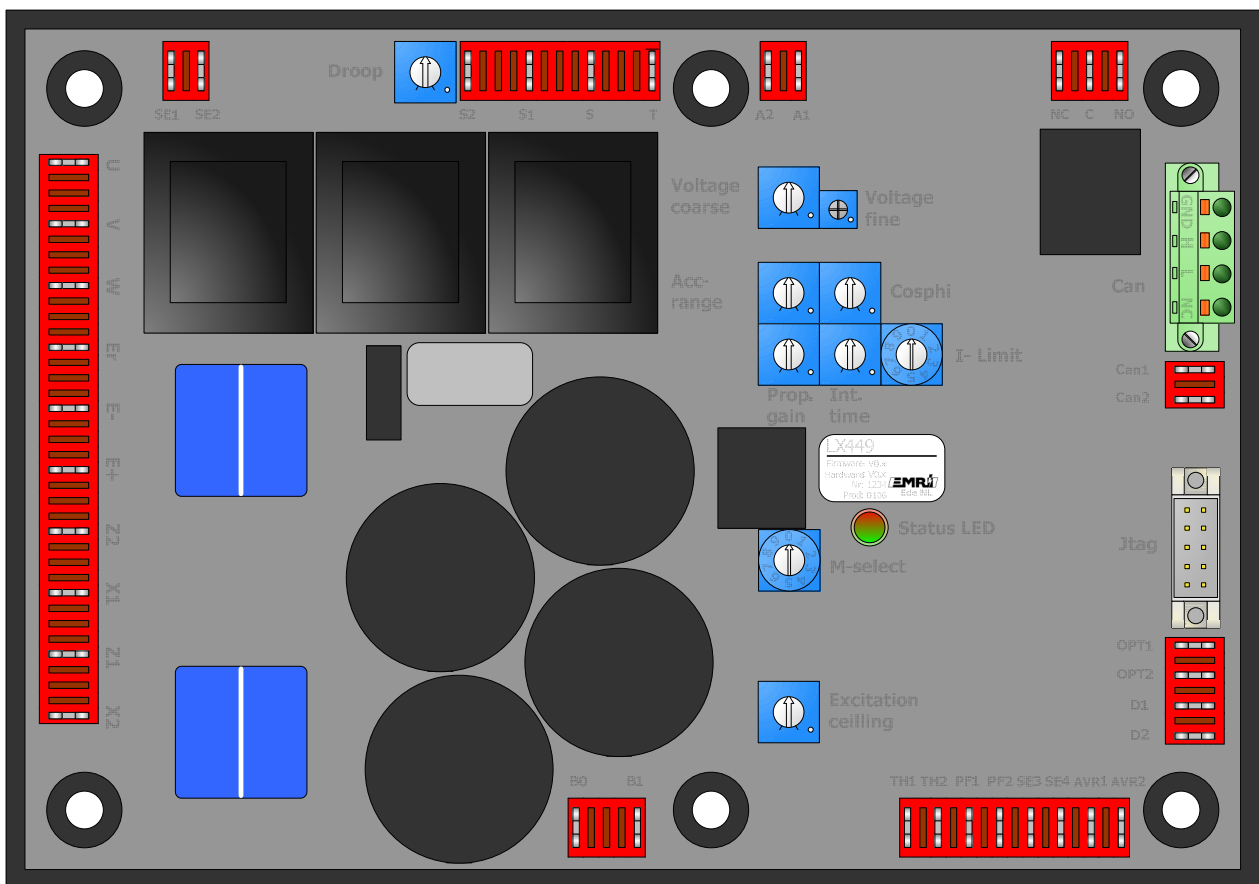


LX449

Voltage regulator for generators



Instruction Manual

Product version V1.5.0

Revision history

The table below provides a historical summary of the changes made to the LX449 AVR. Revisions are listed in chronological order.

Product version	1.0.0	Change
Hardware version	1.0.0	<i>First release.</i>
Software version	1.0.0	
Manual revision	1.0.0	
Product version	1.1.0	Change
Hardware version	1.1.0	<i>Inserted software calibration option, PCB fix.</i>
Software version	1.0.0	
Manual revision	1.0.0	
Product version	1.2.0	Change
Hardware version	1.2.0	<i>Added more sw advanced options.</i>
Software version	1.0.0	
Manual revision	1.1.0	
Product version	1.2.2	Change
Hardware version	1.2.2	<i>Software bug fix PI controller.</i>
Software version	1.0.0	
Manual revision	1.4.0	
Product version	1.3.0	Change
Hardware version	1.2.0	<i>Improved CAN readout, measurement. SW excitation measurement improved.</i>
Software version	1.0.0	
Manual revision	1.4.1	
Product version	1.3.3	Change
Hardware version	1.2.0	<i>Voltage matching option added.</i>
Software version	1.3.3	
Manual revision	1.4.2	
Product version	1.4.0	Change
Hardware version	1.3.0	<i>Improved HW filtering and CAN readout.</i>
Software version	1.4.0	
Manual revision	1.4.4/1.4.5	
Product version	1.4.1	Change
Hardware version	1.4.0	<i>Added inverse mode, external cosphi setpoint added.</i>
Software version	1.4.1	
Manual revision	1.4.6	
Product version	1.4.3	Change
Hardware version	1.4.0	<i>Improved voltage match function. Added more sw advanced options.</i>
Software version	1.4.3	
Manual revision	1.4.6	
Product version	1.4.4	Change
Hardware version	1.5.0	<i>JTAG connector changed. Minor pcb changes.</i>
Software version	1.4.3	
Manual revision	1.4.6	
Product version	1.5	Change
Hardware version	1.6.0	<i>Minor software changes Minor hardware changes</i>
Software version	1.6.0	
Manual revision	1.5.0	

WARNINGS



WARNING

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



WARNING

Never work on a LIVE generator. Unless there is another person present who can switch off the power supply or stop the engine

WARNING

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.



**ELECTRICAL HAZARDOUS VOLTAGES
DANGEROUS DO NOT OPERATE WHEN
NOT FAMILIAR WITH GENERATORS**



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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1. INTRODUCTION

1.0 General description

The LX449 AVR is designed as a replacement for the R448 AVR and R449 AVR, incorporating at least the same standard functionality as the R448 and R449.

The LX449 AVR is a digitally controlled AVR, providing optimal flexibility and configurability as is reflected by the additional capabilities of the LX449 AVR.

Nevertheless installation, maintenance and adjustments don't require special application software. Additional sensing leads must be wired for three phase sensing instead of dual phase sensing of the R449.

Additional features

Selectable mode of operation:

- Volt per Hertz control.

- Constant voltage control

Modes of 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 limited motor start and volt per hertz control

Protections:

- Generator phase loss

- AVR over temperature

- Generator over voltage

- Generator over current

- Generator over temperature

- Loss of excitation during PFC

- Loss of current sensing during PFC

Flexible protections:

- User adjustable underspeed knee

- User adjustable field over excitation

- User adjustable generator current limit

Communication:

- CAN bus

- AVR status LED

- AVR status contact

1.1 AVR dimensions

The AVR LX449 is size compatible to the original Leroy Somer R449 & R448 and therefore easy to exchange. Two additional terminals are provided for three phase sensing. The AVR is protected from the environment by a PUR coating. Prefabricated links are provided for TH1-TH2, S-T, AVR1-AVR2, SE1-SE2, SE3-SE4 and CAN1-CAN2.

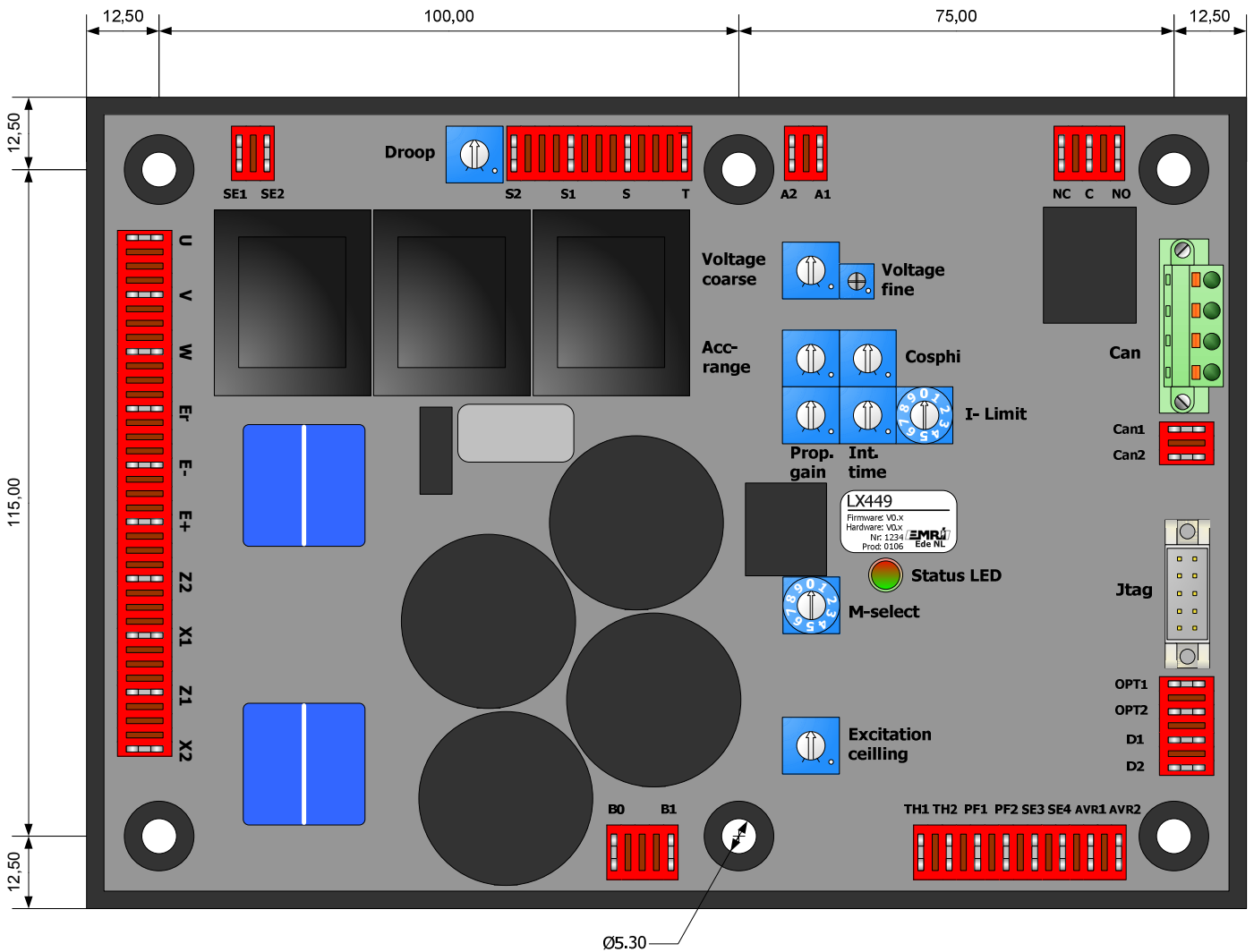


Fig 1. AVR dimensions

- Measurements in mm
- height ± 75mm

1.2 Absolute maximum ratings

Symbol	Parameter	Condition	Min.	Max.	Unit
U, V, W	Voltage sensing input ⁽³⁾	< 30 s @ 50Hz < 30 s @ 60Hz	-	480 520	V _{AC} V _{AC}
E-, E+	AVR field current	< 10 s	-	15 ⁽¹⁾	A _{DC}
X1-X2 Z1-Z2	Supply input	X1-X2, Z1-Z2 DC or 25 - 400 Hertz (No DC on X1)	20 22	300 135	V _{AC} V _{DC}
X1-X2	Supply input self excitation	Input SE1-SE2 must be closed	5	-	V _{AC}
R _{field}	Field resistance	@ 50 V _{x1-x2, z1-z2} (rms) @ 150 V _{x1-x2, z1-z2} (rms)	5 15	- -	Ω Ω
T _{AMB}	Operating temperature	95 % RHD non condensing	-30	+70 ⁽¹⁾	°C
T _{STG}	Storage temperature	95 % RHD non condensing	-55	+85	°C
A1, A2	Accessories input ^{(2) (4)}		-12	+12	V _{DC}
S1, S2	Droop, PFC, Limit CT 1A	Isolated CT < 30 s	-	3	A _{AC}
NO, C, NO	Status contact switching current	U _{MAX} 30V _{DC} U _{MAX} 230V _{AC}	- -	4 10	A _{DC} A _{AC}
B0, B1	Trip coil output	R _{load} ≥ 120Ω	- -	0,5 60	A _{DC} V _{DC}

Table 1. Absolute maximum ratings

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

(2) Isolated.

(3) Depending on voltage selection range see tabel 5.8.0.

(4) Input resistance is 1,1kΩ .

1.3 Commissioning information

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.

Defects in the generator or AVR may cause consequential loss. Precautions must be taken to prevent this from occurring.

Never work on a LIVE generator. Unless there is another person present who can switch off the power supply or stop the prime mover.

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.

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.

2. INSTALLATION

For a complete wiring diagram see Chapter 6.

2.0 Interfaces overview

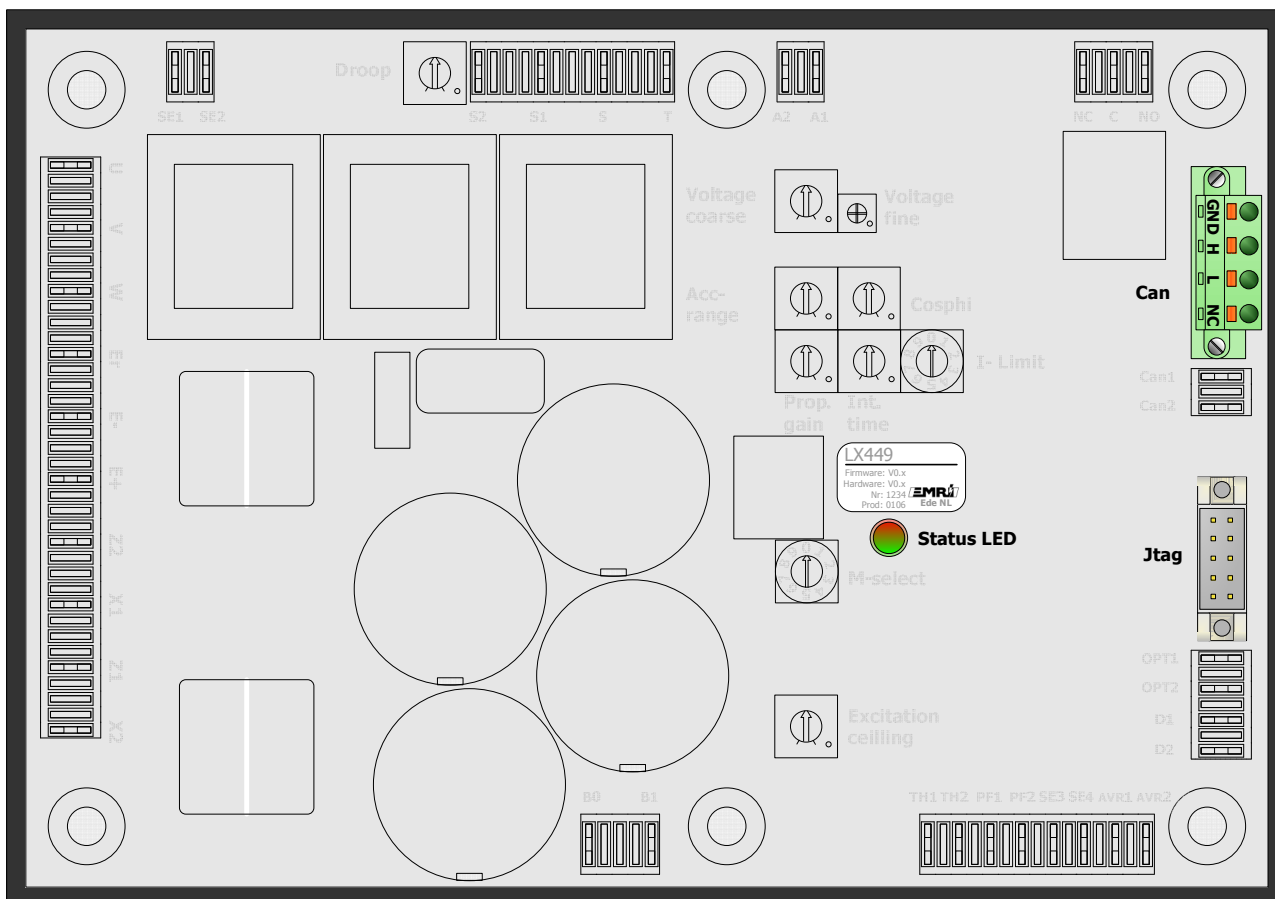


Fig 2. Interfaces overview

Symbol	Description	Notes
Status LED	AVR control mode & Error diagnostics	See Table 6 and 8
CAN	CAN bus I/O	
JTAG	Maintenance port	

Table 2. Interfaces

2.1 Adjustments overview

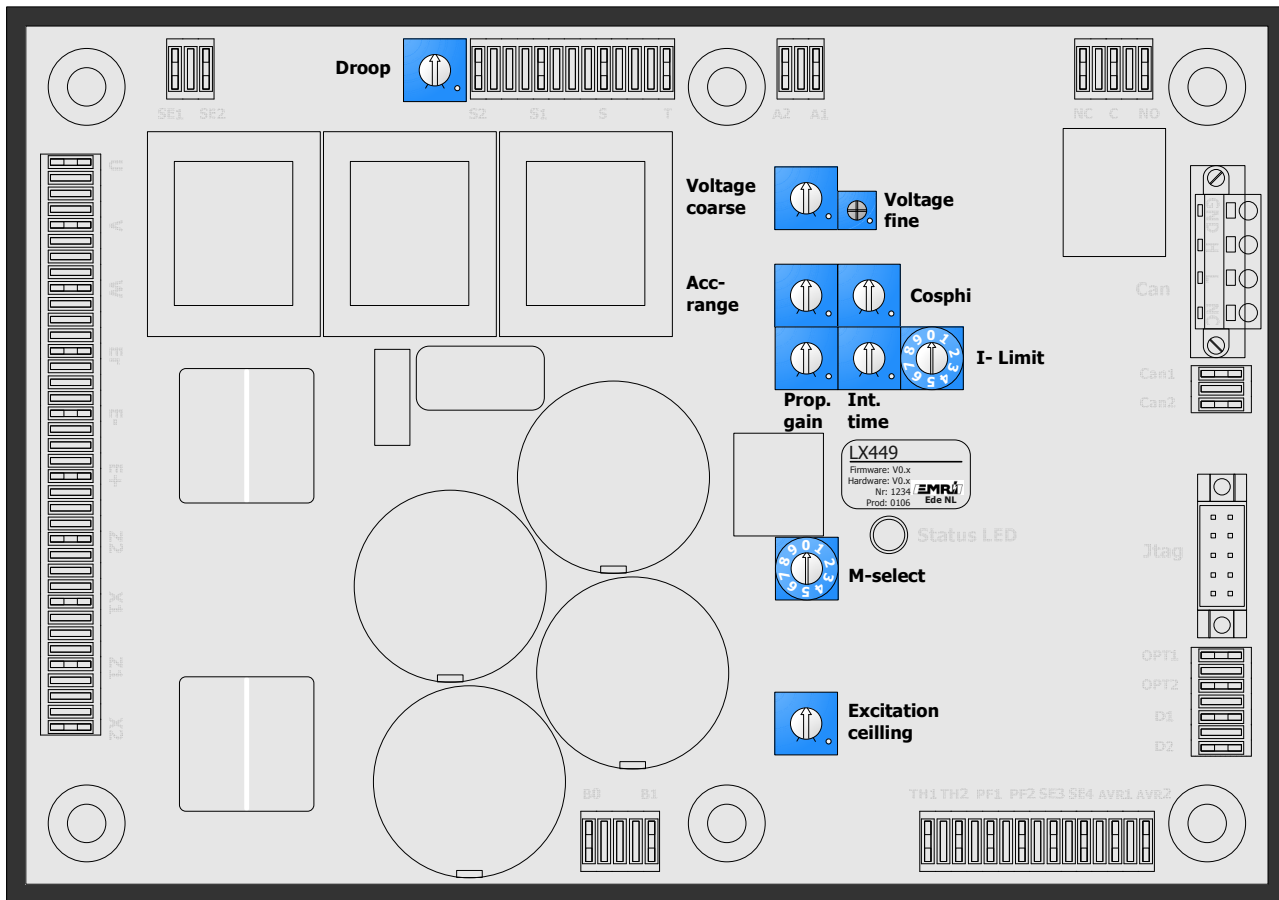


Fig 3. Adjustments overview

Symbol	Description	Notes
Voltage coarse	Coarse generator voltage setpoint	
Voltage fine	Fine generator voltage setpoint	
I- Limit	Generator current limit setting	
M-Select	AVR mode selection	Also special control modes, see 5.2
Prop. Gain	Proportional gain setpoint	Stability adjustment
Int. time	Integral time setpoint	Stability adjustment
Droop	Voltage droop setpoint	For parallel operation
Acc- range	Accessory input range adjustment	A1+, A2-
Excitation ceiling	Over excitation setpoint	
Cosphi	Cosphi setpoint	Only enabled during parallel PFC

Table 3. Adjustments

2.2 Terminals overview

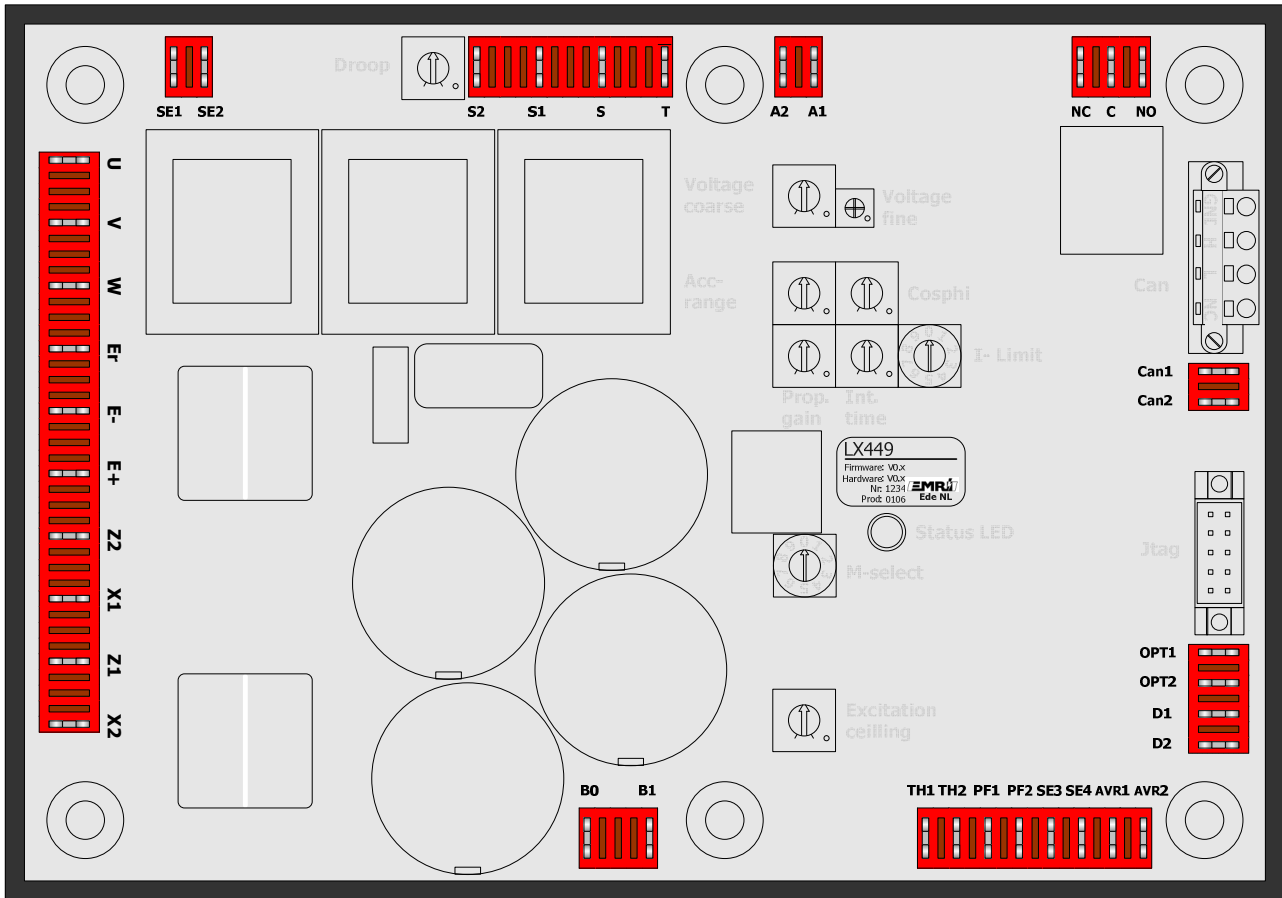


Fig 4. Terminals overview

Symbol	Description	Notes
U, V, W	Voltage sensing input	phase sequence U → V → W (Clockwise)
S, T	External voltage adjust input	
AVR1, AVR2	AVR On / Off input	Off for ≥ 10s. resets previous AVR errors
X1, X2, Z1, Z2	Supply input	
E-, E+	Field excitation output	E- (Field-), E+ (Field+)
Er	Common ground	
A1, A2	Accessory input (Isolated)	Function dependent on M-select setting
S1, S2	CT input for current sensing	1A _{ac} input
B0, B1	Over voltage CB trip coil output	B0+, B1-
SE1, SE2	Self Excitation link (Caution: High voltage)	Never fit or remove link while generator is in operation!
SE3, SE4	Self Excitation link	Never fit or remove link while generator is in operation!
TH1, TH2	Thermistor sensing input	KTY sensor input or 50Hz/60Hz select
PF1, PF2	Power factor control input	Closed for PFC
Can1, Can2	Can termination contact	Can bus termination 120 Ohm when placed
OPT1, OPT2	Advanced options input	See chapter 5.9.2 for all options
D1, D2	Optional analogue output	0-10Vdc / 0-20mAdc
NC, C, NO	Status contact	C-NO closed when AVR operational

Table 4. Terminals

2.3 Electrical characteristics

Symbol	Parameter	Condition	Min	Max.	Unit
U, V, W	Voltage sensing input	50Hz, Clockwise (CW) 60Hz, Clockwise (CW)	-	450 500	V _{AC} V _{AC}
E+, E- (3)	AVR field current	@ T _{AMB} ≤ 70°C @ T _{AMB} ≤ 50°C	-	10 (1) 13 (1)	A _{DC} A _{DC}
R _{field}	Field resistance		15	-	Ω
X1, X2, Z1, Z2	Supply input	30 - 400 Hertz	20	240	V _{AC}
X1-X2	Supply input for self excitation	Input SE1-SE2 must be closed (No DC on X1)	5	-	V _{AC}
A1, A2	Accessory input	Constant voltage control	-10	+10	V _{DC}
A1+, A2- (2)		0-100% Control	0	+10	V _{DC}
S1, S2 (U)	Droop, PF CT, Limit CT	2 VA, Isolated CT	-	1	A _{AC}
S,T	External Volt adjust	R _{s-t} 470Ω R _{s-t} 1kΩ	0 0	-5 -10	% %
			-	5	kΩ
NO, C, NO	Status contact switching current	U _{MAX} 30V _{DC} U _{MAX} 230V _{AC}		3 6	A _{DC} A _{AC}
TH1, TH2 (KTY81-1..)	Temperature sensing input	Temp.error if R _{TH1-TH2} >1K7	0	3	kΩ
	Underspeed frequency selection	Linked = if R _{TH1-TH2} <1K Open = if R _{TH1-TH2} >3K	0 3	1 -	kΩ kΩ
B0, B1	Trip coil output	R _{load} ≥ 120Ω	-	0,5	A _{DC}
	B0+, B1-		-	60	V _{DC}
T _{AMB}	Operating temperature	95 % RHD non condensing	-30	70 (1)	°C
T _{STG}	Storage temperature	95 % RHD non condensing	-55	+85	°C
	Static control accuracy			1	%

Table 5. Electrical characteristics

- (1) Always mount with heatsink fins aligned vertically and allow for sufficient airflow.
- (2) Isolated.
- (3) See below for the safe operation area of the LX449 voltage regulator.

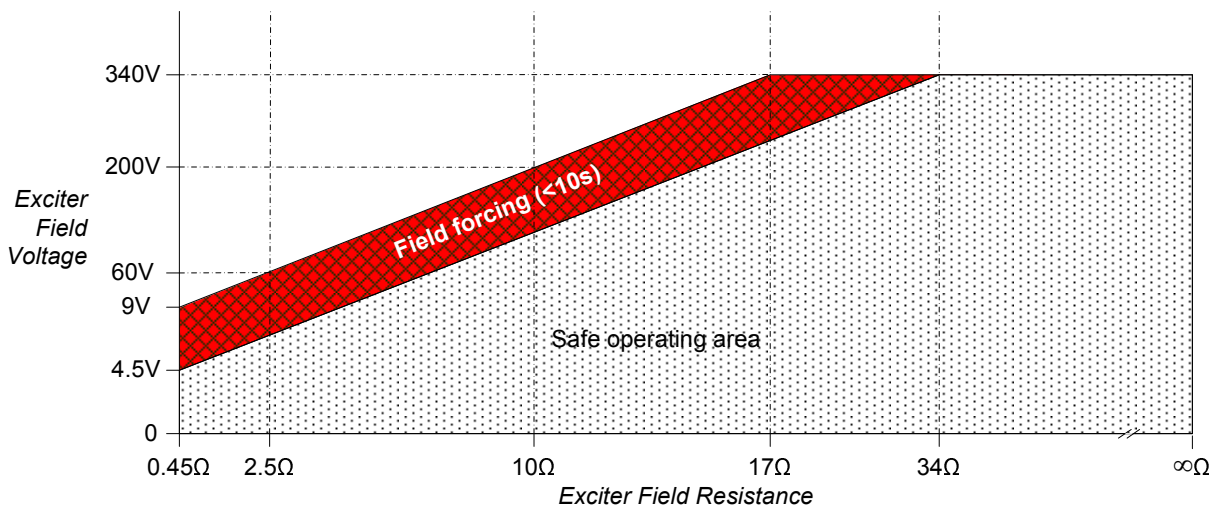


Diagram 1. Operation area

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.

3. Operation and maintenance

3.0 AVR Status

The AVR's status is indicated by the status LED. The options are depicted in table 6.







LED Color / Blinks	AVR status	Colour code
	Idle	Green blink
	Buildup	Orange blink
	Voltage control	Continuous green
	Current control/ PF control	Continuous orange
	Underspeed	Continuous red
	Error code	Red/ green blink

Table 6. AVR status

3.1 Modes of control

3.1.0 Idle

When a supply is connected to the AVR and contact AVR1-AVR2 (AVR On/Off) is open, the AVR enters idle mode. During idle mode, field excitation is inhibited and protections are reset.

The AVR will start from idle mode after resetting an error condition.

When SE links are closed the AVR will start field flashing.
For more information about this option see 3.1.1 and 3.1.2

3.1.1 Buildup (PMG only)

When contact AVR1-AVR2 (On/Off) is closed, the AVR enters build up mode. Protections are enabled and the generator voltage is ramped up to the nominal voltage. When the generator voltage is close to the nominal setpoint, the status contact is energized. Diagram 2 shows the sequence of events.

Remove SE1-SE2 and SE3-SE4 for PMG operation!

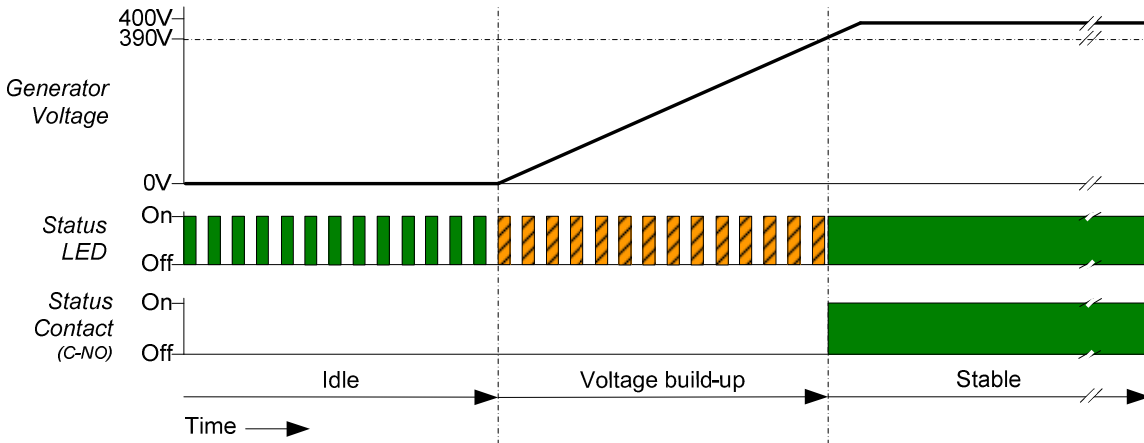


Diagram 2. Build up (PMG)

3.1.2 Buildup (Self Excited)

For self excitation (SE) mode, links over AVR1-AVR2, SE1-SE2 and SE3-SE4 must be placed. After starting the generator, the AVR will field flash and enter build up mode. Protections are enabled and the generator voltage is ramped up to the nominal voltage. When the generator voltage is close to the nominal setpoint, the status contact is energized. Diagram 3 shows the sequence of events.

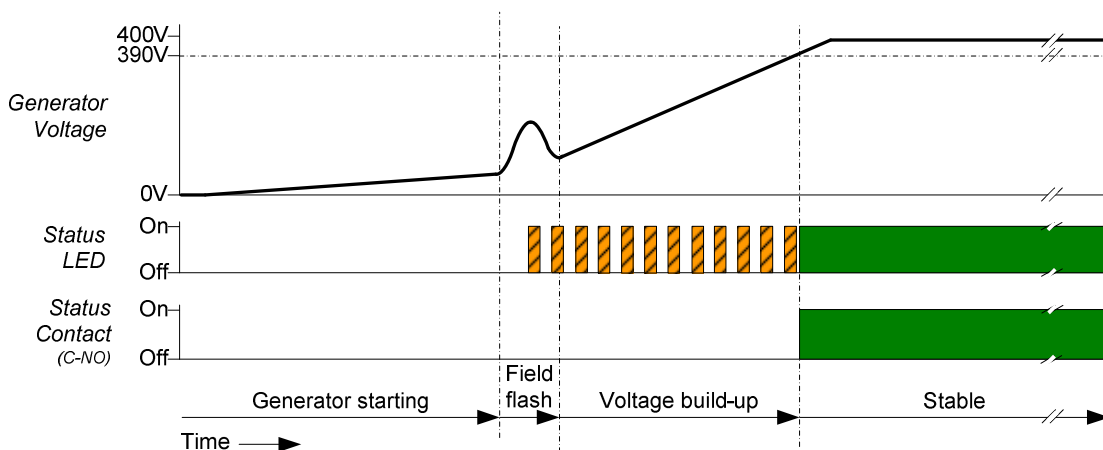


Diagram 3. Build up (SE)

3.1.3 Constant Voltage control

The AVR starts constant voltage control after finishing the build up mode when this is selected with the M-Select switch (M-select mode 0, 1, 4, 5).

The voltage/frequency characteristics are depicted in diagram 4.

Below the underspeed frequency, the generator voltage is controlled according a Volt per Hertz slope. Both the underspeed knee frequency and the VPH slope are user adjustable.

For a detailed description see table 10.

When the generator frequency drops below 25 Hertz, the generator voltage is always controlled to a low level. In PMG-mode 60Vac and in Self excitation-mode 150Vac.

An underspeed situation is visualized by a continuously red status LED.

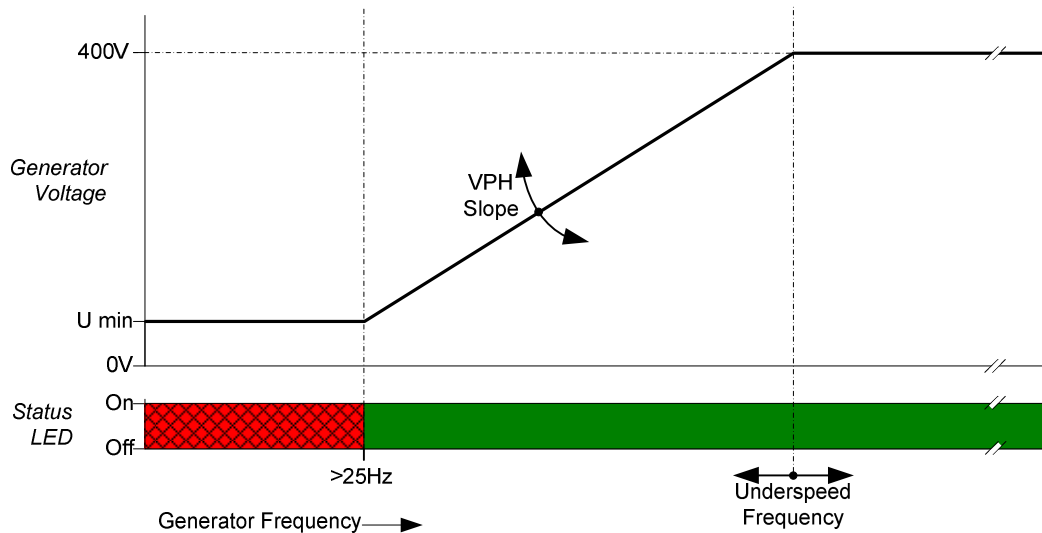


Diagram 4. Constant Voltage control

3.1.4 Volt per Hertz control

The AVR performs Volt Per Hertz (VPH) control after finishing the build up mode when this is selected with the M-select switch (M-select mode 8, 9). The voltage/frequency characteristics are depicted in diagram 5. Note that the voltage is limited to a maximum of 500V irrespective of the generator frequency.

When the generator frequency drops below 25 Hertz, the generator voltage is always controlled to a low level. In PMG-mode 60Vac and in Self excitation-mode 150Vac. An underspeed situation is visualized by a continuously red status LED.

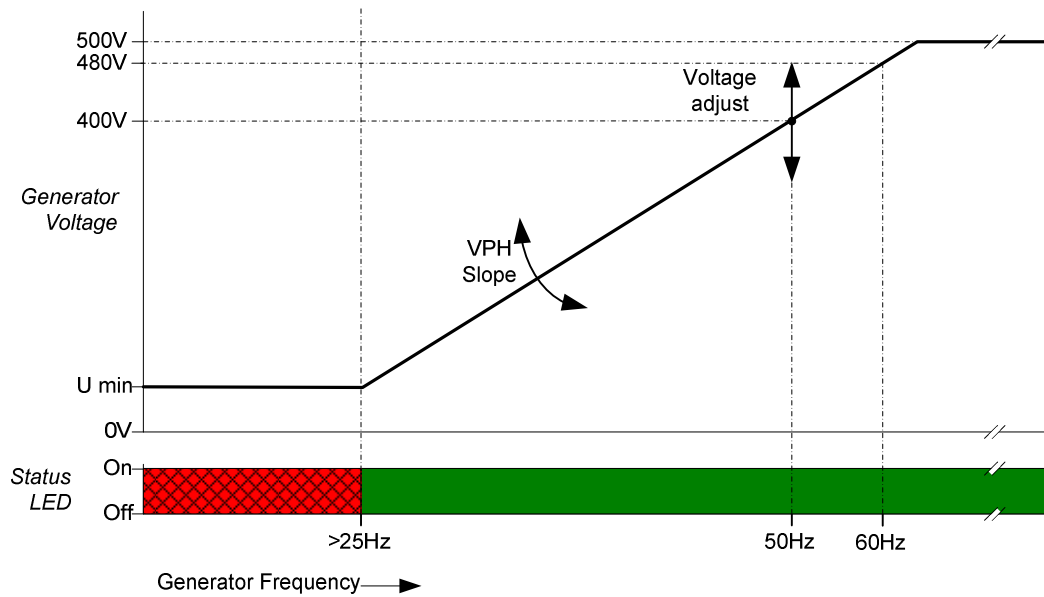


Diagram 5. VPH control

3.1.5 Current control

The AVR switches to current control when the generator current exceeds the generator current limit. The current limit is user selectable from 60% to 300% of the nominal generator current. To ensure sufficient supply voltage to the AVR during current limiting an external supply or PMG is usually required.

3.1.6 Power factor control

The AVR performs Power Factor Control (PFC) when contact PF1-PF2 is closed. When the AVR is in Power factor control, both loss of excitation protection as well as the loss of current sensing protection are enabled. The power factor is user adjustable from 0.9 capacitive to 0.6 inductive. For more details about setting the power factor, see 5.7.

3.1.7 Error condition

If an error condition triggers the AVR's protections, field excitation is disabled and an error code is signaled by the status LED. See Chapter 4 (Error conditions) for a detailed description of the AVR's protections.

3.2 Special Applications

3.2.0 Parallel operation

If the generator operates in parallel operation with one or more generators, reactive current sharing can be accomplished by means of Quadrature Droop Compensation (QDC). The amount of voltage droop must be precisely set equal for all generators under equal load conditions. The influence of the voltage droop on the generator voltage is depicted in diagram 6.

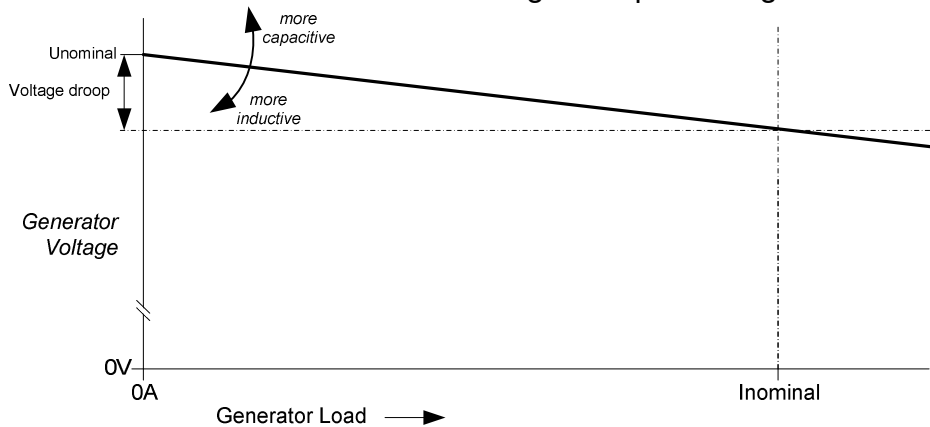


Diagram 6. Voltage droop

If current limiting is enabled during parallel operation, all generators must have the same current limit and M-select (mode of control) settings.

3.2.1 Parallel soft start

When several AVR's are used in parallel for a motor start application, all AVR's must have the same current limit setting and M-select (mode of control) setting. To perform a synchronous start, it is required to make all AVR1-AVR2 (AVR On/Off) contacts simultaneously. To ensure sufficient supply voltage to the AVR during current limiting an external supply or PMG is usually required. Diagram 7 shows a sequence of events of a parallel soft start application.

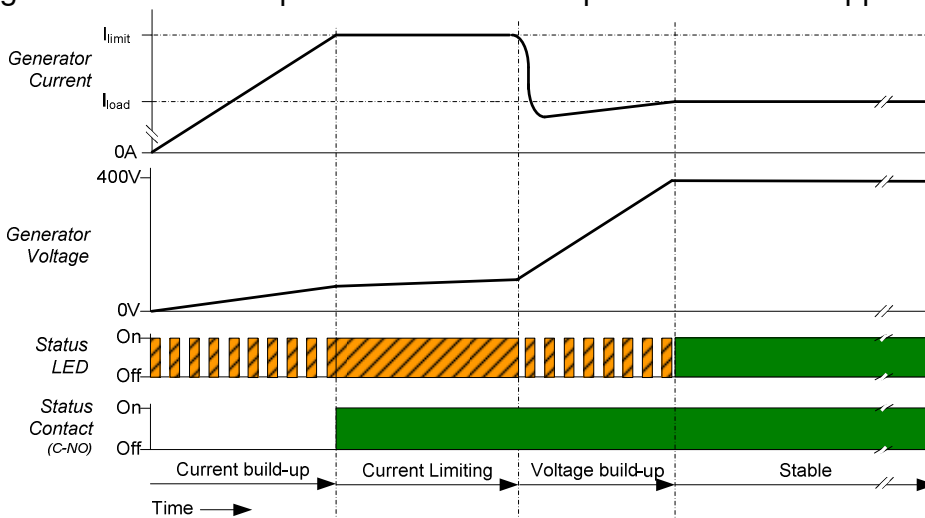


Diagram 7. Parallel soft start

3.2.2 0-100% Voltage control

When M-select (mode of operation) is set to position 2 or 6, the generator voltage setpoint is controlled by an external supply source. The generator voltage setpoint is linear proportional with the voltage level supplied at terminals A1-A2. Terminal A1 is connected to the positive side of the external supply, terminal A2 connects to the negative supply side.

The accessories range potentiometer may be used to adjust the generator's voltage range as is depicted in diagram 8. If the Acc- range potentiometer is completely clockwise, 10V_{dc} input on A1-A2 corresponds with the generator voltage setpoint as set with the voltage potentiometers.

If the Acc- range potentiometer is completely counter clockwise, influence on the generator voltage by A1-A2 is effectively disabled. To ensure sufficient supply voltage to the AVR during current limiting an external supply or PMG is usually required.

During 0-100% voltage control, underspeed protection is disabled!

Note: Link SE1-SE2 and SE3-SE4 must be removed.

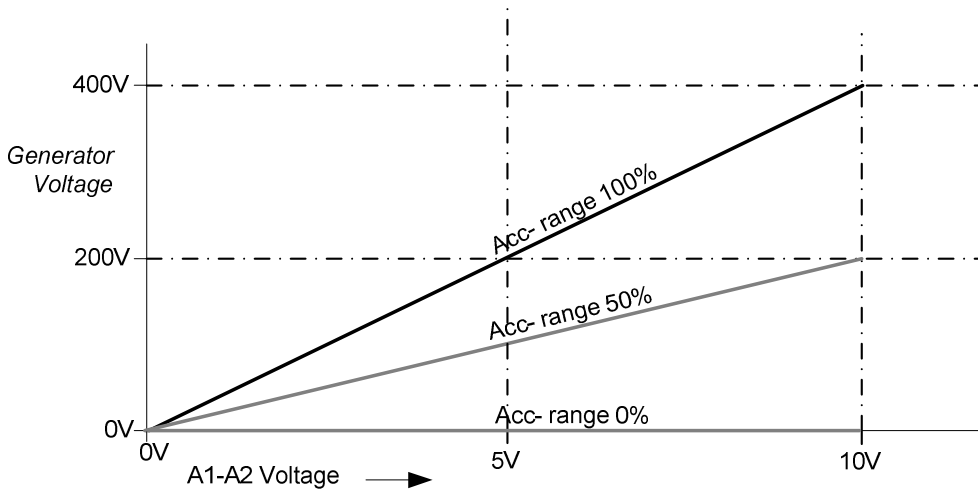


Diagram 8. Acc- range influence

3.2.3 0-100% Current control

When M-select (mode of operation) is set to position 3 or 7, the generator current limit setpoint is controlled by an external supply source. The generator current limit setpoint is linear proportional with the voltage level supplied at terminals A1-A2. Terminal A1 is connected to the positive side of the external supply, terminal A2 connects to the negative supply side.

The accessories range potentiometer may be used to adjust the generator’s current limit range as is depicted in diagram 9. If the Acc- range potentiometer is completely clockwise, 10V_{dc} input on A1-A2 corresponds with the generator current limit setpoint as set with the I-limit switch.

If the Acc- range potentiometer is completely counter clockwise, influence on the generator current limit by A1-A2 is effectively disabled. To ensure sufficient supply voltage to the AVR during current limiting an external supply or PMG is usually required.

Note: Link SE1-SE2 and SE3-SE4 must be removed.

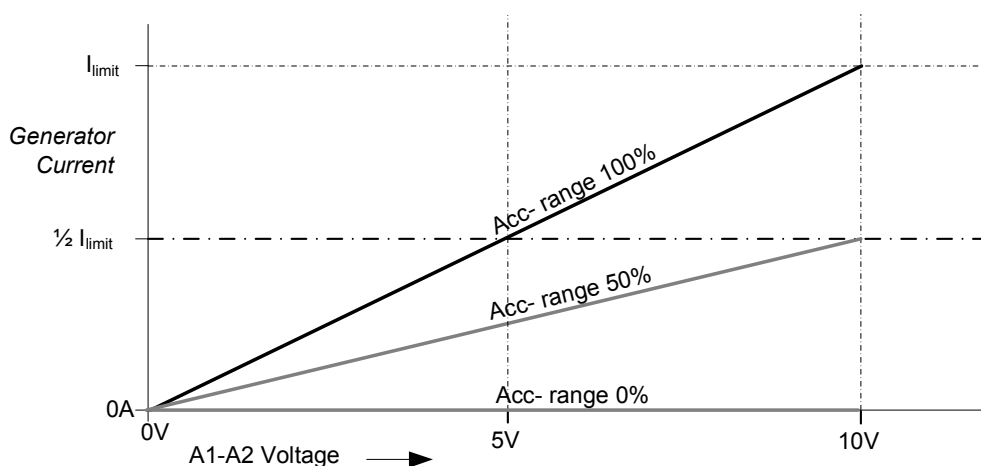


Diagram 9. Acc- range influence

3.2.4 Options

The LX449 AVR can be functionally extended with the following options:

Type	Description	Interface
Droopcat	Required for parallel operation	AVR terminals S1-S2
LX_VMA	Required for voltage matching	AVR terminals A1-A2
3F-Filter	For filtering the generator sensing.	AVR terminals U-V-W
LX_TRIP CB+Coil	Overvoltage trip protection	B0-B1

Table 7. LX449 options

4. Protections and diagnosis

4.0 Led error codes

When the feature is enabled (see protections in table 5.10.1) the AVR stops field excitation due to a fault condition, the fault that caused this is indicated by the status LED. Table 8 shows the relation between the number of red blinks and the error condition.

AVR switch-off at fault condition is default disabled!
For activation please check ‘protections’ table 5.10.1.









LED Color / Blinks	Error condition
	1 Overvoltage
	2 Overcurrent
	3 Excitation error
	4 Overtemperature AVR
	5 Overtemperature Gen
	6 Phaseloss / Phase sequence error
	7 Loss of excitation during PFC
	8 Loss of current sensing during PFC

Table 8. Error codes

The AVR may be reset from the error condition by opening contact AVR1-AVR2 (AVR On/Off) for at least 10 seconds. After a successful reset the AVR commences in idle mode and any information concerning the causing error is lost. In Self excitation-mode you must shut down the generator. If AVR is not working at all or not under load condition check 15Amp external fuses (F01, F02) inside the generator.

4.1 Protections for Self Excited generators

When a protection is triggered and excitation is consequently stopped, this effectively also interrupts the AVR supply source for a Self Excited generator. Because the supply to the AVR is interrupted, the AVR is reset and will restart building up voltage again. If the cause of the error is still present this will cause a continuous tripping and restarting of the system.

To prevent this, the B0-B1 contacts or the AVR status contact outputs can be used in conjunction with external circuitry to inhibit an automatic restart in case a protection is triggered.

4.2 Protections

4.2.0 Over voltage

The over voltage protection validates the generator voltage on terminals U, V and W. If the over voltage limit of 520V is exceeded for 1 second, the AVR switches off the status contact.

If the error condition still exists 1 second after opening the status contact, field excitation is stopped and the trip coil, connected to terminals B0-B1, is energized.

In Self excitation-mode the AVR will shutdown and restart buildup, therefore you must shut down the generator in case of an error.

If the overvoltage condition is relieved within 1 second after opening the status contact, the contact closes again and normal operation proceeds.

An over voltage error is visualized by the status LED blinking red once.

Removing the power supply by stopping the generator or opening the AVR On/Off contact at terminals AVR1-AVR2 for 10 seconds will reset the AVR.

Diagram 10 shows a sequence of events for diagnosis purposes in case of an over voltage error.

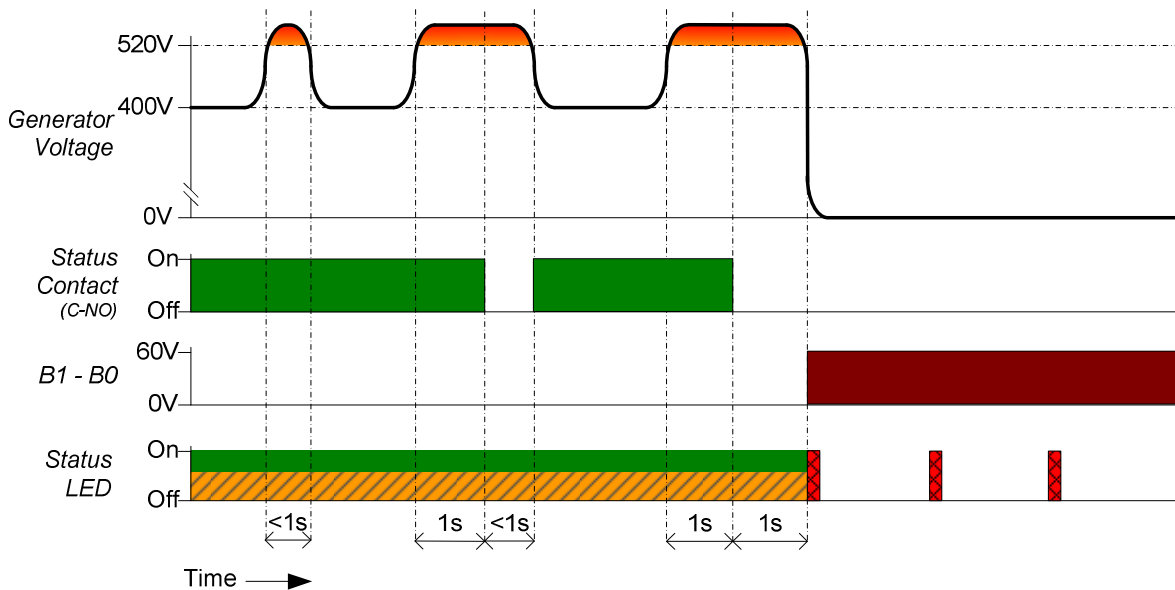


Diagram 10. Over voltage

4.2.1 Over current

The over current protection validates the generator current measured on terminals S1 and S2. If the current limit, set by the user, is exceeded by 200% for 1 second, the AVR switches off the status contact.

If the error condition still exists 1 second after opening the status contact, field excitation is stopped. In Self excitation-mode the AVR will shutdown and restart buildup, therefore you must shut down the generator in case of an error.

If the over current condition is relieved within 1 second after opening the status contact, the contact closes again and normal operation proceeds.

An over current error is visualized by the status LED blinking red twice. Removing the power supply by stopping the generator or opening the AVR On/Off contact at terminals AVR1-AVR2 for 10 seconds will reset the AVR.

Diagram 11 shows a sequence of events for diagnosis purposes in case of an over current error.

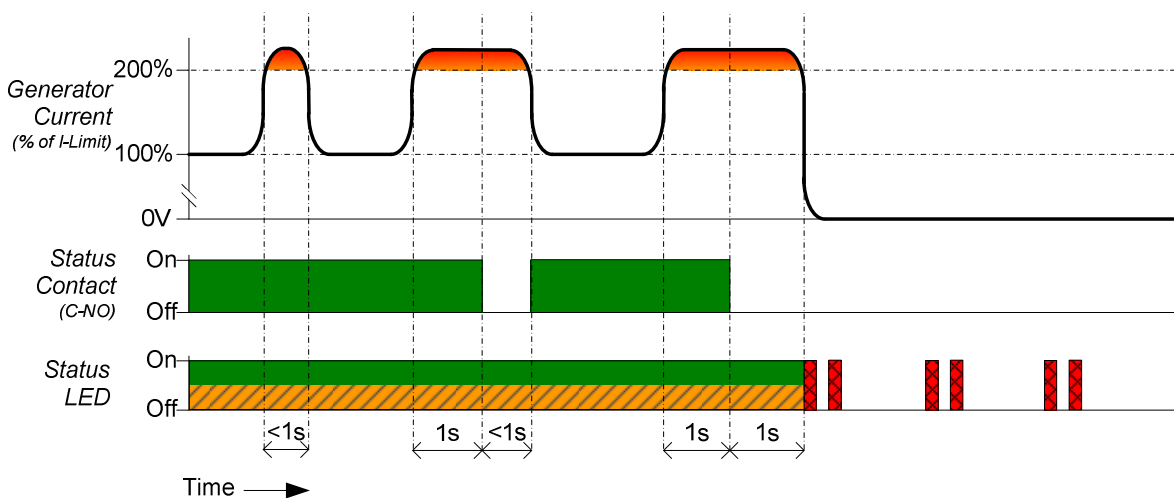


Diagram 11. Over current

4.2.2 Over excitation

The over excitation protection validates the generator field excitation measured on terminals E+ and E-. If the field excitation current exceeds the Excitation ceiling setpoint for more than 10,3 sec, the AVR switches off the status contact. The Excitation ceiling setpoint is user adjustable, from 1 Amps to 15 Amps, by means of the Excitation ceiling potentiometer.

If the error condition still exists 10 seconds after opening the status contact, field excitation is stopped. In Self excitation-mode the AVR will shutdown and restart buildup, therefore you must shut down the generator in case of an error.

If the over excitation condition is relieved within 10 seconds after opening the status contact, the contact closes again and normal operation proceeds.

An over excitation error is visualized by the status LED blinking red three times. Removing the power supply by stopping the generator or opening the AVR On/Off contact at terminals AVR1-AVR2 for 10 seconds will reset the AVR.

Diagram 12 shows a sequence of events for diagnosis purposes in case of an over excitation error.

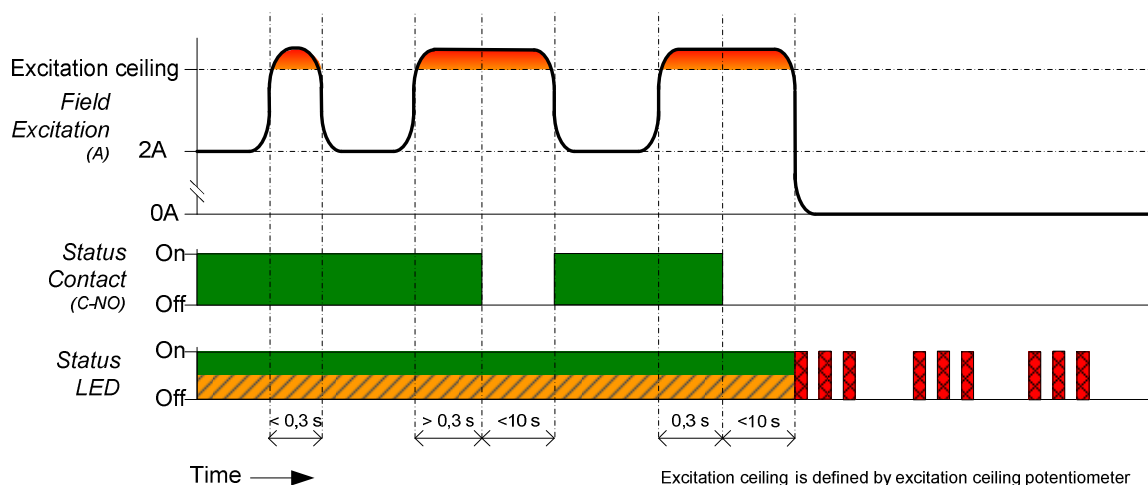


Diagram 12. Over excitation

4.2.3 AVR over temperature

The AVR over temperature protection validates the AVR temperature, measured internally. If the over temperature limit of 85°C is exceeded for 10 seconds, the AVR switches off the status contact.

If the error condition still exists 10 second after opening the status contact, field excitation is stopped. In Self excitation-mode the AVR will shutdown and restart buildup, therefore you must shut down the generator in case of an error.

If the AVR over temperature condition is relieved within 10 second after opening the status contact, the contact closes again and normal operation proceeds.

An AVR over temperature error is visualized by the status LED blinking red four times. Removing the power supply by stopping the generator or opening the AVR On/Off contact at terminals AVR1-AVR2 for 10 seconds will reset the AVR.

Diagram 13 shows a sequence of events for diagnosis purposes in case of an AVR over temperature error.

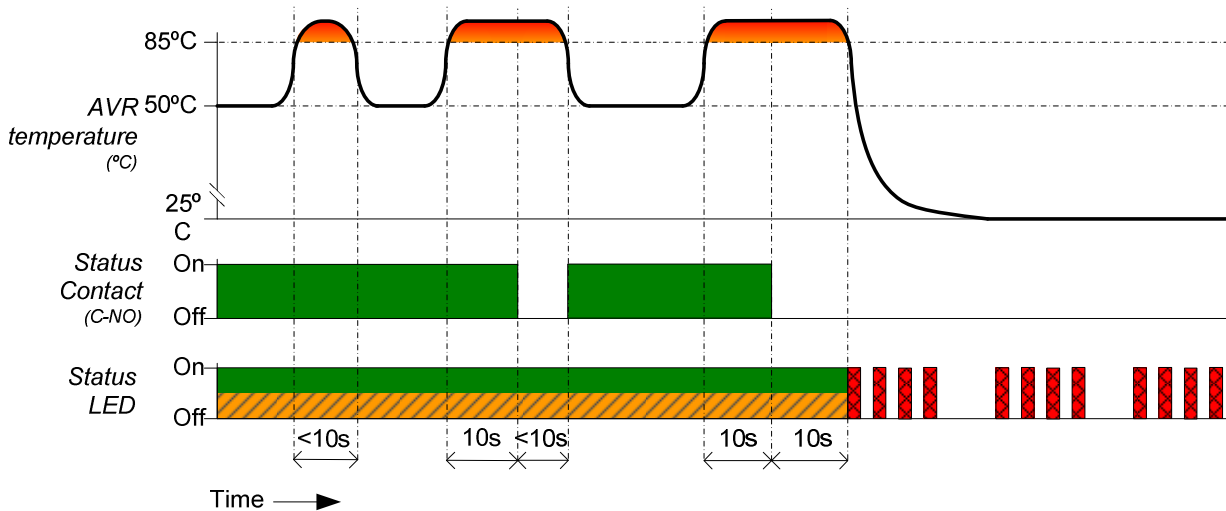


Diagram 13. AVR over temperature

4.2.4 Generator over temperature

The generator over temperature protection validates the generator temperature, measured on terminals TH1-TH2. Temperature sensor may be connected, providing a high impedance signal ($1K7 < R_{TH1-TH2} < 3K$ Ohms) in case of temperature error. If no temperature protection is required, terminals TH1-TH2 must be shorted.

If an over temperature error is detected for 10 seconds, the AVR switches off the status contact.

If the error condition still exists 5 second after opening the status contact, field excitation is stopped.

If the generator over temperature condition is relieved within 5 second after opening the status contact, the contact closes again and normal operation proceeds.

A generator over temperature error is visualized by the status LED blinking red five times. Removing the power supply by stopping the generator or opening the AVR On/Off contact at terminals K1-K2 for 10 seconds will reset the AVR.

Diagram 13 shows a sequence of events for diagnosis purposes in case of a generator over temperature error.

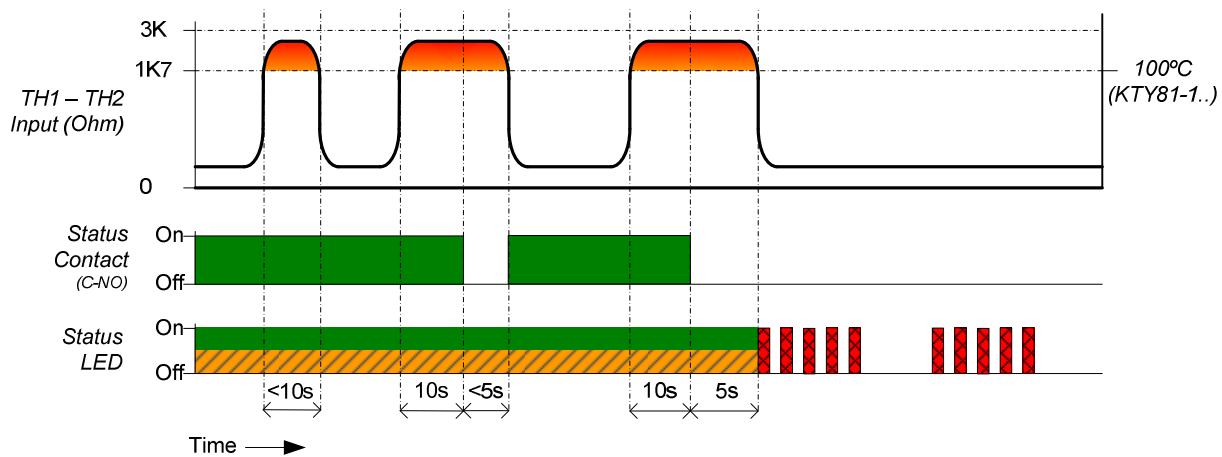


Diagram 14. Generator over temperature

4.2.5 Phase loss

The phase loss protection validates the presence of three generator phases on the terminals U, V and W.

Upon missing of one or more phases for 300ms, the AVR switches off the status contact and decreases the voltage set point to a low level. Phase loss is visualized by the red status LED.

If the error condition still exists 5 second after opening the status contact, field excitation is stopped. Self excitation-mode the AVR will shutdown and restart buildup, therefore you must shut down the generator in case of an error.

If the generator phase loss condition is relieved within 5 seconds after opening the status contact, the contact closes again and the voltage set point is ramped up again.

A phase loss error is visualized by the status LED blinking red six times.

Removing the power supply by stopping the generator or opening the AVR On/Off contact at terminals AVR1-AVR2 for 10 seconds will reset the AVR.

Phase loss protection is disabled in current control and the generator voltage is below 40Vac.

Diagram 15 shows a sequence of events for diagnosis purposes in case of a phase loss error.

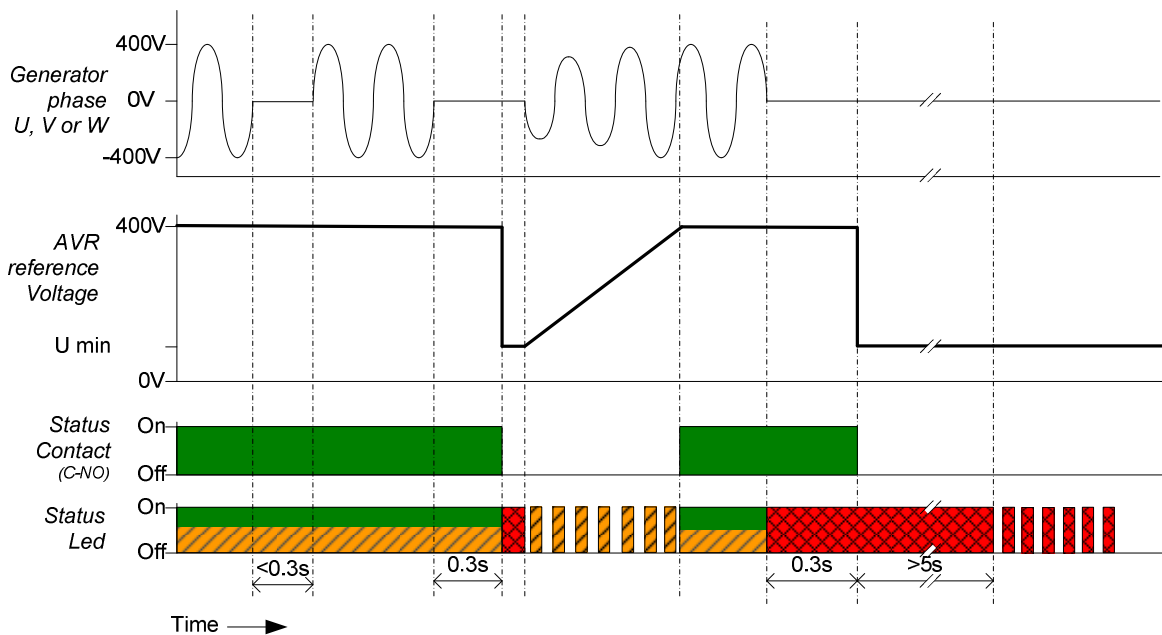


Diagram 15. Phaseloss

4.2.6 Loss of excitation (only for PFC)

If the AVR is in Power factor control, by shorting the PF1-PF2 terminals, the loss of excitation protection is enabled.

The loss of excitation protection validates the field excitation current on terminals E+, E-.

If an excitation current lower than 100mA is detected for 5 seconds, the AVR switches off the status contact. This status signal can be used to disconnect the generator from the bus.

If the error condition still exists 1 second after opening the status contact, field excitation is stopped. In Self excitation-mode the AVR will shutdown and restart buildup, therefore you must shut down the generator in case of an error.

If the loss of excitation condition is relieved within 1 second after opening the status contact, the contact closes again and normal operation proceeds.

A loss of excitation error is visualized by the status LED blinking seven times. Removing the power supply by stopping the generator or opening the AVR On/Off contact at terminals AVR1-AVR2 for 10 seconds will reset the AVR.

Diagram 16 shows a sequence of events for diagnosis purposes in case of a loss of excitation error.

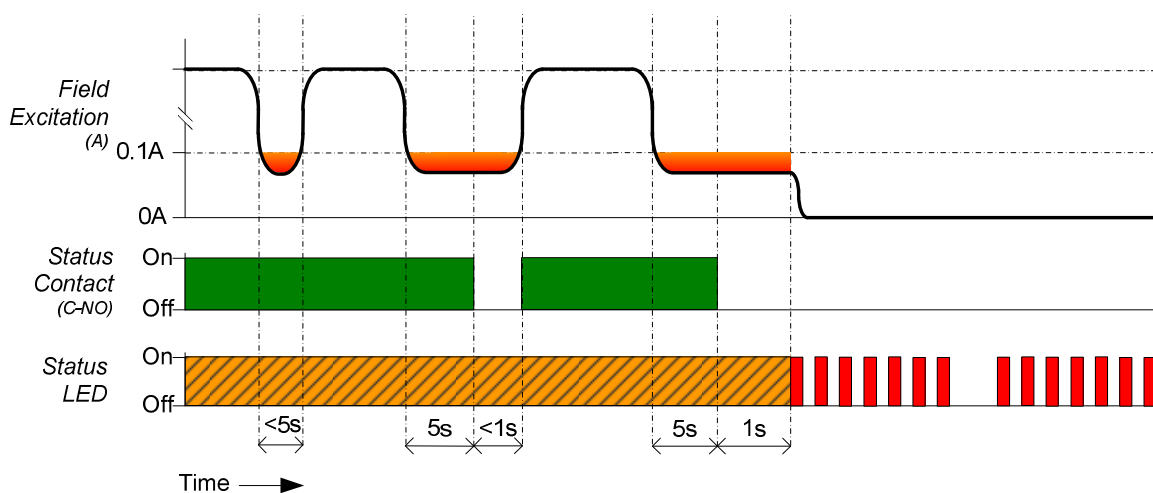


Diagram 16. Loss of excitation

4.2.7 Loss of current sensing (only for PFC)

If the AVR is in Power factor control, by shorting the PF1-PF2 terminals, the loss of current sensing protection is enabled.

The loss of current sensing protection validates the generator current on terminals S1, S2.

If a generator current lower than 2.5% of I nominal is detected for 5 seconds, the AVR switches off the status contact. This status signal can be used to disconnect the generator from the bus.

If the error condition still exists 1 second after opening the status contact, field excitation is stopped. In Self excitation-mode the AVR will shutdown and restart buildup, therefore you must shut down the generator in case of an error.

If the loss of current sensing condition is relieved within 1 second after opening the status contact, the contact closes again and normal operation proceeds.

A loss of current sensing error is visualized by the status LED blinking eight times. Removing the power supply by stopping the generator or opening the AVR On/Off contact at terminals AVR1-AVR2 for 10 seconds will reset the AVR.

Diagram 17 shows a sequence of events for diagnosis purposes in case of a loss of current sensing error.

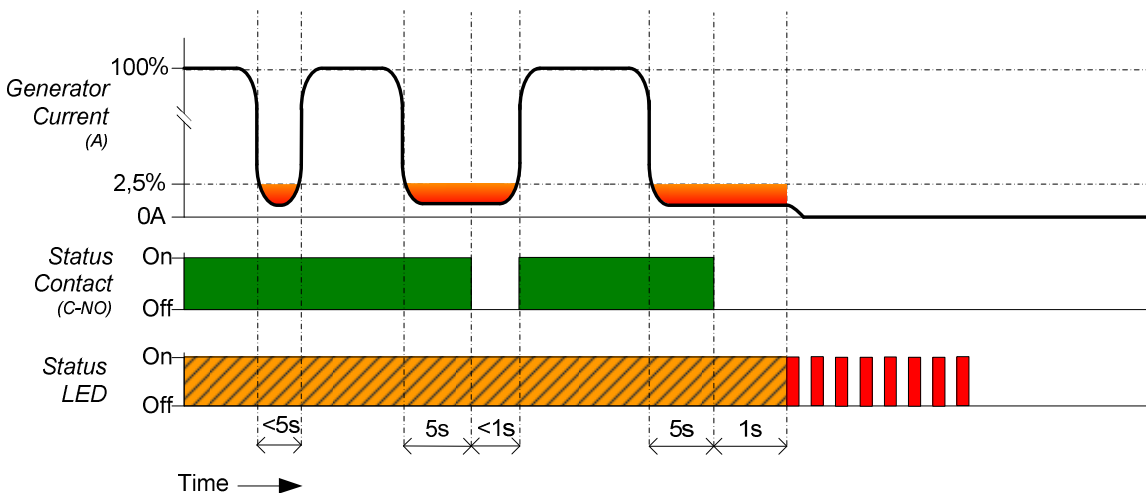


Diagram 17. Loss of current sensing

5. Settings and adjustments

5.0 Generator Voltage

The generator voltage setpoint is user adjustable by means of two voltage potentiometers. The coarse voltage potentiometer range is $U_{nom} \pm 25\%$. The fine voltage potentiometer range is $U_{nom} \pm 1,5\%$. Turning the potentiometers clockwise increases the generator voltage, turning counter clockwise decreases the generator voltage.

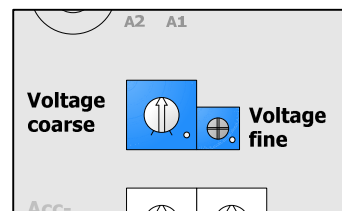


Fig 5. Voltage adjustments

5.1 Current Limit

The generator current limit is adjustable by means of the I-limit switch. The switch positions and corresponding current limits are depicted in table 9.

The current limit percentages are derived from the nominal generator current. The nominal generator current of 100% corresponds with a $1A_{ac}$ current on terminals S1 – S2.

Please note that switch position 9 disables current limiting as well as the over current protection. Operation with current limit settings above the generator’s nominal current should always take place under continuous qualified supervision and within the limits set by the generator thermal damage curve.

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

Table 9. Current limit

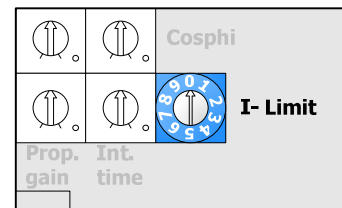


Fig 6. Current Limit

5.2 M-select (mode of operation select)

The M-select (mode of operation) switch determines the AVR's mode of operation and underspeed characteristics. The switch positions and corresponding modes are depicted in table 10. Ensure that the AVR's is in idle mode before changing the M-select setting. For a more elaborate description of the control modes refer to Chapter 3.

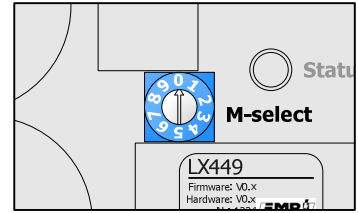


Fig 7. M-select

Switch position	Description Control Mode	A1-A2 range	Underspeed Frequency	Underspeed VPH slope
0	Constant Voltage Control	$\pm 10V_{dc}$	47 Hz	8 V/Hz
1	Constant Voltage Control	$\pm 10V_{dc}$	47 Hz	16 V/Hz
2	0-100% Voltage Control with A1-A2	0-10V _{dc}	-	-
3	0-100% Current Control with A1-A2	0-10V _{dc}	47 Hz	8 V/Hz
4	Constant Voltage Control	$\pm 10V_{dc}$	57 Hz	8 V/Hz
5	Constant Voltage Control	$\pm 10V_{dc}$	57 Hz	16 V/Hz
6	0-100% Voltage Control with A1-A2	0-10V _{dc}	-	-
7	0-100% Current Control with A1-A2	0-10V _{dc}	57 Hz	8 V/Hz
8	Volt per Hertz Control	$\pm 10V_{dc}$	-	8 V/Hz
9	Volt per Hertz Control	$\pm 10V_{dc}$	-	8 V/Hz

Table 10. M- select (mode of operation)

5.3 Stability

The generator stability and control response are adjustable by means of the proportional gain and integral time potentiometers. Turning the proportional gain potentiometer clockwise increases the proportional gain, turning counter clockwise decreases the proportional gain. Turning the integral time potentiometer clockwise increases the integral time, turning counter clockwise decreases the integral time. Turning the PI-controller must be performed by a control specialist to prevent damage to the AVR and generator.

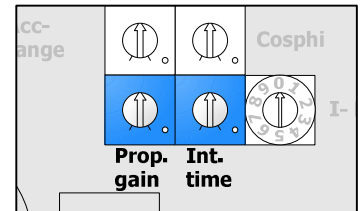


Fig 8. Stability adjustments

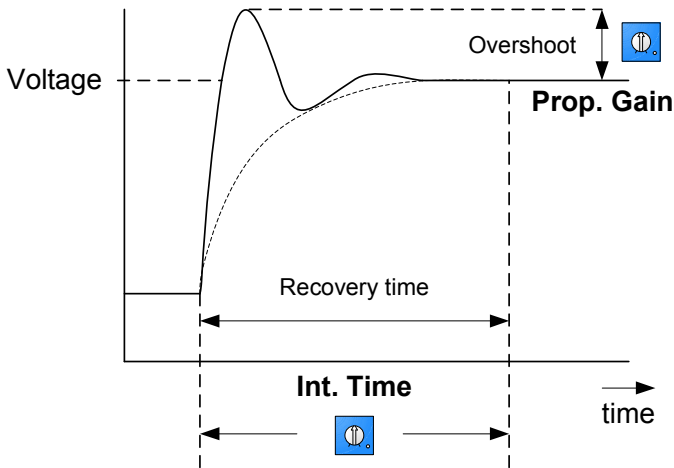


Fig 9. Stability behavior

5.4 Droop

When the generator is in parallel operation with one or more generators, Quadrature Droop Compensation is used to enable load sharing. The amount of voltage droop can be adjusted by means of the potentiometer. The droop potentiometer range is $U_{nom} - 10\% @ \cos\phi 0,85$ inductive. Turning the potentiometer clockwise increases the voltage droop, turning counter clockwise decreases the voltage droop. If the generator is not operating in parallel, turn the droop potentiometer completely counter clockwise to disable voltage droop. For a more detailed description of voltage droop see 3.2.0.

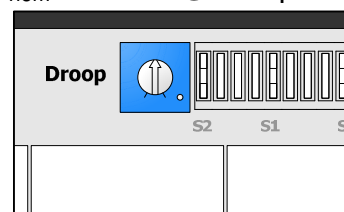


Fig 10. Droop adjustment

5.5 Accessories Range

Terminals A1-A2 are used to connect external accessories that influence the AVR's setpoint. The amount of influence can be adjusted by means of the Accessories range potentiometer. Terminals A1-A2 accept 0-10V or +/-10V, dependent on the mode of operation as is described in table 11. If the no external accessory is connected to terminals A1-A2, disable the input by turning the accessories range potentiometer completely counter clockwise. Setpoint is limited by U_{min} and maximum voltage setpoint.

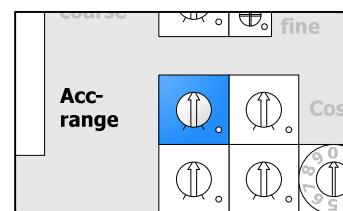


Fig 11. Accessories adjustment

Description Control Mode	A1-A2 range (A1+ , A2-)	Accessories influence on setpoint	
		C.C.W.	C.W.
Constant Voltage Control	0 .. -10V _{dc}	0% $U_{nominal}$	-40% $U_{nominal}$
	0 .. +10V _{dc}	0% $U_{nominal}$	+40% $U_{nominal}$
0-100% Voltage Control with A1-A2	0 .. +10V _{dc}	0% $U_{nominal}$	+100% $U_{nominal}$
0-100% Current Control with A1-A2	0 .. +10V _{dc}	0% $I_{nominal}$	+100% $I_{nominal}$

Table 11. Accessories influence

5.6 Excitation ceiling

The excitation ceiling potentiometer is used to adjust the trip level of the over excitation protection. The excitation ceiling potentiometer range is linear, ranging from 1 to 15 Amps. Turning the potentiometer clockwise increases the excitation ceiling current setpoint, turning counter clockwise decreases the excitation ceiling current setpoint. Be aware that increasing the excitation ceiling above generator limits can cause permanent damage to the generators exciter field. For a more detailed description of the over excitation protection see 4.2.2.

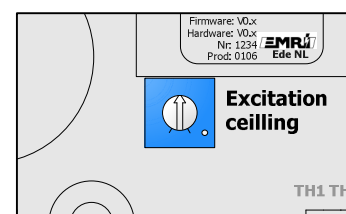


Fig 12. Excitation ceiling

5.7 Cosphi

The cosphi potentiometer is used to adjust the power factor setpoint for power factor control. The cosphi potentiometer range is 0.9 capacitive to 0.6 inductive.

Turning the potentiometer clockwise will set a more inductive power factor setpoint, turning counter clockwise a more capacitive setpoint. Centre position corresponds with power factor 1.

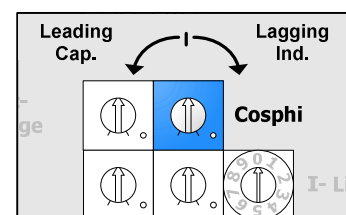


Fig 13. Cosphi adjustment

5.8 Factory settings

All new or AVR's returned from service are supplied with factory settings as described in table 12. Adjusting the factory settings must only be performed by qualified personnel who understand the danger of electric shock hazards and have read and understood the user instructions

Parameter	Value	Unit
Output Voltage	400	V _{ac}
Current limit	125%	I _{nom}
Control mode	Constant voltage	
Underspeed knee	47	Hz
Underspeed ramp	8	V/Hz
Prop. gain	50	%
Int. time	50	%
Droop	0	V _{ac}
Acc. range	0	%
Excitation Ceiling	100	%
Cosphi	1	
SE1-2	Closed	
SE3-4	Closed	
TH1-TH2	Closed	
CAN1-CAN2	Closed	
S-T	Closed	
AVR1-AVR2	Closed	
PF1-PF2	Open	
OPT1-OPT2	Open	

Table 12. Factory settings

5.9 Advanced settings

The LX449 features the option to change several advanced settings to optimize regulation. This chapter describes which settings can be adjusted and how to change those settings. The advanced settings are available for firmware version 1.2 and higher.

Read this chapter carefully before changing any settings!

5.9.1 Flowchart adjusting advanced settings

Advanced settings can be adjusted according the following flowchart.

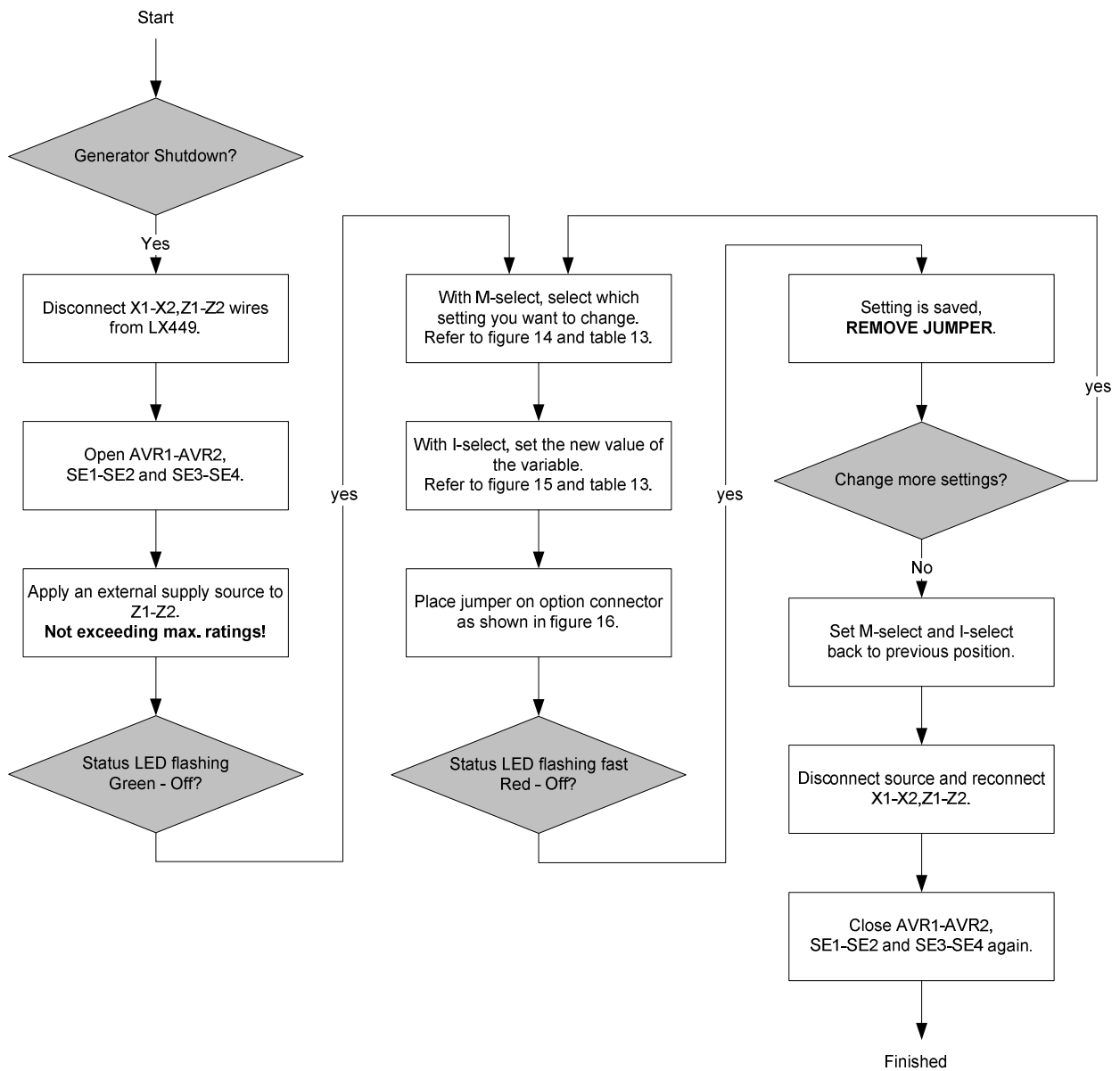


Diagram 18. Flowchart advanced settings

The M-select switch is used for selecting which setting to adjust.
The I-limit switch is used for adjusting the selected setting.

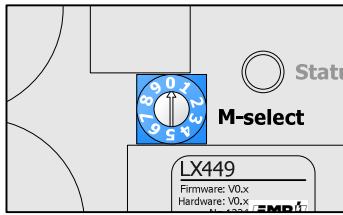


Fig 14. M-select for variable select

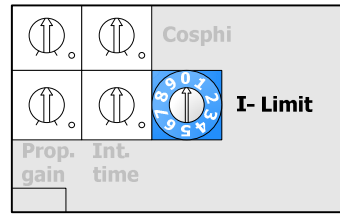


Fig 15. I-limit for variable changing

Place the programming jumper as shown on fig 16.
Damage to the AVR can occur in case the jumper is misplaced

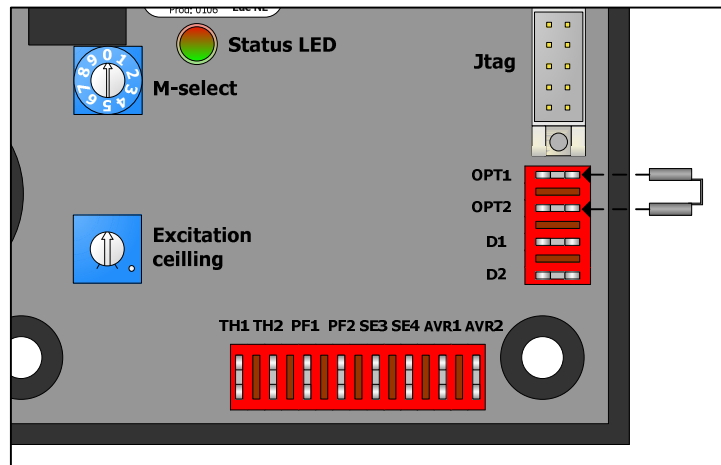


Fig 16. Jumper on option connector

5.9.2 Advanced settings table

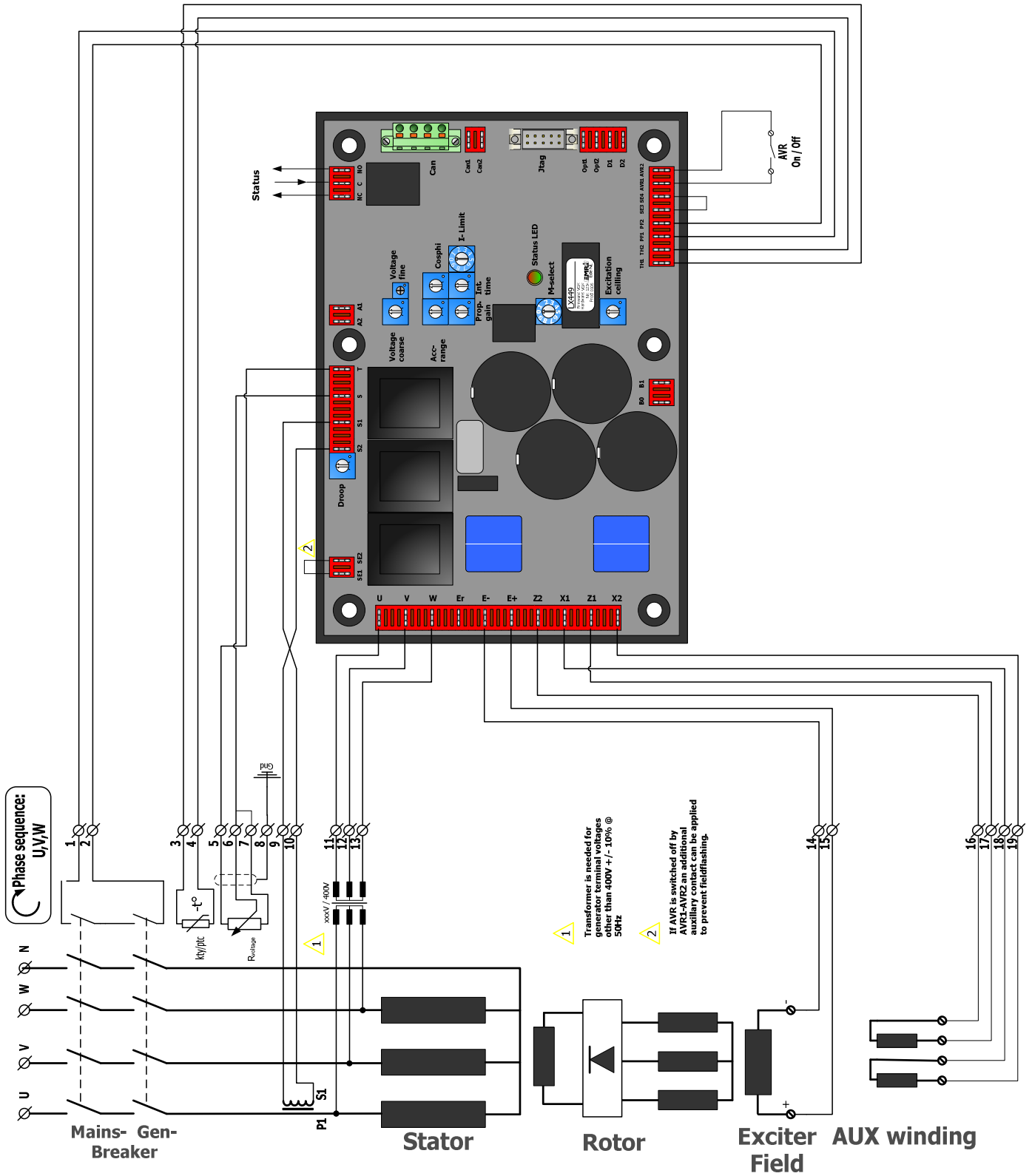
M-select I-limit	Pos. 1: Buildup gain (MULT)	Pos. 2: Stability gain (DIV)	Pos. 3: Min. setpoint, SE mode.	Pos. 4: Protections	Pos. 5: Buildup time @ startup	Pos. 6: Option output	Pos. 7: ACC input modes	Pos. 8: Operation modes
Pos. 0	0,1 (slowest)	1 (fastest)	0 V _{ac}	Excitation loss disabled	1 sec.	Unused	Voltage Match disabled	Inverted output disabled
Pos. 1	0,2	5	30 V _{ac}	Excitation loss enabled	3 sec.		Voltage Match enabled	Inverted output enabled
Pos. 2	0,5	10	60 V _{ac}	Phase loss disabled	5 sec.		Cosphi setpoint disabled	Unused
Pos. 3	1	15	90 V _{ac}	Phase loss enabled	7 sec.		Cosphi setpoint enabled	Unused
Pos. 4	2	20	120 V _{ac}	Current loss disabled	10 sec.		Unused	Unused
Pos. 5	4	25	150 V _{ac}	Current loss enabled	20 sec.		Unused	Unused
Pos. 6	6	30	180 V _{ac}	Unused	30 sec.		Unused	Unused
Pos. 7	8	35	210 V _{ac}	Unused	45 sec.		Unused	Unused
Pos. 8	10	40	240 V _{ac}	Switch off after error disabled	60 sec.		Unused	Unused
Pos. 9	14 (fastest)	45 (slowest)	270 V _{ac}	Switch off after error enabled	Cosphi setpoint 0..255 sec.		Unused	Unused
Description	Extra multiplication factor for proportional gain. Only applied during field flash.	Extra division factor for proportional gain.	Initial setpoint from which the AVR's ramps up after field flash	Enable or disable the desired protections.	The speed by which the AVR ramps from the minimum setpoint to the nominal setpoint.	Unused	Enable or disable the desired modes of operation.	Enable of disable mode of operation

Table 13. Advanced settings

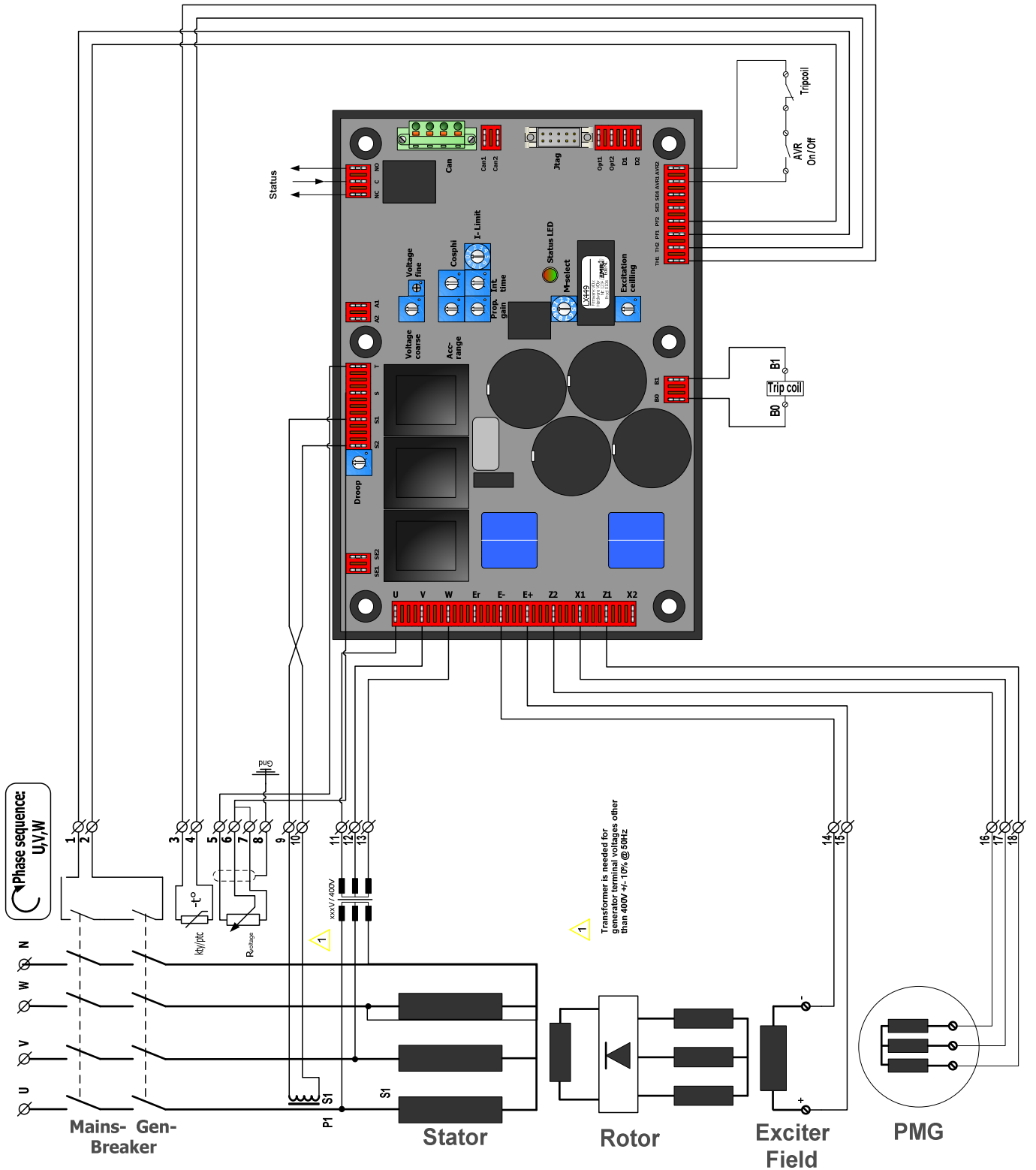
By setting both M-select and I-limit at 9 and by placing the programming header will reset the AVR to **factory default** settings. **Default factory** settings are highlighted in table 13.

6. Wiring Diagrams

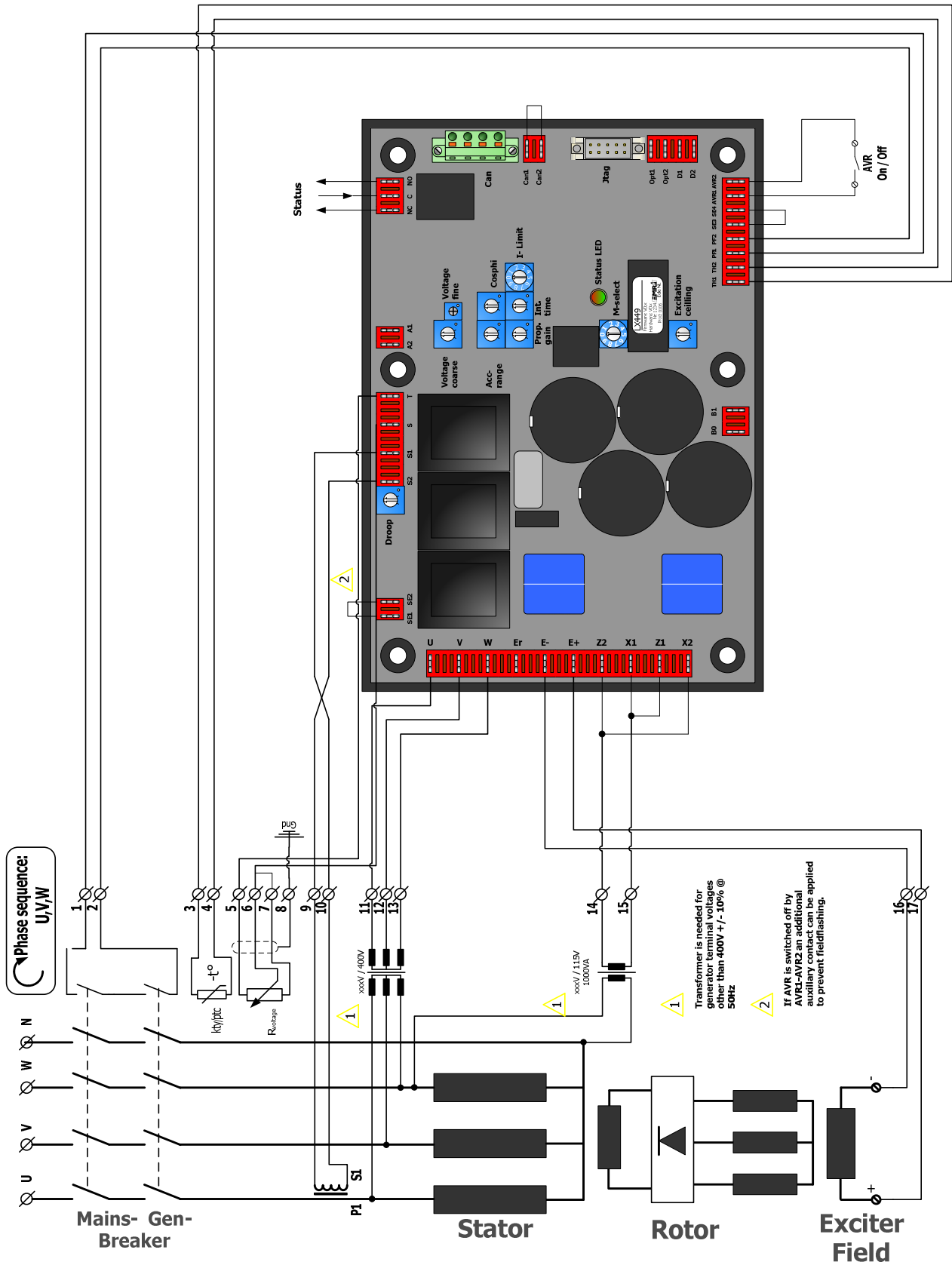
6.0 Wiring diagram LX449 with aux windings and self excite



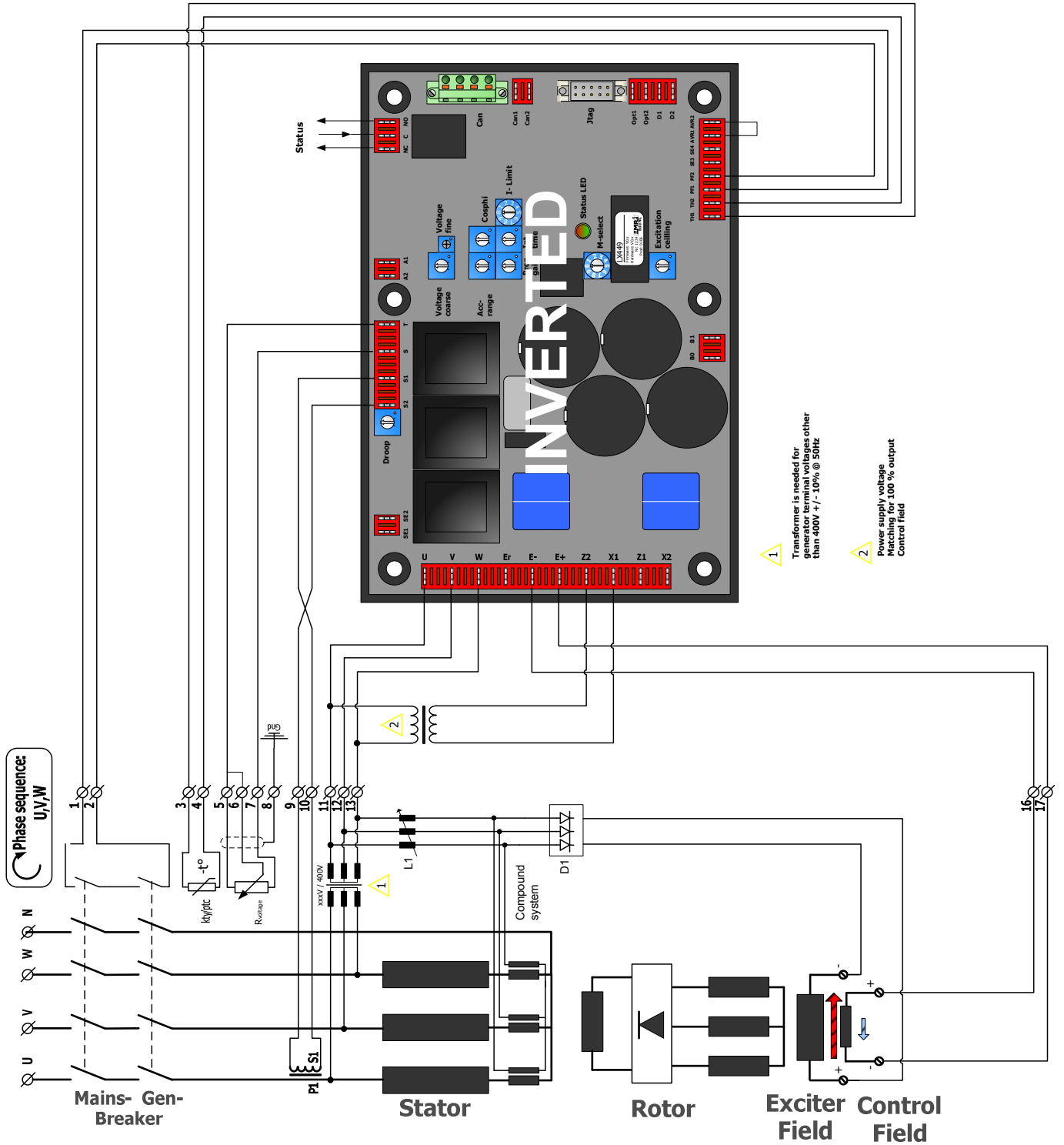
6.1 Wiring diagram LX449 with PMG



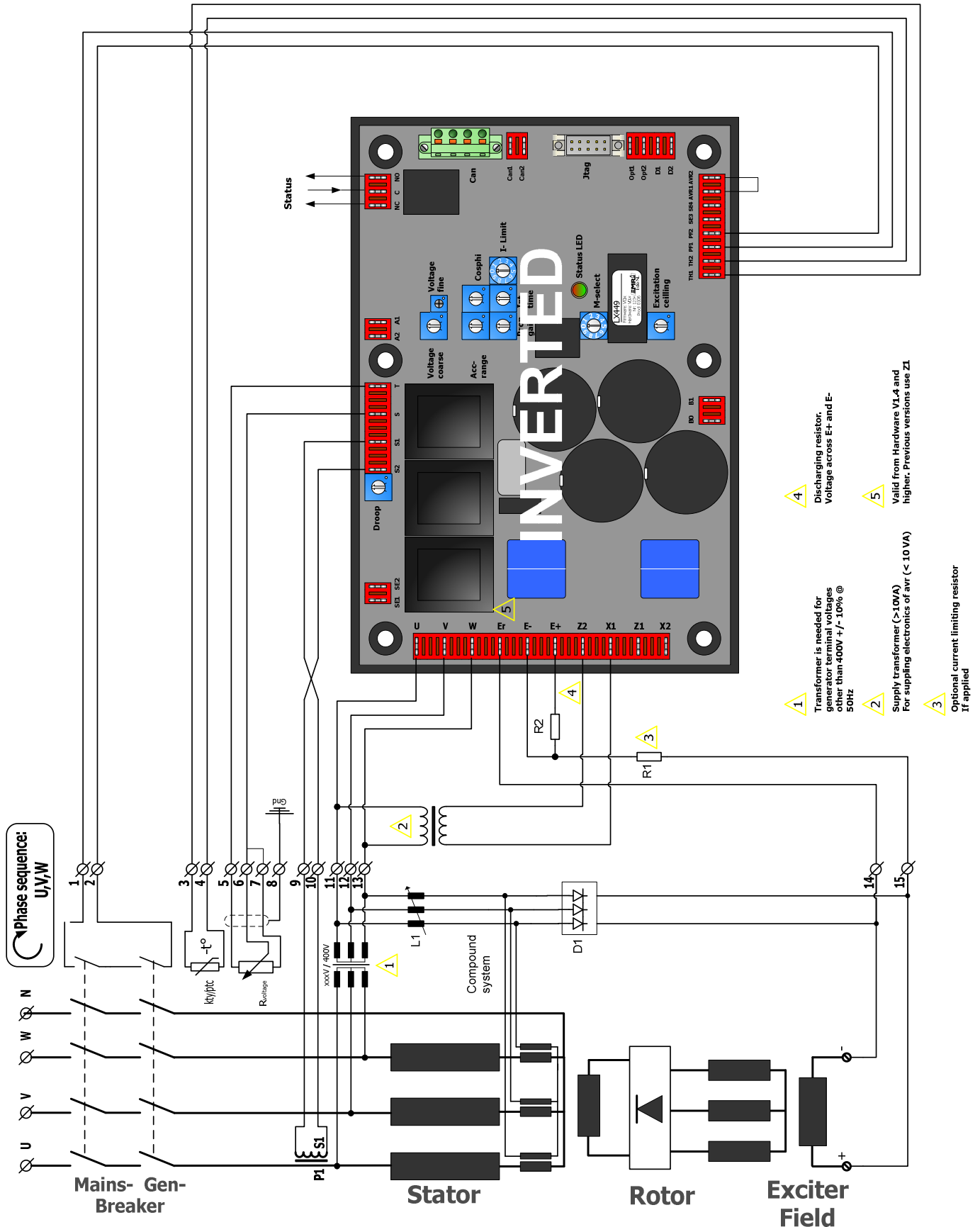
6.2 Wiring diagram LX449 self excite



6.3 Wiring diagram LX449 inverted operation



6.4 Wiring diagram LX449 subtractive operation



7. CAN Interface

For external monitoring of the LX449 EMRI give you the possibility to read out several values by a serial CAN interface.

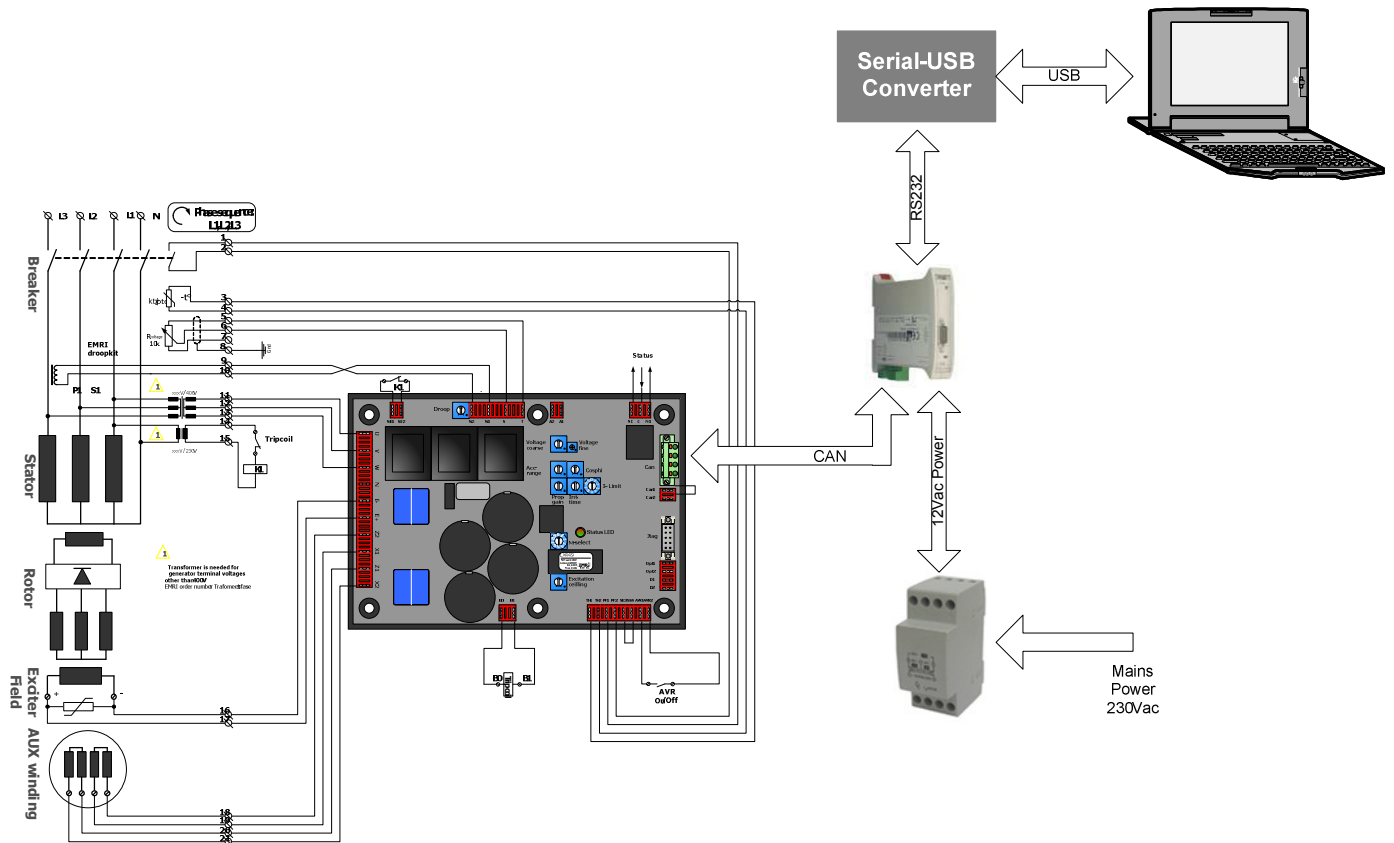


Fig 17. CAN interface

For more information about this option please contact EMRI.

Appendix

A.1 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.
- Mounting of the product should be done in such a way that maximum cooling (direction of cooling ribs and direction of airflow) is achieved.
- Mounting of the product should be done in such a way that no humid air can flow through the product or condensation occurs.
- Mounting of the product should be done in such a way that dust or other materials or residue will not remain in or on the product.
- Mounting of the product should be done in such a way that the maximum vibration is not exceeded.
- Mounting of the product should be done in such a way that 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 E+ and E-, or Phase and neutral, S1 and S2.
- 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 E+ and E- 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 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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A.2 Contact

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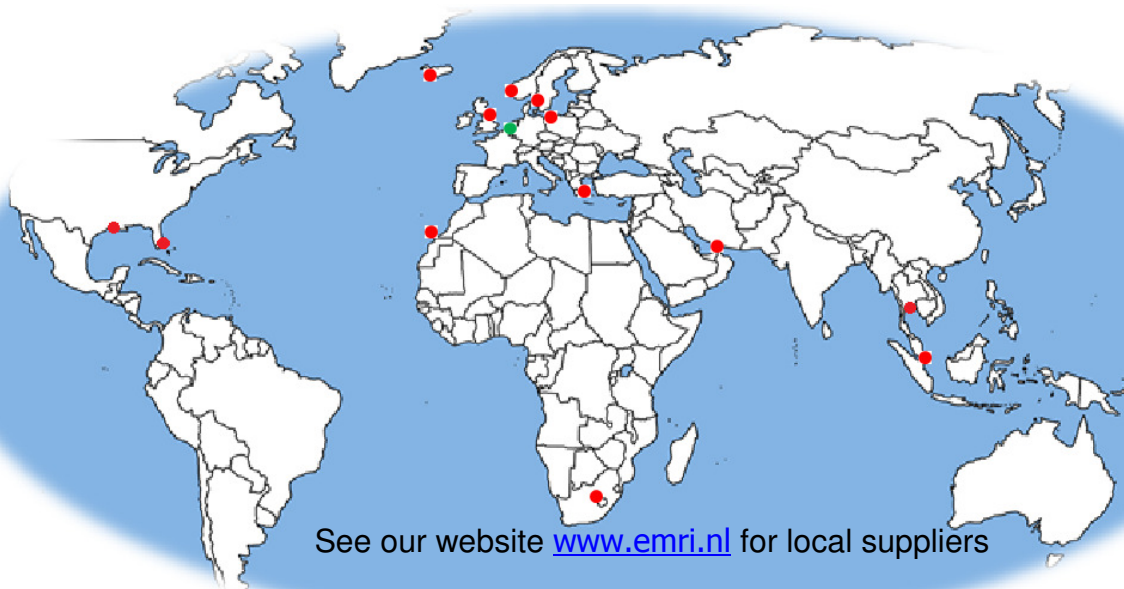
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