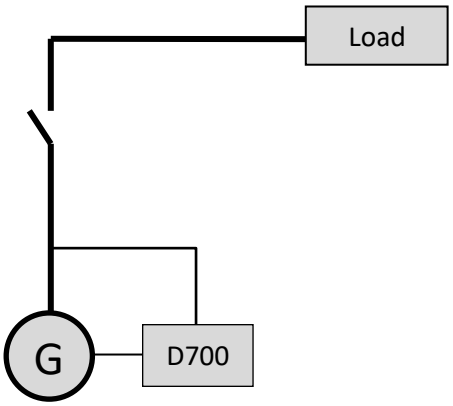


3.3. Description of operating and runtime modes

3.3.1. Regulation modes

The various regulation modes to be configured depend on the alternator operation (standalone, parallel between machines, parallel with the grid). Based on these different operating modes, certain regulation modes will need to be enabled (some of which are strongly recommended, or even mandatory, and others optional).[11] The simplest examples are shown below:

- **Example no. 1: The alternator only is connected to a load (factory, lighting, pump, etc.)**



- **The AVR is operating in voltage regulation mode only.**

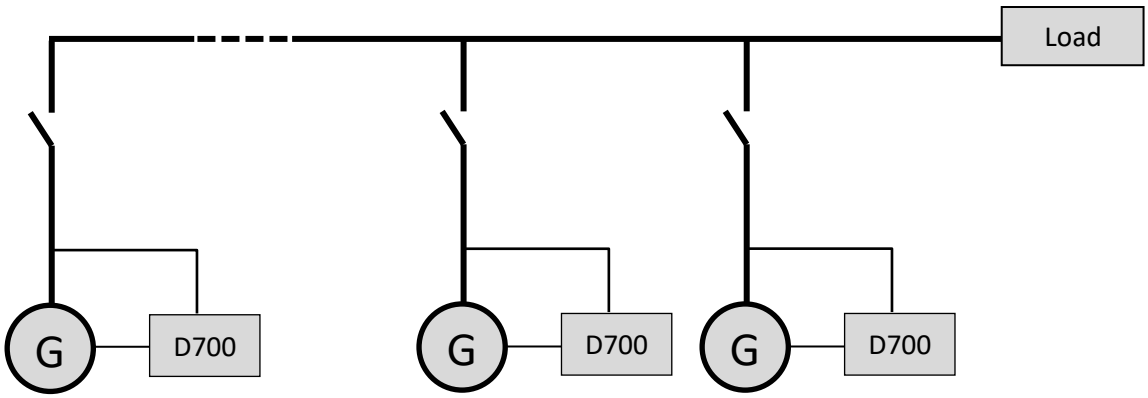
- There is no need to measure the alternator current. In this example, no power rating can be indicated, and the stator current limit cannot be enabled, nor load compensation nor quadrature droop.
- No quadrature droop or cross-current correction is needed.
- Load compensation can be enabled in the case of long-distance connections so as to ensure there is a minimum voltage at the load terminals.[12]

- **Field current regulation is optional**. In this case, the reference must be permanently set so that it matches the existing load and will not risk any damage to the load or the machine (risk of overvoltage or under voltage and risk of over excitation).

[11] The following schematics are given for information only, they do not take into account any step-up transformers or voltage sensing transformers. The presence of a transformer for measuring the alternator current is however indicated depending on the regulation mode.

[12] In this case, at least one alternator current measurement transformer is needed.

- **Example no. 2: The alternator is connected to other alternators and a load (factory, lighting, pump, etc.).**



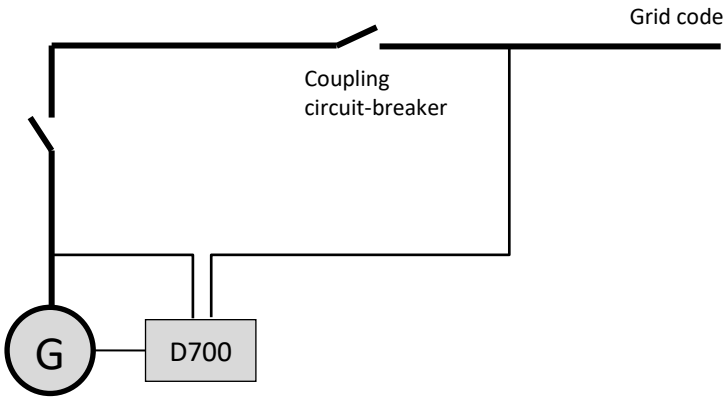
- **The AVR is operating in voltage regulation mode only.**

- In order to divide the load reactive power equally between all the machines which are running, select one of the two following modes:
  - Quadrature droop: voltage drop according to the percentage of rated reactive load applied to the machine. In this case, alternator current measurement is mandatory on the alternator current measurement input.
  - Cross current: reactive load sharing from a current loop. In this case, a dedicated CT needs to be connected and a current loop needs to be created on the “Cross current” input.

- NOTE: Load compensation cannot be enabled if quadrature droop or cross current is active.

- **Field current regulation is optional**. In this case, the reference must be permanently set so that it matches the existing load and will not risk damaging the load or the machine (risk of overvoltage or under voltage and over excitation).

- **Case no. 3: The alternator is in parallel with the grid[13]**



  - **The AVR is operating in voltage regulation mode when the alternator starts.** Quadrature droop or cross-current correction is not needed if only the alternator is connected to the grid.
  - **The voltage match circuit is used to adjust the alternator to the grid voltage prior to connection.** This can be done automatically by directly measuring the voltage after the coupling circuit breaker, or by changing the alternator reference.
  - **Regulation of the alternator power factor, kVAr, or power factor at one point on the grid must be enabled once the coupling circuit breaker is closed**.
    - Alternator current measurement is essential in all these regulation scenarios.
    - Regulation of the power factor at one point on the grid also requires alternator voltage and current measurements:
      - Measurement of the grid voltage and current at the required point (in this case, the power factor is calculated by the D700).
      - Remote measurement of this power factor through a D700 analog input or by a fieldbus provided too long of a delay is not introduced into the measuring circuit loop (need to match the delay and the speed of the PID).

  - **Field current regulation is optional**. In this case, the reference must be permanently set so that it matches the existing load and will not risk damaging the load or the machine.

NOTE: Different regulation types have priority. The order is as follows (highest priority down to lowest priority):

- **Field current**
- **If the grid code connection contactor is closed:**
  - **Grid power factor**
  - **Alternator kVAr**
  - **Alternator power factor**
- **Voltage match circuit**
- **Voltage**

See appendix 7.4. for AVR priority.

NOTE: Switching from one regulation mode to another is bumpless.

[13] A grid is deemed to be any electricity supply whose power rating is at least ten times higher than the alternator rated power.

3.3.2. Control of modes and information

Switching from one regulation mode to another, transferring operating modes, and monitoring of alarms or trips can be done by several means: inputs and outputs or communication. See section "*4. Setup instructions*" for the description of regulation modes control

Also, see the schematic for the alternator on which your AVR is installed.

3.3.3. Protection devices

The D700 integrates certain protection devices; see section "*4.3.9.6. Step 6: Definition of the protection devices*" for their settings:

- Under voltage;
- Open diode trip, diode short-circuited trip;
- Overvoltage (Code ANSI 59);
- Under frequency (Code ANSI 81L);
- Over frequency (Code ANSI 81H);
- Active reverse power (Code ANSI 32P);
- Reactive reverse power (Code ANSI 32Q);
- Synchro check (Code ANSI 25).

3.3.4. Related functions

Other D700 functions can be used to record events, supervise the phase synchronizing the alternator with the grid, or create simple control systems or functions for monitoring references. These different functions are described in section "*4. Setup instructions*".

3.4. Anomalies and incidents

A number of anomalies can occur on the AVR which may lead to it being replaced. The main faults are listed in the table below:

ANOMALIES	CAUSES	REMEDIES	RESTARTING
Voltage sensing trip	Alternator sensing VT broken	Replace faulty VT	Stop the alternator and once the faulty VT has been replaced, restart the alternator
	Internal measurement broken	Replace the AVR	Replace the AVR as described in section 3.5.
Excitation trip	Faulty component or opening of the field excitation circuit which caused a voltage surge on the transistor	Replace the AVR	Replace the AVR as described in section 3.5
24 VDC auxiliary supply trip	External supply trip	Replace the 24 VDC power supply	Stop the alternator and once the faulty power supply has been replaced, restart the alternator
	Voltage converter trip	Replace the AVR	Replace the AVR as described in section 3.5

ANOMALIES	CAUSES	REMEDIES	RESTARTING
The AVR is not responding (display frozen, no communication, etc.)	Microcontroller trip	Replace the AVR	Replace the AVR as described in section 3.5
The regulation mode controlled by an input is not active	Faulty input	Switch control of the regulation mode to another input	Stop the alternator and once the new settings have been entered, restart the alternator
		Replace the AVR	Replace the AVR as described in section 3.5
	The wiring is faulty	Check that the input has been enabled by shunting the 0 V and the input locally and checking the input state on the HMI	Restart the alternator
The field excitation does not start	Faulty starting input	Switch control of starting to another input	Stop the alternator and once the new settings have been entered, restart the alternator
	The AVR power is not switched on	Check the VBus voltage on the HMI	Restart the alternator
	The 24 VDC power supply is faulty	Check that the AVR is powered up by looking at the HMI LEDs (green power LED on)	Restart the alternator
Regulation of the power factor is unstable	The active power is too low to have a correct power factor measurement	Use kVAr mode for low load regulation (less than 10% of rated load)	Change the AVR settings and restart the alternator
	The stator current measurement is incorrect	Check the CT wiring on the current measurement input and the CT	Restart the alternator
		Replace the AVR if the wiring is correct	Replace the AVR as described in section 3.5

3.5. Replacing a faulty AVR

These operations must be performed by qualified staff. See the warning symbols in section 3.1.

To replace a faulty D700 AVR, proceed as follows:

- Stop the alternator if not already done.
- Switch off and electrically isolate the auxiliary supply and power supply, and check that no voltage is present.
- Carefully remove all the AVR connectors, noting their position.
- Undo all the AVR mounting brackets so it can be removed from its position.
- If you do not have the AVR configuration file, the factory output configuration can be found on the D700 SD card.
- Still using the PC software, export the retrieved configuration to the new D700 AVR.
- Disconnect the D700 USB stick.
- Fix the new D700 in place of the faulty AVR.
- Replace all the connectors on the new AVR.
- Power up the auxiliary supply and check that the AVR is energized (HMI green “Power” LED on).
- Start up the alternator drive system.
- Power up the power supply without exciting the machine.
- Before exciting the alternator, check the alternator voltage measurement and power supply voltage (VBus).
- Switch on the alternator excitation.
- Check all the AVR measurements and regulation modes, and any controlled outputs.

4. Setup instructions

4.1. General parameter-setting information

The D700 parameters can be set in 3 ways:

- Via the HMI interface on the product (display and buttons)
- Using the PC software distributed with the product
- Via the communication buses (parameter table in appendix)

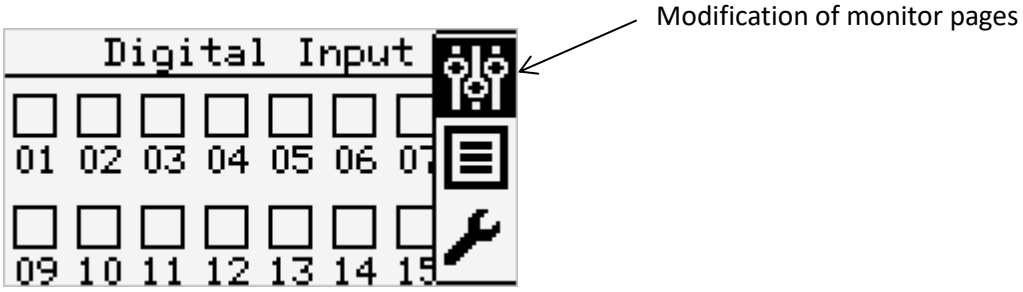
NOTE: Not all parameters can be accessed by the communication buses.

4.2. Set the HMI Interface parameters

4.2.1. Set the menu "0" page parameters

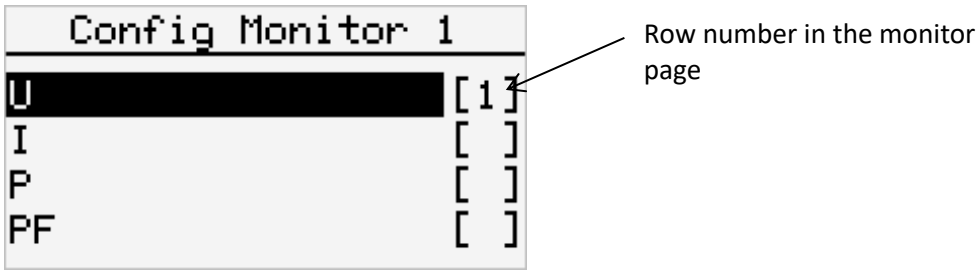
Pages 1 to 6 of the "User" menu can be modified directly via the HMI:

- Press "OK", a menu appears on the right of the display containing 3 icons:



- Go to the active monitor page modification icon by pressing the "up" button.
- Press "OK".
- Move around using the "left" and "right" buttons on the page to be modified.

The configuration page appears which contains the list of all the parameters which can be displayed in the monitor page. Indicated on the right, in square brackets, is the row number in the monitor page assigned to this parameter (in the example below, the alternator average voltage "U" is on the first row of page 1).



NOTE: There can be up to 4 parameters on one page.

To change parameter, the procedure is as follows:

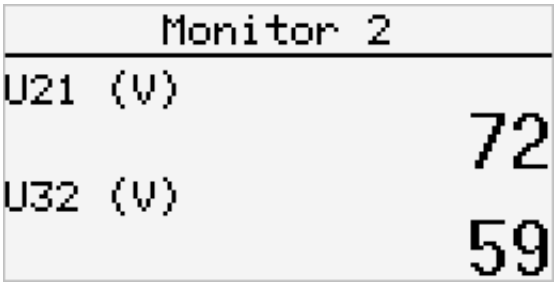
- If all 4 parameters are displayed:
  - Press “OK” on the row containing the parameter you wish to delete from the page.
  - Move around using the “Up” and “Down” buttons in order to reach the parameter you wish to display.
  - Press “OK”: a digit appears, indicating the row number of this parameter in the page.
- If not all 4 parameters are displayed:
  - Move around using the “Up” and “Down” buttons in order to reach the parameter you wish to display.
  - Press “OK”: a digit appears, indicating the row number of this parameter in the page.

After making your choices, press the “Back” button to return to the monitor pages.

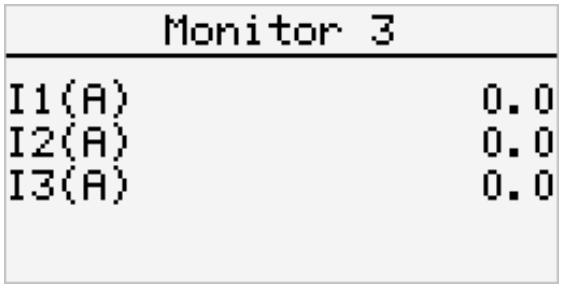
NOTE: Depending on the number of parameters selected, the display will be modified:

- For 1 displayed parameter:

- For 2 displayed parameters:



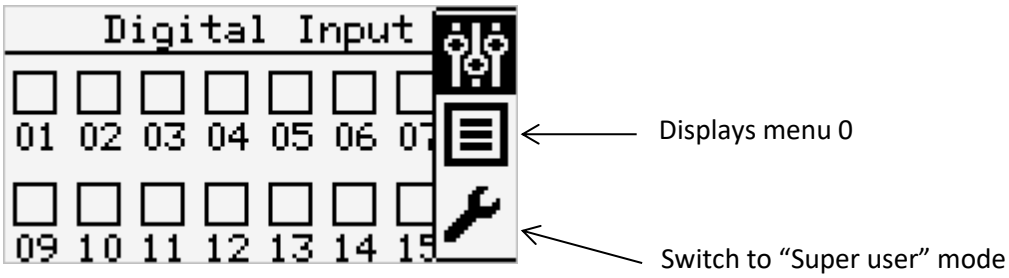
- For 3 or 4 displayed parameters:



4.2.2. "Super User" mode

This mode allows users to read and write the various D700 parameters (depending on authorizations).
To activate this mode:

- Press "OK" on one of the monitor pages to bring up the menu on the right.



- Using the "up" and "down" buttons, go to the spanner icon.
- Press "OK".
- The following is displayed:

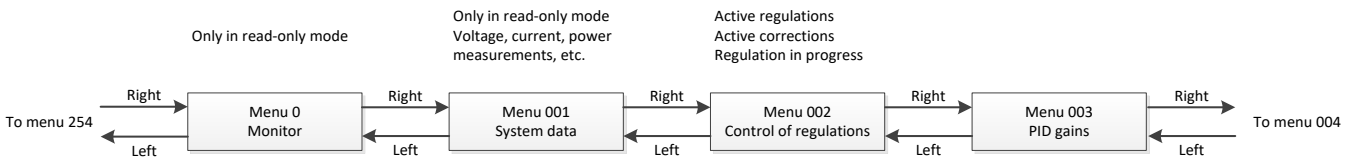
- To change the value of a digit:
  - Move to the desired digit with the "left" or "right" button.
  - Once on the desired digit, press the "up" and "down" buttons to change the value (between 0 and 9).
- Once all the digits have been configured, press "OK" to confirm the password.

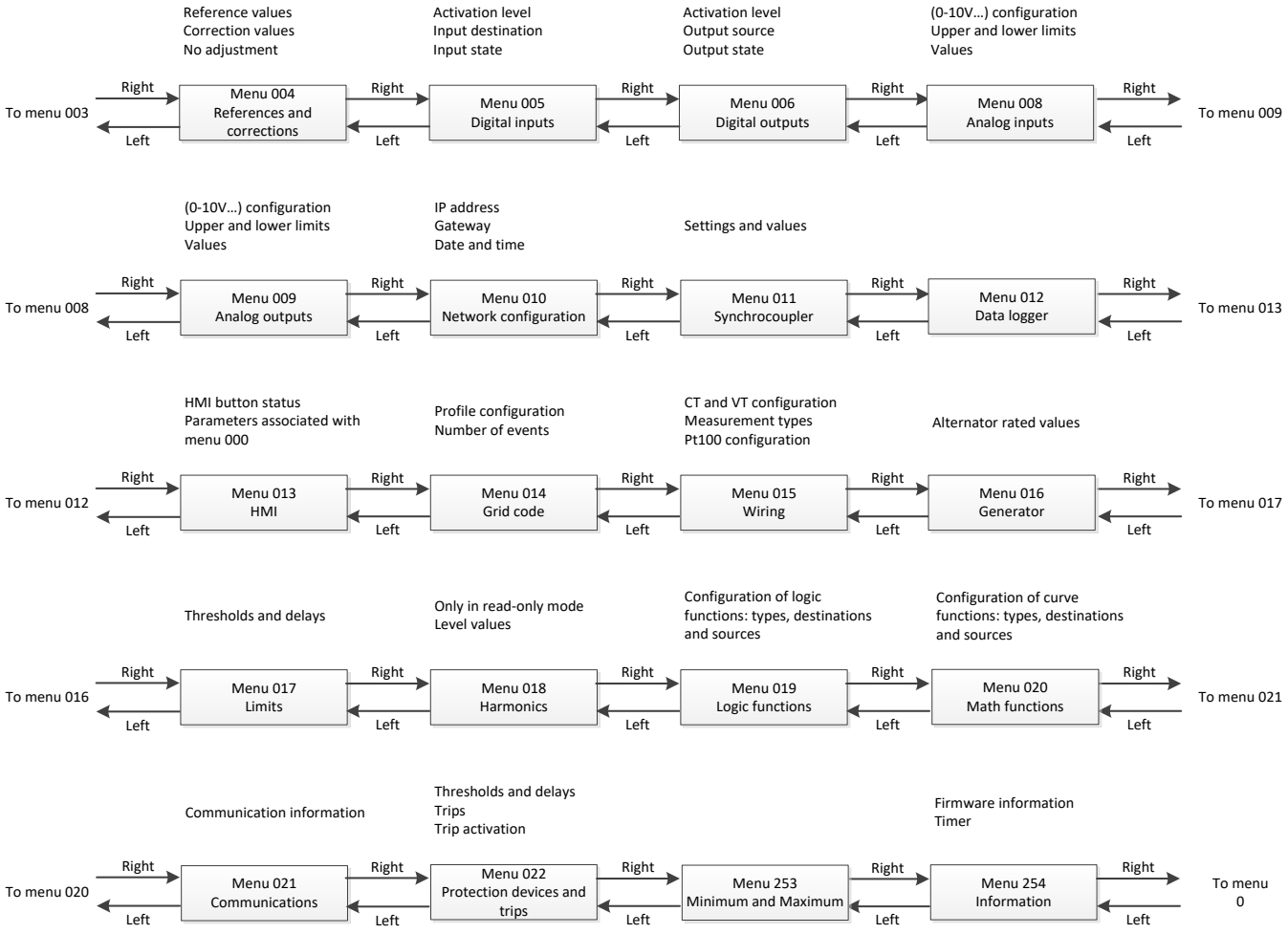
NOTE: On leaving the factory, the password is "0000".

4.2.3. Parameter modification in "Super user" mode

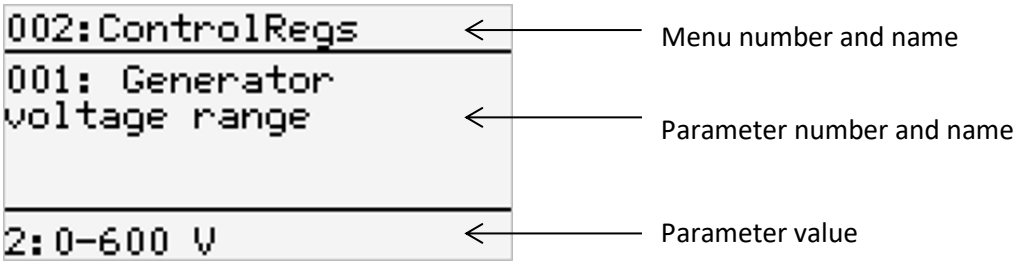
When "Super User" mode is active, users can read and/or modify (depending on access rights) parameters in the various menus (except for the calibration menu).

The "left" and "right" buttons are used to move between menus.

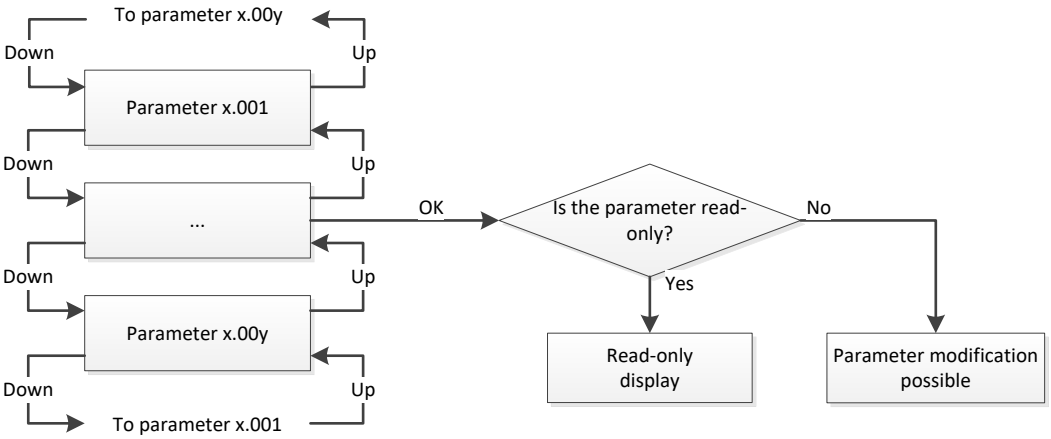




In each menu, the “up” and “down” buttons are used to reach the desired parameter number. The screen corresponding to each parameter looks like this:

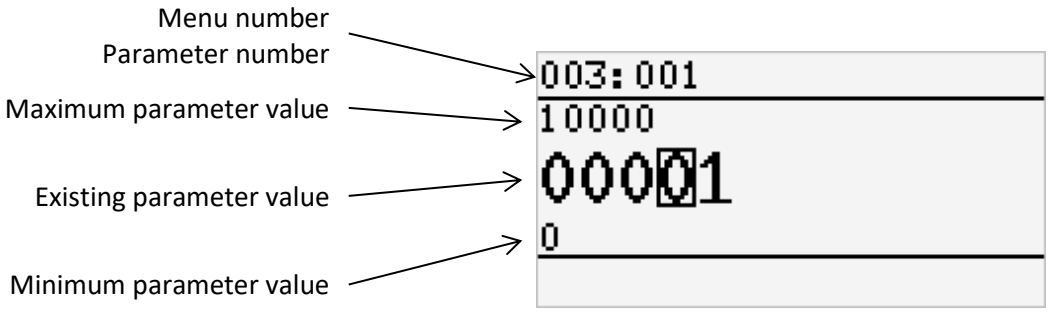


Pressing “OK” allows the parameter to be modified if it is not read-only.



If modification is authorized, the value can be changed:

- **For parameters which require a value modification** (done one digit at a time):
  - To modify the value of a digit:
    - Move to the desired digit with the “left” or “right” button.
    - Once on the desired digit, press the “up” and “down” buttons to modify the value (between 0 and 9).
    - Once all the digits have been configured, press “OK” to confirm.
- **For parameters which require a choice to be made between a number of options:**
  - Press the “up” and “down” buttons to modify the value.
  - Once the desired value is displayed, press “OK” to confirm.



In both cases, pressing the “back” button reverts to the previous screen without changing the parameter value.

4.2.4. Return to “User” mode from “Super user” mode

To return to “User” mode, press the “Back” button for more than 2 seconds. The password will need to be entered again to go back to super user mode.

4.3. PC software

All the D700 settings can be entered using the "EasyReg Advanced" software supplied with the AVR. The parameter-setting pages describe primarily the alternator parameters, regulations, limits, and protection devices.

The D700 can be supervised by various pages, including the oscilloscope, monitoring, and the harmonic analysis.

Additional functions such as creating simple control systems by means of logic gates, configuring the data logger, and sending e-mails are also possible.[14]

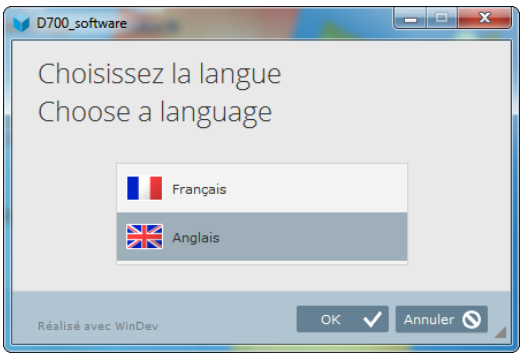
4.3.1. Software installation

An installation CD is included with your AVR. It contains an installation file "EasyReg Advanced", and the AVR setup and supervision software.

NB: This program is only compatible with computers running WINDOWS® versions Windows 7 and Windows 10 operating systems.

Execute this program, checking first that you have “Administrator” rights for your terminal.

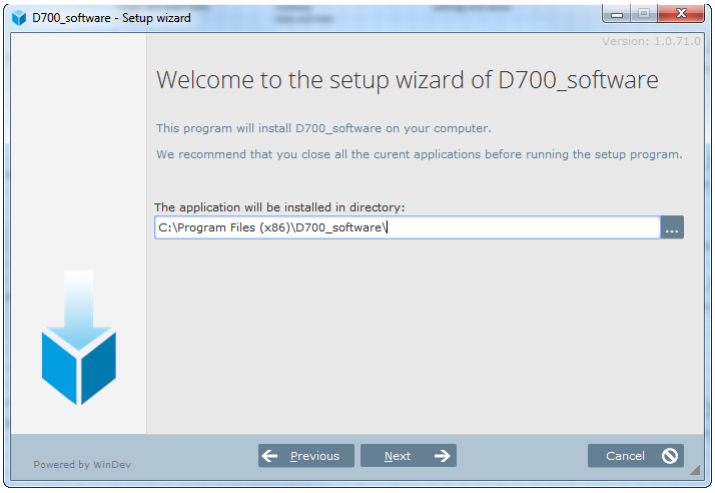
Step 1: Choose the installation language



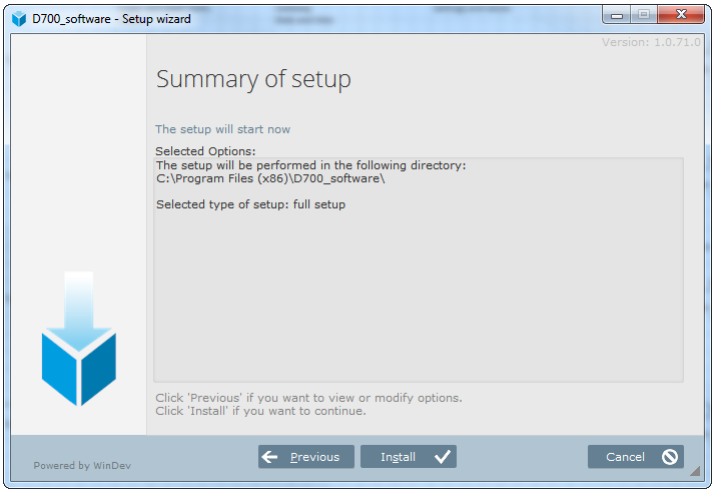
Step 2: Choose the installation type:

- Quick installation: the files are copied automatically and the software directory is created
- Custom installation:
  - Choose the installation directory

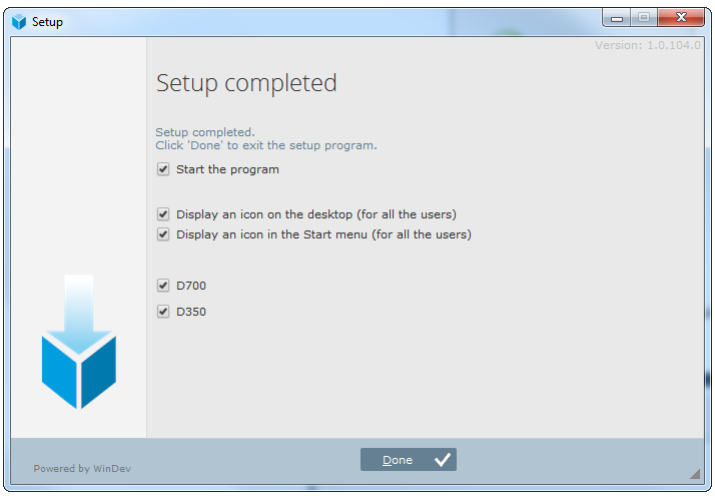
[14] Ethernet must be configured for this function



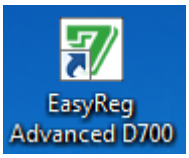
- After choosing the directory, click “Next”
- Validate or not the signature of HTTP installer, click on "Next"
- Confirm by clicking “Install” if the path is as expected



Step 3: Once installation is complete, you can choose to start the software (box ticked by default) , to display an icon on the desktop, to display an icon in the start menu, to have shortcuts for D700 and D350 (common PC-software) and in the start menu, and click “Done”



A shortcut is created on your desktop:

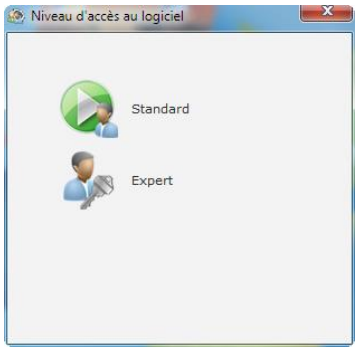


4.3.2. Home form

When the software is started, following form appears. Click on the icon according to the mode you want exchange with the D700:

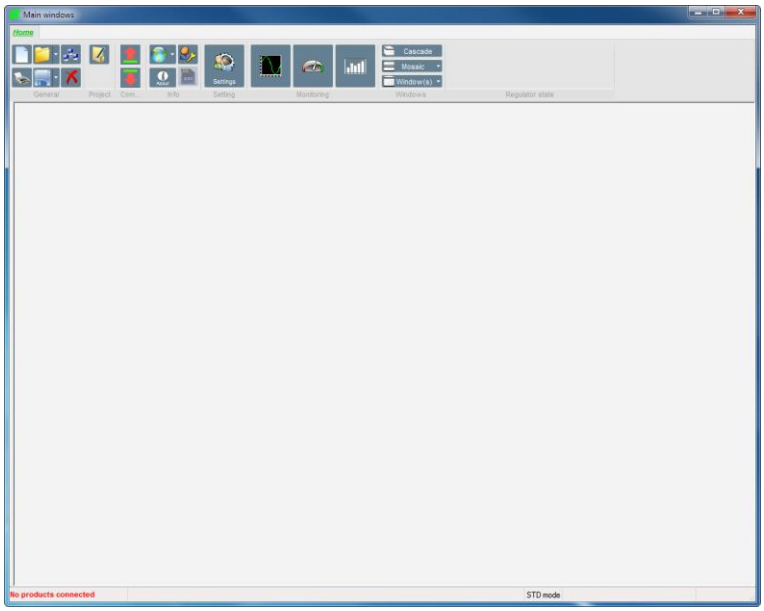
- Standard: configuration parameters are read only access mode
- Expert: configuration parameters are in read/write access mode.

In both cases, monitoring of the D700 is possible.



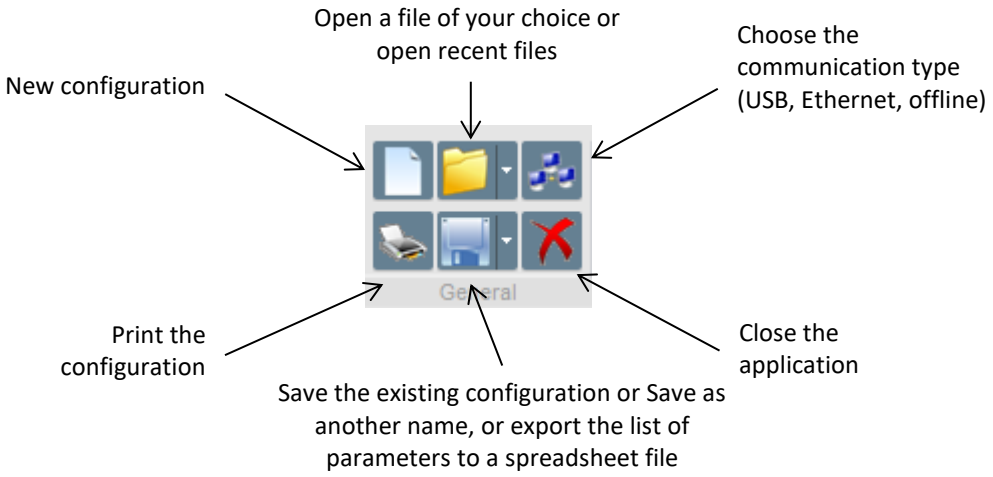
4.3.3. Description of the banner and tabs

The software takes the form of a single window with a general banner and a zone in which sub-windows open.

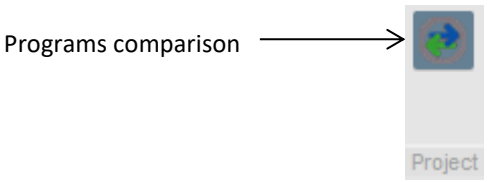


The banner consists of 8 groups:

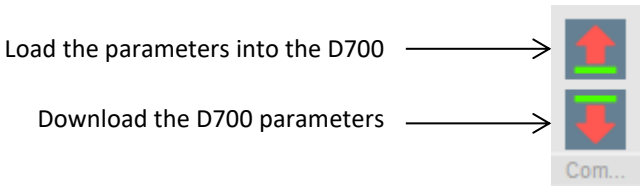
- **“General” group:**



- **“Project” group:**



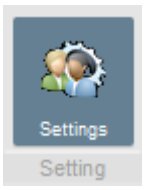
- **“Communication” group:**



NOTE: Before parameters are exported the user will be asked to confirm and to check the product status (regulation in progress or not). If regulation is in progress, confirmation is requested again.

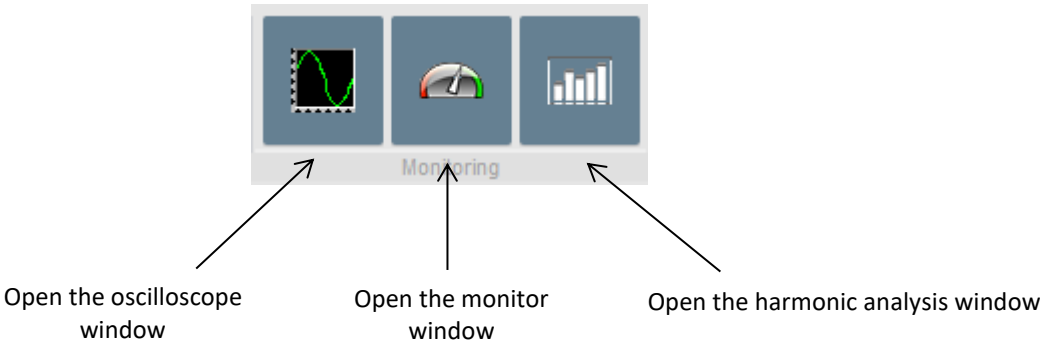
- **“Information” group:**

- **“Setting” group:**

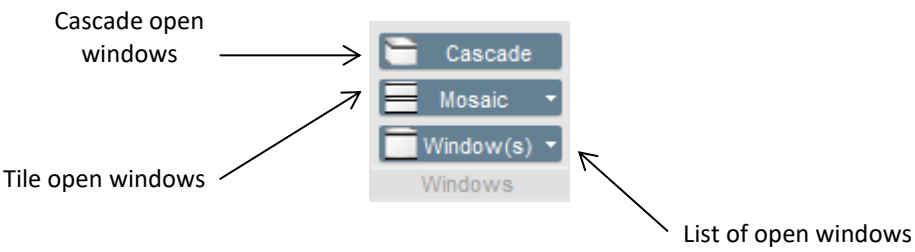


Open the configuration window (general information about the alternator, references, limits, etc.)

- **“Monitoring” group:**



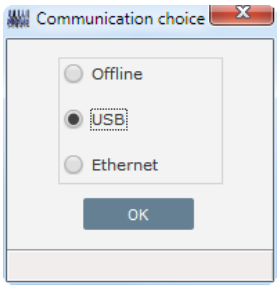
- **“Windows” group:**



4.3.4. Communication with the D700

To communicate with the D700 and PC software, two modes are possible: USB or Ethernet. To define your communication mode, click on the following icon in the "General" group on the banner

A form will open, in which a communication mode can be chosen:

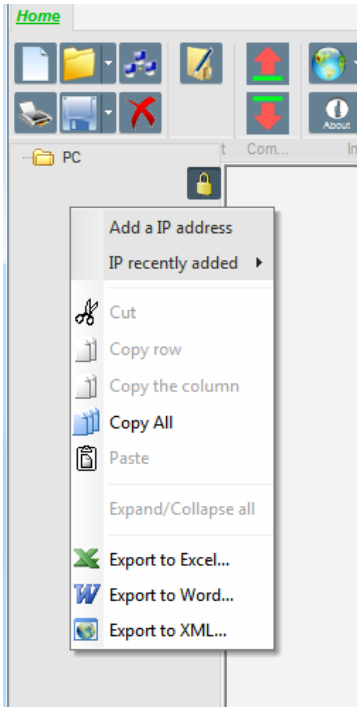


4.3.4.1. USB

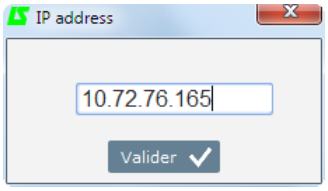
- For "USB" communication, use the dedicated cable with connector USB "A" on computer side, and USB "B" connector on AVR side
- Click on "OK" button
- If a D700 is connected, it must appear on the bottom left of the PC software

4.3.4.2. Ethernet

- For "Ethernet" communication, use a RJ45 cable and connector on the Ethernet plug in front of the D700
- Click on "OK" button
- A panel is opened on the left side of the PC software. Do a left click to let the contextual menu appear:

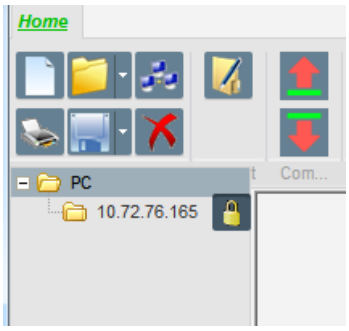


- Select "Add a IP address": the following form appears. Write the IP address in the text box and click on "OK" button



Note: See chapter "*4.3.14.1. Network configuration*" to set IP address and address type of your D700

- In the left panel, the D700 should appear:



- The same address is indicated on the bottom left of the PC software when your D700 is connected

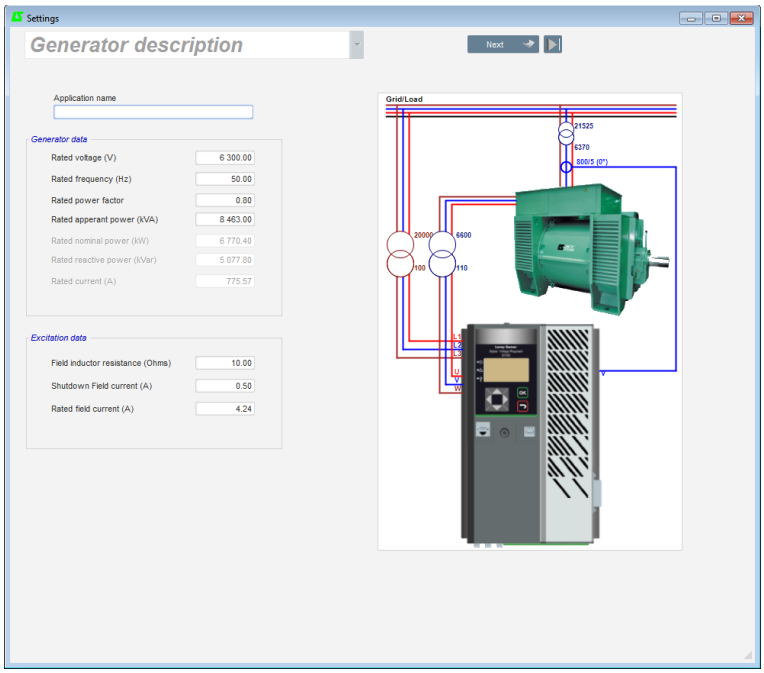
Note: A Windows® event can occur, and a window can appear. In this case consult IT

4.3.5. “Configuration” window

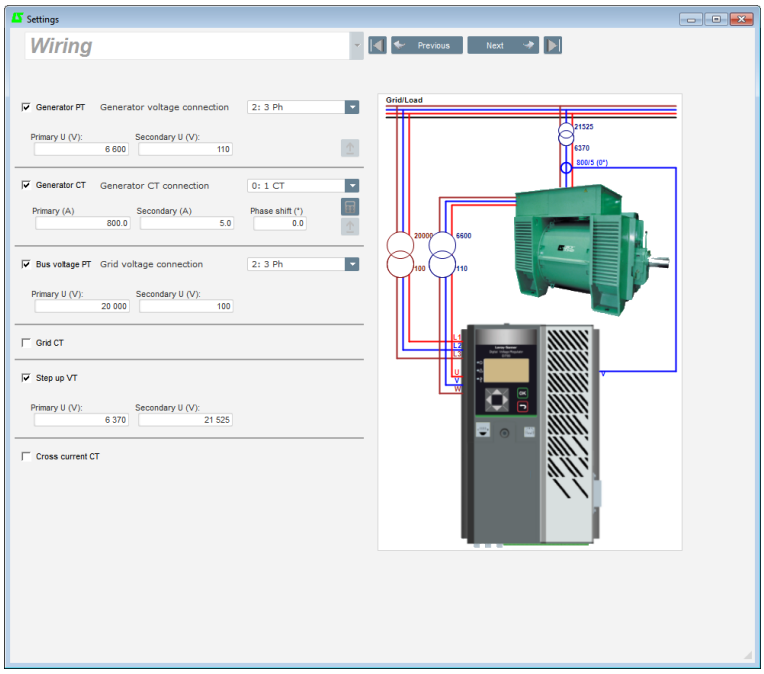
This window consists of several pages for configuring the entire alternator operation. To move between pages, use the “Next” or “Previous” buttons or click on the list of pages.

NOTE: More details of these pages are given in the section describing how to create a new configuration.

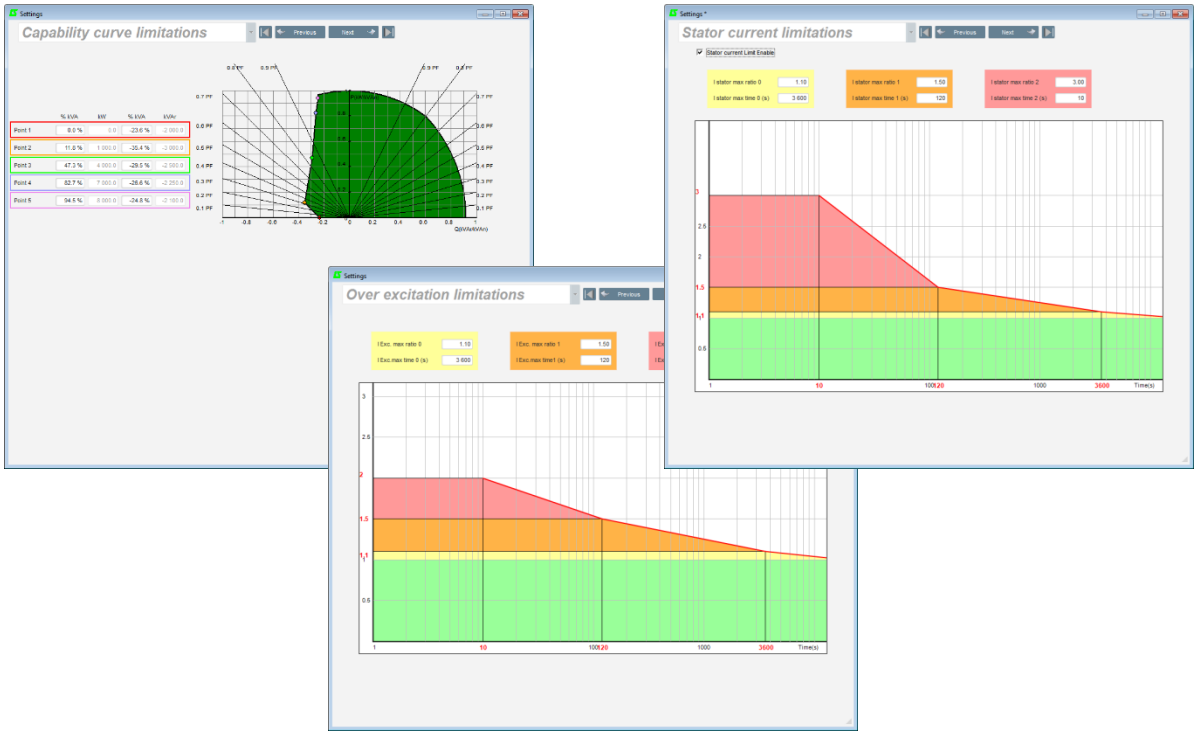
- **Description of the alternator**: this page contains all the alternator electrical characteristics, plus the field excitation data.



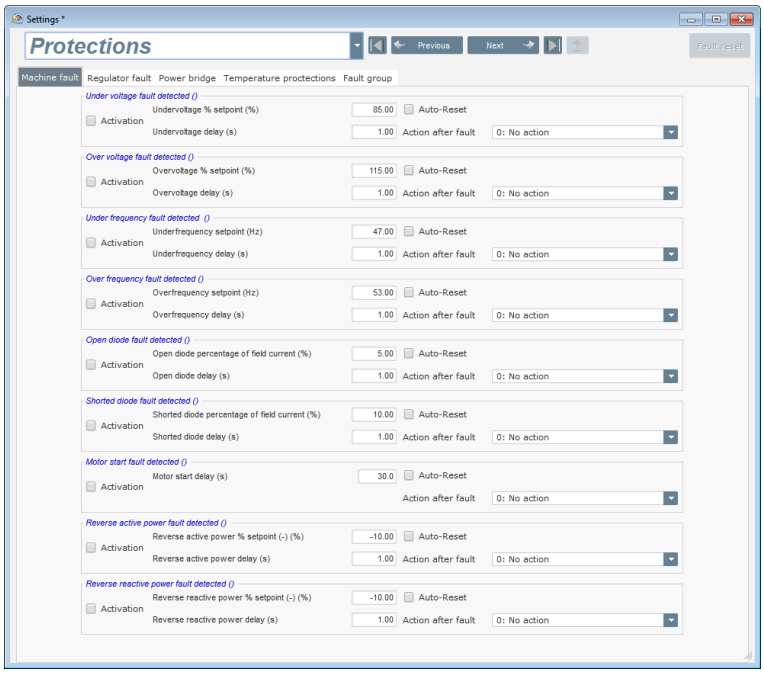
- **Wiring**: this page contains all the D700 wiring data for the measurement inputs (alternator voltage, alternator current, grid voltage, grid current). Each time the wiring is modified by selection of a VT or CT, the drawing changes.



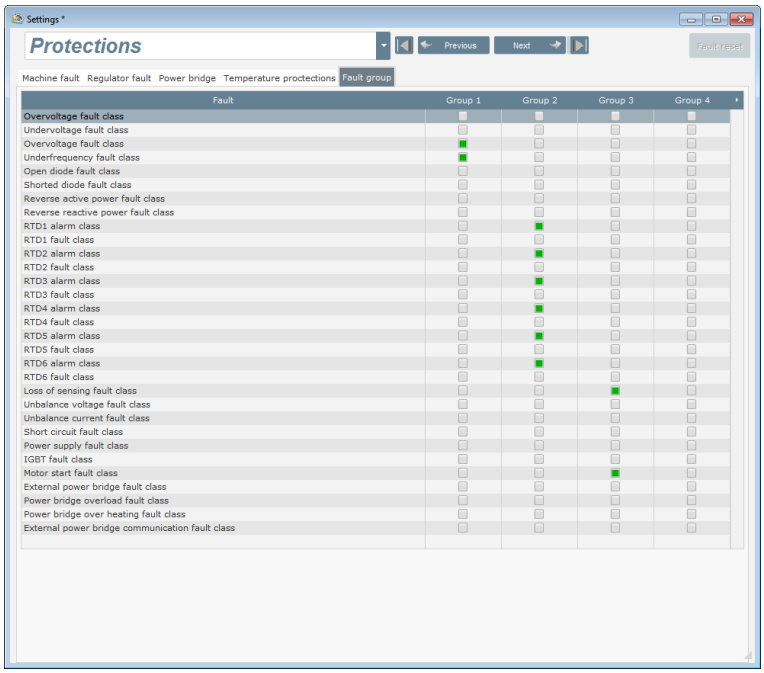
- **Limits**: this page contains the parameter settings for the various machine limits (maximum and minimum field current, stator current limit).



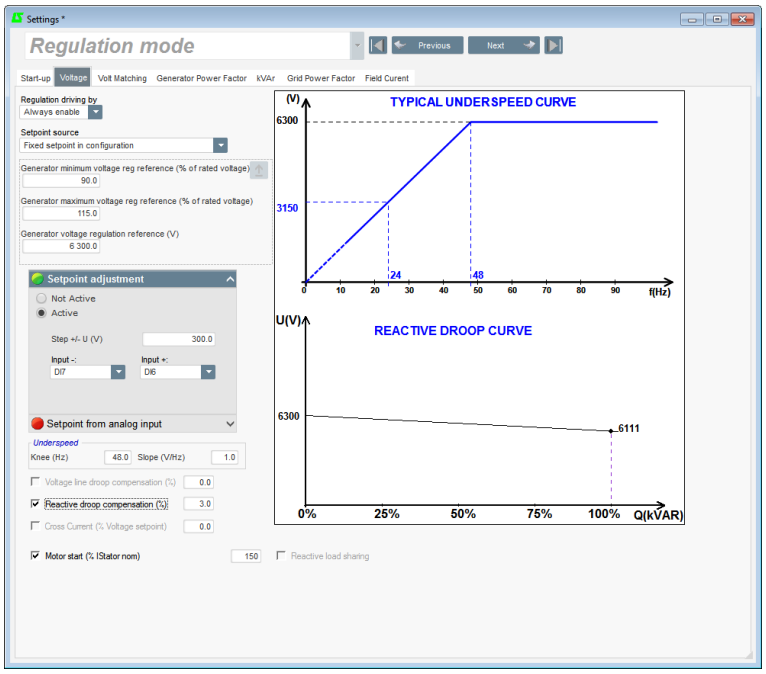
- **Protection devices**: this page contains the parameter settings for the protection devices provided by the D700 (rotating diode trip, overvoltage and under voltage, temperatures… etc.).



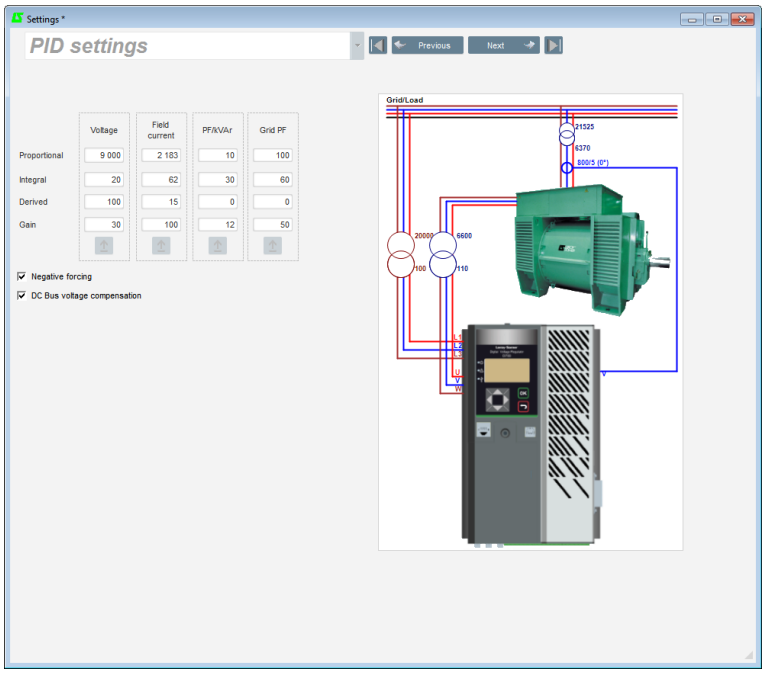
One page allows doing some groups faults to realize information as "fault synthesis"



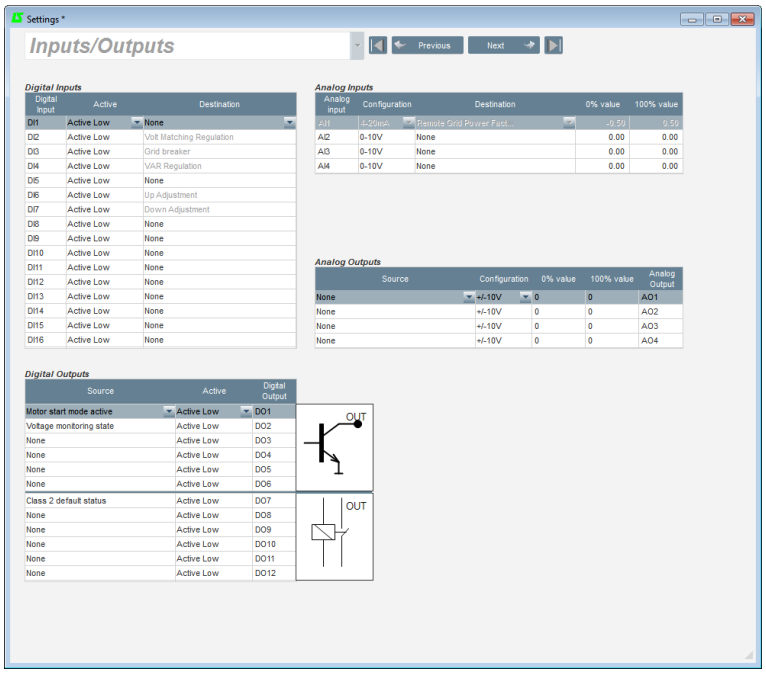
- **Regulation modes**: this page contains all the regulation parameter settings: active regulations, references and their adjustments.



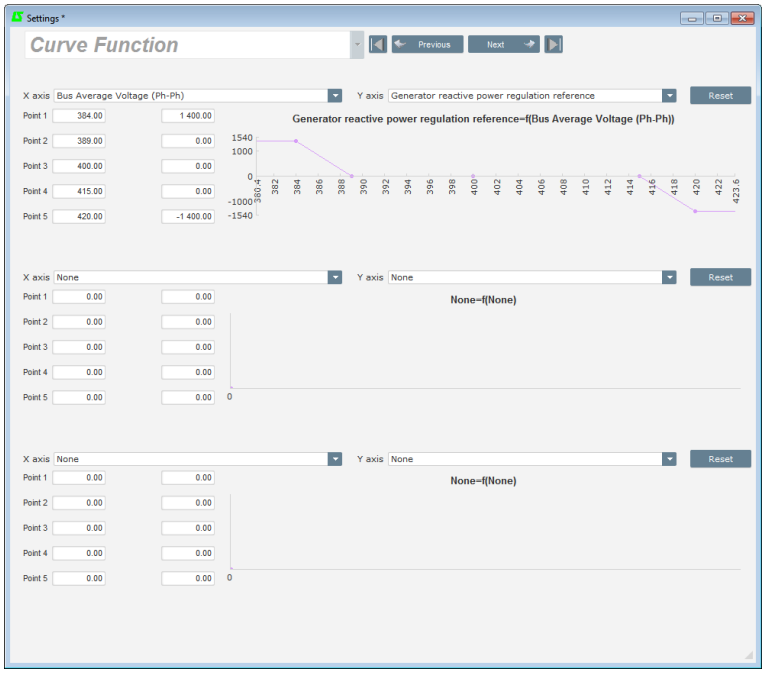
- **PID gains**: this page contains all the values for the PID settings.



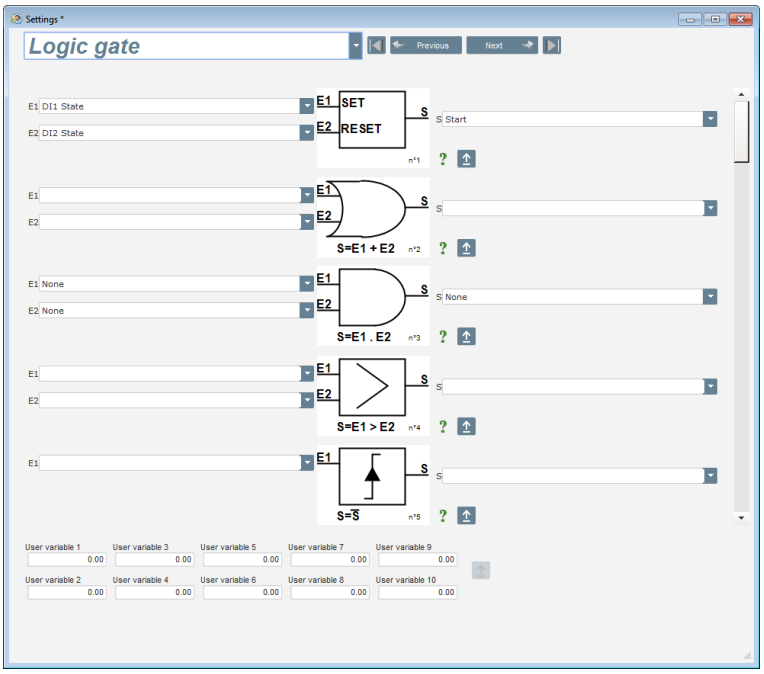
- **I/O**: this page contains an overview of the digital and analog I/O parameter settings.



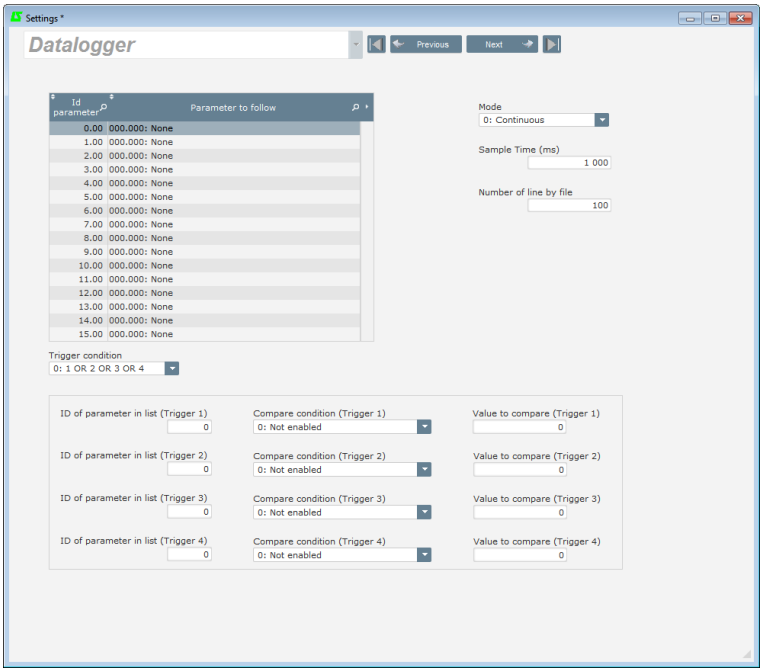
- **Curve functions**: this page is used to define the control functions of a parameter as a function of another by plotting 5 points. A description of these functions and some examples are given in section "***Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.***".



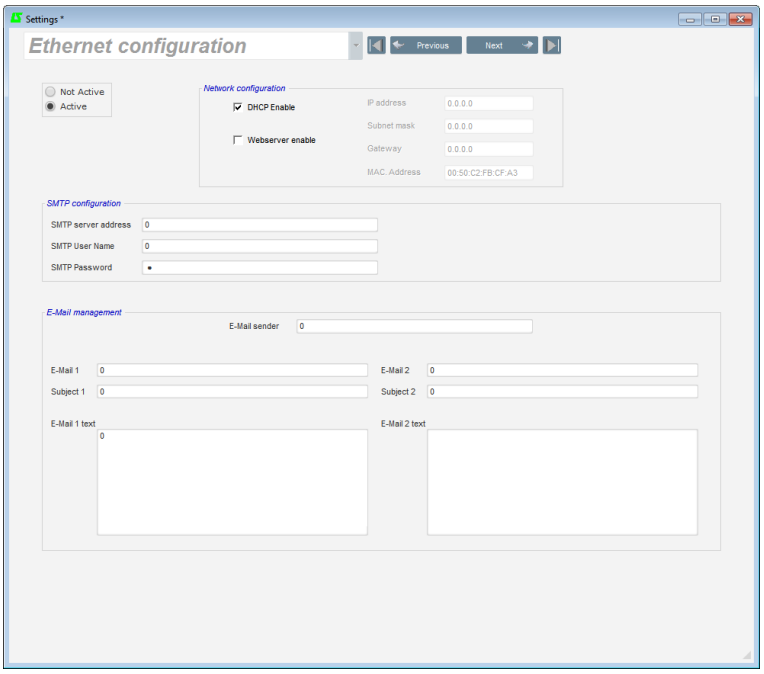
- **Logic functions**: this page is used to configure simple logic functions at I/O level and the type of gate. A description of these gates and some examples are given in section "4.3.11. *Logic gates"*.



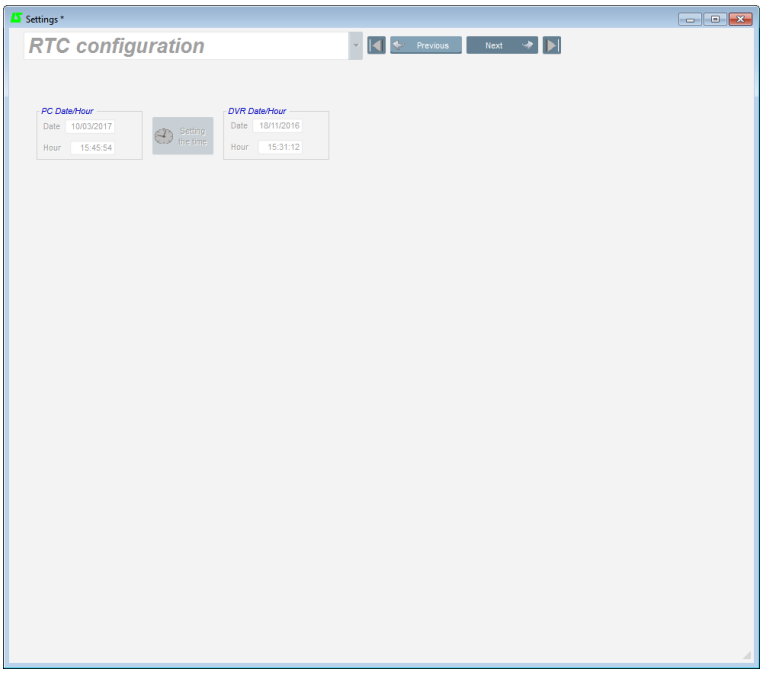
- **Data logger**: this page is used to define the parameters and triggers for saving to a log. The various operating modes for these triggers, the parameter trigger values and the sampling speed can be configured.



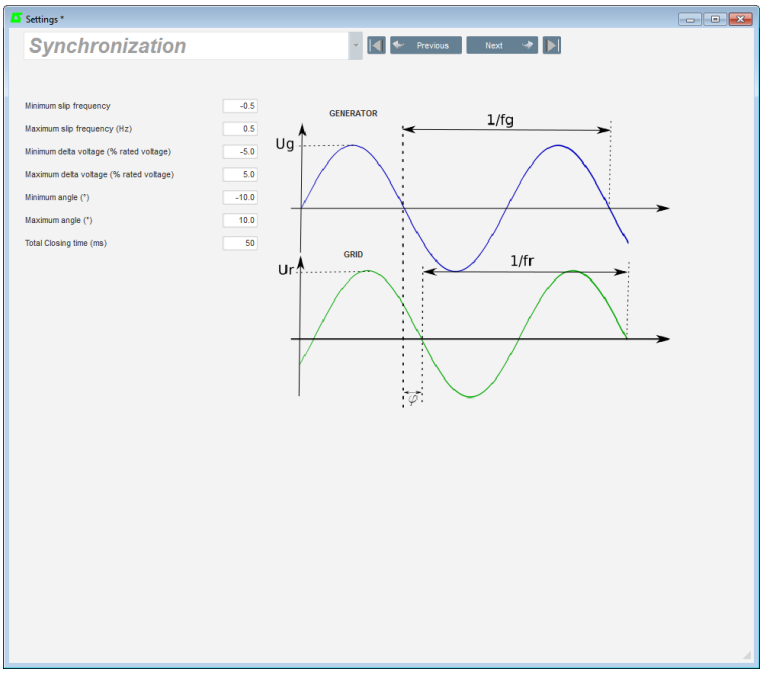
- **Ethernet configuration:** this page is used to define the D700 Ethernet parameters, manage e-mails from the D700 and configure the server and SMTP account.



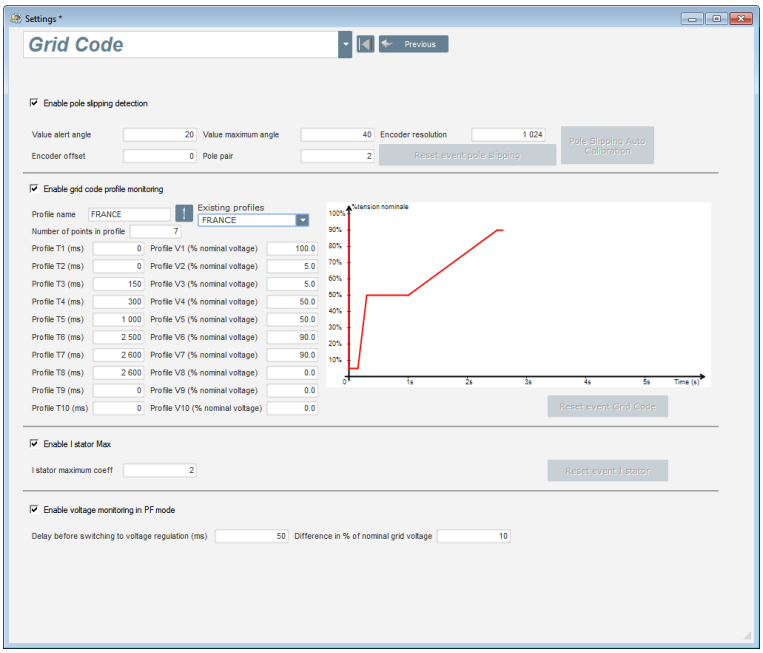
- **RTC configuration:** this page is used to set the D700 time based on the PC date and time.



- **Synchronization**: this page is used to define the parameters for synchronization between the alternator and the grid.

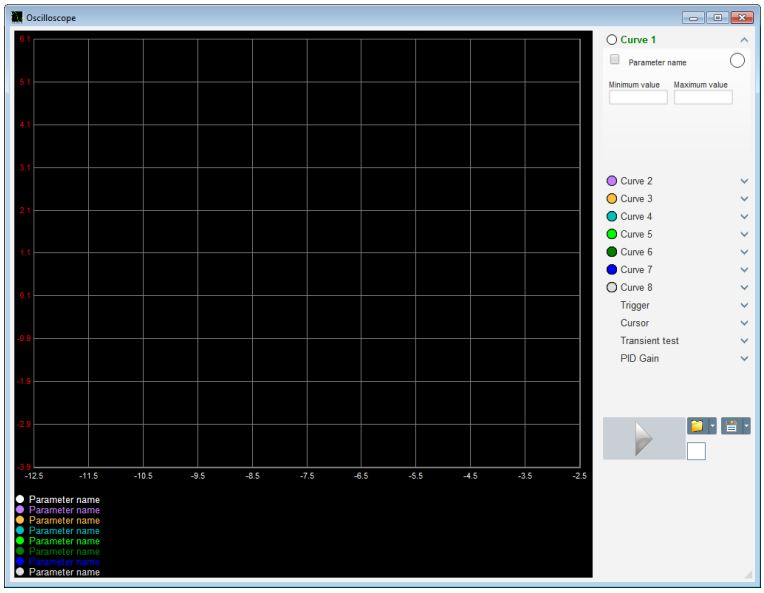


- **Grid code**: this page is used to define the parameters dedicated to grid code protections



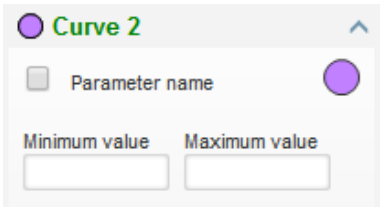
4.3.6. "Oscilloscope" window

This window is used to trace the values of up to 8 parameters simultaneously.

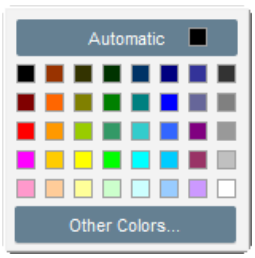


4.3.6.1. Curves

Each curve is described by: its color, its source parameter, its minimum and maximum values. It has its own axis, which is the same color as the curve.

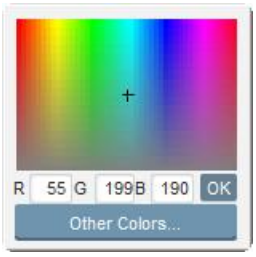


- **To change the color**:
  - Click on the colored disk to the right of the curve name, and a predefined palette will open.



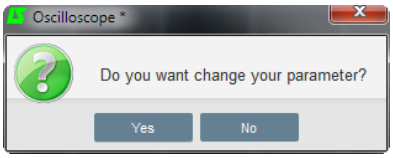
  - Click on the new curve color from those available.
  - The color selection window is then automatically closed, and the disk then takes on its selected color.

- Should you wish to configure a color not in the palette, click on the “Other colors…” button. The palette is then transformed. Move the black cross to the selected color or fill in the text boxes (each value between 0 and 255) to define the RGB color values. Then click “OK”.

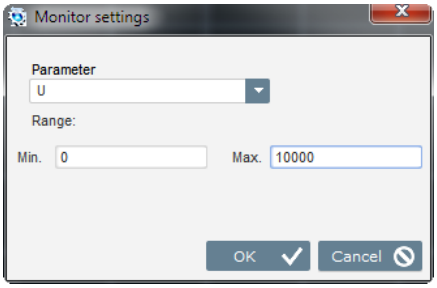


NB: When you no longer wish to change the color, just click outside the palette. It will close automatically.

- **Select a parameter to plot**
  - Click on the tick box
    - If the box was already selected, a confirmation message appears. On clicking “Yes”, a window opens with the list of parameters.



    - If the box was not already selected, the window with the list of parameters opens directly.
  - Select the parameter you wish to track from the drop-down list. This parameter can be an analog or digital value (regulation mode for example).
  - Click “OK” to use the selected parameter, or “Cancel” if you don't wish to change anything.

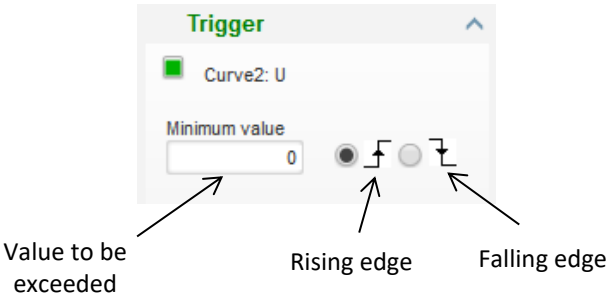


- **Refine the plotting range:** change the minimum and maximum values if necessary. These values are taken into account and the trace is re-scaled as soon as one of the boxes is exited or the keypad “Enter” key is pressed.

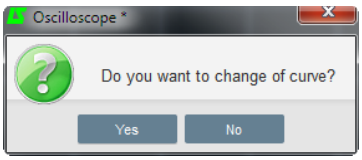
When the monitor is on, the current value appears in square brackets.

4.3.6.2. Trigger

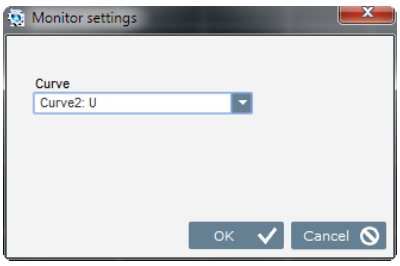
The trigger is used to launch oscilloscope operation once the chosen parameter value exceeds the value entered either upwards (arrow facing up) or downwards (arrow facing down).



- **Select whichever of the curves caused the trip**
  - Click on the tick box
    - If the box was already selected, a confirmation message appears. On clicking “Yes”, a window opens with the list of parameters.



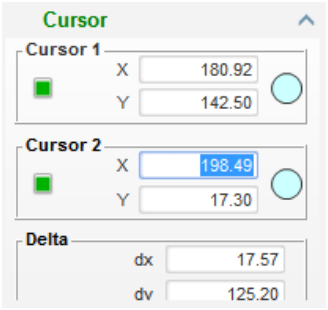
    - If the box was not already selected, the window with the list of parameters opens directly.
  - Select the parameter you wish to track from the drop-down list. This parameter can be an analog or digital value (regulation mode for example).
  - Click “OK” to use the selected parameter, or “Cancel” if you don't wish to change anything.



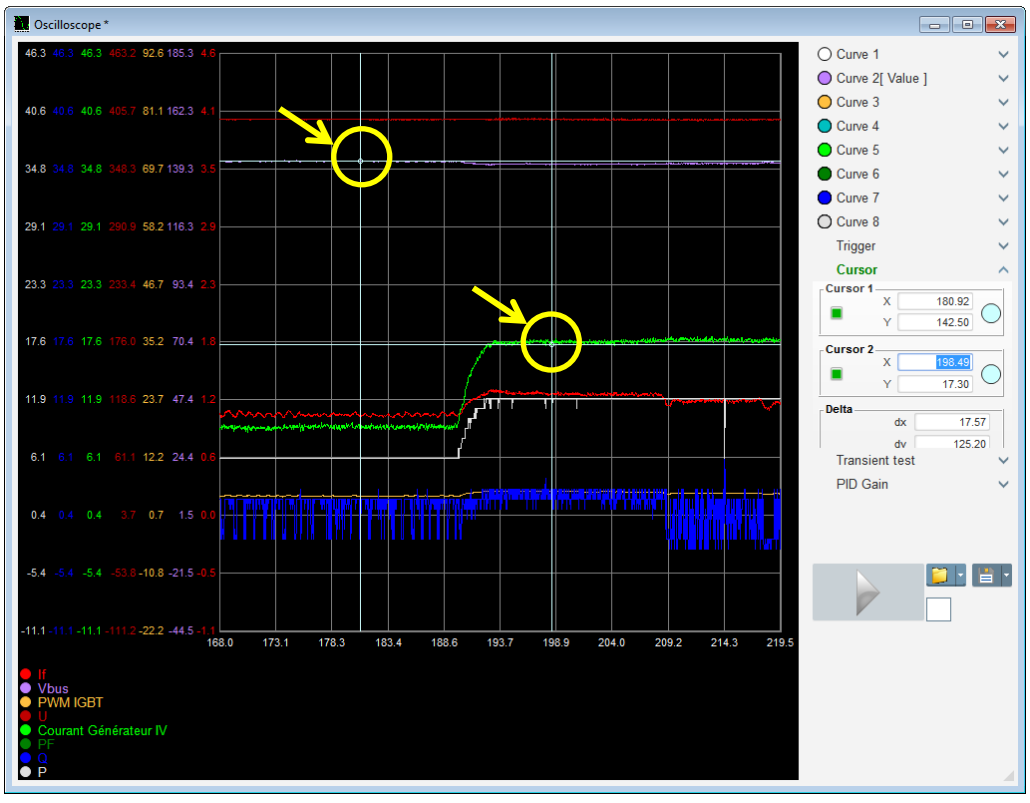
- **Enter the threshold value** to be exceeded
- **Choose the overshoot direction** (up or down)
- **To launch the trigger, click “GO”**
- **To cancel the trigger, deselect the curve**

4.3.6.3. Cursors

Two cursors are available for browsing the curves. The difference between the two values of X (time in seconds) and Y (curve value) is displayed in the “Delta” part.



The 2 cursors can be moved from one curve to the other by clicking on the cursor dot and dragging it to the desired curve. In the example below, cursor 1 is on the bottom curve and cursor 2 is on the top curve.



4.3.6.4. Transient test

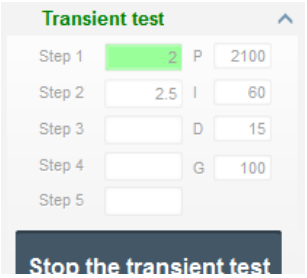
The transient test is used to check the PID response when changing the voltage reference.
It is divided into 5 steps maximum, each of which can take a different reference value.
The PID parameters can be changed directly when the command is sent.

- Click on the “Start a transient test” button. The following window opens:

- To configure your transient test:
  - Select between 1 and 5 steps by clicking on the corresponding tick box
  - For each selected step, define the reference value
  - Define the time between each step
- The PID values can be changed in order to adjust the gains.

Once the parameters have been set, click “OK”.

The test then starts. Steps in progress are shown by the reference turning green.



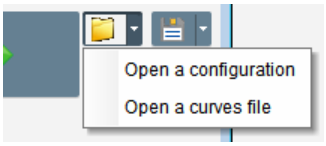
NOTE:

- **This test can be stopped at any time by clicking on the “Stop the transient test” button. The display then reverts to the original reference.**
- **Transient tests cannot be performed if the control reference input is controlled by an analog input, as this has priority.**
- **During this transient test, the defined minimum and maximum upper and lower limits are not exceeded.**

4.3.6.5. Open a curve or an oscilloscope display configuration

The “Open” button (yellow folder) at the bottom right of the oscilloscope window can be used to open an oscilloscope display configuration file (curves, minimum and maximum values, etc.).

By clicking on this folder's right-hand arrow, you can choose to also open a file saved in “.csv” format. Caution, only files generated by the software can be opened.



When a curve in “.csv” format is opened, the curve configuration in progress is replaced by the saved curve configuration.

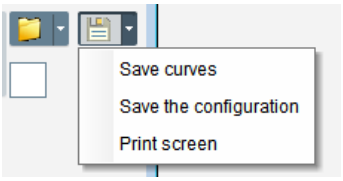
There are two ways to zoom in:

- Click in the oscilloscope plotting area
- Use the mouse wheel: both the X and Y axes are then modified
- Press the “X” button on your keypad and scroll the mouse wheel: only the X axis is modified, the scales on the Y axis remain the same
- Press the “Y” button on your keypad and scroll the mouse wheel: only the Y axis is modified, the scales on the X axis remain the same

4.3.6.6. Save a curve or an oscilloscope display configuration

The “Save” button (disk icon) at the bottom right of the oscilloscope window can be used to save an oscilloscope display configuration file (curves, minimum and maximum values, etc.).

By clicking on this folder's right-hand arrow, you can choose to also save the oscilloscope curves as a “.csv” file.



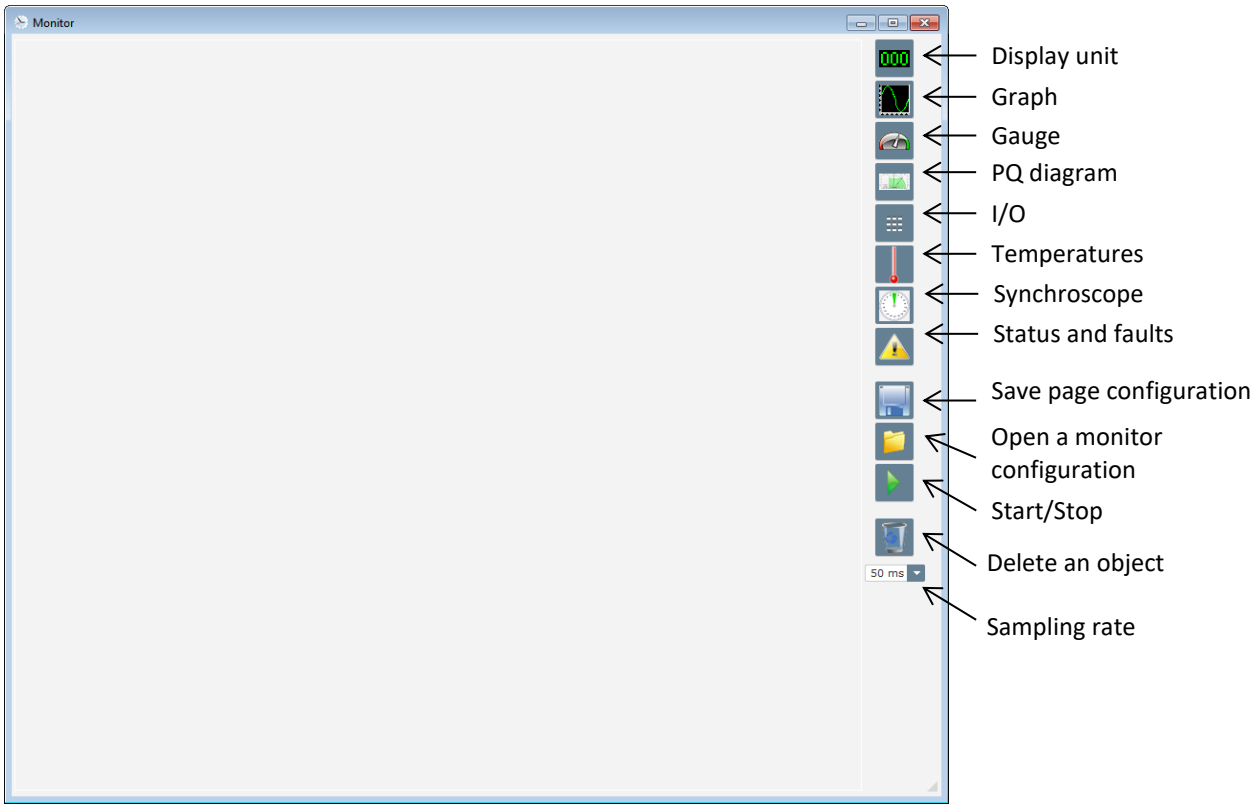
4.3.6.7. Change the plotting area background

The oscilloscope background color can be changed to black by clicking on the white square.

4.3.7. "Monitor" window

This window is used to configure the parameter display in different forms (gauges, graphs, display units), as well as certain AVR-specific components: PQ diagram, I/O, temperatures.

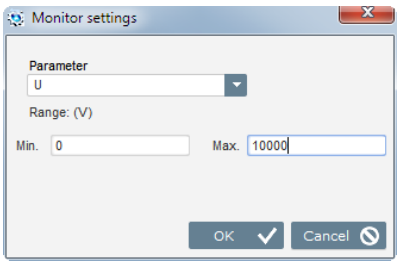
It is fully configurable and the various objects can be added, moved, modified and/or deleted.



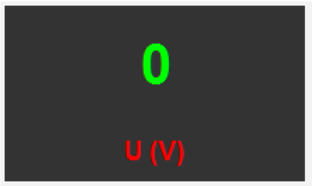
4.3.7.1. Display units

To add a new display unit:

- Click on the "Display" button, a window opens.
- Select the parameter you wish to track from the drop-down list. This parameter can be an analog or digital value (regulation mode for example).



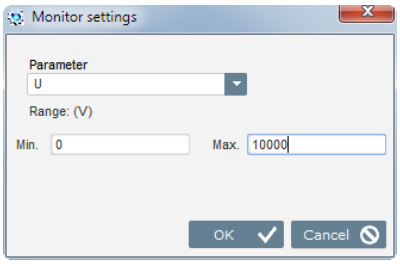
- Click "OK" to use the selected parameter, or "Cancel" if you don't wish to change anything.
- The display unit is then inserted in the monitor in the first free slot (from left to right and then from top to bottom).



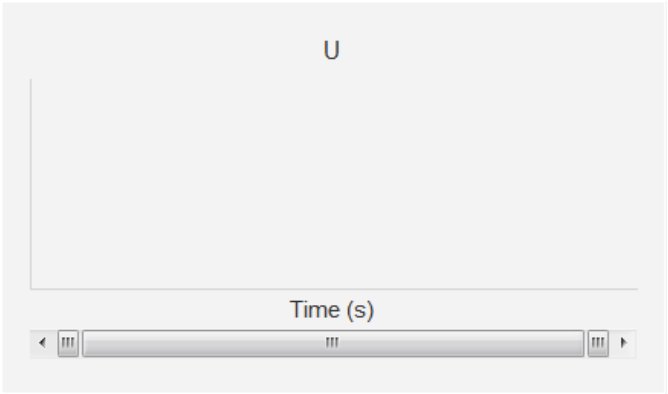
4.3.7.2. Graph

To add a new graph:

- Click on the “Graph” button, a window opens.
- Select the parameter you wish to track from the drop-down list. This parameter can be an analog or digital value (regulation mode for example).



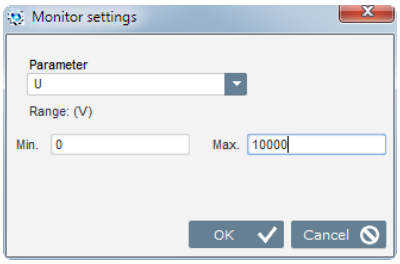
- Click “OK” to use the selected parameter, or “Cancel” if you don't wish to change anything.
- The graph is then inserted in the monitor in the first free slot (from left to right and then from top to bottom).



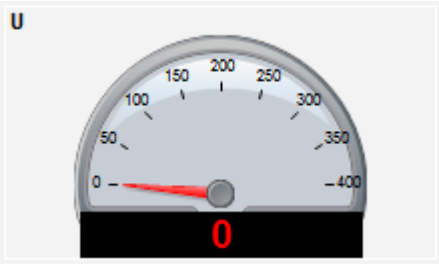
4.3.7.3. Gauges

To add a new gauge:

- Click on the “Gauge” button, a window opens.
- Select the parameter you wish to track from the drop-down list. This parameter can be an analog or digital value (regulation mode for example).

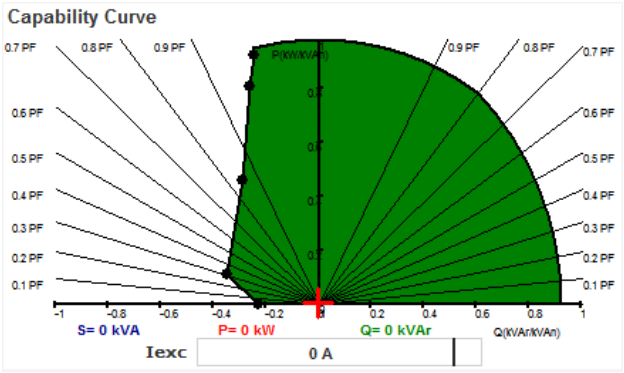


- Click “OK” to use the selected parameter, or “Cancel” if you don't wish to change anything.
- The gauge is then inserted in the monitor in the first free slot (from left to right and then from top to bottom).



4.3.7.4. Capability curve

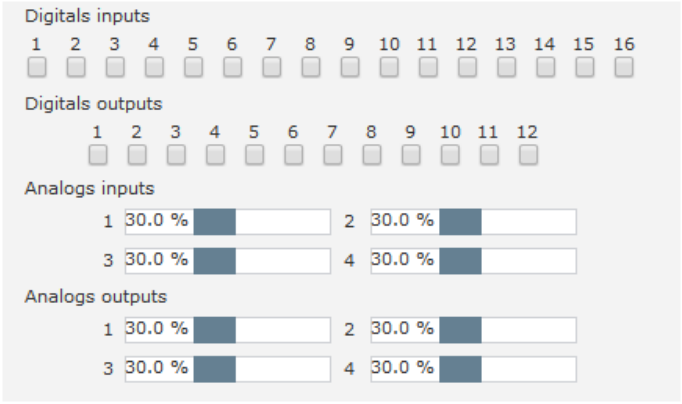
To add a capability curve, click on the corresponding button. The curve is then inserted in the monitor in the first free slot (from left to right and then from top to bottom).



NB: Only one PQ diagram can be displayed

4.3.7.5. I/O

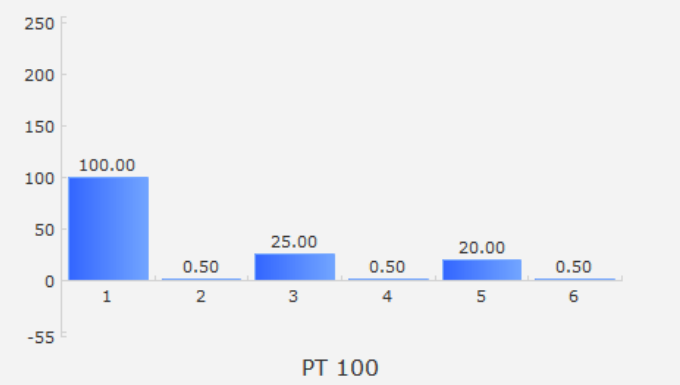
To add the I/O module, click on the corresponding button. The module is then inserted in the monitor in the first free slot (from left to right and then from top to bottom).



NB: Only one I/O module can be displayed

4.3.7.6. Temperatures

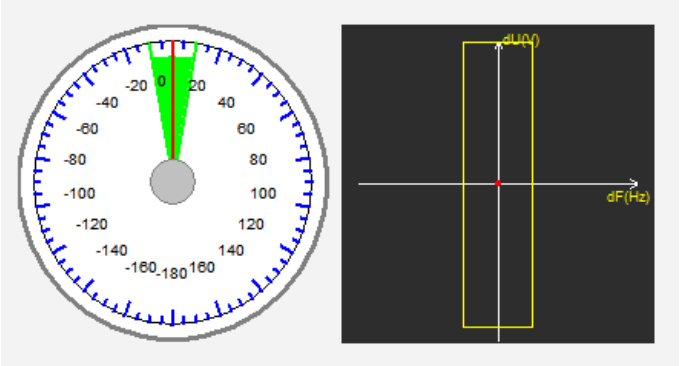
To add the temperature module, click on the corresponding button. The module is then inserted in the monitor in the first free slot (from left to right and then from top to bottom).



NB: Only one temperature module can be displayed

4.3.7.7. Synchronization

To add the synchronization module, click on the corresponding button. The module is then inserted in the monitor in the first free slot (from left to right and then from top to bottom).

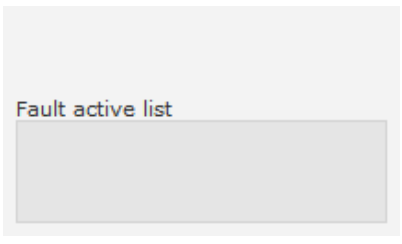


In the left-hand section, the gauge indicates the angle difference between the grid voltages and the alternator voltage. In the right-hand section, the graph indicates with a red dot whether the difference in frequency and voltage between the alternator and the grid voltage is in the configured range.

NB: Only one synchronization module can be displayed

4.3.7.8. AVR status and faults

To add the AVR status and fault module, click on the corresponding button. The module is inserted in the monitor in the first free slot (from left to right and then from top to bottom).

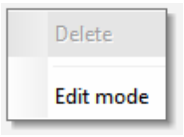


This module contains the D700 operating information, the regulation mode in progress, as well as the list of active faults.

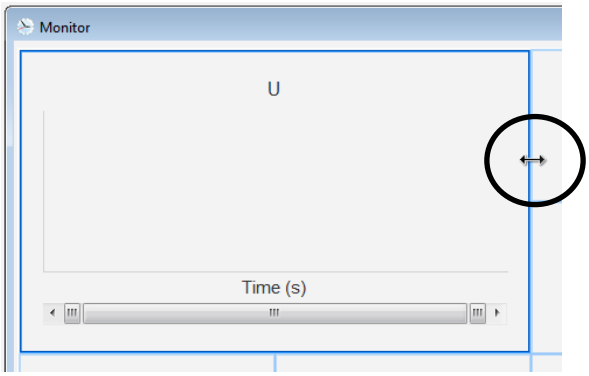
4.3.7.9. Change the size of an object

It is possible to change the size of graphs, gauges and the PQ diagram.

- Switch to Edit mode by right-clicking in the monitor area
- Click on “Edit mode”



- Go to the middle of one side or corner of the diagram: the cursor becomes a double arrow



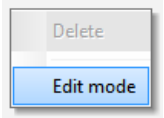
- Click, hold and drag until it is the desired size.

Exit “Edit mode” either by pressing the “Esc” key or by right-clicking in the monitor area and deselecting “Edit mode”.

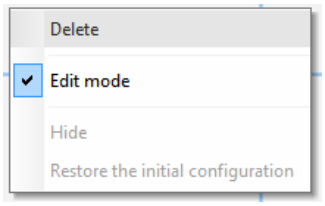
4.3.7.10. Delete an object

To delete an object (display unit, graph, gauge, etc.):

- Switch to Edit mode by right-clicking in the monitor area
- Click on “Edit mode”



- A grid then appears indicating the position of the various objects
- Right-click on the display unit you wish to delete
- Click “Delete”



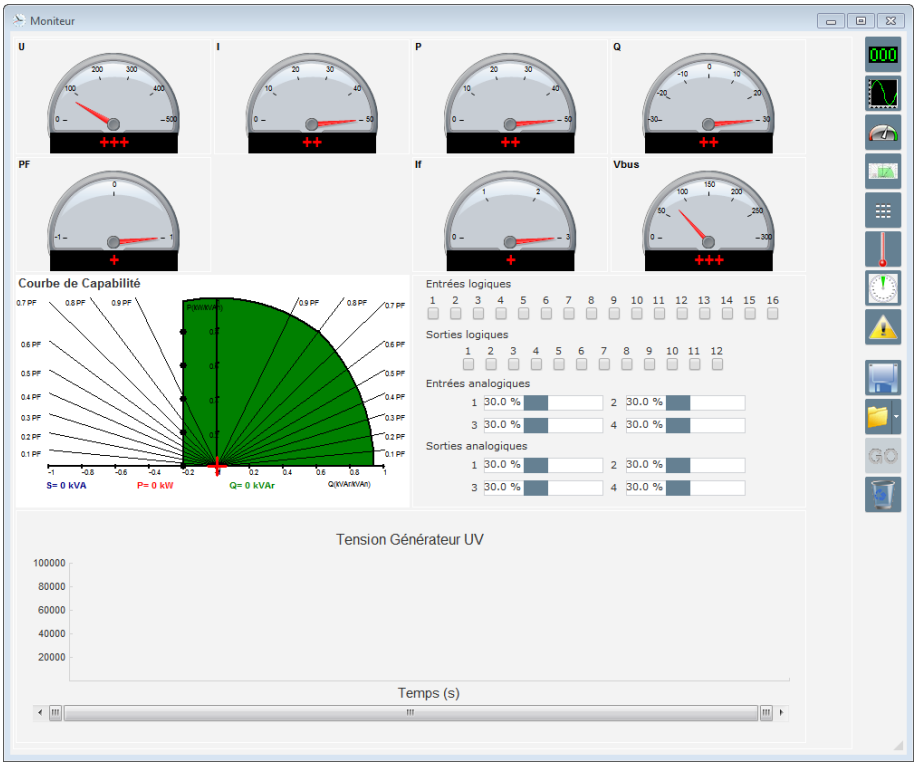
Exit “Edit mode” either by pressing the “Esc” key or by right-clicking in the monitor area and deselecting “Edit mode”.

4.3.7.11. Save a monitor configuration

A monitor configuration can be saved in order to be reused later. Click on the “Save” button and a window will open. Give the name of the desired monitor configuration, and select “Save”.

4.3.7.12. Open a monitor configuration

Click on the “Open” button to retrieve a monitor configuration and a window will open. Select the desired monitor configuration, and select “Open”.

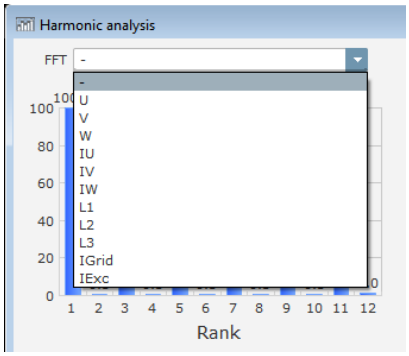


4.3.8. "Harmonic analysis" window

This window is used to display the harmonic levels from number 1 to number 12, found on the voltage and current measurements. 6 harmonic analyses can be conducted simultaneously.

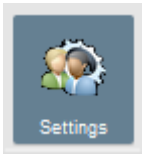
Select from the drop-down list the type of signal you wish to monitor:

- U, V, W: alternator voltages
- IU, IV, IW: alternator currents
- L1, L2, L3: grid voltages
- I Grid: grid current
- IExc : field current

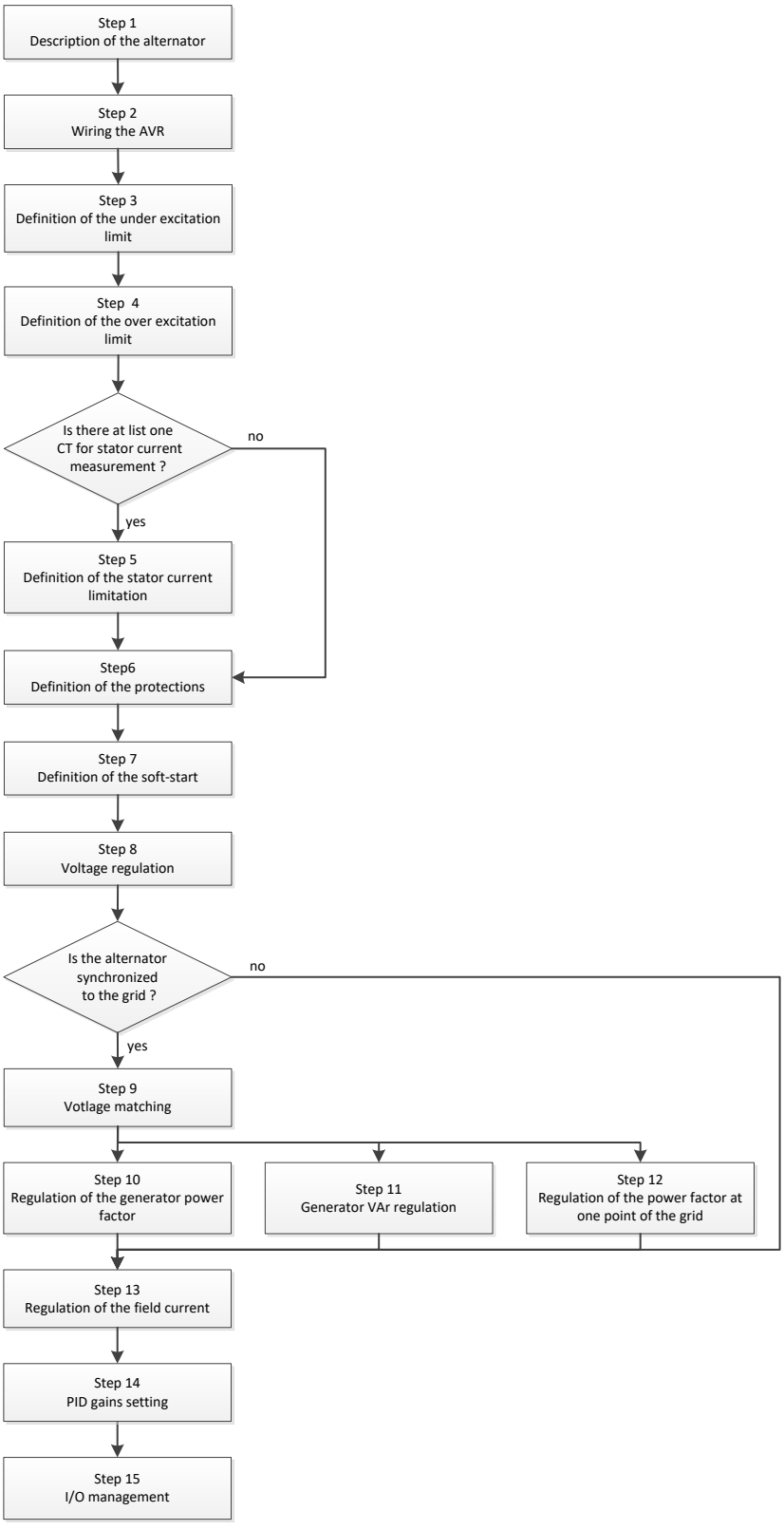


Once all the parameters have been chosen, click on the "GO" button to start reading.

4.3.9. Create a new configuration

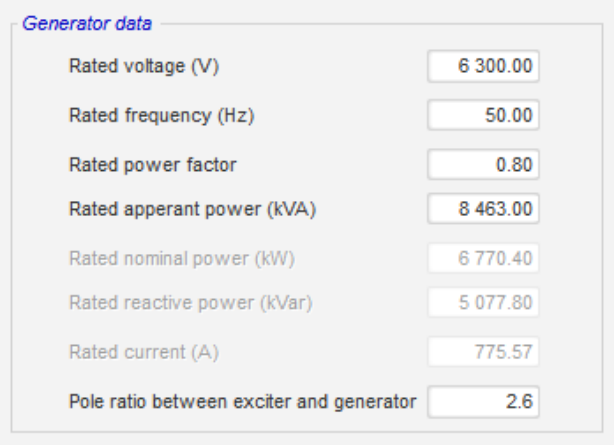


Click on the “Configuration” button, which opens the settings window.
The sequence of configuration steps is shown in the diagram below:

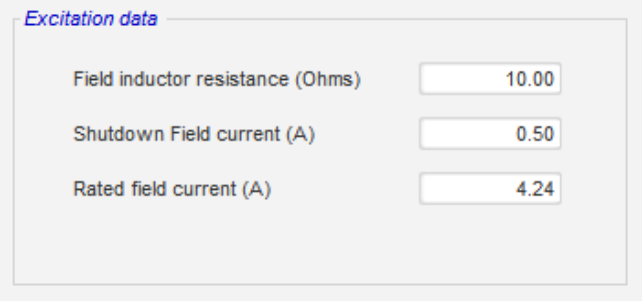


4.3.9.1. Step 1: Description of the alternator

- Describe all the alternator characteristics: voltage (in Volts), apparent power (in kVA), frequency (in Hz), and power factor.
- Fields: rated current, reactive power and active power are calculated automatically.
- Pole ratio for diode fault (exciter poles number divided by generator poles number)



- Describe all the field excitation characteristics: exciter field resistance (in ohms), shutdown field current (in Amps), and rated field current (in Amps).



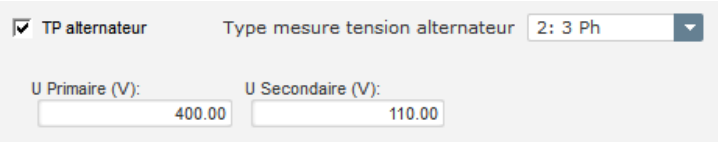
- Click on the “Next” button.

4.3.9.2. Step 2: AVR wiring

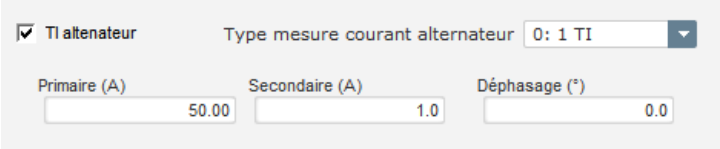
This wiring must be typical of the connections between the AVR and the alternator (see section 2.3. “*Connections*”). As your configuration develops, the wiring diagram in the right of the window changes: representation of VT and/or CT, number of conductors, etc.

NOTE: By default, the alternator voltage measurement and the grid code voltage measurement are shown.

- **Alternator voltage measurement VTs**:
  - If these are present, select the box. The various parameters can then be set.
  - State the primary and secondary winding voltages (in Volts).
  - State the type of measurement: phase-neutral, phase-phase, 3 phases or 3 phases and neutral.

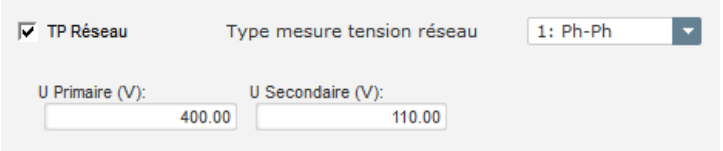


- **Alternator current measurement CTs**:
  - If these are present, select the box. The various parameters can then be set.
  - State the primary and secondary winding current (in Amps).
  - State the number of CTs present: 1 or 3.



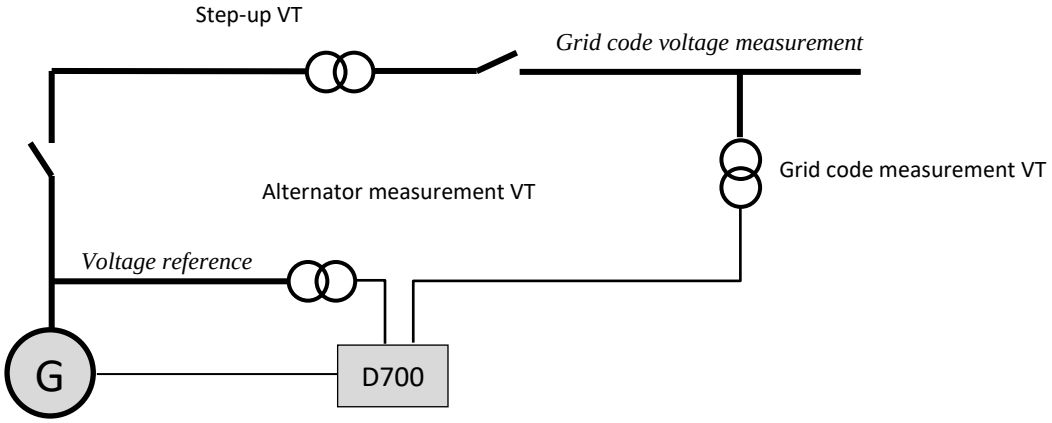
NOTE:
- **The phase shift value should be set during tests and commissioning. It is used to compensate for the phase difference caused by the CTs and VTs.**
- **If an isolation CT is present, the secondary parameter value should correspond to the isolation CT secondary.**

- **Grid code voltage measurement VTs:**
  - If these are present, select the box. The various parameters can then be set.
  - State the primary and secondary winding voltages (in Volts).
  - State the type of measurement: phase-neutral, phase-phase, 3 phases or 3 phases and neutral.



- **Grid code current measurement CT:**
  - If this is present, select the box. The various parameters can then be set.
  - State the primary and secondary winding current (in Amps).

- **Step-up VT:**
  - This VT corresponds to a power transformer which can be found between the alternator and the grid. It makes it easier to calculate the voltage when matching the grid voltage, especially if the ratios between the primary and secondary on the various measurement VTs are not identical.
  - The “primary” corresponds to the machine (on the production side) and the secondary on the grid side.



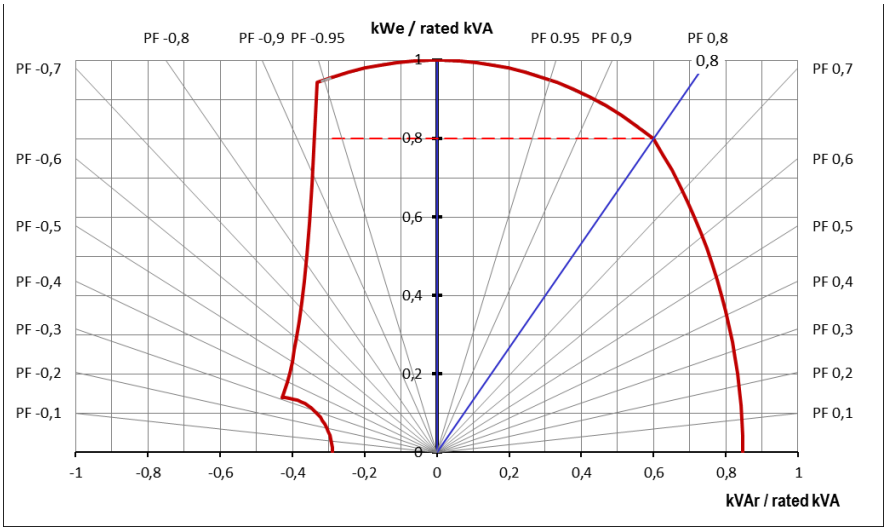
  - Hence when matching the grid voltage, the voltage reference given to the AVR is calculated using the formula below:

$$Voltage\ reference = Grid\ code\ voltage\ measurement \times \frac{Step-up\ VT\ primary}{Step-up\ VT\ secondary}$$

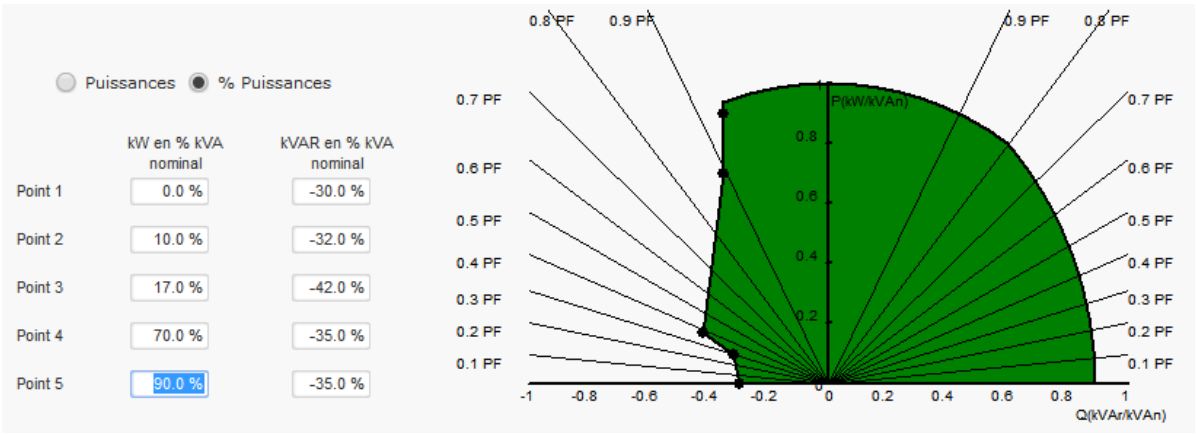
  - If this is present, select the box. The various parameters can then be set.
  - Indicate the primary and secondary winding voltages (in Volts)

4.3.9.3. Step 3: Definition of the under excitation limit

- This limit corresponds to the absorption limit defined in the capability curve. It is divided using 5 points which define the areas. We recommend using kVAr values slightly higher than the curve point so that the alternator can operate in complete safety. These points can be defined as an actual value (kVAr and kW) or as a percentage of kVA. Example of a capability curve:



By choosing the points carefully, the software representation gives a similar diagram:

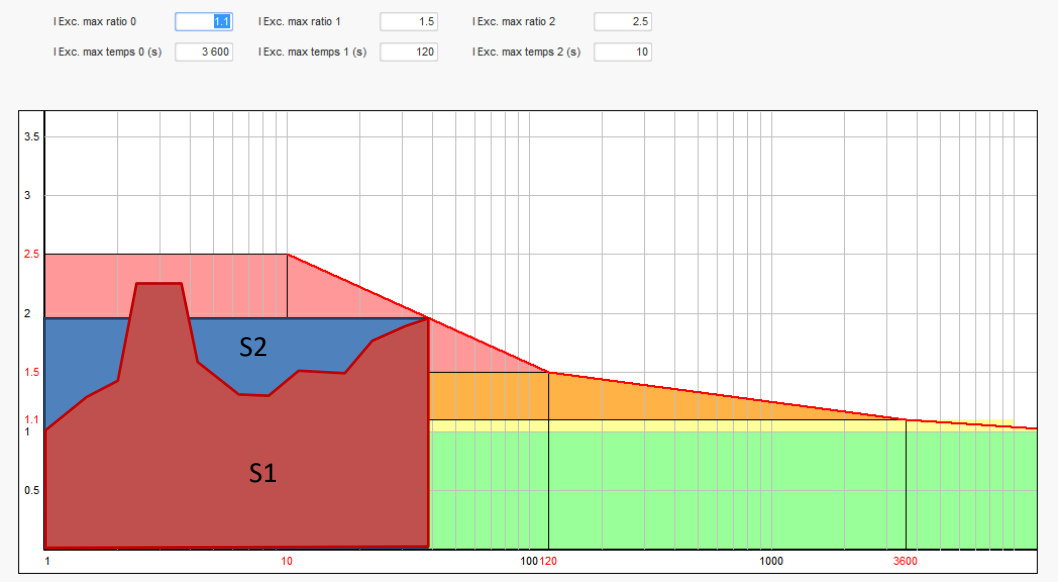


- This limit is active as soon as the operating point reaches this limit. The field current is then controlled so that the alternator stays in the domain defined by the capability curve.

4.3.9.4. Step 4: Definition of the over excitation limit

- This limit is divided into 3 different parts using 3 points which define the areas. These points are determined according to the machine capability. The common adjustment values are:
  - Twice the rated field current for 10 seconds for the stator short-circuit
  - 1.5 times the rated field current for 10 seconds for 120 seconds
  - 1.1 times the rated field current for 10 seconds for 3600 seconds

- As soon as the field current exceeds the value of the rated current, a counter is triggered. The S1 “field current measurement x time” area (shown in red below) is then compared with the “maximum field current x time” area (shown in blue below). If S1 equals S2, the limit is active and the D700 limits the field current to 99% of the rated current (which in this case results in the regulation mode in progress reference not being tracked).



- If the limit is active, in order to protect the machine, it is only possible to have a current higher than 99% of the rated current after 24 hrs.

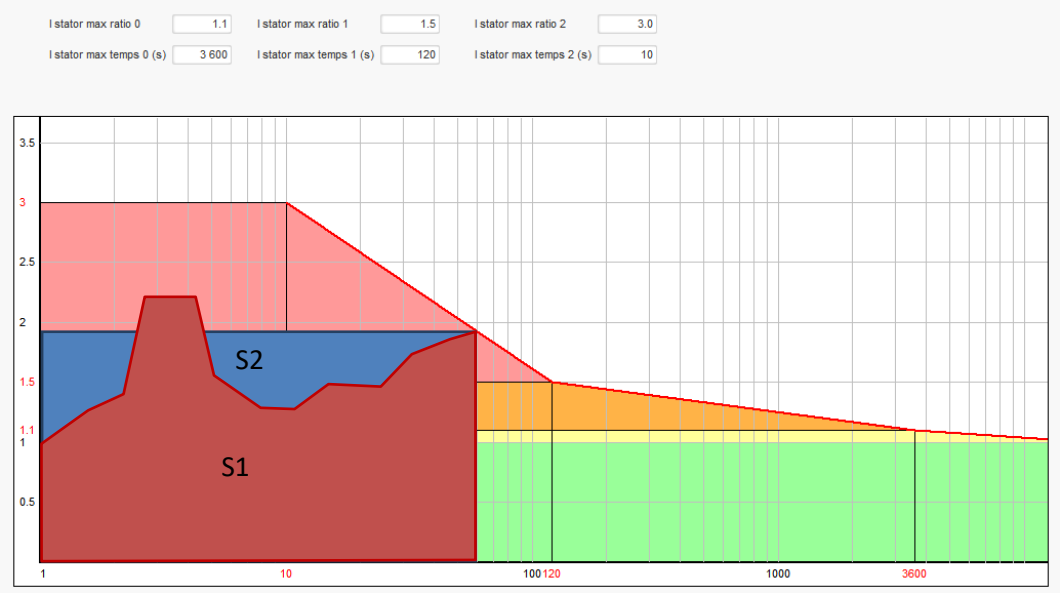
4.3.9.5. Step 5: Definition of the stator current limit

- In principle this limit is identical to the field current maximum limit.

- It can only be enabled in voltage regulation mode.

- It is divided into 3 different parts using 3 points which define the areas. These points are determined according to the machine capability. The common adjustment values are:
  - Three times the rated stator current for 10 seconds for the stator short-circuit
  - 1.5 times the rated stator current for 120 seconds
  - 1.1 times the rated stator current for 3600 seconds

- As soon as the stator current exceeds the value of the rated current, a counter is triggered. The S1 “stator current measurement x time” area (shown in red below) is then compared with the “maximum stator current x time” area (shown in blue below). If S1 equals S2, the limit is active and the D700 limits the stator current to 99% of the rated current (which in this case results in the voltage reference not being tracked).



4.3.9.6. Step 6: Definition of the protection devices

There are 3 types of protection devices:

- Generator faults
- Regulator faults
- The alarm and trip thresholds for each temperature sensor

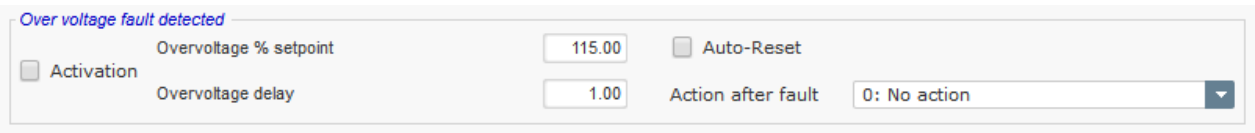
All protections have the same architecture

- An activation of the protection
- A threshold
- A delay
- An action to realize (or not) when the delay is over. This action is chosen in a list:
  - No action : the regulation will continue
  - Regulation stopped: the excitation is then stopped
  - Regulation in field current mode at shutdown value
  - Regulation in field current mode at the field current value before fault: no bump in the regulation.

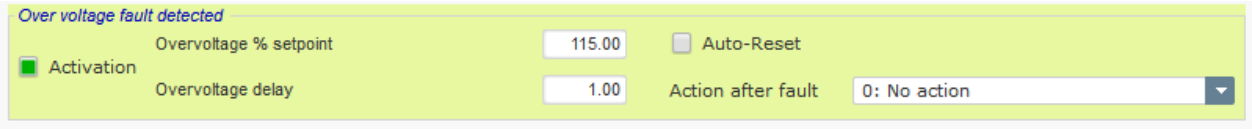
Each protection has an auto-reset option:

- If this option is selected: if fault disappears, regulation will return to the automatic mode (voltage mode, or PF mode… etc.)
- If this option is not selected, action chosen is maintained

Below is an example for overvoltage



On activation of this fault, background becomes light green



- **Under voltage and overvoltage:** These protections can be enabled by ticking the checkboxes "Activation" and defining a threshold (in percentage of the rated voltage) and a delay before the activation of the protection. In the case below:
  - Under voltage fault is activated if the generator voltage is less than 85% of the rated voltage for at least 1 second. This fault is active only if the regulation is enabled and the soft start ramp achieved.
  - Overvoltage fault is active if the generator voltage is higher than 115% of the rated voltage and for at least 1 second.

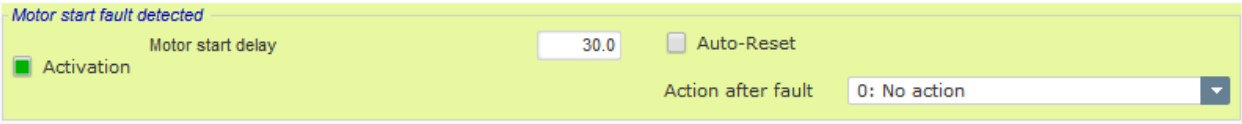
- **Under frequency and over frequency:** These protections can be enabled by ticking the checkboxes "Activation" and defining a frequency value and a delay before the activation of the protection. In the case below:
  - Under frequency fault is activated if the generator frequency is less than 45Hz for at least 5 seconds. This fault is active only if the regulation is enabled.
  - Over frequency fault is active if the generator frequency is higher than 55Hz for at least 5 seconds.

- **Diode fault:** These protections can be enabled by ticking the checkboxes "Activation" and defining a percentage of harmonics of the field current and a delay before the activation of the protection.
  - If the pole ratio (number of exciter poles divided by the number of poles of the generator) is known, the percentage of harmonics supervised by the AVR is the sum of the two harmonics closer of the ratio. For example, for an exciter of 16 poles, and a generator of 6 poles, pole ratio is 2.66, so the percentage of harmonics 2 and 3 are summed.
  - If the pole ratio is unknown, percentage of harmonics supervised by the AVR is the sum of all of the harmonics.

In the case below:

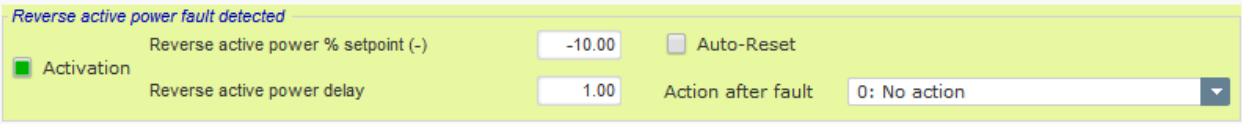
- Open diode fault is activated if the percentage of the field current harmonics is higher than 5% for at least 1 second. This fault is active only if the regulation is enabled.
- Diode shorted fault is active if the percentage of the field current harmonics is higher than 10% for at least 5 seconds.

- **Start motor fault:** See chapter "*4.3.9.8. Step 8: Voltage regulation*" for the principle. This protection can be enabled by ticking the checkbox "Activation" and defining a delay. In the case below, fault is activated if the generator voltage is less than the voltage setpoint when the 30 second delay is complete.



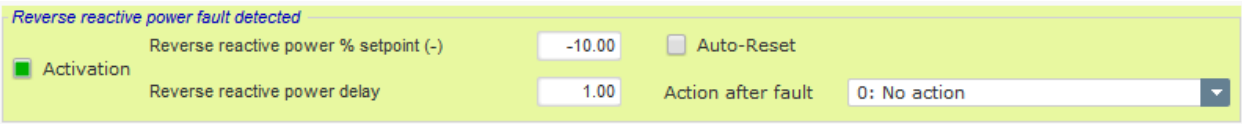
- **Active power reversal**: this protection device can be enabled by ticking the checkbox "Activation" and defining an active power threshold (as a percentage of the rated active power), as well as a delay before activation of the protection device.

  NOTE: In this case, the power is negative, in other words the alternator is then in “motor” mode.

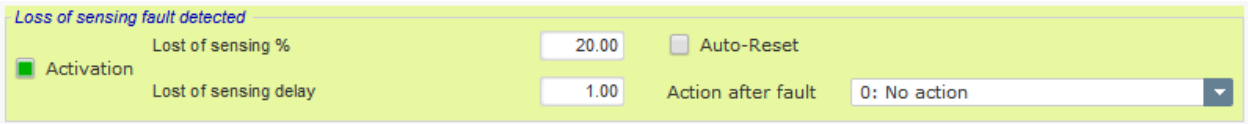


- **Reactive power reversal**: this protection device can be enabled by ticking the checkbox "Activation" and defining a reactive power threshold (as a percentage of the rated reactive power), as well as a delay before activation of the protection device.

  NOTE: In this case, the reactive power is negative.



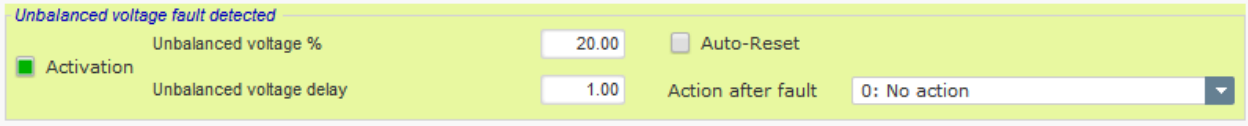
- **Loss of sensing**: this protection can be enabled by ticking the checkbox "Activation" and defining a voltage threshold in percentage of the generator voltage setpoint, as well as a delay before activation of the protection device. In the case below, the trip is active if the generator voltage is less than 20% of the voltage setpoint after 1 second.



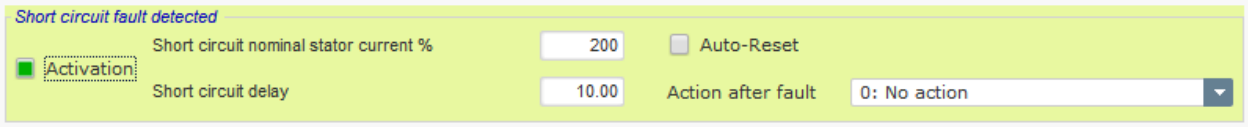
- **Unbalance voltage**: this protection can be enabled by ticking the checkbox "Activation" and defining a percentage of voltage unbalance as well as a delay before activation of the protection device. Calculation of the voltage unbalance is according to the NEMA standard:

$$Unbalance\ percentage\ = \frac{Maximum\ generator\ voltage}{Average\ of\ generator\ voltage} \times 100$$

In the case below, this fault is activated if the percentage of unbalance is at least 20% after 1 second



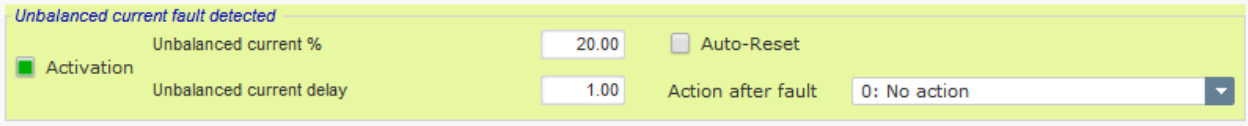
- **Short-circuit**: this protection can be enabled by ticking the checkbox "Activation" and defining a minimum stator current threshold in percentage of the generator rated current, as well as a delay before activation of the protection device. In the case below, the trip is active if the generator current measurement is higher than 200% of the rated stator current after 10 seconds.



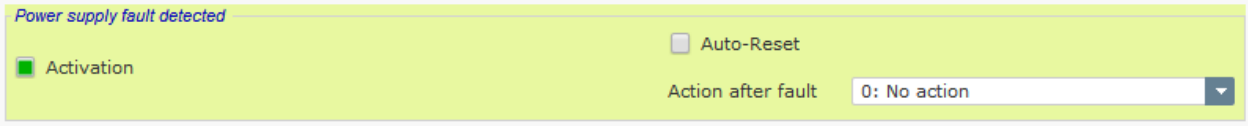
- **Unbalance current**: this protection can be enabled by ticking the checkbox "Activation" and defining a percentage of current unbalance as well as a delay before activation of the protection device. Calculation of the current unbalance is realized with the same formula as the unbalance voltage:

$$Unbalance\ percentage\ = \frac{Maximum\ generator\ current}{Average\ of\ generator\ current} \times 100$$

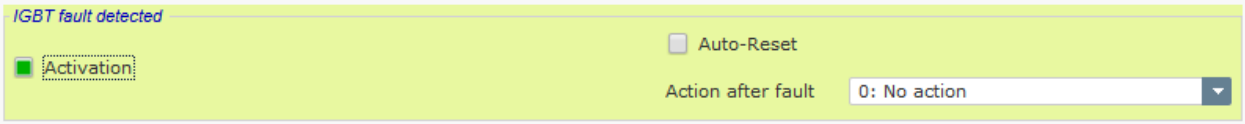
In the case below, this fault is activated if the percentage of unbalance is at least 20% after 1 second



- **Power supply fault**: this protection can be enabled by ticking the checkbox "Activation". It's the result of a control of internal supplies of the D700. In the case below, the trip is active if one of the internal supplies is missing

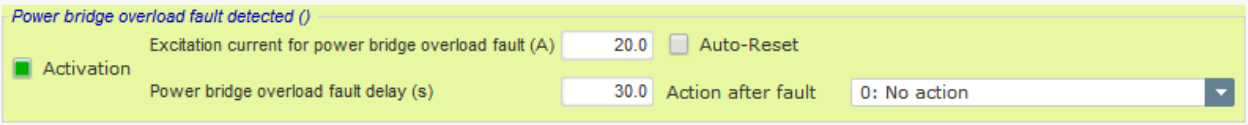


- **IGBT fault**: this protection can be enabled by ticking the checkbox "Activation". The trip is activated if a coordination fault between the command and the action of the power transistors is detected. On trip if no action is set, the AVR will continue to regulate the setpoint but with a degradation in the accuracy. It's necessary to change the D700 quickly.

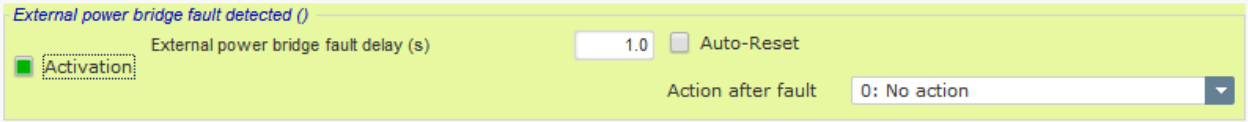


- Click on "Next" button

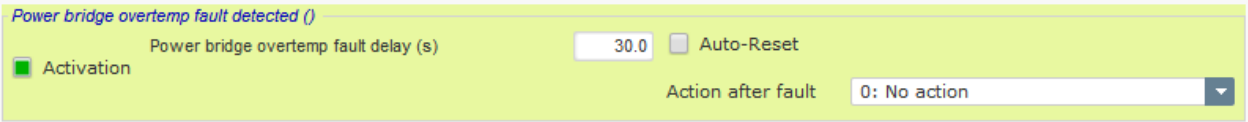
- **Power bridge overload detected**: this protection can be enabled by ticking the checkbox "Activation" and defining a percentage of current unbalance as well as a delay before activation of the protection device. In the case below, the trip is active if the field current is higher than 20A after 30 seconds.



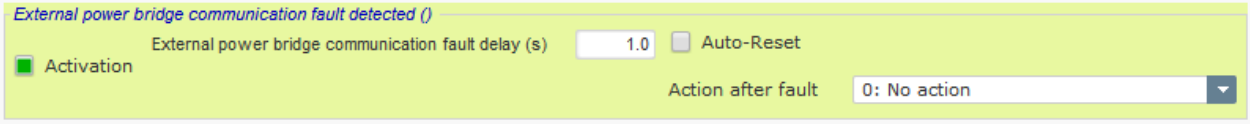
- **External power bridge fault detected:** this protection can be enabled by ticking the checkbox "Activation" and defining a delay. In the case below, fault is activated after 1 second.



- **Power Bridge over temperature fault detected:** this protection can be enabled by ticking the checkbox "Activation" and defining a delay. In the case below, fault is activated after 30 seconds.

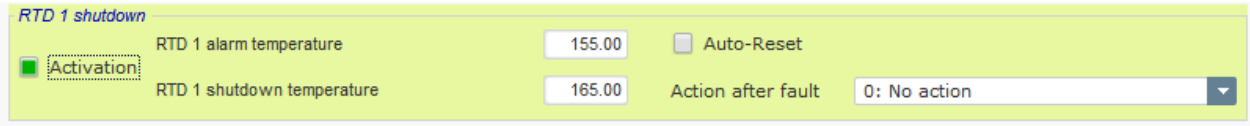


- **External power bridge communication fault detected:** this protection can be enabled by ticking the checkbox "Activation" and defining a delay. This fault is used only if MENTOR® external power bridge is used. In the case below, fault is activated after 1 second.

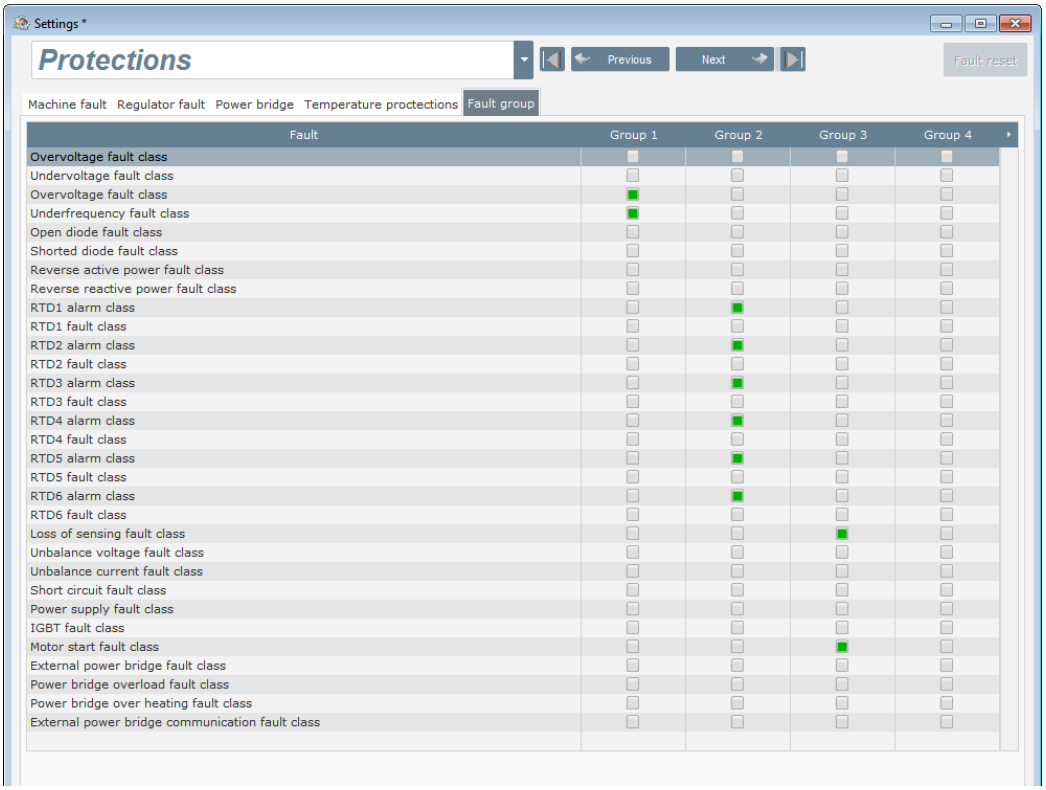


- Click on "Next" button

- **Temperature protection**: these protections can be enabled by ticking the checkbox "Activation" and defining the trip and alarm temperature thresholds. The screenshot below demonstrates RTD 1 only (identical for RTD 2 to 6).



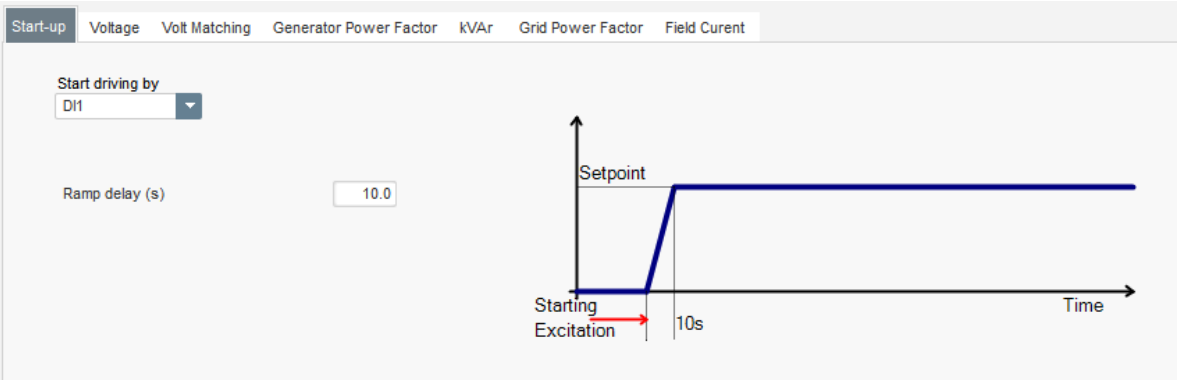
On the last protections page, fault groups can be defined: all protections can be grouped to activate one or several signals (digital output for example), to do a synthesis of several faults. If one of these faults is activated, the entire group is activated. This information can be a destination for one output or can be used in logical functions. For example below, group1 correspond to diode faults, group 2 to temperature faults, group 3 to internal faults.



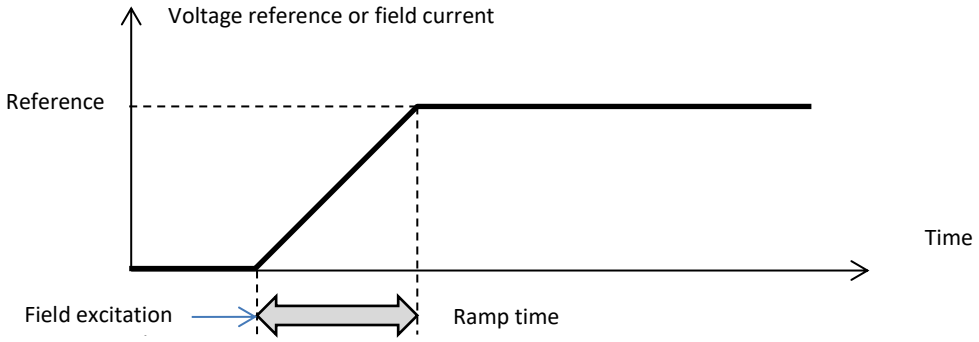
- Click on "Next" button

4.3.9.7. Step 7: Setting the ramp

- The ramp time corresponds to the time taken to reach the machine's voltage reference (or field current reference). If starting needs to be instantaneous, put “0” in the ramp time.



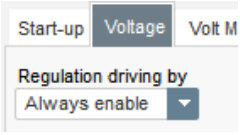
- Select the field excitation starting mode from the drop-down list. This can be:
  - Controlled by a digital input (DI1 to DI16)
  - Always enabled by selecting “Always active”. In this case, the field excitation is always energized as soon as the product is powered up (for example: black-start application)
  - Not controlled directly, but the result of a logic gate for example



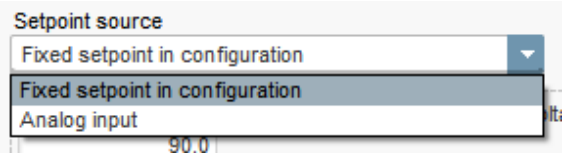
- Click on the “Next” button.

4.3.9.8. Step 8: Voltage regulation

- This regulation must always be active, so select “Always active” in the drop-down list.

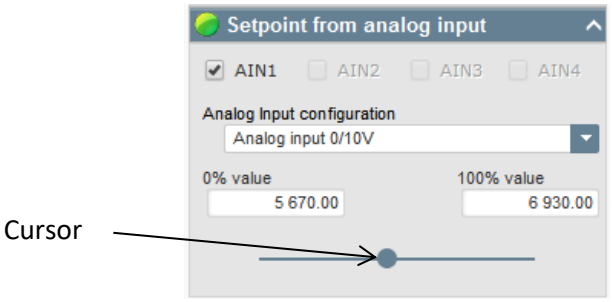


- **The home reference point** is determined by the drop-down list: via a fixed value in the configuration, or by an analog input with a range to be determined. If a fixed value, this value can be changed by the fieldbus.



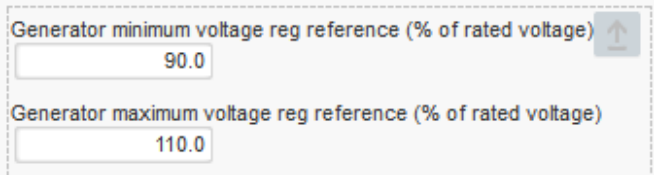
- **If the “Analog input” option is selected,** the “Reference via analog input” part is enabled further down. Select the desired analog input box, determine its mode (+/-10 V, 0/10 V, 4-20 mA, potentiometer) and the voltage values at 0% and 100%. [15]

[15] The voltage terminals can be swapped: the minimum voltage for 100% of the analog input, and the maximum voltage for 0% of the analog input.

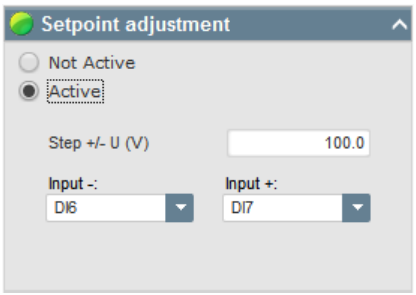


NOTE: By moving the cursor, it is possible to view the values obtained on the voltage and under frequency curves displayed on the right.

- **The limits of this reference** should be fixed, depending on the machine capability (in the example below, the minimum voltage reference is 90% of 400 V (i.e. 360 V), and the maximum voltage reference is 110% of 400 V, (i.e. 440 V).

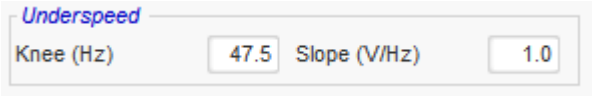


- **With a fixed reference, the reference can be adjusted** by two up and down inputs, one pulse corresponding to going up one “step” or down one “step”. Both the inputs and the value of the step need to be fixed, and this adjustment can be accessed by setting the selector to “Active”:

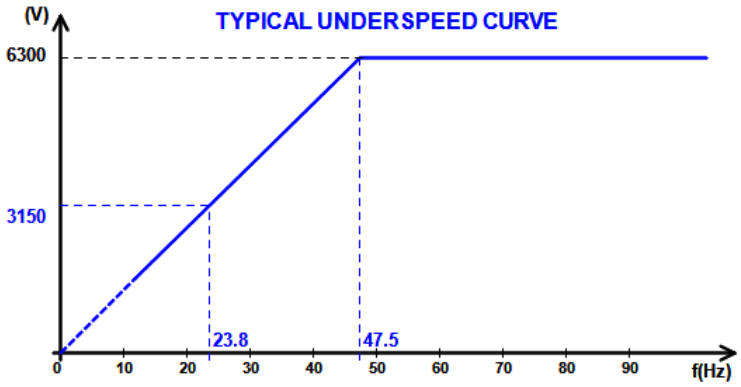


NOTE: The “faster” and “slower” inputs are the same for all regulation modes, but only affect the regulation modes in which they were enabled.

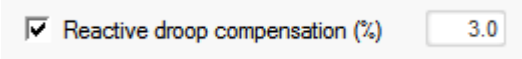
- **Underfrequency:** These two fields are used to set the voltage drop as a function of the alternator speed.
- **Knee-point value**: The typical values are 47.5 Hz for an alternator at 50 Hz, 57 Hz for an alternator with 60 Hz rated frequency and 380 Hz for an alternator at 400 Hz.
- **Slope**: Adjustable from 0.5 to 3. The higher the slope value, the greater the voltage drop will be if the drive motor speed drops.



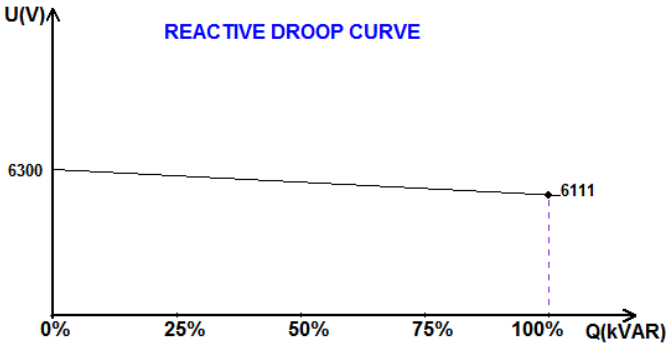
- The curve drawing changes as a function of these two values.



- **Quadrature droop**: Select the box to enable this and give a voltage drop percentage between -20% and +20% (caution, a negative value corresponds to an increase in voltage). This function is mainly used in the case of alternators operating in parallel with one another. This value is set to 3% by default.

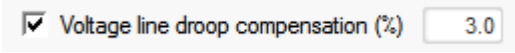


The quadrature droop curve drawing changes as a function of the reference.

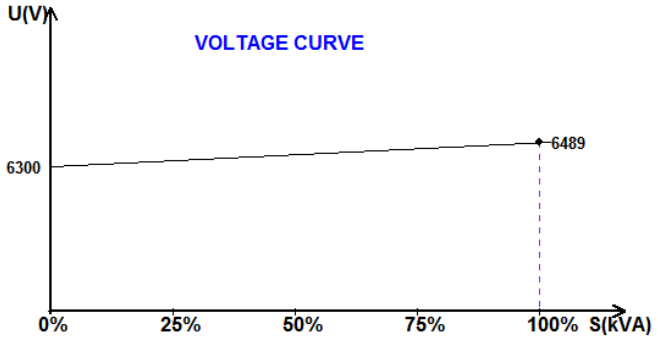


NOTE: If quadrature droop has been enabled, it is no longer possible to have load compensation or cross-current function.

- **Load compensation**: Select the box to enable this and give a voltage reference change percentage between -20% and +20%. This function is mainly used, depending on the kVA delivered by the machine, to:
  - Increase the voltage reference (with a percentage between 1 and 20%) in the case of particularly long distribution lines
  - Decrease the voltage reference (with a percentage between -20% and -1%) to balance the loads for machines connected to a rectifier (DC bus)

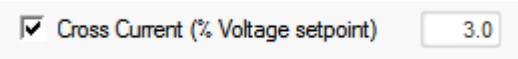


The compensation curve drawing changes as a function of the reference.



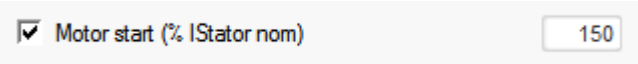
NOTE: If load compensation has been enabled, it is no longer possible to have quadrature droop or the cross-current function.

- **Cross current**: Select the box to enable this and give a voltage correction percentage as a function of the measured residual kVAr. The system automatically corrects the voltage (temporarily) to permanently cancel the kVAr difference between machines, yet without lowering the regulation point. This function requires special wiring (see section 2.3. *Connections*").



NOTE: If the cross-current function has been enabled, it is no longer possible to have quadrature droop or load compensation.

- **Motor start**: Select the box to enable the starting motor function, and give a percentage of rated stator current. This function is active only in voltage regulation mode and allows limiting the stator current at a defined value.



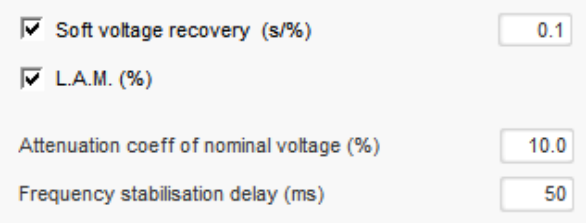
When the breaker is closed between the motor and the generator, the D700 continues to regulate the voltage until the stator current measured reaches the limitation value. In this case, the D700 regulates the stator current. When the motor reaches its rated speed, the current will decrease naturally and the voltage will increase. The D700 will then return to voltage regulation mode.

To prevent and detect a possible bad motor starting event, a delay can be set between 1s to 60s in the protections page. If the voltage is not at its voltage setpoint when the delay is over, the regulator will then respond based on the chosen action, as for all the others fault:

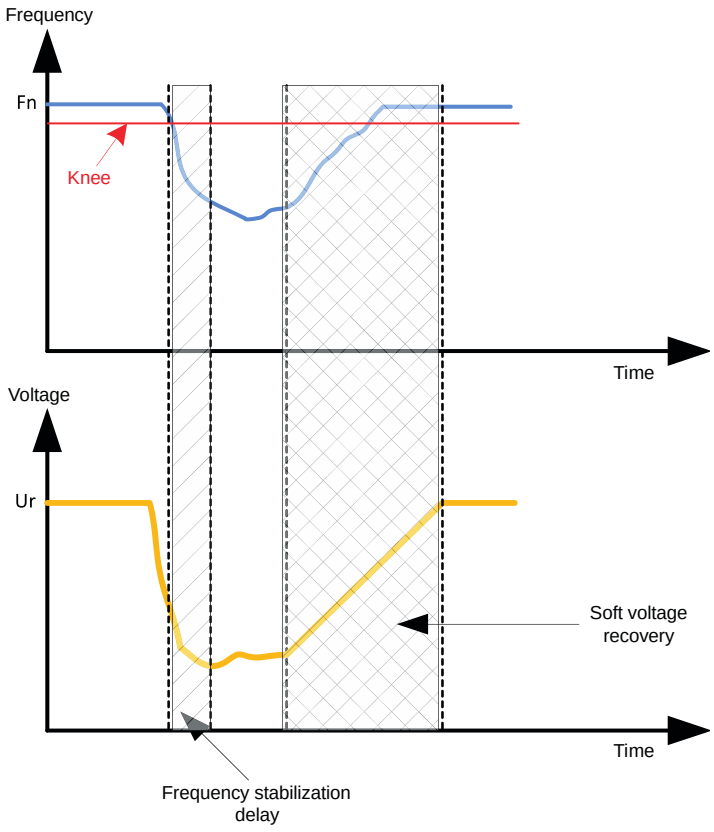
- No action
- Stop the regulation
- Field current regulation mode at shutdown value
- Field current regulation mode at value before the fault

If the motor breaker is closed before energizing, this limitation has the priority and ramp time is not respected.

- **LAM**: Load Acceptance Module. This function improves the generator response reducing the voltage setpoint on load impacts.
  - When generator frequency measured is below the under-speed knee defined in the configuration (example 48Hz or 58Hz), voltage setpoint is decreased to a defined value (in example below, 10% under the rated voltage)

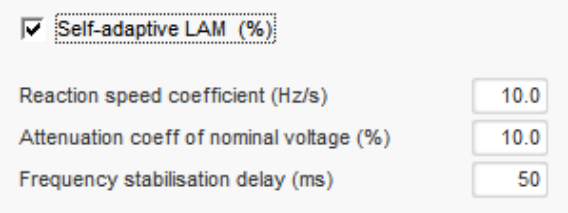


  - If frequency continues to fall, the voltage is regulated according to the U/f law.
  - Soft voltage recovery helps the speed recovery of the group: it is given in seconds per percent of the rated voltage (s/%). For example the above setting means that if the frequency decreases by 10% then the progressive rise time will be 1 second (i.e. 0.100s /% * 10%). Note that if the slope of progressive rise is greater than the U/f law, then the latter will be used to raise the voltage.
  - The frequency stabilization delay corresponds to the waiting time before the voltage setpoint is raised gradually (according to the increase of the frequency).
  - The figure below shows the operating details of the LAM:



- **Self-adaptive LAM**: it has the same role as the classical LAM described above. The difference lies in the fact that the percentage of voltage drop is no longer fixed by the user but is automatically adapted to the level of the load impact. Thus for each load impact:
  - The controller measures the operating frequency and calculates its derivative permanently;

- From this derivative value, an attenuation coefficient (K) of the voltage is calculated according to the parameters configured by the user. In the example below, for a frequency variation of 10Hz/s, the applied voltage drop will be 10% of the nominal voltage.



For each load impact, the voltage attenuation is determined by the formula $\Delta U = K*Ur$ where Ur is the rated voltage of the alternator.

The frequency stabilization delay corresponds to the waiting time before the voltage setpoint is raised gradually (according to the increase of the frequency).

Note: During the motor starting, all the others limitations, faults and protections (under voltage, over voltage, stator limitation, under speed, under excitation, over excitation) are active.

- Click on the "Next" button

4.3.9.9. Determination of the regulation modes

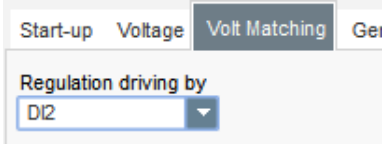
The various regulation modes to be configured depend on the alternator operation (standalone, parallel between machines, parallel with the grid). See section *3.3.1. Regulation modes*" for more details.

NOTE: If the alternator is not connected to the grid, pass directly to step 11.

4.3.9.10. Step 9: Voltage match circuit

- To connect an alternator to the grid, the grid voltage and the alternator voltage must already be very close in value (less than 5% difference between the two measurements). The voltage match circuit function is used to measure the instantaneous grid voltage as an alternator voltage reference.[16]

- To enable the voltage match circuit, select the activation type from the drop-down list. This can be:
  - Controlled by a digital input (DI1 to DI16).
  - Always enabled by selecting "Always active". In this case, the voltage match circuit is always switched on, depending on the order of priority of the regulations.
- If "None" is selected, the voltage match circuit is never enabled or is enabled by a logic gate.

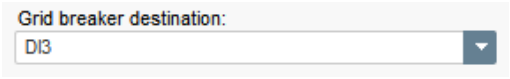


- Click on the "Next" button

[16] This function requires one or two grid code voltage measurement transformer(s).

4.3.9.11. Step 10: Regulation of the generator power factor:

- This regulation must be enabled as soon as the machine is connected to the grid (grid contactor closing data item), and disabled as soon as the machine is disconnected from the grid. The destination of the grid connection contactor should be stated at the bottom of the page:

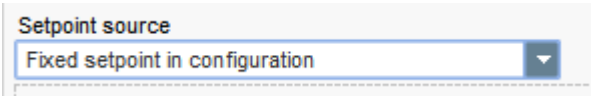


- It can be chosen with kVAr regulation and regulation of the power factor at one point on the grid for machines connected to the grid (see steps 11 and 12).

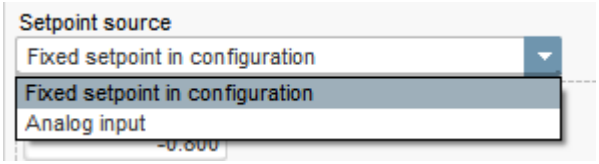
- This regulation is used to regulate the power factor at the machine terminals. For this, the alternator current measurement must be connected (1 or 3 current transformers).

- This regulation is activated by default as soon as the grid breaker is closed. The others regulation modes kVAr or power factor at a grid point, have the priority on this regulation.

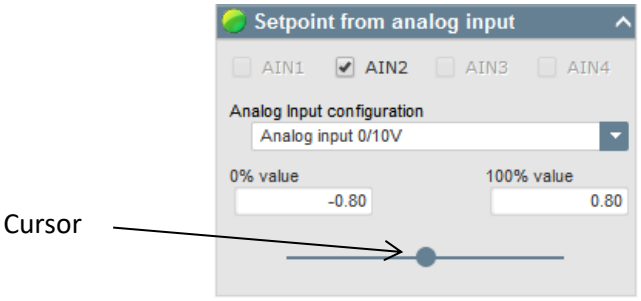
- **The home reference point** is determined by the drop-down list:
  - By a fixed value in the configuration. In this case, this value can be changed by the fieldbus.



  - By an analog input with a range to be determined.

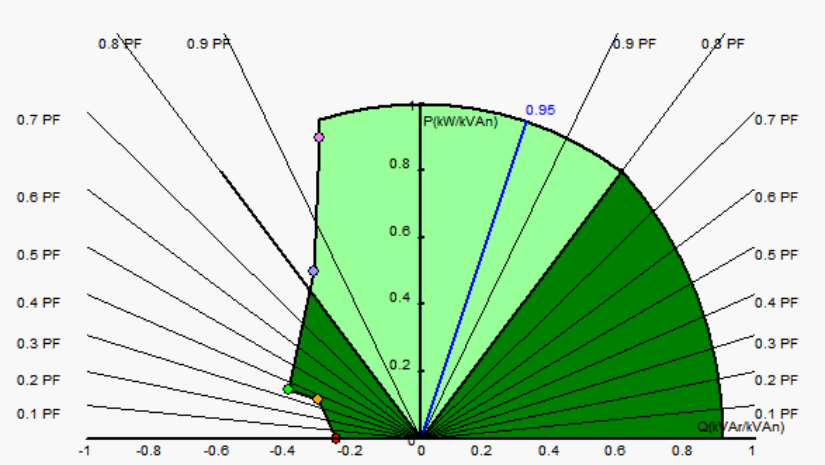


- **If the "Analog input" option is selected,** the "Reference via analog input" part is enabled further down. Select the desired analog input box, determine its mode (+/-10 V, 0/10 V, 4-20 mA, potentiometer) and the power factor values at 0% and 100%. [17]

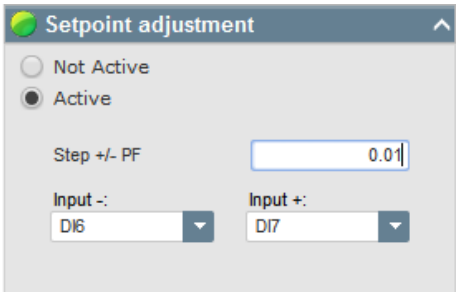


[17] The power factor reference terminals can be swapped: the minimum power factor for 100% of the analog input, and the maximum power factor for 0% of the analog input.

NOTE: By moving the cursor, it is possible to view the power factor reference (blue line) on the capability diagram located on the right of the page.

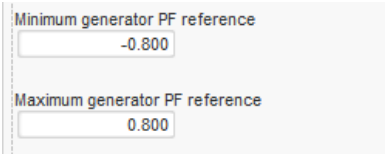


- **With a fixed reference, the reference can be adjusted** by two up and down inputs, one pulse corresponding to going up one “step” or down one “step”. Both the inputs and the value of the step need to be fixed, and this adjustment is enabled by setting the selector to “Active”:



NOTE: The “faster” and “slower” inputs are the same for all regulation modes.

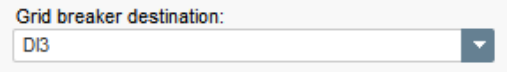
- **The limits of this reference** should be fixed according to the machine capability (in the example below, the power factor reference is fixed between -0.85 (drawing reactive power as seen by the generator) and 0.8 (supplying reactive power as seen by the generator).



These reference limits define the light green area on the capability diagram in which the reference can vary.

4.3.9.12. Step 11: Regulation of generator kVAr

- This regulation must be enabled as soon as the machine is connected to the grid (grid contactor closing data item), and disabled as soon as the machine is disconnected from the grid. The grid connection contactor source should be stated at the bottom of the page:

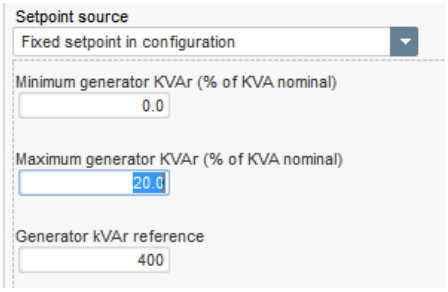


- The other options are regulation of the generator power factor or regulation of the power factor at one point on the grid for machines connected to the grid (see steps 10 and 12).

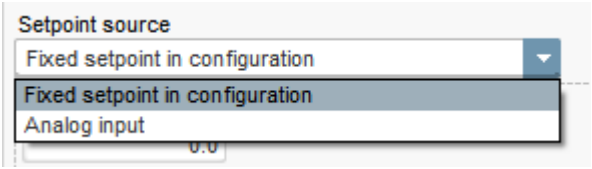
- This regulation is used to regulate the kVAr value at the machine terminals. For this, the alternator current measurement must be connected (1 or 3 current transformers).

- To enable kVAr regulation, select the activation type from the drop-down list. This can be:
  - Controlled by a digital input (DI1 to DI16).
  - Always enabled by selecting “Always active”. In this case, kVAr regulation is always active, depending on the order of priority of the regulations.
- If “None” is selected, kVAr regulation is never enabled or is enabled by a logic gate.

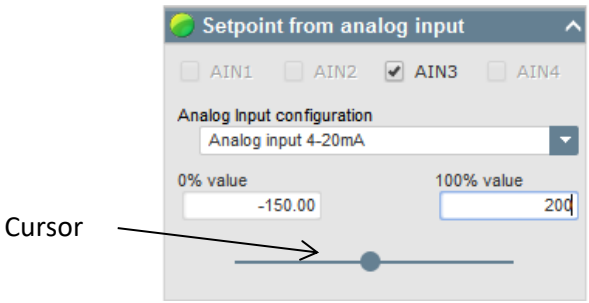
- **The home reference point** is determined by the drop-down list:
  - By a fixed value in the configuration. In this case, this value can be changed by the fieldbus.



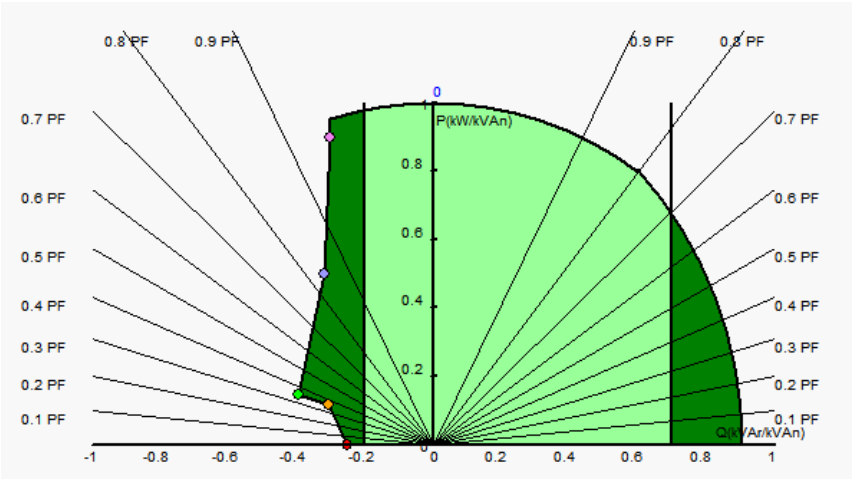
  - By an analog input with a range to be determined.



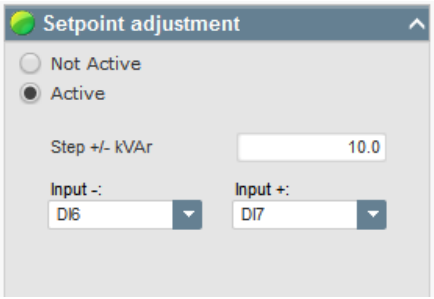
- **If the "Analog input" option is selected,** the "Reference via analog input" part is enabled further down. Select the desired analog input box, determine its mode (+/-10 V, 0/10 V, 4-20 mA, potentiometer) and the kVar values at 0% and 100%. [18]



NOTE: By moving the cursor, it is possible to view the kVAr regulation (blue line) on the capability diagram located on the right of the page.



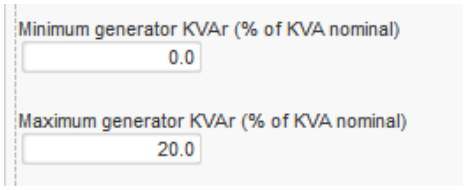
- **With a fixed reference, the reference can be adjusted** by two up and down inputs, one pulse corresponding to going up one "step" or down one "step". Both the inputs and the value of the step need to be fixed, and this adjustment is enabled by setting the selector to "Active":



NOTE: The "faster" and "slower" inputs are the same for all regulation modes.

[18] The kVAr regulation terminals can be swapped: the minimum value for 100% of the analog input, and the maximum value for 0% of the analog input.

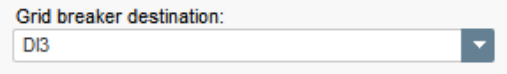
- **The limits of this reference** should be fixed according to the machine capability (in the example below, the kVAr regulation is fixed between -10% of the alternator rated kVA power (drawing reactive power as seen by the generator) and 62% of the alternator rated kVA power (supplying reactive power as seen by the generator).



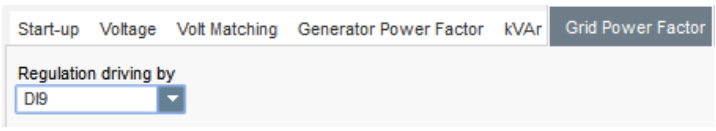
These reference limits define the light green area on the capability diagram in which the reference can vary.

4.3.9.13. Step 12: Regulation of power factor at one point on the grid

- This regulation must be enabled as soon as the machine is connected to the grid (grid contactor closing data item), and disabled as soon as the machine is disconnected from the grid. The grid connection contactor source should be stated at the bottom of the page:

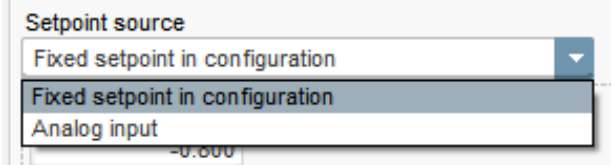


- The other options are regulation of the generator power factor and kVAr regulation for machines connected to the grid (see steps 10 and 11).
- This regulation is used to regulate the power factor at one point on the grid. For this, the alternator current measurement must be connected (1 or 3 current transformers).
- To enable regulation of the power factor at one point on the grid, select the activation type from the drop-down list. This can be:
  - Controlled by a digital input (DI1 to DI16).
  - Always enabled by selecting “Always active”. In this case, regulation of the power factor at one point on the grid is always enabled, according to the order of priority of the regulations.
- If “None” is selected, regulation of the power factor at one point on the grid is never enabled or is enabled by a logic gate.

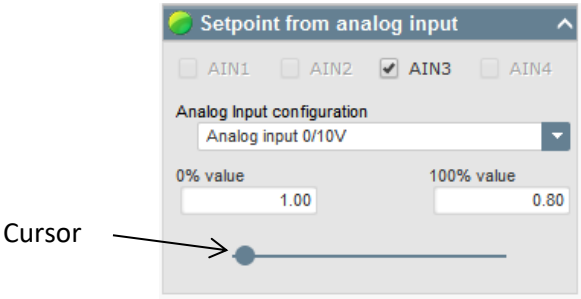


- **The home reference point** is determined by the drop-down list:
  - By a fixed value in the configuration. In this case, this value can be changed by the fieldbus.

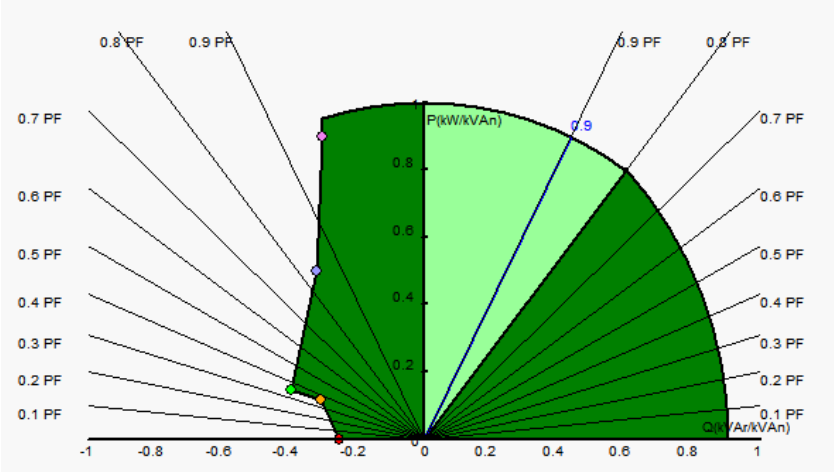
  - By an analog input with a range to be determined.



- **If the "Analog input" option is selected,** the "Reference via analog input" part is enabled further down. Select the desired analog input box, determine its mode (+/-10 V, 0/10 V, 4-20 mA, potentiometer) and the power factor values at 0% and 100%. [19]

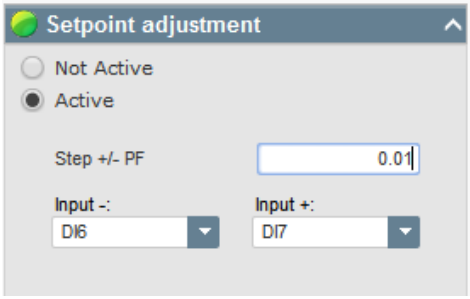


NOTE: By moving the cursor, it is possible to view the power factor reference (blue line) on the capability diagram located on the right of the page.



NOTE: This capability diagram is fictitious because it describes evolution of the power factor at one point on the grid, not at the alternator terminals.

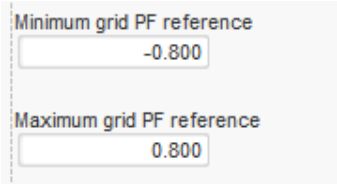
- **With a fixed reference, the reference can be adjusted** by two up and down inputs, one pulse corresponding to going up one "step" or down one "step". Both the inputs and the value of the step need to be fixed, and this adjustment is enabled by setting the selector to "Active":



NOTE: The "faster" and "slower" inputs are the same for all regulation modes.

[19] The minimum and maximum power factor reference terminals can be swapped: the minimum power factor for 100% of the analog input, and the maximum power factor for 0% of the analog input.

- The limits of this reference should be fixed as required. In the screenshot below they are 1 (drawing reactive power as seen by the generator) and 0.8 (supplying reactive power as seen by the generator). The active limits should be those of the alternator to keep the machine in its capability diagram, but also those fixed in this page. In certain conditions, there can be a grid power factor reference limit without actually being at the limit of this reference because the machine power factor reference is active.



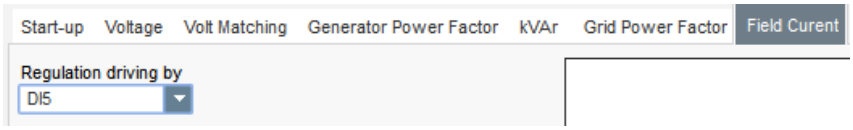
These reference limits define the light green area on the capability diagram in which the reference can vary.

4.3.9.14. Step 13: Regulation of the field current (manual mode)

- This regulation is used to control the value of the field current directly. It is mainly used during commissioning or as fallback mode if a measurement is incorrect on the AVR (alternator voltage measurement or alternator current measurement for example).

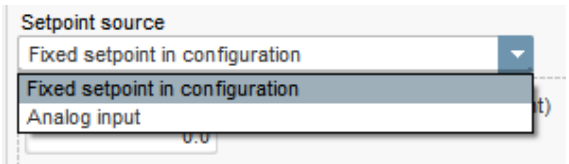
- It takes priority over all the other regulation modes that might be active.

- To enable field current regulation, select the activation type from the drop-down list. This can be:
  - Controlled by a digital input (DI1 to DI16).
  - Always enabled by selecting “Always active”. In this case, field current regulation is always enabled, depending on the order of priority of the regulations.
- If “None” is selected, field current regulation is never enabled or is enabled by a logic gate.

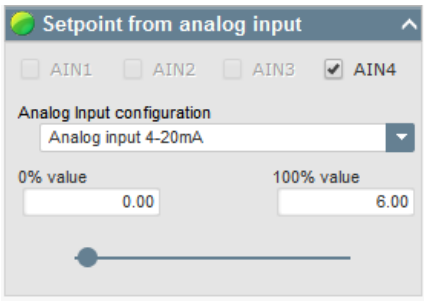


- **The home reference point** is determined by the drop-down list:
  - By a fixed value in the configuration. In this case, this value can be changed by the fieldbus.

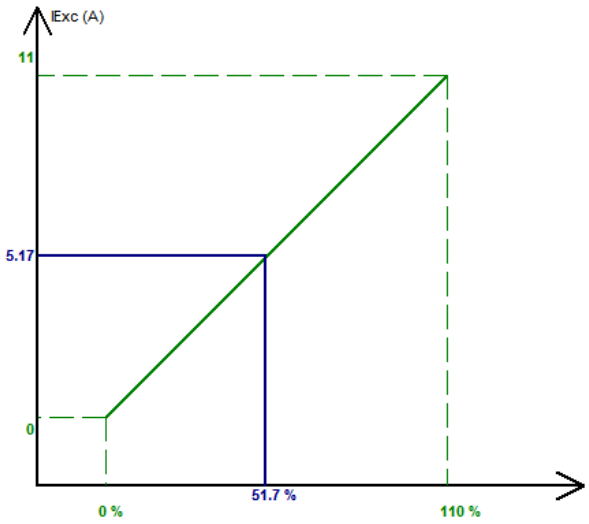
  - By an analog input with a range to be determined.



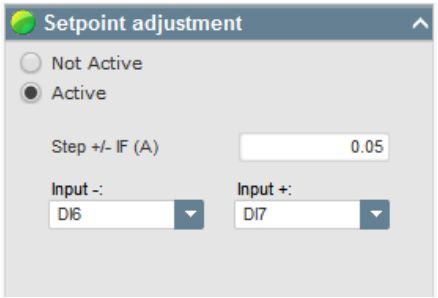
- **If the "Analog input" option is selected,** the "Reference via analog input" part is enabled further down. Select the desired analog input box, determine its mode (+/-10 V, 0/10 V, 4-20 mA, potentiometer) and the power factor values at 0% and 100%. [20]



NOTE: By moving the cursor, it is possible to view the field current reference (blue line) on the graph located on the right of the shape.



- **With a fixed reference, the reference can be adjusted** by two up and down inputs, one pulse corresponding to going up one "step" or down one "step". Both the inputs and the value of the step need to be fixed, and this adjustment is enabled by setting the selector to "Active":



NOTE: The "faster" and "slower" inputs are the same for all regulation modes.

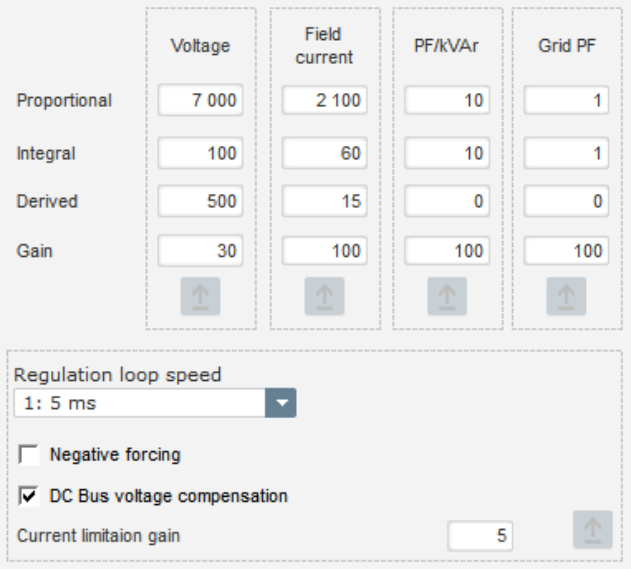
[20] The minimum and maximum field current reference terminals can be swapped: the minimum field current for 100% of the analog input, and the maximum field current for 0% of the analog input.

- **The "tracking" function**, when switching from a regulation mode to manual mode, allows the field current measurement to be used as a reference. This prevents any visible "jumps" on the machine. The reference can then be changed using the up and down inputs.

NOTE: This function is only possible if the home reference point is fixed.

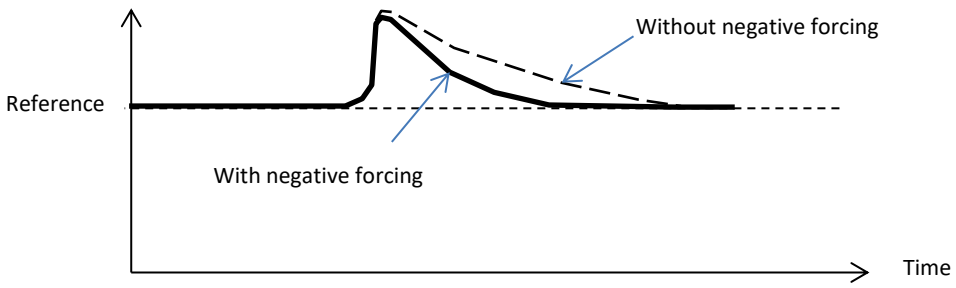
4.3.9.15. Step 14: Setting the PID gains

- Set the various PID gains. Default values are ever given in the fields

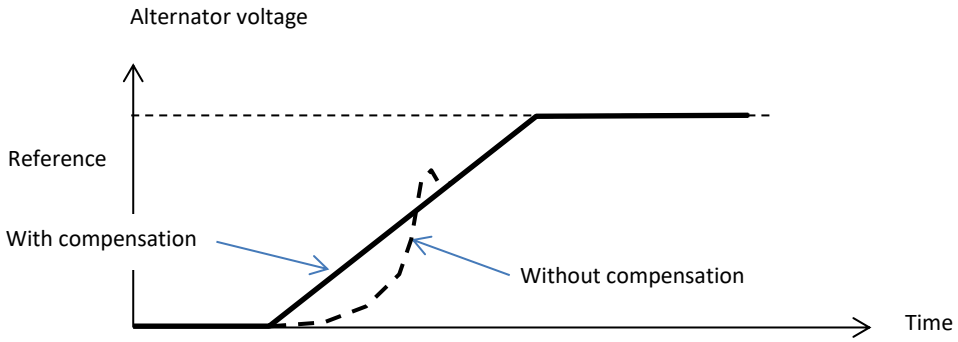


- Regulation loop speed can be modified according to the response time of the generator, between 2.5ms and 20ms by 2.5ms steps. If this value is modified, it will be necessary to adjust PID gains.

- If alternator operation requires various load steps, whether adding and/or shedding, (standalone operation or parallel machine operation) it may be a good idea to select "negative forcing". This function is used to invert the voltage at the exciter field terminals briefly in order to improve the time it takes to return to the rated voltage.



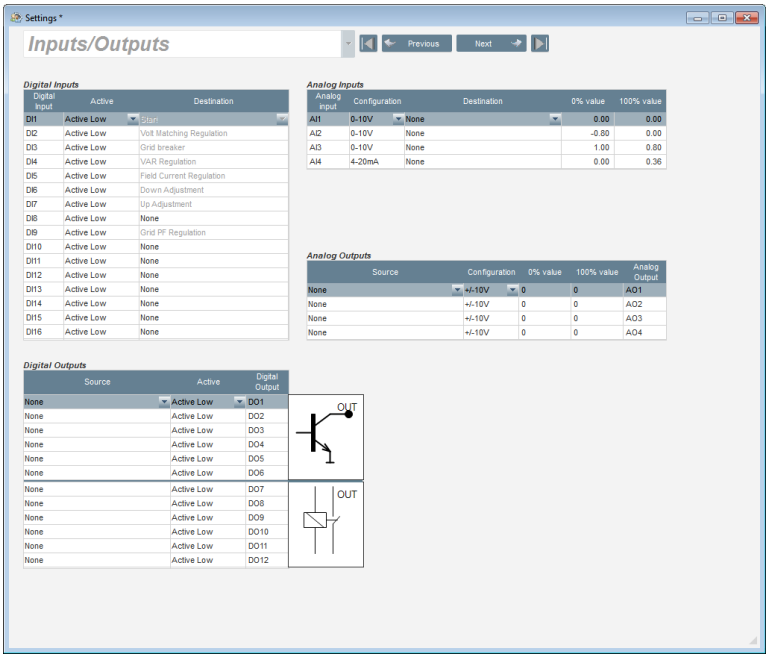
- If a shunt or AREP type field is being used, the power supply voltage depends directly on the voltage at the alternator terminals. As a result, it can fluctuate with the load and therefore influence the PID's behavior. To compensate for these fluctuations, it may be advisable to select the “VBus compensation” box. Below is an example of ramp starting with and without compensation in the case of a shunt field:



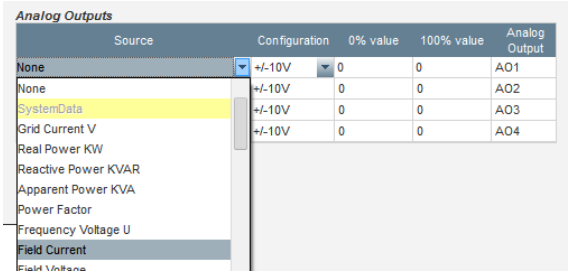
- Click on the “Next” button.

4.3.9.16. Step 15: I/O management

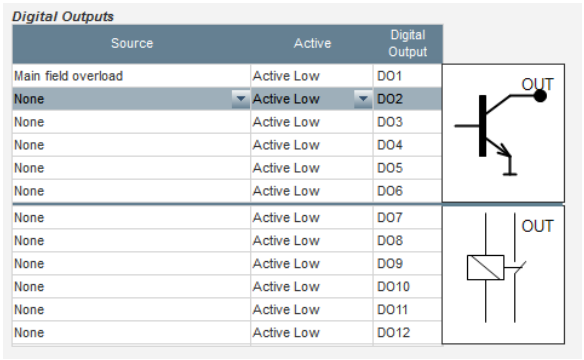
- Go to the I/O page.
- Additional inputs can be configured on top of those used in the regulation configuration pages (which are shown already greyed out).



- **The analog outputs** can be configured by defining the source, the configuration and the 0% and 100% values.



- **The digital outputs** can be configured by defining the source, the activation (active low = closed if the condition is fulfilled, “active high” = output open if the condition is fulfilled). You can tell which output type is configured as the illustration shows a relay or a transistor.



4.3.10. Curve functions

4.3.10.1. Overview

Curve functions are used to control a parameter as a function of another parameter. For example:

- The kVAr reference as a function of the voltage during kVAr regulation
- The maximum stator current as a function of the stator temperature
- The maximum field current as a function of the temperature or an analog input
- The voltage reference as a function of the speed
- The field current as a function of the active power
- Specific scaling
- Etc.

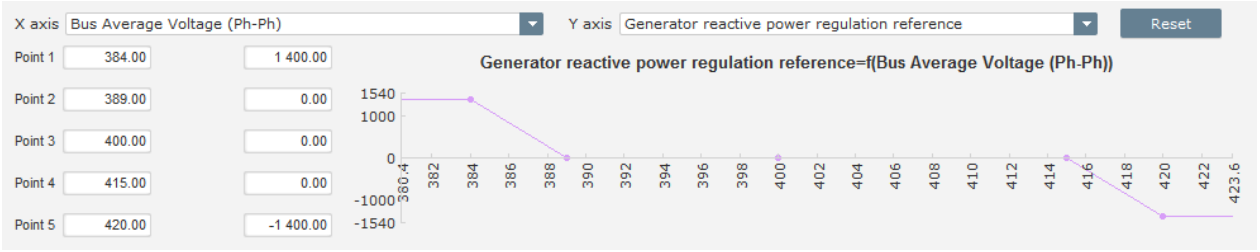
3 curve functions can be created.

For the curve function to work, the X and Y axis parameters need to be defined, as well as 5 points. These functions are active as soon as the curve is created.

The curve fields can be reset by clicking on the “Reset” button of each curve.

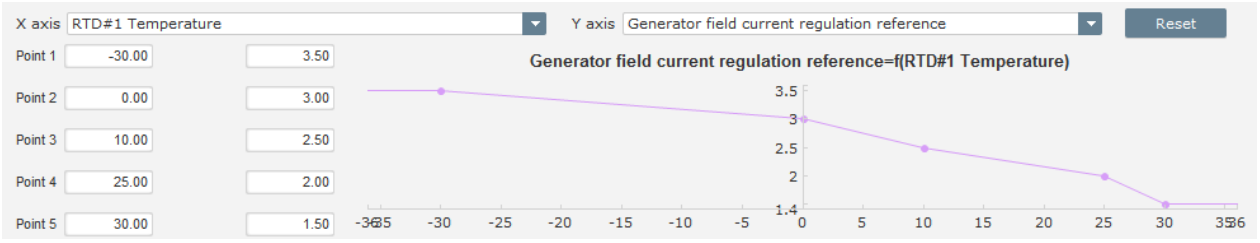
4.3.10.2. Example of curve functions

- **Reactive power reference as a function of the grid voltage** for a 400 V machine



NOTE: We can see that for a voltage value below that defined at point “1”, the power reference is held at the value defined at point “1”. For a voltage value higher than that defined at point “5”, the reactive power reference is held at the value defined at point “5”.

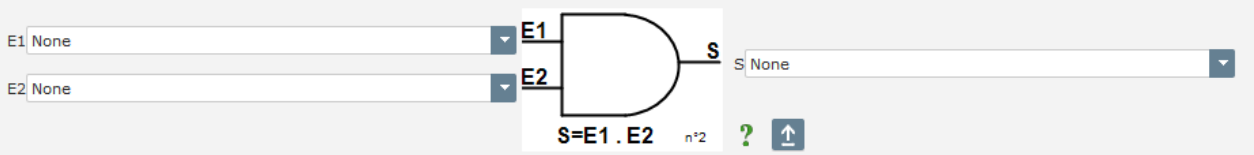
- **Field current reference as a function of the temperature measured at the stator** (in our example temperature 1). For a low temperature, increasing the field current is then authorized.



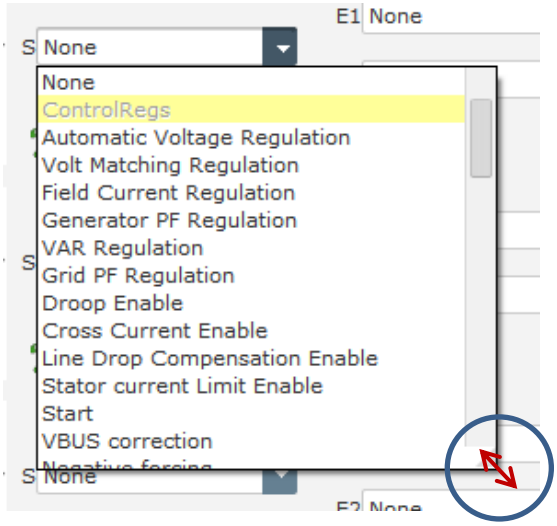
4.3.11. Logic gates

4.3.11.1. Overview

Logic gates are used for simple control with one or two inputs and one configurable output by means of drop-down lists.

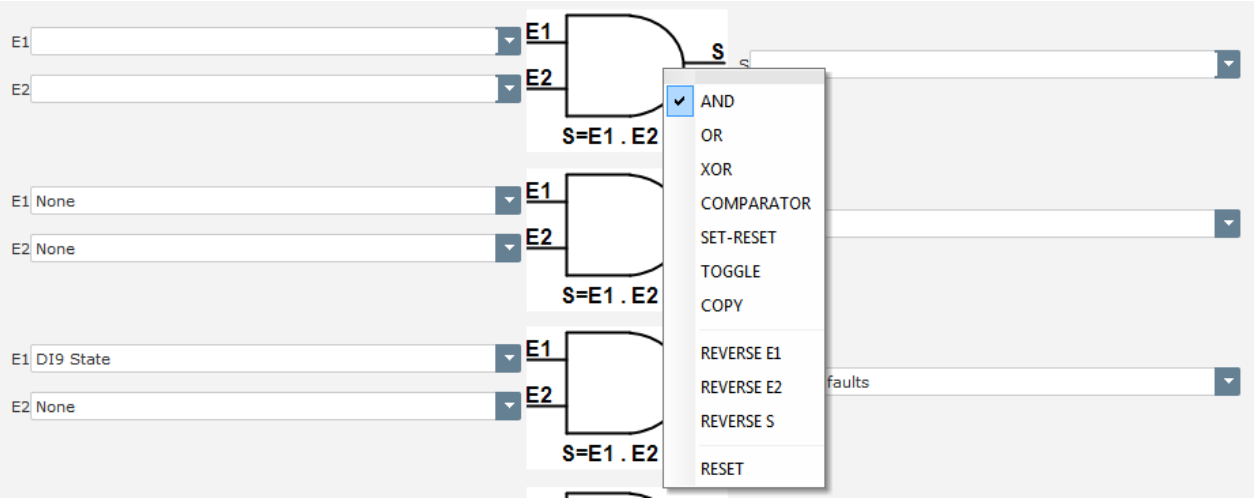


The parameter lists can be enlarged by clicking at the bottom right of the list and holding down until they are the desired size:



TIP: To select a parameter more quickly, you can enter its first few letters in the drop-down list.

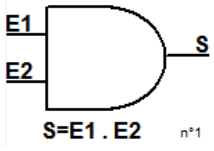
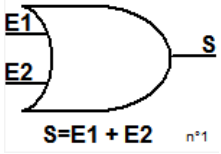
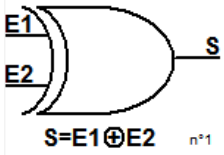
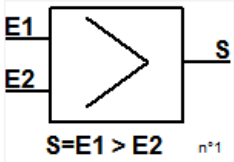
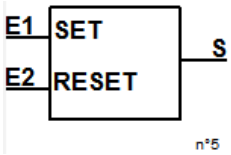
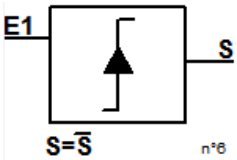
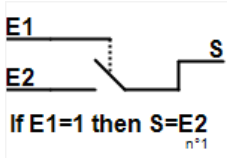
The type of gate can be changed by right-clicking on the relevant gate. A pop-up menu then appears:



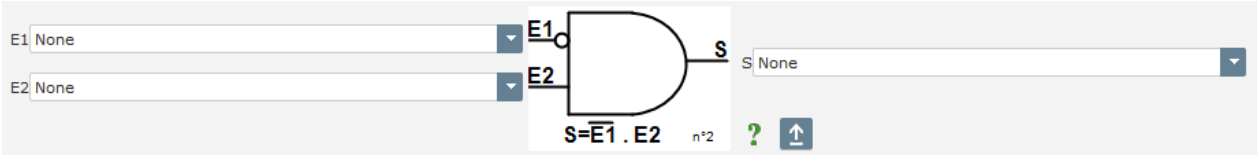
A maximum of 10 gates with 2 inputs can be used.

They can be linked in sequence (using an output gate as an input condition for another gate). Digital “user” variables can be used as a gate input parameter in comparator mode.

The following gates are available:

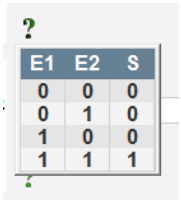
Gate type	Representation	Parameter type	Truth table
AND		Binary	E1 E2 S 0 0 0 0 1 0 1 0 0 1 1 1
OR		Binary	E1 E2 S 0 0 0 0 1 1 1 0 1 1 1 1
Exclusive OR		Binary	E1 E2 S 0 0 0 0 1 1 1 0 1 1 1 0
COMPARATOR		Decimal E1 and E2 Binary O	 E1<E2 0 E1=E2 0 E1>E2 1
SET-RESET		Binary	E1 E2 S 0 0 O 0 1 0 1 0 1 1 1 O
SWITCHING		Binary	On the rising edge of I1, O changes state
COPY		E1 Binary E2 and S Decimal	E1 E2 S 0 0 0 0 E2 0 1 E2 E2

The inputs and the output can be swapped in the case of AND, OR, EXCLUSIVE OR gates, again using the gate pop-up menu. In this case a white circle symbolizes the reversal and the gate equation is updated. Example below with the E1 input swapped on an AND gate:



A logic gate's fields can be reset by using the gate pop-up menu and clicking “RESET”.

A help is available by clicking on the question mark, which brings up the truth table for the active gate. This is an AND gate[21].

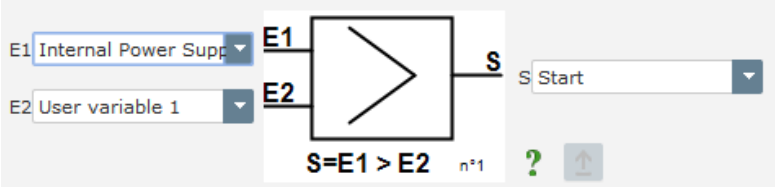


E1	E2	S
0	0	0
0	1	0
1	0	0
1	1	1

4.3.11.2. Examples of gate programming

- **Starting the AVR on power supply voltage threshold**: as soon as the power is switched on, the power supply voltage increases. A threshold should therefore be set above which the ramp will be able to be executed. A user-defined variable is used ().

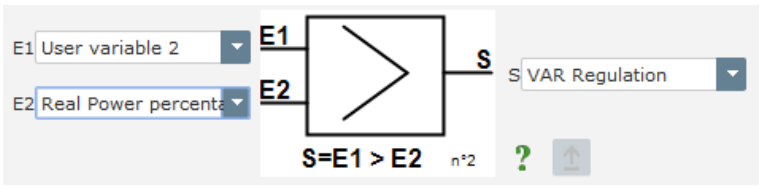
  The “COMPARATOR” gate is then chosen with the following variables:
  - E1 “Internal power supply Volts”
  - E2 “User variable 1”, set at 10 (DC bus 10 V)
  - S “Starting”



NOTE: the value of "User variable 1" depends on the voltage your field excitation system can deliver to the residual. In our example we will put 10 V

- **VAr regulation for a load less than 10% of the rated power (connected to the grid)**: as soon as the machine is connected to the grid, without a load being present, instabilities can appear due to the stator current measurement interference. We therefore recommend kVAr regulation if the active power is less than 10% of the alternator rated power.

  The “COMPARATOR” gate is then chosen with the following variables:
  - E1 “User variable 2”, set at 10 (10% reactive power)
  - E2 “Real power percentage”
  - S “VAR regulation”

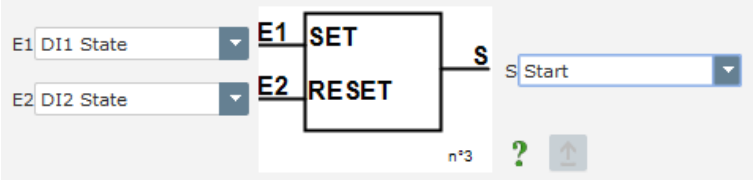


[21] Truth tables do not take account of any swaps configured on the gate.

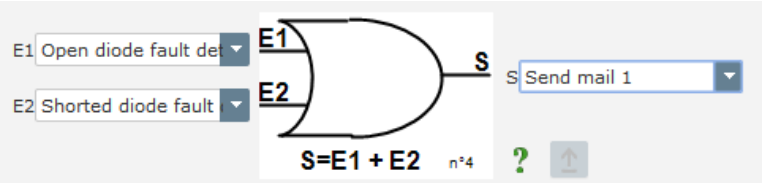
- **Pulsed Starting and Stopping:** The regulation function is switched on by a maintained input. As soon as this input changes state, field excitation is stopped. Pulsed starting and stopping can be configured using a SET-RESET gate:

  - E1 “DI1”, which sends the start pulse
  - E2 “DI2”, which sends the stop pulse
  - S “Starting”

  The result is then as follows:



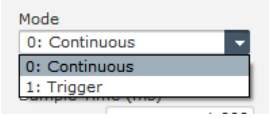
- **Send e-mail on condition**: on an alarm, after definition of the e-mail text and the Ethernet configuration settings (see chapter "*4.3.14.1. Network configuration" and 4.3.14.2. Managing e-mails"*). In the example below, send e-mail on an open diode trip or diode short-circuited trip.



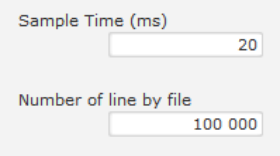
4.3.12. Data logger

The data logger is used to create text or csv type files, which will be stored in the AVR on an SD card, and can then be exploited using a spreadsheet to create graphs.

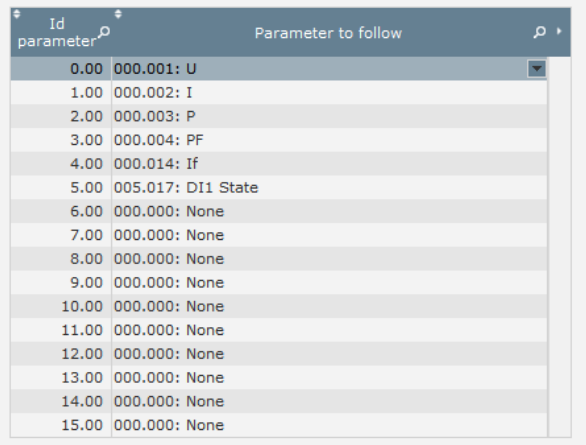
The data logger can either run continuously (continuous recording of values) or be launched by trigger parameters (trigger mode).



Sampling time is limited between 20ms and 60 s, with the number of samples configurable between 2000 and 100,000 to limit the file size.



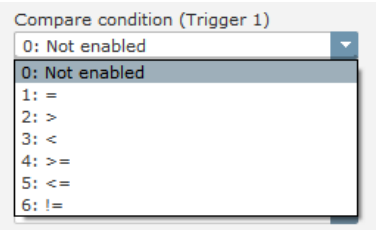
Each parameter you might wish to track can be selected from the drop-down list:



Id parameter	Parameter to follow
0.00	000.001: U
1.00	000.002: I
2.00	000.003: P
3.00	000.004: PF
4.00	000.014: If
5.00	005.017: DI1 State
6.00	000.000: None
7.00	000.000: None
8.00	000.000: None
9.00	000.000: None
10.00	000.000: None
11.00	000.000: None
12.00	000.000: None
13.00	000.000: None
14.00	000.000: None
15.00	000.000: None

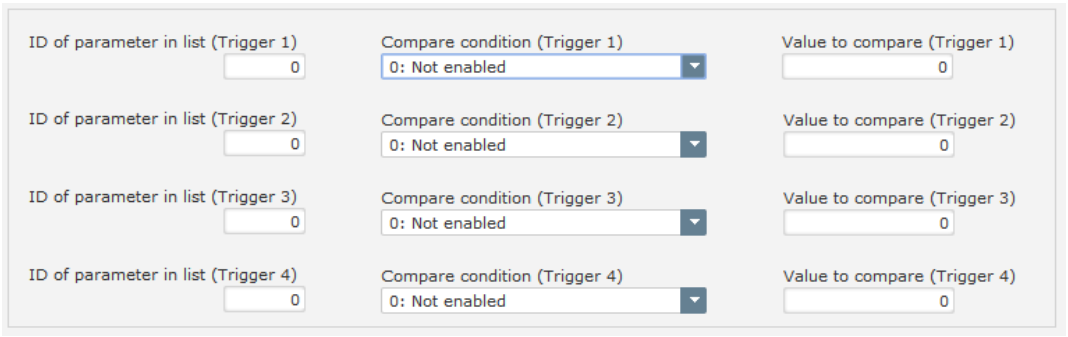
If “trigger” mode is selected, you need to define:

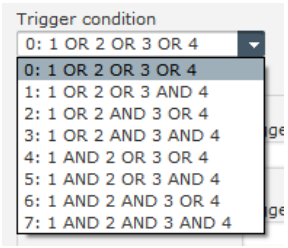
- **At least one parameter** which will trigger recording in the data logger. This parameter number corresponds to the one in the previous list. For example, parameter “7” for state of DI1.
- **The trigger condition**: 7 conditions are possible (none, equal to, strictly greater than, strictly less than, greater than or equal to, less than or equal to, not equal to).



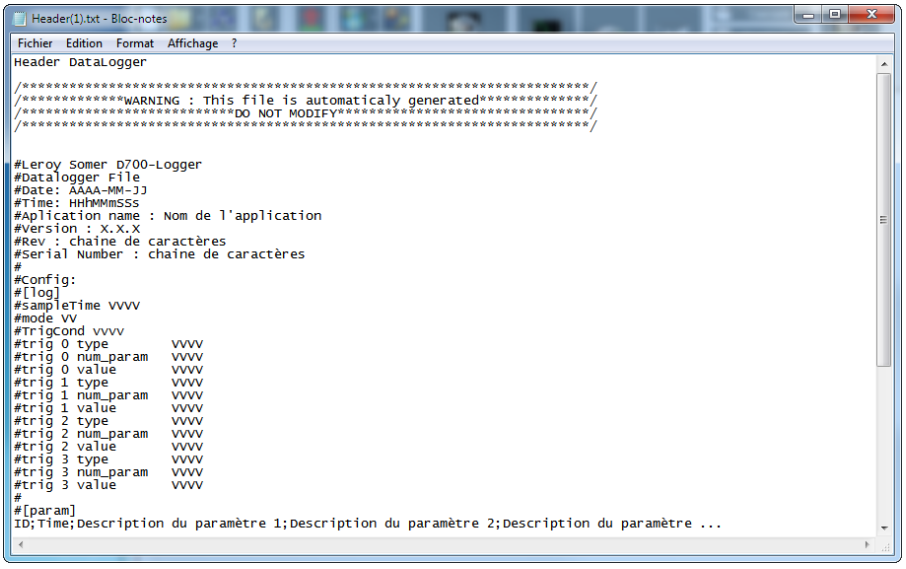
- **The parameter threshold which triggers the data logger**

4 trigger sources can be entered and it is possible to select which condition between triggers will be applied (“AND” or “OR”).





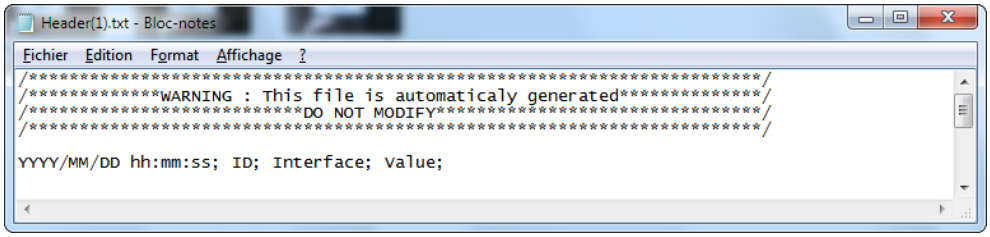
Each file created in the data logger is saved in the “Log_YYYY-MM-DD_HHh-MMm-SSs.csv” format (year, month, day, hour, minute, second). The parameters are saved after the headers and the file has the following structure:



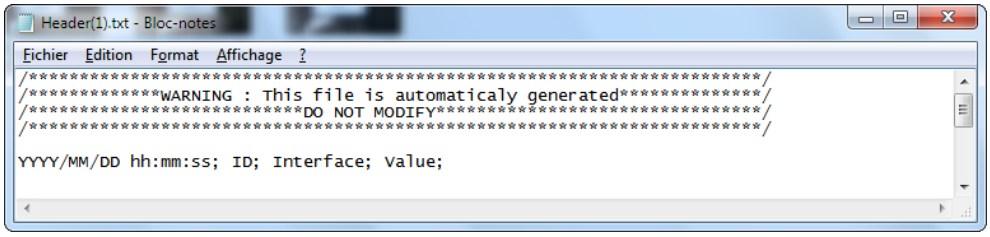
NOTE: The “vvvv” notations correspond to the value of the selected equation and the trig parameter number.

Two other files are saved:

- **Changes to the AVR configuration:** These are saved in the “LogConfig_YYYY-MM.csv” format. This file is created for each month of each year and contains the modified configuration parameters, with the date and time of modification.



- **Events that have occurred on the AVR:** These are recorded in the “LogEvent_YYYY-MM.csv” format. This file is created for each month of each year. A number of headers in this file describe the information it contains:



4.3.13. Access to files on SD card

To access to the files stored on the SD card, D700 must be connected in USB. Click on the "SD" button in "Info" group in the banner:

D700 is then disconnected and the communication is stopped to become a gateway to access to the SD card. Using software as files explorer, you can access these files and copy them.

NOTES:

- **These files must not be deleted from the SD card, and not modified**
- **During this type of access, no data is stored by the D700 on the SD card.**

To go back to normal use, unplug the USB, and re-plug the USB.

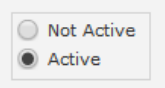
4.3.14. Ethernet

4.3.14.1. Network configuration

The Ethernet configuration page is used to configure a network to communicate with the D700:

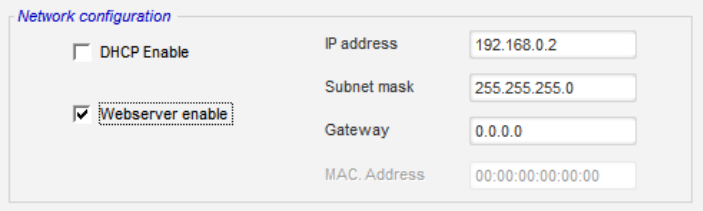
- Reading and writing parameters using a higher-level control system (PLC, supervision system)
- Dialogue with the EasyReg Advanced over Ethernet rather than the USB
- The definition of emails sent on a condition (see trigger by logic gate in section *4.3.11.2. Examples of gate programming*").

The Ethernet is enabled by setting the selector switch to "Active".



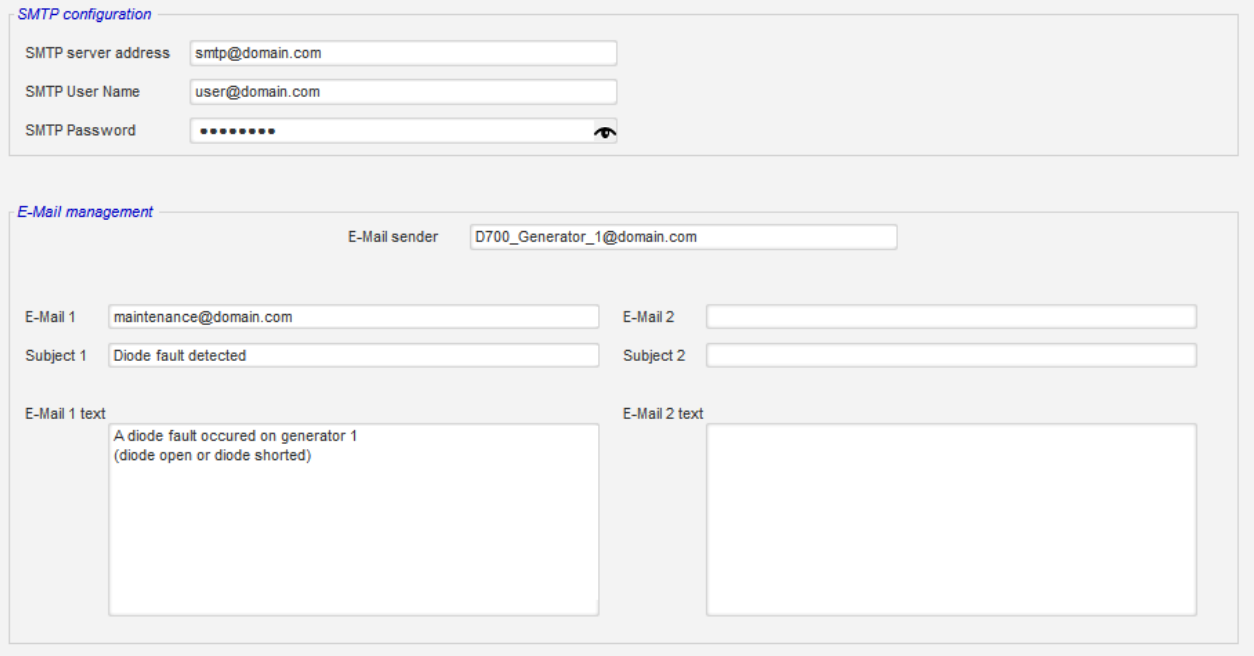
If the DHCP box is selected, the IP address, the network mask, and the gateway address are automatically assigned by the network (provided that the D700 is connected to it). Otherwise, these addresses should be defined manually. The D700 MAC address is also displayed in the network configuration.

If the "Web Server active" box is selected, the D700 can be connected directly via an Internet browser by simply entering its IP address (in development).



4.3.14.2. Managing e-mails

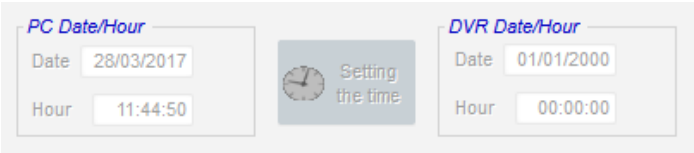
Two different e-mail addresses can be configured. All the text fields must be filled in (sender, recipient, subject, e-mail text, SMTP server address, as well as the user name and the password for the SMTP account).



NOTE: E-mail sending is triggered by a logic gate.

4.3.15. Setting the D700 time

The time of the D700 internal clock (Real Time Clock) is set on the “RTC Configuration” page by clicking on the “Time setting” button. The PC time is copied to the D700.

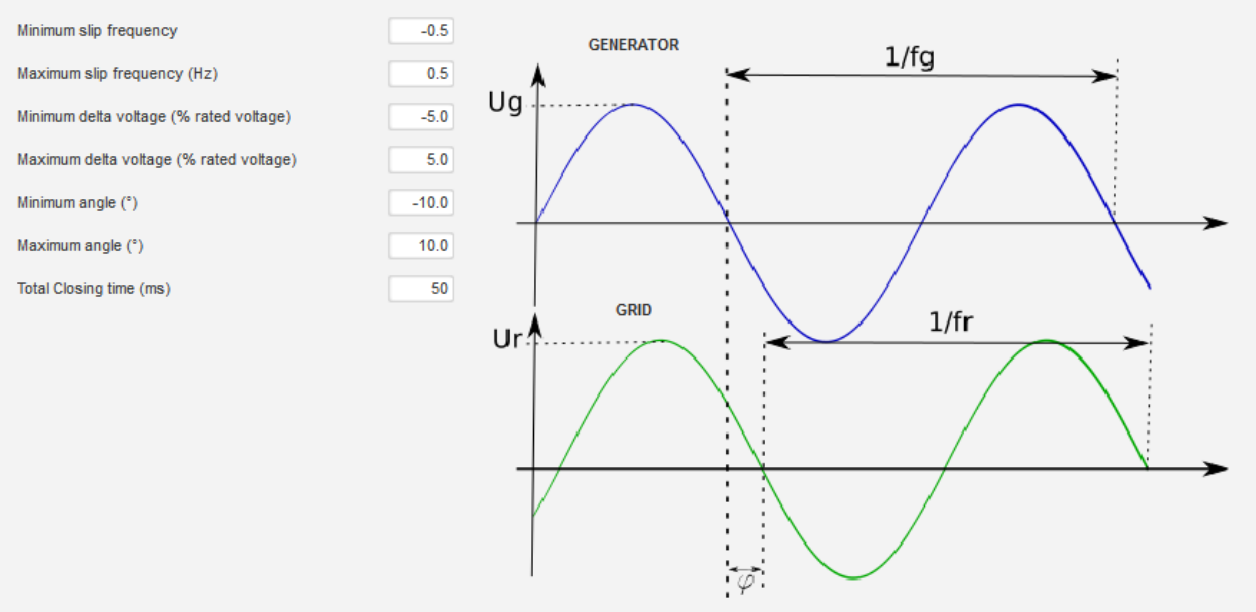


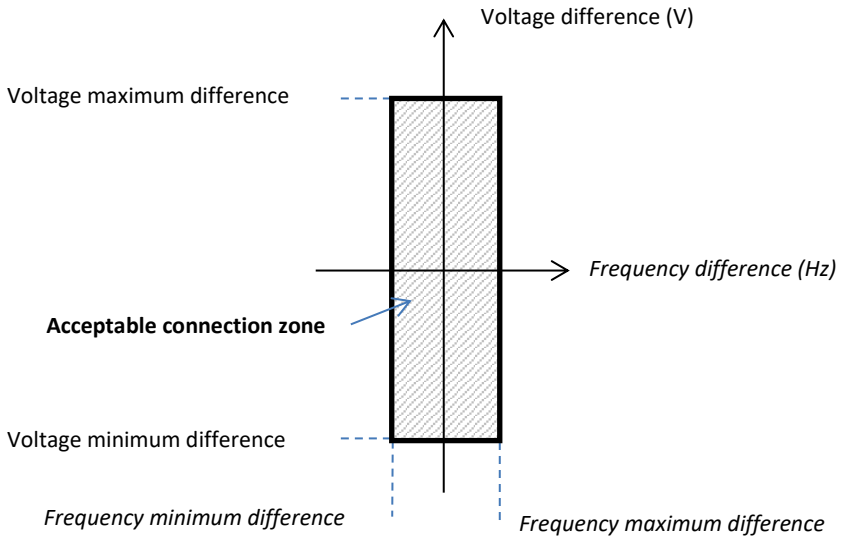
4.3.16. Synchronization

As long as the grid code voltage measurement is wired, the D700 is capable of running the grid synchronization sequence. In this case, check that the phase order is correct (since the D700 does not do this) and that the grid and the generator have the same measurement type (single-phase, or three-phase).

The frequency, voltage and phase angle ranges must then be set. These must be complied with so that connection can take place without damaging the machine.

The time it takes the circuit breaker to close between the alternator and the grid must also be configured. This ensures that synchronization can be performed and completed before the end of the configured connection zone.





The synchronization sequence is controlled by a parameter which is kept active (controllable from an input, communication, or a logic gate).

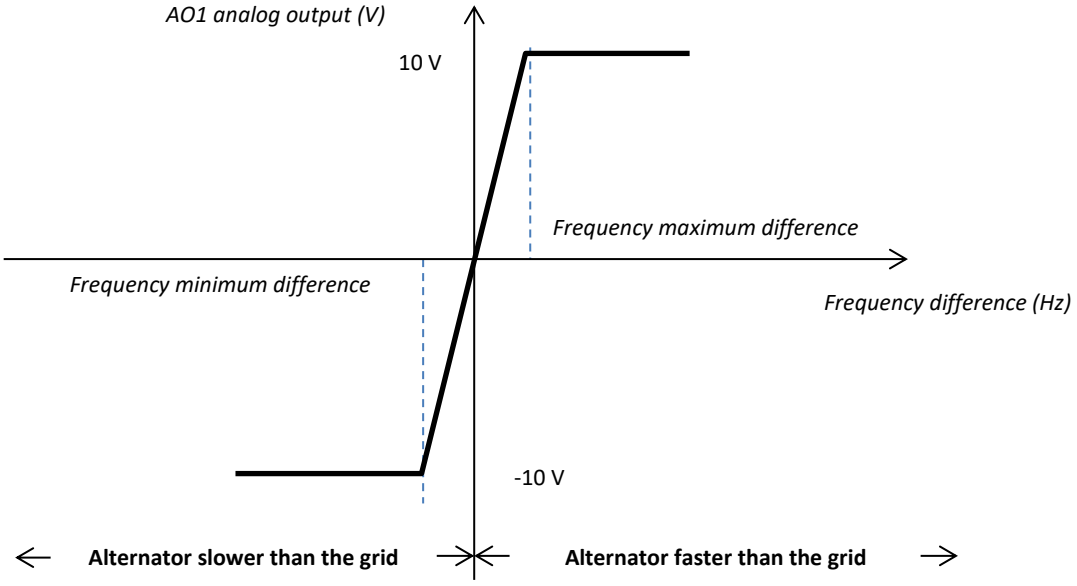
The possible synchronization pulse remains active as long as the frequency difference and voltage difference are in the range defined by the upper and lower limits. A latch should therefore be provided for closing the grid connection contactor.

The frequency difference can be used to control an analog output so as to inform the genset controller (or any other control device), that the driving system frequency needs to be increased or decreased. The parameters should be set in the "I/O" page. Example for a frequency difference between -0.5 Hz and +0.5 Hz[22].

Analog Outputs

Source	Configuration	0% value	100% value	Analog Output
Delta frequency for synchronisation	+/-10V	-0.5	0.5	AO1

This gives us the following diagram:



[22] The minimum and maximum upper and lower limits for this signal can be swapped.

4.3.17. Grid code

Grid code function allows activating one or several devices to detect faults coming from the grid, as LVRT events (Low Voltage Ride Through) or FRT (Fault Ride Through). These events can damage the generator. 4 independent functions are embedded in the D700:

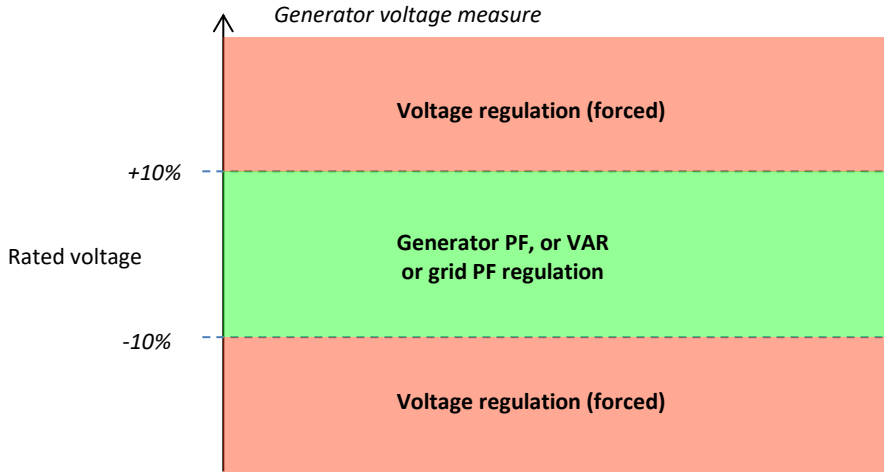
- Voltage measurement monitoring for grid code fault
- Grid code profile monitoring
- Pole slipping monitoring
- Maximum stator current monitoring

It allows also saving some parameters as generator voltage measure, generator current measure, internal angle (if a coder is wired)

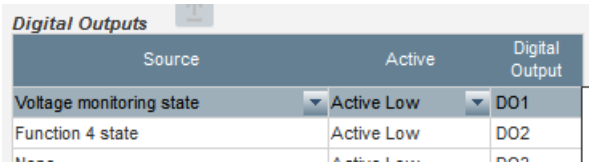
4.3.17.1. Voltage measurement monitoring

This device is active selecting "Enable voltage monitoring in PF mode". Implement delay before switch in voltage mode (in ms) and the voltage difference in percentage of the rated grid voltage.

With this device, the D700 will force voltage regulation mode to sustain the grid absorbing or producing reactive power in case of the voltage measured at generator terminals is out of the limited range. In the case below with a difference of 10%:

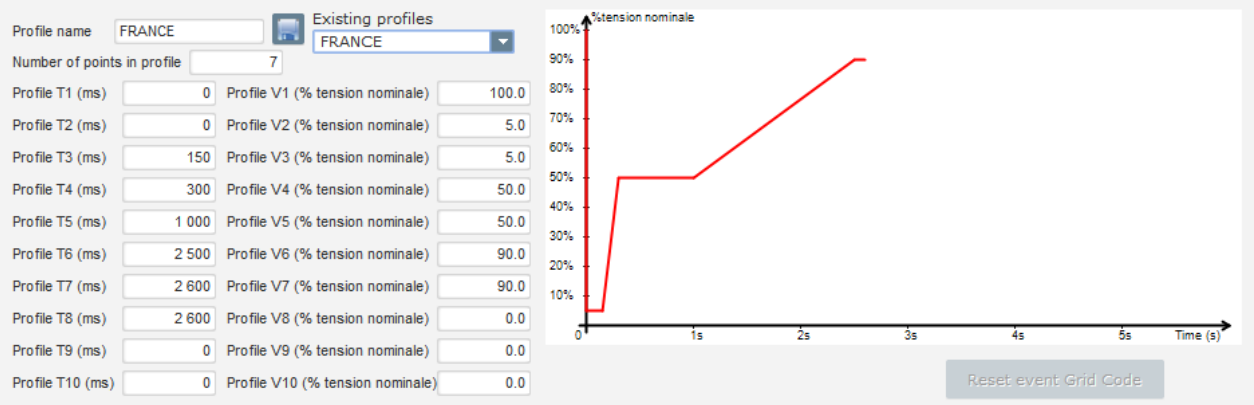


Status of this monitoring can be affected to a logical output or used in logical functions. Below an example with this fault addressed on output DO2 in "Inputs/Outputs page"

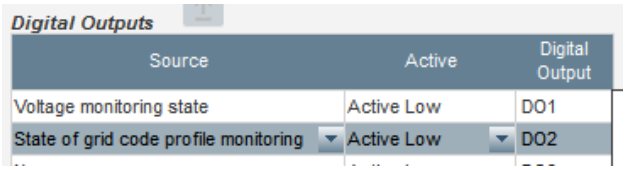


4.3.17.2. Grid code profile monitoring

This device is activated selecting "Enable grid code profile monitoring". It's also imperative to fill values of the profile, imposed by the grid code standard applied in the location where the D700 is implemented. It allows monitoring that generator voltage is always at least greater or equal to the value given in the profile, as soon as the grid code event is started. If the voltage is lower than the value determined by the profile, the fault is activated.



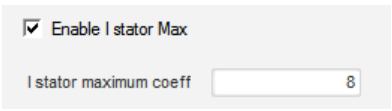
Status of this monitoring can be affected to a logical output or used in a logical function. Below an example with this fault addressed on DO2 in "Inputs/outputs" page.



4.3.17.3. Stator current monitoring

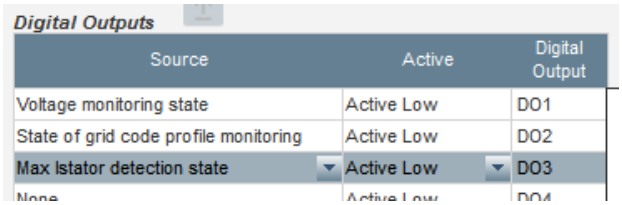
This device is activated by selecting "Enable I stator Max" and giving values for maximum current that can stand the generator (in times of rated stator current). Such an over current can occur when the grid reappear after a grid code fault, if the difference between angular position of the rotor and electric angle is too much important.

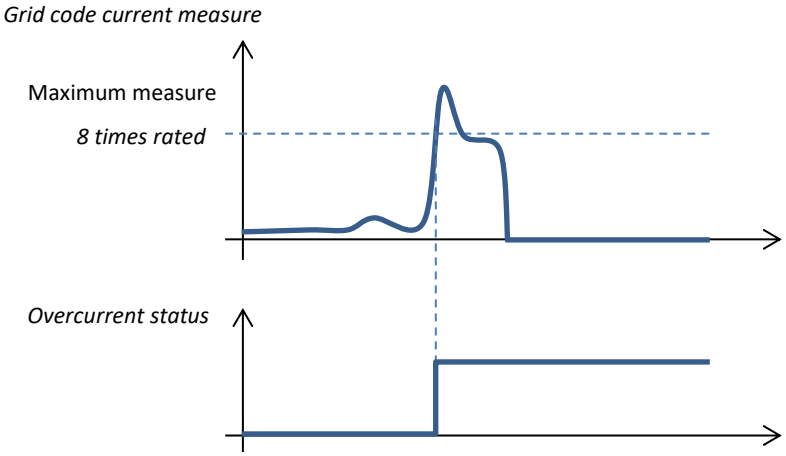
Measure of overcurrent is realized with a dedicated CT connected on "Grid code" CT input. Values for the primary and the secondary have to be set in "Wiring" page. Here an example with a coefficient set at "8"



NOTE: as the overcurrent is very fast, the fault status won't be an auto reset fault

The overcurrent status can be affected to an output or used in a logical function. Below, an example with this fault affected on DO3 in "Inputs/outputs" page





4.3.17.4. Pole slipping monitoring

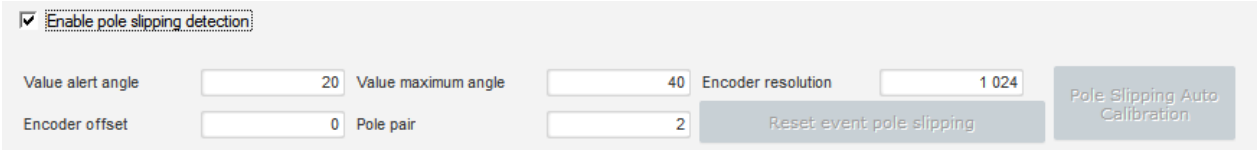
This monitoring system is possible only if an encoder is wired and installed on the D700 on the encoder input

This function is activated by selecting "Enable pole slipping detection" and giving values for the different parameters:

- Alert angle value (in degrees)
- Maximum angle value
- Encoder resolution in points
- Encoder offset
- Number of generator pole pairs

The internal angle monitoring, when grid voltage is significantly reduced or lost, controls that the generator internal angle does not exceed a defined value. Indeed, if the internal angle is shifted, when the grid reappears, important mechanical and electrical damages can occur, and can lead to destruction of some elements in the generator.

An auto-calibration function for pole slipping is also possible



The pole slipping status can be affected to an output or used in a logical function.

4.4. Comparison window

This window is available by clicking on the button in the home page banner:

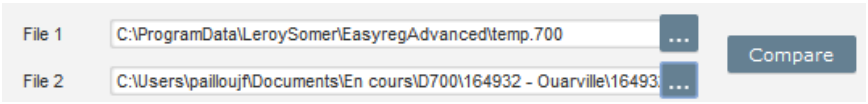
The “Comparison” is used to:

- **Compare the D700 configuration with a file**
  - Click on the file 1 “…” button to select the configuration file.

  - Click on the “Run the comparison between the AVR and the file…" button.
  - The modified parameters appear in the list below.

Paremeter Number	Parameter name	Open file value	AVR Value	Unit
002.001	Automatic Voltage Regulation	Active		
002.002	Volt Matching Regulation	Not active		
002.003	Field Current Regulation	Not active		
002.004	Generator PF Regulation	Active		
002.005	VAR Regulation	Not active		
002.006	Grid PF Regulation	Not active		
002.007	Droop Enable	Active		
002.008	Cross Current Enable	Not active		
002.009	Line Drop Compensation Enable	Not active		
002.010	Stator current Limit Enable	Not active		

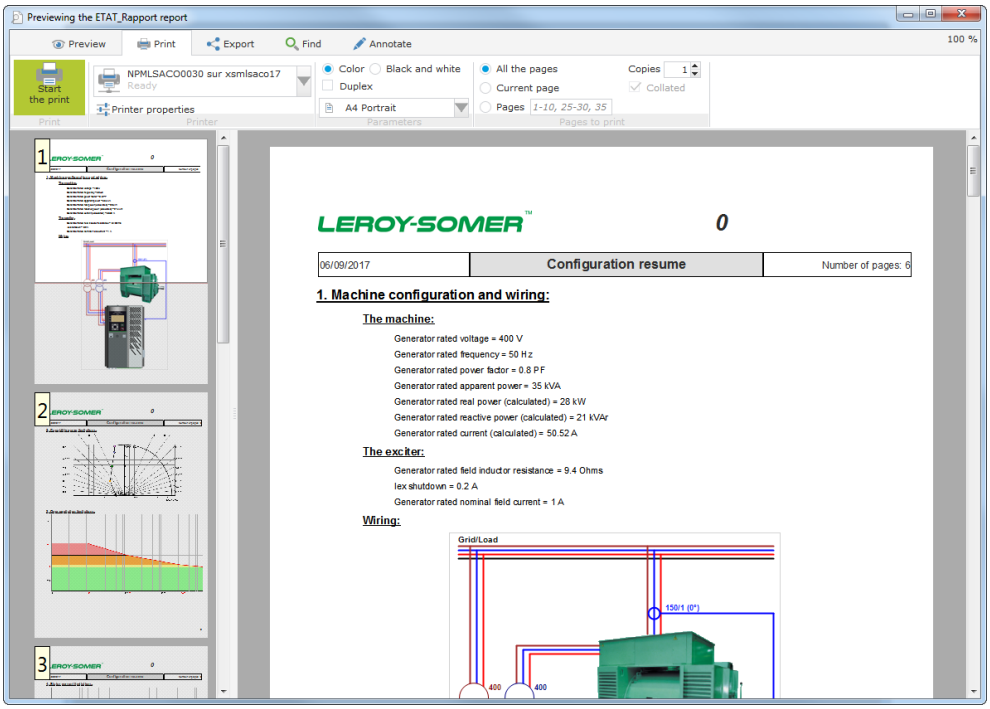
- **Compare two configuration files**
  - Click on the file 1 “…” button to select the first configuration file.
  - Click on the file 2 “…” button to select the second configuration file.
  - Click on the “Compare” button on the right.



  - The modified parameters appear in the list.

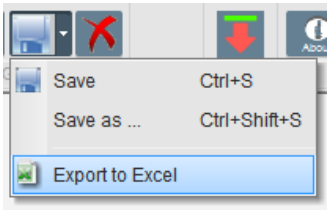
4.5. Print reports

A resume of the configuration as a report is possible using "Print" button (this one is active only if settings page is open). This report indicates configuration data of the regulator. A form is open and this report can be printed or/and exported in another format.



4.6. Excel Export

Configuration can be exported as an excel file by a click on the Save button arrow:



The file created contains each parameter with:

- Identifier (Id),
- Parameter name,
- Minimum value,
- Maximum value,
- Value
- Default value
- Unit

Values in grey are read only, others are in read/write.

Id	Parameter name	Minimum value	Maximum value	Value	Initial value	Unit
000.000	Monitor Menu					
000.001	U	0	100000	0	0	V
000.002	I	0	10000	0.0	0	A
000.003	P	0	1000000	0	0	kW
000.004	PF	-1	1	0.000	0	PF
000.005	F	0	500	0.0	0	Hz
000.006	U21	0	100000	0	0	V
000.007	U32	0	100000	0	0	V
000.008	U13	0	100000	0	0	V
000.009	I1	0	10000	0.0	0	A
000.010	I2	0	10000	0.0	0	A
000.011	I3	0	10000	0.0	0	A
000.012	Q	0	1000000	0	0	kVAR
000.013	S	0	1000000	0	0	kVA
000.014	If	0	50	0.00	0	A
000.015	Vf	0	500	0.0	0	V
000.016	Vbus	0	500	0.0	0	V
001.000	SystemData					
001.001	Voltage UN	0	100000	44	0	V
001.002	Voltage VN	0	100000	44	0	V
001.003	Voltage WN	0	100000	45	0	V
001.004	Voltage UV	0	100000	77	0	V
001.005	Voltage VW	0	100000	77	0	V
001.006	Voltage WU	0	100000	77	0	V
001.007	Line Current U	0	10000	5.2	0	A

5. Maintenance instructions

5.1. Warning symbols

See section *1.4. Safety devices and general warning symbols*".
Preventive maintenance on the D700 AVR should be performed with the alternator stopped, and all power sources switched off and isolated.

5.2. Preventive maintenance instructions

During phases of alternator downtime for preventive maintenance, check that the wires are tight in the connectors (tightening torque between 0.6 Nm and 0.8 Nm), blow dry air through to get rid of any dust that may have settled on and around the D700. Special care should be taken to ensure free circulation of air around the aluminum heatsink at the back of the device.

The D700 has a timer, accessible via parameter 254.008 (parameter 8 of menu 254) (in hours and minutes). Keep an eye on the running time and if this exceeds 40,000 hours, consider changing the AVR.

NOTE: This timer is only incremented every 10 minutes, and only if the voltage reference is reached.

6. Reycling instructions

LEROY-SOMER and KATO ENGINEERING are committed to minimizing the environmental impacts of its manufacturing operations and of its products throughout their life cycle. To this end, we operate an Environmental Management System (EMS) which is certified to the International Standard ISO 14001.

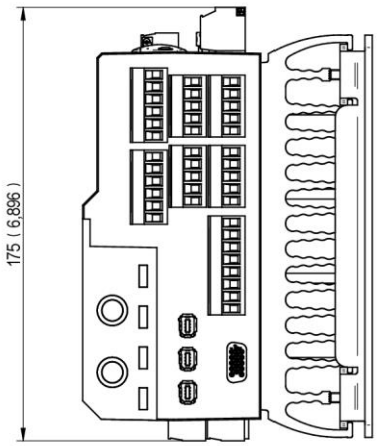
The automatic voltage regulators manufactured by LEROY-SOMER and KATO ENGINEERING have the potential to save energy and (through increased machine/process efficiency) reduce raw material consumption and scrap throughout their long working lifetime. In typical applications, these positive environmental effects far outweigh the negative impacts of product manufacture and end-of-life disposal.

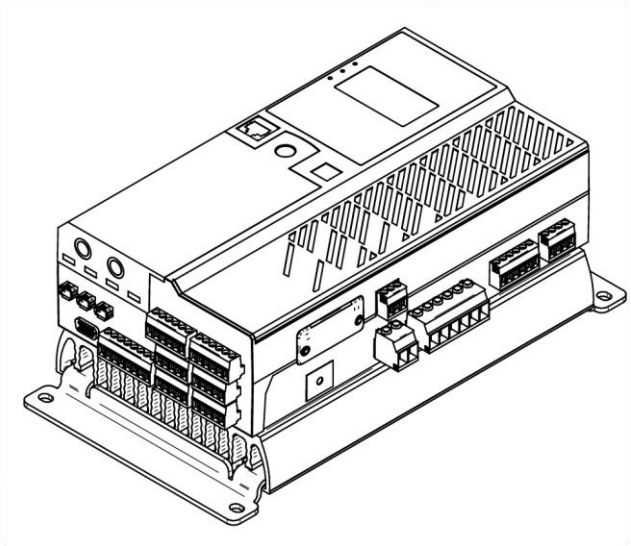
Nevertheless, when the products eventually reach the end of their useful life, they must not be discarded but should instead be recycled by a specialist recycler of electronic equipment. Recyclers will find the products easy to dismantle into their major component parts for efficient recycling. Many parts snap together and can be separated without the use of tools, while other parts are secured with conventional fasteners. Virtually all parts of the product are suitable for recycling.

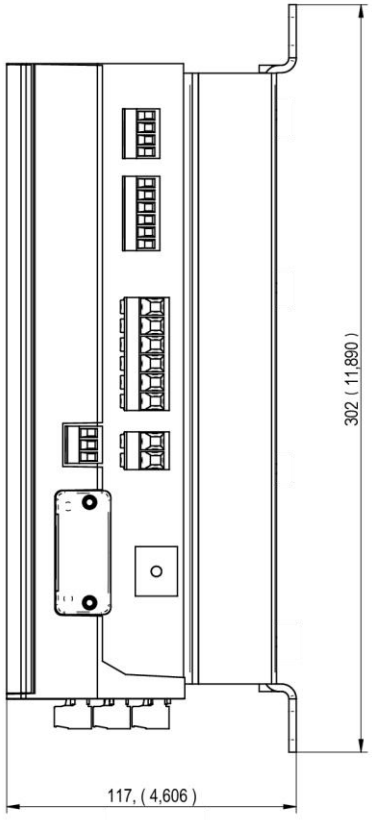
Product packaging is of good quality and can be re-used. Large products are packed in wooden crates; while smaller products come in strong cardboard cartons which themselves have high recycled fiber content. If not re-used, these containers can be recycled. Polythene, used on the protective film and bags for wrapping product, can be recycled in the same way. When you will be preparing to recycle or dispose of any product or packaging, please observe local legislation and best practice.

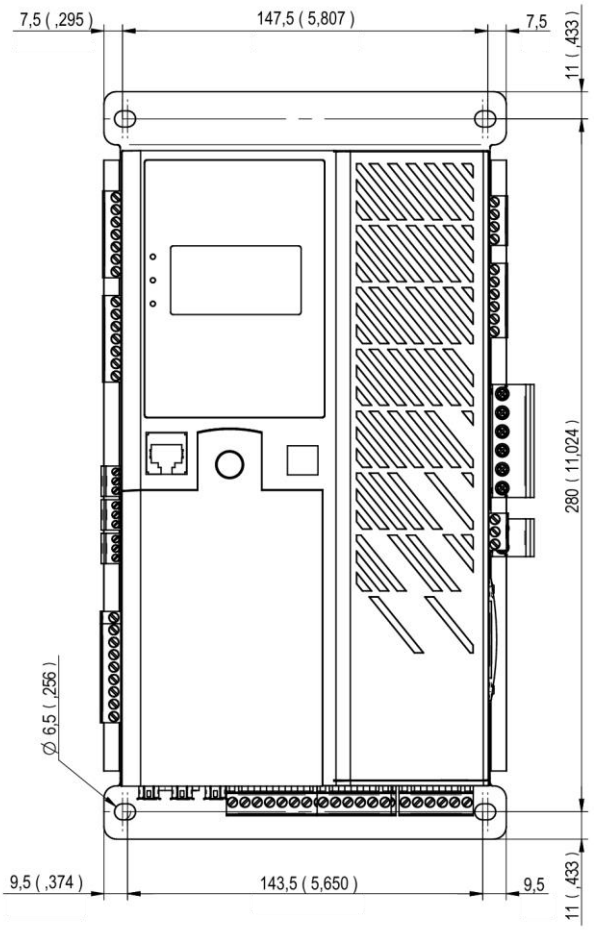
7. APPENDICES

7.1. Diagram of D700 with standard support plates

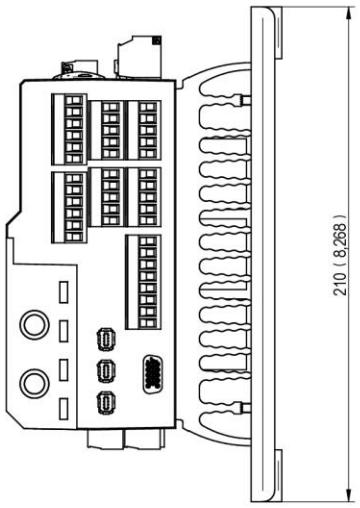


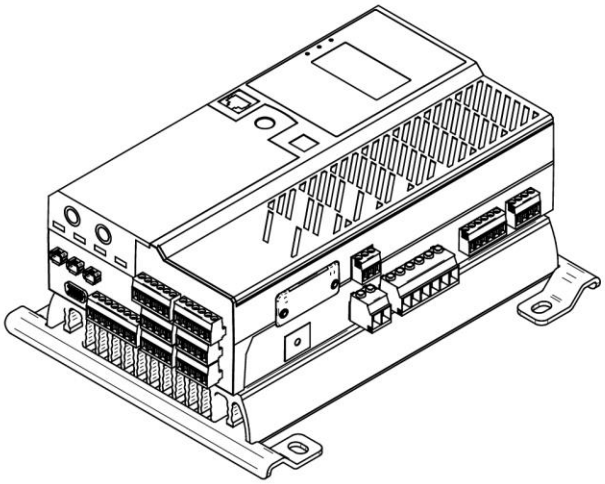


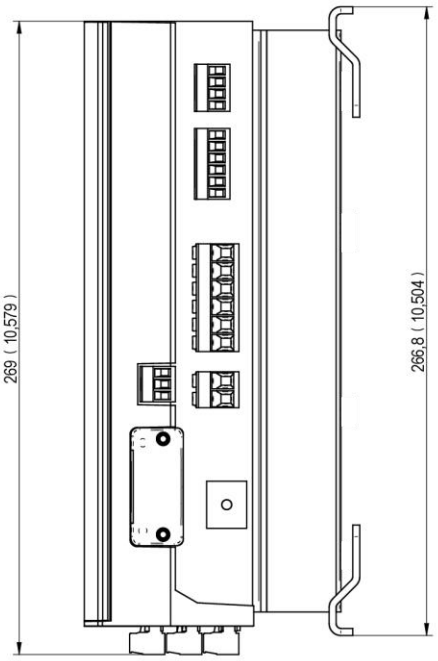


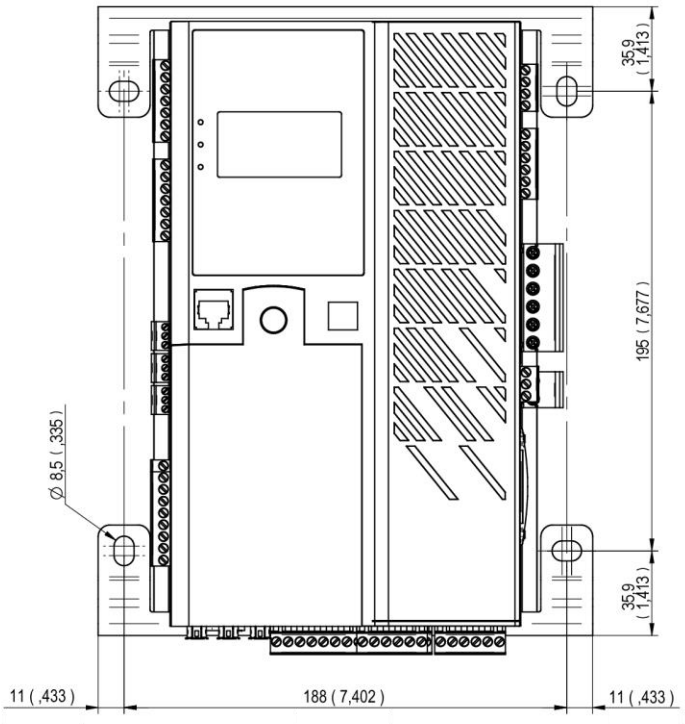


7.2. Diagram of D700 with variant plates









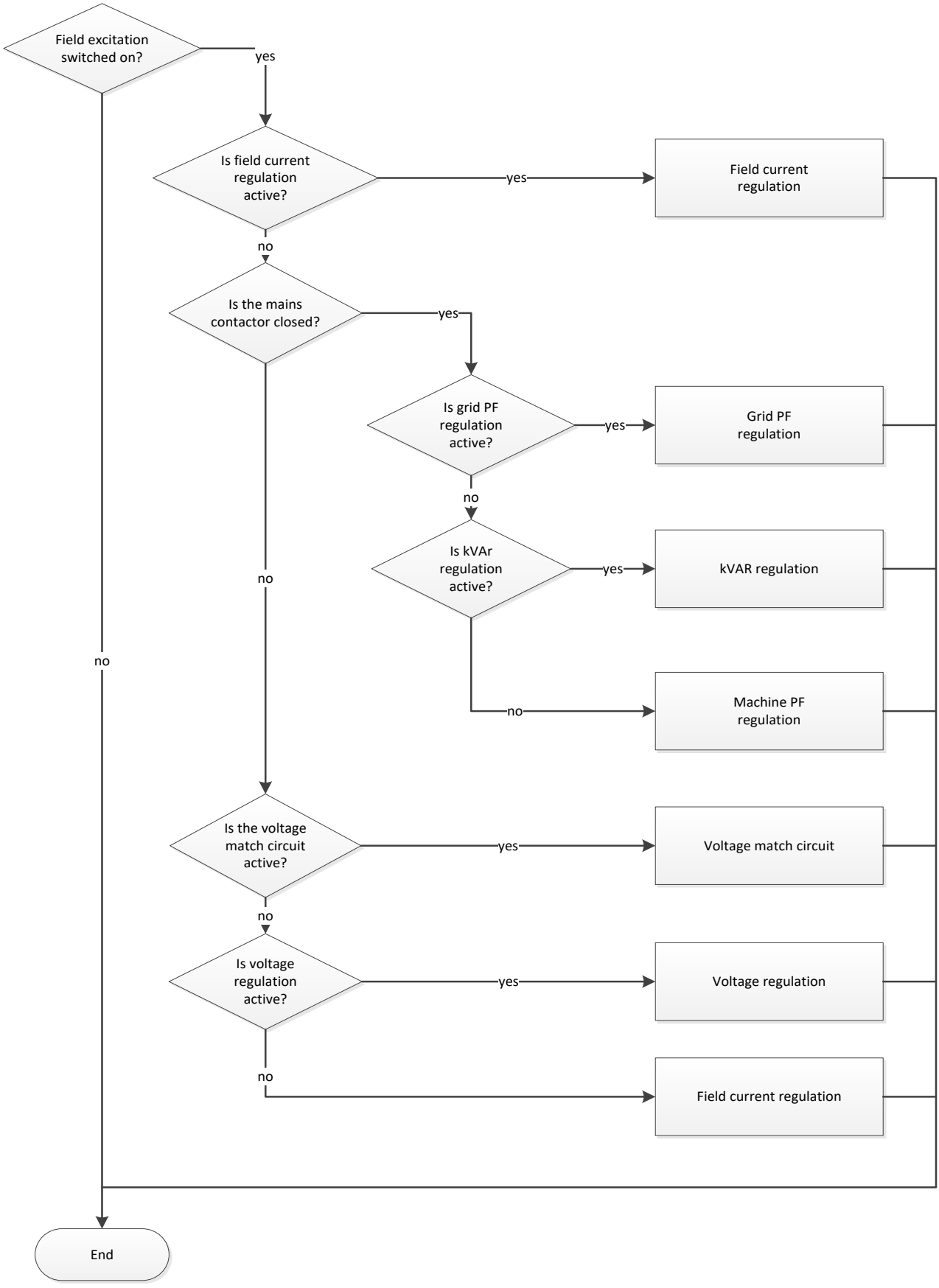
7.3. Vector permutations

If only one stator current measurement CT is wired up, the vector permutations can compensate for voltage measurement and current measurement transformer layouts which generate incorrect power and power factor (cos phi) calculations.

The D700 wiring then needs to be altered. The table below gives the possible permutations according to the phase used for the stator current measurement CT.

Position of stator current measurement CT	Alternator direction of rotation (a/c IEC 60034-1).	Alternator voltage measurement			
		AVR terminals	U	V	W
Phase V (standard)	Clockwise	Alternator phases (three-phase measurement)	U	V	W
		Alternator phases (phase/phase single-phase measurement)	U	-	W
	Anti-clockwise	Alternator phases (three-phase measurement)	W	V	U
		Alternator phases (phase/phase single-phase measurement)	W	-	U
Phase U	Clockwise	Alternator phases (three-phase measurement)	W	U	V
		Alternator phases (phase/phase single-phase measurement)	W	-	V
	Anti-clockwise	Alternator phases (three-phase measurement)	V	U	W
		Alternator phases (phase/phase single-phase measurement)	V	-	W
Phase W	Clockwise	Alternator phases (three-phase measurement)	V	W	U
		Alternator phases (phase/phase single-phase measurement)	V	-	U
	Anti-clockwise	Alternator phases (three-phase measurement)	U	W	V
		Alternator phases (phase/phase single-phase measurement)	U	-	V

7.4. AVR priority



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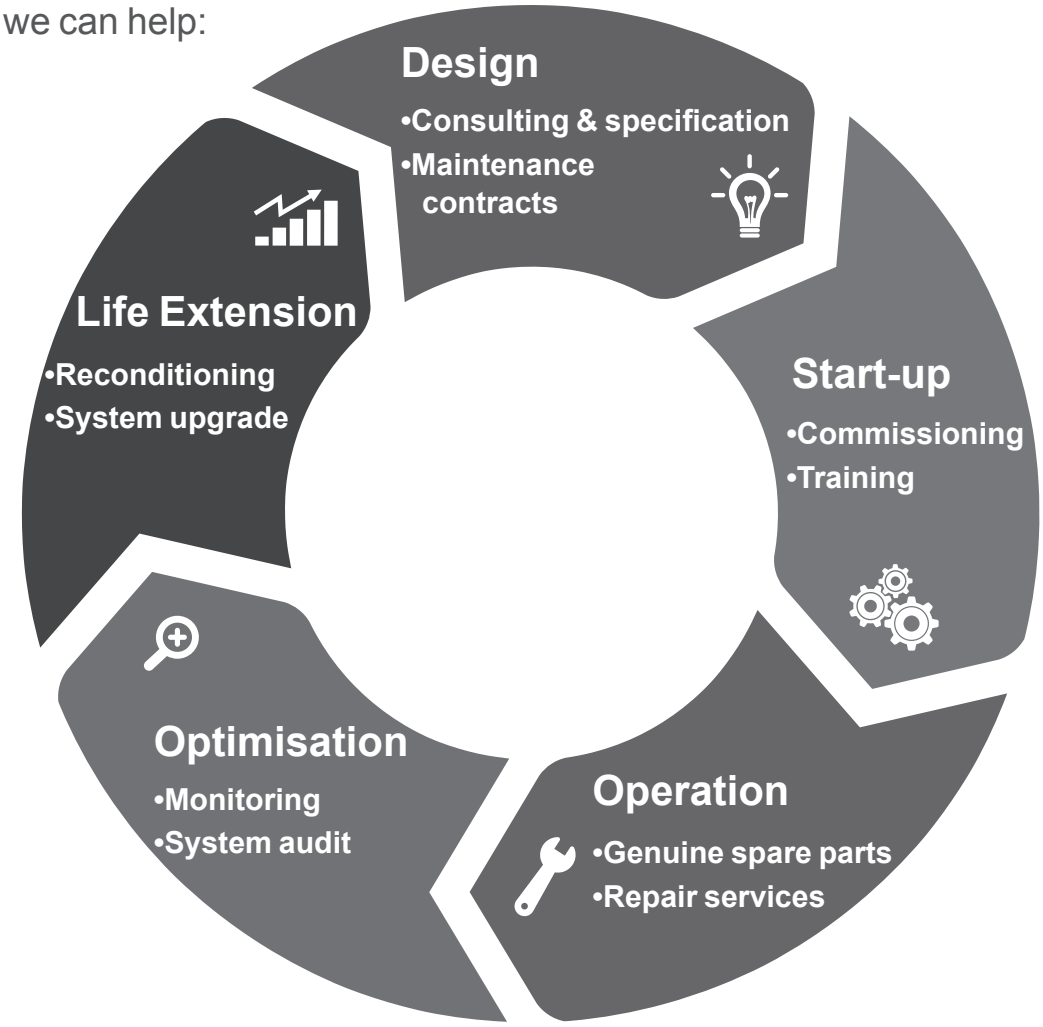

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