



LXCOS

Voltage regulator for generators

Instruction Manual V2.1.2

Product version V1.4.3.2



**Marine approved
Smartgrid compliant**

EMRI ELECTRONICS
POWER IN CONTROL



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	
For info about older revisions contact your supplier.				
V1.3.5.0	1.3	1.3.6	1.6.2	<i>Bugfix, deviation of current measurement at temperatures above 60C. Minor software improvement.</i>
V1.3.7.0	1.3.1	1.3.7	1.6.3	<i>Modified hardware to improved filtering. Software bugfix, SR2 mode activation.</i>
V1.3.9.0	1.3.1	1.3.9	1.7	<i>New layout manual. Range Cosphi setpoint. Changed I-setpoint potentiometer in SR2 mode.</i>
V1.4.0.0	1.3.1	1.4.0	1.8	<i>kVAr regulation/sharing added. Improvement PF readout. Changed VPH curve during UF mode.</i>
V1.4.0.1	1.3.1	1.4.1	1.9	<i>AFD mode bugfix, voltage drop at underspeed during buildup.</i>
V1.4.1.0	1.3.1	1.4.3	1.9.1	<i>Underspeed >25Hz LED indication added. AFD mode bugfix. Extended initial setpoint at SE. Extended Buildup time.</i>
V1.4.2.0	1.4	1.4.3	2.0	<i>Added header for subtractive operation.</i>
V1.4.3.0	1.4	1.4.4	2.1	<i>Protections added and changed.</i>
V1.4.3.1	1.4.1	1.4.4	2.1.1	<i>Minor hardware improvement.</i>
V1.4.3.2	1.4.2	1.4.4	2.1.2	<i>Smartgird & Lloyds Marine type approval specified. Factory settings for I-limit changed to unlimited (position 9).</i>
The table provides a historical summary of the changes made to the AVR. Revisions are listed in chronological order.				

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 automatic voltage regulator is designed as a direct form fit and function for the Cosimat N+ and its additional modules, as well as applicable as versatile strong and flexible AVR with all common and special functionalities to cover all kind generator applications.

Installation, maintenance and adjustment are easy and don't require special application software.

Mode of control		Cosimat N+	AVR
Volt per Hertz control			✓
Constant voltage control		✓	✓
Power factor control (PFC)			✓
Raise / Lower voltage control			✓
0-100% generator current control			✓
0-100% generator voltage control			✓
Quadrature voltage droop for parallel operation		✓	✓
Current control (Current limiting / Limited motor start)			✓
kVAr regulation/sharing			✓
Protection			
Generator phase loss & phase sequence			✓
AVR over temperature			✓
Generator over temperature			✓
Generator over voltage			✓
Generator over current			✓
Generator over excitation current		✓	✓
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 Droop, PF Control, Current Limiting	k – I	
LX_VMA	Required for voltage matching	A1 – A2	
3F-Filter	For filtering the generator sensing voltage	U – V - W	
AVR Assistant	Handheld programming and monitor device	CAN	
DFD7.5	Diode failure detector	Separate unit	
AFD	Dual channel AVR for generators	Separate unit	
RunDect	Motor stall protection & End of run-up detection	Separate unit	
Jump R121	0-20 mA shunt for COSPHI-2 setpoint	TH1– TH2	
Jump R500	0-20 mA shunt for accessoires input (0-10Volt)	A1 – A2	

Marine applications:

The automatic voltage regulator has been tested satisfactory in accordance with the relevant requirements of the Lloyds Register Type Approval System for marine applications.

Lloyd's Register Type Approval System

Test Specification Number 1 07/15

Certificate : GRO.TA 1605 214 HLR & No. 17.30044

Defence / Navy applications NSN 5963-17-126-7799, HG H2H29

Smart-grid:

The automatic voltage regulator is compliant for applications in generators - power generation sets which should meet:

Smartgrid BDEW Technische Richtlinie „Erzeugungsanlagen am Mittelspannungsnetz.
 Dynamic grid support,
 Low voltage ride through (LVRT),
 Under voltage ride through (UVRT),
 High voltage ride through (HVRT)
 Contribution to short-circuit,
 Reactive power control strategies ($\cos \psi$),

VDE-AR-N-4100:2019-04

VDE-AR-N-4105:2019-04

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Condition	Min.	Max.	Unit
U, V, W	Voltage sensing input ^{(2) (6)}	50Hz, continuous 50Hz, Intermitted < 30s. 60Hz, continuous 60Hz, Intermitted < 30s.	-	450 480 500 520	V _{AC} V _{AC} V _{AC} V _{AC}
I1, K1	AVR field current	Continuous ⁽¹⁾ Intermitted < 10s.	-	7 15	A _{DC} A _{DC}
	Field resistance I1(+), K1(-)	@ 70V _{AC} supply ^{(4) (5)} @ 170V _{AC} supply	5 12	- -	Ω Ω
UH1-UH2 VH1-WH2 UH1-VH1-WH1	Supply input	UH1-UH2, WH1-WH2, UH1-VH1-WH1, SE from > 5Vac DC or 25 - 400Hz	15 15	240 135	V _{AC} V _{DC}
A1, A2	Accessories input ⁽²⁾	A1(+), A2(-) ⁽³⁾	-13	+13	V _{DC}
k, l	Droop, PFC, Limit CT ⁽²⁾	Isolated CT > 2VA, Intermitted < 30s.	-	1.5	A _{AC}
T _{AMB}	Operating temperature	95% RHD non condensing ⁽¹⁾	-40	+70	°C
T _{STG}	Storage temperature	95% RHD non condensing	-40	+70	°C
	Static control accuracy			1	%

(1) Always mount with heatsink vertically for sufficient airflow.

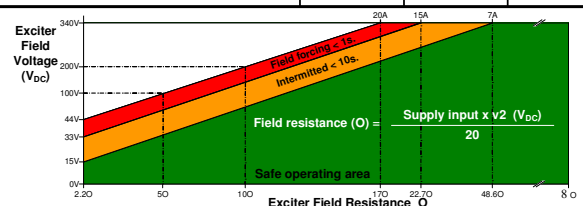
(2) Isolated input.

(3) Input resistance is 10K Ω .

(4) See table below for safe operation area of the AVR.

(5) See formula for calculating minimum field resistance.

(6) Depending on voltage selection



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.

PROTECTIONS

When a fault condition is active for more than time **T1**, the status contact deactivates.

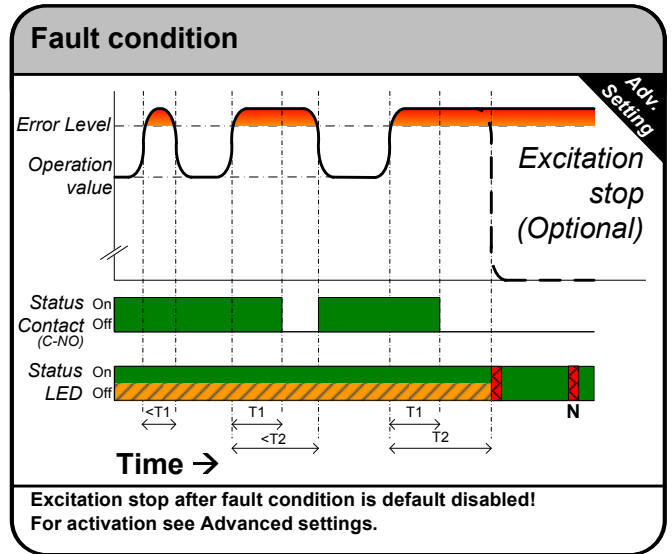
When a fault condition is active for more than time **T2**, the fault is indicated by the status led with **(N)umber of red blinks**.

When protection “Excitation stop” is enabled, the AVR stops field excitation due to a fault.

To **reset** the fault, open contact **AVR1-AVR2** for at least 10s, the AVR returns in idle mode.

In self excitation mode you must shut down the generator.

Check fuse if AVR is not working.



Protection	Blinks	Fault Condition	T1	T2
Over voltage	1	127% at 50Hz and 146% at 60Hz ⁽¹⁾	1 s.	2 s.
Over current	2	300% at current sensing input k-l	2 s.	4 s.
Over excitation	3	125% of Exc. Ceiling setpoint	0.3 s.	10 s.
Over temperature AVR	4	85 °C	10 s.	20 s.
Over temperature generator	5	$R_{TH1-TH2} = < 1K8$ or $R_{TH1-TH2} = > 3K$	10 s.	15 s.
Loss of sensing	6	Loss of voltage sensing	2.5 s.	5 s.
Loss of excitation during PFC	7	Excitation current $< 250mA$ ⁽²⁾	5 s.	6 s.
Loss of current sensing during PFC	8	Current sensing $< 2.5%$ ⁽²⁾	5 s.	6 s.
Voltage sensing sequence error	9	ccw field of rotation U,V,W ⁽²⁾	2.5 s.	5 s.
100% excitation	10	Output excitation voltage 100% ⁽³⁾	2.5 s.	5 s.

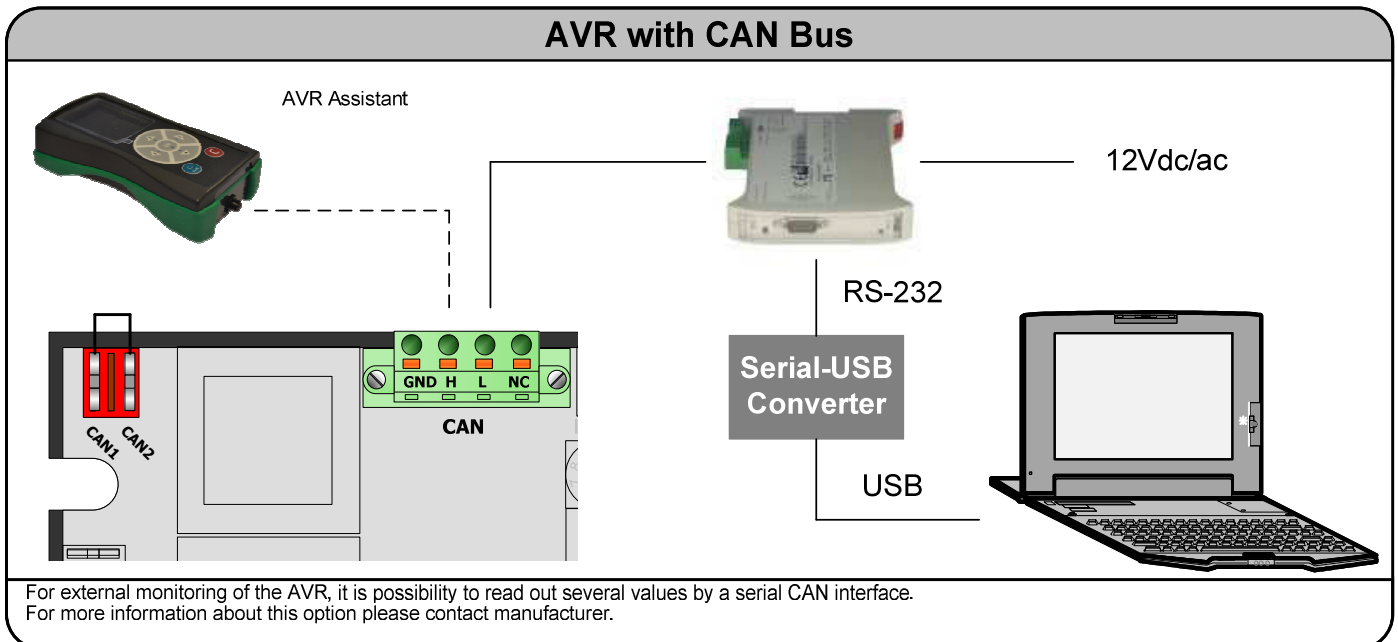
Excitation stop after fault condition is default disabled! For activation see Advanced settings.

⁽¹⁾ Overvoltage level depending on nominal voltage selection: 100V, 200V or 400V.

⁽²⁾ No “Excitation stop at fault”. Only status contact. ⁽³⁾ “Excitation stop at fault” cannot be disabled.

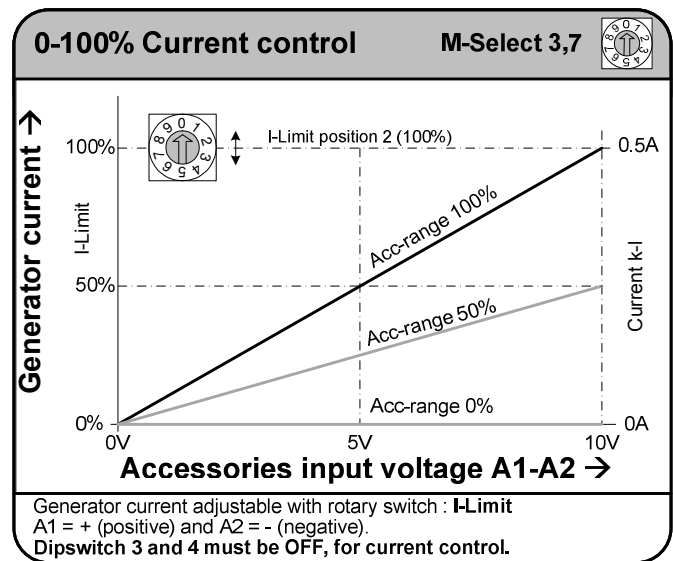
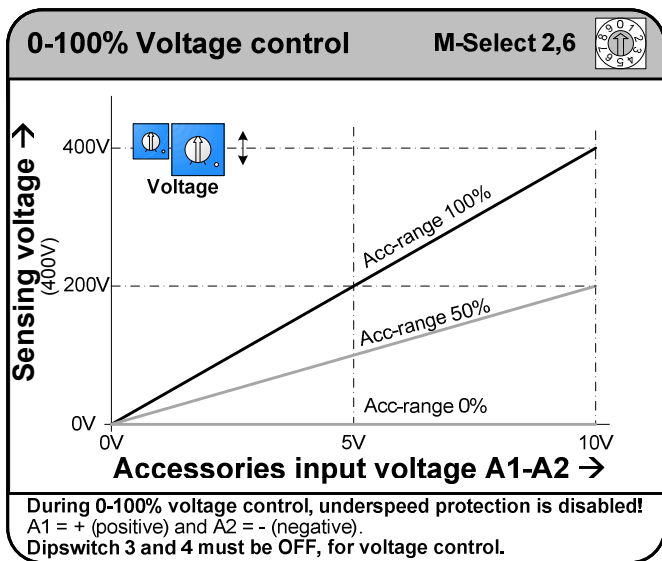
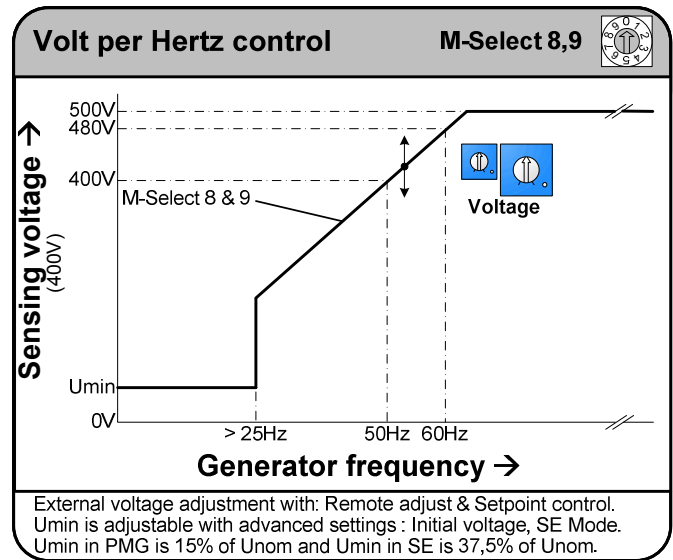
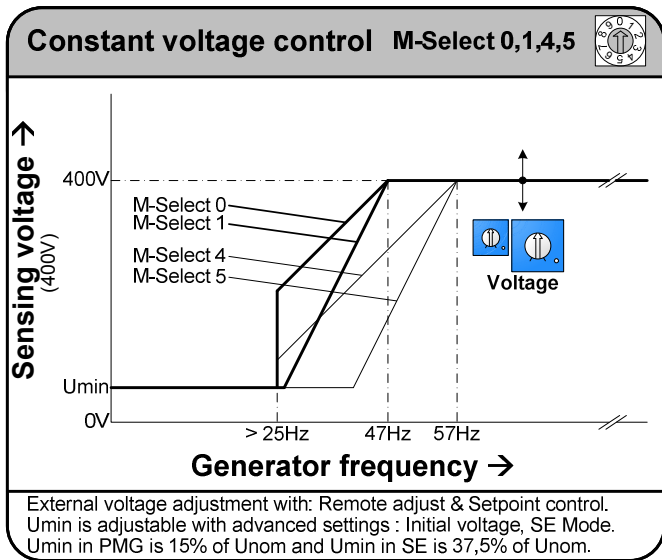
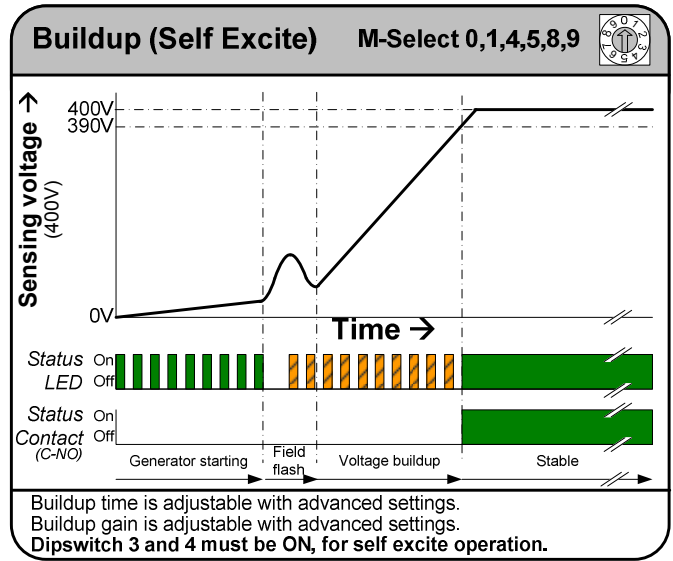
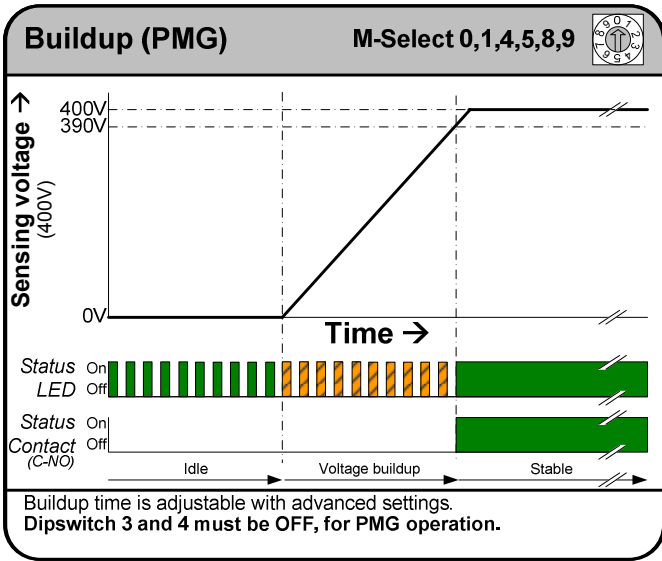
CAN INTERFACE

AVR with CAN Bus

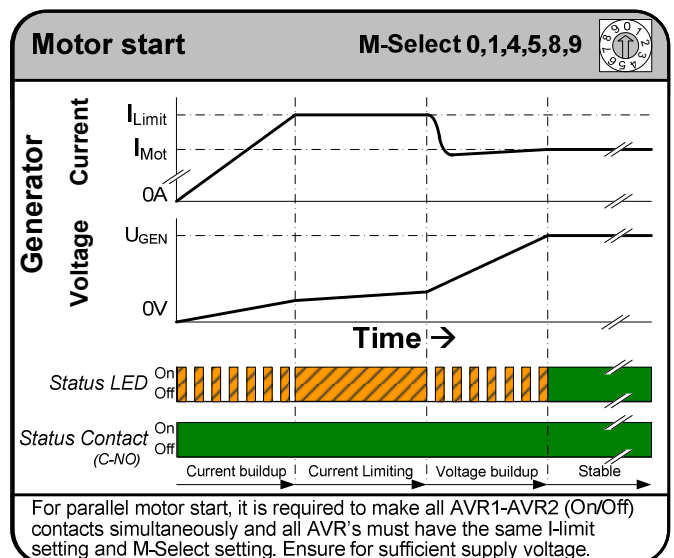
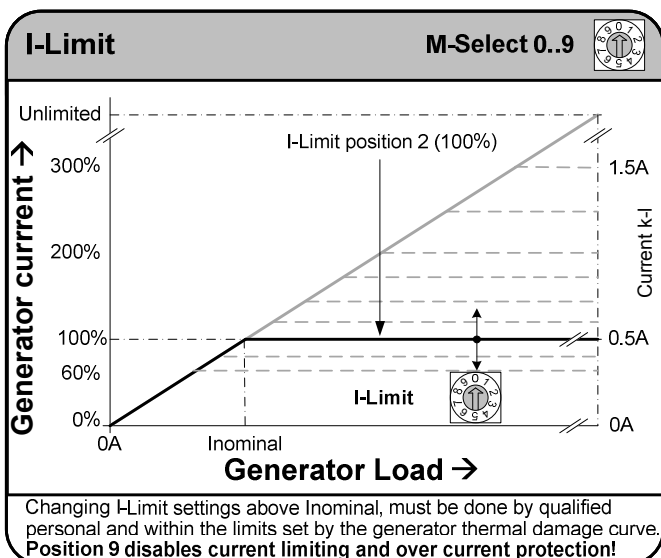
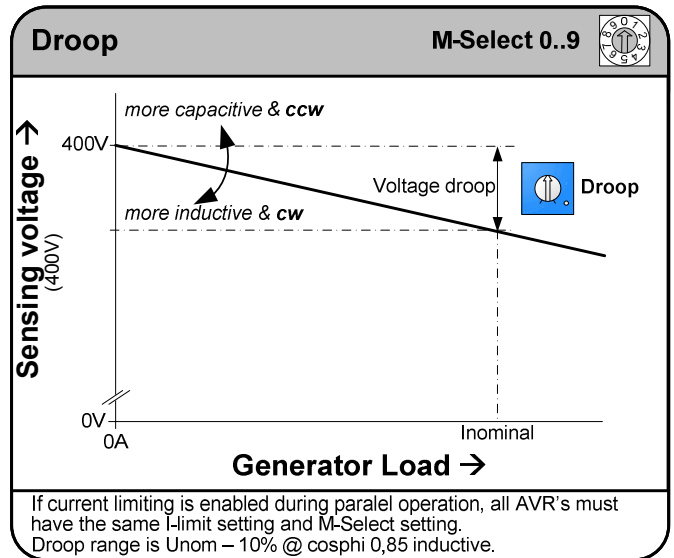
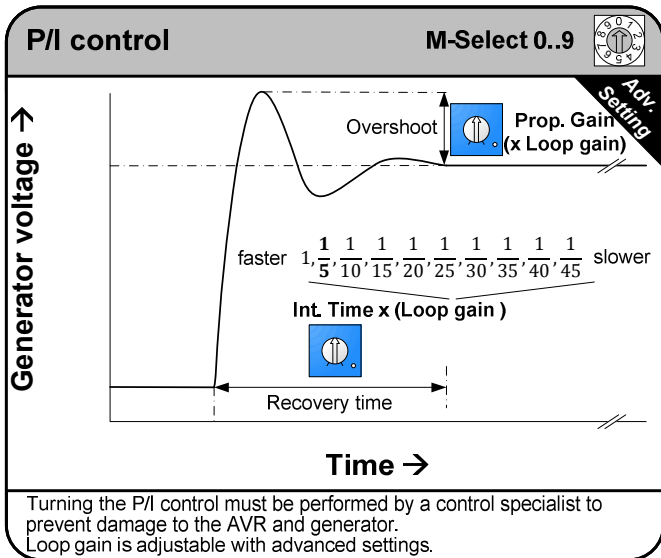
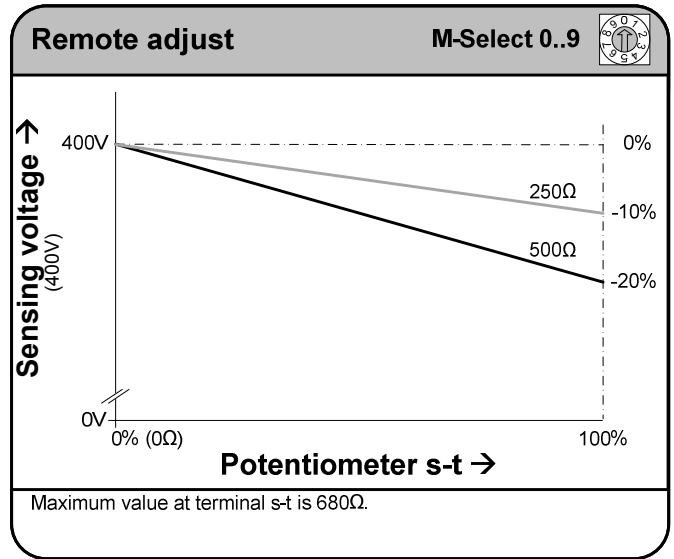
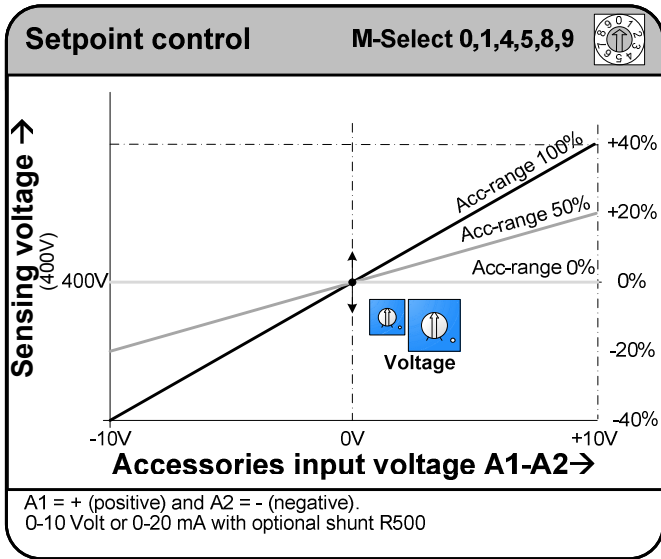


For external monitoring of the AVR, it is possibility to read out several values by a serial CAN interface. For more information about this option please contact manufacturer.

MODES OF CONTROL I



MODES OF CONTROL II



MODES OF CONTROL III

Voltage matching

M-Select 0,1,4,5

Sensing voltage → (400V)
500V
400V
300V
0V

0V 6V 8V 10V
Accessories input voltage A1-A2 →

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

Cosphi setpoint

M-Select 0,1,4,5

Cosphi
0
+0.6
-0.8
Cap(-)

0V / 0mA 0V / 0mA +10V / 20mA
Accessories input voltage A1-A2 →

Limit +0.6
Acc-range 100%
Acc-range 50%
Acc-range 0%
Limit -0.8

Enable Cosphi setpoint with advanced settings.
A1 = + (positive) and A2 = - (negative).
0 - 10 Volt or 0 -20 mA with Jump shunt R500

Raise / Lower voltage control (Electronic potentiometer)

M-Select 0,1,4,5,8,9

Sensing voltage → (400V)
500V
Uset
Min
0V

Time →

Acc-range
10% / Sec.
0.05% / Sec.
RAISE →
LOWER →
0.05% / Sec.
10% / Sec.

Uset RAISE 12Vdc

Uset LOWER 12Vdc

Enable Raise / Lower voltage control with advanced settings: Raise / Lower setpoint

U/F Mode

M-Select 0,1,4,5

Sensing voltage →
400V
Umin
0V

Frequency →
>25Hz

① ccw Steepness
② Voltage
③ PF1 PF2 (13/14)
④ Knee Frequency
⑤ Bus Freq. 50 or 60Hz selection

Status LED green
Adjust sequence: ① ② ③ ④ ⑤
Open = Constant Volt mode
Closed = U/F Mode active

Enable U/F mode with advanced settings and activate with contact.
In U/F mode is PF Control (Cosphi) disabled.
In U/F mode the Exc. ceiling is set to 7A. (Fixed setpoint)

SR2 Mode

M-Select 0,1,4,5,8,9

I-setpoint % of I-Limit

I_{Limit}
I_{Mot}
0A

U_{GEN}
0V

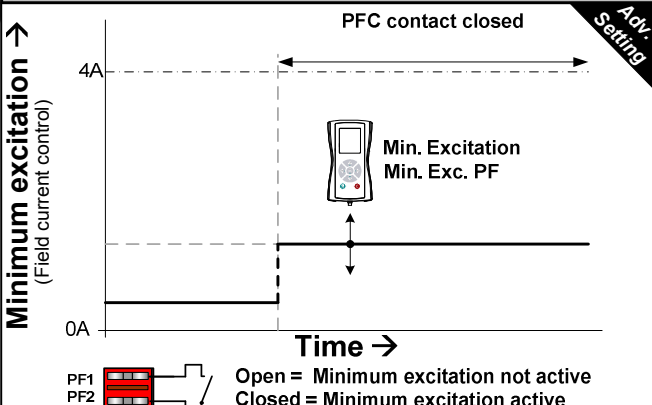
Time →

PF1 PF2 (S6)
Open = No current limiting!
Closed = SR2 Mode active



Enable SR2 mode with advanced settings and activate with contact.
In SR2 mode the Acc-range is set to 100%. (Fixed setpoint).

MODES OF CONTROL IV

Min. excitation at Cosphi M-Select 0,1,4,5

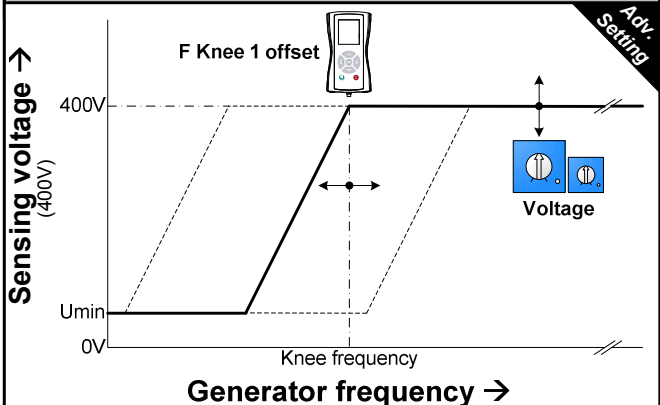


Adv. Setting

PF1  PF2  Open = Minimum excitation not active
Closed = Minimum excitation active

AVR Assistant required to set 'Minimum excitation at cosphi'.
Enable minimum excitation with AVR Assistant.
Change value minimum excitation PF with AVR Assistant.

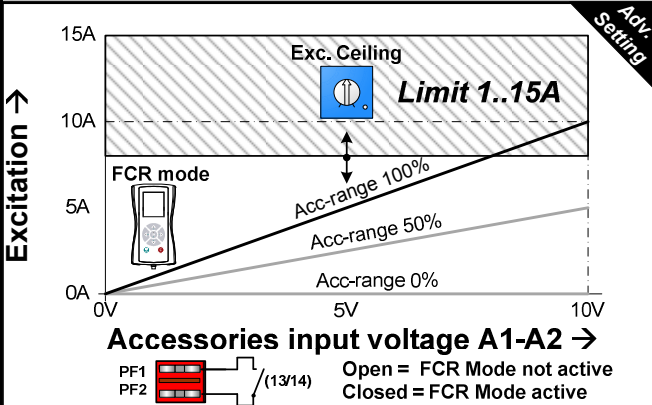
Frequency Knee offset M-Select 0,1,4,5





Adv. Setting

AVR Assistant required to set 'Frequency Knee offset'.
Change value Frequency Knee offset with AVR Assistant.
Range Frequency Knee offset = -12.7Hz ... +12.7Hz

Field Current Regulation M-Select 0..9

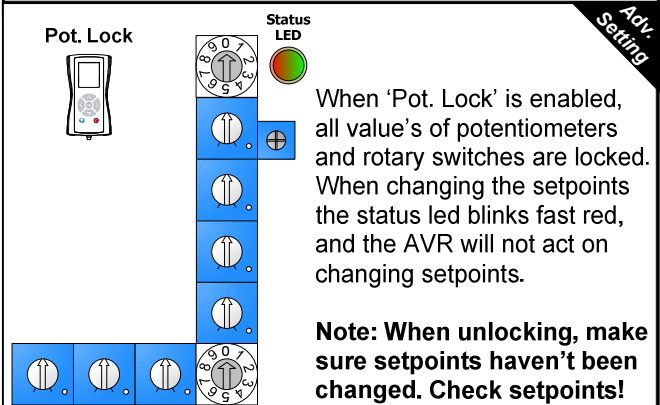


Adv. Setting

PF1  PF2  (13/14) Open = FCR Mode not active
Closed = FCR Mode active

AVR Assistant required to set 'Field Current Regulation'.
During FCR mode, underspeed protection is disabled and there's no generator voltage regulation!

Lock setpoints M-Select 0..9



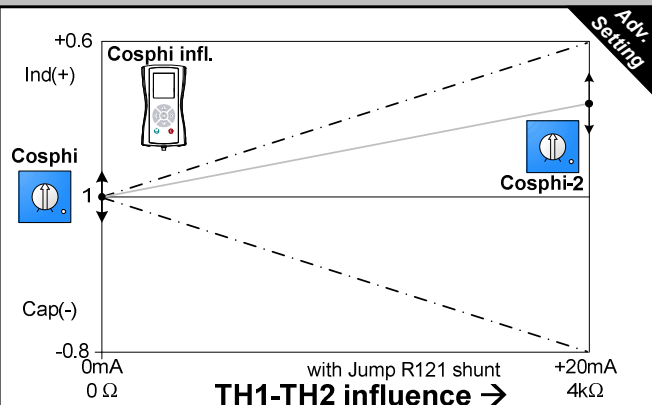
Adv. Setting

When 'Pot. Lock' is enabled, all value's of potentiometers and rotary switches are locked. When changing the setpoints the status led blinks fast red, and the AVR will not act on changing setpoints.

Note: When unlocking, make sure setpoints haven't been changed. Check setpoints!

AVR Assistant required to set 'Lock setpoints'.
Enable 'Pot.Lock' with AVR Assistant.

Cosphi-2 setpoint (TH1-TH2) M-Select 0,1,4,5



Adv. Setting

AVR Assistant required to set 'Cosphi-2 setpoint'.
0..20mA can be applied on Jump R121 when mounted.
In Cosphi-2 setpoint Exc. ceiling is set to 7A. (Fixed setpoint)

kVAr regulation/sharing M-Select 0,1,4,5

For more information about this option please contact manufacturer.

AVR Assistant required to set 'kVAr regulation/sharing'.

QUICK REFERENCE I

Voltage

Coarse Fine

Stability

Prop. Gain (x Loop gain)

Int. time (x Loop gain)

Droop

I-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 U/F mode

0.8 Cap Cosphi 0.6 Ind
3V/Hz Steepness 17V/Hz

Exc. Ceiling / Knee frequency / Cosphi-2

Normal mode U/F mode

1A Exc. Ceiling 15A
30Hz Knee frequency 60Hz

Cosphi-2 setpoint

0.8 Cap Cosphi-2 0.6 Ind

Acc. Range / I-setpoint

Normal mode SR2 mode

0% Acc. Range 100%
% of input A1-A2

0% I-setpoint 100%
% of I-Limit

M-Select

M-Select	Modes of Control	Underspeed		
		TH1 – TH2		Slope (400V)
		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

Sensing

100V 200V 400V Sensing

Coarse Coarse Coarse

88V 132V 158V 253V 300V 500V

U-V-W clockwise

Accessories input

Max. rating: -13V .. +13V

0.20mA Jump FREQ A1 A2

M-Select

- Constant voltage.....(-10V .. +10V)
- VPH.....(-10V .. +10V)
- 0..100% Voltage control.....(0V .. +10V)
- 0..100% Current control.....(0V .. +10V)

Advanced settings

- Voltage match.....(+6V .. +10V)
- Cosphi setpoint.....(-10V .. +10V)
- Raise/Lower.....(+12V / -12V)

Anal. Outp. D1<< D1,2 10Vdc 10 kΩ A1 A2

Status Led

Green Blink	Idle
Orange Blink	Buildup
Green Continuous	Voltage control
Orange Continuous	Current control PF control
Green with Orange blink	Underspeed (>25Hz) VPH control
Red Continuous	Underspeed (<25Hz)
Green with Red blink	Error: (n) number of red blinks
N	Error
1	Over voltage
2	Over current
3	Over excitation
4	Over temperature AVR
5	Over temperature generator
6	Loss of sensing
7	Loss of excitation during PF control
8	Loss of current sensing during PF control
9	Sensing sequence error
10	100% excitation

Exciter 0.7A dc

Check (Formula)

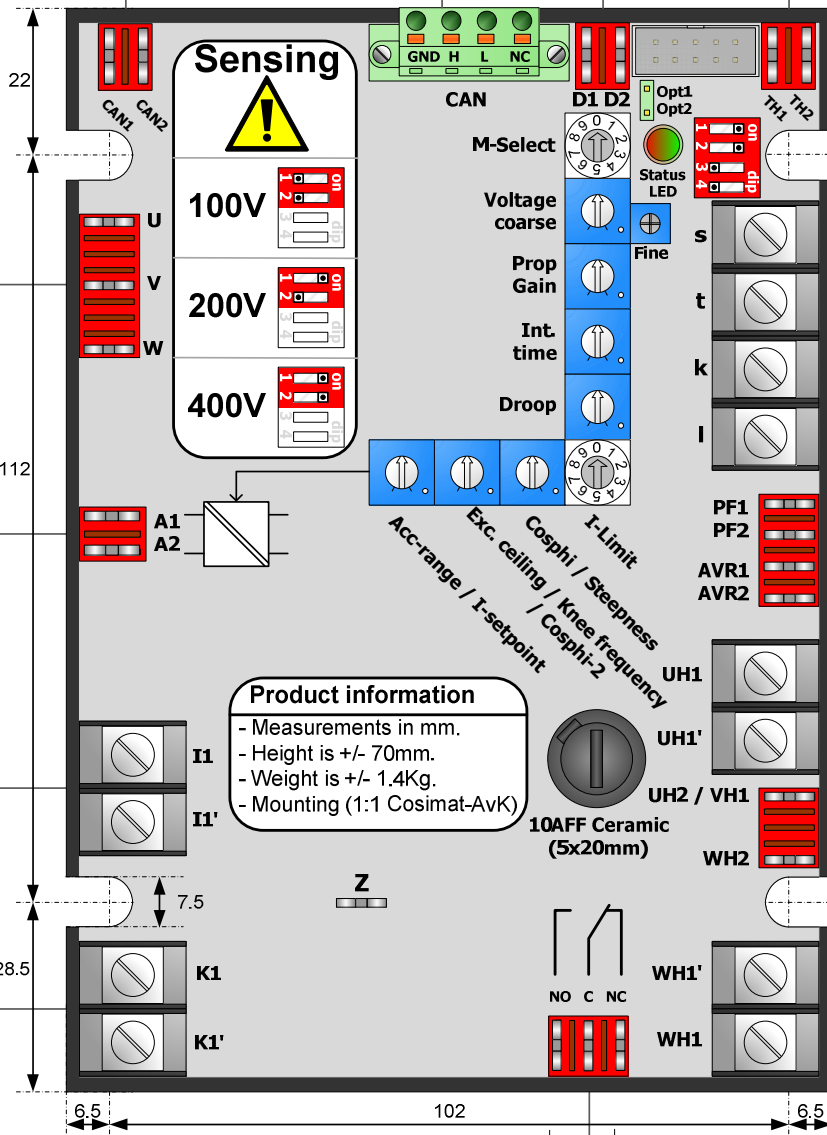
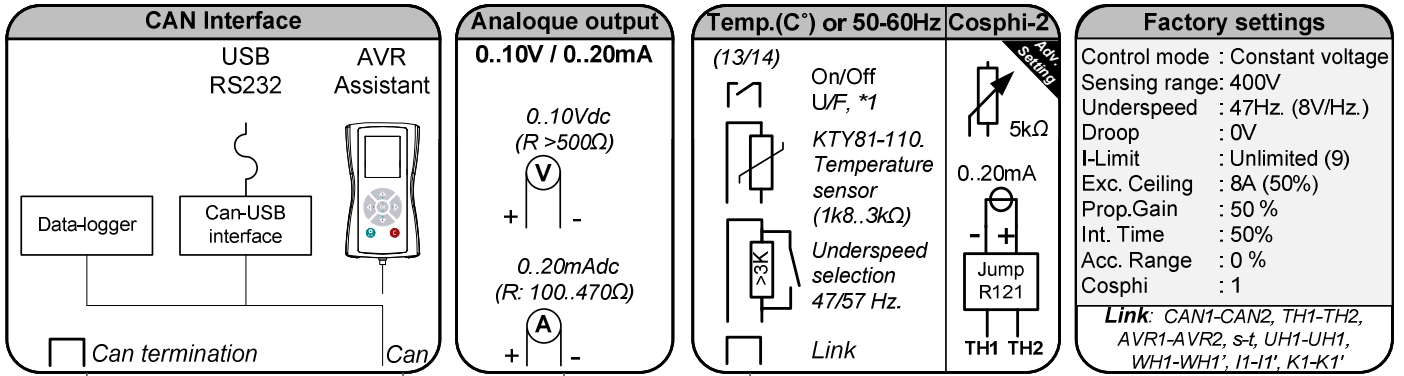
Max. rating: Intermittent 15A < 10s.

Formula

Minimum field resistance

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

QUICK REFERENCE II



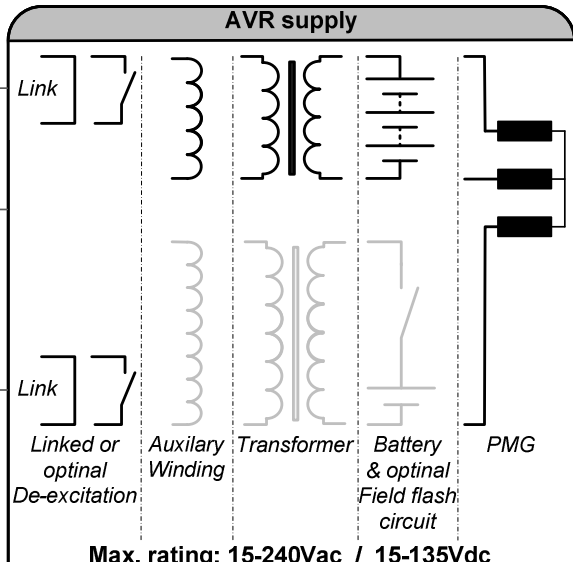
Product information
 - Measurements in mm.
 - Height is +/- 70mm.
 - Weight is +/- 1.4Kg.
 - Mounting (1:1 Cosimat-AVK)

Advanced settings
 Programming (Page 12,13)
 Opt1 Opt2

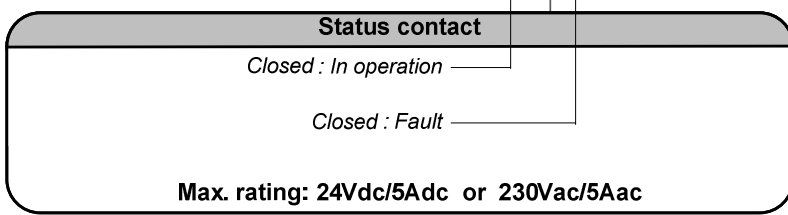
Remote adjust
 Max. value: 680Ω
 Link 0 .. 500Ω

Current sensing
 Droop, PF control, I-Limit
 v phase 0.5A
 (Droopkit, CT or Original AvK CT)

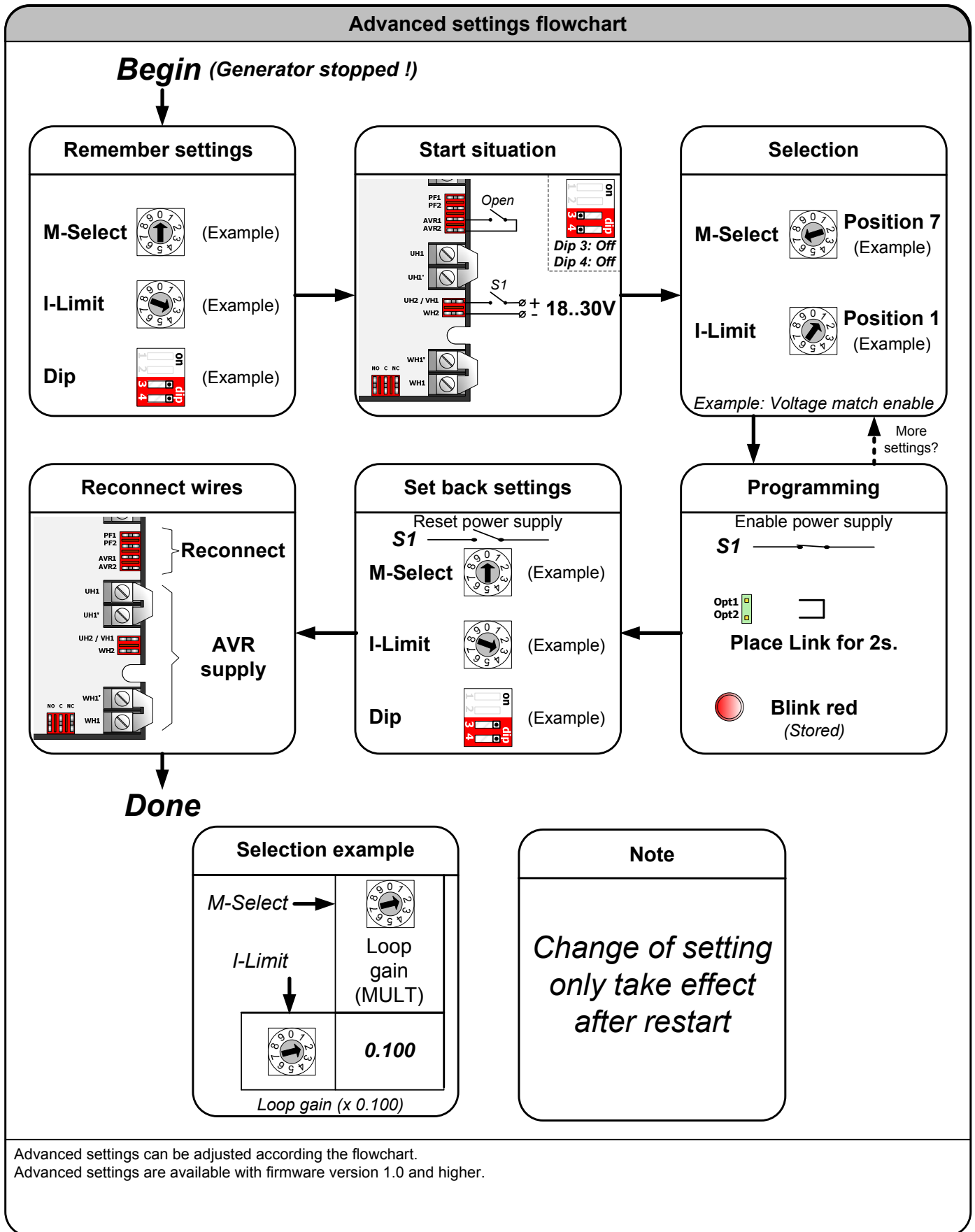
Digital input
 (13/14) On/Off : PF Control (SR2,U/F,kVAR,FCR)
 *1(Check advanced settings for mode selection)
 Link On/Off : AVR





















Self Excite from > 5Vac
 Dip 3: On = Initial Voltage SE mode (See Advanced settings)
 Dip 4: On for SE (Self Excitation)



ADVANCED SETTINGS I



ADVANCED SETTINGS I I

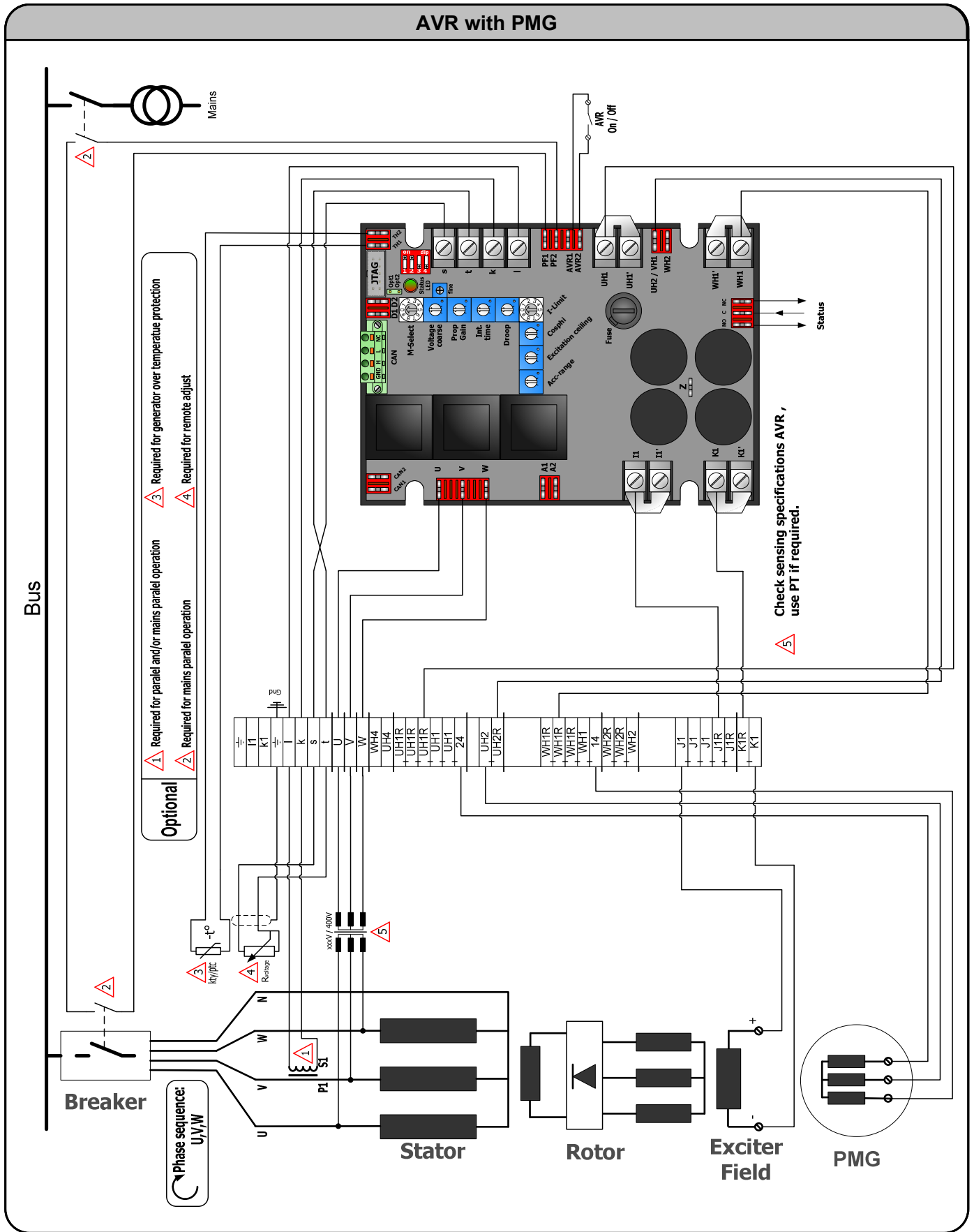
Advanced settings table								
M-Select								
	 Buildup gain (MULT)	 Loop gain (MULT)	 Initial voltage, SE Mode.	 Protections	 Buildup time @ startup	 Option output	 Accessory input modes	 Operation modes
I-Limit								
	0.1 (slowest)	1.000 (fastest)	0%	Excitation loss disabled	1 sec.	Do not use *	Voltage match disabled	Inverted output disabled
	0.2	0.200	7.5%	Excitation loss enabled	3 sec.		Voltage match ** enabled	Inverted output enabled
	0.5	0.100	15%	Phase loss disabled	5 sec.		Cosphi setpoint disabled	SR2 Mode disabled
	1	0.066	22.5%	Phase loss enabled	7 sec.		Cosphi setpoint enabled	SR2 Mode enabled
	2	0.050	30%	Current loss disabled	10 sec.		Raise/lower setpoint disabled	U/F Mode disabled
	4	0.040	37.5%	Current loss enabled	20 sec.		Raise/lower setpoint enabled	U/F Mode enabled
	6	0.033	45%	Do not use *	30 sec.		Do not use *	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.			AFD Mode disabled
	14 (fastest)	0.022 (slowest)	67.5%	Exc. stop after error enabled	Cosphi setpoint 0..255 sec.			AFD Mode *** enabled
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 desired protections.	The speed by which the AVR ramps from the minimum setpoint to the nominal setpoint.	Special application	Enable or disable the desired modes of operation	Enable or disable the desired modes of operation

* Used only by manufacturer. Contact for more information.

** LX_VMA unit required. *** AFD unit required.

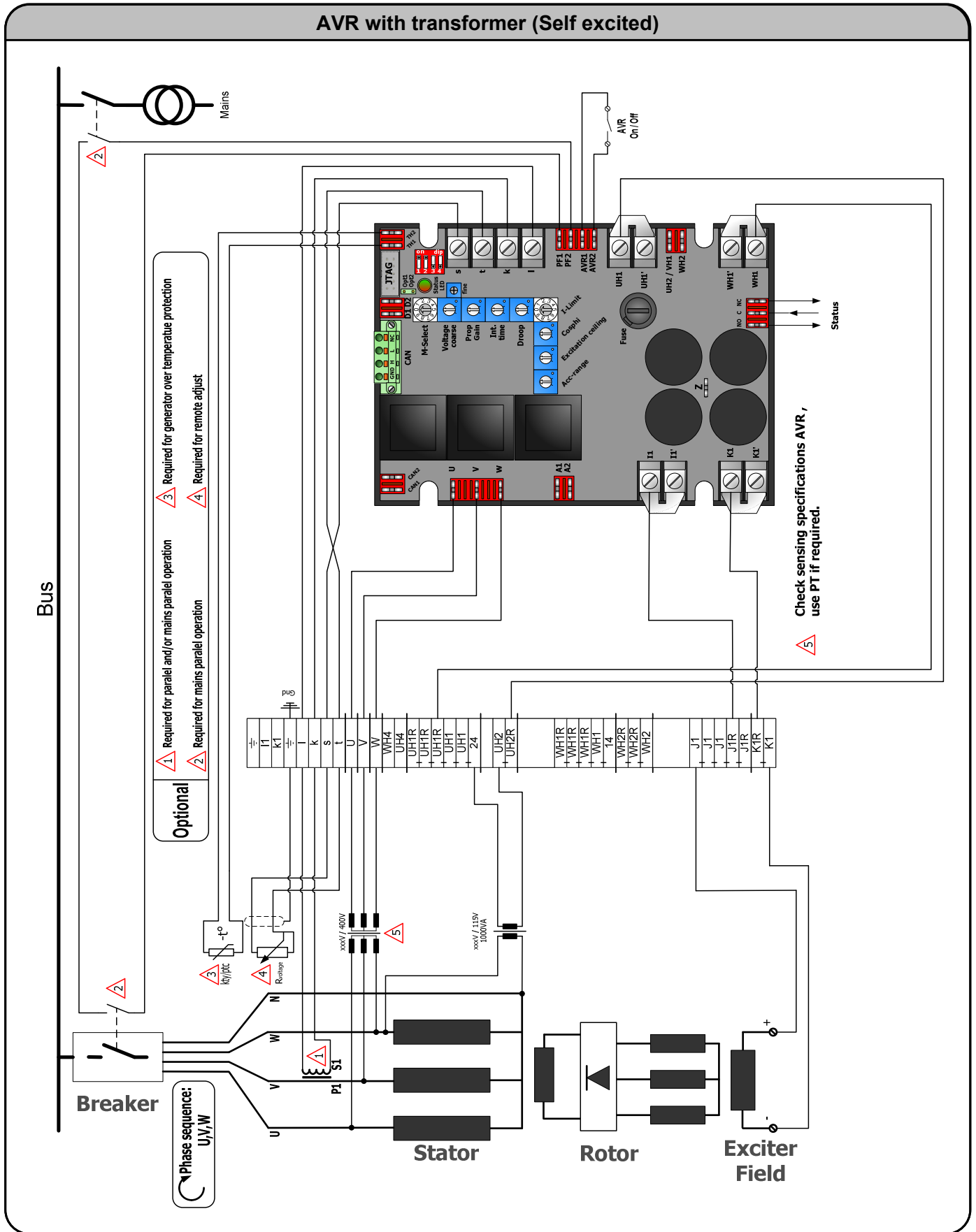
Default factory settings are highlighted in table. By setting both M-Select and I-Limit at position 9 and placing the programming jumper, will reset the AVR to **default factory settings**.

WIRING DIAGRAM I

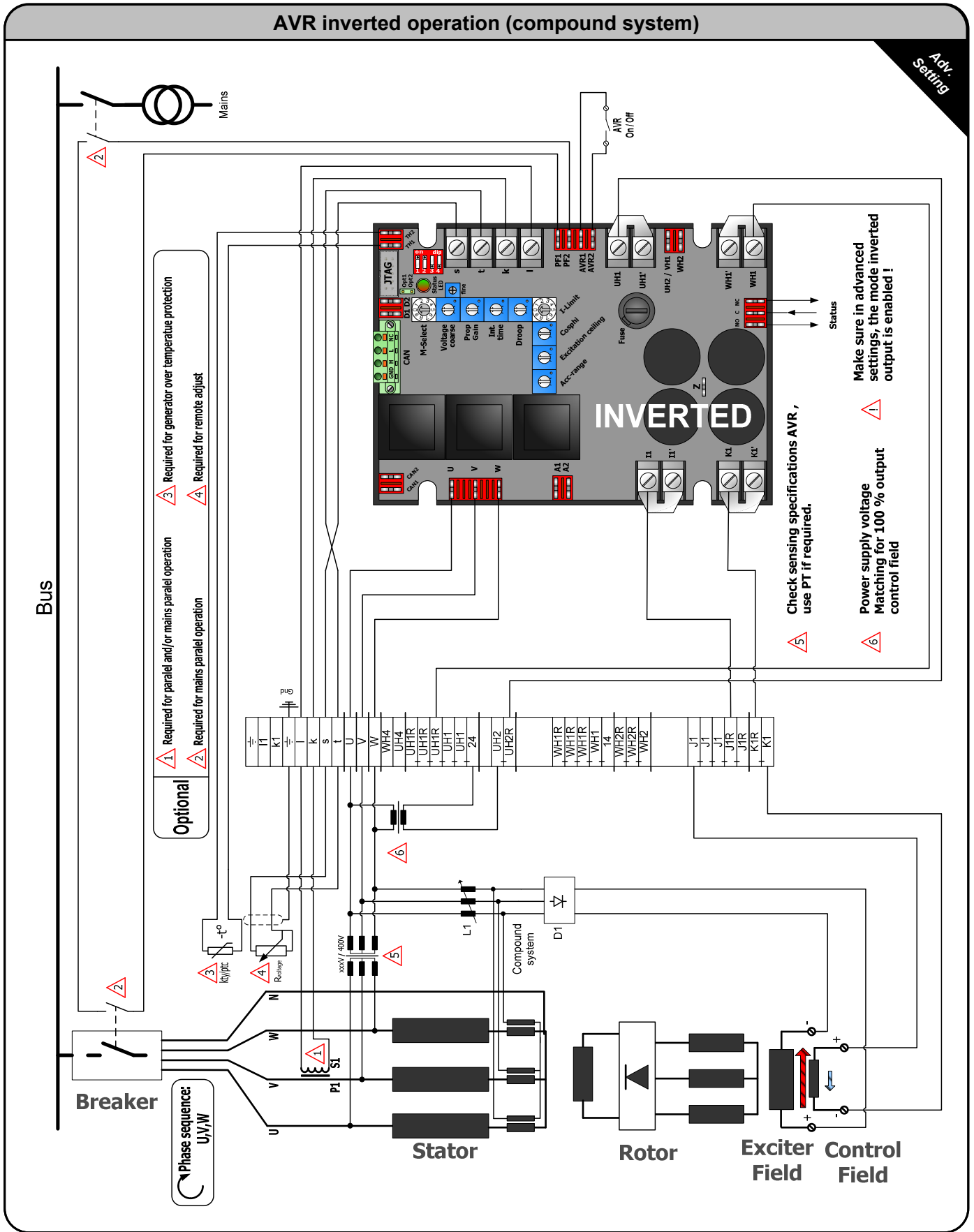


WIRING DIAGRAM I I I

AVR with transformer (Self excited)



WIRING DIAGRAM IV



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.

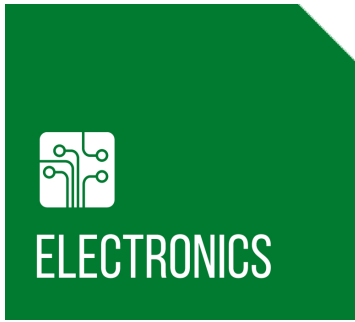
Wiring

- 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 I1 (+) and K1 (-), or Phase and neutral, or s and t.
- 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 I1 (+) and K1 (-), 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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