THE POWER OF SYNERGY

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

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

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.

TABLE OF CONTENTS

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		✓
Contstant 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

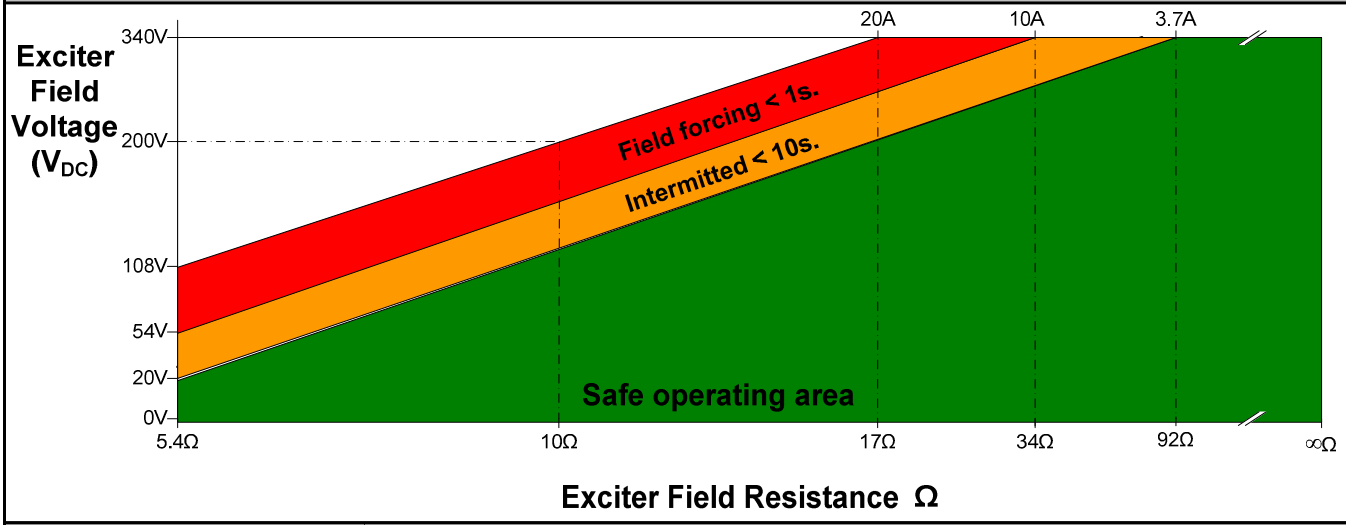
Symbol	Parameter	Condition	Min.	Max.	Unit
6, 7, 8	Voltage sensing input	50 - 60Hz, Intermitted < 30s.	-	260	V_{AC}
X, XX	AVR field current	Intermitted < 10s. (1)	-	10	A_{DC}
	Field resistance X(+), XX(-)	@ $70V_{AC}$ supply (4) (5) @ $170V_{AC}$ supply	5 12	- -	Ω
P2, P3, P4	Supply input (PMG)	Isolated,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

(1) Always mount with heatsink fins aligned vertically and allow for sufficient airflow.
(2) Isolated input.
(3) Input resistance is 1KΩ.
(4) See table below for safe operation area of the AVR.
(5) See formula for calculating minimum field resistance.

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

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.

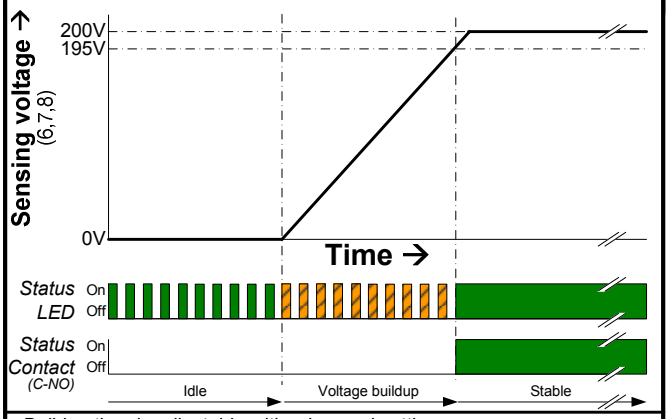
Operating Area



Exciter Field Voltage = Supply input x √2 (V_{DC})

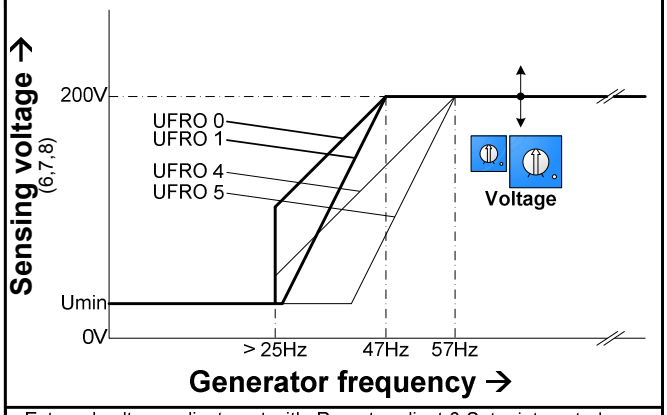
MODES OF CONTROL I

Buildup (PMG) — UFRO 0,1,4,5,8,9



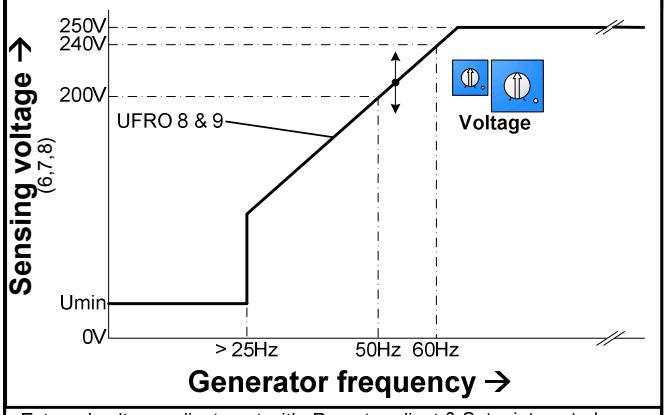
Buildup time is adjustable with advanced settings.

Constant voltage control — UFRO 0,1,4,5



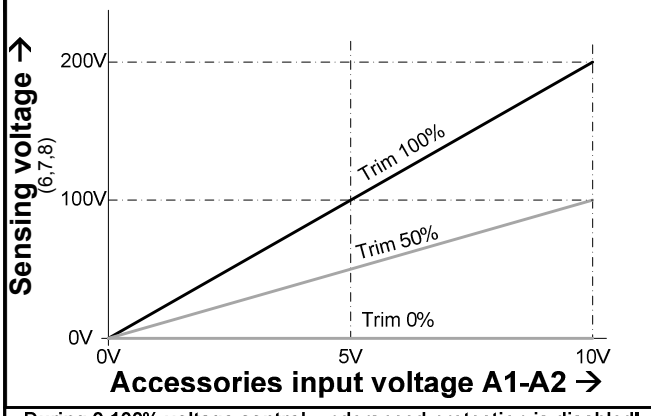
External voltage adjustment with: Remote adjust & Setpoint control.
Umin is adjustable with advanced settings : Minimum setpoint.

Volt per Hertz control — UFRO 8,9



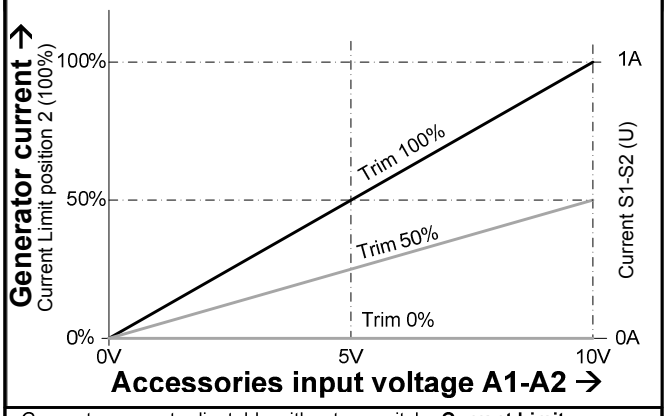
External voltage adjustment with: Remote adjust & Setpoint control.
Umin is adjustable with advanced settings : Minimum setpoint.

0-100% Voltage control — UFRO 2,6



During 0-100% voltage control, underspeed protection is disabled!
A1 = - (negative) and A2 = + (positive).

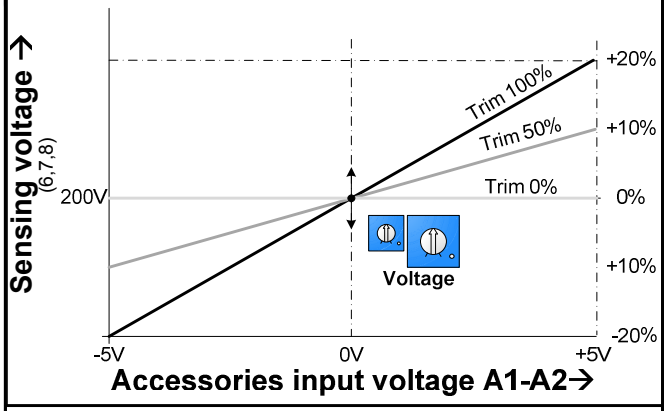
0-100% Current control — UFRO 3,7



Generator current adjustable with rotary switch : **Current Limit**
A1 = - (negative) and A2 = + (positive)

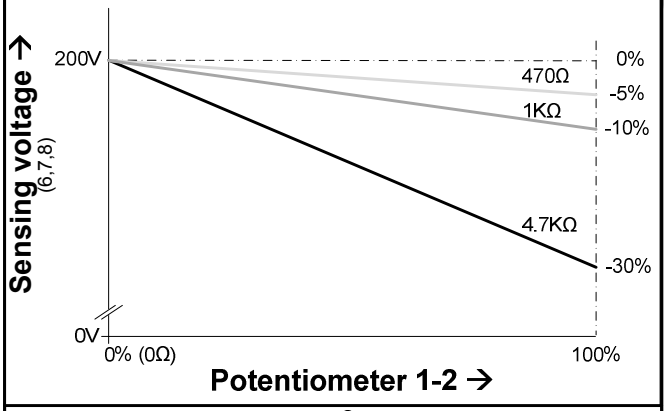
MODES OF CONTROL II

Setpoint control — UFRO 0,1,4,5,8,9



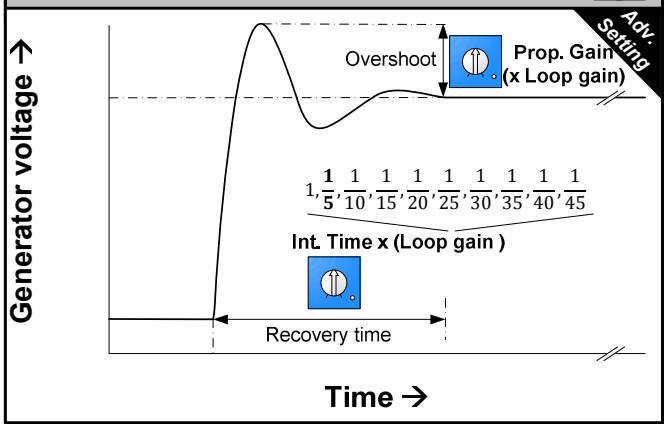
A1 = - (negative) and A2 = + (positive).

Remote adjust — UFRO 0..9



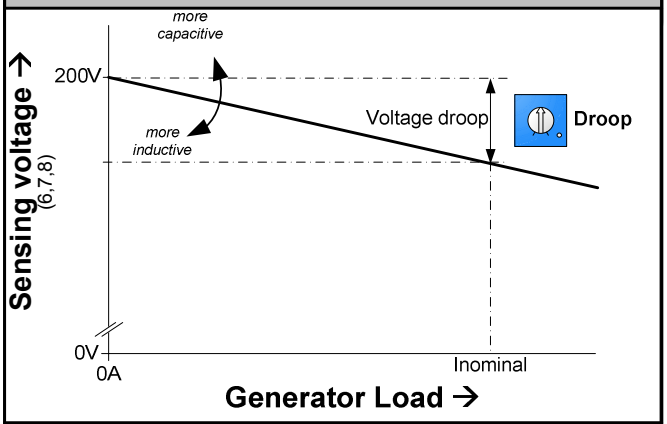
Maximum value at terminal 1-2 is 5KΩ.

P/I control — UFRO 0..9



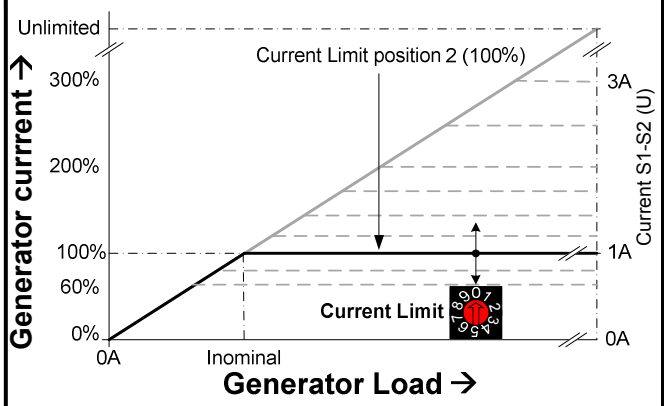
Turning the P/I control must be performed by a control specialist to prevent damage to the AVR and generator.
Loop gain is adjustable with advanced settings.

Droop — UFRO 0..9



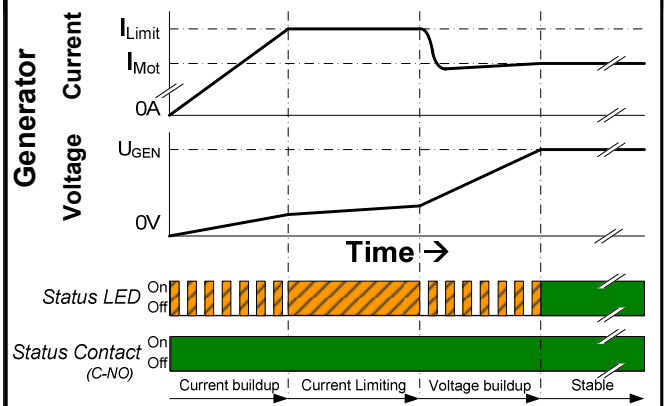
If current limiting is enabled during parallel operation, all AVR's must have the same current limit setting and UFRO setting.
Droop at 0.22A : Unom – 5% @ cosphi 0 inductive.

Current Limit — UFRO 0..9



Changing current limit settings above Inominal, must be done by qualified personal and within the limits set by the generator thermal damage curve.
Position 9 disables current limiting and over current protection!

Motor start — UFRO 0,1,4,5,8,9

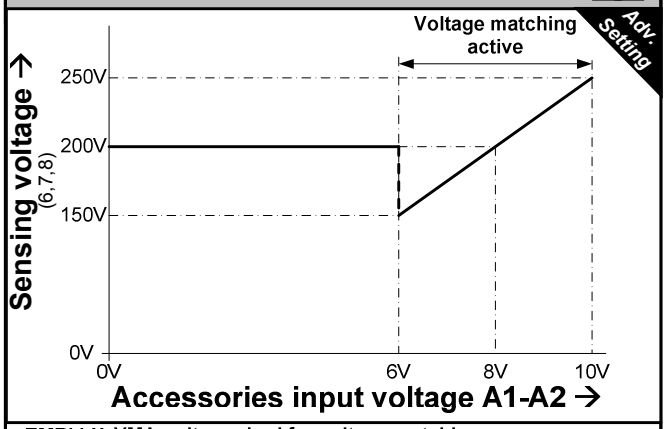


For parallel motor start, it is required to make all K1-K2 (AVR On/Off) contacts simultaneously and all AVR's must have the same current limit setting and UFRO setting. Ensure for sufficient supply voltage.

MODES OF CONTROL III

Voltage matching

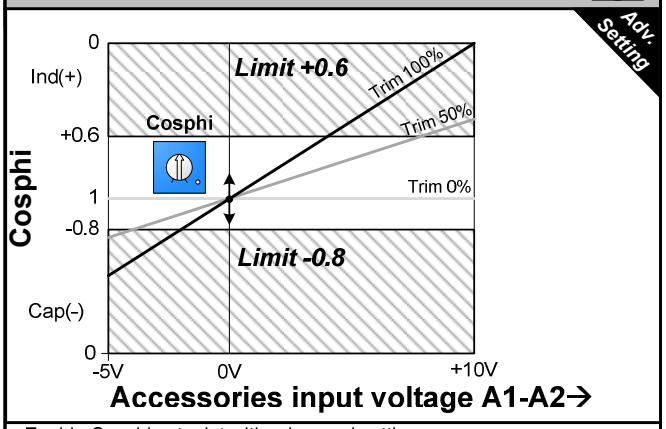
UFRO 0,1,4,5



EMRI LX_VMA unit required for voltage matching.
Enable voltage matching with advanced settings.
A1 = - (negative) and A2 = + (positive).

Cosphi setpoint

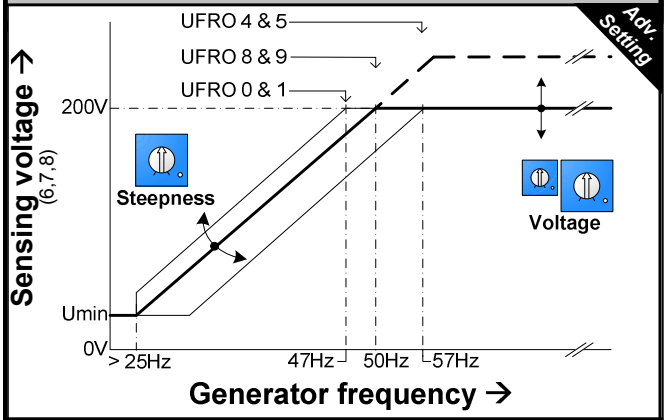
UFRO 0,1,4,5



Enable Cosphi setpoint with advanced settings.
A1 = - (negative) and A2 = + (positive).

VPH mode

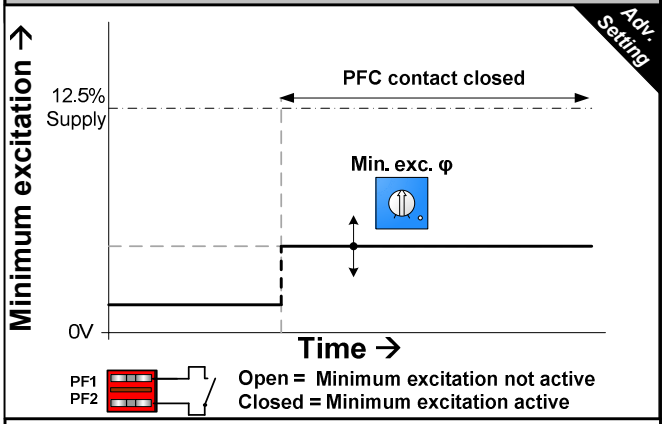
UFRO 0,1,4,5,8,9



In VPH mode the PF is set to cosphi 1 (Fixed setpoint)
Enable VPH mode with advanced settings.

Min. excitation at Cosphi

UFRO 0,1,4,5



Enable minimum excitation at cosphi with advanced settings.
In Min. exc. at cosphi mode, Trim is set to 100%. (Fixed setpoint)

QUICK REFERENCE I

Voltage

Coarse

200V

150V — 250V

Fine

-3V — +3V

Stability

Adv. Setting

Prop. Gain
(x Loop gain)

- +

Adv. Setting

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

1

0.8 Cap — 0.6 Ind

Cosphi

Adv. Setting

VPH mode

3V/Hz — 17V/Hz

Steepness

Exc. Trip

1A — 6A

Trim / Min. exc. φ

Normal mode

0% — 100%

% of input A1-A2

Trim

Adv. Setting

Min. Exc. at Cosphi

0% — 12.5%

% of AVR supply

Min. exc. φ

UFRO

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

		Underspeed TH1 – TH2 Linked	*Underspeed* TH1 – TH2 Open	*Slope* @ Unom=400V
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 PF control
Red Continuous		Phase sequence 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

<3K

TH1 — TH2

KTY81-110. Temp. sensor (1k8..3kΩ)

Underspeed selection 47/57 Hz.

Link

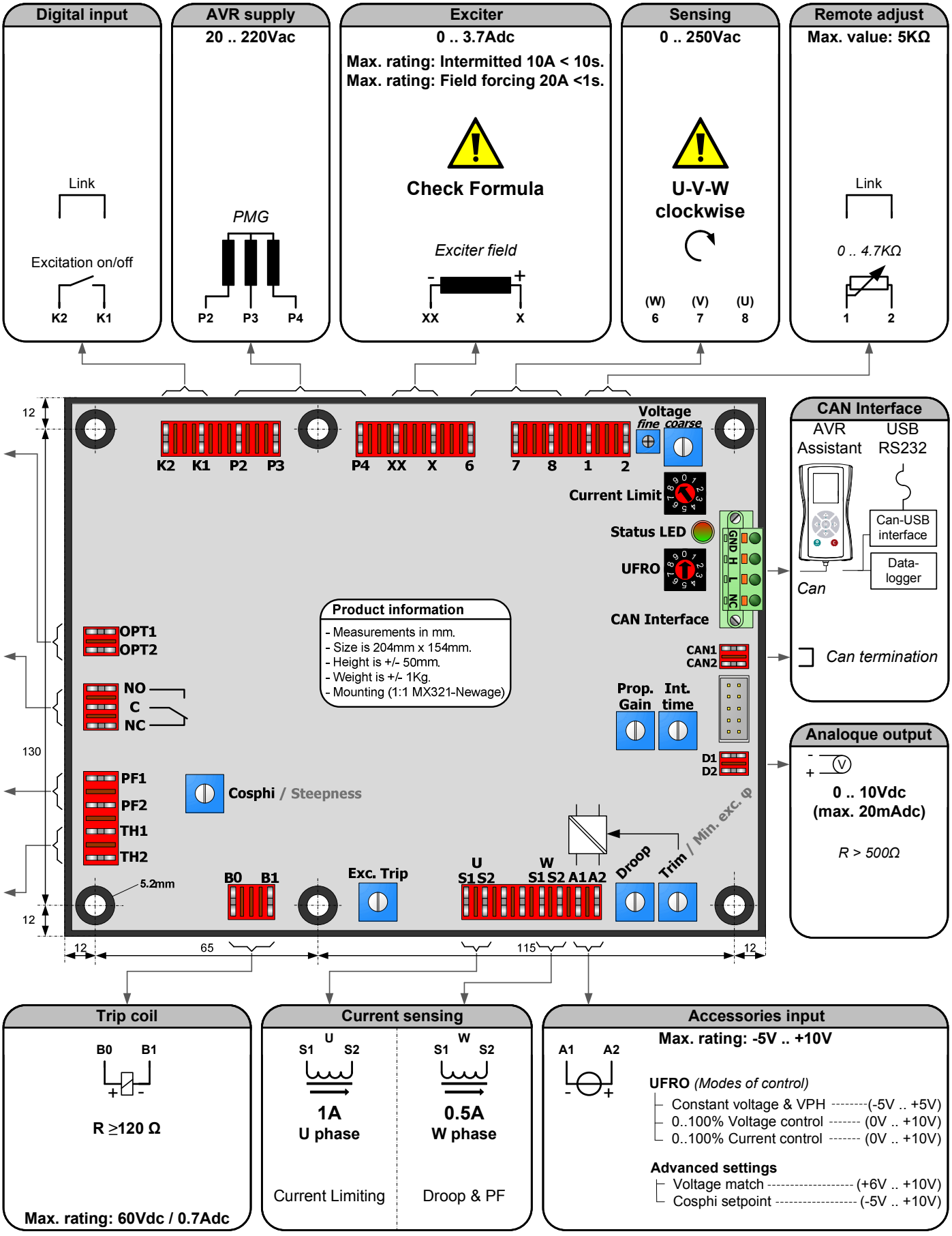
Minimum Rfield

Formula

Minimum field resistance

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

QUICK REFERENCE II



ADVANCED SETTINGS I

Advanced settings flowchart

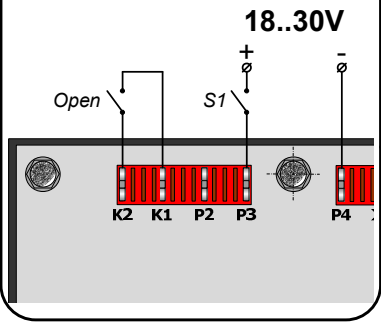
Begin ***(Generator stopped !)***

Remember settings

UFRO (Example)

Current Limit (Example)

Start situation



Selection

UFRO **Position 7** (Example)

Current Limit **Position 1** (Example)

Example: Voltage match enable

More settings?

Programming

Enable power supply

S1

OPT1
OPT2

Place Link for 2s.

Blink red
(Stored)

Set back settings

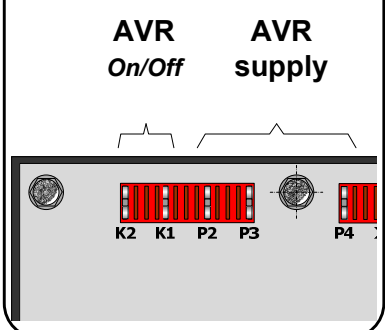
Reset power supply

S1

UFRO (Example)

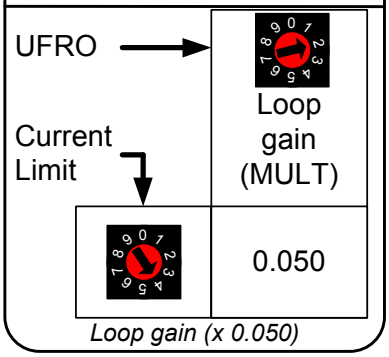
Current Limit (Example)

Reconnect wires



Done

Selection example



Note

Change of setting only take effect after restart

Advanced settings can be adjusted according the flowchart.
Advanced settings are available with firmware version 3.0, 5.0 and higher than 5.0.

ADVANCED SETTINGS II

Advanced settings table

UFRO

Current Limit	Buildup gain (MULT)	Loop gain (MULT)	Initial voltage, SE Mode.	Protections	Buildup time @ startup	Option output	Accessory input modes	Operation modes
	0.1 (slowest)	1.000 (fastest)	0%	Excitation loss disabled	1 sec.		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 *	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 wich 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

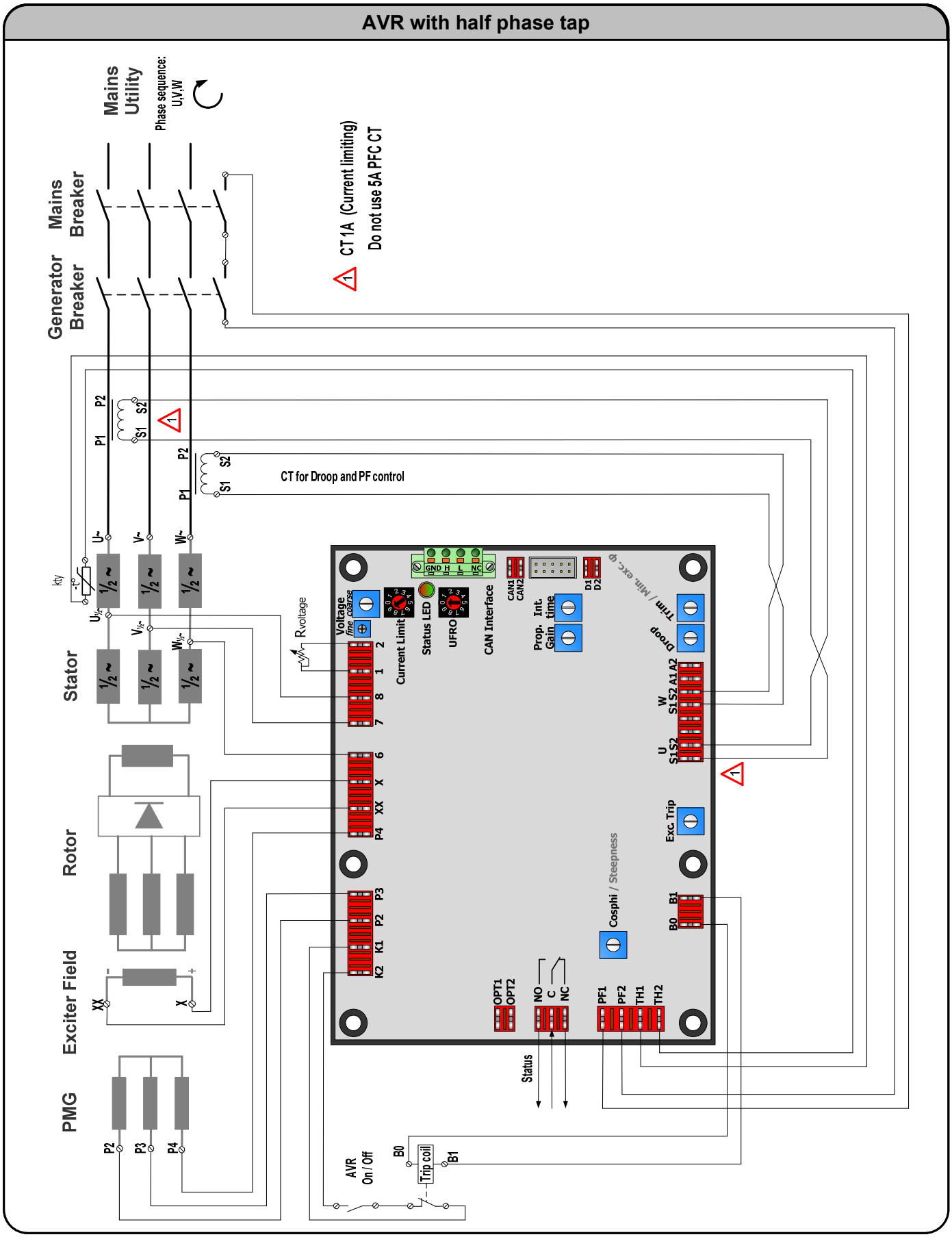
* Used only by manufacturer. Contact for more information.

** 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**.

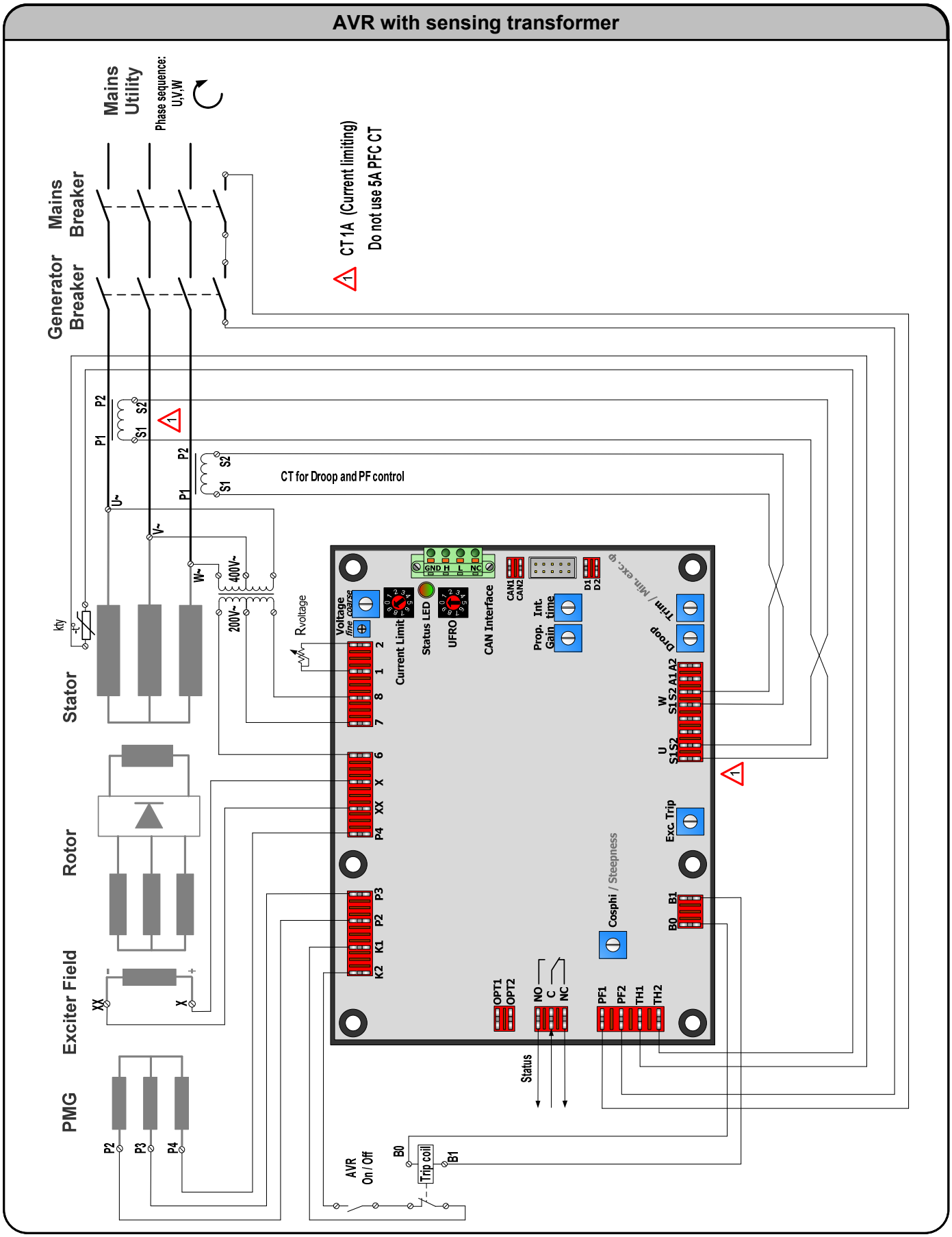
WIRING DIAGRAM I

AVR with half phase tap



WIRING DIAGRAM II

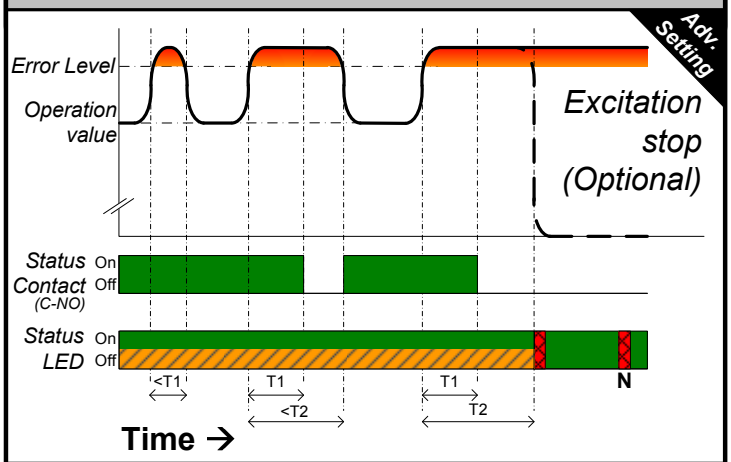
AVR with sensing transformer



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

Fault condition



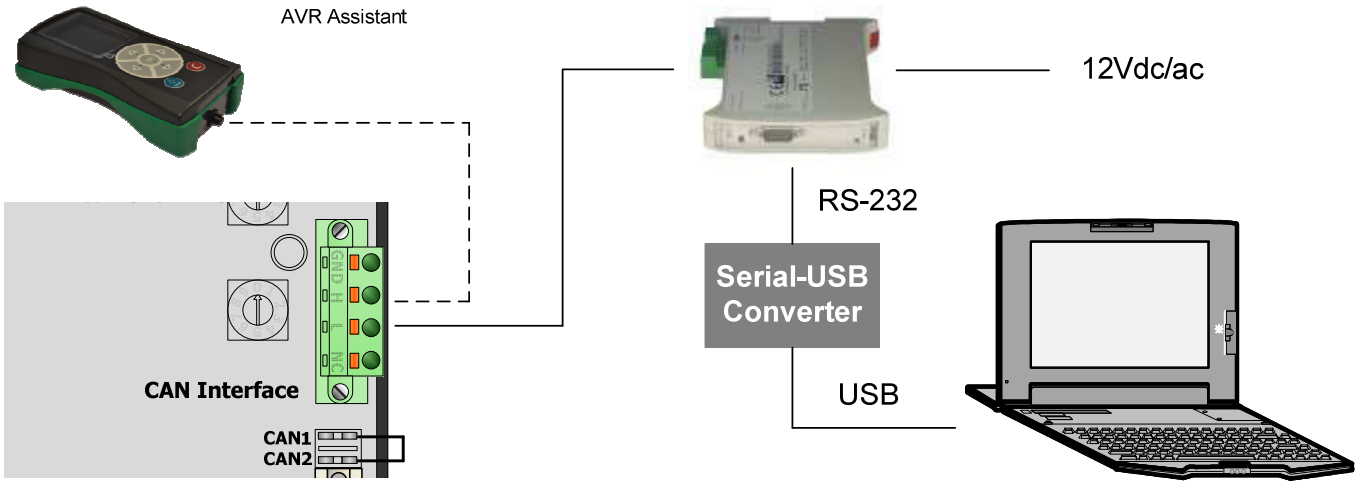
Excitation stop after fault condition is default disabled!
For activation see Advanced settings.

Protection	N	Fault Condition	T1	T2
Over voltage (1)	1	260V (2)	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 < $R_{TH1-TH2}$ < 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.
(1) Trip coil (B0-B1) activated when AVR Excitation stop is enabled. (2) Sensing voltage 6, 7, 8

CAN INTERFACE

AVR with CAN Bus



For external monitoring of the AVR, it is possibility to read out several values by a serial CAN interface.
For more information about this option please contact EMRI.

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 sacks and peeks 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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