



# LX321

*Voltage regulator for generators*

**Instruction Manual V1.2.1**

Product version V2.2.1.0

# WARNINGS AND COMMISSIONING INFORMATION



## HAZARDOUS VOLTAGES.



### DO NOT OPERATE WHEN NOT FAMILIAR WITH GENERATORS.

- **Check the isolation of the generator windings before installation. Poor isolation will cause damage to the AVR and dangerous situations for persons.**
- The system should not be installed, operated, serviced or modified except by qualified personnel who understand the danger of electric shock hazards and have read and understood the user instructions.
- Never work on a LIVE generator. Unless there is another person present who can switch off the power supply or stop the engine.
- Dangerous voltages are present at the voltage regulator board. Accidental contact with live conductors could result in serious electrical shock or electrocution.
- Disconnect the power source before making repairs, connecting test instruments, or removing or making connections to the voltage regulator or generator.
- Defects in the generator or AVR may cause consequential loss. Precautions must be taken to prevent this from occurring.
- The unit should be installed with respect to the environmental specifications as well as the rules mentioned in the General installation information.
- For safety reasons the voltage level potentiometers are best turned completely counter clockwise in order to start at the lowest possible voltage.
- Never change the rotary switch or dipswitch settings during operation.
- Never apply supply voltage when generator is not running, unless exciter field is disconnected.

## REVISION HISTORY

| Product         | Version  |          |        | Change                                                                                                                                                                      |
|-----------------|----------|----------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | Hardware | Software | Manual |                                                                                                                                                                             |
| <b>V2.0</b>     | 1.3      | 3.0      | 1.0    | <i>Range setpoint: Voltage, Droop, Prop action &amp; int action. Function OPT header. Function and specification TH header. Setpoint and protection of over excitation.</i> |
| <b>V2.1.0.0</b> | 1.3      | 5.0      | 1.1    | <i>Bugfix constant voltage control influence at A1-A2.</i>                                                                                                                  |
| <b>V2.2.0.0</b> | 1.3.1    | 5.1      | 1.2    | <i>Manual new layout. Minor hardware improvement. Added function: VPH Mode and Minimum excitation at cosphi.</i>                                                            |
| <b>V2.2.1.0</b> | 1.3.1    | 5.2      | 1.2.1  | <i>Bugfix negative AVR temperature.</i>                                                                                                                                     |

The table provides a historical summary of the changes made to the AVR.

Revisions are listed in chronological order.

**Previous version with software version V2.8 or lower are not 1:1 exchangeable. See manual for changes.**

The manual does not cover all technical details of the product. Specifications may be modified by the manufacturer without notice. For further information, the manufacturer should be contacted.

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## GENERAL DESCRIPTION

The LX321 is designed as a replacement for the MX321, providing optimal flexibility and configurability as is reflected by the additional capabilities of the AVR.

Nevertheless installation, maintenance and adjustment don't require special application software. The AVR is protected from the environment by a PUR coating.

| Mode of control                                          | MX321 | LX321 |
|----------------------------------------------------------|-------|-------|
| Volt per Hertz control                                   |       | ✓     |
| Constant voltage control                                 | ✓     | ✓     |
| Power factor control (PFC)                               |       | ✓     |
| 0-100% generator current control                         |       | ✓     |
| 0-100% generator voltage control                         |       | ✓     |
| Quadrature voltage droop for parallel operation          | ✓     | ✓     |
| Current control (Current limiting / Limited motor start) |       | ✓     |
| Protection                                               |       |       |
| Generator phase loss & phase sequence                    |       | ✓     |
| AVR over temperature                                     |       | ✓     |
| Generator over temperature                               |       | ✓     |
| Generator over voltage                                   | ✓     | ✓     |
| Generator over current                                   | ✓     | ✓     |
| Generator over excitation                                | ✓     | ✓     |
| Loss of excitation during PFC                            |       | ✓     |
| Loss of current sensing during PFC                       |       | ✓     |
| User adjustable underspeed knee                          | ✓     | ✓     |
| User adjustable over excitation current                  |       | ✓     |
| User adjustable generator current limit                  |       | ✓     |
| Communication                                            |       |       |
| AVR Status LED                                           | ✓     | ✓     |
| AVR Status contact                                       |       | ✓     |
| CAN bus                                                  |       | ✓     |

| Options           |                                                  | Terminals     |
|-------------------|--------------------------------------------------|---------------|
| DROOPKIT          | Required for parallel operation                  | S1 – S2 (W)   |
| DROOPCAT          | Required for current limiting                    | S1 – S2 (U)   |
| LX_VMA            | Required for voltage matching                    | A1 – A2       |
| LX_TRIP CB + COIL | Over voltage trip protection                     | B0 – B1       |
| AVR Assistant     | Handheld programming and monitor device          | CAN           |
| DFD7.5            | Diode failure detector                           | Separate unit |
| RunDect           | Motor stall protection & End of run-up detection | Separate unit |

# ABSOLUTE MAXIMUM RATING

| Symbol           | Parameter                        | Condition                                                                    | Min.    | Max.   | Unit            |
|------------------|----------------------------------|------------------------------------------------------------------------------|---------|--------|-----------------|
| 6, 7, 8          | Voltage sensing input            | 50 - 60Hz, Intermitted < 30s.                                                | -       | 260    | V <sub>AC</sub> |
| X, XX            | AVR field current                | Intermitted < 10s. <sup>(1)</sup>                                            | -       | 10     | A <sub>DC</sub> |
|                  | Field resistance<br>X(+), XX(-)  | @ 70V <sub>AC</sub> supply <sup>(4) (5)</sup><br>@ 170V <sub>AC</sub> supply | 5<br>12 | -<br>- | Ω               |
| P2, P3, P4       | Supply input (PMG)               | Isolated, DC or 25 - 200Hz.                                                  | 20      | 240    | V <sub>AC</sub> |
|                  |                                  |                                                                              | 22      | 135    | V <sub>DC</sub> |
| A1, A2           | Accessories input <sup>(2)</sup> | A1(-), A2(+) <sup>(3)</sup>                                                  | -5      | +10    | V <sub>DC</sub> |
| S1, S2 (W)       | Droop and PF CT                  | Isolated CT > 2VA, Intermitted < 30s.                                        | -       | 1      | A <sub>AC</sub> |
| S1, S2 (U)       | Current Limit CT                 | Isolated CT > 2VA, Intermitted < 30s.                                        | -       | 3      | A <sub>AC</sub> |
| T <sub>AMB</sub> | Operating temperature            | 95% RHD non condensing <sup>(1)</sup>                                        | 0       | +70    | °C              |
| T <sub>STG</sub> | Storage temperature              | 95% RHD non condensing                                                       | -40     | +85    | °C              |
|                  | Static control accuracy          |                                                                              |         | 1      | %               |

<sup>(1)</sup> Always mount with heatsink fins aligned vertically and allow for sufficient airflow.

<sup>(2)</sup> Isolated input.

<sup>(3)</sup> Input resistance is 1KΩ.

<sup>(4)</sup> See table below for safe operation area of the AVR.

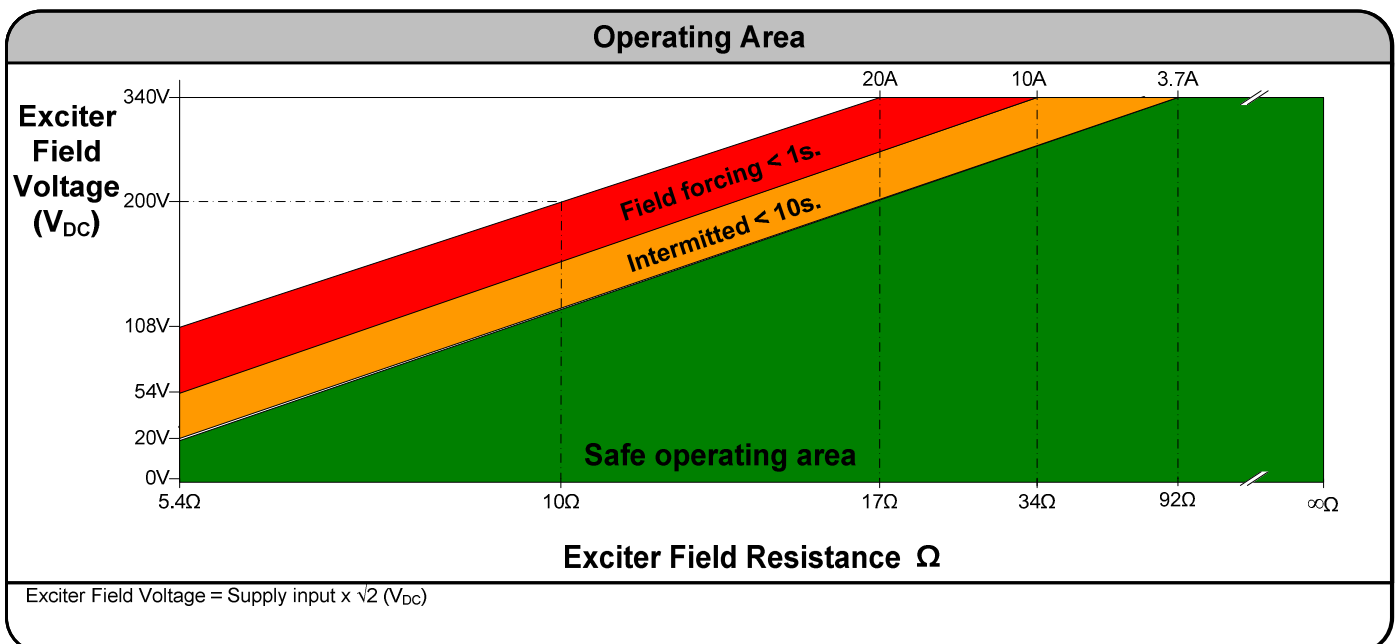
<sup>(5)</sup> See formula for calculating minimum field resistance.



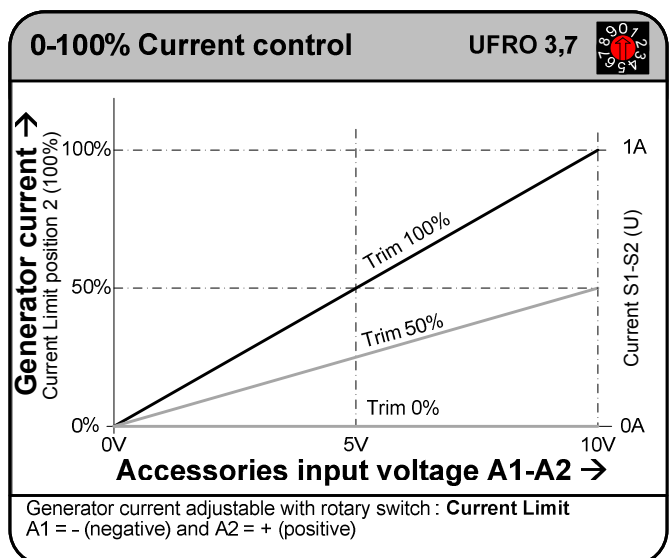
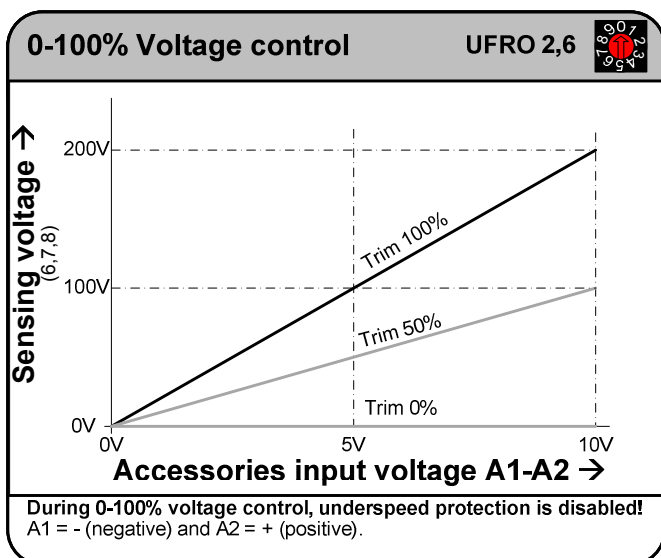
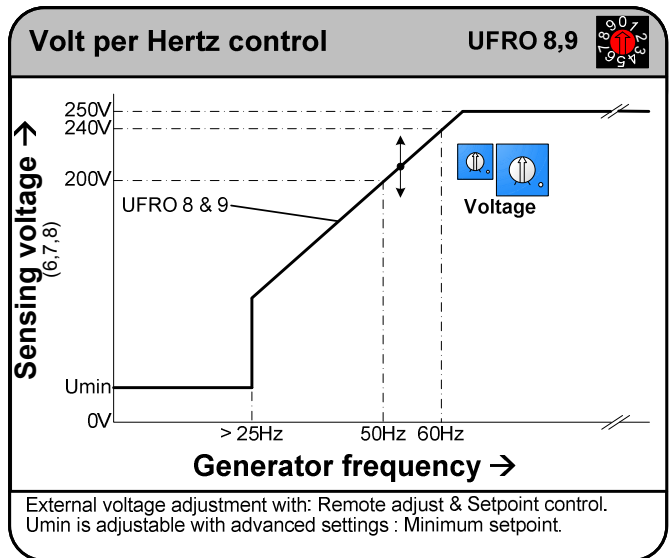
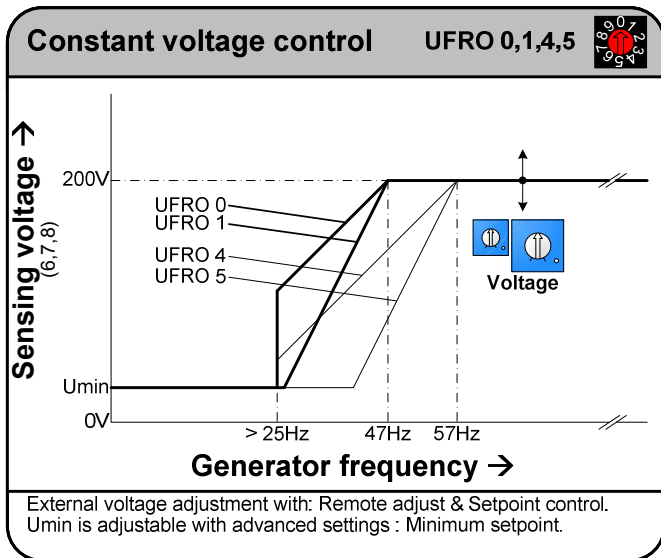
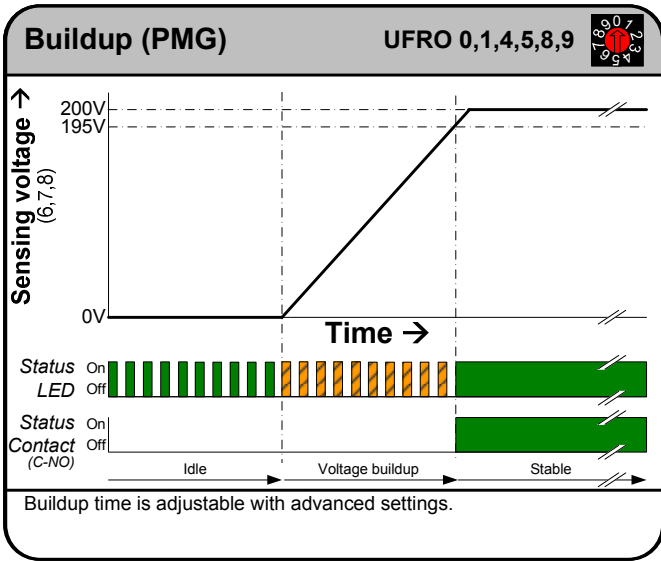
$$\text{Field resistance } (\Omega) \geq \frac{\text{Supply input} \times \sqrt{2} \text{ (V}_{\text{DC}}\text{)}}{20}$$



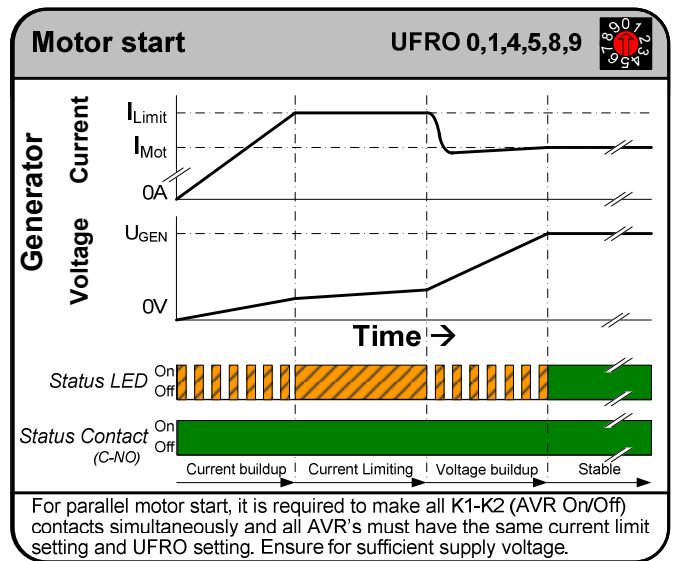
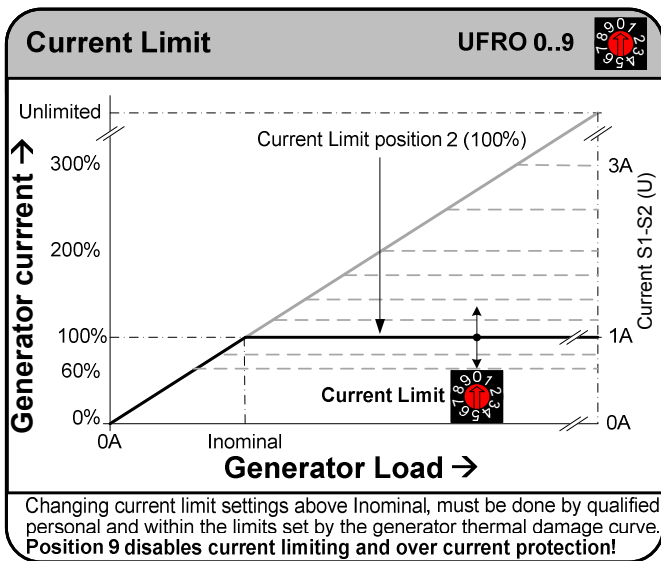
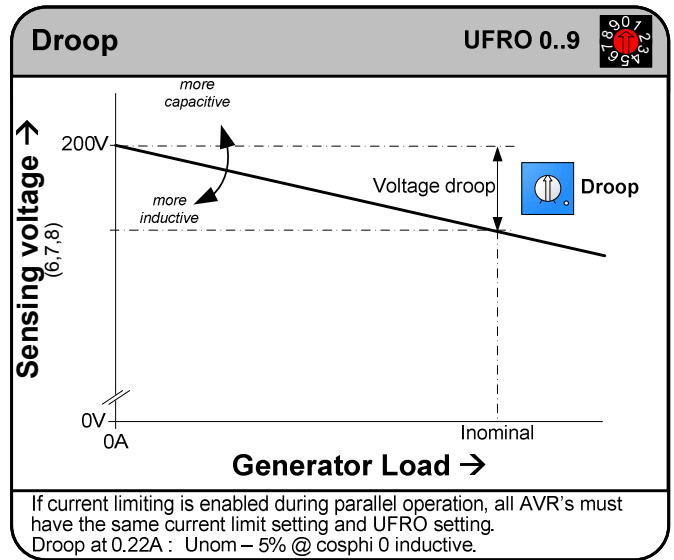
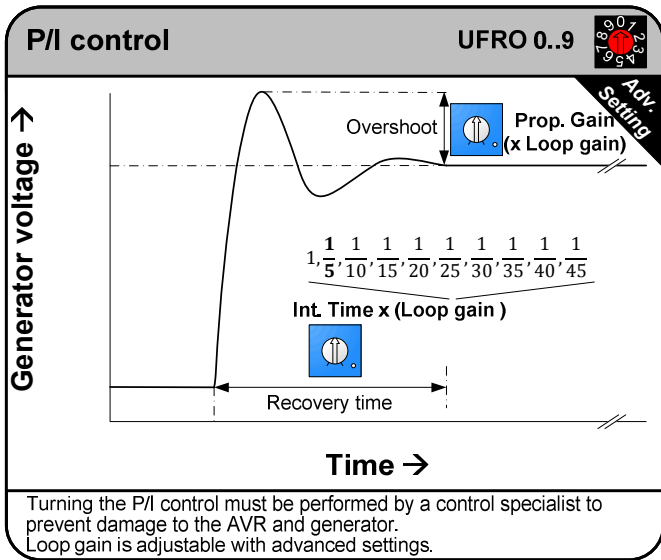
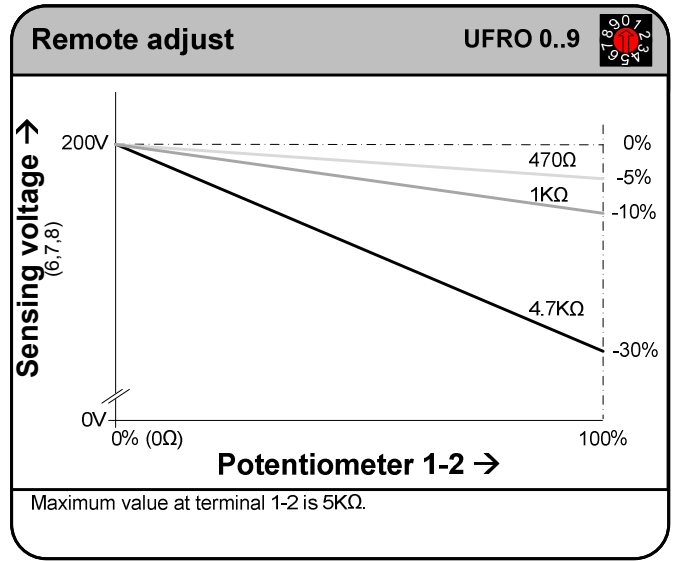
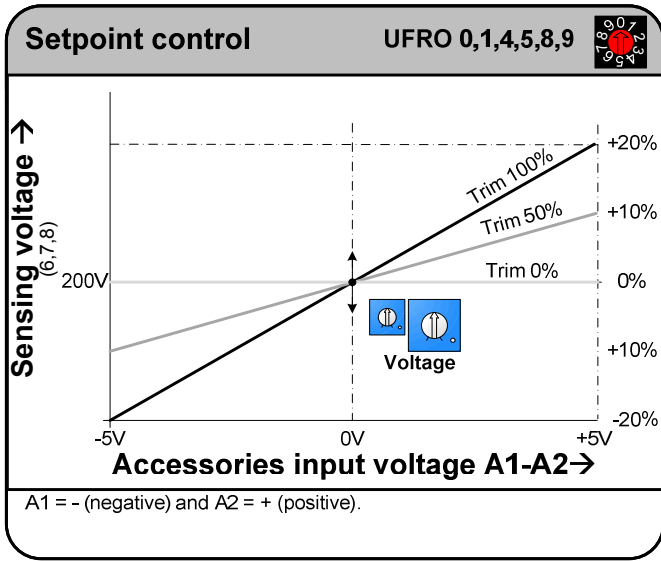
Stresses above “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only, the functional operation of the device or any other conditions indicated in the “operation area” of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability and lifetime.



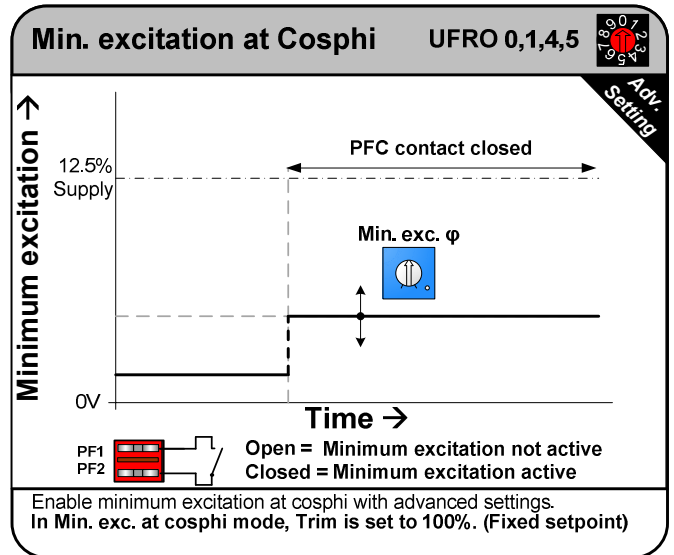
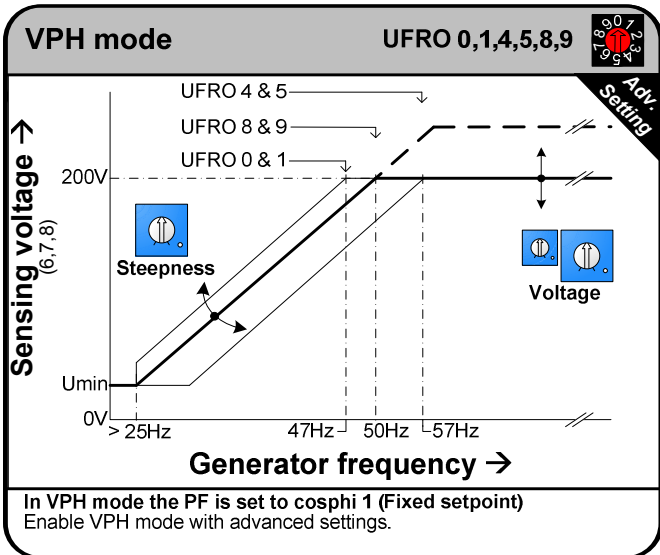
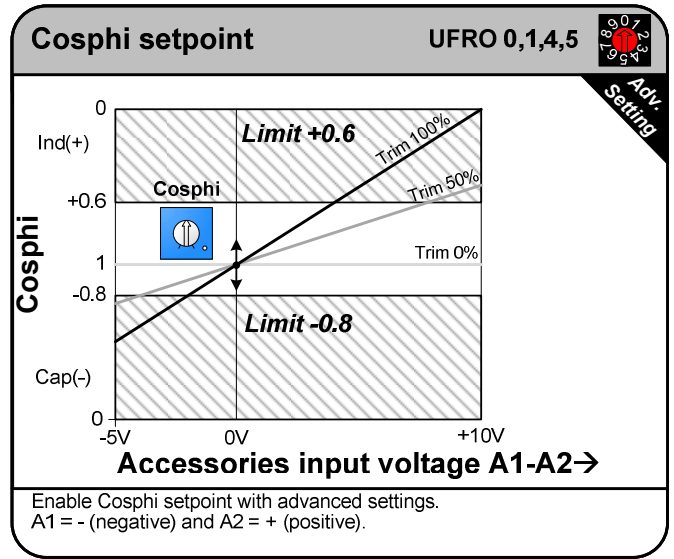
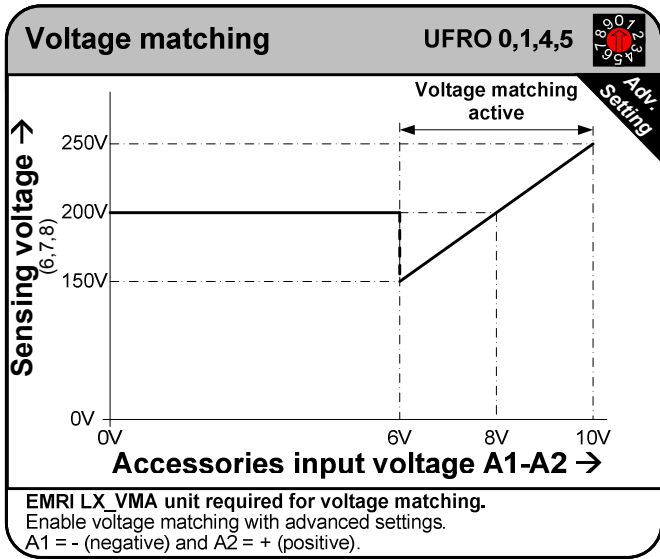
# MODES OF CONTROL I



# MODES OF CONTROL II



# MODES OF CONTROL III



# QUICK REFERENCE I

**Voltage**

**Coarse**  
200V  
150V 250V

**Fine**  
-3V +3V

**Stability**

**Prop. Gain**  
(x Loop gain)

**Int. time**  
(x Loop gain)  
Fast Slow

**Droop**

0% 100%

**Current Limit**

0 = 60% 5 = 175%  
1 = 80% 6 = 200%  
2 = 100% 7 = 250%  
3 = 125% 8 = 300%  
4 = 150% 9 = Unlimited

**Cosphi / Steepness**

**Normal mode**  
0.8 Cap 0.6 Ind  
**Cosphi**

**VPH mode**  
3V/Hz 17V/Hz  
**Steepness**

**Exc. Trip**

1A 6A

**Trim / Min. exc.  $\varphi$**

**Normal mode**  
0% 100%  
% of input A1-A2  
**Trim**

**Min. Exc. at Cosphi**  
0% 12.5%  
% of AVR supply  
**Min. exc.  $\varphi$**

**UFRO**

**UFRO (Modes of control)**  
(Page 5,6,7)

|   |                                   | Underspeed          |      | Slope<br>@ Unom=400V |
|---|-----------------------------------|---------------------|------|----------------------|
|   |                                   | TH1 – TH2<br>Linked | Open |                      |
| 0 | Constant voltage control          | 47 Hz               | 57Hz | 8 V/Hz               |
| 1 | Constant voltage control          | 47 Hz               | 57Hz | 16 V/Hz              |
| 2 | 0-100% Voltage control with A1-A2 | -                   | -    | -                    |
| 3 | 0-100% Current control with A1-A2 | 47 Hz               | 57Hz | 8 V/Hz               |
| 4 | Constant voltage control          | 57 Hz               | 47Hz | 8 V/Hz               |
| 5 | Constant voltage control          | 57 Hz               | 47Hz | 16 V/Hz              |
| 6 | 0-100% Voltage control with A1-A2 | -                   | -    | -                    |
| 7 | 0-100% Current control with A1-A2 | 57 Hz               | 47Hz | 8 V/Hz               |
| 8 | VPH (Volt per Hertz) control      | -                   | -    | 8 V/Hz               |
| 9 | VPH (Volt per Hertz) control      | -                   | -    | 8 V/Hz               |

**Factory settings**

Control mode : Constant voltage  
Sensing : 200V  
Underspeed : 47Hz. (slope 8V/Hz.)  
Droop : 0V  
Current Limit : Unlimited (Pos. 9)  
Exc. Trip : 6A  
Prop. Gain : 50%  
Int. Time : 50%  
Trim : 0%  
Cosphi : 1

**Link:**  
1-2, K1-K2, TH1-TH2, CAN1-CAN2

**Advanced settings**

Programming (Page 10,11)

**OPT1**  
**OPT2**

**Status contact**

Max. rating: 24Vdc/4Adc or 230Vac/10Aac

**In operation**  
NO  
C  
NC

**Fault**  
NO  
C  
NC

**Status Led**

|                      |                                       |
|----------------------|---------------------------------------|
| Green Blink          | Idle                                  |
| Orange Blink         | Buildup                               |
| Green Continuous     | Voltage control                       |
| Orange Continuous    | Current control<br>PF control         |
| Red Continuous       | Phase sequence<br>Underspeed (<25Hz.) |
| Green with Red blink | Error: (n) number of red blinks       |

| n | Error                                     |
|---|-------------------------------------------|
| 1 | Over voltage                              |
| 2 | Over current                              |
| 3 | Over excitation                           |
| 4 | AVR over temperature                      |
| 5 | Generator over temperature                |
| 6 | Phase loss or Phase sequence              |
| 7 | Loss of excitation during PF control      |
| 8 | Loss of current sensing during PF control |

**PF control**

PFC on/off

PF1  
PF2

**Temperature or Underspeed**

Temp. sensor (1k8..3k $\Omega$ )  
Underspeed selection 47/57 Hz.  
Link

TH1  
TH2

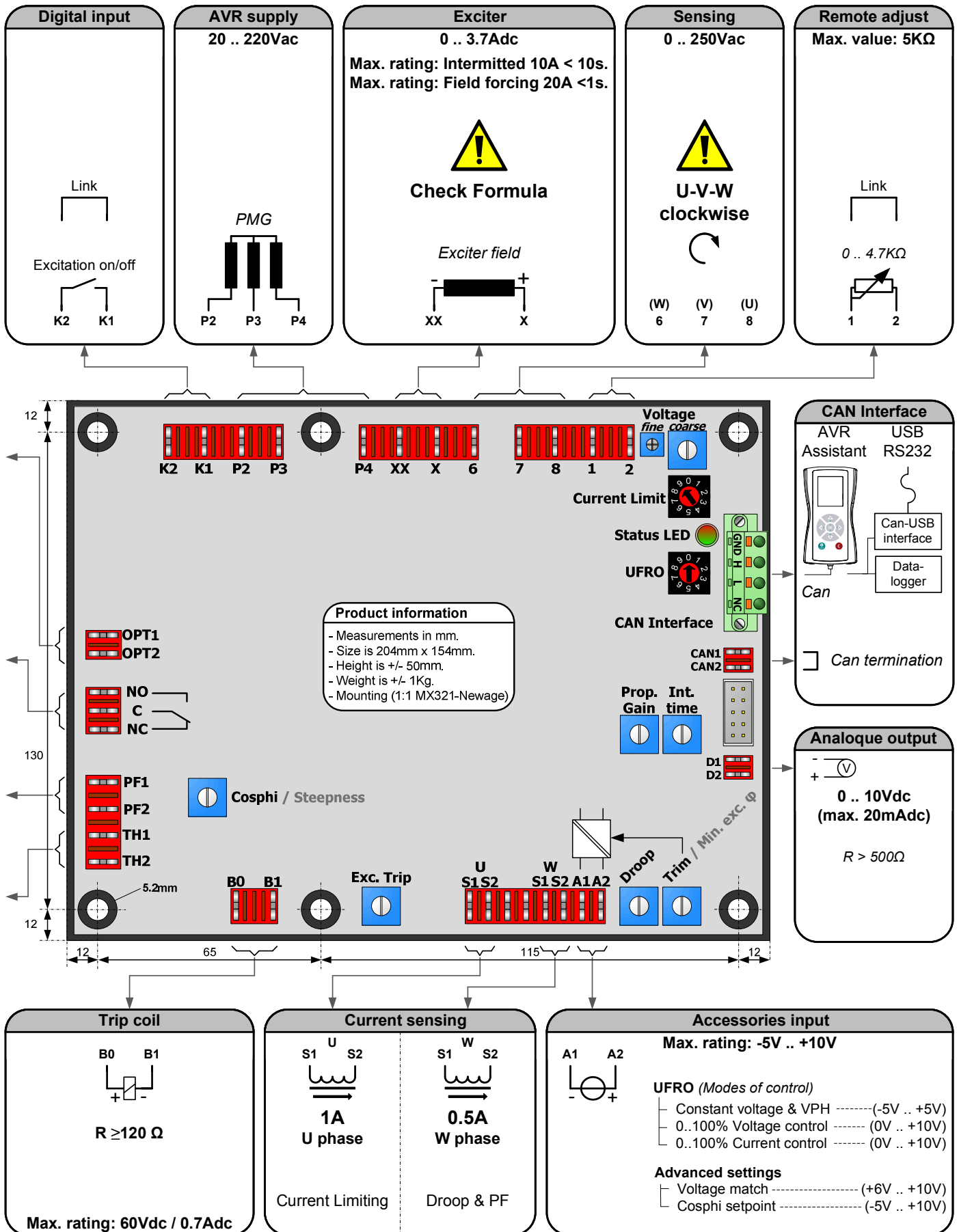
**Minimum Rfield**

**Formula**

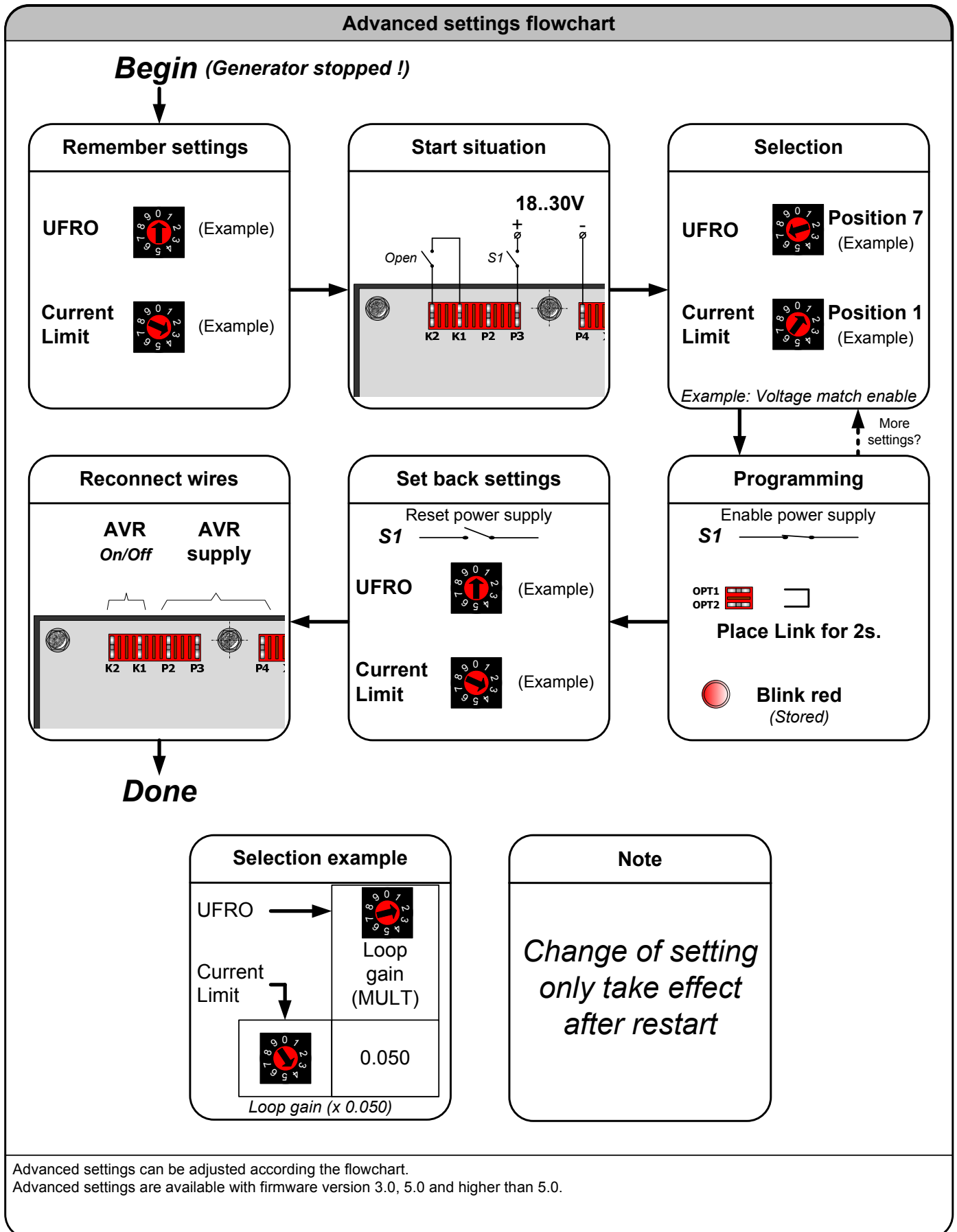
Minimum field resistance

Field resistance ( $\Omega$ )  $\geq \frac{\text{Supply input} \times \sqrt{2} (V_{DC})}{20}$



















# QUICK REFERENCE II



# ADVANCED SETTINGS I



# ADVANCED SETTINGS I I

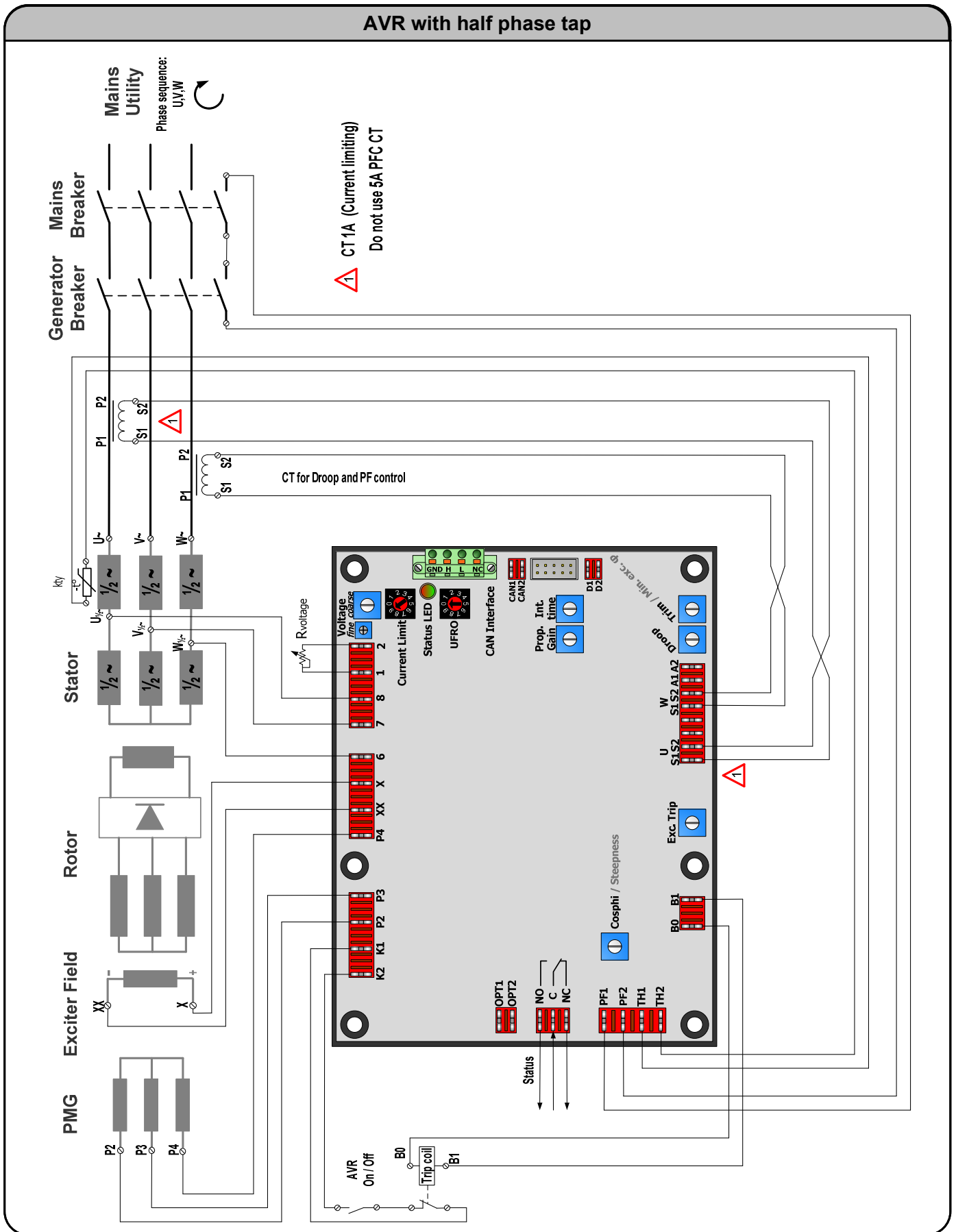
| Advanced settings table                                                             |                                                                                                          |                                                                                                       |                                                                                                                |                                                                                                  |                                                                                                             |                                                                                                      |                                                                                                              |                                                                                                        |                                                   |              |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------|
| UFRO                                                                                |                                                                                                          |                                                                                                       |                                                                                                                |                                                                                                  |                                                                                                             |                                                                                                      |                                                                                                              |                                                                                                        |                                                   |              |
|                                                                                     | <br>Buildup gain (MULT) | <br>Loop gain (MULT) | <br>Initial voltage, SE Mode. | <br>Protections | <br>Buildup time @ startup | <br>Option output | <br>Accessory input modes | <br>Operation modes |                                                   |              |
| Current Limit                                                                       |                                                                                                          |                                                                                                       |                                                                                                                |                                                                                                  |                                                                                                             |                                                                                                      |                                                                                                              |                                                                                                        |                                                   |              |
|    | 0.1 (slowest)                                                                                            | 1.000 (fastest)                                                                                       | 0%                                                                                                             | Excitation loss disabled                                                                         | 1 sec.                                                                                                      | Do not use *                                                                                         | Voltage match disabled                                                                                       | Inverted output disabled                                                                               |                                                   |              |
|    | 0.2                                                                                                      | 0.200                                                                                                 | 10%                                                                                                            | Excitation loss enabled                                                                          | 3 sec.                                                                                                      |                                                                                                      | Voltage match ** enabled                                                                                     | Inverted output enabled                                                                                |                                                   |              |
|    | 0.5                                                                                                      | 0.100                                                                                                 | 15%                                                                                                            | Phase loss disabled                                                                              | 5 sec.                                                                                                      |                                                                                                      | Cosphi setpoint disabled                                                                                     | Do not use *                                                                                           |                                                   |              |
|    | 1                                                                                                        | 0.066                                                                                                 | 22.5%                                                                                                          | Phase loss enabled                                                                               | 7 sec.                                                                                                      |                                                                                                      | Cosphi setpoint enabled                                                                                      |                                                                                                        |                                                   |              |
|   | 2                                                                                                        | 0.050                                                                                                 | 30%                                                                                                            | Current loss disabled                                                                            | 10 sec.                                                                                                     |                                                                                                      | Do not use *                                                                                                 |                                                                                                        | VPH Mode disabled                                 |              |
|  | 4                                                                                                        | 0.040                                                                                                 | 37.5%                                                                                                          | Current loss enabled                                                                             | 20 sec.                                                                                                     |                                                                                                      |                                                                                                              |                                                                                                        | VPH Mode enabled                                  |              |
|  | 6                                                                                                        | 0.033                                                                                                 | 45%                                                                                                            | Do not use *                                                                                     | 30 sec.                                                                                                     |                                                                                                      |                                                                                                              |                                                                                                        | Min. Exc. at Cosphi disabled                      |              |
|  | 8                                                                                                        | 0.028                                                                                                 | 52.5%                                                                                                          | Do not use *                                                                                     | 45 sec.                                                                                                     |                                                                                                      |                                                                                                              |                                                                                                        | Min. Exc. at Cosphi enabled                       |              |
|  | 10                                                                                                       | 0.025                                                                                                 | 60%                                                                                                            | Exc. stop after error disabled                                                                   | 60 sec.                                                                                                     |                                                                                                      |                                                                                                              |                                                                                                        |                                                   | Do not use * |
|  | 14 (fastest)                                                                                             | 0.022 (slowest)                                                                                       | 67.5%                                                                                                          | Exc. stop after error enabled                                                                    | Cosphi setpoint 0..255 sec.                                                                                 |                                                                                                      |                                                                                                              |                                                                                                        |                                                   |              |
| Description                                                                         | Extra multiplication factor for proportional gain. Only applied during field flash.                      | Extra multiplication factor for proportional gain.                                                    | Initial setpoint from which the AVR ramps up after field flash. Setpoint in % of Unom.                         | Enable or disable the required protections.                                                      | The speed by which the AVR ramps from the minimum setpoint to the nominal setpoint.                         | Special application                                                                                  |                                                                                                              | Enable or disable the required modes of operation                                                      | Enable or disable the required modes of operation |              |

\* Used only by manufacturer. Contact for more information.

\*\* LX\_VMA unit required.

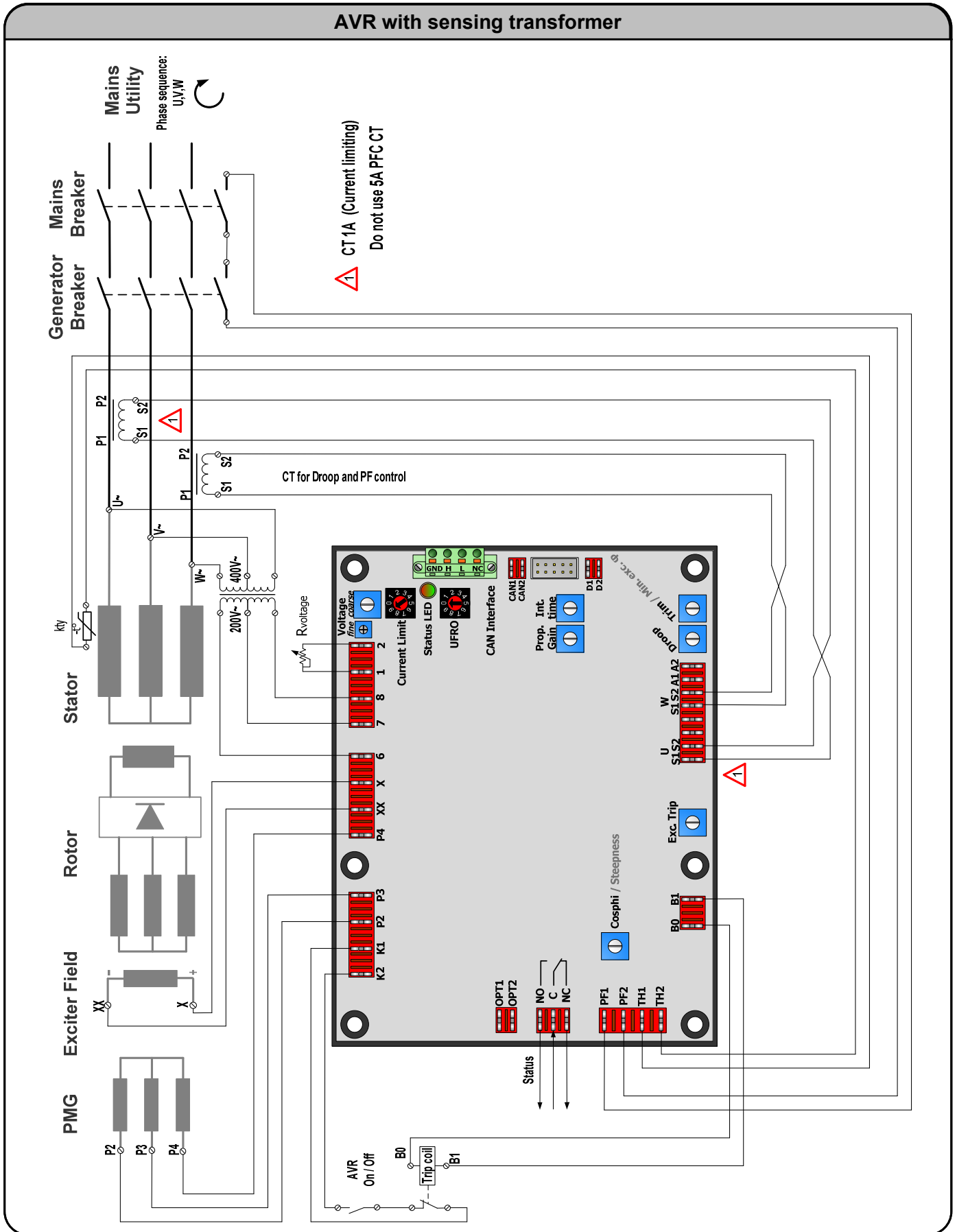
**Default factory settings** are highlighted in table. By setting both UFRO and Current Limit at position 9 and placing the programming jumper, will reset the AVR to **default factory settings**.

# WIRING DIAGRAM I



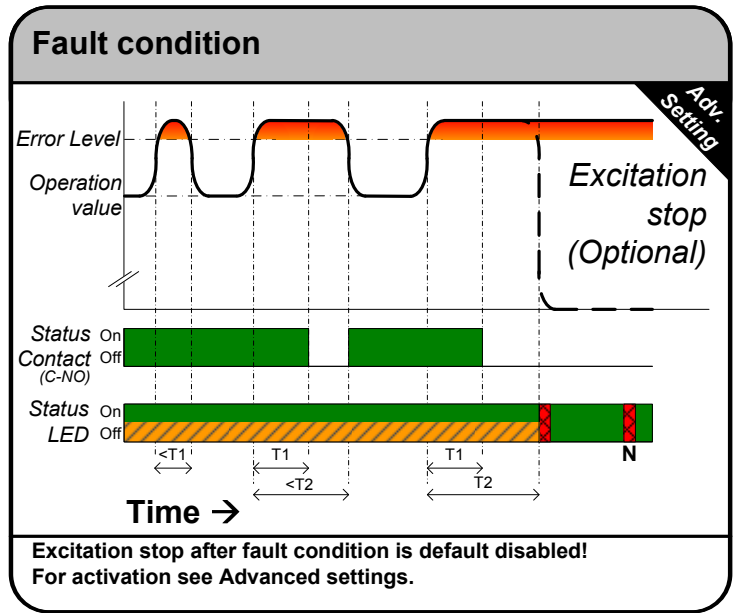
# WIRING DIAGRAM II

## AVR with sensing transformer



# PROTECTIONS

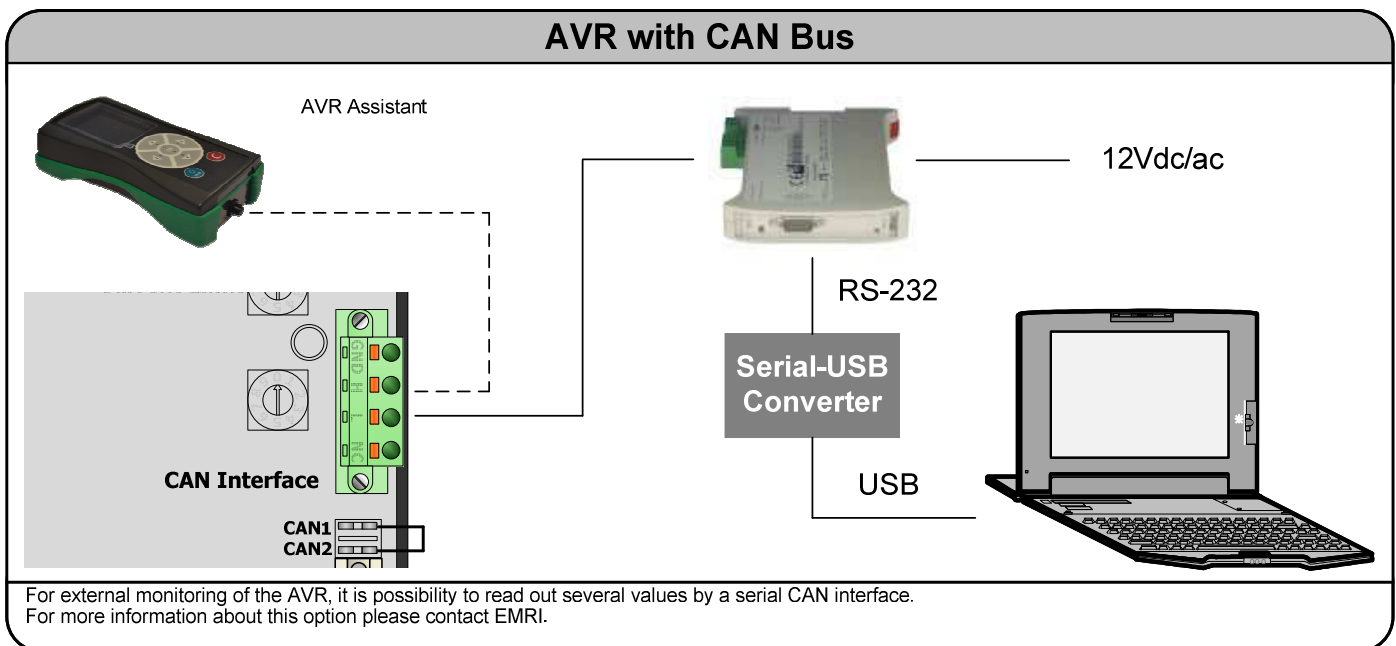
When a fault condition is active for more than time **T1**, the status contact deactivates. When a fault condition is active for more than time **T2**, the fault is indicated by the status led with **(N)umber of red blinks**. When protection "Excitation stop" is enabled, the AVR stops field excitation due to a fault. To **reset** the fault, open contact **K1-K2** for at least 10s, the AVR returns in idle mode



| Protection                         | N | Fault Condition                    | T1     | T2      |
|------------------------------------|---|------------------------------------|--------|---------|
| Over voltage <sup>(1)</sup>        | 1 | 260V <sup>(2)</sup>                | 1 s.   | 2 s.    |
| Over current                       | 2 | 200% of I-Lim                      | 1 s.   | 2 s.    |
| Over excitation                    | 3 | 120% of Exc. Trip                  | 0.3 s. | 10.3 s. |
| AVR over temperature               | 4 | 85 °C                              | 10 s.  | 20 s.   |
| Generator over temperature         | 5 | 1K8 < R <sub>TH1-TH2</sub> < 3K    | 10 s.  | 15 s.   |
| Phase loss & Phase sequence error  | 6 | Phase loss or Phase sequence error | 0.3 s. | 5.3 s.  |
| Loss of excitation during PFC      | 7 | Excitation current < 100mA         | 5 s.   | 6 s.    |
| Loss of current sensing during PFC | 8 | Current sensing < 2.5%             | 5 s.   | 6 s.    |

Excitation stop after fault condition is default disabled! For activation see Advanced settings.  
<sup>(1)</sup> Trip coil (B0-B1) activated when AVR Excitation stop is enabled. <sup>(2)</sup> Sensing voltage 6, 7, 8

# CAN INTERFACE



# GENERAL INSTALLATION INFORMATION

## Absolute Maximum Ratings

- The Absolute Maximum Ratings are those limits for the device that, if exceeded, will likely damage the device. Exceeding the absolute maximum ratings voids any warranty and/or guarantee.

## Mounting

Mounting of the product should be done in such a way that:

- the absolute maximum ambient temperature rating of the product will never be exceeded.
- maximum cooling (direction of cooling ribs and direction of airflow) is achieved.
- Mounting no humid air can flow through the product or condensation occurs.
- dust or other materials or residue will not remain in or on the product.
- the maximum vibration is not exceeded.
- personal contact with persons is impossible.

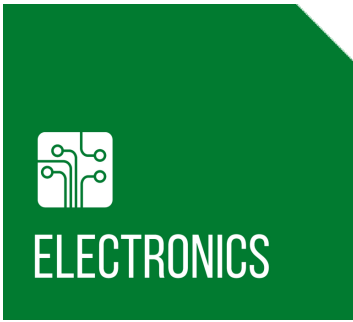
## Wiring

- Diameter size of the wiring should be enough to carry the expected current. Wire insulation should be enough to withstand the expected operating voltages and temperatures.
- To improve EMC emission and immunity, care should be taken for the lay out of the wiring. This in respect to all wiring in the installation.
- Keep current carrying wires as short as possible.
- Keep wires carrying a total sum of zero Ampere close to each other, or in one single cable, E.g. U, V, W, or X (+) and XX (-), or Phase and neutral, or 1 and 2.
- Avoid current carrying conductors next to sensing or control wiring. Especially current controlled by SCR's or PWM controlled transistors.
- If sensitive sensing signal cables need to be laid across distance along other cabling, shielded cable is preferred. Keep the shield as long as possible and the wiring outside the shield as short as possible. Do not solder or shrink the shield to a regular wire. Connect the original shield to ground at one side with an as large as possible contact surface.

## Additional installation information

- When the product is supplied by means of a transformer, it should never be an auto-transformer. Auto-transformers react as voltage sweep up coil and may cause high voltage peaks.
- Standard fit capacitors or over-voltage suppressers across X (+) and XX (-), or exciter field terminals inside the generator should be removed.
- When the product is supplied by means of a transformer, it should be able to carry at least the maximum expected current. Advisable is, to have a transformer which can carry twice the maximum expected current. Inductive loads make voltage sags and peaks into the secondary voltage of a transformer, from which the device may malfunction.
- It is not recommended to apply switches in dc outputs. It is preferred to use switches in the ac supply inputs of devices. In case it is unavoidable to have switches in the dc output of a device, action must be taken to avoid over voltage damage to the device due to contact arcing. Use a voltage suppressor across the output.
- It is not recommended to apply switches or fuses in the sensing lines. Defects can cause high voltage situations due to over-excitation.
- When using a step down transformer in medium or high voltage generators, the transformer should be three phase (if three phase sensing), and the transformer should be suitable for acting as a sensing transformer. If the transformer is unloaded, connect a resistor to avoid voltage waveform distortion.
- The phase relation from the generator to the AVR is important. Also when voltage transformers and/ or current transformers are installed.
- When using a step down or insulation transformer in the droop circuit, phase relation from the generator to the AVR is important.
- CT's wiring, connected to the AVR should never be grounded.
- Always disconnect electronic products, circuits and people before checking the insulation resistance (Megger check).
- Due to differences in generators impedance's, EMC behavior is not predictable. Therefore the commissioner / installer should be aware of proper and correct installation.
- Large, highly inductive, exciter stator windings can cause destructive high voltage peaks. Adding a resistor from 10 to 20 times the exciter stator field resistance reduces voltage spikes. If necessary filter can be fitted additionally. (e.g. snubber, RC-network)
- Upon problems during commissioning, faulty behavior or defects in the generator, consult the fault finding manual at our web site
- Some advises may be overdone or seem extraordinary, but since the electrical rules are the same everywhere, these advises are given.

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