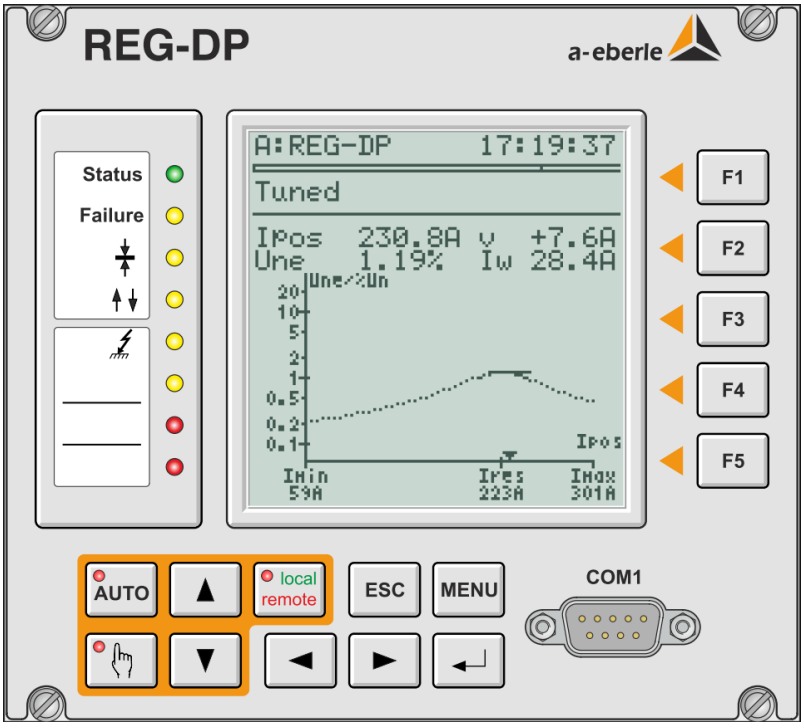
a-eberle

Operating Instructions

for

The Petersen-Coil Regulator



including

Current Injection (CI)

and

High Power Current Injection (HPCI)

REG-DP, CIF, HPCI

GB

Operating Instructions

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Contents

List of images

1. User Guide and Notes

1.1 Warnings

Types of warnings

Warnings are distinguished by the type of risk they represent by the following signal words:

- **Danger** warns of a risk of death
- **Warning** warns of risk of physical injury
- **Caution** warns of risk of property damage

Structure of the warnings

 **SIGNAL WORD**	**Nature and source of the danger!** Possible consequences Prevention measure 1 Prevention measure 2

1.2 Notes

Notes on the appropriate use of the device.

1.3 Other symbols

Instructions

Structure of the instructions:

Instructions for an action.

Indication of an outcome, if necessary.

Lists

Structure of unnumbered lists:

- List level 1
  - List level 2

Structure of numbered lists:

1) List level 1
2) List level 1
   1. List level 2

2. List level 2

1.4 Other applicable documents

For the safe and correct use of the regulator, please read the other documents that are delivered with the system as well as the relevant standards and laws.

1.5 Storage

Store the operating instructions and other relevant documents near the system so they are readily available.

2. Delivery scope/Order codes

2.1 Delivery scope

- REG-DP hardware in housing B01 (19” slide-in device)
- Null modem cable (RS-232) to communicate with the WinEDC or WinREG operating software.
- CD with current operating software, firmware, operating instructions and datasheet
- Removal tool for 19” slide-in device
- Operating Instructions
- Test report
- 1 set of project planning documents

2.2 Order codes

The current order codes can be found in the current REG-DP and REG-DPA datasheets.

3. Safety instructions

The REG-DP/ REG-DPA Arc Suppression Coil Regulator (P-coil) met all of the relevant safety requirements at the time when left the factory. To ensure that it continues to meet them and function as it is supposed to do, the user must follow all of the instructions and warnings in the operating instructions.

- Read the operating instructions.
- Always store the operating instructions near the device.
- The device may only be used if it is in perfect working order.
- Never disassemble the device. A device needing service must be sent to the factory.
- Make sure the device is only used by qualified personnel.
- Connect the device only as described in the instructions.
- Make sure the device is only operated in its original state.
- Only use recommended accessories.
- Make sure the device is not operated outside of the ratings (see the separate technical datasheet).
- Do not use the device in environments where explosive gases, dust or fumes occur.
- Clean the device only with commercially available cleaning agents.
- The REG-DP/ REG-DPA P-coil regulator must have a protective earth conductor. This condition is met by connecting the device to an auxiliary voltage system with protective earth conductor (European power supply systems). If the auxiliary voltage system does not have a protective earth conductor, an additional connection must be established between the protective earth-terminal connection and the earth.
- The upper limit of the permissible auxiliary voltage Uh may not be exceeded continuously or even momentarily.
- The REG-DP/ REG-DPA P-coil regulator must be completely disconnected from the auxiliary voltage Uh before changing the fuse. The fuse may only be replaced with a fuse of the same type and rated current.
- A REG-DP/ REG-DPA P-coil regulator that shows visible damage or clearly malfunctions may not be used and must be secured against accidental activation.
- Only qualified engineers are allowed to perform maintenance and repair work on an open REG-DP/ REG-DPA P-coil regulator.

4. Technical specifications

Please read the current datasheet!
The REG-DP and REG-DPA datasheets contain all of the standards met by the device.
The same applies to the technical data for current injection and HPCI.

5. Intended use

The REG-DP/ REG-DPA P-coil regulator is intended solely for use in power engineering installations and facilities where the required work is performed by trained and qualified engineers. Qualified engineers are people who are familiar with the installation, assembly, commissioning and operation of such products and have the appropriate qualifications.

The REG-DP/ REG-DPA P-coil regulator is manufactured in accordance with IEC 10110/EN61010 (DIN VDE 0411), Safety class I and tested against this standard before it leaves the factory.

6. Applications

The REG-DP/ REG-DPA P-coil regulator is a component of the REGSys™ measurement, control, regulator and recording system.

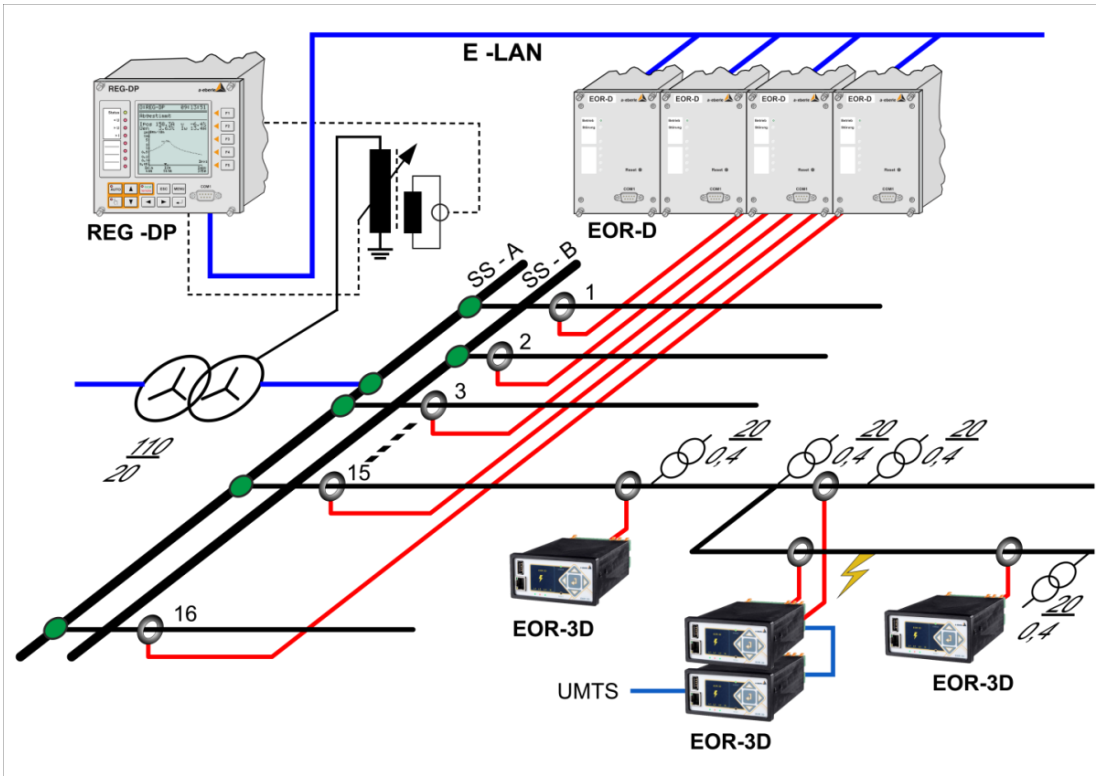


Figure 1: REGSys™ REG-DP

The programmable REG-DP/ REG-DPA P-coil regulator can be used with continuously adjustable P-coils in both medium and high voltage grids.

The regulator can also perform all of the measurement, control and recording tasks that are performed on a P-coil.

The REG-DP/ REG-DPA regulator is a component of the REGSys™ system and can be used with the REG-D/DA, EOR-D Earth Fault Detection Relay, PQI-D Power Quality Measurement Device, DMR-D Grid Dynamic Relay etc., at any time. All of the components can be connected to each other through an E-LAN (communication bus between the devices). This means that the devices that are connected through the E-LAN can be parameterized, programmed, and their data read out through one interface.

This also means that all of the information can be shared between the system components. This feature is particularly useful when it comes to transmitting information to a control centre through IEC 61850, IEC 60870-5-101, - 103 and -104, DNP3.0 or MODBUS protocols.

6.1 Definitions

REG-DP/ REG-DPA	Regulator for P-coil
EOR-D	Earth fault detection relay
CI	Current injection
CIC	Current injection controller
ASC	Arc suppression coil (Petersen coil, P-coil)
'U_{NE}'	Large index for primary quantities
'U_{ne}'	Small index for secondary quantities
HPCI	High-power current injection (for regulation and location detection)

6.2 The basics of regulating a P-coil

Neutral point treatment with a P-coil is one of the most important ways of improving the voltage quality in power grids.

The main advantage of this technique is the ability to continue operating the network during a single pole-to-earth fault.

Medium voltage grids should be compensated as much as possible so that only the residual current flows across the faulty section when an earth fault occurs.

Overcompensation and undercompensation are only recommended for special applications or in overhead transmission grids with a higher unbalance.

In the past, the only controlled variable that was used to regulate a coil was the absolute value of the zero sequence voltage U_{NE}. Although this was the obvious thing to do, it doesn't always achieve the desired result in today's grids. The increase in power lines has balanced the grids and reduced the zero sequence voltage. But the load can still affect the zero sequence voltage and cause it to flicker. This is why other techniques have to be used to regulate the coil. (For more information, please see the chapter on Current injection).

6.2.1 The basics of resonant earthing

In medium and high voltage grids, Petersen coils are used to compensate the capacitive current across the faulty section by a similarly large counter-flowing inductive current when a single phase-to-earth fault occurs. This is done by setting the coil (in the grid's healthy state) to an inductive resistance X_L that corresponds approximately to the grid's capacitive resistance X_C.

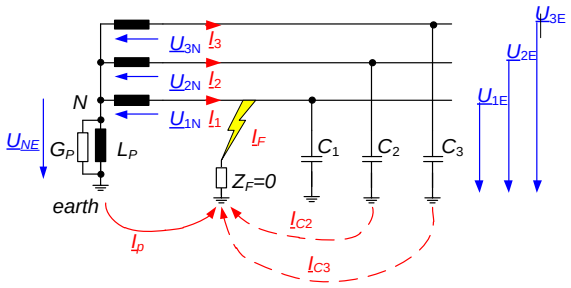


Figure 2: The equivalent circuit of a resonant earthed neutral system with P-coil and a single phase-to-earth fault

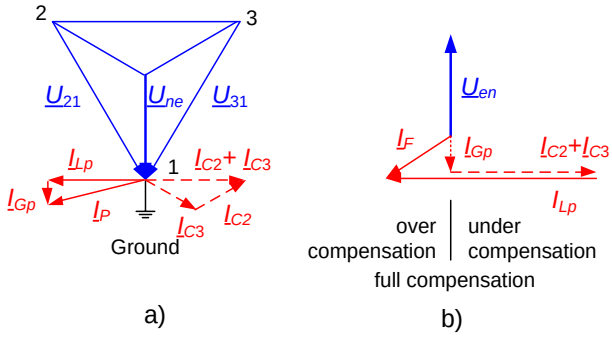


Figure 3: a) Vector diagram with earth fault in phase L1 (fault impedance 0 Ω)
b) Impact of different tuning positions on fault current I_F

L_P, G_P	P-coil (inductance and conductance)
C_1, C_2, C_3	Line-to-earth capacitances
Z_F	Impedance at the faulty section
N	Neutral point of the transformer
U_{1E}, U_{2E}, U_{3E}	Phase voltages
U_{NE}	Zero sequence voltage
I_{C2}, I_{C3}	Capacitive currents in the two healthy lines
I_P	Current through the P-coil when an earth fault occurs
I_{GP}	Active component of I_P
I_{LP}	Reactive component of I_P
I_F	Current across the faulty section

The following assumptions are made for the derivatives:

- The line-to-earth capacitances and conductances are symmetrical
- All unbalances are allocated to Line 1
- For first observations, no load current is flowing

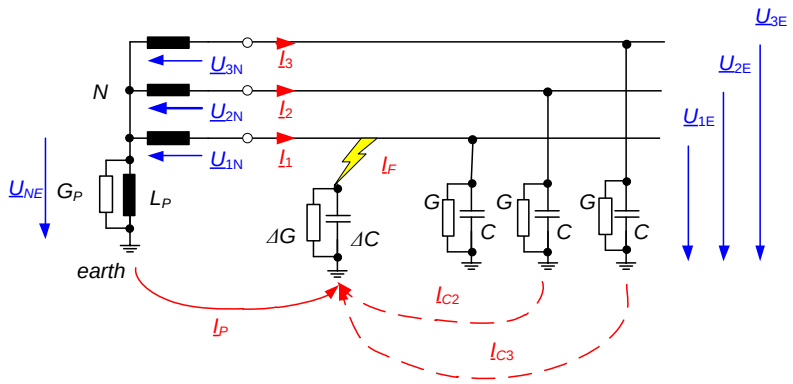


Figure 4: A simplified equivalent circuit

For the equivalent circuit in Figure 4: , the following equations can be formulated:

$$0 = \underline{I}_P + \underline{I}_1 + \underline{I}_2 + \underline{I}_3 \quad (1.1)$$

$$\underline{U}_{NE}\underline{Y}_P = \underline{I}_P \quad (1.2)$$

$$(\underline{U}_{1N} + \underline{U}_{NE})\underline{Y}_1 = \underline{I}_1 \quad (1.3)$$

$$(\underline{U}_{2N} + \underline{U}_{NE})\underline{Y}_2 = \underline{I}_2 \quad (1.4)$$

$$(\underline{U}_{3N} + \underline{U}_{NE})\underline{Y}_3 = \underline{I}_3 \quad (1.5)$$

The conductances yield:

$$\underline{Y}_P = G_P + \frac{1}{j\omega L_P} \quad (1.6)$$

$$\underline{Y}_1 = (G + \Delta G) + j\omega(C + \Delta C) \quad (1.7)$$

$$\underline{Y}_2 = \underline{Y}_3 = G + j\omega C. \quad (1.8)$$

In a symmetrical three-phase system, the phase voltages are rotated 120° against each other. This can be used by the rotation operator $\underline{a} = e^{-j120°}$ to clearly display the equations. $0 = 1 + \underline{a} + \underline{a}^2$ applies. For voltages $\underline{U}_2$ and $\underline{U}_3$ this results in the following expressions:

$$\underline{U}_2 = \underline{a}^2\underline{U}_1 \quad \text{and} \quad \underline{U}_3 = \underline{a}\underline{U}_1 \,. \quad (1.9)$$

Using it in equation (1.1) yields:

$$0 = \underline{U}_{ne}(\underline{Y}_P + \underline{Y}_1 + \underline{Y}_2 + \underline{Y}_3) + \underline{U}_1(\underline{Y}_1 + \underline{a}^2\underline{Y}_2 + \underline{a}\underline{Y}_3) \quad (1.10)$$

or equivalently

$$\underline{U}_{ne} = -\frac{\underline{Y}_1 + \underline{a}^2\underline{Y}_2 + \underline{a}\underline{Y}_3}{\underline{Y}_P + \underline{Y}_1 + \underline{Y}_2 + \underline{Y}_3}\underline{U}_1 \quad (1.11)$$

Using equations (1.6) - (1.8) yields:

$$\underline{Y}_1 + \underline{a}^2\underline{Y}_2 + \underline{a}\underline{Y}_3 = \Delta G + j\omega\Delta C \quad (1.12)$$

$$\underline{Y}_1 + \underline{Y}_2 + \underline{Y}_3 = (3G + \Delta G) + j\omega(3C + \Delta C) \quad (1.13)$$

Used in equation (1.11) yields:

$$\underline{U}_{ne} = -\frac{\underline{Y}_U}{\underline{Y}_U + \underline{Y}_W + j(B_C - B_L)}\underline{U}_1 = -\frac{\underline{Y}_U}{\underline{Y}_U + \underline{Y}_O}\underline{U}_1 \qquad (1.14)$$

Where:

$\underline{Y}_U = \Delta G + j\omega\Delta C$	Unbalance at the faulty section
$\underline{Y}_W = 3G + G_P$	Watt-metric component of Y_O
$\underline{B}_C = \omega 3C$	Capacitive component of Y_O
$\underline{B}_L = \frac{1}{\omega L_P}$	Inductive component of Y_O

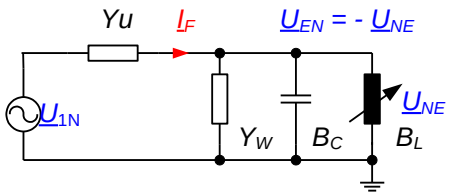


Figure 5: Single-phase equivalent circuit for single-pole unbalance

The equivalent circuit for equation (1.14) is displayed in Figure 5: . This circuit is valid for low-impedance single pole faults as well as grids with a natural capacitive unbalance under the abovementioned assumptions.

The next two sections discuss the dependence of $\underline{U}_{NE}$ and $\underline{I}_F$ based on the coil position.

6.2.2 The natural, capacitive unbalance in a healthy grid

In this case, the conductance ΔG to the earth is negligible compared with the capacitive unbalance ΔC of the whole grid. This is why the current is more or less constant across the faulty section. (see also Figure 5:)

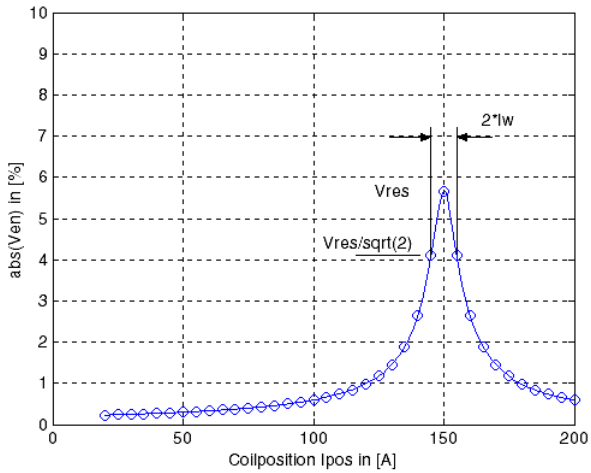


Figure 6: The absolute value of the zero sequence voltage U_{NE} based on the coil position I_{pos}

Continuing from the previous chapter, Figure 6: shows the progression of the absolute value of the zero sequence voltage U_{NE} based on the coil position ($I_{pos}=B_L U_{1N}$). Figure 7: shows the corresponding locus (absolute value and phase) based on the coil position.

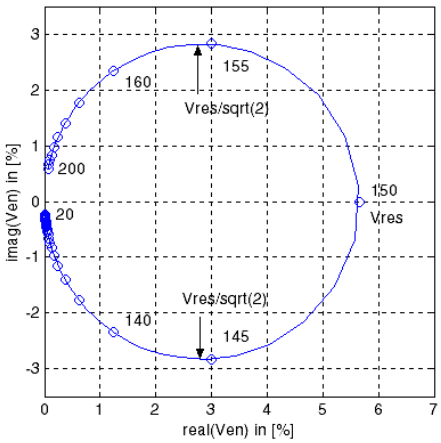


Figure 7: Locus of zero sequence voltage U_{NE}

The resonance curve of a healthy grid can be described by the following parameters:

$\underline{U}_{res}$	Maximum zero sequence voltage
$\underline{I}_{res}$	Coil position Ipos in Ures point; corresponds to the momentary grid capacitance ICE
$\underline{I}_{w}$	Expected a watt-metric current across the faulty section, when a low impedance earth fault occurs.

These three parameters are easily determined from the resonance curve.

At the resonance point ($B_C=B_L$), equation (1.14) is simplified to:

$$\underline{U}_{Res} = -\frac{\underline{Y}_U}{\underline{Y}_U + Y_W}\underline{U}_{1N} \qquad (1.16)$$

In order to understand $I_{W,}$ we have to take a look at the point on the resonance curve where:

$$\left|\frac{\underline{U}_{NE}}{\underline{U}_{Res}}\right| = \frac{1}{\sqrt{2}} \qquad (1.17)$$

There, based on the assumption that $Y_U << Y_W$, the following equation applies to the corresponding coil position $I_{pos},W=B_{L,W}U_{1N}$.

$$\left|\frac{\underline{U}_{ne}}{\underline{U}_{res}}\right| = \frac{1}{\sqrt{2}} = \left|\frac{1}{1+\frac{j(B_C - B_{L,W})}{\underline{Y}_U + Y_W}}\right| \approx \left|\frac{1}{1+\frac{j(B_C - B_{L,W})}{Y_W}}\right| \qquad (1.18)$$

Multiplying expression

$$(B_C - B_{L,W}) = Y_W. \qquad (1.19)$$

by U_{1N} yields

$$(B_C - B_{L,W})\underline{U}_{1N} = I_{res} - I_{pos,W} = Y_W \underline{U}_{1N} = I_W \qquad (1.20)$$

Equation (1.20) shows that the difference between the coil position, at the resonance point, and coil position $I_{pos,W}$ is equal to U_{Res} /√2 at that point.

A better understanding of the control algorithm that the REG-DP/ REG-DPA uses is obtained by looking at the inverse of the zero sequence voltage's progression.

$$\frac{1}{\underline{U}_{NE}} = -\frac{\underline{Y}_U + Y_W + j(B_C - B_L)}{\underline{Y}_U \underline{U}_1} \qquad (1.21)$$

The progression is shown in Figure 8: and Figure 9: .

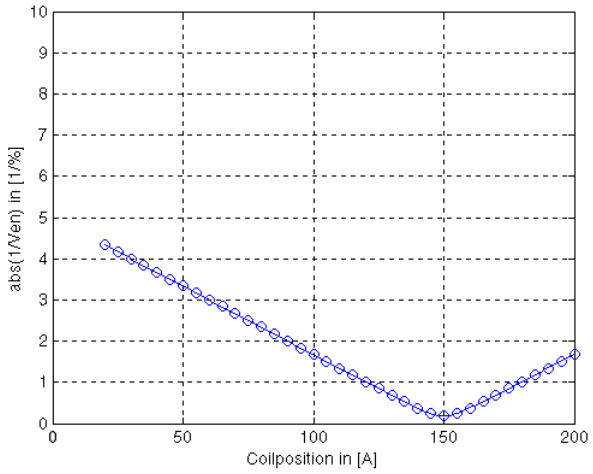


Figure 8: The absolute value of the inverse of zero sequence voltage $1/U_{NE}$

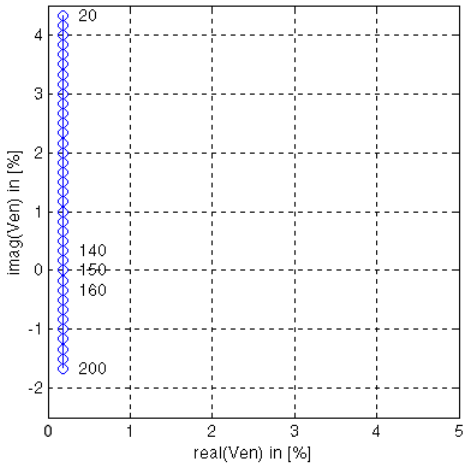
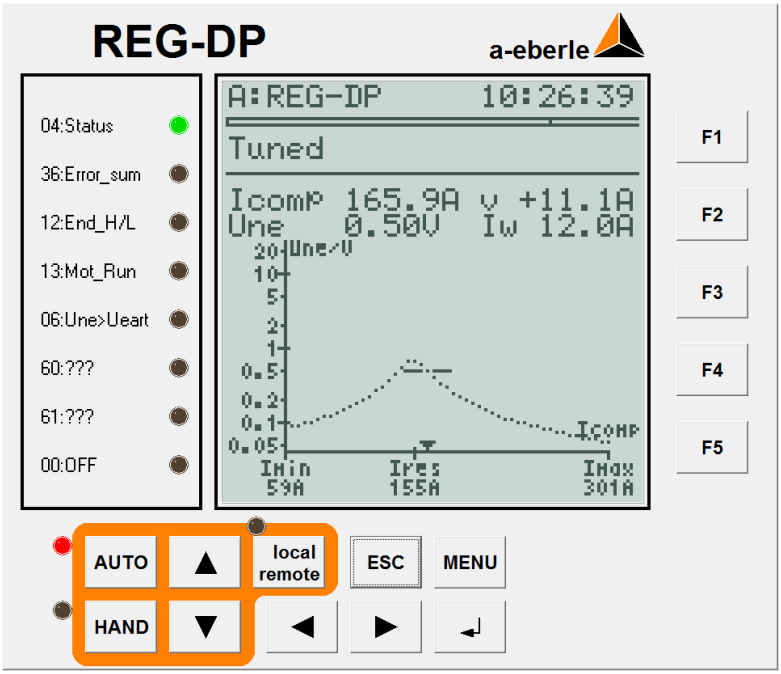


Figure 9: Locus of the inverse of zero sequence voltage $1/U_{NE}$

6.2.3 Grid parameters calculated by the regulator

During tuning, the regulator records all of the values needed to calculate the resonance curve and displays the results on the embedded screen.



Definitions

I_{pos}/I_{comp}	Current coil position without/with other connected coils in the grid
v	Current detuning in [A] or [%]
U_{ne}	Momentary value of the zero sequence voltage. Can be displayed in [%],[V] or [kV]
I_w	Expected residual current across the faulty section when a low impedance earth fault occurs
I_{res}	Equivalent value of the grid capacitance corresponding to the coil position in the resonance point
I_{Min}	Minimum value to which the coil can be set
I_{Max}	Maximum value to which the coil can be set

Based on these determined values, the expected current at the faulty section can already be determined when the grid is in a healthy state.

The current across the faulty section will be at its smallest value, when the capacitive current on the healthy lines is equal to the current through the P-coil. Both currents have opposite signs and cancel each other, at the faulty section position. However, residual current will still flow across the faulty section, even in the presence of full compensation. It is basically not possible to compensate completely with the classic P-coil.

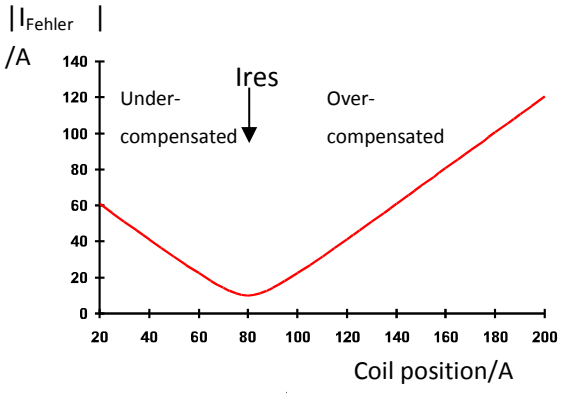


Figure 10: The absolute value of the fault current based on the P-coil setting (V curve)

Looking only at the 'absolute value of the current' across the faulty section, based on the set coil position produces the curve displayed in Figure 10: . This representation is also frequently referred to as the 'V curve'.

The quantity of reactive current across the faulty section, meaning detuning v, can be calculated either as an ‘absolute value’ or as a ‘relative value’. The following equations[1] describe these two types of calculation:

Detuning in A: $$v[A] = Ipos[A] - Ires[A] \quad (1.22)$$

Detuning in %: $$v[\%] = \frac{Ipos[A] - Ires[A]}{Ires[A]} * 100 \quad (1.23)$$

In both equations, **positive** values stand for an 'over compensation' and **negative** values for an 'under compensation'. A value of **zero** stands for full compensation.

6.2.3.1 Advantages of specifying absolute detuning

The regulator adjusts the reactive current flowing across the faulty section, so that it always has the same size. The reactive current is the same size for both large and small grids. Fixed coils that are installed in the same compensation district do not have to be taken into account. This results in a clear indication of the size of the expected reactive current across the faulty section when the regulator has successfully finished the tuning process and an earth fault occurs.

If detuning is specified as a percentage, the expected reactive current will depend on the size of the grid (Ires). And in this case, any fixed coils that are installed in the grid must be considered in the calculation. The actual value of the fixed coil(s), or which and how many are currently active in the grid, is usually difficult to determine. It is even more difficult to constantly adjust the regulator to the cumulative value of the fixed coils.

If detuning is specified in percentage, the expected reactive current I_V in A across the faulty section is calculated according to the following formula

$$I_v = \frac{(I_{res} + I_{fix}) * v}{100} \qquad (1.24)$$

I_v	Detuning current (reactive current) in A
I_{res}	Current through the adjustable P-coil in the resonance point. I_{res} is equal to the grid's capacitive current, when an earth fault occurs
I_{fix}	Current of a connected fixed coil on a grid
v	Detuning in %

In very large grids, the values recommended in VDE 0228 Part 2 for the self-extinguishing current limit may be exceeded (up to 20 kV: 60 A, at 110 kV ca. 130 A).

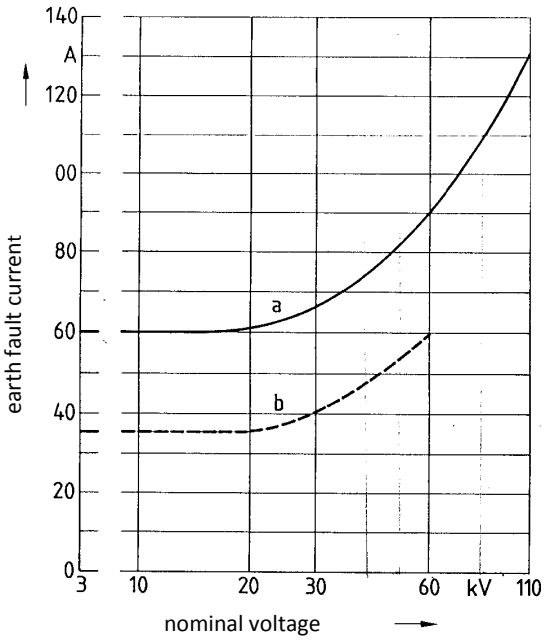


Figure 11: Self-extinguishing current limit in accordance with VDE 0228, Part 2

Curve a:	Self-extinguishing current limit for earth-fault residual current for grids with earth-fault compensation. This curve also applies to cable networks with up to 20 kV nominal voltage with a small component of overhead cables even if their neutral point is isolated.
Curve b:	Networks with isolated neutral point.

7. Technical specifications REG-DP

The technical specifications can be found in the current REG-DP/ REG-DPA datasheets. The current versions of all of our documents can be downloaded from our website www.a-eberle.de.

You can also request a copy by sending an email to info@a-eberle.de .

The datasheet with the connection instructions and these operating instructions are important documents that ensure the safe operation of the REG-DP and REG-DPA.

8. Connecting the measurands to the REG-DP

8.1 Connecting the zero sequence voltage

Regulation should be based on the zero sequence voltage measured on the P-coil. A transformer error can create an error in the percentage range on the open delta winding by adding three large voltage indicators $\underline{U}_{ne}$ = ($\underline{U}_{1E}$ + $\underline{U}_{2E}$ + $\underline{U}_{3E}$)/3. At small zero sequence voltages, which are found during healthy operation, errors in the percentage range are relatively big values resulting in an incorrect tuning.

The P-coil's winding is generally designed to apply a zero sequence voltage of 100 V when a saturated earth fault occurs on the primary side of the transformer. In the following the secondary circuit is specified in lowercase letters.

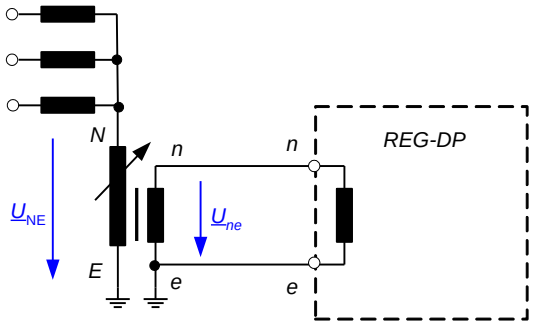


Figure 12: $\underline{U}_{ne}$ directly from the P-coil

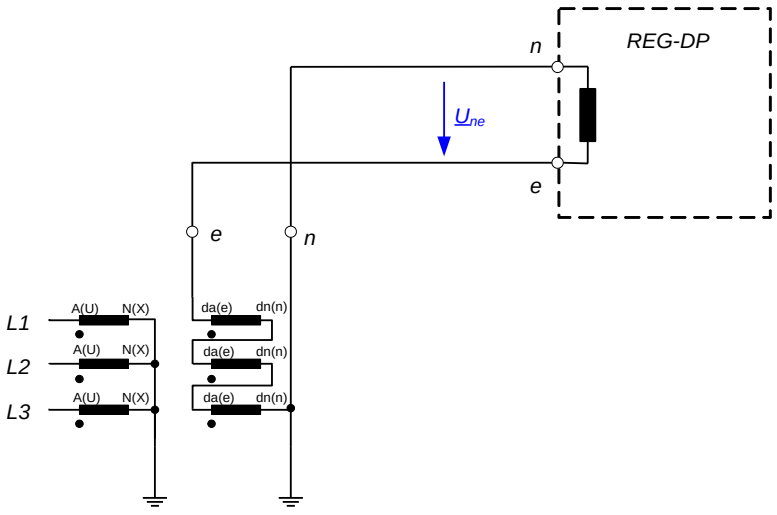


Figure 13: $\underline{U}_{ne}$ from the open delta winding

8.2 Connecting the synchronization voltage

The synchronization voltage U_{sync} is used as a reference voltage, when measuring the phase angle for both zero sequence voltage U_{ne} and currents I_1 and I_2. A few calculation methods use these quantities for regulation purpose. The line-to-line voltage U_{12}, for example, can be used as the synchronization voltage. Other voltages, that are at least grid-synchronized and not affected by a single pole-to-earth fault, can also be used. The input for the synchronization is designed for a nominal voltage of up to 230 VAC but a voltage of 50 VAC is also sufficient. The voltage is transformed internally into a square wave signal so that no special requirements must be met, except the required minimum value and synchronicity with the 50 Hz voltage. This synchronization voltage synchronizes an internal phase-locked loop (PLL), hence interruptions in the synchronization voltage in the seconds range have no effect, for example, when switching the internal transformer to another busbar.

To adjust the P-coil, the regulator usually needs an auxiliary voltage of 230 VAC in the P-coil's motor drive unit. The regulator cannot adjust the P-coil if it fails. This auxiliary voltage is usually enough to supply the regulator. The regulator's data and parameters are buffered and do not get lost, which is why it is possible to use the auxiliary voltage as a synchronization voltage. When used in a system with multiple busbar connectors, the advantage is that a synchronization voltage is always available, irrespective of the switching state.

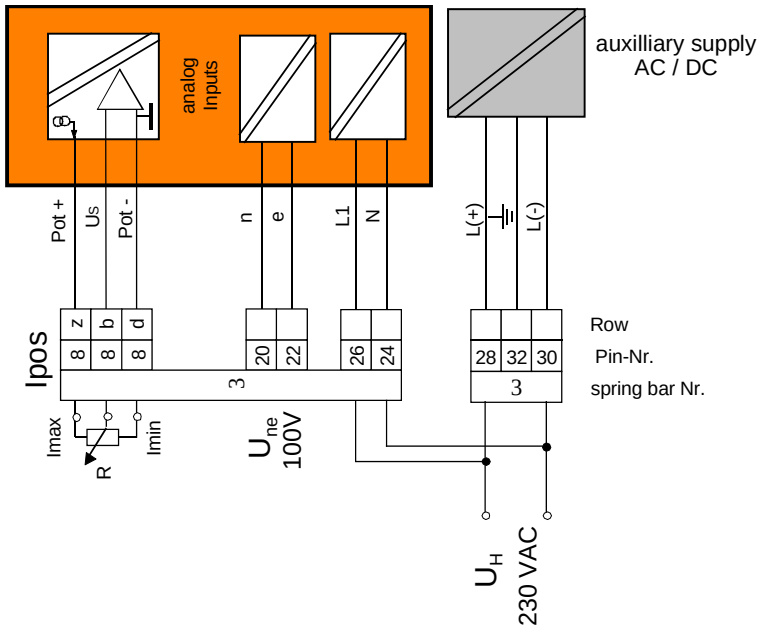


Figure 14: Cabling suggestion for U_{sync} with an auxiliary voltage of 230 VAC

CAUTION	The right hardware version is required to wire the synchronization input with 230 VAC. This information is displayed on the regulator's status screen by pressing <Menu>, <F3>, <F5>, <F1>, <F5>: **MeasHW: NTZ2 / 230 V**

8.3 Connecting the potentiometer or the ammeter (coil position)

The position of the P-coils is measured by the potentiometer's voltage divider ratio. The potentiometer's resistance range (terminal Pot+/Pot-) can be between 150 Ohm and 3 kOhm. The coil position–inductance function is linearized during commissioning.

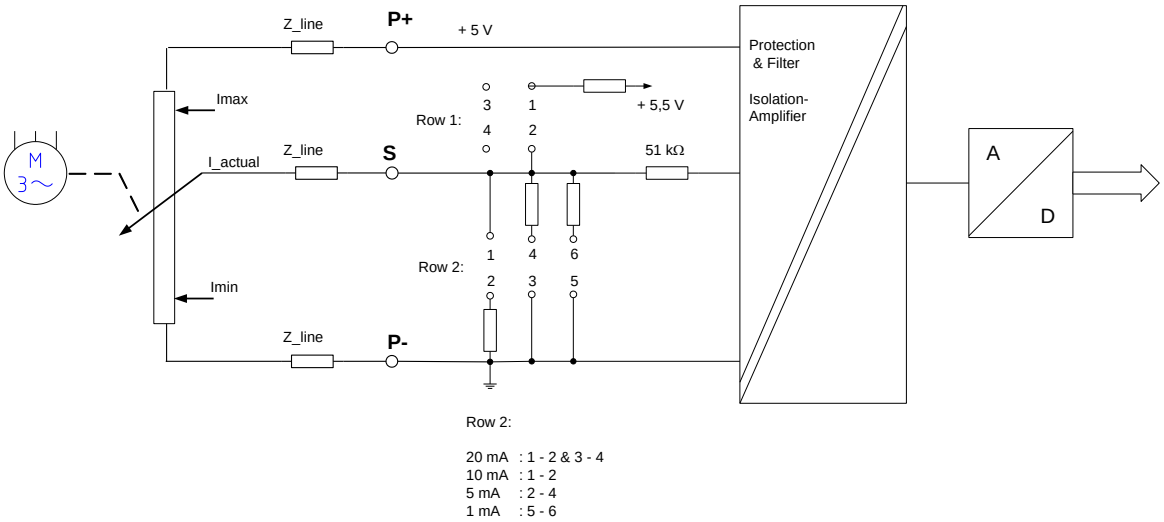


Figure 15: Basic design of the analogue input for the coil position

The below figure shows the corresponding positions of the jumpers on the subprint of circuit board 3:

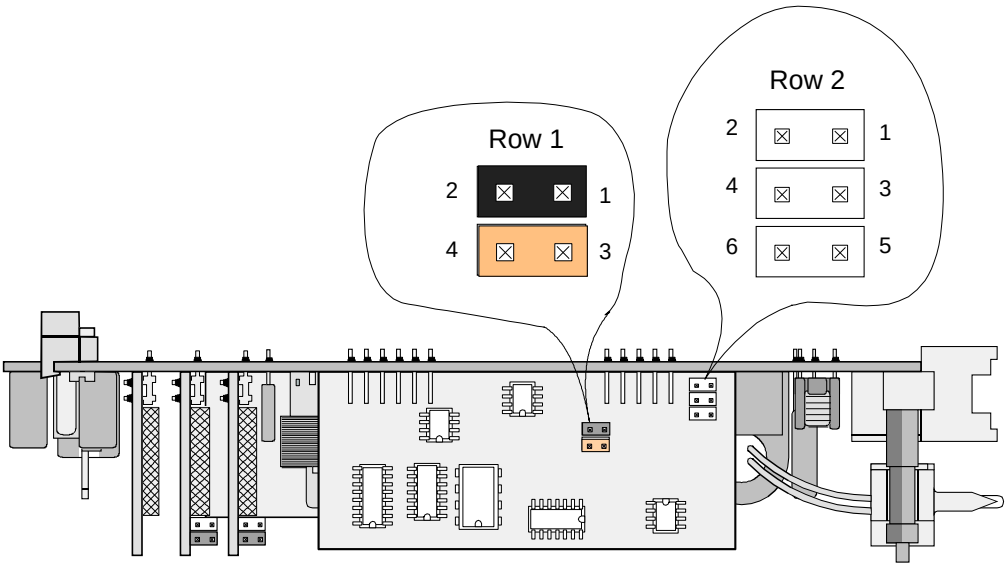
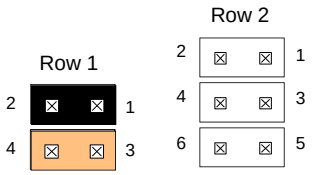


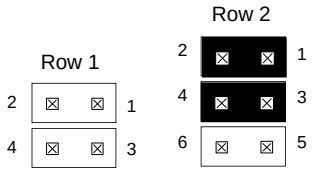
Figure 16: Position of the jumpers for the coil position

Note: The row 1, position 3-4 is empty and can be used as carrier for spare jumpers and is potentially allocated (on the following images: orange or light grey jumper).

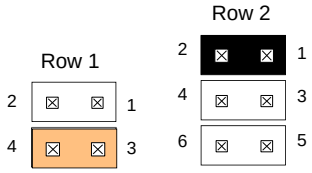
Potentiometer (180 Ohm .... 3 kOhm)



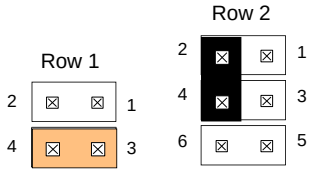
Current-source 20 mA



Current-source 10 mA



Current-source 5 mA



Current-source 1 mA

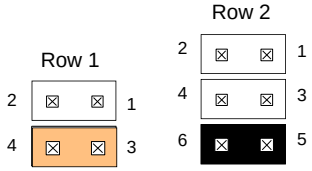


Figure 17: Jumper allocation based on the input function

Note: The factory settings for the jumpers are for a classical potnetiometer. mA signals must be changed according to the described jumper settings.

Source of current	Input resistance	Resistance connection
20 mA	235 Ω	470 Ω parallel 470 Ω
10 mA	470 Ω	470 Ω
5 mA	940 Ω	470 Ω in series to 470 Ω
1 mA	4700 Ω	4700 Ω

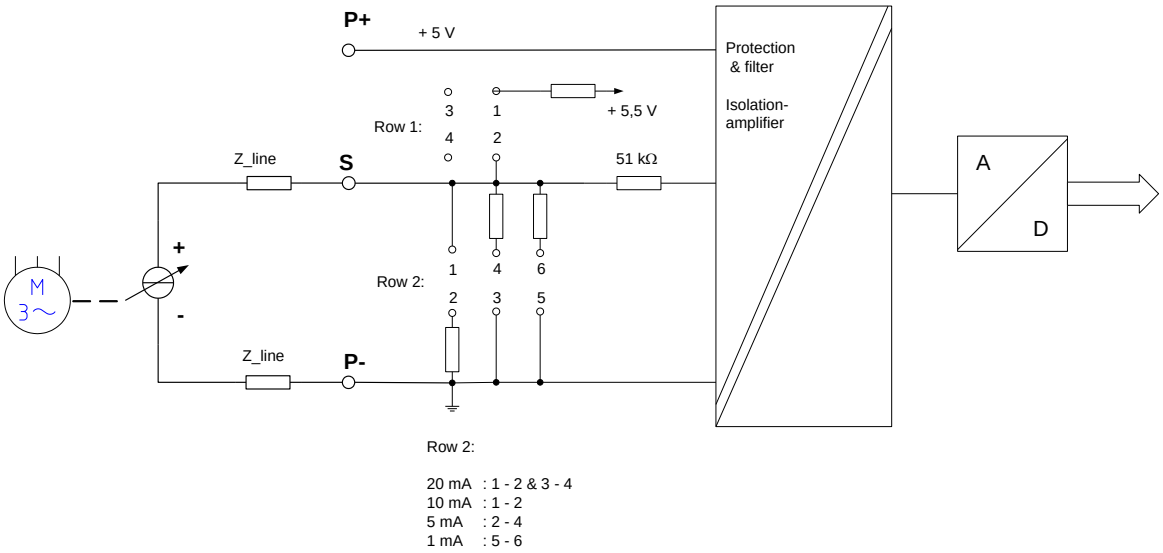


Figure 18: Coil position across controlled current source

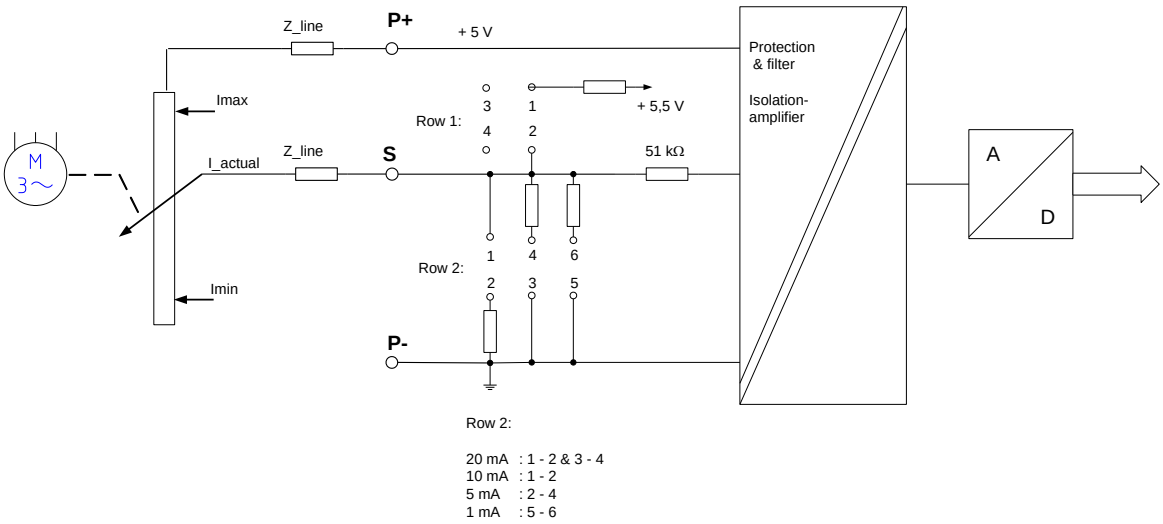


Figure 19: Potentiometer for the coil position in the two-line wiring

If the potentiometer for the coil position is only available as a two-line connection, the connection shown in Figure 19: can be used. In this case, jumper 1-2 in row 1 may not be allocated. Based on the potentiometer's maximum resistance, a jumper must be allocated in row 2 must according to the below table and Figure 17: .

Potentiometer resistance range	Equivalent current source in mA
0 … 225 Ohm	20
0 … 450 Ohm	10
0 … 900 Ohm	5
0 … 4500 Ohm	1

8.3.1 Example of a REG-DP and P-coil connection

The below figure shows the minimum connections that are required between the regulator and the P-coil, as well as the usual connections that are required between the regulator and the control room.

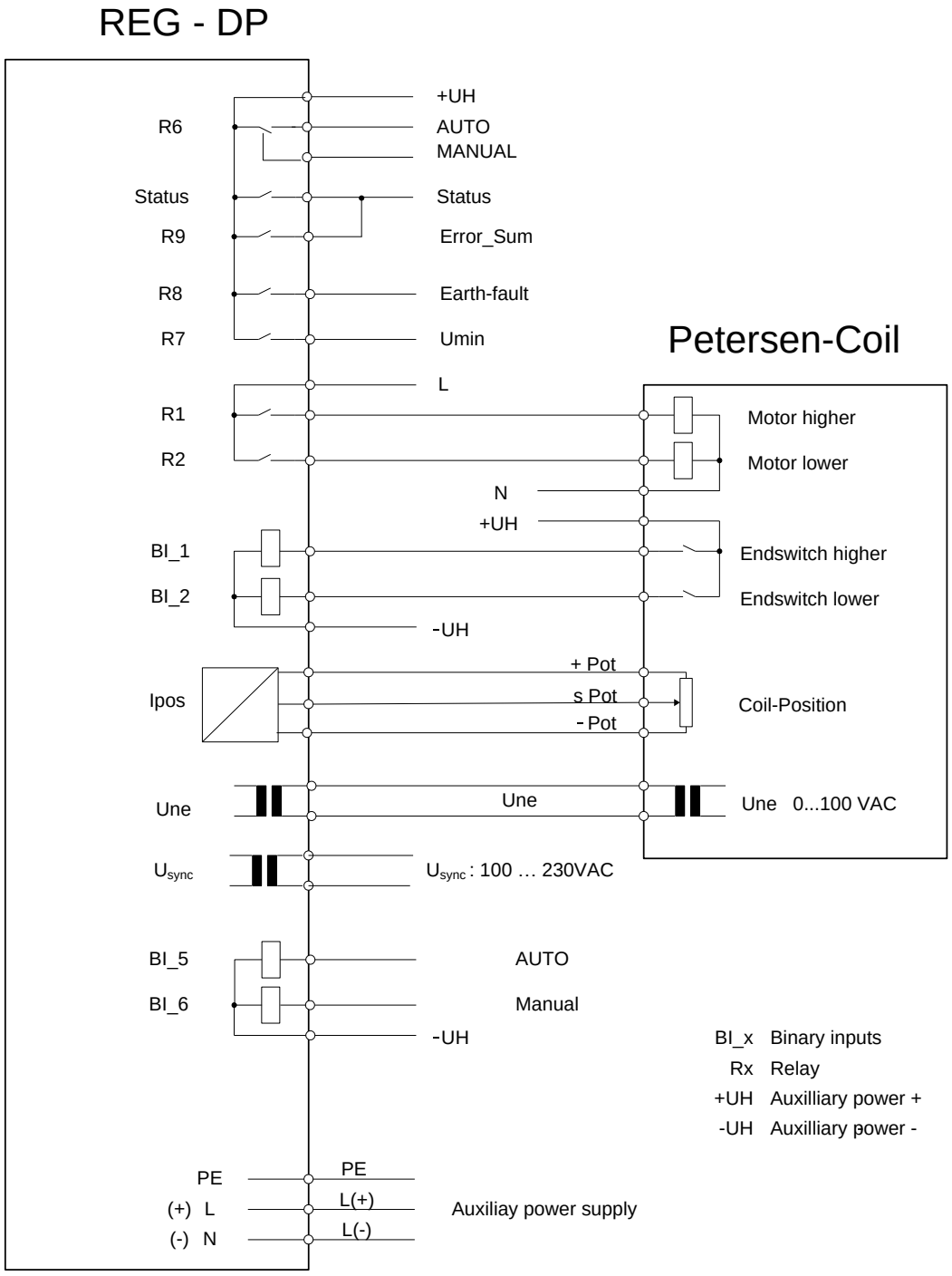


Figure 20: Example of a REG-DP and P-coil connection

9. Operating the REG-DP directly

9.1 Screens and operating controls

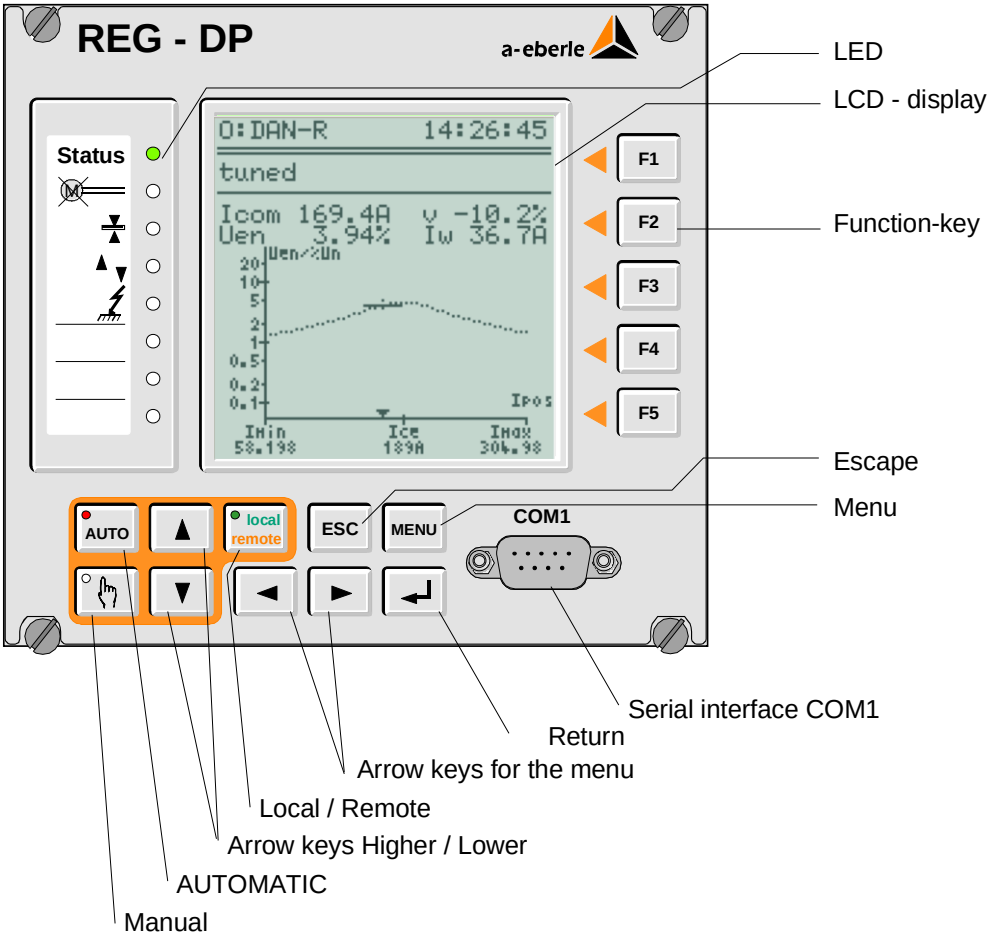


Figure 21: Screens and operating controls

9.1.1 Description of the LC display fields

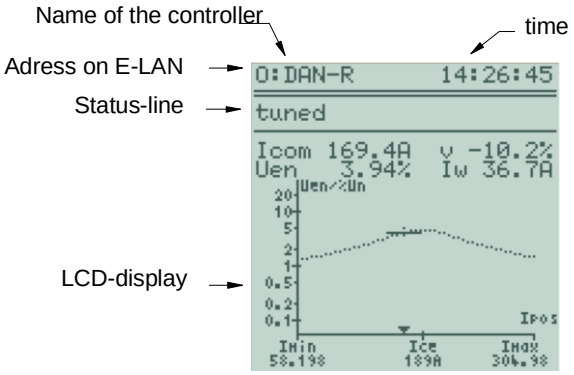


Figure 22: LC display in regulator mode

Graphical display in the resonance curve screen	Description
Imin	End position 'Lower'
▼	The current coil position I_{pos}
IMax	End position 'Higher'
Ires	Currently valid resonance point
Uen	Current value of zero sequence voltage U_{NE}

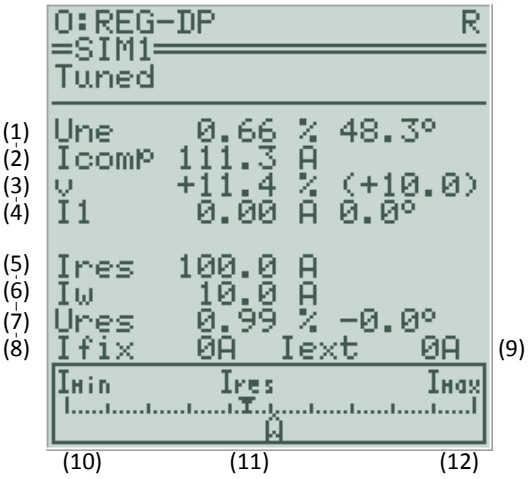


Figure 23: Detailed view

Graphical display in the detailed view	Description
Une	Momentary value of the zero sequence voltage by absolute value and phase
Icomp or Ipos	Current coil position including any fixed coils or external coils (when information is available in the REG-DP/ REG-DPA) Coil position without external coils or fixed coils
v	Current detuning in % or as an absolute value
I1	Current I1 through the P-coil's current transformer
Ires	Currently valid resonance point (until the next search)
Iw	Determined active current for the whole galvanically connected grid range
Ures	Value of the zero sequence voltage at the resonance point (maximum U_{NE} for this grid)
Ifix	Value of an additional fixed coil  The fixed coil's size and ON/OFF information must be transmitted to the REG-DP/ REG-DPA
Iext	Value of an external coil
Imin	Coil value in end position 'Down': lower end switch
Ires	Resonance point from the last calculation
IMax	Coil value in end position 'Up': upper end switch
	Coil position inside the set target detuning
	Coil position outside the set target detuning

LEDs		
Status	Green	Regulator status
Failure or 	Orange	Sums - Error message. A short message is displayed in the status bar. Details are displayed by pressing <MENU><F5>
	Orange	End switch 'Higher' or end switch 'Lower' reached.
	Orange	Command to position the coil 'Higher' or 'Lower'. (Running message)
	Orange	Earth fault
LED 6	Orange	Freely programmable
LED 7	Red	Freely programmable
LED 8	Red	Freely programmable

9.1.2 Keys on the REG-DP

Function keys (F1-F5)

Used to select different display modes and set-up the REG-DP P-coil regulator.

AUTO key

Used to automatically control the regulator based on the set parameters.

MAN key

Use to control the P-coil manually.

Local/Remote key

The following keys are blocked in 'Remote' mode:

- <MAN>
- <AUTO>
- <Higher>
- <Lower>

The menu keys are not blocked. You can navigate the menu and view and change settings.

ESC (Cancel)

- Short press of the key:
  - Takes you up a level in the menu.
- Long press of the key:
  - Returns to the previously active display mode (standard display, large display or resonance curve)

Controlling the P-coil manually

The 'Higher' and 'Lower' arrow keys are used to control the P-coil in 'MAN' mode.

Note:

The keys are only active when the regulator is running in manual ('MAN') mode. If the Local/Remote function is active, only in Local Mode.

MENU and arrow keys <⇒> and <⇐>

The Menu key is used to switch between the different operating modes (Display, Recorder, Statistics and Troubleshooting) and to switch to 'SETUP' to set parameters.

In 'SETUP', the left and right arrow keys <⇒> and <⇐> are used to browse between the different menu screens. Function key <F1> can also be used to browse between menu screens.

ENTER

Used to confirm a change to a parameter in a 'SETUP' menu.

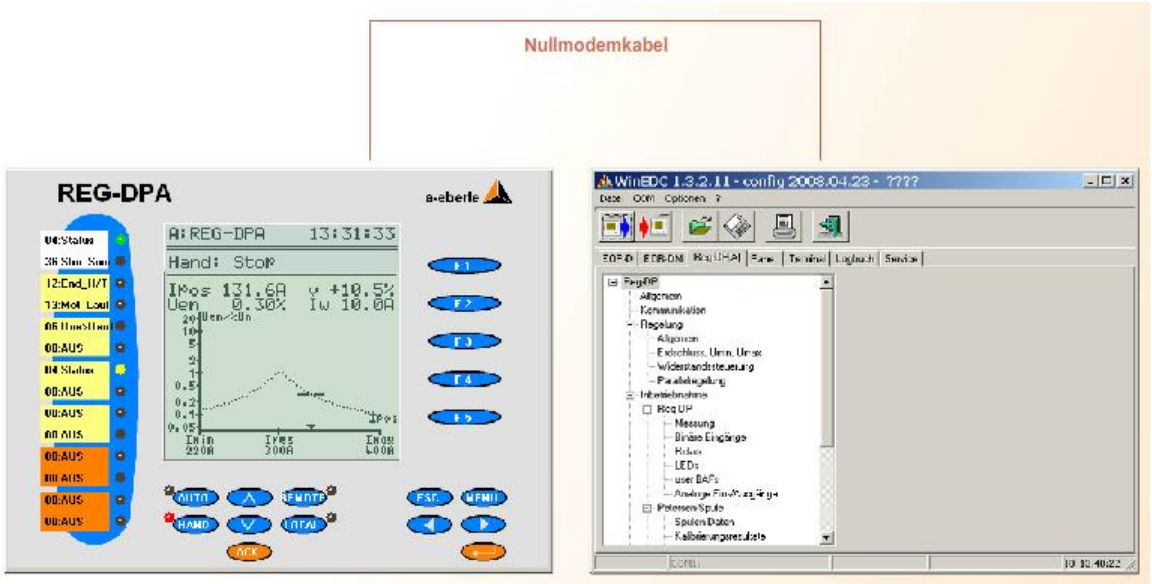
Repeat function

If a key is pressed and held for a longer period of time, the key's function is repeated every second. The repeat frequency increases after about 3 s.

9.1.3 Plug connection on the front

Serial interface COM1

9.2 Connecting the P-coil regulator to external devices such as a laptop or modem.

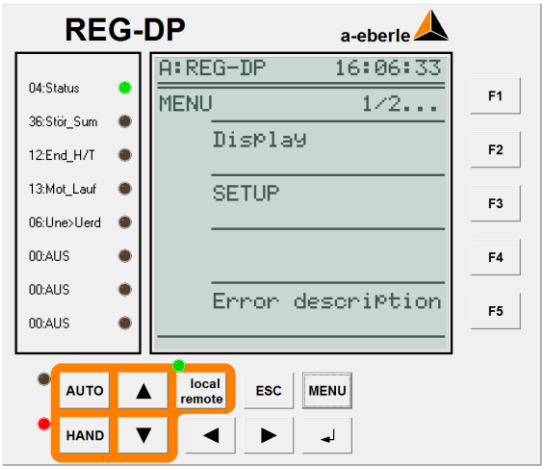


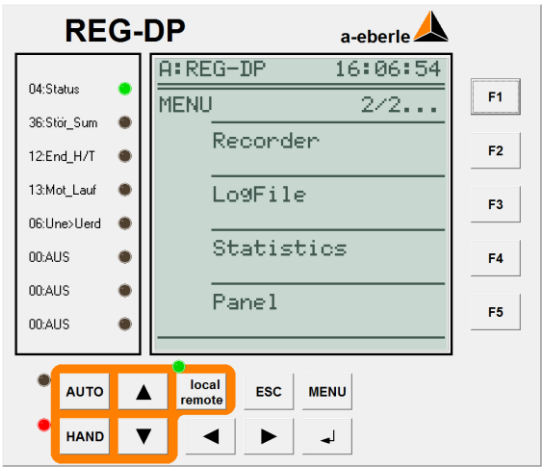
9.3 Operating basics

The operation of the REG–DP(A) P-coil regulator is fully menu driven.

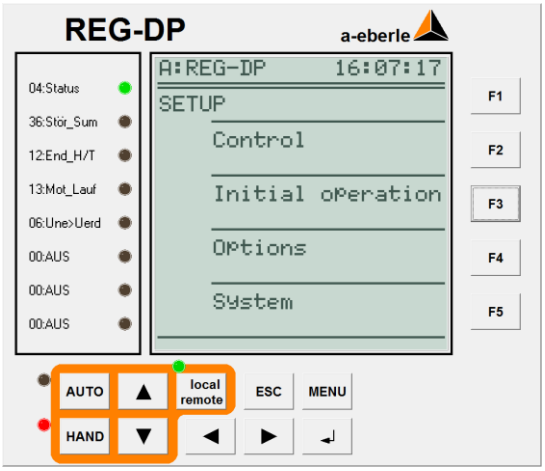
The following applies to setting or changing parameters:

- Switching between AUTO/MAN operation
  - <MAN> Switches to manual operation
  - <AUTO> Switches to automatic operation
- Switching between local/remote operation
  - Press the <local/remote> key to switch between local and remote operation mode (Note: You can also use the menu to switch operating modes)
- Switching operating mode - menu and parameterization
  - Pressing the <MENU> key displays a list of the available operating modes

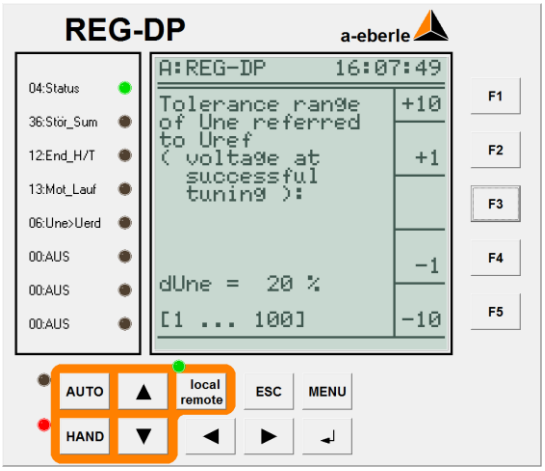




- Press <F3> to select menu item 'SETUP'



- Use <F1> to <F5> and the left and right arrow keys to browse through the parameters.



- Set the value of the parameter with the function keys.
  - <F1> Increments the value in large steps
  - <F2> Increments the value in small steps
  - <F4> Decrements the value in small steps
  - <F5> Decrements the value in large steps
- Use < ⇐ > and < ⇒ > to change the value in the number range in the right column. This makes it easy to navigate through very big number ranges.
- In some 'SETUP' menus, <F3> is configured with special functions.
- To confirm an entry, press <ENTER>. The regulator switches to the next highest menu level.
- Press <ESC> shortly to exit the Setup menu.
- Press and hold <ESC> to exit parameterization and return to the original display mode.

- If this menu is displayed, the regulator may be running in the background if its operating mode is set to 'AUTO'.
- The 'Higher' and 'Lower' keys are locked in 'AUTO' mode.

9.4 General functions

9.4.1 Display options

Note: Switching between different display modes: In addition to the menu, <F1> can be used to switch between display modes without having to first press the <MENU> key.

The following menu is displayed by pressing <MENU> <F2>**.**

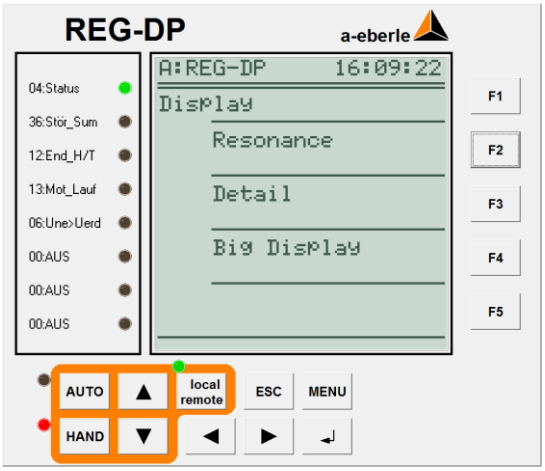


Figure 24: Switching between display modes/description

You can switch between the regulator's different display modes in this screen:

The upper rows never change regardless of the display mode you select:

1. row:

A:	Address of the regulator on the E-LAN bus
REG-DP	Name of the regulator
15:12:10	Time

2nd row:

This row displays the regulator's current status and search delay. If a search delay is not displayed, the regulator is still within the parameterized tolerance limits.

9.4.1.1 <F2> Resonance curve:

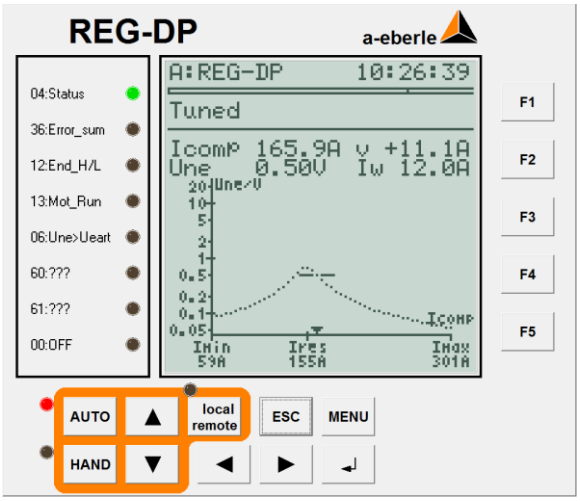


Figure 25: Resonance curve screen

This screen displays

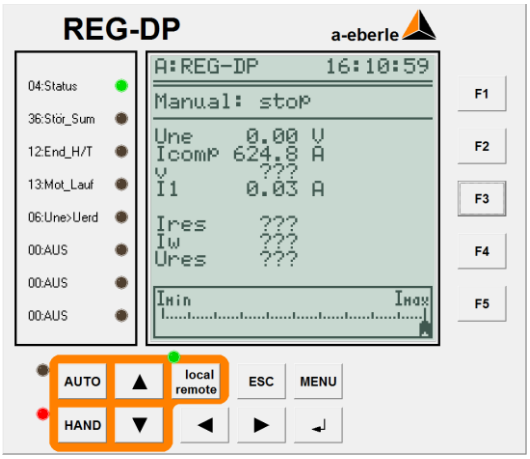
- the status of the regulator
- the measured values Une and Ipos
- the calculated detuning current v and the active current Iw
- the resonance curve as a graphic

The following values are displayed from the 3rd row:

Parameters	Description
U_{en}	Current measured zero sequence voltage Une in % in relation to 100 V as secondary voltage of the voltage transformer or as primary voltage in V
Ipos	Current coil position in A or % that was measured and linearized using the potentiometer. When a fixed coil is activated, there is an option to display it on the screen.
v	Current detuning in relation to the resonance point that was measured or calculated in the last search process
Iw	Calculated active current component in A across the faulty section when a low impedance earth fault occurs.

The upper and lower end position of the P-coil are also displayed as a summary message by an orange LED. The movement of the P-coil is also displayed as a running message by an orange LED.

9.4.1.2 <F3> Detailed view:

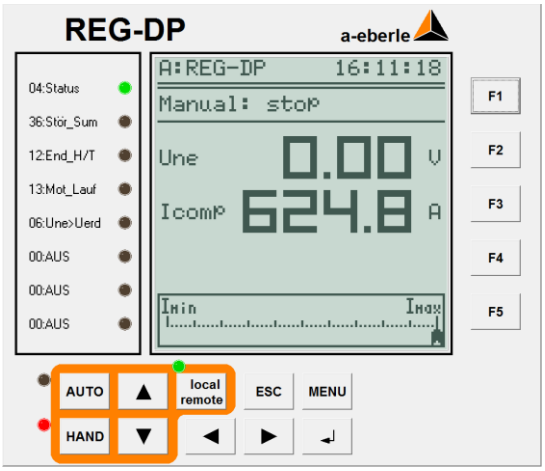


The screen displays the following information:

- Regulator status
- Measured value for the zero sequence voltage $\underline{U}_{en}$ by absolute value and angle
- Current coil position $\underline{I}_{pos}$
- Calculated detuning v
- Current measured across converter $\underline{I}_1$ by absolute value and angle
- Calculated curve parameters $\underline{I}_{res}$, $\underline{I}_w$ and $\underline{U}_{res}$

Parameters	Description
Uen	Current measured zero sequence voltage $\underline{U}_{ne}$ in % in relation to 100 V as secondary voltage of the voltage transformer in V or as primary voltage in kV.
Ipos	Current coil position in A or % that was measured and linearized using the potentiometer. When a fixed coil is activated, there is an option to display it on the screen.
v	Current detuning in relation to the resonance point that was measured or calculated during the last search process
I_1	Measured current for current transformer 1 (e.g., the current that was actually measured across the current transformer by the P-coil in A)
Ires	Last measured or calculated coil position in A at which the maximum zero sequence voltage (Ures) was found
Iw	Calculated active current component in A across the faulty section when a low impedance earth fault occurs.
Ures	Calculated zero sequence voltage $\underline{U}_{ne}$ at the resonance point ($\underline{I}_{pos}$ => $\underline{I}_{res}$)
Alternative for Ires, Iw, Ures:	
Ires	Last measured or calculated coil position in A at which the maximum zero sequence voltage (Ures) was found
d	Grid damping in A or %. If specified in %, an activated fixed coil can be taken into account (configurable)
k	Calculated grid unbalance

9.4.1.3 <F4> Large screen:



The following is displayed:

- Regulator status
- Measured values U_{ne} and I_{pos}
- Current coil position I_{pos}

The following values are displayed from the 3rd row:

Parameters	Description
Uen	Current measured zero sequence voltage U_{ne} in % in relation to 100 V as secondary voltage of the voltage transformer in V or as primary voltage in kV
Ipos	Current coil position in A or % that was measured and linearized using the potentiometer. A fixed coil that is activated is not displayed on the screen.
Alternative	
Uen	Current measured zero sequence voltage U_{ne} in % in relation to 100 V as secondary voltage of the voltage transformer in V or as primary voltage in kV
v	Current detuning in relation to the resonance point that was measured or calculated in the last search process
v (SP)	Set target - Detuning

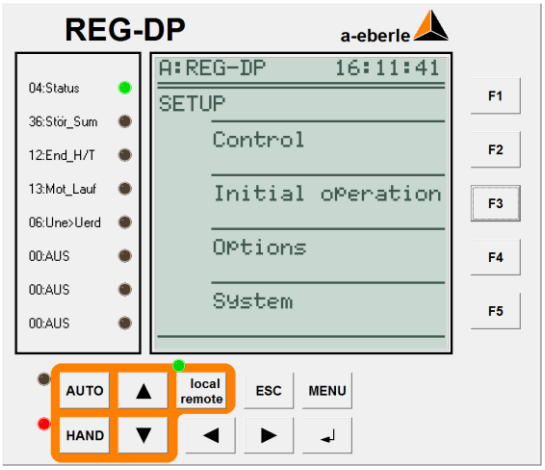
Changing the display options

Key	Switching screens
<F3>	Ipos <=> v, v [Target position]

Graphical display of the coil position

The graphic shows the current coil position in the P-coil's I_{min} to I_{max} adjustment range. The measured or calculated resonance point I_{res} is indicated by a downward pointing arrow.

9.4.2 Menu item/menu structure Setup



This menu contains the setup options for the following groups:

F2: Control

Control	F1	Page 1/2	Page 2/2
	F2	Standard Param.	Umin
	F3	(Current Injection)	R-Control
	F4	Earth fault	Parallel operation
	F5	Umax	

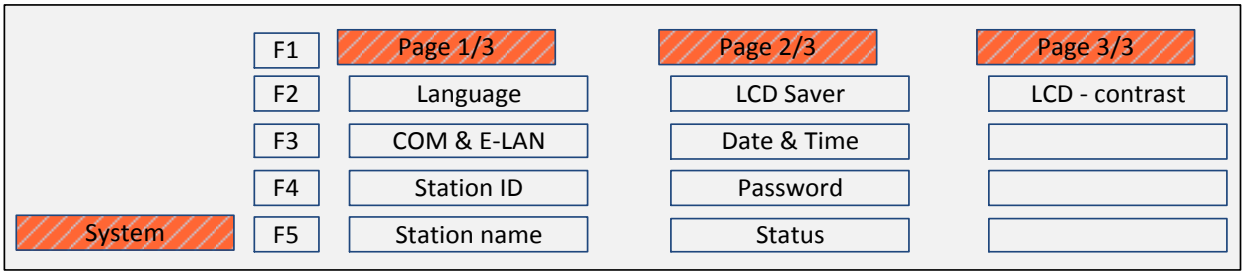
F3: Initial operation

Initial operation	F1	Seite 1/2	Page 2/2
	F2	Voltage measurement	Inputs/Outputs
	F3	Current measurement	
	F4	(Current Injection)	SCADA
	F5	P-Coils	

F4: Options

Options	F1	Page 1/2	Page 2/2
	F2	Local / Remote	Simulation
	F3	Enable Loc/Rem	Net model
	F4	Loc/Rem function	Display Options
	F5	Reset Behaviour	Up/Down continuous moving

F5: System



9.4.3 Recorder for coil position and zero sequence voltage

The recorder's screen is accessed by pressing: **<MENU> <F1> <F2>** The recorder enables the progress of various selectable quantities, which are to be displayed.

Note:

The following data are recorded using the default settings:

Channel 1 Ipos (coil position)

Channel 2 Une (absolute value of the zero sequence voltage)

Channel 3 Une phi (angle of the zero sequence voltage)

9.4.3.1 The Recorder screen

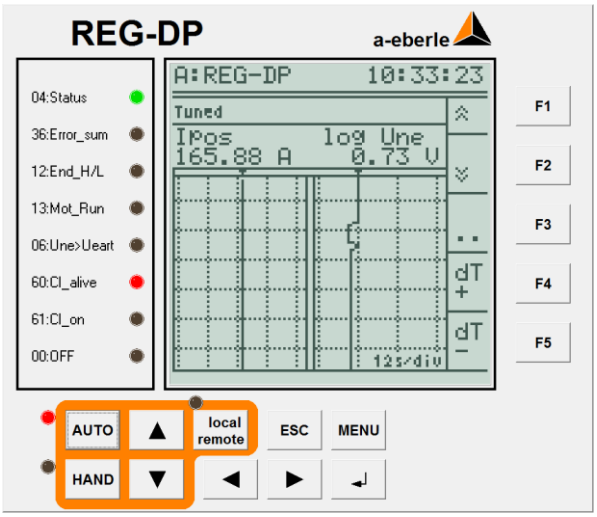


Figure 26: Recorder file in the REG-DP/ REG-DPA's display

The screen shows the chronological progression of coil position Ipos and the zero sequence voltageUne as a one-line diagram. The linearized coil position Ipos is displayed on the left in A and the zero sequence voltage Une is displayed on the right in V logarithmically over three decades, which corresponds to a range of 0.1 V to 100 V.

In the grid, all of the current values are at the top. These current values are characterized by the small downward pointing arrows. The measured values are also displayed digitally to make them easier to read.

The regulator's current status is displayed in the form of digital values for Ipos and Une, meaning that the regulator's status is also displayed in 'Recorder' mode.

Function keys

The current feed rate is displayed in the bottom right corner of the display and can be selected in several increments by pressing **<F4>** and **<F5>**:

- 12s/Div
- 1 min/Div
- 5 min/Div
- 10 min/Div

<F1> and **<F2>** are used to switch to **History** mode. The memory can be searched forward or backward using the arrow keys.

9.4.3.2 Recorder settings

Pressing <F3> in the Recorder screen displays the next menu and the below described settings for the recorder.

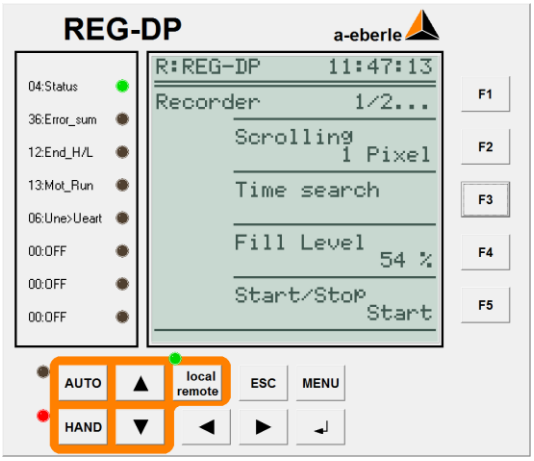


Figure 27: Screen 1 of the Recorder settings

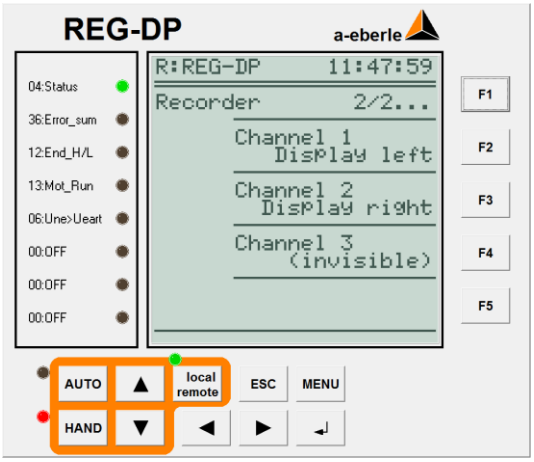


Figure 28: Screen 2 of the Recorder settings

<F2> Scroll (screen 1):

This parameter is used to set different feed rates for <F1: > and <F2: > at which the Recorder's memory is searched. The following increments can be selected for each key:

- 1 Pixel
- 1 Div
- 3 Div
- 5 Div
- 1 min
- 1 h

<F3> Time search (screen 1):

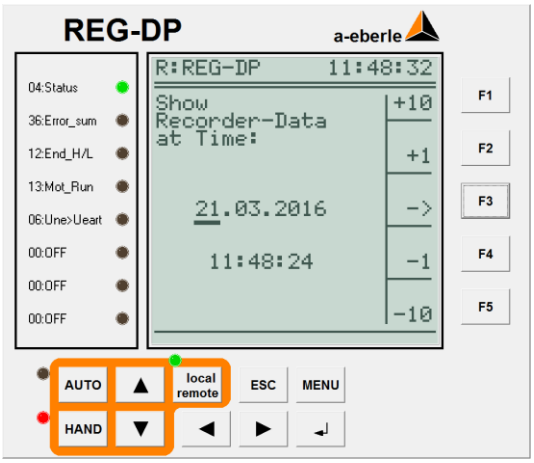


Figure 29: Search history in the Recorder - Time setting

To speed up memory searching, enter the date and time of the period you would like to examine. The period corresponds to the position of the recording pen.

Select the value you would like to change with <F3> or using the < ⇐ > and < ⇒ >arrow keys. Use <F1>, <F2> or <F4>, <F5> to set the desired value.

Press < ESC> to cancel the entry and <ENTER> to confirm it.

<F4> Used space (screen 1):

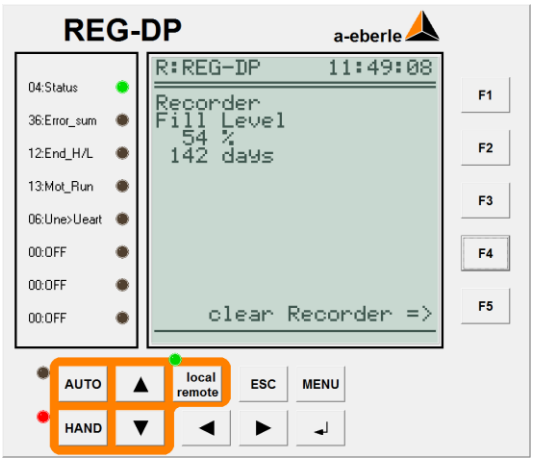


Figure 30: Display the used space; clear the memory

The actual amount of space used is displayed in % or days.

How the recorder records

Every second, the recorder checks whether the measurement channels to be recorded have changed in relation to a set threshold. A full data set is stored in the recorder when either the upper or lower threshold is exceeded, creating a very compact recording.

The memory is set up as a circular buffer, meaning that as soon as the buffer is full the oldest datasets are overwritten. The thresholds are set to record normal changes in the grid for three channels over a period of ca. 1-2 months.

<F5> clears the memory.

<F5> Start/Stop (screen 1):

Press <F5> to stop or start a recording. Pressing this key freezes the recording, for example, to transfer the data to a PC at a later point in time.

<F2> Channel 1, left graph (screen 2):

The allocation and the thresholds of the measured values to be recorded are freely definable:

Measured value	Description
Not used	No recording
Une	Absolute value of the zero sequence voltage $\underline{U}_{ne}$, stored in V, displayed as parameterized – knu is also recorded
Une_Phi	Angle of the zero sequence voltage $U_{NE,}$ in relation to $\underline{U}_{sync}$
I1	Absolute value of the current input $\underline{I}_1$ in A (recording of secondary value and kni)
I1_Phi	Angle of the current $\underline{I}_1$, in relation to $\underline{U}_{sync}$
I2	Absolute value of the current input $\underline{I}_2$ in A (recording of secondary value and kni) - (the regulator is delivered ex factory with only one channel - I1).

Measured value	Description
I2_Phi	Angle of the current I2, in relation to Usync
Ipos	Coil position in A
Usync	Absolute value of the synchronization voltage.

<F3> is used to set the threshold that triggers a new recording. If the value changes more than the resolution that is set on the recorder (in %), the new value is used for the recording.

The zero sequence voltage Une is stored logarithmically and displayed on a logarithmic scale. This recording guarantees a good resolution even for small zero sequence voltages

Standard allocation for the left channel: Ipos

<F2> Channel 2, right graph (screen 2):

The options are the same as for channel 1

Standard allocation for the right channel: Une

<F4> Channel 3, (hidden) (screen 2):

Additional information can be stored in this channel, for example, the angle information of the zero sequence voltage $\underline{U}_{ne}$.

Standard allocation for the hidden channel: Angle of $\underline{U}_{ne}$

▶ **Caution:**

When the value that is set to be recorded by a recording channel is changed, all of the data in the recorder are deleted.

9.4.4 Statistics

9.4.4.1 Displaying statistics

The statistics are displayed as summary statistics or as statistics in calendar weeks (CW). Press <F3> to switch between the different screens. Press <F1> or use the <⇐> and <⇒> arrow keys to scroll to the different values displayed in the below table.

The following data are recoded as statistics:

Parameters	Description
Automatic	Summary time of Automatic mode: Overflow at 100 000 h Automatically switches the output to days: d
Motor On	Summary time of the adjustment commands 'Higher' and 'Lower' The P-coil's 'Mot_Run' entry is also taken into account.
Earth fault duration	Summary time of the earth faults including transient earth faults
Current injection	Period during which the CI was active
Search	Number of started search processes
Tuned	Number of successful tuning processes

Tuned NC	Number of unsuccessful tuning processes
Tuned Umin	Number of reached Umin positions
Transient earth faults	Number of transient earth faults (earth faults smaller than the set transient earth-fault time)
Earth faults	Number of continuous earth faults (without transient earth faults)
Iw – Increases	Number of residual current triggers (Number of R_on)
Triggers	Number of triggers (when the tolerance range is left)

9.4.4.2 Summary statistics:

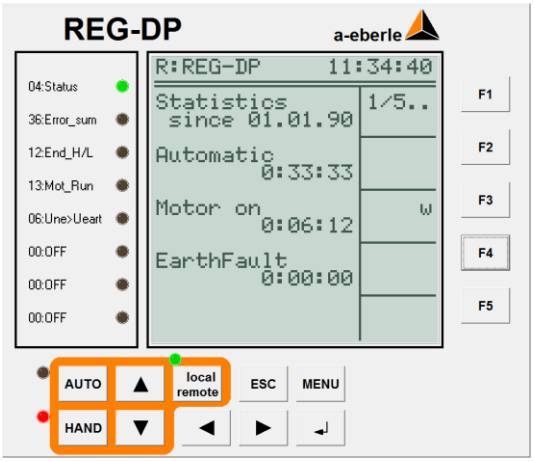


Figure 31: Statistics screen 1

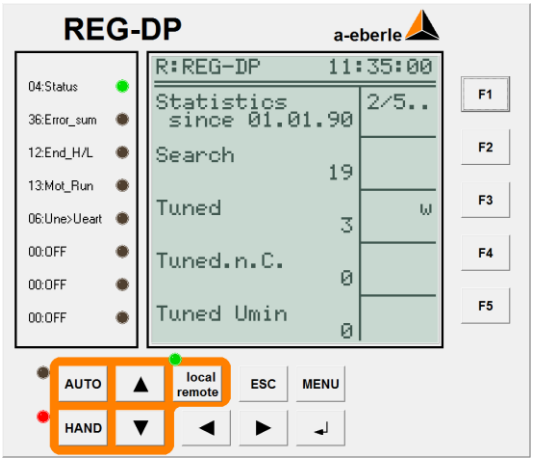


Figure 32: Statistics screen 2

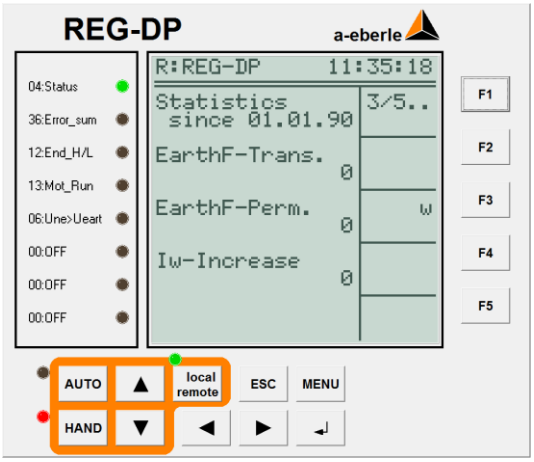


Figure 33: Statistics screen 3

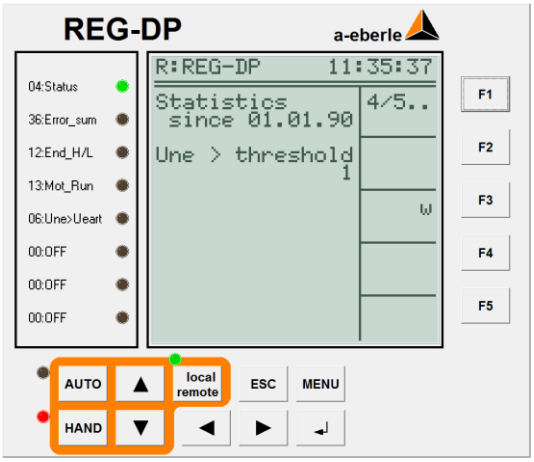


Figure 34: Statistics screen 4

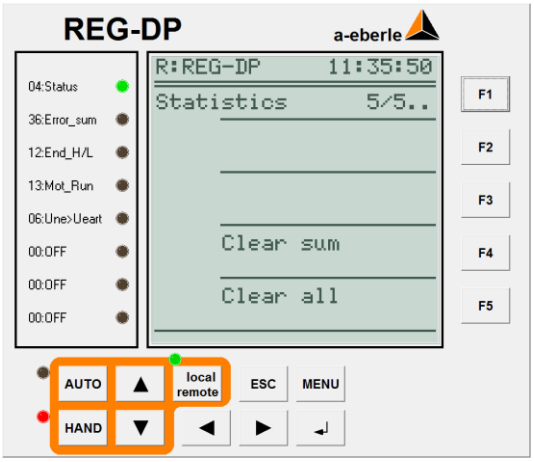


Figure 35: Statistics screen 5

The recorded statistics can be deleted on the last screen.

Delete sum: Deletes the data except for the calendar week counter

Delete everything: Deletes the sum and the calendar week counter

9.4.4.3 Statistics by calendar week:

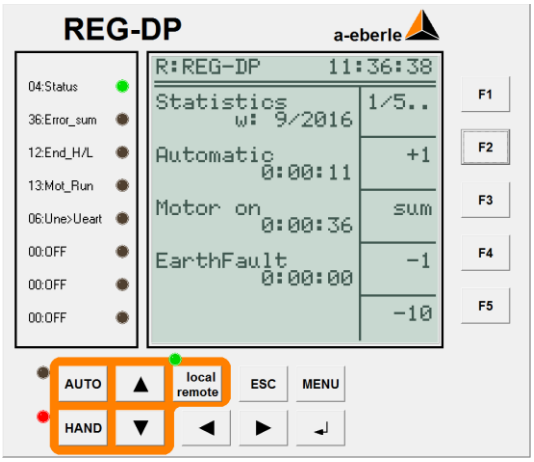


Figure 36: Statistics screen sorted by calendar week

The above figure displays the statistics for calendar week 34.

A calendar week is selected using function keys <F2>, <F4> and <F5>.

The data can also be read out using the terminal window in the WinEDC/WinEOR parameterization software by entering the following REG commands and then copied and pasted into an Excel spreadsheet or Word file:

9.4.4.4 Statistics examples

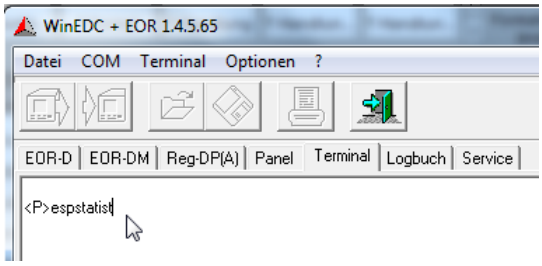


Figure 37: Commands to retrieve statistics

Summary statistics:

<A>espstatist

Statistics

	Auto	Mo-torOn	Earth-flt	Search	Tuned	Tu-nedNC	Tu-nedUmin	EarthfltW	EarthfltIw-Incr	Trigger
Sum	02:21:57	00:06:09	00:00:01	6	5	1	0	1	0	0	2

since 01/01/1990

Statistics from CW 42 to CW 44

espstatist 42 44

Statistics

	Auto	Mo-torOn	Earth-flt	Se-arch	Tuned	Tu-nedNC	Tu-nedUmin	EarthfltW	EarthfltIw-Incr		Trigger
CW42/2001	00:00:00	00:00:00	00:00:00	0	0	0	0	0	0	0	0
CW43/2001	00:00:00	00:00:00	00:00:00	0	0	0	0	0	0	0	0
CW44/2001	02:26:33	00:03:01	00:00:01	6	5	1	0	1	0	0	2
Sum	02:26:33	00:03:01	00:00:01	6	5	1	0	1	0	0	2

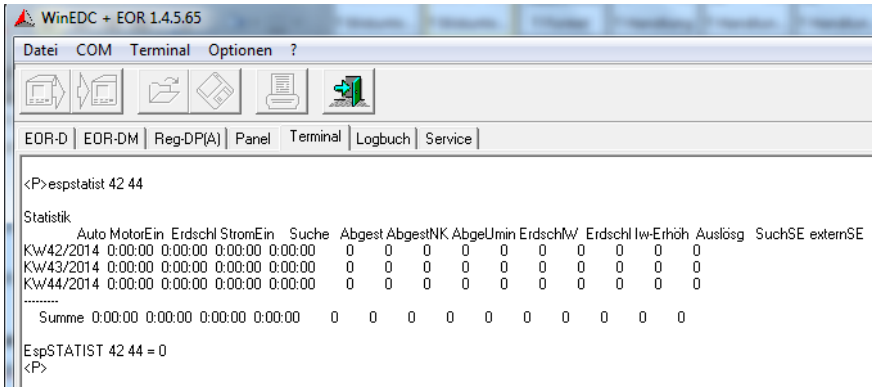


Figure 38: Retrieving statistics from CW 42 to CW 44; List by week

9.4.5 Definitions

Information	Description
Auto	Time in automatic mode
MotorOn	Motor switch-on time
Earthflt	Total time of earth fault
CurrentOn	Current injection time (when using optional current injection)
Search	Number of search triggers
Tuned	Number of successful tuning processes
TunedNC	Number of tuning processes; the coil was adjusted to the best possible tuning point but was outside the parameters
TunedUmin	Number of tuning processes in which Uen was below the minimum threshold. The tuning point is either: the last tuning point OR the standby position (parameterizable)
EarthfltW	Number of transient earth faults Default setting 7s All earth faults that extinguish themselves within 7s are considered as transients

Earthflt	Number of earth faults Time by earth fault that is longer than the set transient time
Iw-Incr	Number of residual current increases When the additional resistor is controlled by the REG-DP
Trigger	Number of search triggers The regulator goes into search mode; the regulator doesn't actually have to search for anything if the original Uen value is reached within the time delay
SeachCI	Number of searches with optional current injection Note: This does not change the coil position
externalCI	Number of external current injection requests; typical with EOR-DM (in EDCSys) for the admittance technique for earth fault detection

9.4.6 Troubleshooting

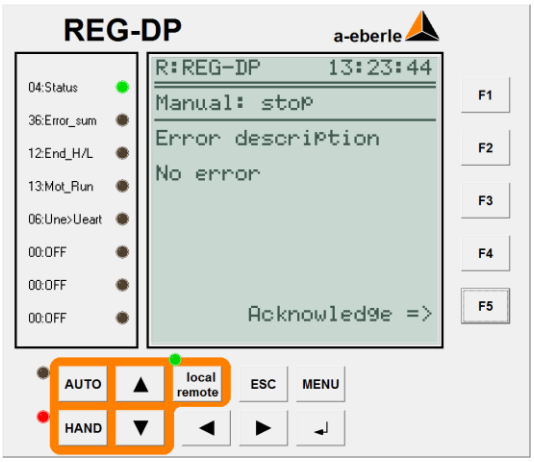


Figure 39: Troubleshooting (REG-DP error messages)

Errors are displayed in the status bar as soon as they occur. Detailed information is obtained by pressing **<MENU> <F5>**.

If several error messages are displayed, use the < > keys to scroll through them.

Press **<F5>** to acknowledge an error message. **All acknowledgeable** errors are reset at the same time.

9.4.6.1 Non-resettable errors/critical errors are:

- Status LED is extinct – the device must be sent in for inspection.
- Firmware error– the firmware doesn't match the used hardware
- CI (current injection) not available
- Blown CI fuse

These messages display until the cause of the error has been fixed.

9.4.7 Panel mode screen

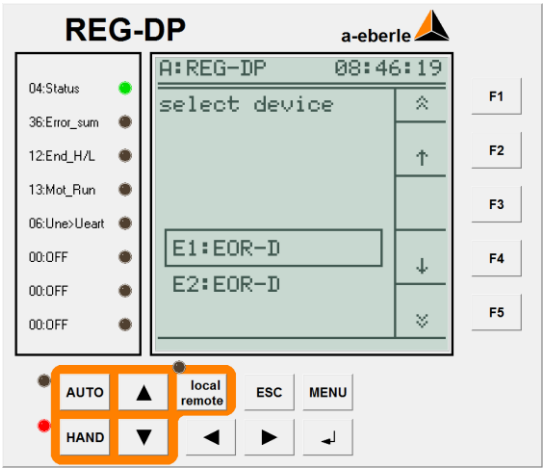


Figure 40: Selection of another device in the E-LAN to display on the REG-DP/ REG-DPA's screen

In Panel mode enables other devices that are installed on the same bus (E-LAN) to be accessed. All of the devices on the bus are listed in this mode. Use the function keys to select a device. Press <Return> to select and display a device.

The LEDs do not change but all of the keystrokes affect the selected device!

Panel mode is exited by a long press of the <ECS> key.

The first press of the <ESC> key takes you back to the list of devices.

You know you are in Panel mode when the time at the right top of the display has been replaced with !Panel!.

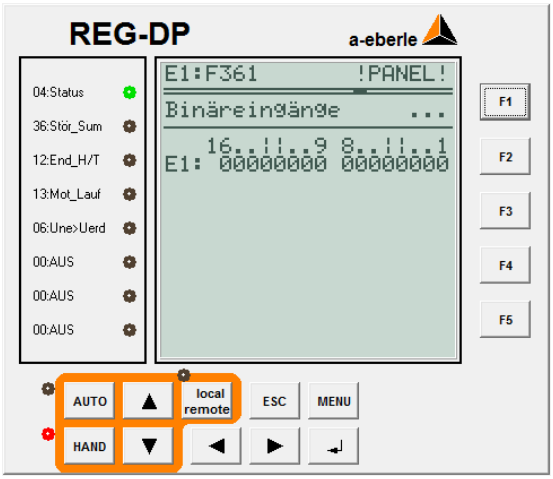


Figure 41: Examples: View of the 16 binary inputs on an EOR-D (E1:)

9.5 The Status menu

Key sequence <Menu><F3><F5><F1><F5>

A variety of information on the REG-DP/ REG-DPA can be queried in the Status menu.

9.5.1 Status screen 1

The first screen (with Current Injection Feature 1/7) displays information about the firmware version (here REG-DP: 2.6.03) and release date, the hardware version and the battery charge level,

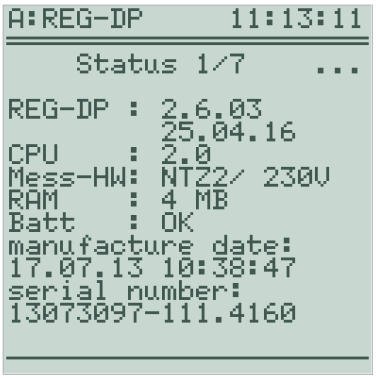


Figure 42: Status screen 1/7

as well as the manufacturing date and the serial number (here 13073097) followed by the item number (here 111.4160). A. Eberle's head office uses this item number to determine how many of the slots on the REG-DP/ REG-DPA are allocated.

9.5.2 Status screen 2

Screen 2/6 displays the binary states of the REG-DP/ REG-DPA.

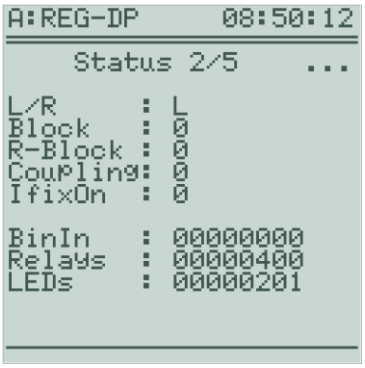


Figure 43: Status screen 2/7 Information on the binary states (hex coded)

Information	Description
L/R	L=Local; R=Remote
Block	0 = Regulator not blocked; 1 = Regulator blocked
R-Block	Residual-current-increase resistor: 0 = not blocked; 1 = blocked

Information	Description
Coupling	Clutch (parallel operation of two REG-DP/ REG-DPAs): 0 = OFF; 1 = ON Information through binary input (input function Clutch)
IfixOn	Fixed coil: 0 = OFF; 1 = ON Information through binary input (input function Fixed coil)
BinIn	State of all binary inputs (hex coded) Ex.: BI 1 and BI 2 ON = 00000003 (1+2=3)
Relay	State of all relay outputs (hex coded)
LEDs	State of all LEDs (hex coded)

9.5.3 Status screen 3

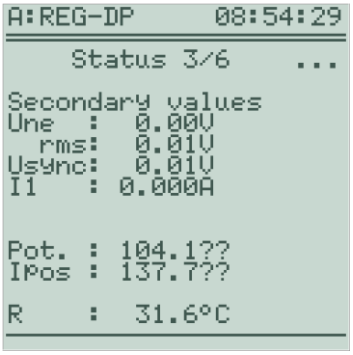
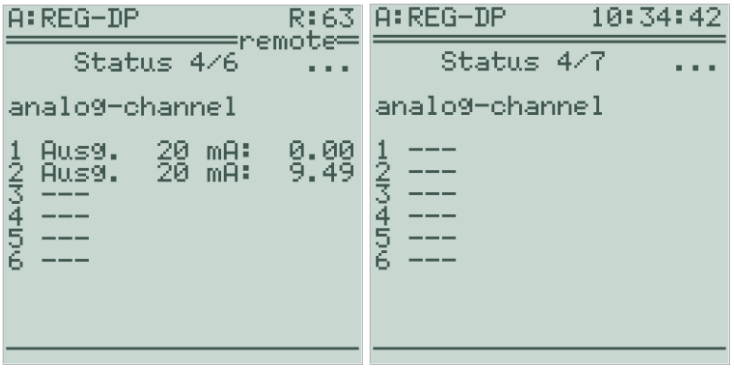


Figure 44: Status screen 3/7 Measured values

All of the values for the analogue channels used to measure the current and voltage are displayed as secondary values.

The value for the potentiometer is displayed in %, the value for the coil position in A, and when resistor control is enabled, the value calculated in the temperature model is displayed.

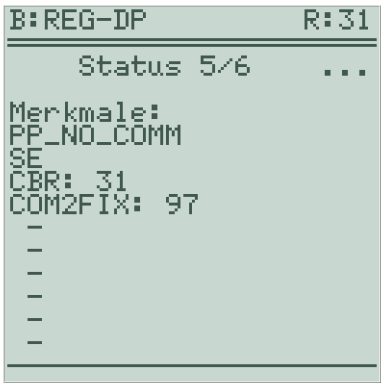
9.5.4 Status screen 4



For plugged and parameterized analogue modules, the momentary values can be verified and compared with the values in the control system.

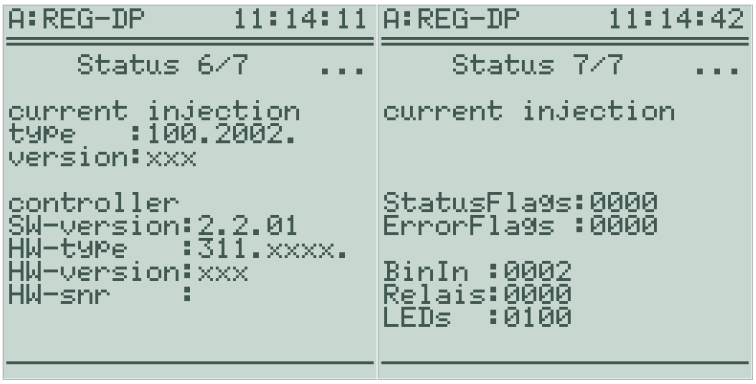
The right figure shows a device without analogue module

9.5.5 Status screen 5



This screen displays an overview of the features used in the REG-DP/ REG-DPA. In the example, PP_NO_COMM stands for parallel control without communication, CI for current injection, CBR is a special feature, and COM2FIX is used to set the speed of COM2 to a specific value.

9.5.6 Status screen 6



When current injection is enabled and the REG-DP/ REG-DPA and the current injection controller are communicating, the hardware version, firmware version and the states of the current injection controller's binary inputs and outputs are displayed.

9.6 Password protection

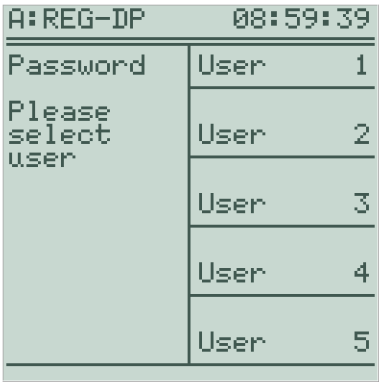
The menu item 'Password protection' is accessed

by pressing <Menu><F3><F5><F1><F4>

Password protection helps prevent unauthorised users from changing parameters.

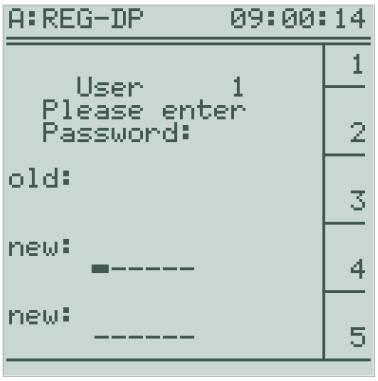
Note:

Parameters can always be changed through WinEDC even when password protection is used!



Five users can be added. All users have the same access rights to all parameters.

An additional option for User 1 is that this user can change the passwords of the other users.



Function keys F1 to F5 are used to select a specific user and enter their password.

Passwords must always be 6 characters long. Here, the function keys correspond to numbers 1 to 5.

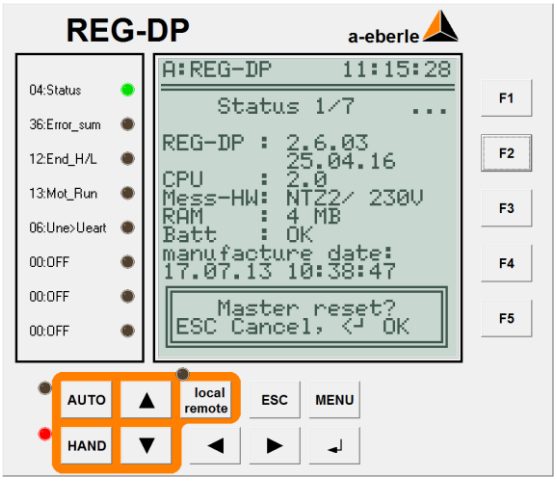
Disabling password protection

User 1 enters the old password and for the new password, the sequence 111111.

The above screen displays showing that password protection has been disabled.

9.7 Factory reset: Master reset:

Pressing <F2> in the Status menu resets the controller:



A master reset resets all of the parameters to their factory settings.

The communication and interface settings remain unchanged.

A master reset is the same as the REG-L terminal command sysreset=590

10. Commissioning

This section describes the commissioning process for the REG-DP based on a typical configuration of a resonant earthed neutral system.

Note

The following sections and the 'Commissioning' menu on the regulator are structured in such a way that the regulator can be fully commissioned by carrying out each of the steps in the sequence in which they are described.

10.1 Hardware – Wiring

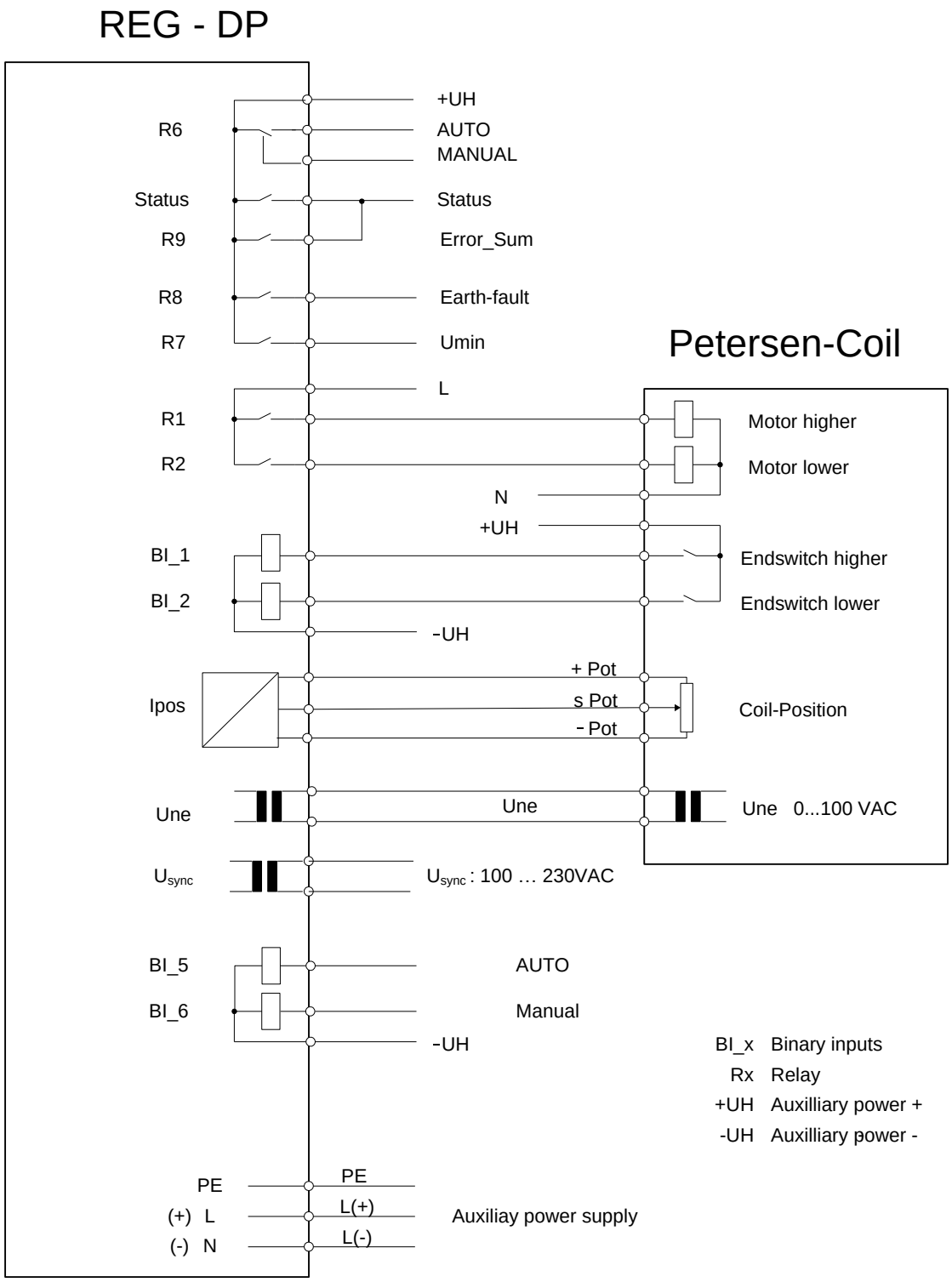


Figure 45: Standard REG-DP/ REG-DPA connection to a P-coil

The wiring described in the following steps must either be performed or checked:

- **Auxiliary voltage** Please observe the regulator's permissible auxiliary voltage (see type plate)
- **End switch messages** from the P-coil to the regulator
  (note the auxiliary voltage for the end switch)
  (note the type of end switch: NCC/NOC)
  - End switch Higher (Input I1)
  - End switch Lower (Input I2)
- **Adjustment commands** from the regulator to the P-coil
  (auxiliary voltage for the motor contactors)
  - Motor Higher (Direction Imax: Relay R1)
  - Motor Lower (Direction Imin: Relay R2)
- Connect the **Potentiometer** to the desired type of circuit. Changes may have to be made to the way the potentiometer is wired to the coil.
- **Zero sequence voltage** Uen of the P-coil's winding
- **Reference voltage** at the Usync connector

Note:
Check the direction of the coil adjustment: The voltage divider ratio must increase when the current (coil position) increases.

- Please check for firmware updates if the device was delivered more than six months ago. The current firmware versions can be downloaded from our website www.a-eberle.de .

10.2 WinEDC Parameterization Software

A CD with the current version of the WinEDC parameterization software is shipped with the REG-DP/ REG-DPA.

The CD contains an exe file and database (.mdb), meaning that the software doesn't have to be installed as one normally would. All you have to do is copy the exe file and the database (.mdb) to a directory of your choice.

The current software version is: WinEDC 1.4.5.65.exe

config_dp_2016_04_xx

The below will guide you through the regulator's initial set up using the software.

10.2.1 Function keys in WinEDC

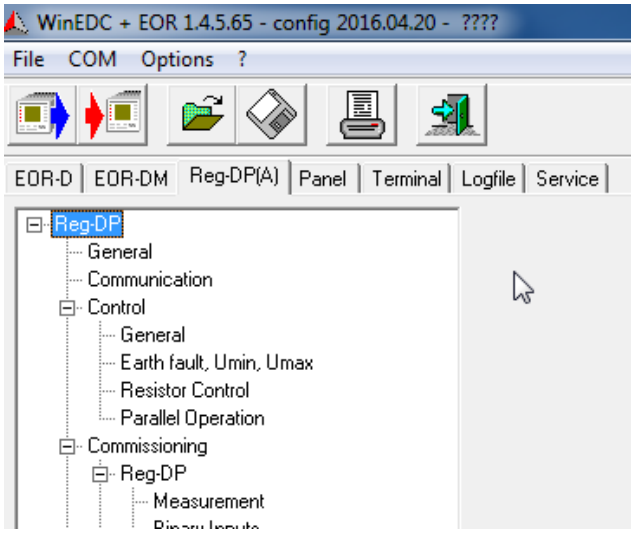


Figure 46: WinEDC operating software interface

Copy current parameter set from device to PC

Copy current parameter set from PC to device

Open available parameter set on data carrier

Save current parameter set

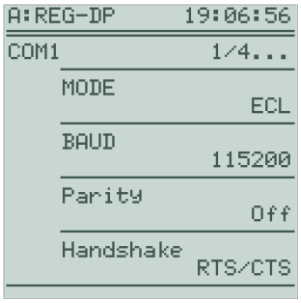
Print open parameter set (to the printer or a different file format)

Exit WinEDC

10.2.2 Connecting the WinEDC software to REG-DP/ REG-DPA

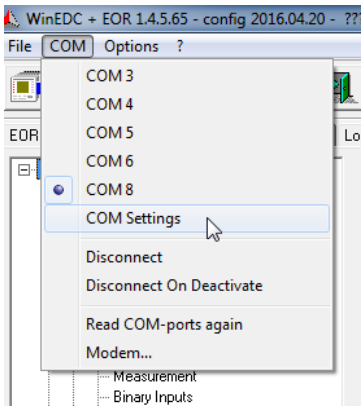
You will need a null modem cable to connect the REG-DP/ REG-DPA to the PC. The interface speed for the serial connection must be the same for the regulator and WinEDC.

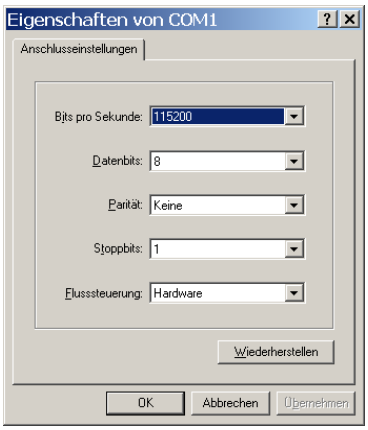
To set the interface speed for the regulator, press **<MENU><F3><F5>**.



The computer is directly connected to the REG-DP/ REG-DPA's COM1 port.

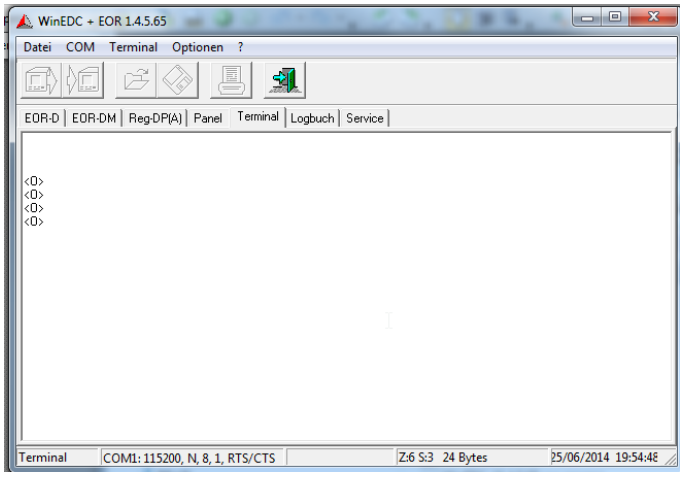
The below figure shows how the interface parameters are changed in WinEDC:





The REG-DP/ REG-DPA and WinEDC now have the same interface parameters and the PC can communicate with the device.

You can confirm this by going to the terminal screen and pressing the <ENTER> key on your keyboard. The device with the ID that is directly connected with the serial cable will respond.



10.2.2.1 USB serial adapter – Re-importing interfaces

In the current version of WinEDC you can re-import the available COM interfaces. You may have to do this when you connect a USB serial adapter to the PC when WinEDC is running.

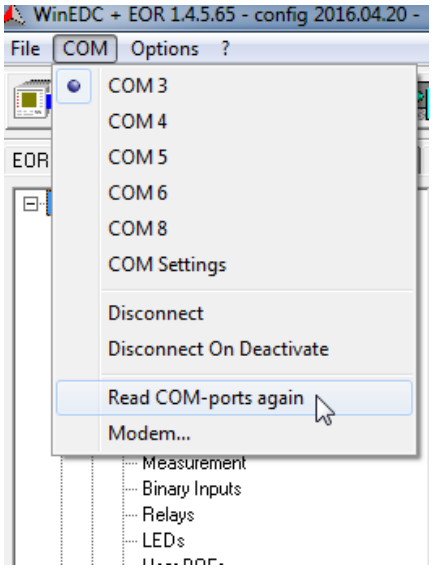


Figure 47: Re-importing COM interfaces

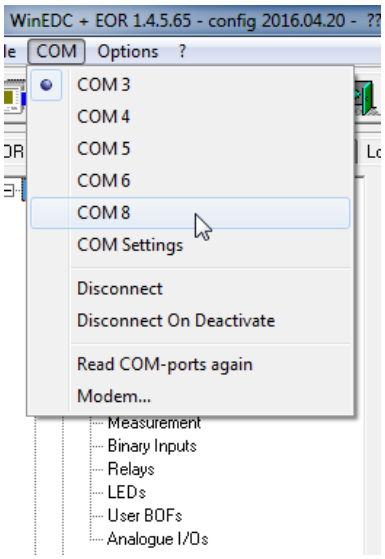


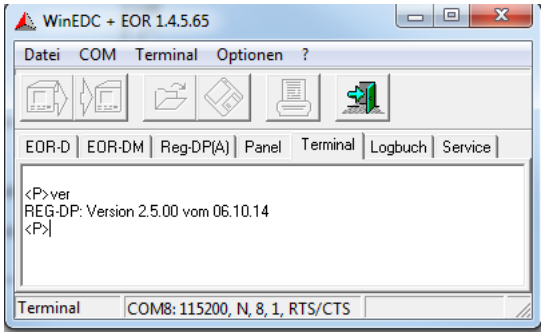
Figure 48: COM 8 visible after re-import

10.2.3 Updating REG-DP/ REG-DPA firmware with WinEDC

You will not have to update the firmware if you start using the regulator shortly after delivery. If there has been a longer period of time between the delivery and the commissioning of the device, you may want to download the current firmware version from our website www.a-eberle.de and update the regulator first.

10.2.3.1 Querying the firmware version with WinEDC

Entering the command 'ver' and pressing <ENTER> after the connection to the REG-DP/ REG-DPA has been established displays the firmware's version number.



10.2.3.2 Querying the firmware version on the REG-DP/ REG-DPA regulator

The firmware version is queried on the regulator by pressing:

<MENU><F3><F5><F1><F5>

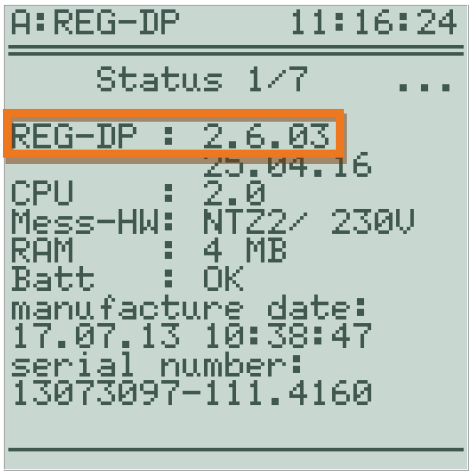


Figure 49: Firmware version displayed on REG-DP/ REG-DPA screen; here it's 2.6.03

10.2.3.3 Selecting the right firmware file

The current firmware version can be downloaded from the A.Eberle website. A distinction is made between devices before May 2009 and devices after May 2009.

Firmware section on the webpage	Name of the firmware file to be installed on the REG-DP/ REG-DPA
Firmware REG-DP V2.4.08 für Geräte ab Mai 2009 for devices as of May 2009 para dispositivos como el de Mayo 2009	dp_2504.moc Typ: MOC-Datei help_dp_2504.moc Typ: MOC-Datei
Firmware REG-DP V2.4.08 für Geräte vor Mai 2009 for devices before May 2009 para dispositivos realizado antes de Mayo 2009	dp_2504_B2012_UNI.moc Typ: MOC-Datei help_dp_2504_UNI.moc Typ: MOC-Datei

Note: With a REG-DP/ REG-DPA bootloader update (at least bootloader v 2.12), you can use the same firmware with the file extension _UNI on all devices.

Note: The advantage of using a bootloader from version 2.12 is the so-called RAM backup for devices with battery-buffered memory that were manufactured until September 2014.

10.2.3.4 Updating firmware

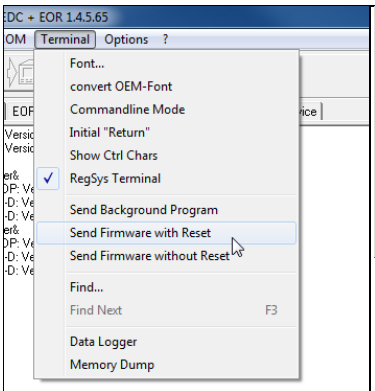
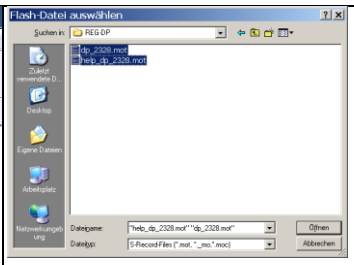
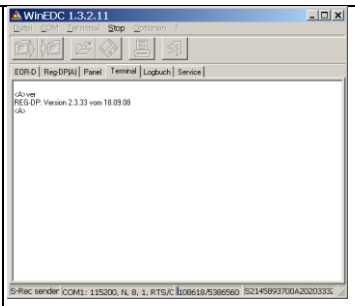
- Put the regulator into bootloader mode for the firmware update

The regulator must be in bootloader mode before the update can start. There are two ways to do this:

Option 1	Option 2
Press **<MENU><F3><F5><F1> <F5>** to access the Status Press and hold **<F1>** for about 10s. ☑ The regulator switches into bootloader mode.	Switching off the power supply on the regulator Press and hold **<F1>** to switch the power supply on again. ☑ The regulator is in bootloader mode.

- Update firmware

With the regulator in bootloader mode, perform the following steps:

		
Select the function 'Firmware update with reset'	Select the directory in which the firmware and the 'Help' are stored	The progress of the update is displayed at the bottom of the screen

Notes:

- The regulator displays a chain of digits until the update has been completed.
- The update does not affect the initial parameterization.
- The update must be repeated if the regulator's power supply is interrupted during the update.
- The regulator restarts automatically at the end of the update.

Query the version number to make sure the update was successful.

10.2.3.5 Bootloader update

A bootloader update is performed in the same way as a firmware update.

The update file always contains the bootloader number. Ex.: boot_2.14.moc

Note: The bootloader is the same for all devices (REG-DP/ REG-DPA(A), REG-D(A), PAN-D, EOR-D, PQI-D and DMR-D)

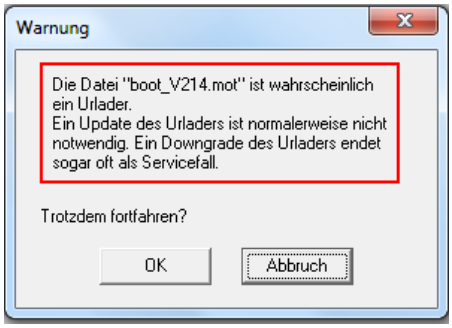


Figure 50: Press OK to confirm warning message during bootloader update

10.2.3.6 RAM backup after bootloader update

Why back up the RAM?

For devices that were manufactured before August 2014, parameters, background programs, logbook and recorder data are stored in battery-buffered RAM. If you don't want to rely on the function of the battery, you can store the parameters in the non-volatile memory.

To perform a RAM backup, put the REG-DP/ REG-DPA in bootloader mode as described in 10.2.3.3.

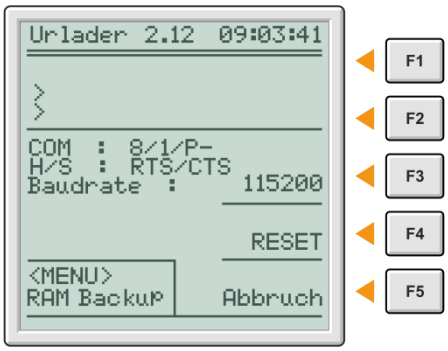


Figure 51: Bootloader with RAM backup option

Press <MENU> on the REG-DP/ REG-DPA to access the RAM Backup menu.

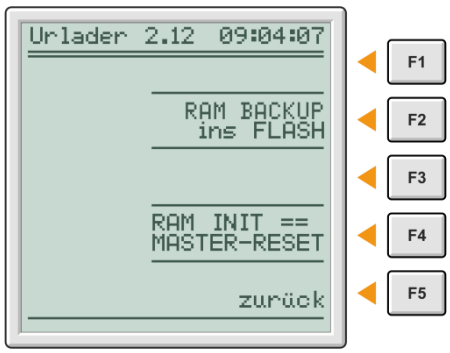


Figure 52: RAM Backup menu without backup

Press F2 to write all of the data to the non-volatile memory.

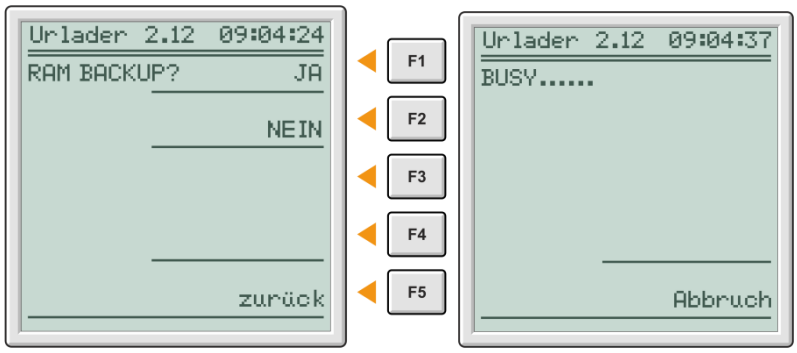


Figure 53: Press F1 to confirm the request (YES) to perform the RAM backup. BUSY …. = backup in progress

Upon successful completion of the RAM backup, the menu will display the backup in the selection list.

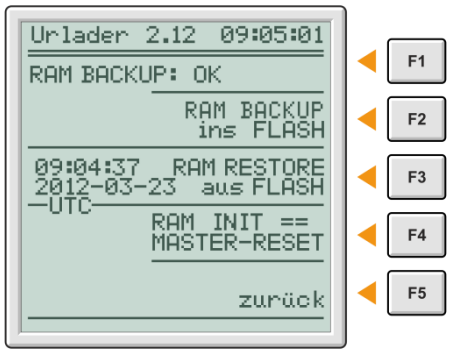


Figure 54: Press F3 to select and restore the RAM backup

Parameters, a background program, the logbook and the recorder data that are restored from a RAM backup are restored to the date on which the backup was performed. Logbook and recorder data that were logged after that date are no longer available.

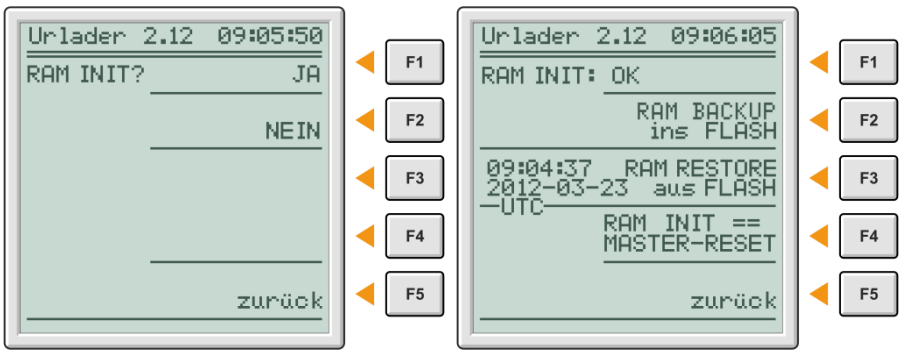


Figure 55: Press F1 (YES) to confirm the restore

If the restore is successful, the message RAM INIT: OK displays

The restore is instantaneous. There is no progress bar as is displayed when backing up to RAM.

10.3 Important commissioning steps (basic parameters)

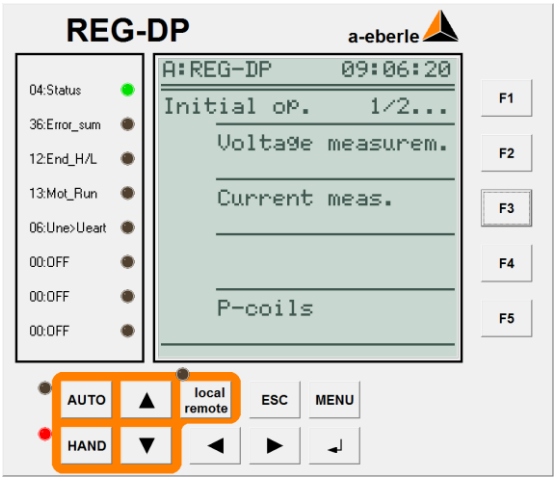
Note: The following steps can be performed without having to connect the P-coil to the medium voltage grid.

The regulator switches on in MAN mode and the parameters are set to their factory settings.

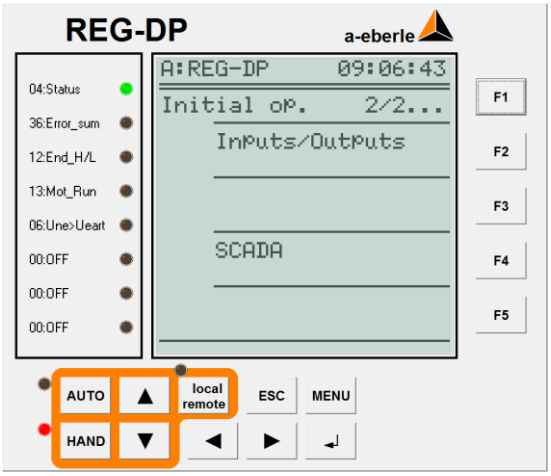
The below steps align the P-coil regulator with the data on the P-coil. To access the commissioning menu, press

<MENU><F3><F3>

The below parameter input screens are available:



Screen 1



Screen 2

10.3.1 Adding coil data

Note: Commissioning can be performed in the same sequence as the menu items are displayed. We recommend setting the basic parameters on the regulator itself.

Voltage measurement (MENU><F3><F3><F2>)

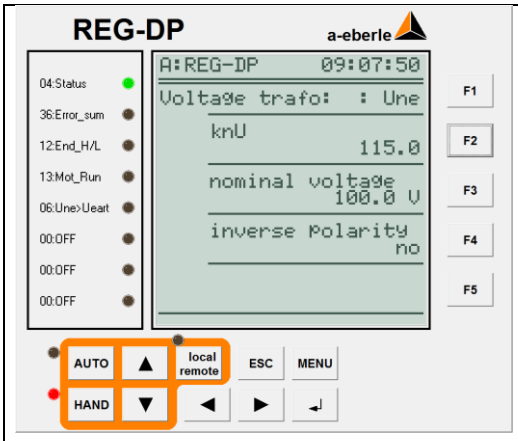


Figure 56: Enter voltage transformer data

F2: Conversion ratio for the voltage transformer for a 20 kV grid is knU = 11547 V/100 V = 115 (default)

F3: Nominal voltage of the transformer to measure the zero sequence voltage in V (range 20 V to 120 V); Default = 100 V

F4:

Current measurement (MENU><F3><F3><F3>)

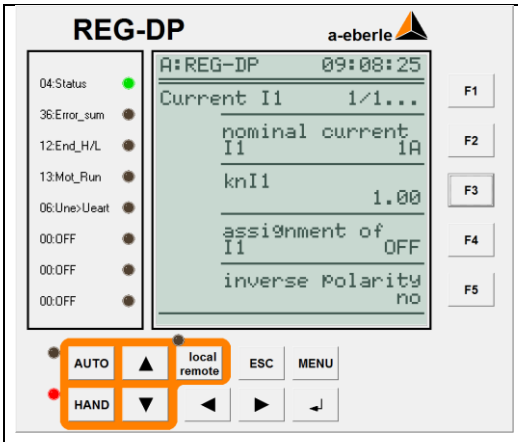


Figure 57: Enter current transformer data

F2: Nominal current of the transformer to measure the actual current through the P-coil in A

F3: Conversion ratio of the current transformer – measurement range selectable through jumper (1 A/5 A) **knI1** = 1.0 (default)

F4: Input function, OFF = channel not used:

F5: Reverse polarity

- **P-coils – Coil parameters (P-coil data) (MENU><F3><F3><F5>)**

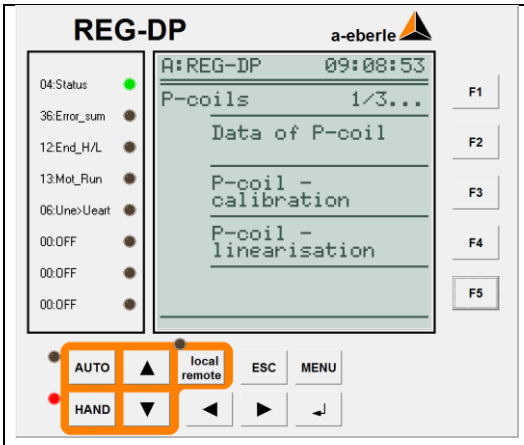


Figure 58: P-coil menu

F2: P-coil data: Coil range, end switch information etc.
F3: Coil calibration – Automatic determination of the coil's operating times, end switch position and motor drive overrun
F4: Coil linearization Manual alignment of the potentiometer information on the regulator with position indicator (in A) in the P-coil

- **P-coil data**

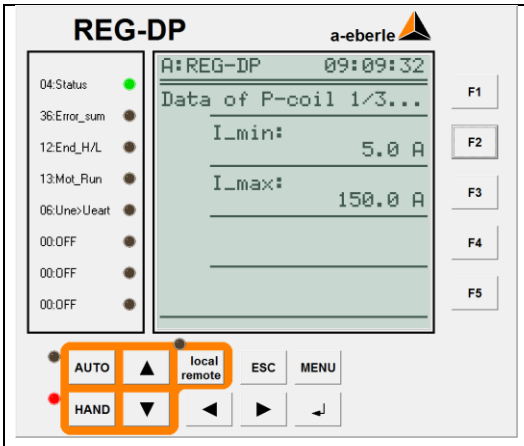


Figure 59: Enter the coil's Imin, Imax

Screen 1/3
F2: I_min coil's smallest value in A
F3: I_max coil's biggest value in A

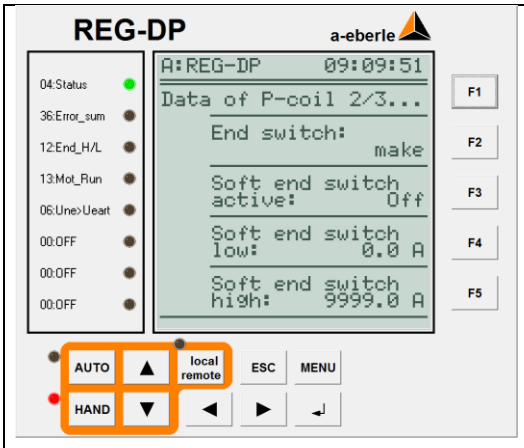


Figure 60: Enter end switch type

Screen 2/3
F2: End switch - End switch information wired as normally open contact or normally closed contact
F3: Soft end switch

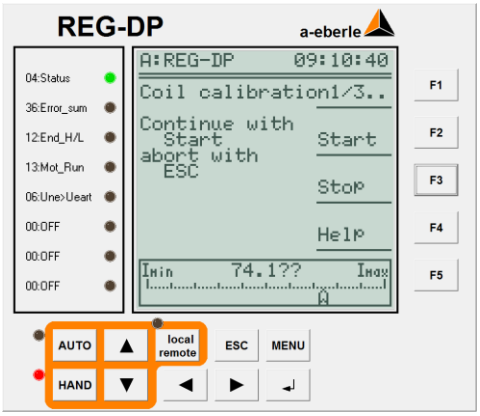
10.3.2 Automatic coil calibration on the REG-DP/ REG-DPA

(<MENU><F3><F3><F5><F3>)

Pressing <F2> starts the automatic coil calibration during which the below P-coil data are determined by the regulator.

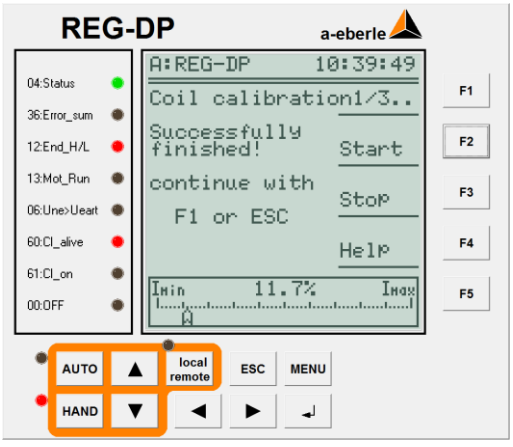
- Test and assign the coil position to the end switches 'Higher' and 'Lower'
- Operating time for the P-coil for the adjustment of the P-coil across the whole range
- Coil backlash
- P-coil overrun
- Checking the correct movement direction (up or down)
- Detection of wiring errors in the position detector's range
- Non-linearity behaviour of the potentiometer

Calibrating the coil

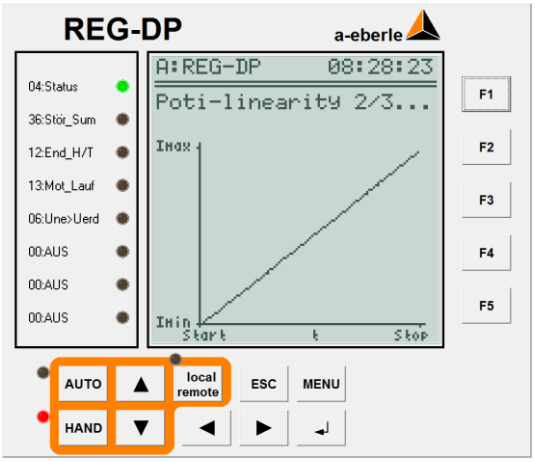


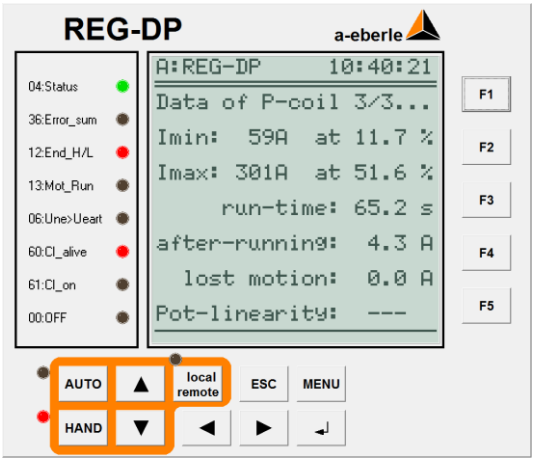
When calibrating the coil, the system first searches for the 'Lower' end switch. The P-coil is then adjusted to the 'Higher' end switch. Once that's done, the coil backlash and coil overrun are determined in the middle of the adjustment range. The P-coil is then set to the lower end position in preparation for linearization.

Successful coil calibration is displayed on the screen as follows:



The calibration results are displayed on the next screens of the 'Coil calibration' menu, which are accessed by pressing <F1>.





Check the wiring if the non-linearity of the potentiometer characteristic is too high (> 2%). If only 2 lines are used, the non-linearity can be increased.

Imin

Coil's compensation current in the lower end switch position. In the example, the potentiometer has a value of 4.5%, which corresponds to a coil current of 20 A.

Imax

The coil's compensation current in the upper end switch position. In the example, the potentiometer has a value of 95.4%, which corresponds to a coil current of 200A.

Operating time

The time needed to move the coil from the lower to the upper end switch.

Overrun

The time that the drive continues to run after the stop command.

Coil backlash

The hysteresis, caused by the mechanical backlash between the coil's iron core, air gap and potentiometer is determined.

The hysteresis is only compensated if the coil is controlled by the regulator. It doesn't work if the coil is adjusted externally (directly on the motor drive unit).

Linear error

Linear error of the potentiometer

The error should be smaller than 2%. Larger deviations are a sign of an error in the potentiometer or a faulty connection.

▶ **Possible reasons for errors**

- The power supply for the coil's motor drive is not switched on
- The wiring of the higher and lower commands is inverted
- The wiring of the end switch information is missing or inverted
- The connection to the potentiometer is wrong or incomplete

10.3.3 Manual coils - Linearization

All coil calibration does is to assign a specific current/position value to the two end switches in Ampere. If the scaling on the P-coil's mechanical display is not linear, the regulation has to be linearized. For the following steps, we recommend positioning someone at the regulator to read the actual values in A and set the coil to the desired value for linearization.

This figure displays the distances on the P-coil's scale in increments of 5 A.

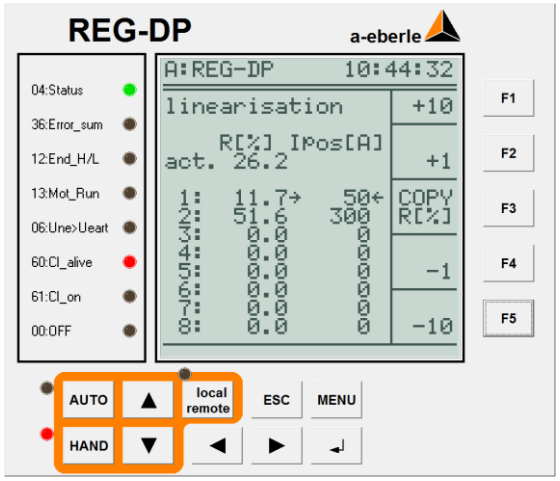


Figure 61: Starting point for manual linearization

We recommend following the below linearization procedure:

- Adjust the P-coils manually to the lower end position –

Note: The coil is already in the lower end position at the end of the automatic calibration**. You can immediately start with the manual linearization**

- Select up to 8 reference points, bearing in mind that more reference points should be used in the lower part of the P-coil because that's where non-linearity is usually the highest.

Only use reference points that are indicated on the P-coil's mechanical display. These reference points should always be approached from bottom to top - one direction of motion - to ensure there is no backlash.

Adjust the coil to the next reference point

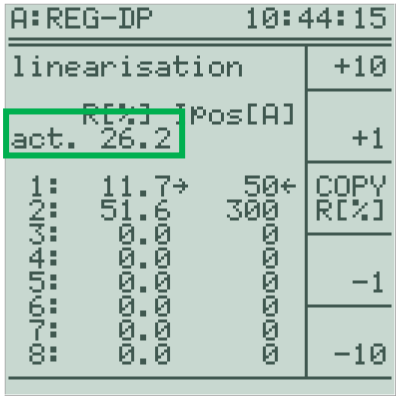


Figure 62: Changed potentiometer values

Use the < ⇒ > arrow key to select the next row (in this example Row 2, the row with the value for the upper end position)

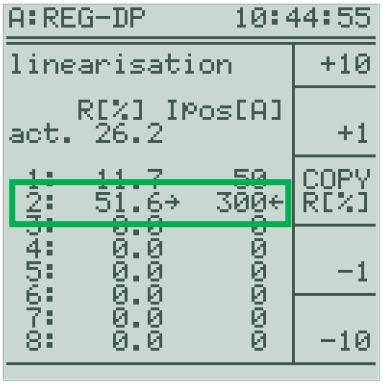


Figure 63: Select Row 2 to accept the coil position in the table

The value for the 300 A in Row 2 is automatically moved to the next row

Press <F3> (Copy[R%]) to accept the measured value returned by the potentiometer on the P-coil

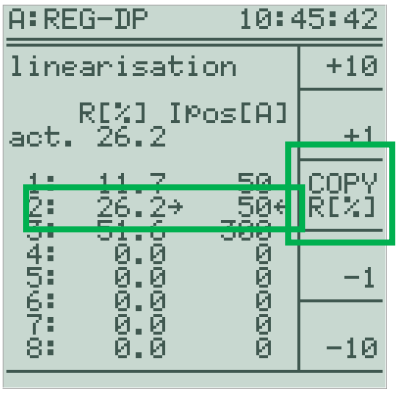


Figure 64: Press F3 (COPY R[%]) to accept the current position

- Correcting the current value in A to the P-coil value that was set on site

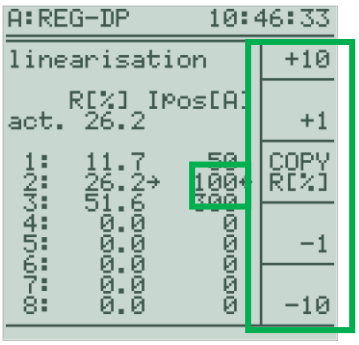


Figure 65: Adjust the coil position in the Ipos column

- Repeat the last four steps until all of the eight values have been set or I_{max} has been reached.
- Remember to press <ENTER> to confirm the determined linearization table.

Once linearization has been completed, it is advisable to download the determined parameters from the regulator and back them up.

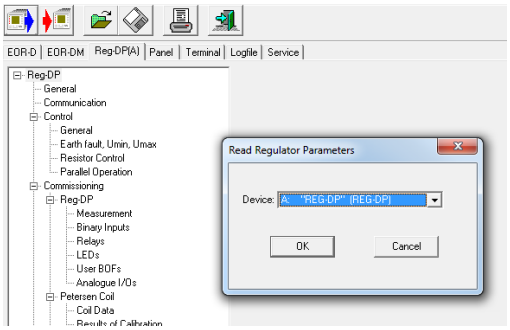


Figure 66: Downloading parameters from REG-DP/ REG-DPA after successful linearization

10.4 Factory settings for certain parameters

If you are only going to use the regulator's standard functions – classic regulation of a P-coil –, the following default settings can be adopted:

The binary inputs and outputs are predefined upon delivery, but the settings can be changed for all inputs and outputs.

The best way to set the parameters that control the regulator's behaviour is to go through the control menu items **(<MENU><F2><F2>)** and set the desired parameters.

The below is a **short** list of the recommended settings for classic regulation without additional current injection:

<F2>: Regulation

Regulation screen 1/2

<F2>: Default param

Default param Screen 1/4

F2: Search method	Move coil
F3: Une tolerance:	20.0%
F4: Delay search by:	10.0 s (should be increased to 180 s)
F5: Delay forced search by:	3.0 s

Default param Screen 2/4

F2: Target tuning Type	absolute[A]
F3: Target tuning	+5 A (absolute detuning recommended)
F4: Min adjustment dIpos/ %:	5.0

Default param Screen 3/4

F2: Exceed resonance peak:	YES
F3: Readjust Uref/min:	5 min
F4: Une angle measurement	On
F5: Check resonance curve:	1.0

Default param Screen 4/4

F2: Max search cycles	10
F3: Motor runtime max/min	45
F4: End position when search cancelled:	tuning point (please select)
F5: Standby position	50.0

<F4>: earth fault

Earth fault Screen 1/2

F2: Uerd threshold[%]	30.0
F3: Uerd message delay:	7.0 s
F4: Transient earth fault:	5.0 s
F5: Locking at Uerd:	Off

Earth fault Screen 2/2

F2: Correction Ipos	OFF:

<F4>: Umax

F2: Umax threshold[%]:	30.0
F3: Delay Umax by:	0.0 s
F4: Umax_end threshold[%]:	0.0
F5: Self-extinguishing current limit:	0.0 A

<F5>: Umin

Une < Umin 1/2

F2: Umin threshold/%	0.2
F3: End position	last tuning position
F4: Une < Umin message after/min:	15.0
F5: New search after/min:	60

Une < Umin 2/2

F2: dUne limitation in Umin/%:	30.0
F3: Locking at Umin:	OFF

Regulation Screen 2/2

<F2>: Umin

Une < Umin Screen 1/2

F2: Umin threshold [%]:	0.20
F3: End position at Umin:	tuning point
F4: Une < Umin message after:	15.0 min
F5: New search after:	60 min

Une < Umin screen 2/2

F2: Locking at Umin:	OFF:

Note:

The regulation of the residual-current-increase resistor is switched off in the below example.

<F3>: R - Regulation

R-Regulation Screen 1/3

F2: Resistor control	OFF
F3: Locking:	OFF
F4: Suppression of transients:	OFF
F5: Thermal replica:	

R-Regulation Screen 2/3

F2: Standby state at Une < Uerd:	OFF
F3: Release delay at standby state = ON	1.0 s
F4: Switch-on delay:	1.0 s
F5: Switch-on time:	1.0 s

R-Regulation Screen 3/3

F2: Repeat cycles:	0
F3: Repeat delay:	1.0 s
F4: Repeat time:	1.0 s

Note:

Parallel regulation of two adjustable coils with two REG-DP/ REG-DPAs. Is switched off in the following.

<F4>: Parallel regulation

Parallel Regulation Screen 1/2

F2: Parallel prog:	Off
F3: Parallel prog active:	Off
F4: Slave ID	---

Parallel Regulation Screen 2/2

F2: Adjust slave	No
F3: Slave position at Umin:	Stop
F4: Fixed position, if slave:	100 A

System parameters such as Language, COM1, COM2, ELAN, Password, Status, Date, Time can be found under the menu item 'System'.

10.5 Commissioning steps on a medium voltage grid

The commissioning steps described in 10.3 could be performed without having to connect the P-coil to the medium voltage grid.

But by connecting the P-coil to the medium voltage grid, the regulator can measure the zero sequence voltage Une. When the regulator is switched from MAN to AUTO mode, it starts searching and performs a tuning test.

Note:

Make sure the regulator is not in simulation mode. If it were, a zero sequence voltage would be simulated. The adjustment commands are not output over the relay contacts in simulation mode. In the below figure, the identification for simulation mode is displayed above the status bar:

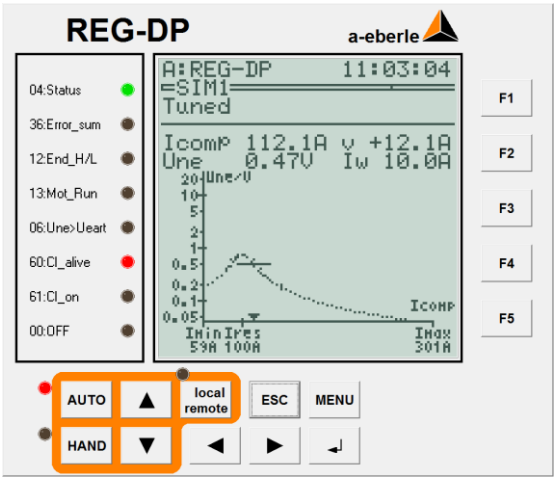


Figure 67: SIM1: Simulation mode 1

10.6 Checking the binary inputs and outputs and the analogue inputs

The conditions of the binary inputs and outputs are tested on the service screen in WinEDC.

This screen is the right-most index card in the WinEDC interface.

The next screen displays an example of the available data. Please note that the service screen displays only data that were supplied by the connected or selected regulator.

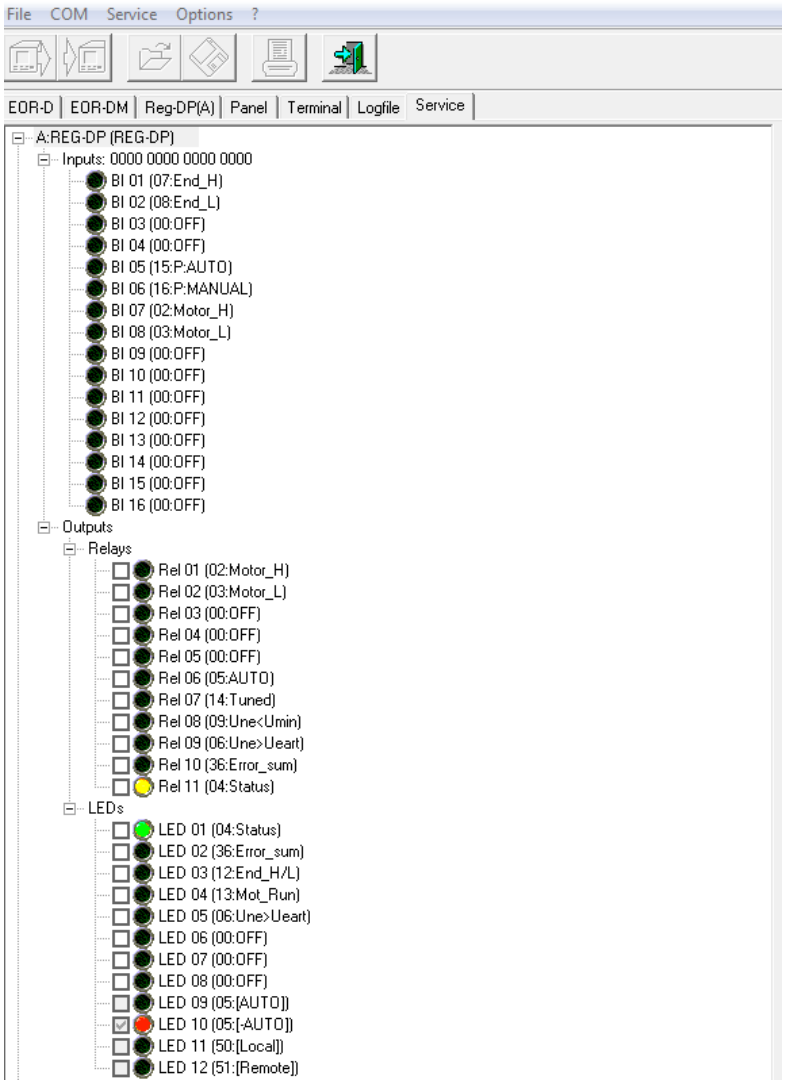


Figure 68: Checking the binary inputs and outputs on the REG-DP/ REG-DPA on the WinEDC service screen

High level for binary inputs and outputs is displayed with a yellow dot in front of the respective input or output. The colour of the LED on the service screen corresponds to the colour of the LED on the regulator.

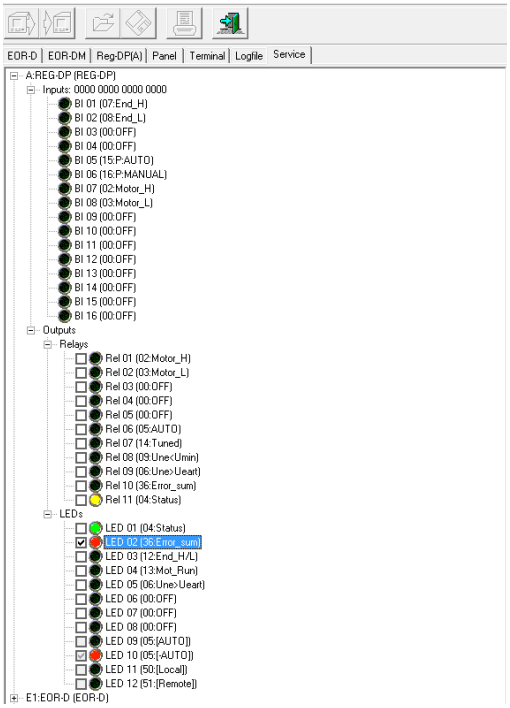


Figure 69: Temporary change of relay output states and LED for test purposes

The states of the individual relay outputs or LEDs can be changed by selecting the checkbox next to the respective output. The temporarily changed states are reset when the service screen is exited.

10.6.1 Checking the analogue measurement inputs

The most important analogue input values are displayed in the column next to the binary inputs and outputs.

Figure 70: Check measured values

10.6.2 Measurement simulation (SCADA system)

Measured values can be changed by selecting 'Override' above the analogue values in the second column. The selected value is adopted by pressing 'Override'. The following example uses 100 A as the Ipos value (coil position in A).

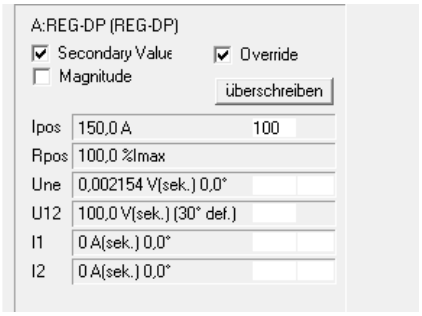
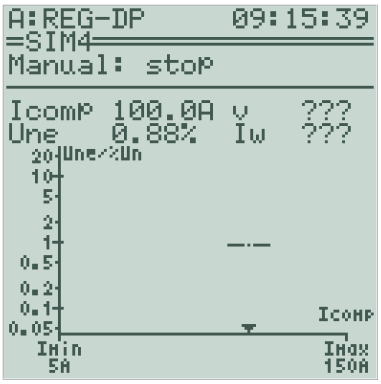


Figure 71: Measurement simulation

It makes sense to test the connection to the **SCADA system** (transfer of measured values). On the regulator, 'SIM4' is displayed below the device ID, and the value for the position selected in this example changes to 100 A.



The system stays in 'Override' mode for 10 minutes and then automatically switches back to its initial state. The function is immediately reset by removing the check from the 'Override' checkbox or exiting the service screen.

The third column in the WinEDC service screen only displays if the current injection feature is enabled.

11. Detailed description of REG-DP/ REG-DPA parameters

All of the parameters are described on the following pages in descending order.

11.1 Menu item General

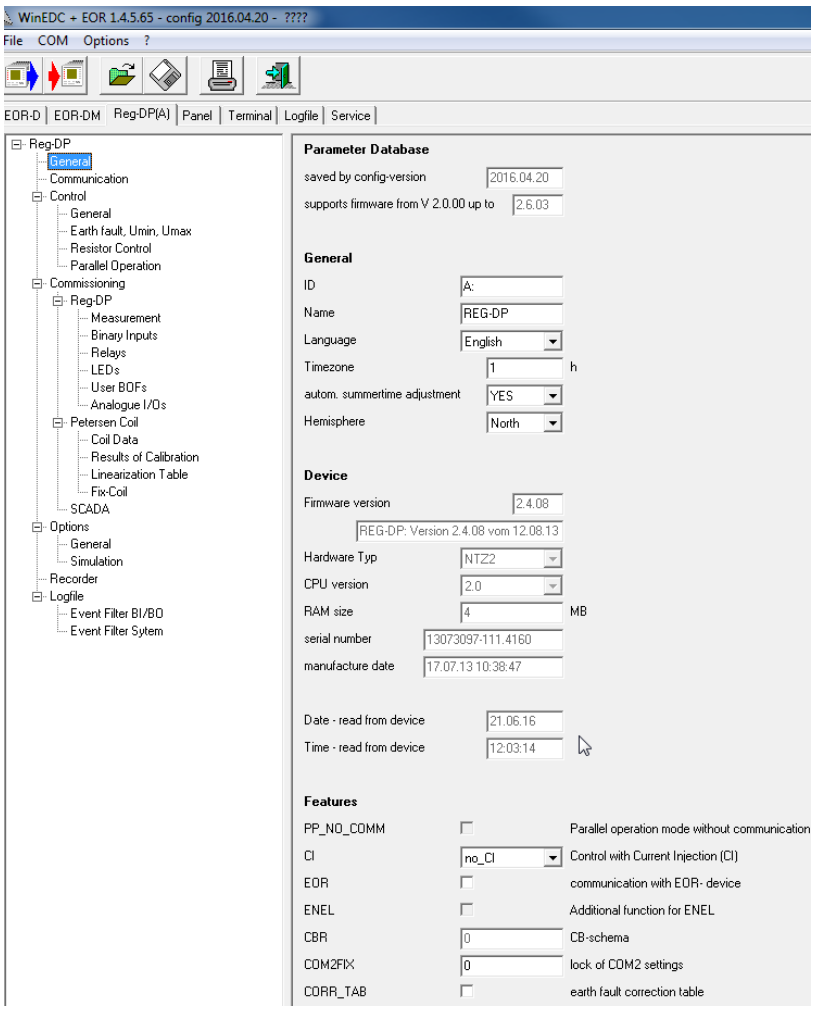


Figure 72: Menu item General in WinEDC

11.1.1 Parameter database

- Saved with config version:

This refers to the config.mdb that is stored in the same directory as the WinEDC.exe files. It is used to change the structure of the parameterization menu when more parameters are selected under the menu item 'Features'.

It defines all of the parameters used to parameterize the REG-DP/ REG-DPA.

- Supports firmware version from 2.0.00 to 2.5.xx

Describes the REG-DP/ REG-DPA firmware versions that are supported by WinEDC.

If the current configuration does not support the selected REG-DP/ REG-DPA firmware, please download and install the latest configuration file from the A.Eberle webpage.

11.1.2 General

- Identification:

Address (ID) of the regulator on the bus (E-LAN). Every regulator must have its own ID.

A total of 255 addresses are possible. You can use the letters A to Z and the digits 0 to 9 for the address.

Each address must start with a letter and may not contain more than 2 characters. The end of an ID is always followed by a colon (:).

Examples: A: …. Z:; A0: … A9:; B0: … B9:; …Z0: … Z4:

Note: A0 → A:

- Name:

The name of the regulator: The name may not contain more than 8 characters. Do not use special characters because the name you choose is automatically used for the name of the logbook and error logs.

- Language:

Select the language to be displayed on the regulator's screen.

The following languages are currently available:

  - German
  - English
  - Italian
  - French
  - Czech
  - Spanish
  - Russian
  - Polish

- Finnish

- Time zone:

The time zone used to set the device to Greenwich Meantime.

- Autom daylight savings time:

Options: YES (default)
NO

- Hemisphere:

Selection options: NORTH (default)
SOUTH

11.1.3 Device

- Firmware version:
  Displays the firmware version that is currently installed on the regulator. The value in this field cannot be changed and is populated when the regulator is accessed for the first time.
- Hardware type:
  Display only field. Shows the acronym for the hardware used.
- CPU version
  Several CPU versions are in use. In our example, version 2.0 is used.
- RAM size
  Available RAM for the REG-DP/ REG-DPA's firmware
- Serial number
  The serial number on the device The serial number enables the year of manufacture and the type of the device to be determined if it is sent in for service.
- Date of manufacture
  Month and year in which the device was manufactured
- Date – read from the device:
  Parameterization date. Shows the date on which the parameters were read out of the regulator.
- Time – read from the device:
  The time at which the parameters were last read by the regulator.

11.1.4 Features

Features and special functions enhance the standard functionality and can only be enabled from the terminal screen in WinEDC. An exception is the CI feature, which can be enabled at anytime by selecting it.

When enabling a feature, make sure that the regulator on which the feature is to be enabled is directly connected to the PC through COM1 port. Features cannot be enabled through the E-LAN.

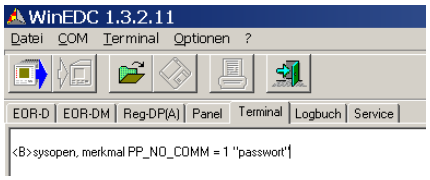
Selecting a specific feature changes the structure of the Parameter screen in WinEDC.

In the following example, the command that is entered in the terminal screen is italicized.

- PP_NO_COMM:
  Setting this parameter enables a system with several P-coils and regulators to communicate without E-LAN.

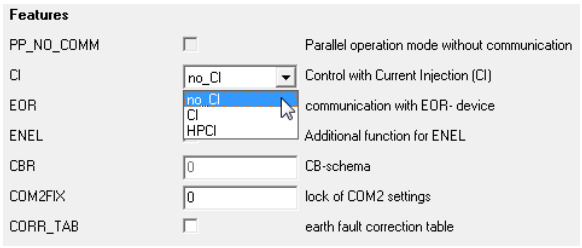
  This function is charged separately and can be enabled upon delivery or at a later stage.

  If this feature is not enabled at the factory, the following must be entered in the terminal screen:



  Please ask A. Eberle's head office for the password.

- CI (current injection)



  - Current injection This feature requires additional hardware (current injection cabinet).
  - HPCI: High Power Current Injection. This feature can also be enabled without password. The HPCI is a separate piece of hardware (control cabinet).

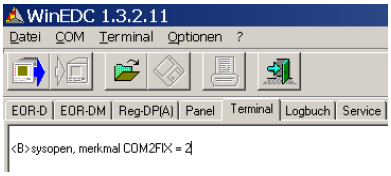
- EOR:
  Is only used in EDC-Sys devices. This function is not necessary when the REG-DP/ REG-DPA is used on its own. No password protection

- ENEL:
  This function/feature is only used with the EDC-Sys and is not necessary when the REG-DP/ REG-DPA is used on its own. No password protection

- CBR:
  This is a special feature. It is used in grids in which damping resistors (NER) and residual-current-increase resistors (Rw) are to be controlled and displayed. This is a special feature.

- COM2FIX:
  This parameter is used to fix the interface speed of the REG-DP/ REG-DPA's COM2 port

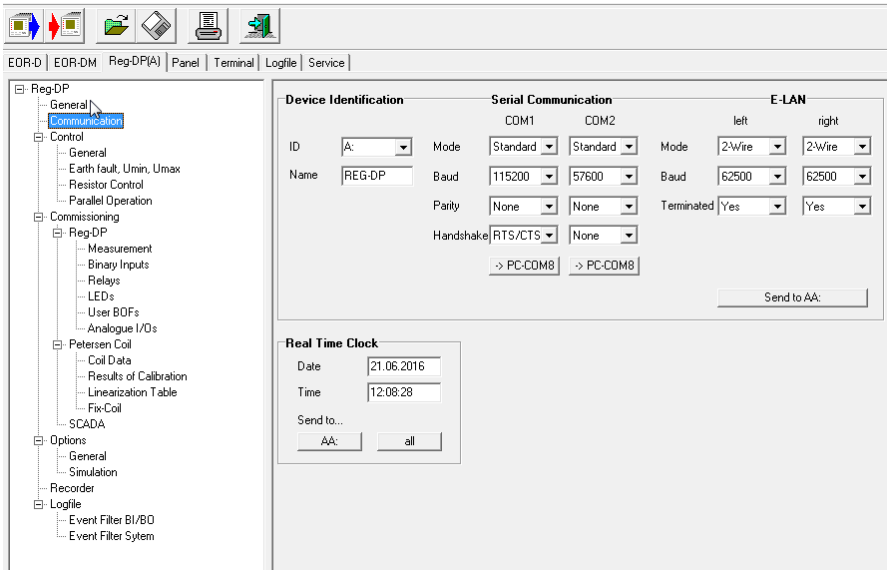
to a specific value. It is used when the COM2 port is connected to a protocol card. The COM2 setting may never be changed again. To prevent unwanted changes, please enter the following:



- CORR_TAB
  This table is used to correct the coil position when an earth fault occurs. The correction table (CORR_TAB) for four possible feeders is displayed in the menu item 'Earth fault, Umin, Umax'.

11.2 Menu item Communication

Clicking 'Communication' in the menu tree displays the index card on which all of the interface parameters are set.



11.2.1 Device identification

- Identification:
  Description see 'General' card
- Name:
  Description see 'General' card

11.2.2 Serial interfaces

- COM1 and COM2:

- Mode:
  Options:
  - OFF: Serial interface is disabled
  - ECL: Serial interface works according to the standard E-LAN communication procedure.
  - DCF77: Serial interface is prepared to receive DCF 77 synchronization signals
- Baud:
  The following transfer rates in bits/seconds are available:
  - 1200
  - 2400
  - 4800
  - 9600
  - 19200
  - 38400
  - 57600
  - 76800
  - 115200 (default setting)
- Parity:
  Options
  - Off (default setting)
  - Odd
  - Even
- Handshake:
  Options
  - None
  - Xon/Xoff
  - RTS/CTS (default setting)
- PC → COMx:

By clicking this button, the parameters that are set for the COM1 or COM2 interface are also used for the COM interface on the PC. This is the best way of ensuring that the interface parameters on the PC are the same as on the regulator.

11.2.3 E-LAN:

- Mode:
  There are two modes:
  - 2-wire

- Four-wire

A 2-wire connection is sufficient for short connections (within a substation, 20 m).

A 4-wire connection is recommended for longer distances. In this case, the right E-LAN, for example, is used as input for the signal. The left E-LAN sends the signal through a 4-wire connection to the next device that is to be connected to the E-LAN. This wiring enables the regulator to function as a repeater. Distances of up to 1.3 km can be bridged.

- Baud:
  The transfer rate can be set for each segment. Meaningful speeds are:
  - 62 500
  - 125 000
- Terminated:
  If a regulator is at the beginning or end of a bus segment, the bus must be closed/terminated at that point with a resistor (wave impedance). The required resistors are already in the regulator and are switched on and off through a relay.
  All of the bus segments have to be terminated for 4-wire connections. For 2-wire connections, termination depends on the bus structure: select YES (for closed/terminated) or NO (for not closed/not terminated).

11.2.4 <Send to AA:>

Click the button to transfer the parameters. AA: Sends the parameters to the connected device.

11.2.5 E-LAN (bus connection between several devices)

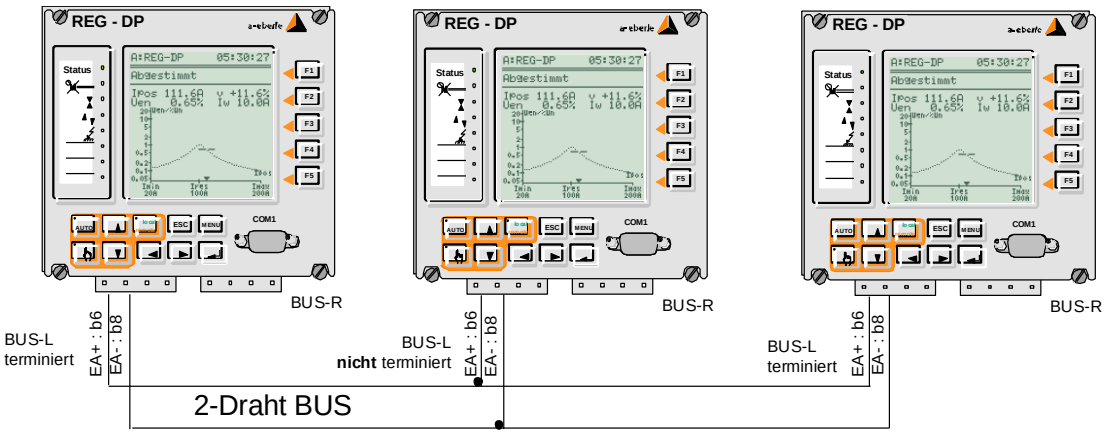
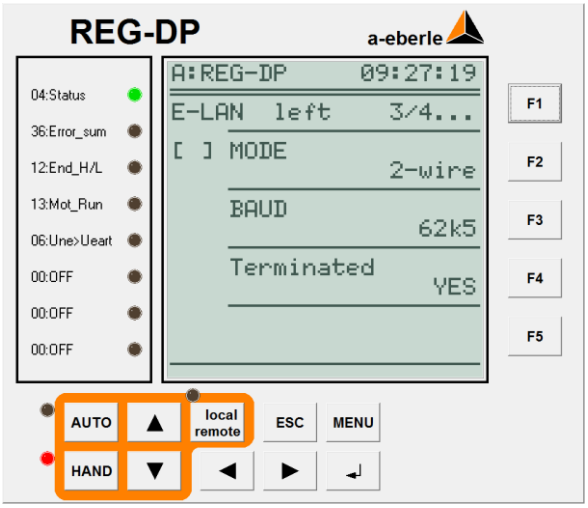


Figure 73: Networking with E-LAN: 2-wire bus

The above figure shows the most commonly used networking configuration. It is important that the bus on both devices is terminated at the beginning and the end of the network. The 'Terminated' parameter should be set to NO for all of the devices in-between.



Each regulator has two full E-LAN interfaces.

ELAN LEFT refers to the settings for the left bus

(female multipoint connector 6, terminals b6, b8, b10 and b12 see page 22).

ELAN RIGHT refers to the settings for the right bus.

(female multipoint connector 6, terminals z6, z8, z10 and z12 see page 22).

Each of these interfaces works with a 2-wire line or 4-wire transmission technology (RS-485).

Female multipoint connector 6				
Bus-L Terminals	**Bus-R Terminals**	**Function**	**2-wire**	**Four-wire**
b6	z6	EA +	'Input +' and 'Output +'	'Output +'
b8	z8	EA -	'Input -' and 'Output -'	'Output -'
b10	z10	E+	No function	'Input +'
b12	z12	E -	No function	'Input -'

A 2-wire cable is usually chosen because it's the only one that enables a bus configuration - with several participants on the same bus cable. The integrated terminating resistor must be switched on for the **first** and the **last** participant on the bus cable (option: **'Terminated'**). All other bus participants must be set to 'Not terminated'.

The bus cannot function properly without terminating resistor because of the reflection at each end of the wire.

Transmission distances > 1000 m or the use of a booster require 4-wire transmission technology. The required terminating resistors are automatically enabled (you do not have to check the '**Terminated**' option).

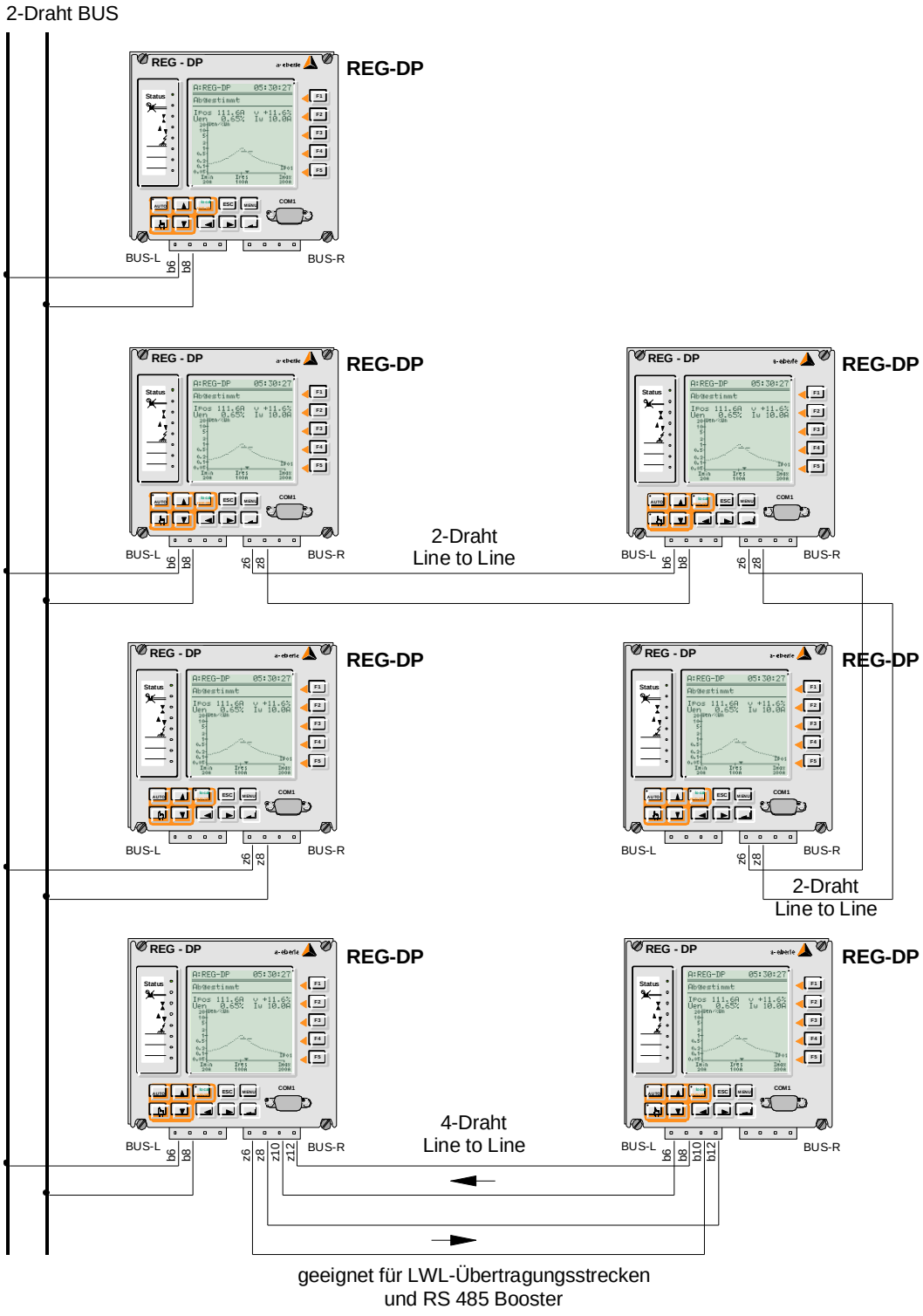
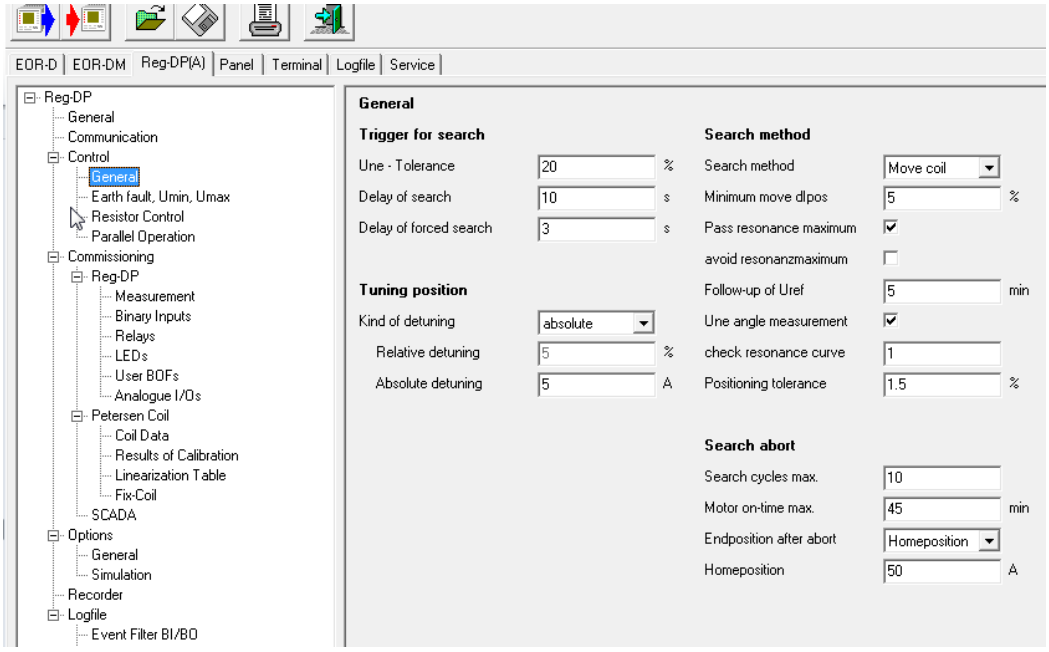


Figure 74: Networking options with E-LAN

11.3 Menu item Regulation

11.3.1 General



11.3.1.1 Trigger threshold

Once the tuning process has been successfully completed, the zero sequence voltage is saved with absolute value and phase (Figure 75: with Une_ref/Usync displayed).

If the absolute value and/or phase changes by a value that is bigger than the specified tolerance as a result of grid switching, the REG-DP/ REG-DPA will start a new search process.

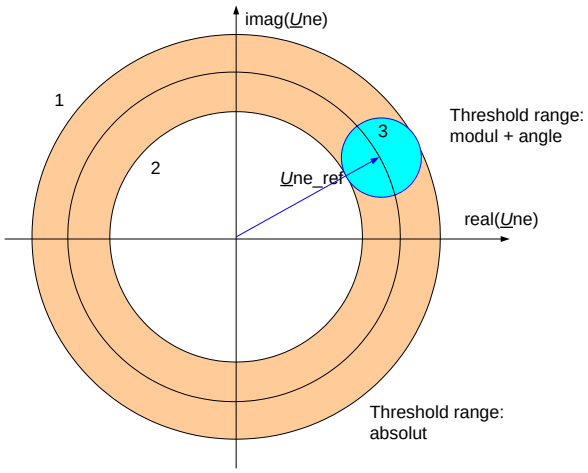


Figure 75: Tolerance range that triggers a tuning process

If the voltage remains within the trip circuit (3), tuning is not initiated.

The circuit is defined as a relative value of the last saved zero sequence voltage.

- Une tolerance:

A value of 20% (default value) means that a search process is started when the zero sequence voltage is outside of the set tolerance range of (Uref * 0.8) to (Uref * 1.2) for longer than the set search delay.

Evaluation of the absolute value of the zero sequence voltage A search process is started when the zero sequence voltage is either outside the biggest circuit (1) or inside the smallest circuit (2) during the total delay time after the grid switches.

Evaluation of the absolute value and angle of the zero sequence voltage A search process is started when the zero sequence voltage is outside the circuit (3) during the total delay time after the grid switches.

- **Evaluating the absolute value and angle reveals that considerably more grid switches were performed.**
- **The parameter 'Une angle measurement' must be enabled and the Usync voltage (reference voltage) must be connected.**

- Delay search by: x s

The zero sequence voltage must be outside the tolerance range during the delay in order for a search to start. If the zero sequence voltage returns to the tolerance range before the end of the delay, the counter is reset to its maximum predefined time. During the delay time, the time remaining until the search starts is displayed in the status bar.

Note:

The default value is between 2 and 3 minutes (120 to 180 s) so that grid switches can be completed before a new search process starts.

The factory setting is 10 s to reduce the waiting times during commissioning.

Default setting: 180 s

- Forced search delay: x s

A shorter response time can be set for changes that do not have to take the history of the grid's state into account, for example, switching from manual to automatic on site or through the SCADA system.

Default setting: 5 s

11.3.1.2 Tuning point

- Target tuning type

This parameter determines **how** tuning is determined

Parameters	Description
%	The percent value relates to the resonance current I_{res}. (Warning: It is possible to exceed the self-extinguishing current limit on large grids!)
A	Detuning always has the same absolute value regardless of I_{res}.

- Target detuning:

The detuning quantity is set in this menu.

- **Positive values** stand for overcompensation (the P-coil supplies more current when an earth fault occurs than the grid's capacitances => overcompensation)
- **Negative values** stand for undercompensation.
- A value of **zero** stands for resonance tuning. Default setting: +5 A

11.3.1.3 Search method

- Search method

The 'Move coil' method is always selected when working without current injection.

When current injection is used, it is not necessary to move the coil to determine the tuning point. The optional current injection feature calculates the resonance point. If necessary, the regulator then positions the coil in the determined tuning point.

- Minimum adjustment dIpos:

In order to estimate the resonance curve, the P-coil must undergo a minimum adjustment in order to obtain sufficient reference points for the calculation.

Default setting: 5%

The value relates to the P-coil's upper end value I_{max} in A.

dIpos in A = x(%) * I_{max}

- Exceed resonance peak:

The exact calculation of the resonance curve can only be determined by exceeding the resonance point. If the resonance point is not exceeded, the 2P method will only be able to estimate the value of the resonance current. But if the resonance point is exceeded, the active current and the voltage in the grid's resonance point will be determined by the considerably more accurate 3P method.

Parameters	Description
YES	Resonance peak must be exceeded
NO	Resonance peak must not be exceeded

- Avoid resonance peak

The coil is started in the opposite direction and reversed if necessary so the system can search on the falling edge (away from the resonance point).

After the first estimate has been determined on the falling edge, the direction is changed and a new, normal search started in the direction of the resonance curve.

The parameter 'Exceed resonance peak' is usually disabled,

meaning that the resonance point is not exceeded unless it has to be for tuning. The coil is positioned in the determined tuning point after the first estimate has been completed.

Note:

This setting makes sense if the grid conditions are very unbalanced, meaning that there are very high zero sequence voltages at the resonance point. This occurs frequently on compensated 110 kV overhead transmission grids.

- Adaptation of Uref:

Grid switches are always relatively fast and over within a few minutes. In contrast, changes due to weather and crosstalk from load current changes are usually very slow. The number of searches can be reduced when the tolerance for slow changes is adjusted. If the zero sequence voltage does not leave the tolerance field during the set time, the current zero sequence voltage will be adopted as the new reference voltage at the end of this observation period. The size of the tolerance range does not change.

Default setting: 5 min **(0 = inactive)**

Note:

Values smaller than 1 min are **invalid**. This function does not help with fast zero sequence voltage changes. (often in cable networks)

- Une angle measurement

Parameters	Description
YES	An angle measurement is performed when the synchronization voltage is connected. It essentially impacts the tolerance range and the number of identified grid switches.
NO	The angle measurement is supressed. The tolerance range only consists of the absolute value of the zero sequence voltage.

- Check resonance curve:

If the regulator displays 'Tune' and this parameter is set, a tolerance threshold is placed around the determined resonance curve. If the measured value leaves this tolerance range (due to switching), the search is aborted and a new search started.

In this case, the 'Forced search delay' is used as delay time (see section 11.3.1.1.)

Check resonance curve (factor) * Une tolerance

Ex.: 1*20% = 20 %

Note:

It can make sense to disable this function for very small zero sequence voltages (value < 0.5%).

Default setting: 1 (0 = inactive)

- Positioning tolerance:

This parameter is used to set the tolerance for the positioning of the P-coil. The percent value is related to the P-coil's Imax.

Note:

When the coil backlash or the overrun is too big, increasing this value will prevent oscillations during positioning.

Default setting: 1.5% (0 = inactive)

Positioning tolerance in A = x (%)* I_{max}

11.3.1.4 Cancelling the search

- Max search cycles

This parameter describes the maximum number of consecutive search cycles. If the regulator cannot find a valid resonance curve within the set search cycles, the REG-DP places the P-coil in a standby position. The type of standby position is set in the parameter **'End position on cancel'**.

A search cycle consists of the following regulator functions:

Starting the search, calculating the resonance curve, moving towards the end position and comparing the reached position with the calculated position.

If the zero sequence voltage in the end position does not correspond to the calculated value or a curve could not be determined for other reasons, the cycle is considered to have completed unsuccessfully and a new search cycle is started.

Default setting: 10

Note:

With current injection, a repositioning search will consist of at least two search cycles. This means that the default setting of 10 **should not be decreased** in combination with current injection.

- Motor runtime max:

In addition to monitoring the maximum number of cycles, the motor runtime is summed. The counter is incremented as soon as the coil is moved. The regulator is in the Tuned state, this counter is reset to a maximum of zero.

This triggers additional monitoring to ensure the coil doesn't move too often. For a coil runtime of ca. 5 min, an error message is displayed after about 10 full cycles if the regulator still hasn't reached a tuned state.

Default setting: 45 min

- End position on cancel:

If the number of search cycles or the specified motor runtime is exceeded, the P-coil is adjusted to a predefined value. There are two options:

Parameters	Description
Standby position	The P-coil is adjusted to a defined A value, which is set in the below parameter.
TuningP	The P-coil is adjusted **to the last valid tuning point**.

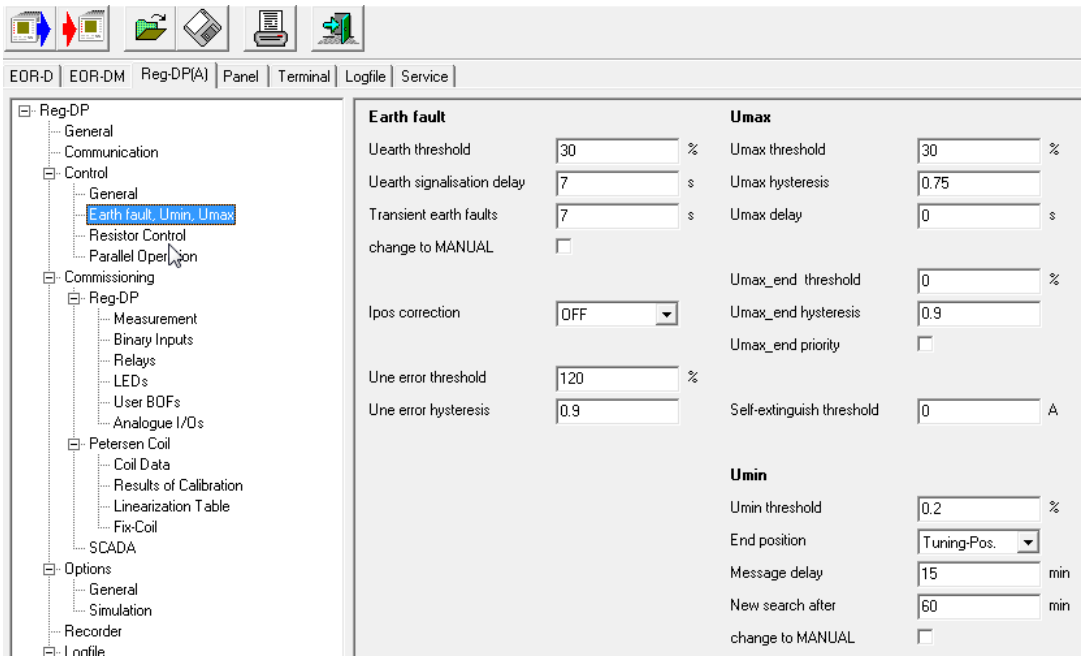
Default setting: Standby position

- Standby position:

If the parameter **End position on cancel** is set to Standby position, enter the corresponding value here. You should choose a value that corresponds to the desired tuning point of the grid's most frequent switching state.

Default setting: 50 A

11.3.2 Earth fault, Umin, Umax



Four parameters determine the regulator's behaviour when an earth fault occurs.

Regulation always stops when an earth fault occurs because the same zero sequence voltage would be measured across the coil's whole adjustment range making regulation impossible. It is also not certain whether older coils can be moved when an earth fault occurs because the drive unit is not always equipped to overcome the high magnetic forces.

11.3.2.1 Earth fault

- Uerd threshold

If the set threshold is exceeded, the coil movements and the current injection (if used) are suppressed. This value relates to the nominal value of the coil's nominal voltage.

Default setting: 30%

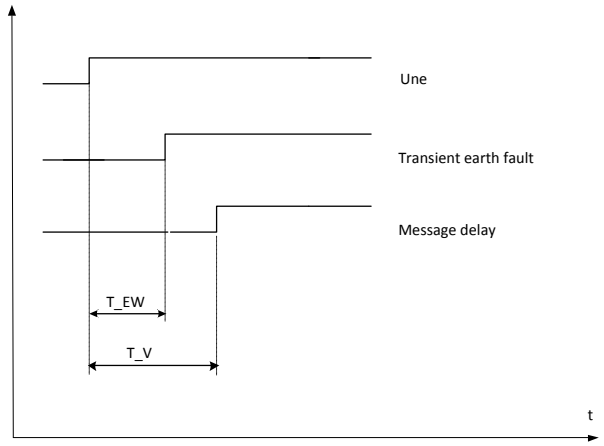
- Uerd message delay:

Transient earth fault

An earth fault is identified when the absolute value of the zero sequence voltage Une is higher than the threshold value set for Uerd. The below figure displays the time behaviour for the regulator.

The earth fault generates two types of messages:

- The immediate earth fault message
  This message is displayed as soon as the earth fault has been identified.
- The delayed earth fault message.
  This message is displayed after the set delay time. The earth fault must also occur during the whole delay time.



$T_{\_EW}$ Transient earth fault time

$T_{\_V}$ Uerd message delay

Figure 76: Time behaviour of the earth fault

In terms of the duration of the earth fault the following applies:

- $t_{erd} < T_{EW}$

  If the regulator was tuned when the earth fault occurred and the zero sequence voltage returned to its initial value within the transient earth fault time, it is assumed that the P-coil successfully extinguished the arc. This probably happened without adjusting the P-coil and without switching off the line sections. The P-coil does not have to be readjusted.

- $t_{erd} > T_{EW}$

  If the earth fault lasts longer than the transient earth fault time, it might be necessary to switch off the lines in order to solve the earth fault. To ensure that the P-coil is set to the right value, a search is started even if the zero sequence voltage has returned to its initial value.

If the regulator is searching for a new resonance point when the earth fault occurs, the search is immediately aborted. A new search process is always started at the end of an - earth fault even if the earth fault time is smaller than the set transient earth fault time T_{EW}.

Default settings: **T_V = 7s**

T_{EW} = 7s

- Locking

The above describes how the regulator automatically starts a new tuning process at the end of the delay time set for an earth fault. This can be suppressed with locking. If locking is enabled, the regulator switches to MAN mode after the transient earth fault time and must be switched back to AUTO mode either manually, through the SCADA system or onsite.

Locking can prevent the P-coil from being automatically adjusted if grid components have to be switched or deactivated during lengthy earth fault searches.

Default setting: OFF:

- Ipos correction

To further minimize the current across the faulty section, the REG-DP resonance regulator can adjust the P-coil when an earth fault occurs.

The switching states of up to four big lines and their capacitive current can be taken into account. A binary input tells the REG-DP/ REG-DPA whether the line is switched ON or OFF.

The below table shows the list of options for the regulator's behaviour:

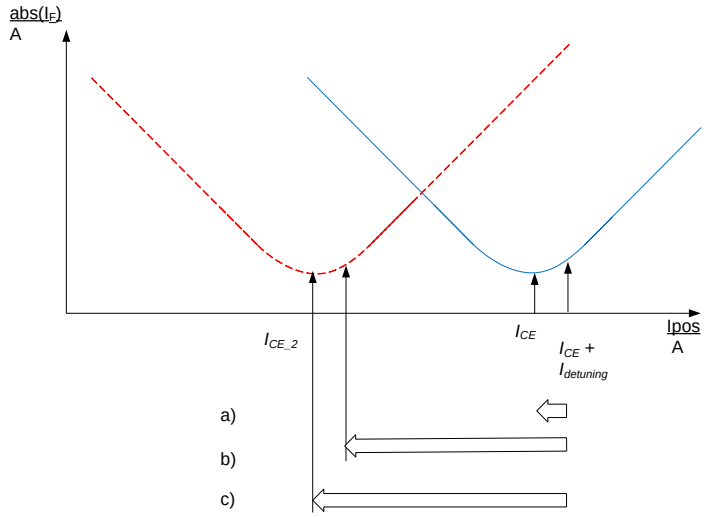
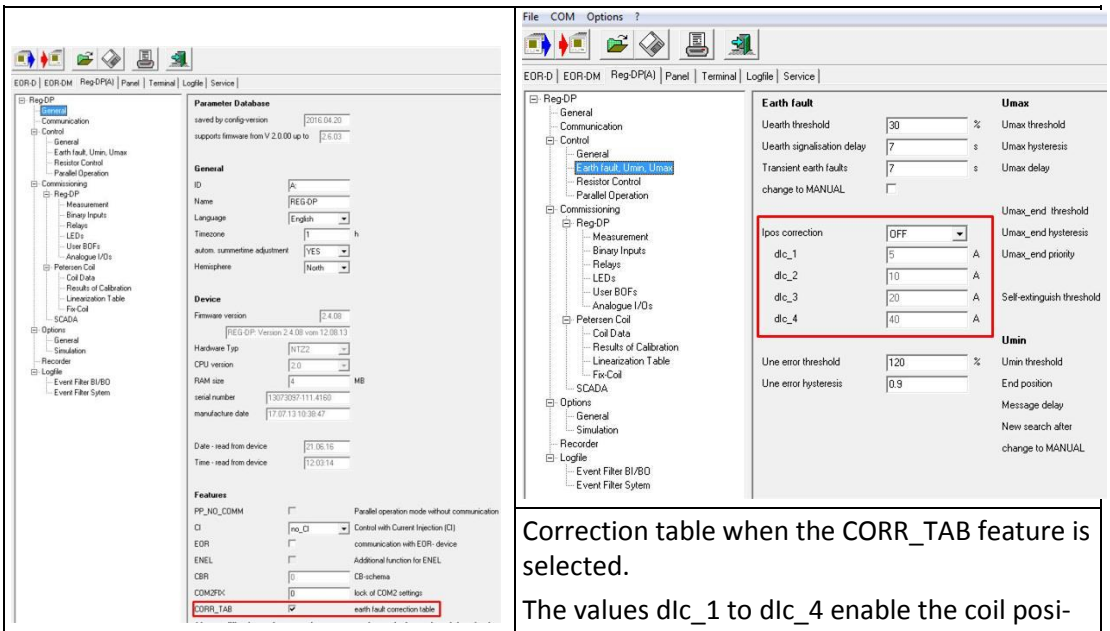


Figure 77: Ipos in the event of an earth fault based on the selected correction method

Parameters	Description	Examples in Figure 77:
None	The coil position is not readjusted when an earth fault occurs.	
Ires	Readjust to the resonance point. At the end of the transient earth fault time, the P-coil is adjusted to the last calculated resonance point.	a)
Tuning+Correction	Readjust by a set value At the end of the transient earth fault time, the P-coil is readjusted by a set value. The determination of the correction value is described further down.	b)
Ires+Correction	Combination of Ires and correction. The coil is adjusted to the resonance point and the current correction.	c)

The correction table is displayed when the CORR_TAB feature is selected in the 'General' menu.



Correction table when the CORR_TAB feature is selected.

The values dIc_1 to dIc_4 enable the coil position to be corrected for 4 lines when an earth fault occurs.

The states of the binary inputs must be allocated to the switch information of the feeders.

The value for the corresponding binary input could be, for example, Ear_Corr1 for the feeder for dIc_1.

If lines are not switched off to detect faults, 'I_{res}' can be selected. In this case, the P-coil is adjusted to the last calculated resonance point.

If, on the other hand, switch-offs or switches to other grids are performed to isolate the earth fault, the current coil position must be corrected by the absolute value of the switch-off or switch.

If this option is enabled, the switching state of the binary inputs during the last search for the resonance point are taken into account. A change in the binary inputs is also detected during the earth fault and the P-coil readjusted to the requirements. In a healthy grid, a change in the binary inputs will always start a tuning process.

Example:

Value set in the menu:

Line 1: + 80 A

Line 2: + 40 A

Type of readjustment: Tuning+Correction

Current value of the regulator:

I_{res} = 200 A

I_{pos} = 220 A (10% overcompensation)

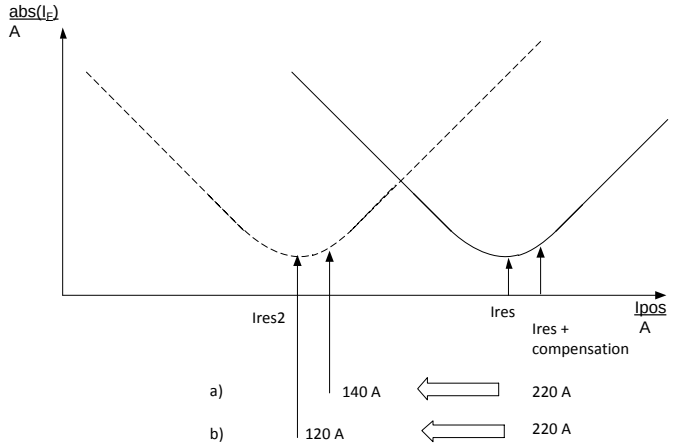


Figure 78: Current across the faulty section

If Line 1 with a capacitive current of 80 A is switched off to isolate the earth fault (Figure 78: Case a), the regulator is notified through a digital input. The switch-off corresponds to shifting the fault current curve to the left. The regulator responds by correcting the current coil position by -80 A. The P-coil is adjusted to a value of 220 A - 80 A = 140 A.

If Line 2 is also switched-off, another correction by -40 A to 100 A is performed.

- Une error threshold

If the zero sequence voltage Une exceeds this limit value, the output function BOF '40:Une_???' is set.

- Une error hysteresis

Factor for the limit value for the Une error threshold.

The output function is not reset until Une < *Une error threshold * Une error hysteresis*.

11.3.2.2 Umax

Note:

The Umax function limits the zero sequence voltage on very unbalanced grids (overhead power lines; 110 kV overhead power grids with compensation) in a healthy state.

Note:

The description applies to firmware > v 2.4.00

- Umax threshold

The below figure displays the limit value for Uerd_Threshold, Umax_Threshold, Umax_End, Umin_Threshold and the self-extinguishing current limit. The threshold Uo_erd was discussed in Chapter 11.3.2.1 under Uerd threshold.

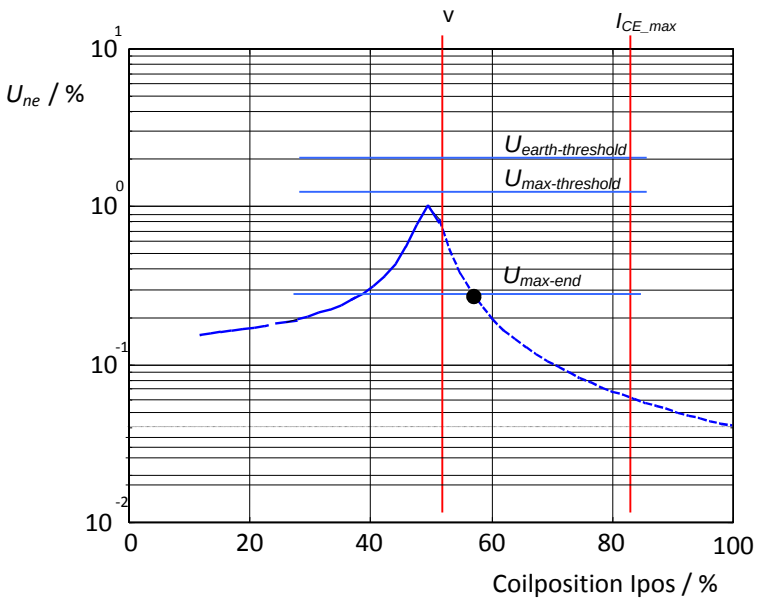


Figure 79: Overview of Umax limit values

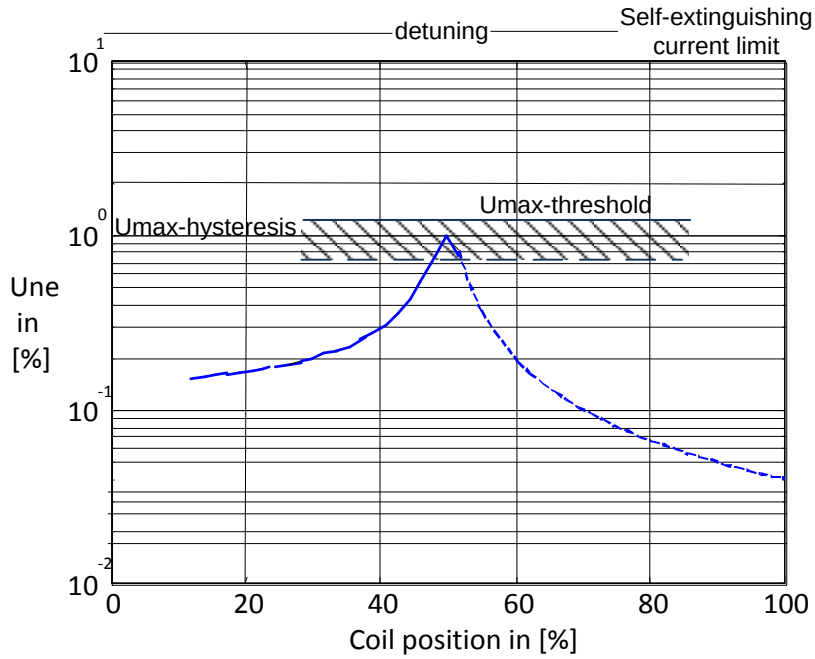


Figure 80: Umax and Umax_Hysteresis

- Umax_Threshold

The regulator is allowed to perform a tuning process as long as the absolute value of the zero sequence voltage $\underline{U}_{ne}$ is smaller than the set threshold. This limit value may not be exceeded during the search. If this threshold value is exceeded during the search, the P-coil will be immediately retracted in order to leave the $\underline{U}_{ne} > U_{max}$ zone. This adjustment takes a hysteresis of 25% into account.

Note:

If Une > Umax but smaller than Uerd at the beginning of the search, the regulator will move the coil until it reaches Une< Umax_Hysteresis*Umax_Threshold. The search process starts as soon as the condition has been met.

A value of 0% disables the Umax function. The function is also disabled if Umax = Uerd.

Default setting: 30%

- Umax_Hysteresis

A normal search is performed when Une<Umax Hysteresis * Umax_Threshold. The regulator moves the coil until the value has been exceeded.

- Umax delay

Delay until the Umax_Threshold parameter kicks in. The parameter does not kick in until this time has elapsed and the limit value has been exceeded.

Default setting: 0 s

Note:

The parameters Umax_Threshold, Umax_Delay and Umax_Hysteresis apply to search processes performed in AUTO mode.

Note:

The parameters Umax_End_Threshold, Umax_End_Priority and Umax_Hysteresis apply to tuning performed in AUTO mode. The regulator displays 'Tune'.

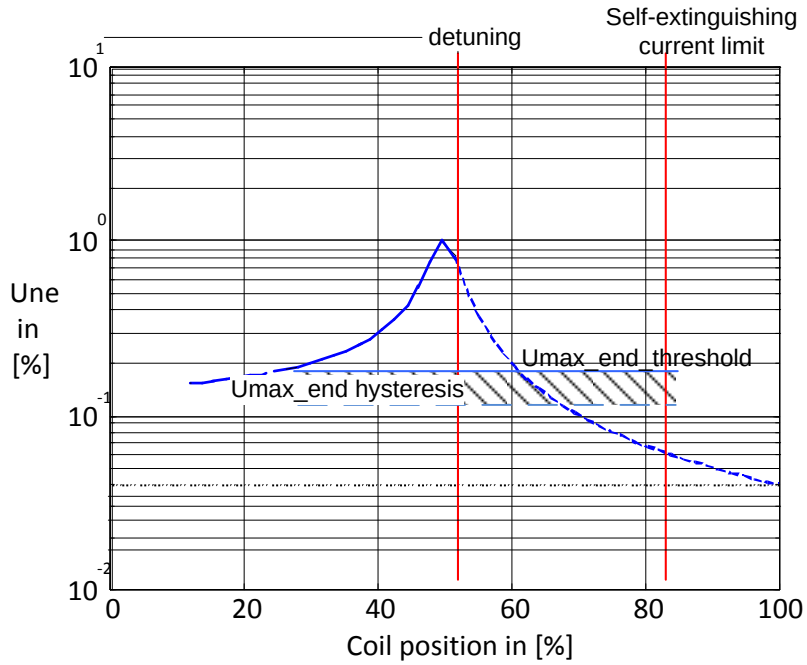


Figure 81: Umax_End and self-extinguishing current limit; Description

- Umax_End threshold

This value is used to set a maximum zero sequence voltage for the tuning point. If, for example, the zero sequence voltage is too high at the target tuning point, the coil is moved away from the resonance point until the smaller zero sequence voltage in Umax_End has been reached.

This function makes sense in very unbalanced grids with a big zero sequence voltage at the resonance point. Too high zero sequence voltage at the tuned state can overexcite earth fault detection systems. Moreover, a high zero sequence voltage in a healthy grid is an increased continuous load for the insulation of a single phase. In this case, the line-to-earth-voltage must be added to the zero sequence voltage (absolute value and phase). This is why it is possible to have too high voltage for at least one line-to-earth-voltage.

A value of 0% disables the 'Umax_End' function.

Default setting: 0 %

- Umax_End hysteresis

Une < Umax_End hysteresis * Umax_End threshold

During tuning, the coil is moved until this value has been reached for Une (below the Umax_End threshold)

A new search is started when the Umax_End threshold has been exceeded.

This is why a smaller tolerance (compared with the default value Une_Tolerance) can be set for a search trigger.

- Umax_End Priority

Default value: No

If the function is enabled, the value Umax_End must be respected.

Ex.: If the coil is close to the upper end switch, it might not be possible to reach the value of Umax_End threshold with overcompensation (end switch kicks in earlier). In this case, the regulator adjusts the coil in the undercompensation range until the Umax_End threshold condition has been reached.

- Self-extinguishing current limit

Moving the coil to a value lower than Umax_End threshold must be limited.

Detuning could otherwise take on very big values.

A value of 0 A disables the self-extinguishing current limit function

Default setting: 0.0 A

Priority	Limit values
1	Umax
2	Self-extinguishing current limit
3	Umax_End
4	Target detuning (v)

Based on the above priorities, the regulator searches for a tuning point without exceeding theses predefined limit values in the 'tuning position'. If one of the limit values is exceeded in the tuning position, for example, the maximum continuous zero sequence voltage (priority 3), the regulator will search for a new tuning position, whereby the target detuning v can no longer be respected (priority 4).

- Umin_Threshold

Zero sequence voltages that are smaller than this limit value are interpreted as measurement noise. As long as the zero sequence voltage is smaller than the set U_{min} threshold during the search, the P-coil's whole adjustment range is searched for a position at which

the zero sequence voltage is $U_{ne} > U_{min}$. Only then are the measured data accepted for the determination of the resonance curve.

Default setting: 0.2%

Parameter end position (at Umin)

In order to calculate and estimate the resonance curve, at least one measurement point must be bigger than the set Umin threshold. If a valid estimate cannot be made, the P-coil is adjusted to a waiting position based on the parameterization. This waiting position can be:

- Standby position or
- Tuning point
  (resonance point including the compensation that was set by the last calculation)

Default setting: Tuning point

A new search process starts if

- the zero sequence voltage $\underline{U}_{ne}$ leaves the tolerance range or
- the regulator is set to perform a cyclical control of the resonance point.

Parameter Message delay (at Umin)

The message delay parameter sets the delay for the Umin message. If a search is not started within this time, the message '$U_{ne} < U_{min}$' is triggered.

This is frequently caused by the transformer or P-coil being temporarily switched off during grid switching. If the P-coil is not reconnected to the grid after the switch, there will not be enough zero sequence voltage for the regulation and the regulator will display a message.

Default setting: 15 min

Figure 82 shows the combination and description of the above-mentioned parameters.

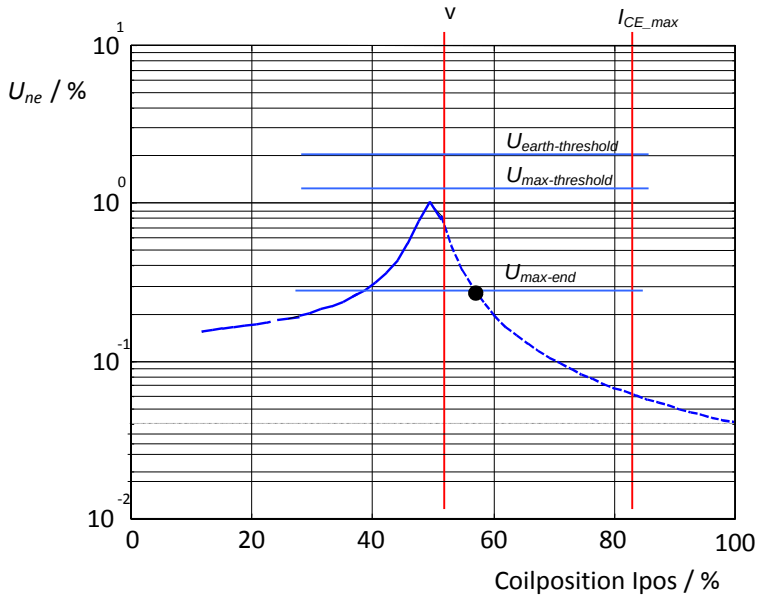


Figure 82: Adjustable limit value for the regulation of the P-Coil

Parameter New search after

If the zero sequence voltage $\underline{U}_{ne}$ stays smaller than the threshold value of Umin during the whole time, a new search for the resonance point will start automatically when this time has lapsed.

On symmetrical cable networks with a big detuning, a switching operation may only achieve a small voltage change. This automatic search ensures that an unidentified switching operation that was performed after this time is correctly tuned.

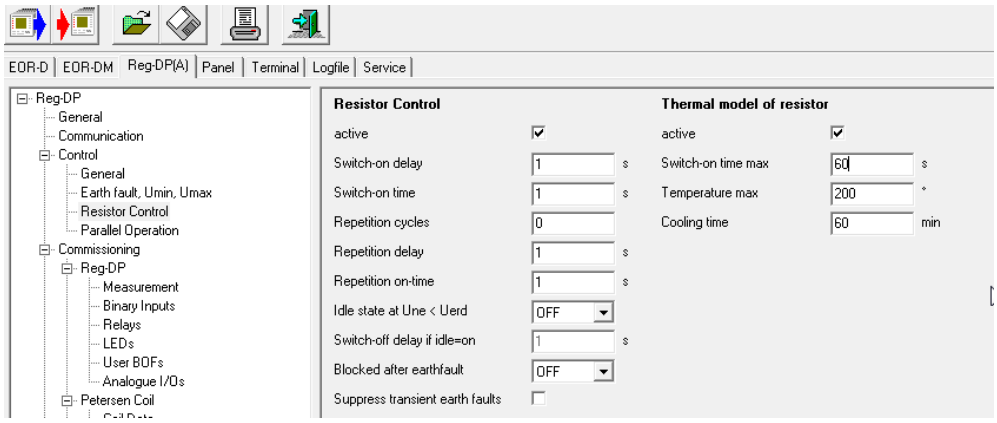
Default setting: 60 min

Parameter Locking (at Umin)

If $\underline{U}_{ne} > U_{min}$ is not found across the P-coil's whole adjustment range, the P-coil is adjusted to the parameterized end position. If locking is enabled, the regulator is switched to MAN and stays in this mode. The regulator must be switched back to AUTO mode either manually or through the SCADA system.

Default setting: OFF:

11.3.3 Resistor control



Note:

Resistor control works independently of regulation.

It is also enabled when the regulator is in ‘Man’ mode.

The response time is limited because the processing speed of the parallel tasks on the regulator is limited. **This function cannot be used for very fast applications (in the 100 ms range).**

The REG-DP/ REG-DPA's resistor control is suitable for KNOSPE applications in the seconds range.

Resistor control has been improved by implementing a thermal replica as a function of the duty cycle and the amount of zero sequence voltage. This protects the resistor from overheating without having to use a temperature sensor.

The additional connections that are available for the REG-DP/ REG-DPA when resistor control is used are described below.

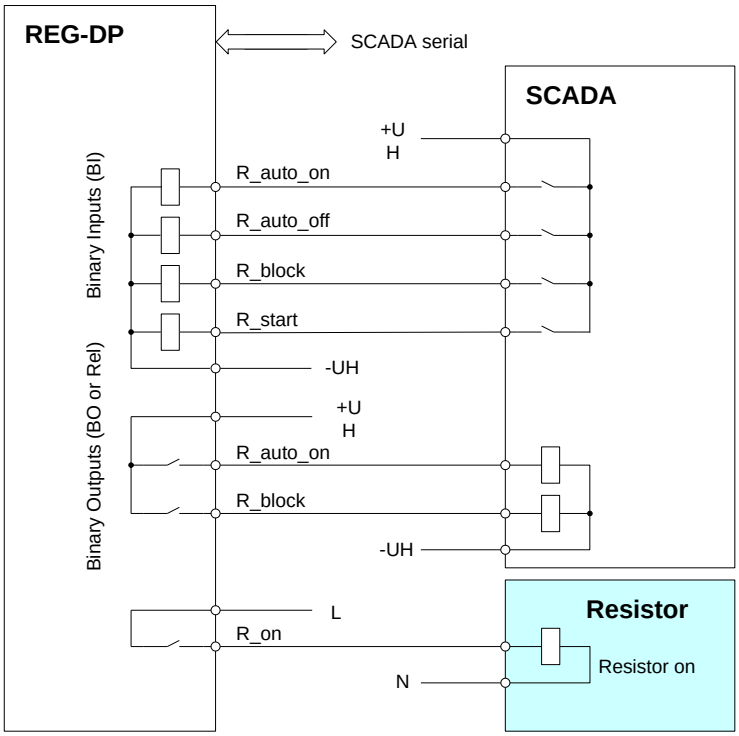


Figure 83: Connection examples when resistor control is used

Note:

Please switch two relay outputs with function R_on in series. This will ensure that the resistor is not switched on for too long and overheats (when a contact is supposed to stay closed).

Functional description

The zero sequence voltage $\underline{U}_{ne}$ that is measured by the regulator is continuously monitored. If the zero sequence voltage exceeds the set Uerd_Threshold when an earth fault occurs, a cycle for the residual current increase is started providing resistor control is enabled. The resistor is connected for the duration of the set switch-on time after the set delay time has lapsed (switch-on delay).

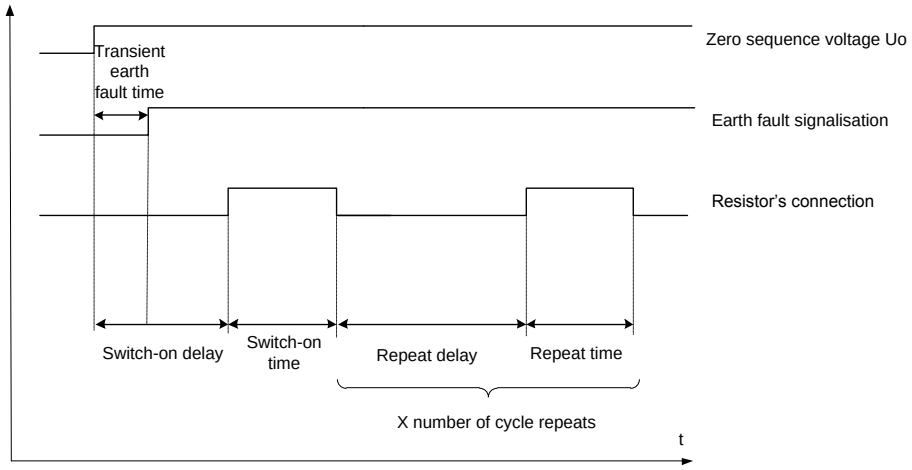


*Figure 84: Time lapse of the resistor control; Standard **without** transient suppression*

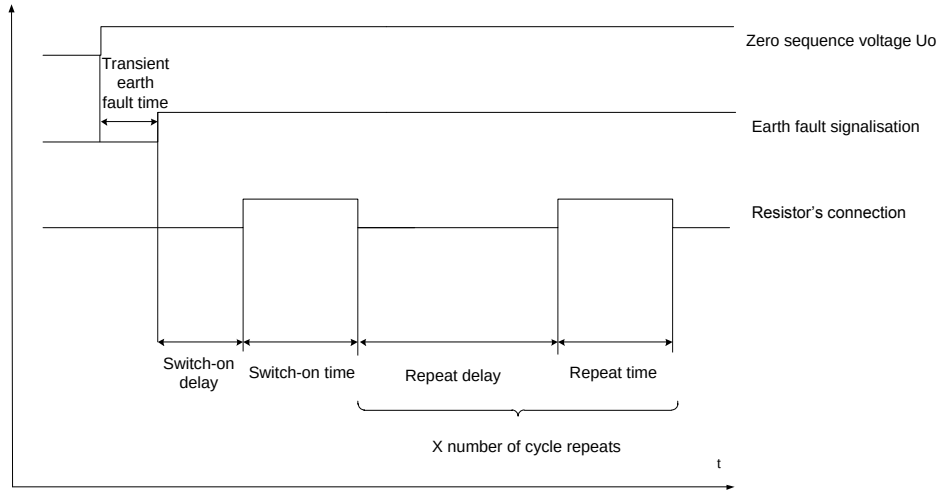


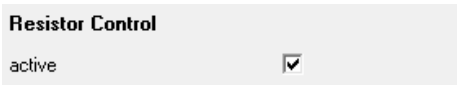
*Figure 85: Time lapse of the resistor control; Standard **with** transient suppression*

The resistor's connection can also be triggered through a binary input or a serial connection to the SCADA system.

Monitoring the resistor's rise in temperature through a thermal model means that the resistor can be tested before it is switched on again to determine whether its limit temperature has been exceeded. If the resistor risks overheating, the REG-DP/ REG-DPA will prevent it from switching on. A full impulse sequence can only be run once the resistor has cooled down sufficiently. The thermal overheating of the resistor is reported.

If the resistor's connection is triggered manually through a binary input or the serial SCADA connection, the connection will be established after the switch-on delay has lapsed. The connection will also be established in the event of manual triggering even if an earth fault did not occur.

- Active



Activates the resistor control and the following settings

Default: Inactive

- Switch-on delay

Time delay to switch the resistor

Default value: 1 s

Note:
The inherent time of the resistor control can be up to 1500 ms.

- Switch-on time

The resistor's duty cycle

Default value: 1 s

Automatic repeat cycle:

The parameter **Repeat cycles** is used to set the number of cycle repeats for the **Repeat delay** and **Repeat time**. If one of the set values is bigger than zero, additional resistor connections will be triggered after the first residual current increase that was automatically triggered by the earth fault.

The thermal replica is also used to check the resistor has switched on again for these cycles.

- Repeat cycles

Number of cycles, how often the resistor should be automatically switched ON and OFF.

Default value: 0 (= inactive)

There are no repeats when this parameter is set to 0.

- Repeat delay

The time delay for the repeats can be set irrespective of the delay for the first cycle.

Default value: 1 s

- Repeat time
- Total time for all repeats. Only active when the parameter Repeat cycles ≠ 0
- Default value: 1 s
- Standby state at Une < Uerd:

Selection options:

Value	Description
OFF:	The resistor is OFF in the grid's normal state
ON	The resistor is ON in the grid's normal state

This function is used in grids in which the resistor is used to dampen the grid in its normal non-faulty state. This is done on very unbalanced grids.

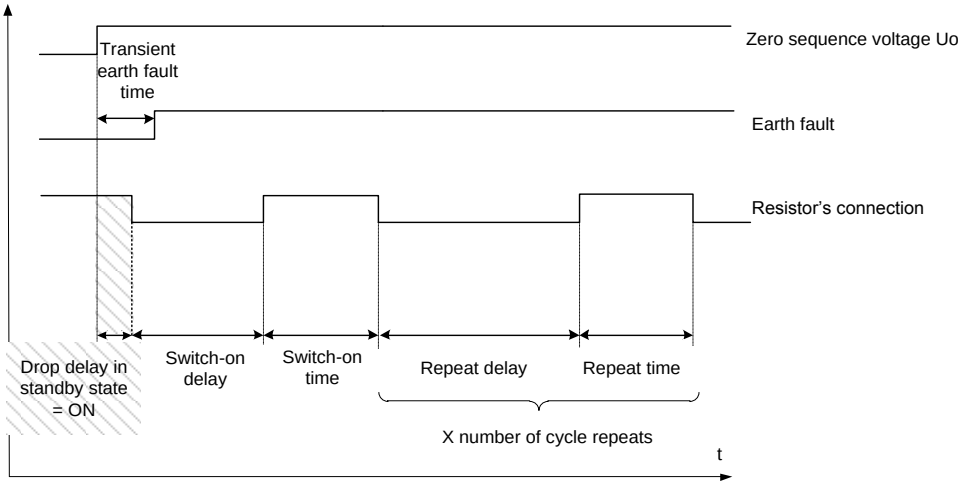


Figure 86: Flow chart for inversed resistor function (standby state ON)

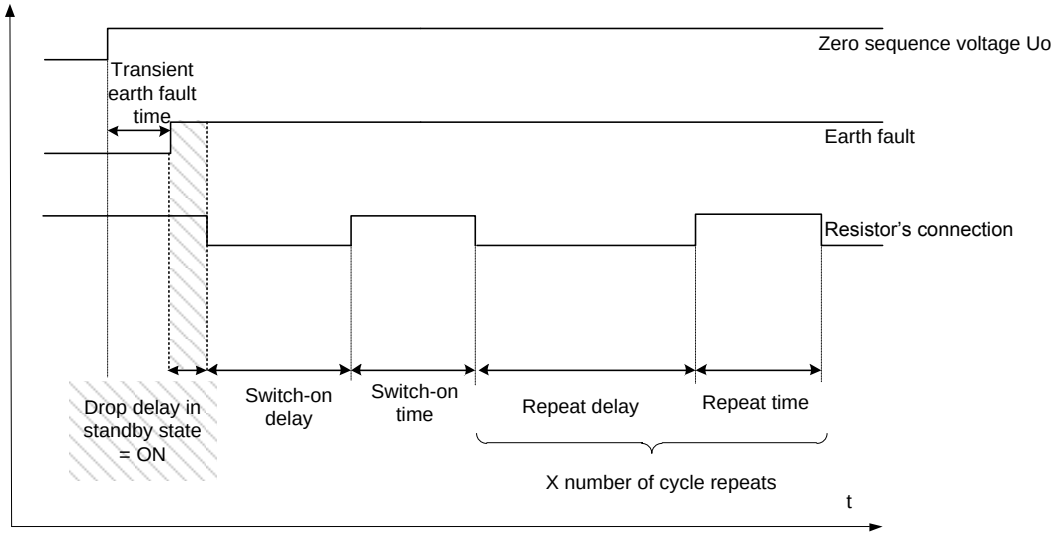


Figure 87: Flow chart for inversed resistor function (standby state ON) and active transient suppression

- Drop delay in standby state = ON

Applies when the previous parameter is set to ON

It defines the time between the identification of the earth fault and the disabling of the resistor. When an earth fault occurs, it reduces the current to the faulty section and increases the chance of extinguishing the arc.

Default setting: 1 s

- Locking:

If locking is active (ON), the resistor is prevented from switching on again after the first automatic residual current increase after the earth fault starts. The resistor control goes into blocking mode. The information about the blocked state can be queried and reported through the BOF R_block.

Locking prevents a resistor from continuously trying to switch on when high impedance or restriking earth faults occur.

The resistor control can be reset to automatic mode through a binary input or a serial connection. The function for the binary input is R_auto_on.

If self-blocking is set to AUTO, the resistor control will be automatically activated for the next earth fault after the cool-down period.

The following settings for the used binary inputs and outputs can be found under the menu item Commissioning.

Locking!

An active block by the Locking parameter is displayed in brackets in the regulator's display.

Ex.: (R:10)

11.3.3.1 Temperature behaviour of the resistor (thermal image)

The thermal model uses the value for Une to estimate the temperature inside the resistor.

On the one hand, this increases the number of possible manual switch-on procedures for the resistor for high impedance earth faults.

On the other hand, it protects the resistor from overheating and blocks the resistor control in the REG-DP/ REG-DPA. The algorithm determines when the resistor has cooled down enough to start another switch-on procedure. This considerably reduces the time to the next possible resistor switch-on time because the resistor is no longer blocked during the whole cool-down period.

- Active

Activates the use of the thermal image.

Default setting: ☑ (active when resistor control is active)

- Max switch-on time

Maximum duty cycle for the resistor at Une = 100% in which it heats up from ca. 40°C to its maximum temperature.

Default setting: 10 s

- Max temperature

A maximum permissible nominal temperature must be set to calculate the resistor's thermal capacity.

Default setting: 200°

- Cool-down time

Time needed to cool down the resistor from its maximum temperature to 40°C. This applies to an ambient temperature of up to 30°C.

Default setting: 60 min

Binary input functions:

Description	Description
R_auto_on	Resistor control on: The resistor control is activated by an impulse
R_auto_off	Resistor control off: The resistor control is deactivated by an impulse
R_auto_onoff	The on-state of the resistor control changes with each impulse on this input line
R_block	The resistor control is blocked
S:BlockT	Simultaneous blocking of the resistor control and the regulator, for example, due to overheating of the P-coil (Buchholz relay)
R_start	Resistor control is triggered manually (The rising edge of this signal is evaluated)

Relay output functions

Description	Description
R_auto_on	The resistor control is active
R_T>>	The resistor is too hot (triggered by the internal thermal replica)
R_on	Command to turn on the resistor
R_block	Summary message of the blocking of the resistor control The resistor is blocked either by the thermal replica or a binary input or the SCADA system. (BIF25: R_block or BIF19: S:Block_T)

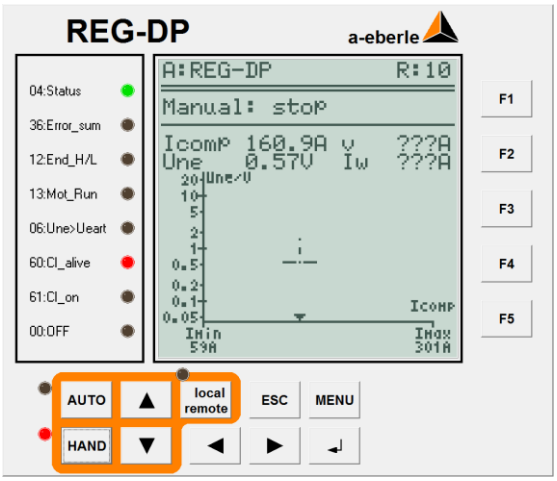
The resistor control is activated by one of the following events:

- From the regulator's menu
- Impulse from the binary input function R_auto_on
- First impulse from the binary input function R_auto_onoff
- Switch-on command from the SCADA system

The resistor control is deactivated by one of the following events:

- From the regulator's menu
- Impulse from the binary input function R_auto_off
- Second impulse from the binary input function R_auto_onoff
- Turn-off command from the SCADA system

When resistor control is active, the regulator displays the remaining number of permissible full impulse sequences for a saturated earth fault in the top right corner.



If desired, the temperature of the thermal replica can also be output by an analogue output or the serial connection to the SCADA system.

Resistor control works whether the regulator is in MAN or AUTO mode!

The following display options are available:

Display	Description
R:10	Resistor control is active, and 10 residual current increases are still possible at full zero sequence voltage
*R:10	The residual current increase is in progress. The asterisk is displayed during the whole switch-on time.
R:0	The resistor is too hot The resistor cannot be switched on again until the remaining residual current increases have a value of at least 1. The relay also sends a notification that the limit temperature has been reached.
[R:10]	Resistor control is blocked; temperature too high
(R:10)	Resistor control is blocked by an active Locking parameter (see description for the Locking parameter)

11.3.4 Parallel regulation

With parallel regulation, you can determine whether the second regulator is connected through the E-LAN.

An E-LAN connection is recommended when both regulators are installed in the same substation because it enables the regulators to exchange information with each other in real time.

The regulators can be operated as master/slave or 'parallel regulation without communication' (special feature).

Regulators that are installed further apart from each other cannot usually communicate over the E-LAN. However, both regulators see the same zero sequence voltage $\underline{U}_{ne}$ as soon as they are switched in the same compensation district. It is only possible to automatically control both regulators in the optional operating mode 'Parallel regulation without communication'.

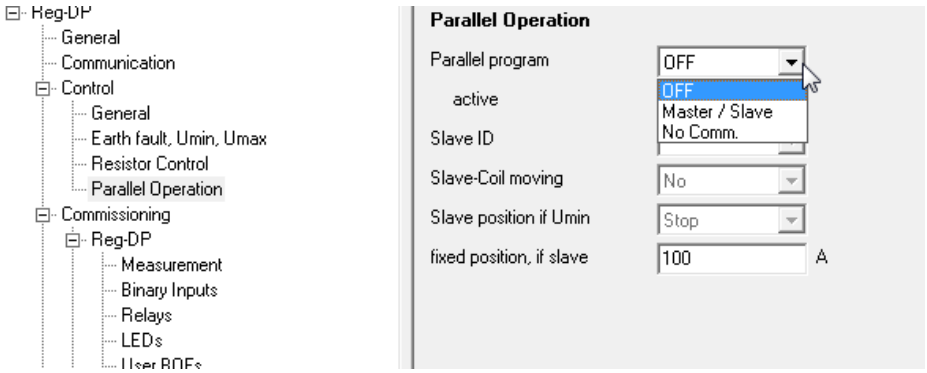


Figure 88: Selecting the parallel program

- Parallel program Master/Slave

The switch information for the coupling is needed (BIF coupling). It is sent to one of the regulator's binary inputs or through the SCADA system (prerequisite: SCADA connection through REG-P, REG-PE or REG-PED) or can be set permanently to ON.

In the simplest form of master-slave operation, the slave regulator is blocked as soon as the coupling of the two regulators is detected and the master has taken over the regulation. The slave's current coil position is transmitted to the master through the E-LAN and if necessary taken into account when calculating the compensation. To calculate the P-coil's target position, any fixed coils that are connected to the master or the slave regulator are also taken into account.

During a tuning process, the master establishes that it cannot reach the desired end position. Moving the slave, however, will change the position of the master's coil. Use 'Move slave coil' (tune) to activate this function (see table).

The following parameters are available for master-slave **parallel regulation** and **may only be set for the master**:

Parameters	Range	Factory set-tings	Description
Parallel pro-gram	OFF; Mas-ter/Slave;	OFF:	Type of parallel regulation used
Active	OFF: ON BB connec-tion	OFF:	Type of activation used to activate the parallel program ON = always active BB coupling = feedback from busbar coupling
Slave ID	A: ... Z4	--	ID of the slave that is connected to the master in the E-LAN
Move slave coil	NO Tune fixed positi-on	NO	If the master regulator should be able to adjust the slave. **No = The master does not perform any action on the slave** **Tune** = When the master regulator's adjustment range is no longer sufficient, the slave coil is ad-justed accordingly **fixedPosition** = The slave coil is adjusted to the value that is set in the Fixed position parameter when the slave is defined
SlavePosition at Umin	Stop Standby position Tuning pos	Stop	Position of the slave when the zero sequence voltage $\underline{U}_{ne}$ < Umin. Stop = No response from the slave regulator Standby position = The slave regulator adjusts its coil to the set standby position Tuning pos = when Une<Umin, the slave adjusts its coil to its last known tuning point
Fixed position, when slave	in Ampere	100A	Predefined position for the slave coil when the option 'Fixed position' is selected in the Move slave coil parameter

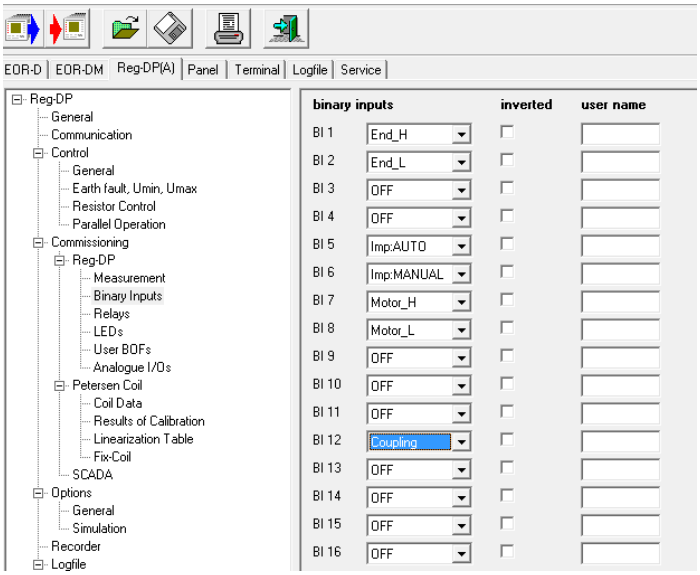


Figure 89: Setting the BB coupling as a function on binary input 12

- Behaviour with active parallel regulation with communication

The master detects the parallel operation, displays it in its display and informs the slave regulator that it is now its slave. The slave receives this information in cycles during parallel operation. As soon as this information is no longer transmitted, the slave becomes an independent regulator again.

The slave shows its 'slave state' in its status bar. The slave must be in AUTO mode. A slave that is in MAN mode **cannot** be adjusted by the master.

The slave is also activated when it is in MAN mode. However, the master is not allowed to adjust the slave even if this option is active and the 'Slave' is not displayed. MAN mode takes precedence.

The slave sends the current position of the coil and any active fixed coils to the master through the E-LAN.

If the slave is readjusted by the master, the slave will display a message indicating that it is being positioned by the master: 'Positioning slave'

- End of parallel operation

Master

The regulator leaves the 'Master' state and starts the search process after the long delay time if the trigger threshold was violated by the switching operation.

Slave in AUTO mode

Slave leaves its state and starts its search process after the short delay time.

- Earth fault behaviour
  - Slave is blocked
  - Only the master is readjusted according to the setting in the menu:

- Off
- $\underline{I}_{res}$
- Table
- $\underline{I}_{res}$ + Table

- Parallel program 'without communication'

For this regulation, data cannot be exchanged through the communication network (E-LAN). A few conditions need to be met to ensure that the regulation remains stable when several regulators are used in a grid district:

Note:

Important! The following parameters **must be set to the same** values for all regulators in the same compensation district:

- Absolute compensation/target detuning (target detuning unit in A)
- The same compensation value in A (target detuning value)
- The option Parallel regulation 'without communication' is active.
- Umax
- Umax_End
- Self-extinguishing current limit
- Uerd
- Position correction at Uerd
- Correction table at Uerd (if used)

Basics of the procedure

The procedure is similar to the behaviour displayed by a small group of people having a conversation. When something is said that several people in the group can respond to, one person will always be the first to speak. As soon as the others notice that someone is speaking, they will wait politely until the person has finished. If they believe that something has been left unsaid, the next person will speak. The others realize that someone is speaking and again wait politely until that person has finished. When everyone has had their say, the group waits for the next event.

This simple procedure is mimicked by the regulators whose common medium is the zero sequence voltage $\underline{\mathbf{U}}_{ne}$. If the zero sequence voltage changes slowly, the conclusion is that another regulator is performing a tuning procedure.

To ensure that the regulators' response time is different for a switching operation, the trigger time is linked to a random number. This means that the delay time set in the menu must be increased to at least 20 s and a random number in the range between zero and 180 s added.

Before the regulator starts its search, the last 20 seconds of the recorded zero sequence voltage are searched to determine whether it left the tolerance range within those 20 seconds. If the regulator did not leave the tolerance range, the assumption is that the other

regulators have finished their tuning processes. The actual zero sequence voltage and the set trigger threshold are used as reference value for the tolerance band.

Notes:

- This procedure is not restricted to two regulators. The time to adjust the whole grid increases with the number of regulators that are switched in parallel.
- With this procedure, it is also not possible to determine whether each regulator will take over a specific part of the compensation. The compensation condition is only met for the whole grid.
- This procedure **should not** be used if the strategy consists of breaking down the main grid into many smaller grids when an earth fault occurs.

11.3.4.1 Parallel regulation without communication with current injection

Current injection can significantly accelerate the above-described time-consuming behaviour.

The precondition is regulation with current injection and activated parallel regulation without communication.

11.4 Menu item Commissioning

This menu item can be broken down into two blocks.

- Regulator REG-DP/ REG-DPA
- Coil

11.4.1 REG-DP/ REG-DPA

11.4.1.1 Measurement

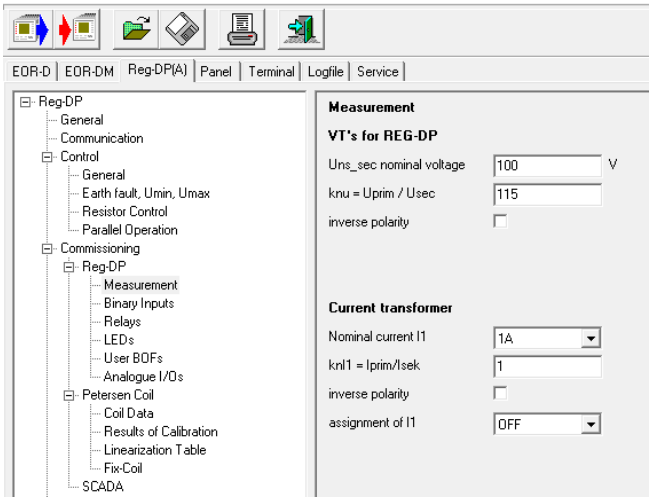


Figure 90: Menu: REG-DP → Measurement

- Voltage transformer

Most P-coil's have a voltage transformer to measure the zero sequence voltage. The voltage transformer is defined by two parameters.

- Nominal voltage Uns_sek

Nominal voltage of the transformer's secondary side, which is connected to the REG-DP/ REG-DPA's measurement input.

Default value: 100 V

- knu = Uprim/Usec

knu is the conversion ratio for the voltage transformer in the P-coil. It usually consists of the coil's primary nominal voltage and the voltage on the secondary side of the voltage transformer.

Example for a 20 kV coil:

Nominal voltage 12000 V, nominal winding voltage 100 V

→ knu = 12000 V/100 V = 120

Reverse polarity

If the parameter is enabled, the polarity of the measurement can be reversed without having to rewire.

- Current transformer

Note:

Only one current channel is available in the REG-DPA and the standard REG-DP.

The jumper settings that adjust the measurement range for the power inputs from 1A to 5A must be set to the same value in the REG-DP.

Female multipoint connector 4: Power inputs, e.g., through the P-coil

Function	Des.	Configuration	Pin
Coil current (AC)	$\underline{I}_1$	k	6
		l	5
Current (AC)	$\underline{I}_2$	k	4
		l	3

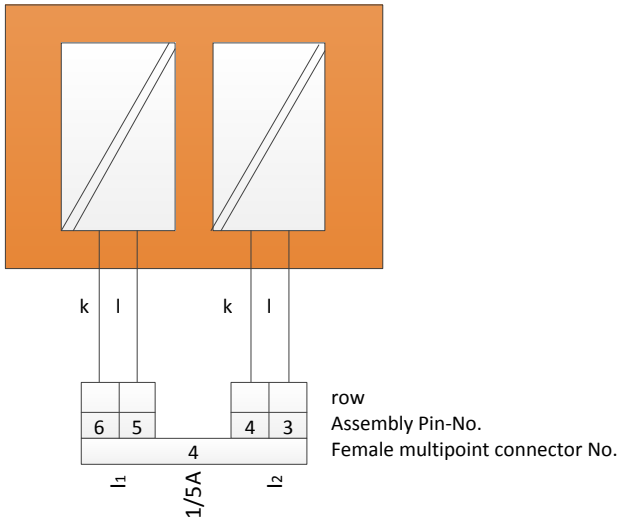


Figure 91: Female multipoint connector 4: Current I_1 (e.g., Ip) and I_2

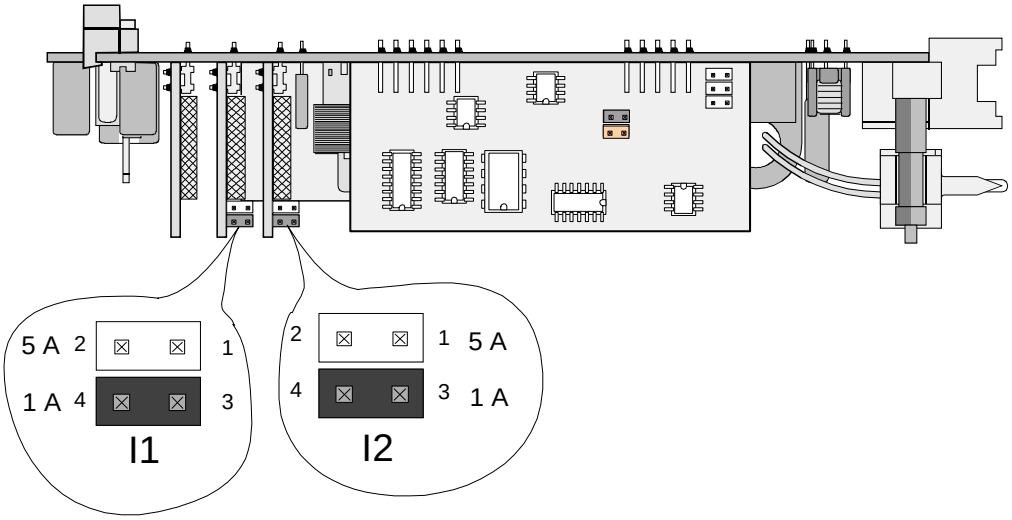


Figure 92: Position of the jumpers for power inputs I_1 and I_2 (older hardware)

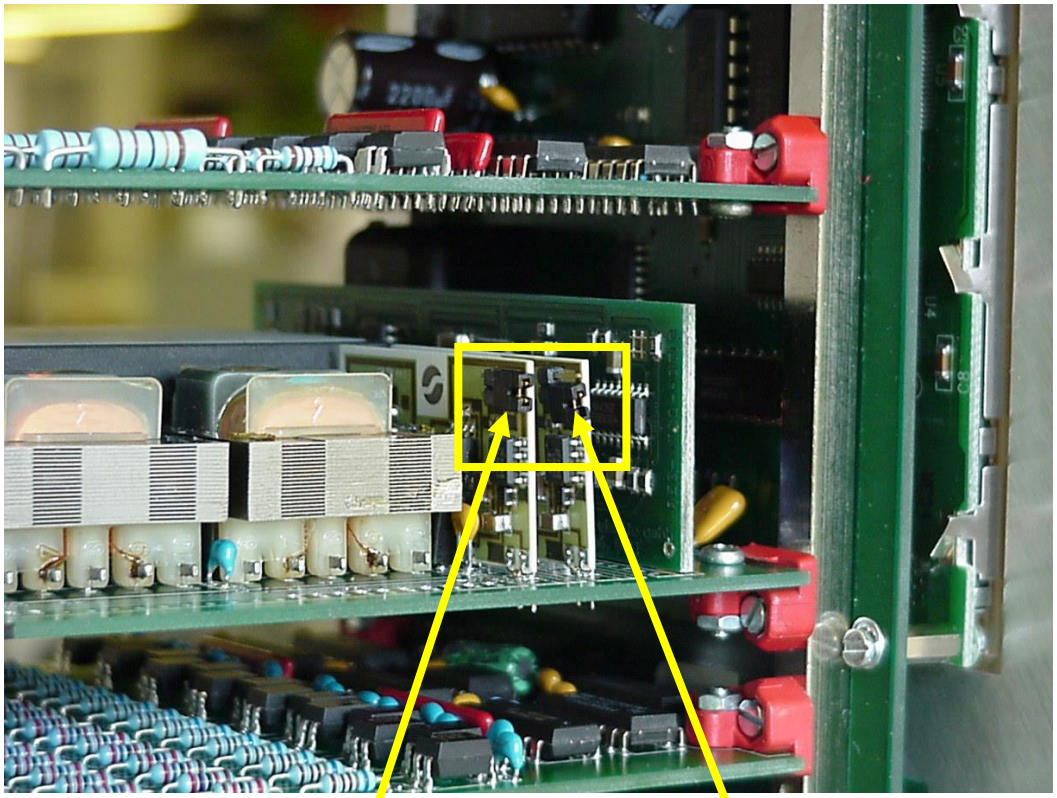


Figure 93: Position of the jumpers for power inputs (current hardware)

Both jumpers must be plugged for the same current (1A or 5A)!!!

Nominal current value I1 and nominal current value I2 (not in REG-DPA)

Two nominal values are available for the measurement input: 1A and 5A

The nominal values can also be set in the software.

- kni = Iprim/Isec

Is the conversion ratio of the current transformer.

Example for a 100 A/1 A transformer:

→ kni = 100 A/1A = 100

- Reverse polarity

If the parameter is enabled, the polarity of the measurement can be reversed without having to rewire.

- Input function: valid for I1 and I2

The following options are available:

- OFF:
  The measured value is not used by the firmware.
- NER:
  The measured value is only used when the 'CBR' feature is enabled
- I_coil:
  If this option is selected the current transformer must be connected to the P-coil here. When an earth fault occurs, the value of the current that was really measured by the P-coil is recorded in the logbook. It is not possible to check the tuning point.

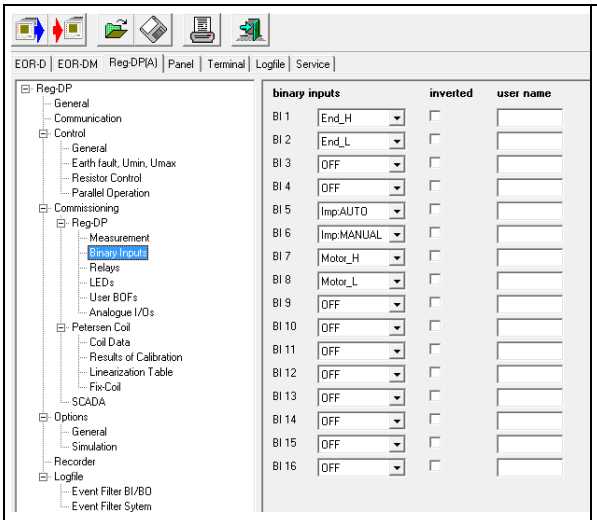
11.4.1.2 Binary inputs, relays, LEDs and user BOFs: Description of the input and output functions

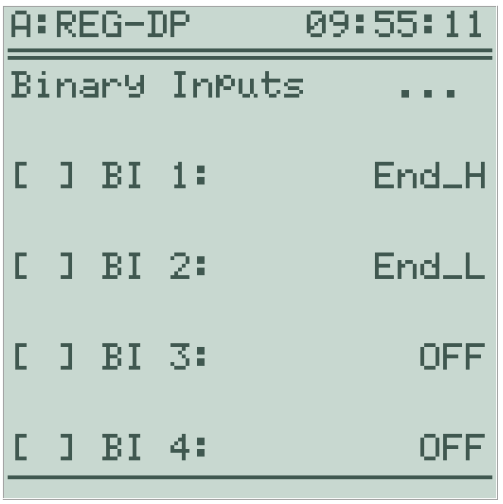
The below block diagram shows the REG-DP/ REG-DPA/ REG-DP/ REG-DPAA's unlimited possibilities for the use of binary inputs and outputs:

- **All binary inputs are freely programmable**
  - Allocation to a specific function
  - Inversion is possible
- **All binary outputs are freely programmable**
  - Allocation to a specific function
  - Inversion is possible
- **A background program (B-Prog) enables every state of every binary input to be read and every binary output to be programmed using specific functions**
- **Simple configuration of user-defined binary output functions (BOF)**
- **All of the output functions can also be output by LEDs.**

- Binary inputs

The following input functions (BIFs) can be allocated to the physical inputs either in WinEDC or directly on the REG-DP/ REG-DPA:





Allocating binary input functions in WinEDC	Allocating binary input functions on the REG-DP/ REG-DPA **Key sequence:** **<MENU><F3><F3><F1><F2><F2>**

Table 7-1: Parameterization options for binary inputs

No.	Name	Function
0	OFF:	The input is not allocated to an input function. The signals are virtually sent out into the air.
1	PROG	The input is only allocated to the background program. The standard regulation process does not use this input.
2	Motor_H	Signal to regulator: Adjust P-coil in direction 'Higher'. Motor runs as long as the signal occurs. Only possible in MAN mode!
3	Motor_L	Signal to regulator: Adjust P-coil in direction 'Lower'. Motor runs as long as the signal occurs. Only possible in MAN mode!
4	Imp_Mot_H	Impulse signal to regulator: Adjust P-coil in direction 'Higher'. The rising edge of the input signal is evaluated and extended to a value that can be selected from the menu. Only possible in MAN mode!
5	Imp_Mot_L	Impulse signal to regulator: Adjust P-coil in direction 'Lower'. The rising edge of the input signal is evaluated and extended to a value that can be selected from the menu. Only possible in MAN mode!
6	Mot_Run	P-coil to regulator: The running message is transmitted for the statistical unit. This enables motor runtimes to be recorded that are not caused by the regulator, e.g., by adjusting the P-coil on site.
7	End_H	P-coil to regulator: **'End position Higher'** reached
8	End_L	P-coil to regulator: **'End position Lower'** reached
9	E:Man	P-coil to regulator: Currently works only on BOF41: E:Man passed on – no function defined!

No.	Name	Function
10	E:Error	P-coil to regulator: Currently works only on BOF41: E:Error forwarded – no function defined!
11	Imp:Local	Impulse to regulator: Regulator should switch to **'Local'** mode
12	Imp:Remote	Impulse to regulator: Regulator should switch to **'Remote'** mode
13	Imp:L/R	Impulse to regulator: Regulator should switch to **'Local/Remote'** mode
14	Stat:R	A static signal switches the regulator to **Remote**
15	Imp:AUTO	Impulse to regulator: Regulator should switch to **'AUTO'** mode
16	Imp:MAN	Impulse to regulator: Regulator should switch to **'MAN'** mode This switch is also used to acknowledge error conditions
17	Imp:A/M	Impulse to regulator: Regulator should switch to **'AUTO/MAN'** mode
18	S:Block	Static signal to regulator: Block the regulator. A search is started after the block has been removed.
19	S:BlockT	Static signal to regulator: Block the regulator because the P-coil's temperature is too high. A search is started after the block has been removed.
20	Search	The signal's rising edge **triggers a search.**
21	R_start	The signal's rising edge triggers the resistor's connection for the **residual current increase**. (for more information see Chapter 7.2.3.3)
22	R_auto_on	Impulse to regulator: Activate resistor control
23	R_auto_off	Impulse to regulator: Deactivate resistor control
24	R_auto_onoff	Impulse to regulator: Switch between activation/deactivation of the resistor control
25	R_block	The resistor’s connection is blocked by an external signal, e.g., by the external temperature monitoring of the resistor
26	Imp_CI_on	REG-DP/ REG-DPA uses an impulse to switch on current injection. Only when used in combination with current injection (**CI** feature)
27	Imp_CI_off	REG-DP/ REG-DPA uses an impulse to switch off current injection. Only when used in combination with current injection (**CI** feature)
28	Reserved	Reserved for future use
29	Coupling	Static signal to regulator: The busbar was connected through a transvers or lateral coupling. Parallel regulation is activated
30	Fix coil on	Static signal to regulator: A fixed coil is connected. This especially impacts the calculation of the relative compensation
31	Quit error	Acknowledge error messages
32	EarthF_Corr1	Static signal to regulator: The P-coil is corrected by a set value when an earth fault occurs. Is used when the **CORR_TAB** feature is selected
33	EarthF_Corr 2	
34	EarthF_Corr 3	
35	EarthF_Corr 4	
36	R_enabled	Releases the resistor control from self-blocking. The resistor control is 'primed' for the next earth fault
37	CI_block	The REG-DP/ REG-DPA blocks the current injection if the input receives a static signal
38	Rw_on	Only in combination with EDC-Sys and the **ENEL** feature Switch on command for resistor Rw
39	Rs2_on	Only in combination with EDC-Sys and the **ENEL** feature

No.	Name	Function
40	Rs12_on	Only in combination with EDC-Sys and the **ENEL** feature
41	CBR_S1	Only in combination with the **CBR** feature Status of switch S1 from the CBR diagram Two pieces of information are needed: 00…01/10…11
42	CBR_S1inv	Only in combination with the **CBR** feature
43	CBR_CB1	Only in combination with the **CBR** feature Status of switch CB1 from the CBR diagram Two pieces of information are needed: 00…01/10…11
44	CBR_CB1inv	Only in combination with the **CBR** feature
45	CBR_S2	Only in combination with the **CBR** feature Status of switch S2 from the CBR diagram Two pieces of information are needed: 00…01/10…11
46	CBR_S2inv	Only in combination with the **CBR** feature
47	CBR_CB2	Only in combination with the **CBR** feature Status of switch CB2 from the CBR diagram Two pieces of information are needed: 00…01/10…11
48	CBR_CB2inv	
49	CBR_S3	Only in combination with the **CBR** feature Status of switch S3 from the CBR diagram Two pieces of information are needed: 00…01/10…11
50	CBR_S3inv	
51	CBR_CB3	Only in combination with the **CBR** feature Status of switch CB3 from the CBR diagram Two pieces of information are needed: 00…01/10…11
52	CBR_CB3inv	
53	CBR_S4	Only in combination with the **CBR** feature Status of switch S4 from the CBR diagram Two pieces of information are needed: 00…01/10…11
54	CBR_S4inv	
55	CBR_CB4	Only in combination with the **CBR** feature Status of switch CB4 from the CBR diagram Two pieces of information are needed: 00…01/10…11
56	CBR_CB4inv	
57	CBR_R_on	Only in combination with the **CBR** feature Status of resistor R 1 = ON; 0 = OFF
58	CBR_RW	Only in combination with the **CBR** feature Status of resistor RW from the CBR diagram Two pieces of information are needed: 00…01/10…11
59	CBR_RWinv	
60	CBR_NER	Only in combination with the **CBR** feature Status of resistor NER from the CBR diagram Two pieces of information are needed: 00…01/10…11
61	CBR_NERinv	

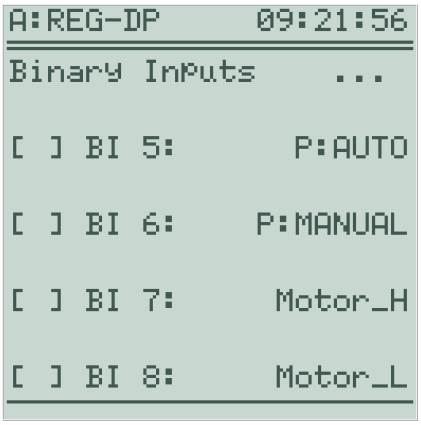
No.	Name	Function
62	CI_Fuse	For feature **CI**. This binary input gets information from the state of the current injection's input and output fuse. By default, binary input 2 (BI2) is used at the CIC. If there is a high-level at the input, the REG-DP/ REG-DPA blocks the current injection and generates an error message.
63	CI_aPulsOn	For feature **HPCI**. Positive edge automatically starts the pulsing procedure with HPCI. The set cycle, including coil detuning, is started. The regulator must be in AUTO mode.
64	CI_aPulsOff	For feature **HPCI**. Positive edge stops the automatic pulsing procedure with HPCI
65	CI_mPulsOn	For feature **HPCI**. Positive edge manually starts the pulsing procedure with HPCI. The regulator must be in MAN mode. The coil is not adjusted automatically
66	CI_mPulsOff	For feature **HPCI**. Positive edge manually stops the pulsing procedure with HPCI

Each binary input can have a specific function. Over 60 options are currently available. If the desired function is not available, the input is set to PROG. This setting enables the input to be queried by a background program. A specific function can be added to the background program.

Please contact the A. Eberle's head office if you need special functions implemented.

The logical function of the input can be substituted in the **Inverted** field.

The **Name** field can have descriptive names that are allocated to the respective input in Panel mode, on the service screen and in the logbook. The **Number of characters** is limited to **8**!



Pressing <F1> switches to the other inputs I5 to I16.

The current power level is displayed in the first column in square brackets. The following variations are possible:

- [ ]... 0
- [x]... 1

The second column lists the names of the physical inputs (e.g., I1 to I4)

The activated inversion for an input is immediately displayed after the colon (:) by a 'minus' sign (see input I2).

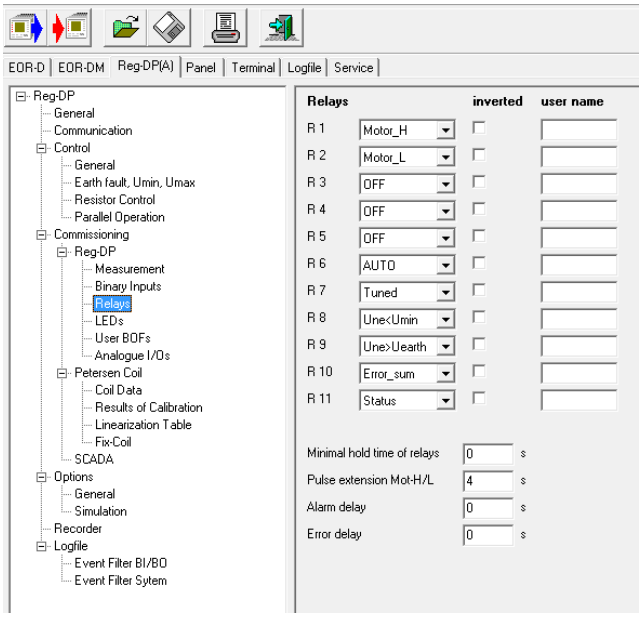
The last column displays the allocation of the physical input to the logical input function of the regulation process. In the example, input I1 is connected to the regulation process's input function 'End_H' (end switch Higher). This means that binary input I1 enables the regulator to recognize when the end switch 'Higher' is activated.

If the same input function is allocated to several binary inputs, the individual inputs are connected in the regulator by an 'OR-gate' that takes the inversion into account.

11.4.1.3 Relays

Similar functions can be set for the relays as for the binary inputs.

Just like the binary inputs, the relay outputs can be inverted and given a name.



The following output functions (BOF) can be allocated to the in the regulation process's physical outputs.

Table 7-2: Set-up options for binary outputs and LEDs

No.	Name	Function
0	OFF:	Relay is not allocated. '0' or '1' is output based on the inversion.
1	PROG	The relay is allocated to the background program. It's put there by EspRelPV.
2	Motor_H	Command to the P-coil: Adjust in direction '**Higher**'.
3	Motor_L	Command to the P-coil: Adjust in direction '**Lower**'.
4	Status	Message: Regulator status: Summary message of all self-test functions, such as ● RAM/ROM ● EEPROM ● Battery empty ● Watchdog
5	<AUTO>	Message: The regulator is in operating mode AUTO.
6	Une > Uerd	Message: The zero sequence voltage is bigger than the set earth fault threshold.
7	Une > Uerd_td	Message delayed: The zero sequence voltage is bigger than the set earth fault threshold Uerd.
8	Une > Umax	Message: The zero sequence voltage is bigger than the set maximum earth fault threshold Umax.
9	Une < Umin	Message: The regulator searched the whole adjustment range and did not find a zero sequence voltage bigger than the set minimum zero sequence voltage. This message is generated after the defined delay time.
10	End_H	Message: The regulator recognized the end position '**Higher**'.
11	End_L	Message: The regulator recognized the end position '**Lower**'.
12	End_H/L	Message: The regulator recognized the end position **'Higher' OR 'Lower'**. This is the OR-gate from the two previous messages.
13	Mot_Run	Message: The regulator recognized a P-coil adjustment. The signal is an OR-gate for the position command 'Motor Higher', 'Motor Lower' and the input 'Mot_Run'.
14	Tuned	Message **tuned**: The search process was completed successfully. The desired compensation value was set successfully.
15	Tnd_nc	Message **tuned not compensated**: The regulator took the preconditions into account and adjusted the coil to the best possible value. The desired compensation value could not be reached because it is outside of the P-coil's adjustment range.
16	Umax_nc	Tuned not compensated message because the set Umax threshold is preventing tuning.
17	Block	Message: The regulator is in operating mode AUTO but blocked by an event.
18	Homepos1	Message: The regulator has reached the end position (standby position or last tuning position). This standby position 1 is moved toward after: ● Unsuccessful search because of $U_{en} < U_{min}$ in the whole adjustment range

		• Search is aborted
19	Homepos2	Reserved
20	Remote	Message: The regulator was switched into 'Remote' mode. The 'Motor Higher' and 'Motor Lower', 'MAN' and 'AUTO' keys on the regulator are blocked by the software. The signals are not physically separated from the P-coil. The menu and the different display modes can still be used.
21	Fix coil on	Message: The fixed coil is taken into account when calculating the compensation.
22	Coupling	Message: Parallel operation of P-coils; corresponds to forwarding input function '29: Coupling.
23	R_auto_on	Message: Resistance control has been activated.
24	R_block	Message: Resistance control is active but blocked.
25	R_on	Command: Turn on resistor for resistance control
26	R_T>>	Message: Resistor is too hot.
27	PotiWarning	Message: Pot measured value is not plausible (pot has a 'gap' at this location).
28	SIM	Internal grid simulation has been activated.
29	Alarm	**Alarm collective message:** • SearchTime exceeded (BOF 38:T_MotOn) • NumberSearch exceeded (BOF 37: n > search) • No CI responsive (BOF 64: CI_missing) • CI measured value too small • No slave responsive (BOF 83: Slave missing)
30	Alarm td	**Alarm collective message delayed**
31	AlarmInt	Reserved
32	E:Dir	Message: P-coil is moving in the wrong direction
33	E:Move	Message: A P-coil adjustment on 'Motor Higher' or 'Motor Lower' command was not detected within a defined period (ca. 20 s).
34	Error	Error message: Summary message for known errors: • Motor error – No movement on adjustment command (33:E:Move) – Wrong direction (32:E:Dir) • Potentiometer error – Cable break (39:PotError) • Both end switches are recognized at the same time • Positioning error • P-coil error message (BIF 10:E:Error)
35	Error_td	Delayed summary error message
36	Error_Sum	**Error collective message** ErrSum • = Error OR Alarm OR Status • = (34:Error) OR (BOF 29:Alarm) • OR (BOF 4:EMERGStatus) Alarm:

		• SearchTime exceeded (BOF 38:T_MotOn) • NumberSearch exceeded (BOF 37: n > search) Error • Motor error – No movement on adjustment command (BOF 33:E:Move) – Wrong direction (BOF 32:E:Dir) • Potentiometer error – Cable break (BOF 39:Pot_???) • Both end switches are recognized at the same time • Positioning error • P-coil error message (BIF 10:E:Error) Status: • All internal errors such as – RAM – E-LAN – Battery – ...
37	> n_Search	Message: The P-coil could not be successfully tuned after '**Searchcycle_max**'.
38	>T_MotOn	Message: The set '**Motor runtime max**' was exceeded.
39	PotiError	Message: Error detected in the measurement of the coil position, (e.g., cable break).
40	Une_??	Message Error detected in the measurement of the zero sequence voltage, Une > 120% of the set nominal voltage.
41	E:MAN	Message: Forwarding of the input message 'E-Man'.
42	E:ERROR	Message: Forwarding of the input message 'E-Error'.
43	CouplSignal	Message: Bus bars are coupled
44	CouplViaNet	**Only when using current injection** Message: Grid is coupled – Testing is done with current injection The **CI** feature and '**check external coupling**' parameter must be enabled in the Parallel regulation menu
45	E-LAN Error	Message: Summary message for E-LAN errors.
46	Usync<<	Reference voltage is smaller than 35 VAC => Angle cannot be measured. Switching to absolute value evaluation.
47	R_armed	Resistor control is primed. The residual current is increased when the next earth fault occurs.
48	SearchDelay	Is set when the regulator is in search delay, meaning that the zero sequence voltage is outside of the tolerance range and the regulator has not yet started searching. It is also set during the forced search delay:
49	ParaProg	Is set when parallel regulation is enabled and activated by the clutch switch.
50	Local	The regulator is in operating mode 'Local'.
51	Remote	The regulator is in operating mode 'Remote'.

52	Uerd Pos	Earth fault AND positioning of the P-coil are completed during the earth fault.
53	Search	Set during the search process: From the start of the search to (Tuned OR Tnd.nc OR Tuned Umin OR SearchCan) The message is reset by: Earth fault, Blocking, MAN, slave mode
54	Umax_End	Is set when the Umax_end threshold is exceeded.
55	Umax_end_K	Is set when a tuning point is found at Umax_end. The target detuning is exceeded.
56	dIce_max	Is set when the self-extinguishing current limit dIce is exceeded.
57	dIce_max_nc	Is set when the regulator is at the self-extinguishing current limit dIce in the state 'Tuned_nc'.
58	Batt low	Message: The charge level of the REG-DP/ REG-DPA's buffer battery is critical. The battery should be replaced within the next 2 months!
59	CI_extern	Only when used in EDC-Sys/EOR-DM Message: Current injection requested from external device – here by earth fault detection (EOR-DM)
60	CI_alive	Message: Communication for current injection is available
61	CI_on	Message: Current injection is active. Current is being injected.
62	CI_blocked	Message: Current injection blocked: ● Signal forwarded from a defined binary input ● Signalling from current injection controller
63	CI_failure	Message: ● Communication error to CIC ● Error message, error in CIC ● Missing synchronization voltage at CIC ● Connection interruption detected between CIC and P-coil ● Short circuit in connection between CIC and P-coil
64	CI_missing	Message: No response from CIC
65	Fix_on	Command: Request from REG-DP/ REG-DPA to activate the fixed coil
66	Pulse:Fix_on	Impulse command: Request from REG-DP/ REG-DPA to activate the fixed coil
67	Pulse:Fix_off	Impulse command: Request from REG-DP/ REG-DPA to deactivate the fixed coil
68	Rs2_on	Only for 'ENEL' feature
69	Rs12_on	Only for 'ENEL' feature
70	Rp_on	Only for 'ENEL' feature
71	Pulse:Rp_on	Only for 'ENEL' feature
72	Pulse:Rp_off	Only for 'ENEL' feature
73	R_nCB_Trip	Only for 'CBR' feature
74	UserBOF1	User-defined binary output functions (BOF) All of the output functions listed here can be grouped to one out-

		put function (BOF) by an OR-gate.
75	UserBOF2	
76	UserBOF3	
77	UserBOF4	
78	UserBOF5	
79	UserBOF6	
80	UserBOF7	
81	UserBOF8	
82	EOR_missing	Only for 'EOR' feature
83	noSlave	Message: Slave regulator in parallel program master/slave is missing
84	Tuned_Umax_end	P-coil is 'tuned' OR positioned to 'Umax_End' (new from firmware V2.4.00) = (BOF 14 OR BOF 55) AND ! BOF 54
85	Tuned_v_invers	P-coil is 'tuned.nc' and is on the wrong side of the resonance curve (new from firmware V2.4.00)
86	HPCI_Puls	HPCI: Pulsing is active. Note: In AUTO mode including coil detuning and move back
87	HPCI_local	HPCI: Location/Remote switch on CIC is set to 'Local' and communication with CIC works
88	HPCI_Remote	HPCI: Location/Remote switch on CIC is set to 'Remote' and communication with CIC works
89	CI_Status	Signal is active, when CI sends “Status = OK” and communication with CI works
90	CI_SearchBlock	Signal is active, when CI sends “Search blocked” and communication with CI works
91	HPCI_PulsBlock	Signal is active, when HPCI sends “Pulse blocked” and communication with CI works

The following four parameters apply to all relay outputs equally.

- Minimum idle time relay

Defines the minimum switch-on time for a relay signal

Default setting: 0 s

- Impulse progr Mot H/L

The external (SCADA system) higher and lower commands for the motor are extended by this value. This, in combination with impulse commands from the SCADA system, ensures that the coil moves smoothly

Default setting: 4 s

- Message delay Alarm

A general delay for alarms can be set here.

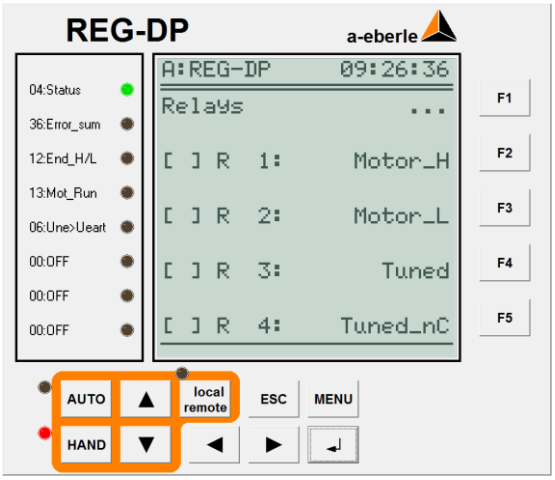
Default setting: 0s 'BOF 30: Alarm_td'

- Message delay Failure

A general delay for error messages can be set here.

Default setting: 0s 'BOF 35: Error_td'

Examples of the digital output options that can be configured directly from the regulator's menu are displayed in the below figure for outputs 1 to 4.



Pressing <F1> switches to the other relay outputs.

The output relay state (i.e. the state of the relay excitation winding) is displayed in the first column in square brackets, whereby the following is possible:

- **[ ]... 0 relay de-energized)**
- **[x].. 1 relay energized**

The names of the physical outputs are displayed in the second column.

The activated inversion for the respective output function is immediately displayed after the colon by a '**minus**' sign (see output R4).

The last column displays the allocation of the physical output to the logical output function of the regulation process. In the example, output R1 is connected to the regulation process's output function 'Motor_H' (motor higher). This means that the regulator can use this output to adjust the P-coil in the direction of 'bigger current'.

11.4.1.4 The status relay (normally open contact or normally closed contact)

Note (Order Codes):

By using the right jumper configuration, the binary output 'Status' can be used either as a 'normally closed' or 'normally open' contact. The position of the jumper is displayed in Figure 95). **The function (jumper) that is not used must be removed.**

The status relay is energized in the regulator's healthy state. Jumpers are used to determine whether the contact is open or closed when an error occurs.

Status relay with normally closed function: The contact opens when an error occurs.

The relay coil is not excited when an error occurs. The status relay's normally open contact is selected through the jumper.

Note:

The following errors are also sent to the SCADA system

- Pulled out slide-in device
- Auxiliary voltage failure on the regulator
- Regulator for internal errors

Remove jumper for normally open contact function, leave jumper for normally closed contact.

Status relay with normally open function: The contact closes when an error occurs.

The relay coil is not excited when an error occurs. The status relay's normally closed contact is selected through the jumper.

Note:

An error is not generated if the slide-in device is pulled out.

Remove jumper for the normally closed function, leave jumper for normally open function.

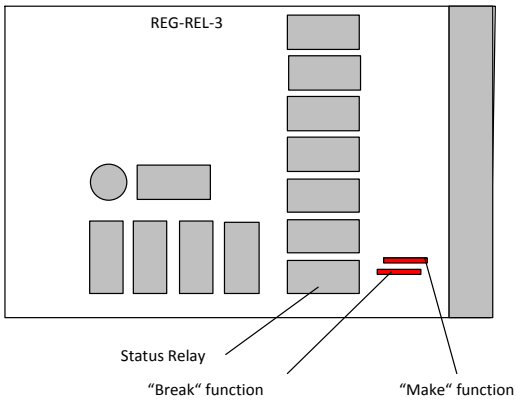
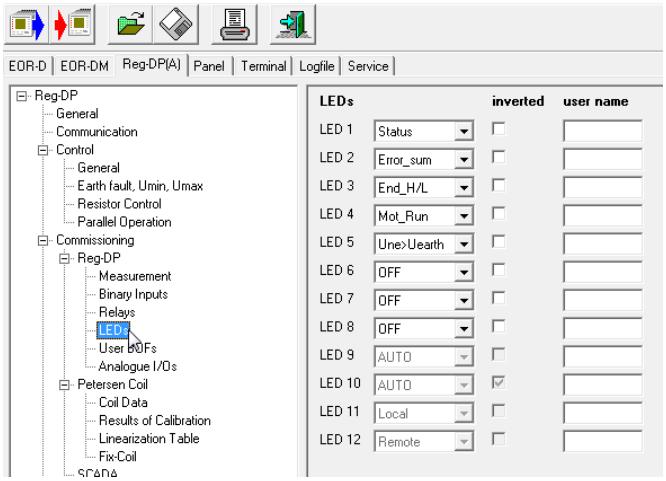


Figure 94: Position of the jumper on PCB 1

11.4.1.5 LEDs

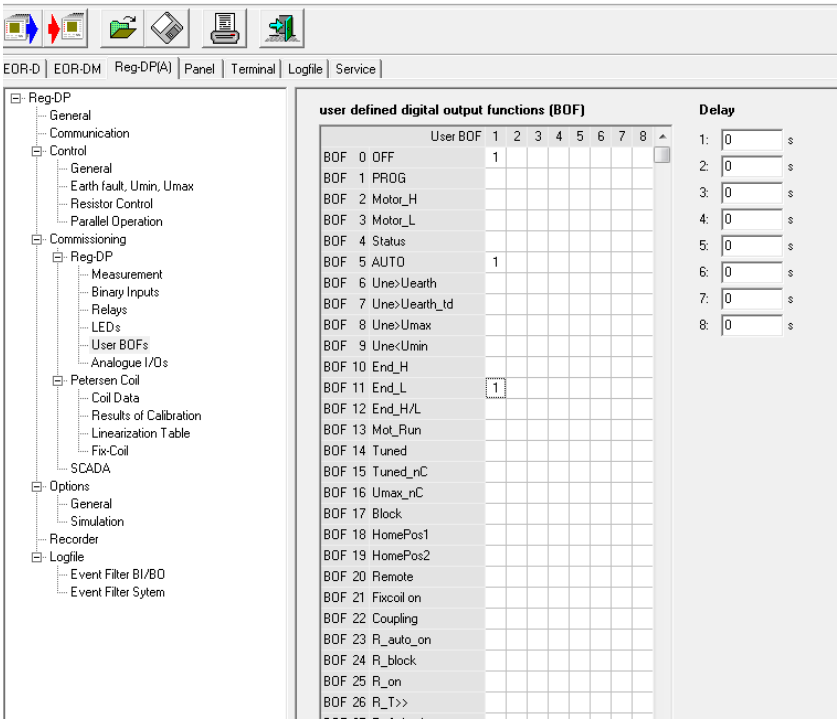


The same output functions for the relay outputs described in Table 7-2 can be used as output functions for the LEDs.

The functions can also be inverted and comments added to the LEDs.

The only difference between the LEDs on the REG-DP and the REG-DPA is that the REG-DPA has 12 LEDs and the REG-DP 9.

11.4.1.6 User-defined binary output functions (user BOFs)



In addition to allocating a specific function to a specific output relay or LED, several functions can be OR-gated through the UserBOF settings.

- **If 1 is entered in a field, it is OR-gated with the other selected functions in the same column.**
- **If -1 is entered in a field, the inverted signal is OR-gated with the other signals in the column.**
- **Up to eight UserBOF can be defined.**
- **A separate output delay in seconds can be set for each of these messages under the menu item Delays.**

11.4.1.7 Analogue inputs and outputs

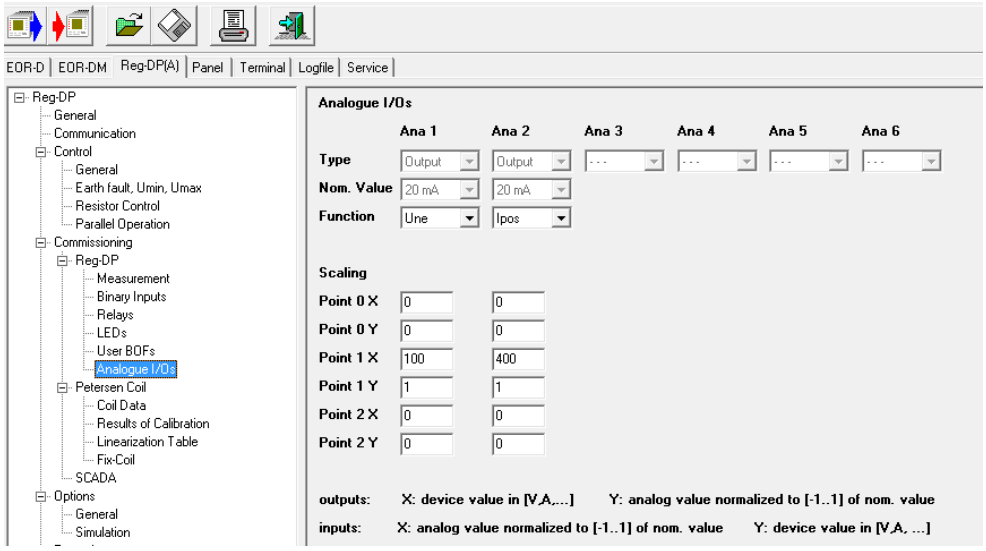


Figure 95: Analogue Channels

Up to six **freely programmable analogue outputs** can be installed in the regulator for the range -20 mA … 0 … + 20 mA.

PT 100 modules are also directly supported by the firmware. If a PT 100 module is plugged, this function must be selected under Type.

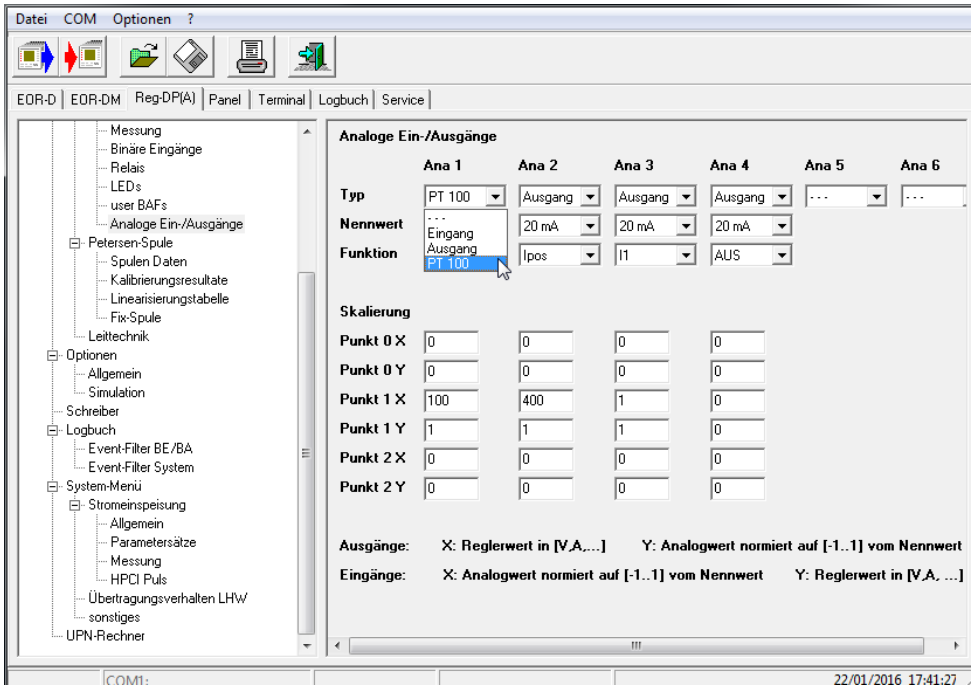


Figure 96: Selecting PT 100 for plugged PT 100 module

The allocation table enables the following quantities, which are determined during the regulation process, to be output to the physical outputs (relays and LEDs):

No.	Name	Function
0	OFF:	The analogue output is not used
1	Prog	The analogue output is allocated to the background program
2	Une	The absolute value of the zero sequence voltage U_{ne} is output (measured secondary value)
3	I1	The **secondary value** measured for current transformer 1 is output (1A or 5A range)
4	I2	The **secondary value** measured for current transformer 2 is output (1A or 5A range) Note: **Not available on REG-DPA!**
5	Rproz	The measured value for the coil position is output (voltage divider ratio for the position measurement, without linearization)
6	Ipos in A	The linearized coil position for the adjustment range is output
7	RTemp	The temperature of the resistor, which is calculated using the thermal replica, is output.

For each channel, the type of transmission characteristic can be described by three reference points so that both a linear characteristic and a knee-point characteristic can be created. If only two points are needed to define the characteristic, only reference points 0 and 1 are used. Point 2 is set to 0.

The coil position that is output is the coil position that is determined using the linearization table. The same coil position is displayed in the control room and on the coil.

Example for a linear characteristic:

The range of the zero sequence voltage U_{ne} from 0 to 100 V is to be displayed in the range from 4 to 20° mA:

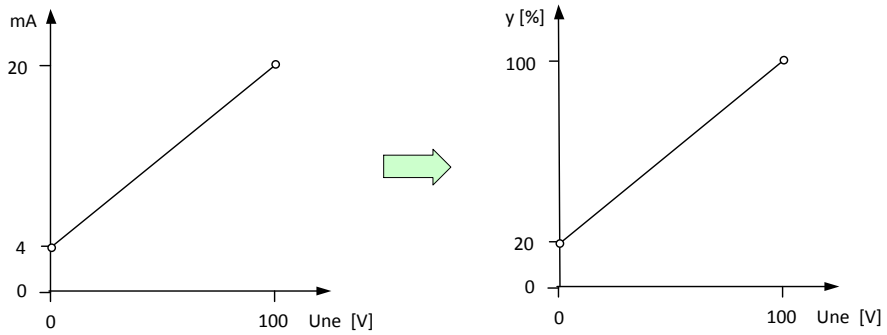


Figure 97: Linear transmission characteristic for analogue module

Parameterization using the menu:

Menu item	Value	Function
Type	Output	An mA - output module is used.
Nominal value	20 mA	Maximum value that the module can physically deliver. The standard modules deliver 20 mA
Function	Une	Allocation of the desired 'analogue measured value' for the output (see above table)
Point 0 X	0	0 according to the smallest value of U_{ne} of 0 V on the x-axis
Point 0 Y	0.2	4 mA on the y-axis corresponds to 20% of 20 mA (standardized = 0.2)
Point 1 X	100	100 V according to the maximum value of U_{ne} on the x-axis
Point 1 Y	1	20 mA on the y-axis corresponds to 100% (standardized = 1)
Point 2 X	0	
Point 2 Y	0	

Example for a knee-point characteristic (magnifier):

The figure shows the magnified voltage range from 0 to 10 V. The 0 to 10 V range is displayed on the 0 to 8 mA range. The 10 to 100 V range is displayed on the remaining 8 to 10 mA range.

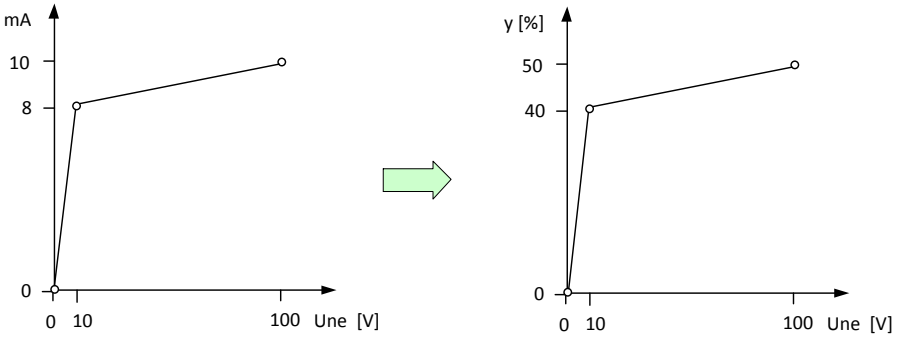


Figure 98: Knee-point characteristic (magnifier) for analogue module

Parameterization using the menu:

Menu item	Value	Function
Type	Output	An mA - output module is used.
Nominal value	20 mA	Maximum value that the module can physically deliver. The standard modules deliver 20 mA
Function	Une	Allocation of the desired 'analogue measured value' for the output (see above table)
Point 0 X	0	0 V corresponding to the smallest value of U_{ne} of 0 V on the x-axis
Point 0 Y	0	0 mA on the y-axis corresponds to 0% of 20 mA
Point 1 X	10	10 V according to the knee-point on the x-axis
Point 1 Y	0.4	8 mA on the y-axis corresponds to **40%** of 20 mA (standardized 0.4)
Point 2 X	100	100 V according to the maximum value of U_{ne} on the x-axis
Point 2 Y	0.50	10 mA on the y-axis corresponds to **50%** of 20 mA (standardized 0.50)

You can use the service screen and the Override function described in Chapter 6 to make sure that the analogue outputs have the right transmission function.

11.4.1.8 Retrofitting analogue channels

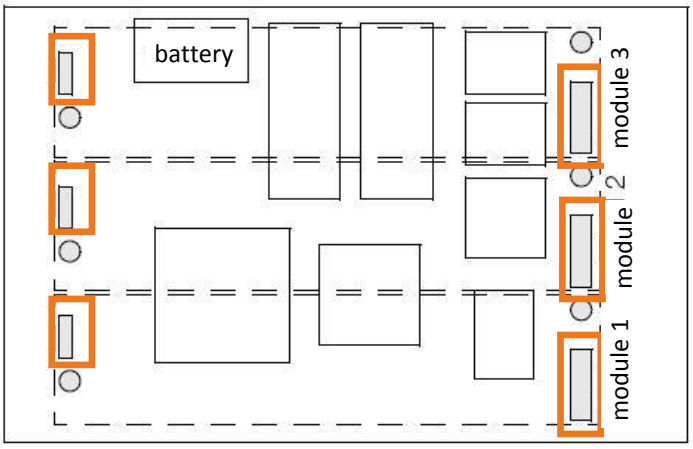
Please check first whether the housing of the subrack has the wiring for the analogue channels. If this is not the case, a rewiring has to be done. It is recommended that this work be carried out at the A. Eberle home office. because we can retrofit the REG-DP ™ with the analogue channels at the same time.

If the housing/subrack is already wired for analogue channels, the analogue channels can be retrofitted according to the below instructions.

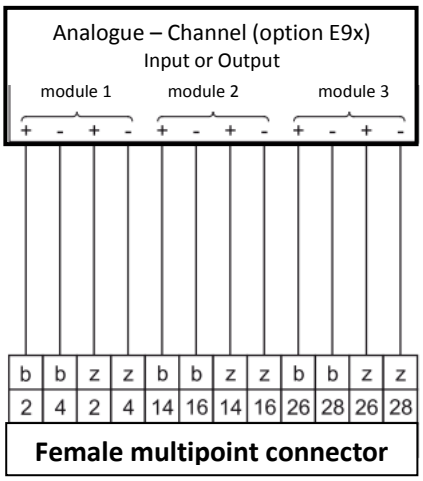
The REG-DP ™ has a total of three slots for the analogue module.

The slots are always numbered from top to bottom, meaning that the first module (top) is recognized by the firmware as channel 1 and 2. The middle slot is for channels 3 and 4, and the bottom slot for channels 5 and 6.

Location of analogue slots on the REG-CPU processor board:



The red rectangles indicate the location of the connectors between the CPU and the analogue modules.



Module 1.1 - Channel 1

Module 1.2 - Channel 2

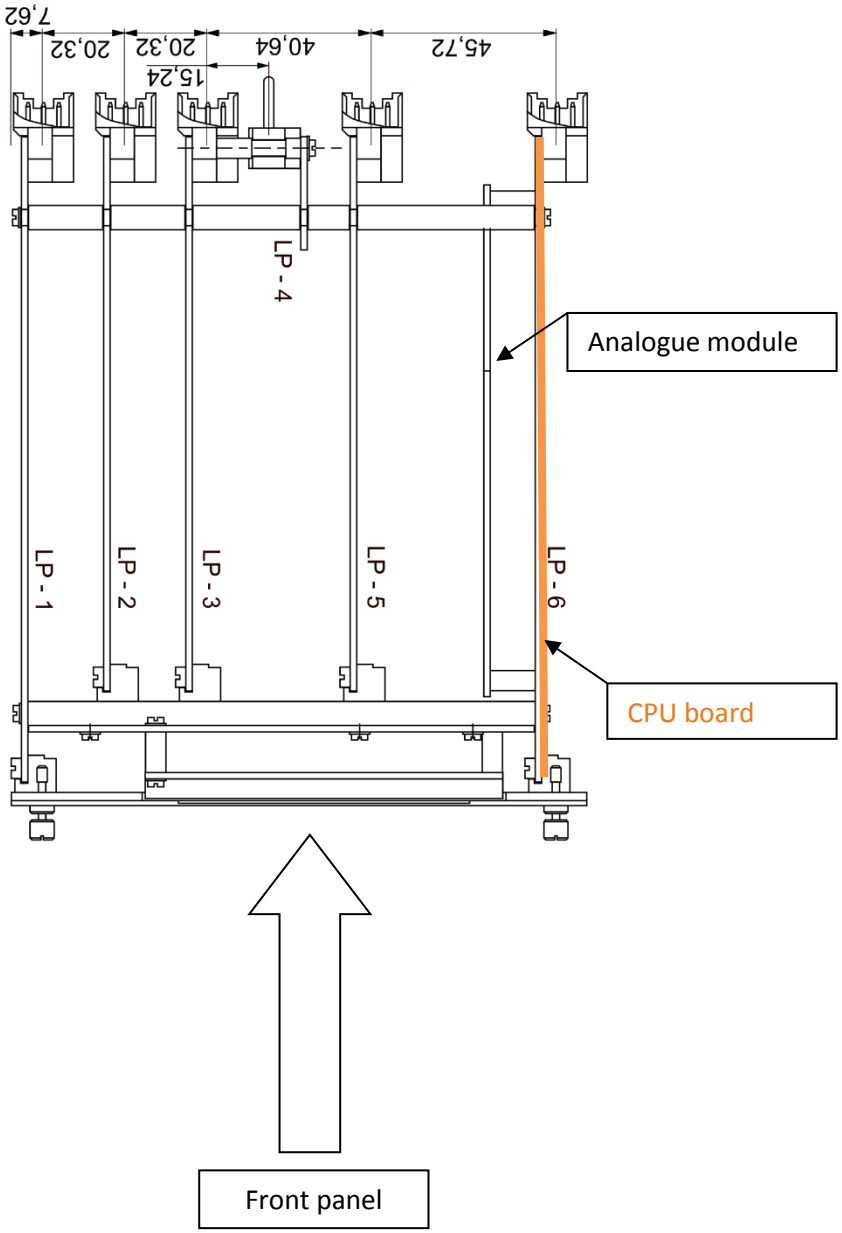
Module 2.1 - Channel 3

Module 2.2 - Channel 4

Module 3.1 - Channel 5

The REG-DP ™ must be taken out of the housing in order to be retrofitted with analogue modules. Loosen the four retaining screws and pull out the REG-DP ™ with the removal tool. Place the REG-DP ™ in front of you on the workbench. To ensure that the allocation of the analogue channels is correct, place the REG-DP ™ on the surface with the right side up, meaning so you can read the indicator plates. The individual printed circuit boards are in a vertical position.

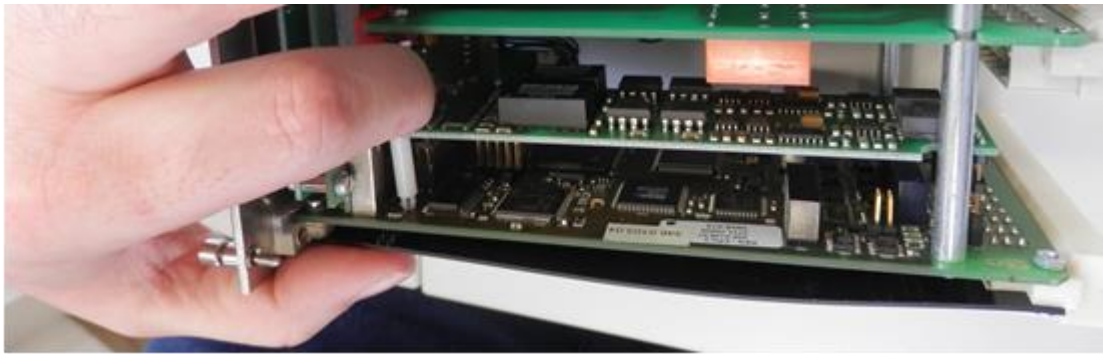
The analogue modules are plugged on the CPU board, which is located on the far right as seen from the front over the display.

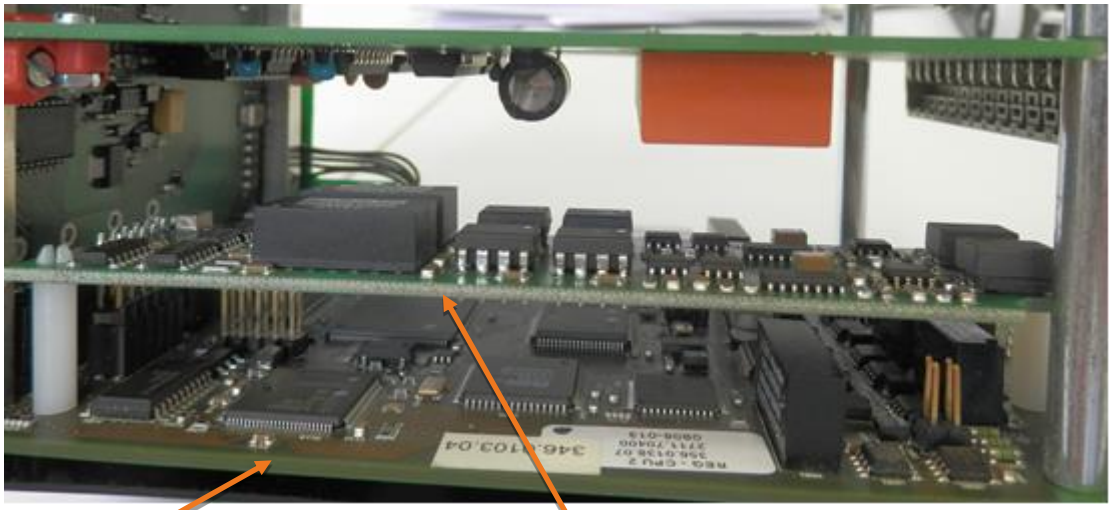


The analogue modules themselves are plugged into the corresponding socket on the CPU board.

Make sure that all of the connectors are correctly placed.

In addition to the connectors, the modules are also connected to the CPU board with two pluggable plastic spacers. Make sure that they are correctly placed too.





Once the analogue modules have been plugged, the REG-DP ™ can be put back into its housing.

The analogue channels are automatically detected by the firmware when the device re-starts and can be parameterized through the menu Setup -6- \ General \ Analogue.. or the WinEDC software.

Please note that analogue channels such as PT 100 Module can only be used directly from firmware version 2.5.xx. A background program is needed for older firmware versions.

If you have any questions, please do not hesitate to contact EORSys Support (eorsys-support@a-eberle.de, +49-(0)911/628108-103).

11.4.2 Petersen Coil

11.4.2.1 Coil data

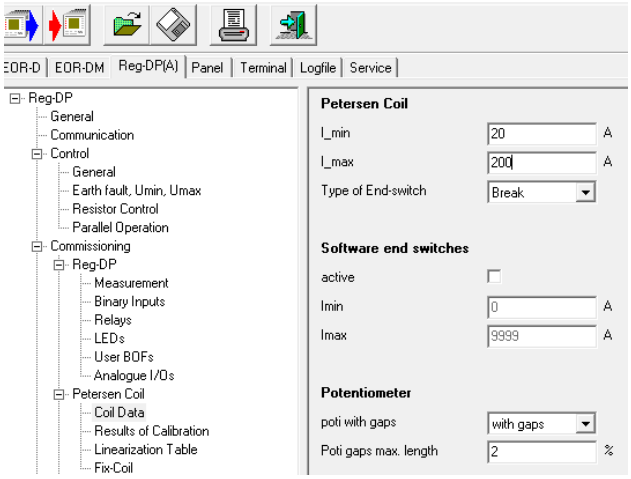


Figure 99: Coil data menu

- Petersen coil
  - I_min (in A)

Current value of the coil at the lower end switch.

Default setting: 20A

  - I_min (in A)

Current of the coil in the upper end switch position.

Default setting: 200A

  - End switch type

The following settings are possible:

Setting	Description
Normally open contact (NOC)	Normally open contact: The contact closes when the position is reached
Normally closed contact (NCC)	Normally closed contact: The contact opens when the position is reached
Not connected	End switch information is not available. The end switch information is determined during calibration. If the potentiometer does not change for more than 5 s to 25 s (depends on the coil speed), the value is used as end switch position (Imin or Imax).

- Software end switches

If no end switches are available or their function is unreliable, the regulator can work with software end switches.

The drive stops when the coil reaches the value that is set for I_min or I_max.

This makes it possible to limit the coil range and stop the coil before the actual end position.

- Active

Software end switch function is active

Default setting: inactive

- I_min

Simulated position for the lower end switch. The decision is derived from the potentiometer's position. This means that the coil must be successfully calibrated during commissioning.

Default setting: 0A

- I_max

Simulated position for the upper end switch. The decision is derived from the potentiometer's position. This means that the coil must be successfully calibrated during commissioning.

Default setting: 9999A

- Potentiometer

You can set the potentiometer's properties here.

- Pot hat gaps

Setting	Description
Without gaps	The potentiometer is adopted as ideal. The regulator generates an error message as soon as the smallest gap occurs in the adjustment range.
With gaps	**Default setting:** Gaps in the position feedback are accepted up to the value in the ***Pot gaps max length*** parameter. An error is not generated until the gaps exceed the value.
No Pot	A potentiometer does not have to be connected if this setting is used. The regulator displays ??? behind Ipos/Icomp. This setting is only recommended if the potentiometer needs servicing. The coil's total runtime is used to estimate its position. The runtime was determined during the automatic coil calibration. **CAUTION!** The end switch information MUST be sent to the REG-DP/ REG-DPA. A combination of both no pot and no end switch does **not** make sense.

- Pot gaps max length

0.5% to 5% of Imax can be set

Default value: 2 %

REG-DP/ REG-DPA identifies the gaps as a silder break. During this period, the coil position from the last measurement point, the values from the calibration and the values from the linearization are interpolated.

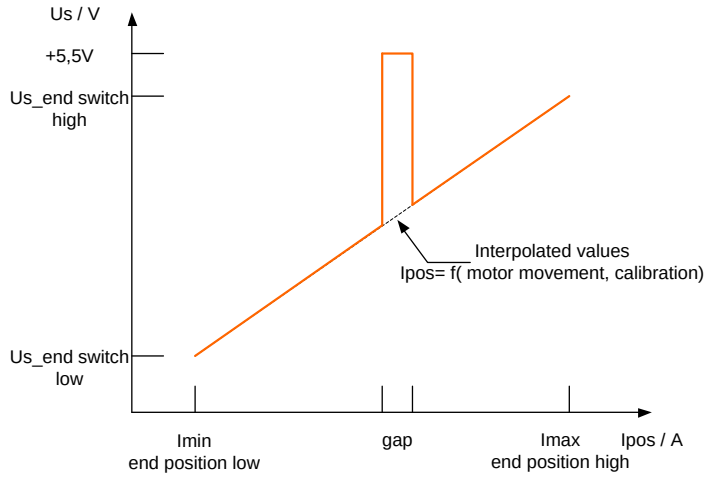


Figure 100: Basics of interpolation when gaps in potentiometer feedback

The value for the gap can be increased if there are problems with the potentiometer. The potentiometer should be thoroughly checked and possibly replaced during the next coil service.

11.4.2.2 Calibration results

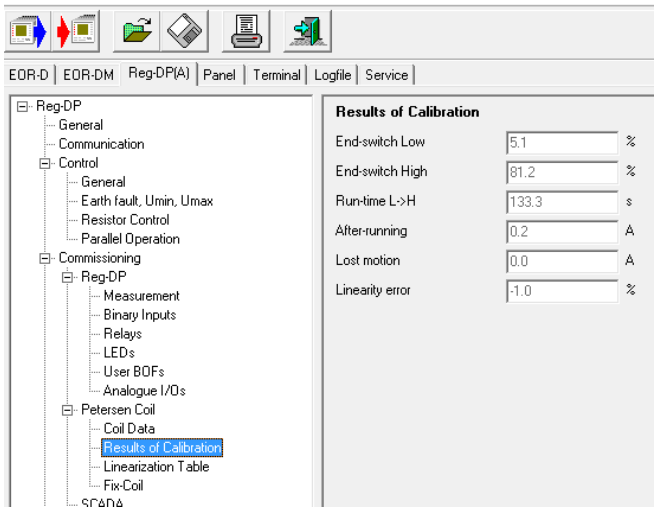


Figure 101: Menu Calibration results

This menu displays the results of the calibration process described in Chapter 10.3.2. The values are read-only.

- End switch Lower

The value of the potentiometer in the lower end switch position expressed in %.

- End switch Higher

The value of the potentiometer in the upper end switch position expressed in %.

- Coil runtime

Indicates the time the coil needs to move from the lower to the upper end switch.

- Coil overrun

The coil overrun is expressed in A. It indicates at how many Ampere the coil continues to run after the stop command.

- Coil backlash

Coil backlash is a result of the mechanical hysteresis in the drive system between the upward and downward movement.

- Linearity error

The movement of the potentiometer wiper is recorded during the calibration of the coil. Normally, the change in position should produce a linear function across the coil's runtime.

If the non-linearity is bigger than 2%, the potentiometer's wires should be checked.

11.4.2.3 Linearization table

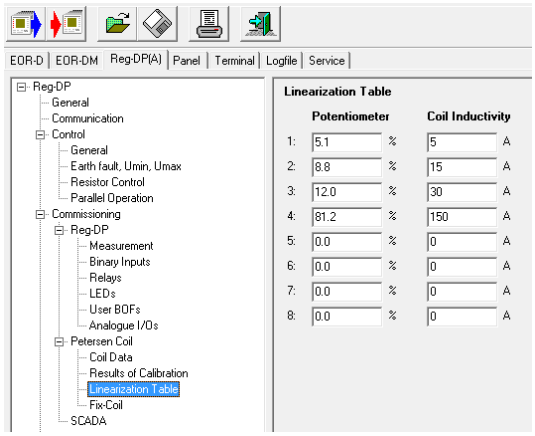


Figure 102: Menu Linearization table

The linearization process is described in Chapter 10.3.3 **Manual coils - linearization**. These values are used to account for the non-linearity between the position displayed on the coil and the potentiometer when the position is displayed.

11.4.2.4 Fix coil

The information about the fixed coil is used to determine the capacitive current for the whole grid.

This information is also needed when the parameter Relative (in %) is selected as the target detuning method.

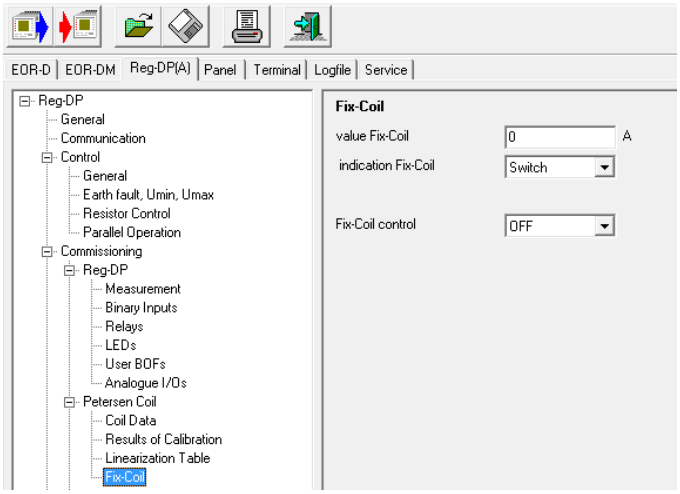


Figure 103: Menu Fixed coil

- Fixed coil value

The value of the connected fixed coil is entered in Ampere (A).

- Feedback fixed coil

Indicates whether the fixed coil is switched on. Can also be sent to the regulator through a binary input.

Settings

Setting	Description
OFF:	A fixed coil is not available or the fixed coil is always OFF.
ON	The fixed coil is always ON.
Switch	The REG-DP/ REG-DPA gets the information about the switching status (ON or OFF) through a binary input or the SCADA system (BIF 30:Fixed coil)

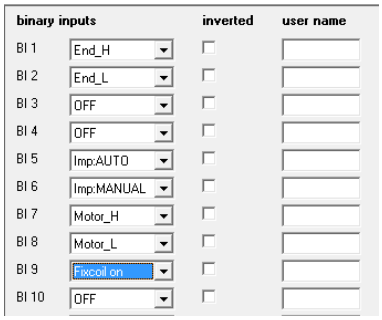


Figure 104: Parameterization of binary input 9 with feedback from the fixed coil

- Fixed coil control

The regulator can control the fix coil (if desired) when the adjustment range of the coil that is regulated by REG-DP/ REG-DPA is not sufficient.

Settings:

Setting	Description
OFF:	The fix coil is not controlled by the REG-DP/ REG-DPA
ON	The fix coil is always on through the REG-DP/ REG-DPA
<AUTO>	The REG-DP/ REG-DPA can automatically switch the fix coil on or off when the adjustment range for the automatic coil is not sufficient

Additional values for the fix coil that are only visible when current injection (CI feature) is used:

- Quality of the fix coil

The quality of the fix coil is: $Q = \frac{imag(I_{fix})}{real(I_{fix})}$

Only calculated when current injection is used with available fix coil information.

- Use fix coil value

Settings:

Requires the P-coil to measure the current. This function only makes sense when the ENEL feature is used together with EDC-Sys.

- Measured fix coil

See comments on 'Use fix coil' – cannot be changed

- Measured quality

See comments on 'Use fix coil' – cannot be changed

11.4.3 SCADA system

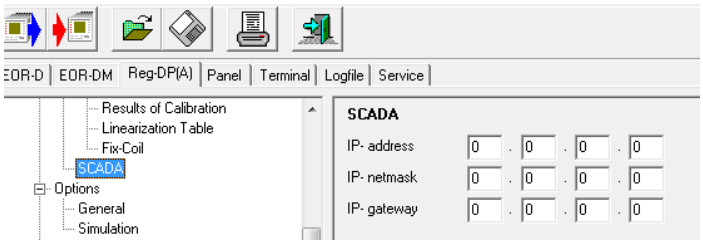


Figure 105: Menu item SCADA system

This is where the network parameters are set for the connected protocol card (REG-PE or REG-PED).

Every time the REG-DP/ REG-DPA is restarted, these settings are sent to the protocol card through the COM2 connection.

11.5 Menu item Options

The parameters for the regulator's general properties are described here.

11.5.1 General

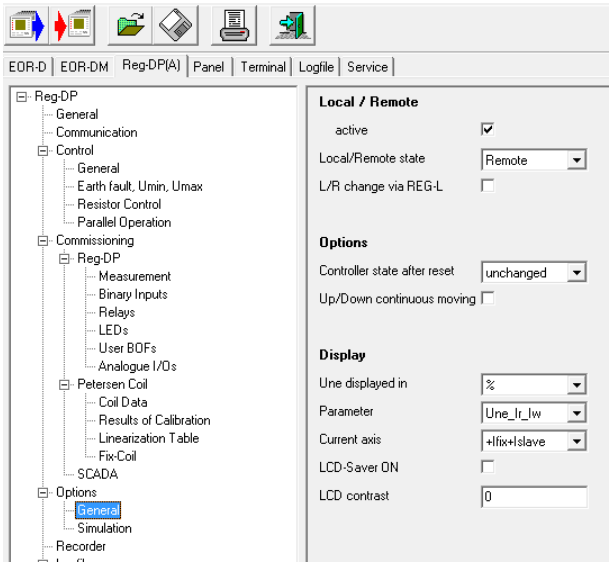


Figure 106: Menu item General (Options)

11.5.1.1 Local/Remote

- Active

Activating this function enables the local/remote key on the REG-DP/ REG-DPA.

Default setting: Active

- Local/Remote state

Defines the state in which the local/remote key on the REG-DP/ REG-DPA is set after the function has been activated for the first time.

Default setting: Local

- L/R switch with REG-L

If this value is set to active, the REG-DP/ REG-DPA's local/remote state can also be switched through the SCADA system.

Default setting: Inactive

11.5.1.2 Options

- Reset behaviour

The state to which the regulator should switch after an auxiliary voltage loss on the regulator is set here.

Settings:

Value	Description
Unchanged	If the REG-DP/ REG-DPA was previously in AUTO mode, it will resume regulation as soon as the supply voltage has been restored
MAN	The REG-DP/ REG-DPA switches into MAN mode after the supply voltage has been restored

- Higher/Lower continuous operation

If this value is set to active, a long press (2 seconds) of the Higher or Lower key will set the position command for the coil to Locking. The Higher or Lower command will be output until the Higher or Lower key is pressed again.

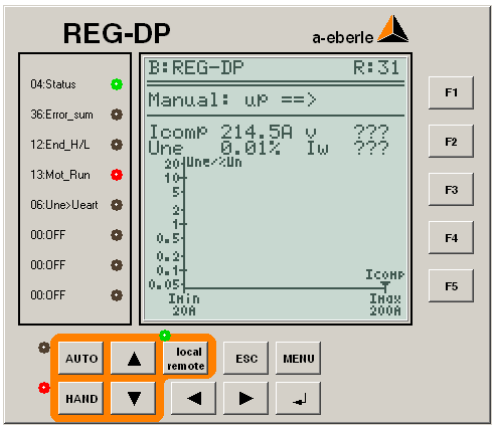


Figure 107: Symbol on the display for continuous operation ==>

Continuous operation is indicated in the second line of the REG-DP/ REG-DPA's display by this symbol == >.

11.5.1.3 Display

- **Display Une in**

Settings:

Value	Description
%	Uen in % of the nominal value (100 V)
V	Uen as secondary value of the voltage transformer in V
kV	Uen as primary value of the voltage transformer in V

- **Parameters**

Settings:

Value	Description
k_v_d	Unbalance k, detuning v and damping d of the grid
Une_Ir_Iw	Zero sequence voltage Une, resonance current (I_{CE} of the grid) Ir and expected residual current

- **Current as**

The following options are available to display the scale range from Imin to Imax on the regulator:

Value	Description
+Ifix	The value of the fixed coil (if parameterized) is added to the value of the own coil and displayed as **Icomp**
+Ifix+Islave	The value of the slave coil in parallel operation of two regulators is added to the value of the own coil and the fixed coil (if parameterized) and displayed as **Icomp**
Only_Ipos	Only the value of the regulated coil, which is displayed as **Ipos**

- LCD screensaver

The **backlight switches off after 15 min** if a RG-DP(A) key hasn't been pressed.

  - Activated

If this parameter is enabled, the REG-DP/ REG-DPA's **graphic display switches off** until the next time a key is pressed.

- LCD contrast

The display's contrast can be optimized to the actual installation situation.

Default value: 0

11.5.2 Simulation

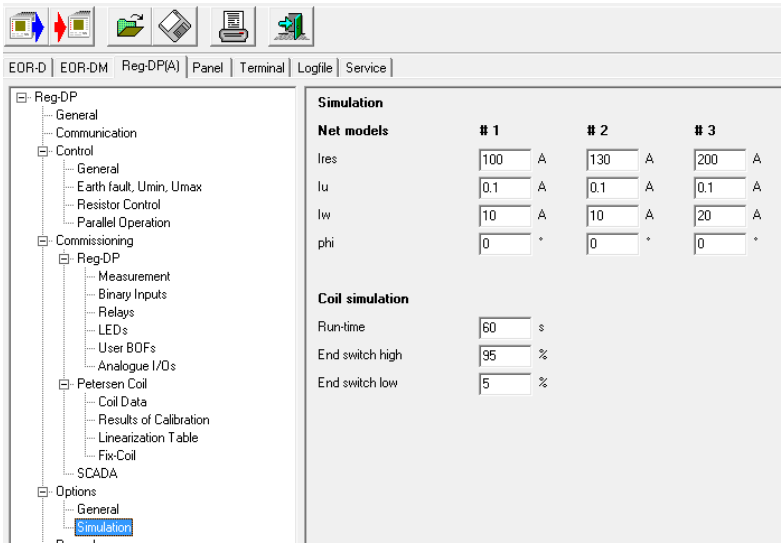


Figure 108: Menu item Simulation

The REG-DP/ REG-DPA also has parameters for three example grids.

No adjustment commands can be run on a coil during a simulation.

- Grid models

Parameters	Description
Ires:	Network resonance point
Iu:	Unbalance current Iu defines the maximum zero sequence voltage
Iw:	Residual current Small Iw currents produce a sharp resonance/V curve, big Iw currents a dull resonance/V curve
Phi:	Defines the phase of the zero sequence voltage at the resonance point in relation to phase L1

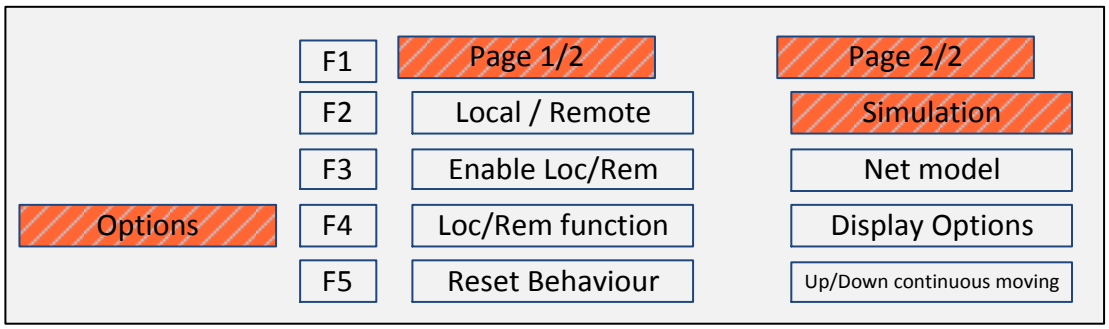
- Coil simulation

The following three parameters are used to define the coil parameters for the simulation.

Parameters	Description
Coil runtime:	Runtime of the coil from the upper to the lower end switch in s
End switch Higher:	Value of the potentiometer at the upper end switch in %
End switch Lower:	Value of the potentiometer at the lower end switch in %

11.5.2.1 Activating simulation mode on the REG-DP/ REG-DPA

Once the grid parameters have been set, simulation mode can be activated from the REG-DP/ REG-DPA's menu.



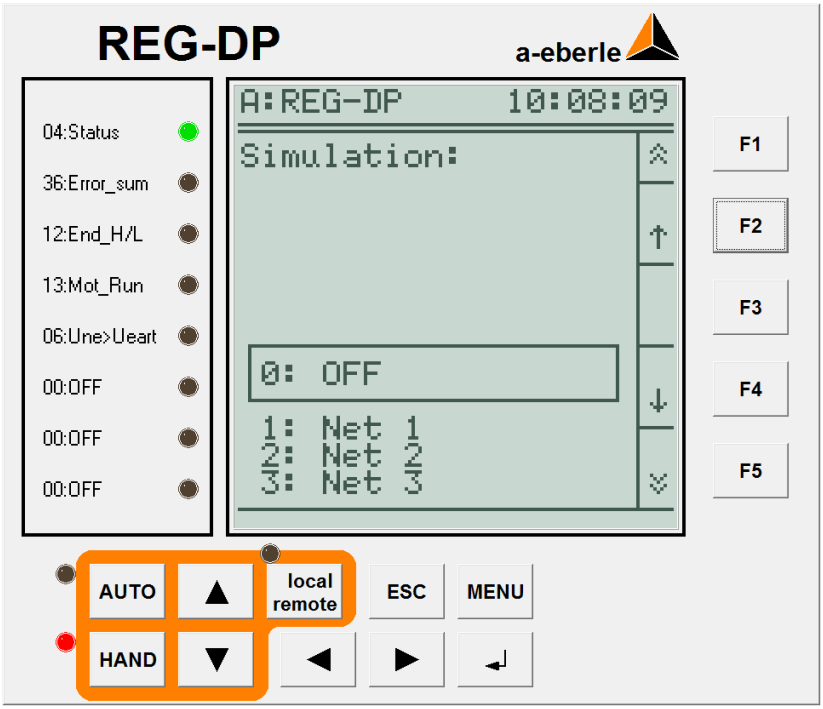


Figure 109: Selecting the grid model (1, 2 or 3) to start the simulation

After you have selected the grid model, go back to the start screen (long press of ESC key).

The REG-DP/ REG-DPA indicates that it is in Simulation Mode 1.

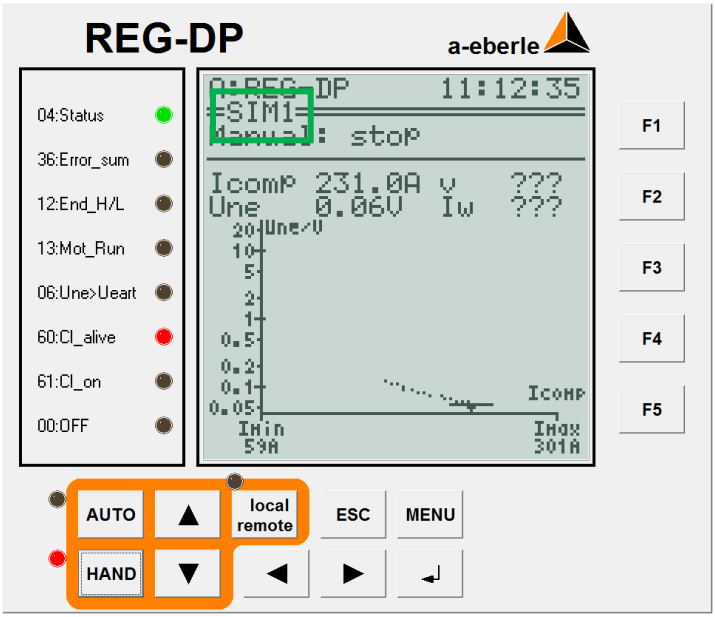
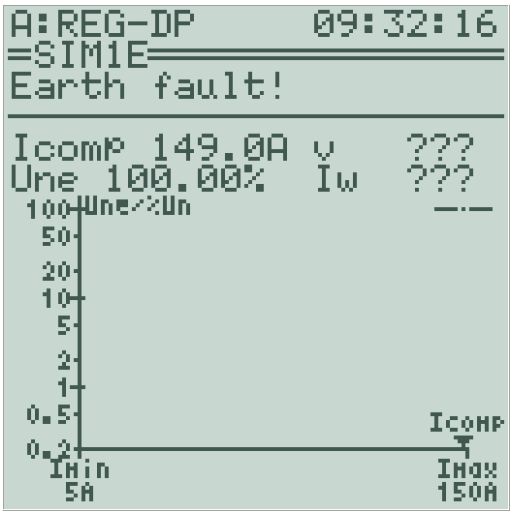


Figure 110: SIM1 = Simulation mode 1 (grid1) selected

11.5.2.2 Description of the function keys in simulation mode

Function key	Description
F1	Browse between screens
F2	Simulate an earth fault for the selected/simulated grid Ex.: SIM1E = Earth fault for grid model 1 
F3:	Switch to grid model 1 SIM1 is displayed
F4	Switch to grid model 2 SIM2 is displayed
F5	Switch to grid model 3 SIM3 is displayed

11.6 Menu item Recorder (recording of measured values)

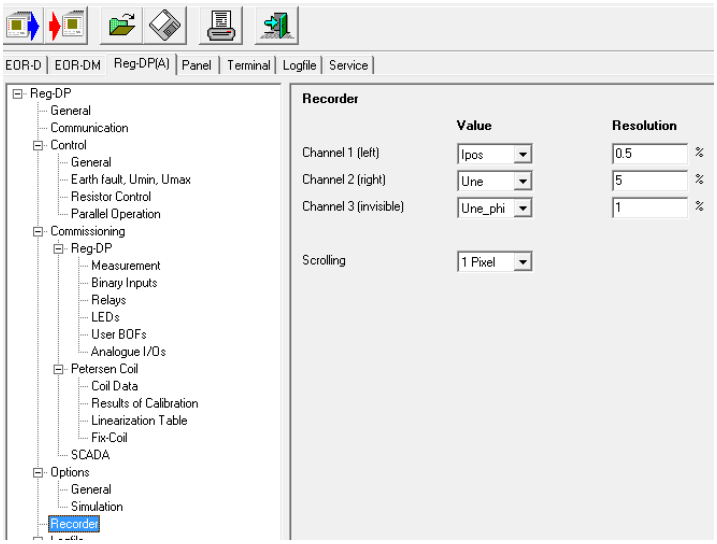


Figure 111: Menu item Recorder (default allocation of the three recorder channels)

Important values that document the quality of the regulation are stored in the REG-DP/ REG-DPA and can be displayed as a graphic in recorder mode.

Three recording channels are available.

The first two channels can be displayed on the regulator's screen as timeline diagrams. The third channel cannot be displayed but is saved.

The recorder data can be downloaded on the Logbook tab in WinEDC.

Each channel can be assigned the following measurands:

Measured value	Description	Reference value for resolution
---	No recording	---
Une	Zero sequence voltage (50 Hz component)	momentary Une
Une_Phi	Angle between Une and Usync	360°
I1	Current from channel I1	I_nominal
I1_Phi	Angle between I1 and Usync	360°
I2	Current from channel I2	I_nominal
2_phi	Angle between I2 and Usync	360°
Ipos	Coil position in A	Imax (coil end value in A)

The memory is designed to save a new value only when a value changes, meaning that the values for the resolution relate to changes to the measured value in %.

Example:

Une is entered as measurand for channel 2. The resolution is 5%. If the current/momentary value of Une changes by 5%, a new entry is written to memory.

11.6.1 Viewing the recorder file on the REG-DP/ REG-DPA's screen

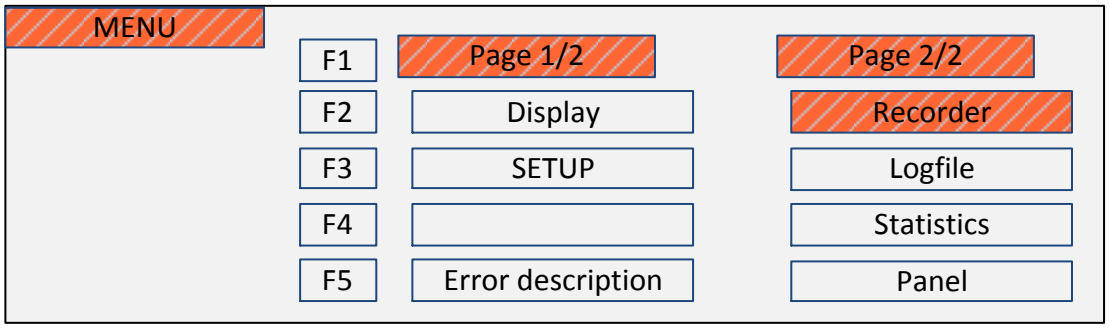


Figure 112: Selecting recorder data in the menu

For more information, see Chapter 9.4.3.

11.7 Logbook

The P-coil's regulation process is complex, with and without current injection. In order to resolve errors, all of the parameters need a subset. Filters can be defined on the next two parameter tabs. This is where the parameters for which a change is entered in the logbook are set.

11.7.1 Events BI/BO event filters

All changes to the binary inputs, relay outputs, binary input functions and binary output functions are recorded in the logbook.

Double clicking the field with the X hides the entry in the logbook.

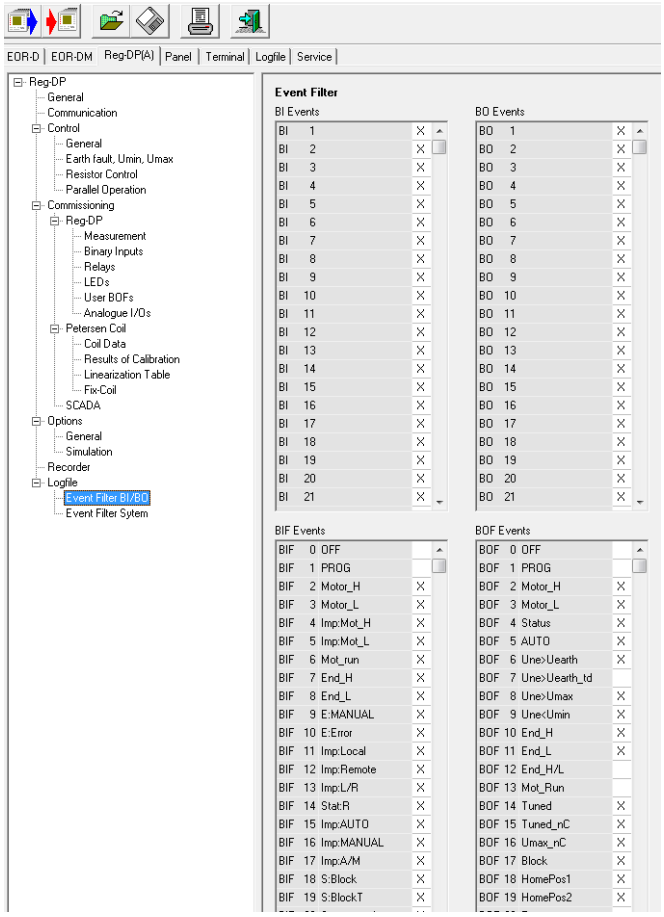


Figure 113: Logbook entries for selected input and output functions

BI events	:	Binary inputs
BO events	:	Binary outputs
BIF events	:	Binary inputs that affect the regulation process
BOF events	:	Binary outputs (relays) that affect the regulation process

11.7.2 Events Event filter system

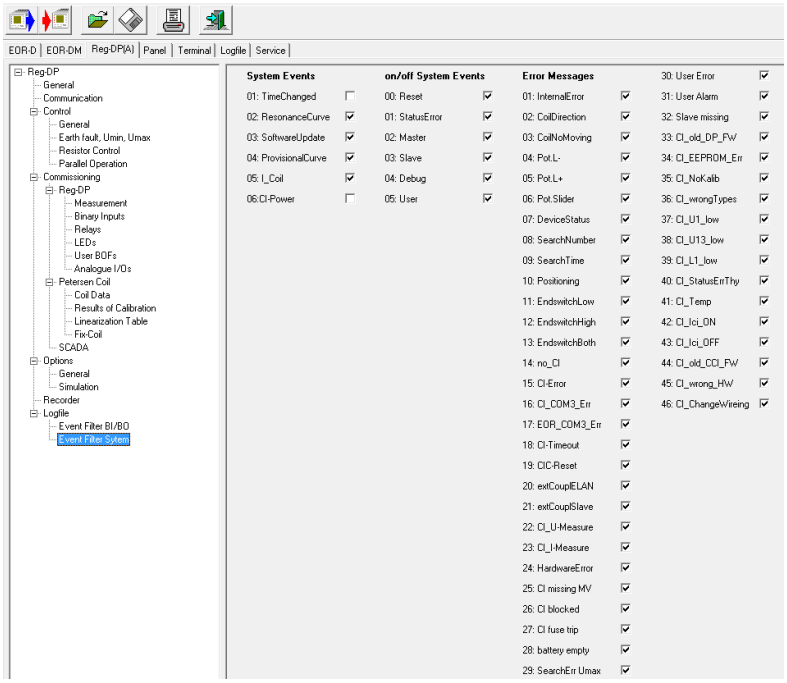


Figure 114: Possible logbook entries for the regulation process (incl. current injection)

This where the system events that are recorded in the logbook are selected.

Note:

If the REG-DP/ REG-DPA has a SCADA connection, its time is synchronized every minute. In this case, system event 01 Time should not be recorded in the logbook. An entry is made for this event every time something changes, meaning that the logbook would quickly fill up with unimportant time synchronization events. The memory is limited and important information could get lost.

11.7.2.1 System events

No.	Name	Description
1	Time	When the time is adjusted by more than ca. +-100..200 ms
2	Resonance curve	The values of the newly determined resonance curve are recorded in the logbook Logbook entry: `ResonanceCurve Ice= 99.6 A Iw= 10.1 A Ures= 0.99 V UresPhi= 0.0° Ifix= 0.0 A Iext= 0.0 A (Ipos + Ifix + I_slave)`
3	Software update	New firmware was installed Logbook entry: `Firmware version 2.4.08 -> 2.5.05`
4	Provisional Curve	Estimated resonance curve during the search. The data have the same size as the resonance curve Not active if default setting
5	I_coil	Current through the P-coil when an earth fault occurs Details: Ib= 281.64 A, Iw= 9.48 A, Une= 11130.63 V, Phi=-175.63°
6	CI-Power	Current Injection Phase and Power Details: CI-Phase=L1 I=100% Une=4.69% (maxUne=100.0%)

11.7.2.2 Incoming/outgoing system events

No.	Name	Description
0	Reset	When the device is switched ON and OFF Logbook entry: outgoing:PowerDown/incoming:PowerUp
1	StatusEr-ror	
2	Master	For parallel operation, as soon as the device is working as master (even if the slave is blocked)
3	Slave	For parallel operation, as soon as the device is working as slave regulator (not in MAN mode and if the regulator is blocked)
4	Debug	Only used for internal purposes. Not supported in the WinEDC logbook
5	User	From FW version 2.3.36: Logbook entries for each REG-L can be created by background program and displayed in the logbook with text. They can be downloaded in WinEDC.

11.7.2.3 Error messages

No.	Name	Description	Message/Response
1	InternError	The error number is written in the logbook and must be evaluated by A. Eberle.	
2	CoilDirection	Coil is moving in the wrong direction	- stops coil movement - goes into MAN state - goes into 'Error' state - BOF 32 'E:Dir' incoming - BOF 34 'Error' incoming - BOF 35 'Error td' incoming - BOF 36 'Err_Sum' incoming
3	CoilNoMoving	Coil is not moving	- stops coil movement - goes into MAN state - goes into 'Error' state - BOF 33 'E:Move' incoming - BOF 34 'Error' incoming - BOF 35 'Error td' incoming - BOF 36 'Err_Sum' incoming
4	Pot L-	Potentiometer: Cable break on L-	- stops coil movement - goes into MAN state - goes into 'Error' state - BOF 39 'PotError' incoming - BOF 34 'Error' incoming - BOF 35 'Error td' incoming - BOF 36 'Err_Sum' incoming
5	Pot L+	Potentiometer: Cable break on L+	- stops coil movement - goes into MAN state - goes into 'Error' state - BOF 39 'PotError' incoming - BOF 34 'Error' incoming - BOF 35 'Error td' incoming - BOF 36 'Err_Sum' incoming
6	Pot slider	Potentiometer: Cable break on slider contact	- stops coil movement - goes into MAN state - goes into 'Error' state - BOF 39 'PotError' incoming - BOF 34 'Error' incoming - BOF 35 'Error td' incoming - BOF 36 'Err_Sum' incoming
7	DeviceStatus	Device status; internal ERROR	- BOF '4:Status' - BOF 36 'Err_Sum'

No.	Name	Description	Message/Response
8	Search Number	Number of allowed search cycles exceeded; search aborted. Regulator displays an error	Search is aborted. Regulator moves into the predefined position. The regulator stays in 'AUTO' mode! BOF 37 '>n_Search' BOF 29 'Alarm' BOF 30 'Alarm td' BOF 36 'Err_Sum'
9	SearchTime	Search unsuccessful! Maximum motor runtime exceeded	Search is aborted. Regulator moves into the predefined position. The regulator stays in 'AUTO' mode! BOF 38 '>T_MotOn' BOF 29 'Alarm' BOF 30 'Alarm td' BOF 36 'Err_Sum'
10	Positioning	Target position for tuning point not reached (check positioning tolerance)	goes into 'Error' state goes into 'MAN' state BOF 34 'Error' BOF 35 'Error td' BOF 36 'Err_Sum'
11	Endswitch Low	End switch 'Lower' not found!	
12	Endswitch High	End switch 'Higher' not found!	
13	Endswitch Both	Check end switch; both are 'ON'	- goes into MAN state - goes into 'Error' state BOF 34 'Error' BOF 35 'Error td' BOF 36 'Err_Sum'
14	No CI	Current injection not available	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
15	CI error	Current injection error message With error number (#: <No>)	- goes into 'Error' state - goes into MAN state BOF '34:Error' BOF '35:Error_td' 'BOF '36:Err_Sum' BOF '63:CI_Error'

No.	Name	Description	Message/Response
16	CI COM3 Err	Error communicating with current injection (#: <No>)	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
17	EOR COM3 Err	Error communicating with EOR-DM (EDCSys) (#: <No>)	BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '82:EOR_missing'
18	CI timeout	Current injection is not responding	- goes into 'Error' state - goes into MAN state BOF '34:Error' BOF '35:Error_td' 'BOF '36:Err_Sum' BOF '63:CI_Error'
19	CIC Reset	Current injection reset	Currently not used
20	extCouplELAN	Communication error between E-LAN and slave (#: <No>)	Aborts the check with the result: 'No external connection' => No parallel operation, but normal search continues to run => No more messages! up to v 2.3.35 - goes into 'Error' state BOF '34:Error' BOF '35:Error_td' 'BOF '36:Err_Sum'
21	extCouplSlave	Slave: Uen measured values not available (#: <No>)	Aborts the check with the result: 'No external connection' => No parallel operation, but normal search continues to run => No more messages!
22	CI U Measure	CI U measured value too small (#: <Channel>)	A new search is started; if necessary 'emergency operation" BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum'
23	CI I Measure	CI I measured value too small (#: <Channel>)	A new search is started; if necessary 'emergency operation" BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum'

No.	Name	Description	Message/Response
24	Hardware error	Firmware is not compatible with the device hardware	goes into 'Error' state
25	CI MV missing	One or more measured values for the CI search algorithm are missing! Check the input functions of the measurement inputs!	A new search is started; if necessary 'emergency operation" BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum'
26	CI blocked	Current injection blocked!	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '62:CI_block' BOF '64:CI_missing’
27	CI fuse trip	An automatic CI fuse has blown!	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
28	Battery empty	Battery is empty	No more responses BOF '4:Status' BOF '36:Err_Sum' BOF '58:Battery empty'
29	SearchErrUmax	Search unsuccessful! Une > Umax could not be kept	Search is aborted. Regulator moves into the predefined position. The regulator stays in 'AUTO' mode! BOF 29 'Alarm' BOF 30 'Alarm td' BOF 36 'Err_Sum'
30	User error	User-defined error (#: <No>) Is created by a background program	- goes into 'Error' state - goes into MAN state BOF 34 'Error' BOF 35 'Error td' BOF 36 'Err_Sum'
31	User alarm	User-defined alarm (#: <No>) Is created by a background program	BOF 29 'Alarm' BOF 30 'Alarm td' BOF 36 'Err_Sum'

No.	Name	Description	Message/Response
32	Slave missing	Slave regulator not available	Parallel operation deactivated BOF 29 'Alarm' BOF 30 'Alarm td' BOF 36 'Err_Sum'
33	CI_old_DP_FW	Firmware on REG-DP is too old for CIC! => Update firmware!	If necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
34	CI_EEPROM_Err	EEPROM error in the CIC	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
35	CI_NoKalib	Error: CIC is not calibrated!	If necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
36	CI_wrongTypes	Error: No or unsuitable CI(C) variants have been configured in the CIC.	If necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
37	CI_U1_low	CIC error: Voltage U1 too small => Check Q1 fuse	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’

No.	Name	Description	Message/Response
38	CI_I13_low	CIC error: Uns voltage is too high to search! (if necessary, check fuse Q1)	AUTO: A search that is in progress is aborted and restarted; If necessary 'emergency operation' MAN: CI is switched off BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
39	CI_L1_low	CIC error: Voltage Usync (L1) missing	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
40	CI_StatusErrThy	CI Error: Control electronics are defective	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
41	CI_Temp	CI Error: Control electronics are too hot	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
42	CI_Ici_ON	CI error: Injection current is too small! => Check fuse F1!	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’
43	CI_Ici_OFF	CI Error: Control electronics are defective! Leakage current at thyristors too big	A search that is in progress is aborted and restarted; if necessary 'emergency operation' BOF '29:Alarm' BOF '30:Alarm_td' BOF '36:Err_Sum' BOF '64:CI_missing’

No.	Name	Description	Message/Response
44	CI_old_CIC_FW	The CIC firmware is too old! Update the firmware!	None
45	CI_wrong_HW	CI feature does not fit the recognized CI hardware	None
46	CI_ChangeWiring	Caution: The wiring of the CI measurement inputs does not meet the standard! Please rewire and reset the parameters for knu/kni!	The functions of the CI measurement inputs are parameterized to the default functions; all knu/kni are reset to 1.0

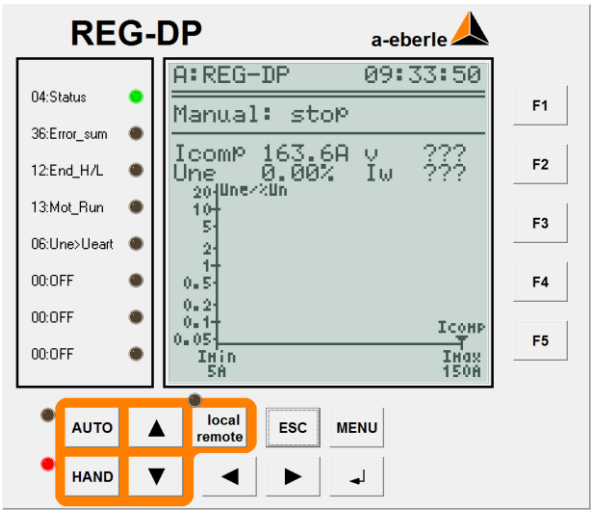
12. Using WinEDC to set-up the REG-DP/ REG-DPA

12.1 Basic functions of the WinEDC software

- The WinEDC software is used to set-up and configure the different devices in the EORSys, REG-Sys and EDCSys system family.
  - EOR-D: Earth fault detection relay for various detection methods
  - EOR-DM: Earth fault detection system for up to 40 feeders – can only be used together with current injection
  - REG-DP/ REG-DPA: P-coil regulator in different versions

In addition to the information on parameterizing EOR-D, EOR-DM and REG-DP/ REG-DPA, you will also find information on the following functions:

- Panel:
  The 'Panel' tab displays the interface of the device being operated (mostly REG-DP/ REG-DPA) as realistically as possible. Users can perform all of the functions on the regulator from their PC.



- Terminal:
  The 'Terminal' window enables users to communicate with the directly connected regulator or the devices connected through the E-LAN in the REG-L programming language. REG-L is used to write background programs, for example, that extend the standard functions based on the user's wishes.
- Logbook:
  The logbook and recorded data that are stored on the regulator can be downloaded in the 'Logbook' tab. All events are written to the logbook with time and date. Logbook and recorder data are used to analyse the regulator's behaviour.
- Service:
  The service screen helps simplify the commissioning process. Here, you can check all binary input and output states and analogue channels at a glance and overwrite them temporarily.

12.1.1 Comparing parameter files

The ‘Compare’ menu enables users to compare parameters sets with each other and display or print out the differences.

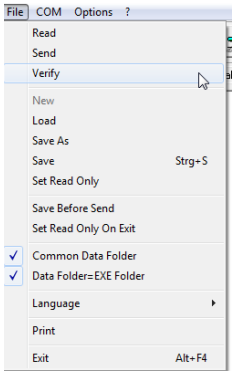
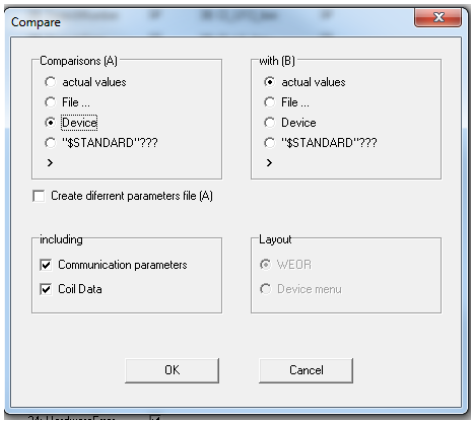


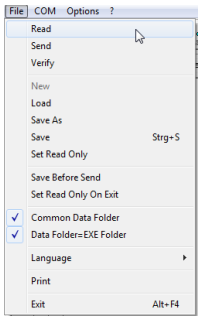
Figure 115: Select Compare to verify parameters



The parameter file in one regulator can be compared with that of another. It is also possible to compare the parameters that are open in WinEDC with the parameters on the device.

The difference can be output to a printer, a file (PDF) or the display.

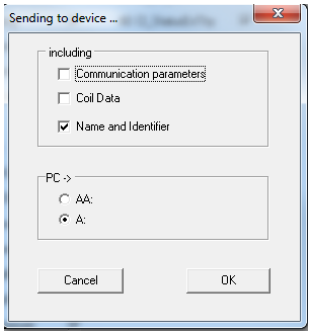
12.1.2 Menu item File



Get:

Transfer data on the device to the PC

Before the process starts, all of the devices that are connected to the E-LAN are displayed. Select the regulator whose parameters you want to transfer to the PC.



Send:

Transfer the current parameters in WinEDC to the device

To avoid sending the whole parameter file, a selection window displays in which you can select the parameters you wish to transfer.

Communication parameter and coil data – calibration and linearization results – should not be transferred each time. When parameters are transferred from another station, the coil data will not match 100%.

The address (of the regulator) must also be clearly defined.

AA: This is where the parameters are sent to the regulator that is directly connected to the PC.

A: The parameter set is sent to the regulator with the ID 'A:' (same as in the parameter set that is loaded).

Load:

This command starts the standard open dialogue (Explorer). A random, already saved parameter file can be loaded in WinEDC.

Save:

The current configuration settings are stored under the current file name.

Save as:

The current configuration settings are stored under a new file name and directory.

Write protection:

Write protection can be set to protect a parameter file from being changed.

Automatic save before send:

The parameter set is saved before it is sent to the device.

Automatic write protection on exit:

If this parameter is set, the parameter set is saved to a read-only file before the program is exited.

Common directory:

If this parameter is set, all of the parameter files, log files and error logs are written to the same directory.

Data directory = Exe directory:

When this item is selected, all data are automatically written to the directory in which WinEDC was started.

Language:

Available languages:

- Deutsch
- English
- Italiano

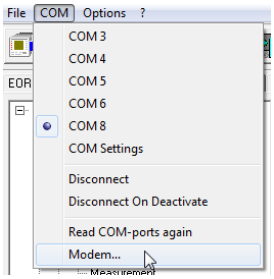
Print:

Prints the current parameter set.

Exit:

Exits the WinEDC software.

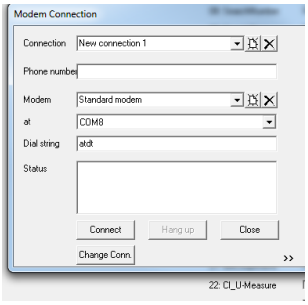
12.1.3 Modem connection:



The modem connection is defined in the menu item 'COM' → Modem.

It is used to connect to a REG-DP/ REG-DPA, that has an external modem connection and is installed in a remote station.

The following is a description of the modem connection fields:



Connection:

- An existing station can be dialled
- A new station can be defined
- An existing station can be deleted
- The name of an existing station can be changed

Number:

Only digits can be entered in this field. Characters that make numbers easier to read are allowed. Examples: '-' 'space' and '/' are allowed

Modem:

The following modems can be used:

- Standard modem
- Standard modem in PBXs, modifies the beginning of the dial string:

  enables a specific COM interface to be dialled and can be a direct modem connection (external or internal modem) or a COM server that can be reached through the network.

Dial string:

Based on the previous settings, a dial string is suggested and can be changed in this field.

Status:

Information field that contains details about the connection situation.

Connect:

The dial string is sent to the selected modem. The answer is logged in the Status field.

Note: The cursor should be in the field until the connection has been established.

Hang up:

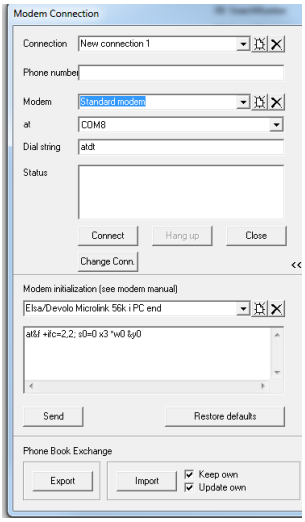
Ends an existing connection.

Exit:

Exits the Modem connection menu. Before the menu can be exited, the existing connection must be ended with **Hang up**.

>> :

This key expands the view for the modem connection with the initialization options.



Modem initialization:

The modems on the regulator and PC side must be initialized with different strings.

Our standard modems have predefined initialization strings that are sent to the modem that is connected to the PC.

Strings can also be added to, deleted or changed.

Send:

Click this button to send the selected string to the previously selected COM interface.

In most cases, the COM interface will have already been selected because a lot of modems automatically synchronize to the transfer rate.

The ability to save the settings in the modem is integrated in the init string.

Copying the contact list

Telephone numbers are stored in WinEDC.

A simple copy program was added to facilitate the exchange/transfer of the contact list to other computers.

13. Commissioning current injection

Once the REG-DP/ REG-DPA has been commissioned, additional steps must be taken to commission CI. The easiest way to commission current injection is to work through the steps in the sequence of the chapters they are discussed in.

General

- It is not necessary, but it is possible, to inject current and move the P-coil at the same time (the resonance curve is calculated and not determined by moving the P-coil).
- The process used to calculate the grid parameters is described in Chapter 2.5.2.
- Currents up to 14 A can occur on the secondary side for a 500 V power auxiliary winding. The cross-section of the power supply line must be laid out accordingly.

Current injection features:

- Two frequencies are used to calculate the grid parameters
- Switches off or reduces the current injection, when the coil moves
- Fast calculation; takes place within a filter cycle (240 ms)
- Works on very symmetrical grids
- Calculation results immune to 50 Hz unbalance and crosstalk from the 50 Hz positive sequence system on the zero sequence system
- Cyclical current injection for the constant monitoring of changes in the grid

13.1 The basics of current injection

All of the known processes are based on the fact that zero sequence voltage is created either by the natural unbalance of the grid or by injecting a 50 Hz current. The general assumption is that the grid situation or the crosstalk behaviour of the load on the zero sequence voltage will not change during the calculation time. **Note that the calculation time can take anywhere from seconds to minutes.**

There are situations, however, in which this simplification is no longer allowed. For example, in industrial grids that are very symmetrical but show significant load fluctuations.

The CIF algorithm (Control by Injecting Frequencies) suppresses the 50 Hz component that is caused by the crosstalk from the load on the zero sequence voltage. Two frequencies that are **unequal to 50 Hz** are injected into the zero sequence system to estimate the grid parameters.

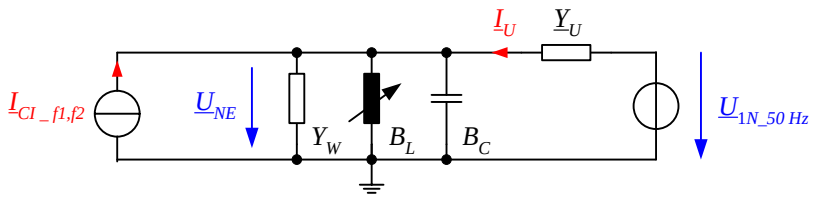


Figure 116: Simplified equivalent circuit for current injection

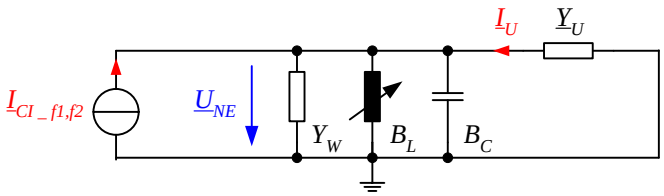


Figure 117: Simplified equivalent circuit with current injection unequal to 50 Hz

The simplified equivalent circuit with current injection in Figure 116 produces the equivalent circuit in Figure 117 when current with a frequency unequal to 50 Hz is injected.

The system's conductance – viewed from the current injection point – can be formulated for current injection as follows:

$$\underline{Y}_{CI\_fn} = \frac{\underline{I}_{CI\_fn}}{\underline{U}_{NE\_fn}} = \underline{Y}_U + Y_W + j(\omega_n C - \frac{1}{\omega_n L}) \qquad (1.33)$$

For symmetrical grids with small $\underline{Y}_U$, this results in:

$$\underline{Y}_{CI\_fn} = \frac{\underline{I}_{CI\_fn}}{\underline{U}_{NE\_fn}} \approx Y_W + j(\omega_n C - \frac{1}{\omega_n L}) \qquad (1.34)$$

If two frequencies f_1 and f_2 are used, two complex equations with three variables are created and can be used to calculate the grid parameters, without adjusting the P-coil. This approach leads to the following solutions:

$$Y_W = real\left\{\frac{\underline{I}_{f1}}{\underline{U}_{NE\_f1}}\right\} \qquad (1.35)$$

$$C = \frac{imag(\underline{Y}_{CI\_f1})\omega_1 - imag(\underline{Y}_{CI\_f2})\omega_2}{\omega_1^2 - \omega_2^2} \qquad (1.36)$$

$$L = \frac{1}{\omega_1(-imag(\underline{Y}_{CI\_f1}) + \omega_1 C)} \qquad (1.37)$$

Based on the assumption that the system is linear, both frequencies can be injected at the same time. The corresponding value $\underline{Y}_{CI\_fn}$ can also be determined at the same time, making it possible to quickly measure and determine the grid parameters. The measurement usually takes 240 ms.

A list of the main method advantages contains:

- Very fast measurement - a change in the grid topology is unlikely during the measurement time
- The process can be used in very symmetrical grids
- All P-coils incl. fixed coils in the grid are recognized

- Immune to 50 Hz crosstalk of the load
- Immune to 50 Hz measurement errors when measured on the open delta winding

Additional requirements for regulation with current injection

Based on the resonance curve and the normal grid operating characteristics, there are a few additional requirements for current injection.

1. It should be possible to change the amplitude of the injected current so it can adjust to the grid losses in different switching states. The current injection must have as little impact as possible on the zero sequence voltage because its absolute value is used as a criterion to detect earth faults. The losses are relatively small in small grids – there is little damping. This is why it's important to inject a lower current especially at the resonance point than further away from the resonance point
2. The injection frequencies should not contain any 50 Hz components.

13.2 Connecting the current injection

The right choice of measurement points, zero sequence voltage and measurement of the injected current when current injection is used is described in detail in the next chapter.

Only four connections are needed to retrofit current injection.

Connection	Notes
Supply voltage (230 V AC, L1-N)	Fused internally with a 16 A fuse CAUTION: Do not use an FI circuit breaker! Use an isolating transformer (S = 2.5 kVA) instead Use a 2.5 mm^2 cable
U_{NE}	Measurement of zero sequence voltage Ideal of a voltage transformer that is not measuring in the same magnetic circuit as the power auxiliary winding. Separate voltage transformer in the P-coil External voltage transformer Measurement on open delta winding on the busbar
PAW On the power auxiliary winding	Use a connection cable that is at least 2.5 mm^2
COM3 connection to REG-DP/ REG-DPA	4-wire RS-485 connection Use a shielded and twisted 2x2 core cable Small signal line!

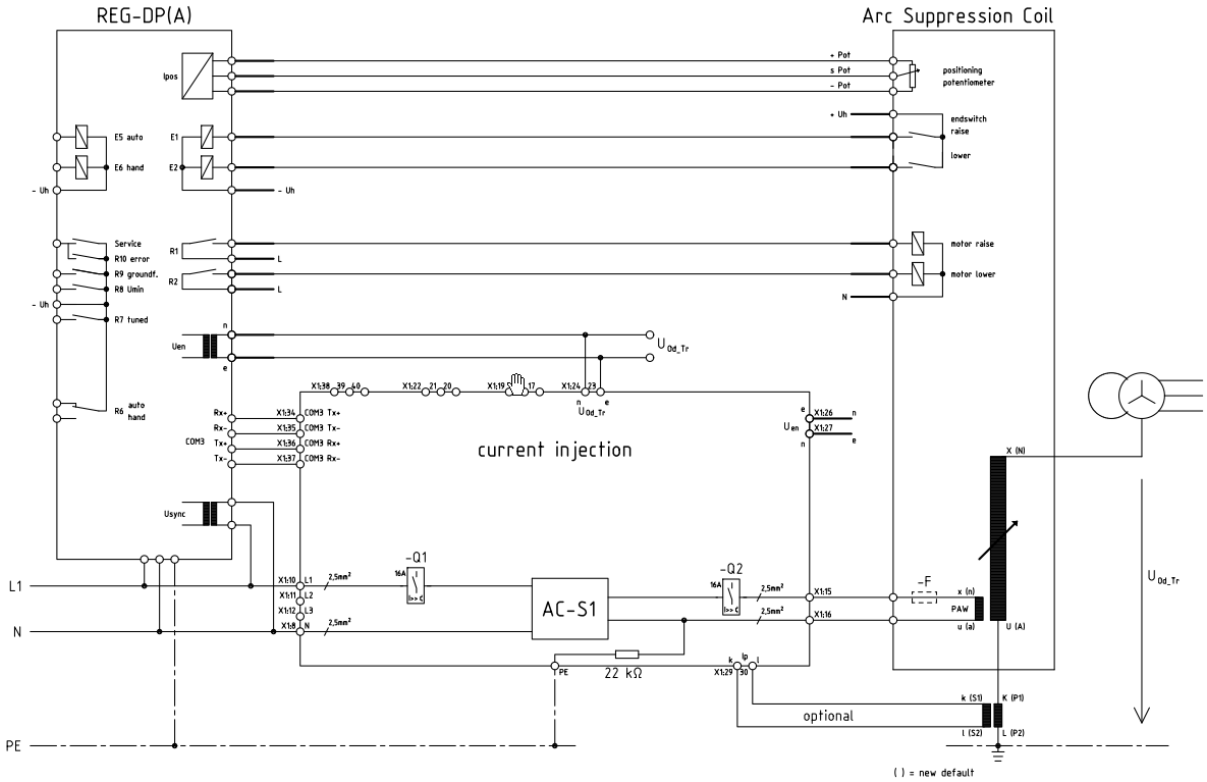


Figure 118: Current injection connection between the REG-DP/ REG-DPA and the P-coil

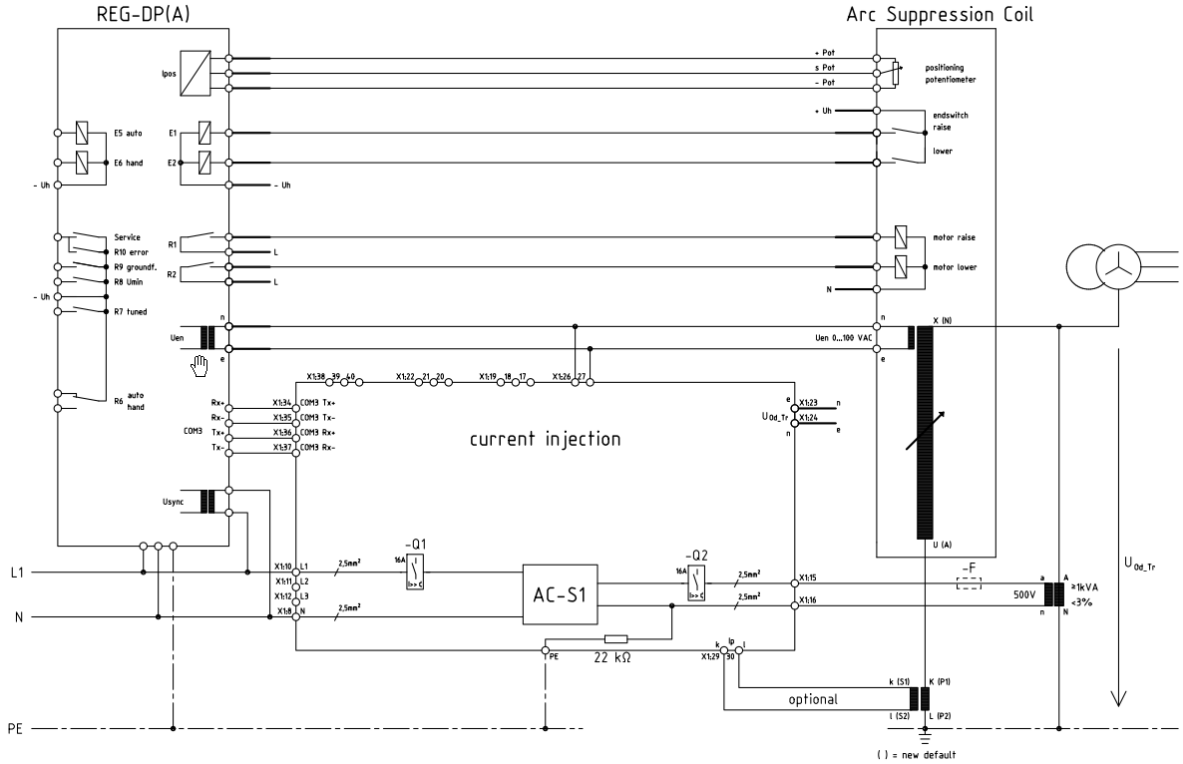


Figure 119: Current injection connection between the REG-DP/ REG-DPA and the P-coil for coils without power auxiliary winding

13.2.1 Standard control cabinets for current injection

13.2.1.1 Indoor installation (single)

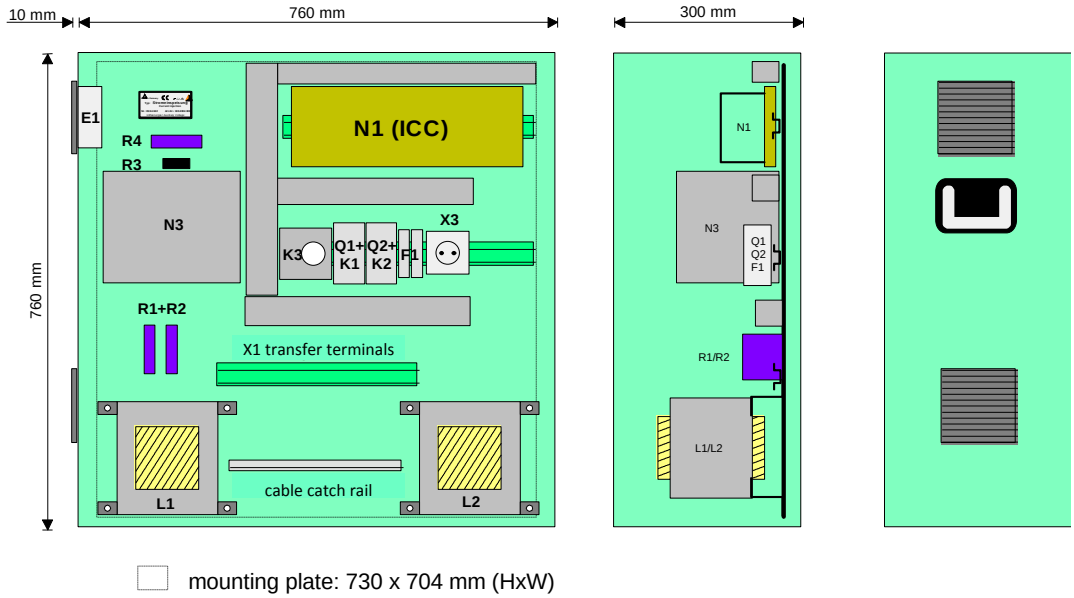


Figure 120: Current injection dimension drawing in control cabinet for indoor installation

13.2.1.2 Outdoor installation (single)

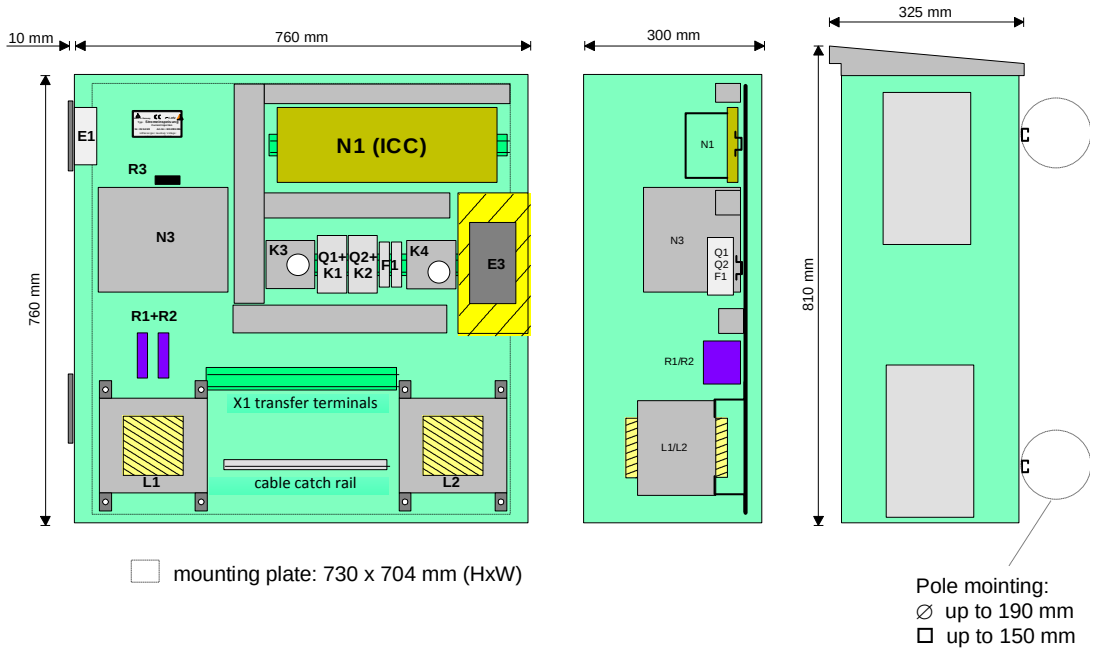
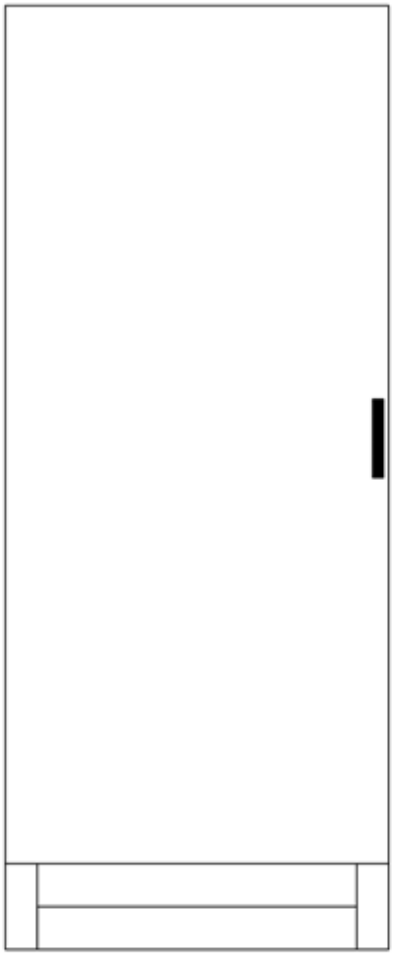
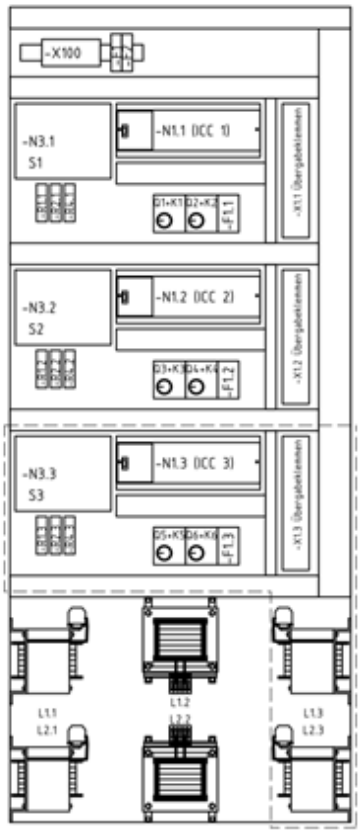


Figure 121: Current injection dimension drawing in control cabinet for outdoor installation

13.2.1.3 Indoor installation (triple)



Height: 2000 mm
Width: 900 mm
Depth: 600 mm
Base: 100 mm



Mounting plate: 1896x799 mm

Figure 122: Example control cabinet for indoor installation for three injected currents

13.3 Current injection options with and without 50 Hz component

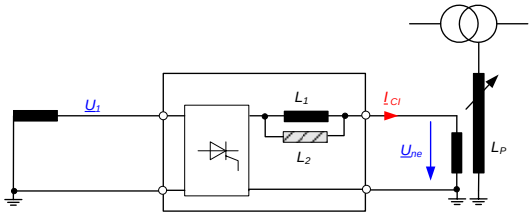


Figure 123: Simplified current injection diagram with three frequencies

The next figure shows the progression of the injected current for the activation displayed in Figure 123. In this case, the power auxiliary winding is earthed directly on the coil.

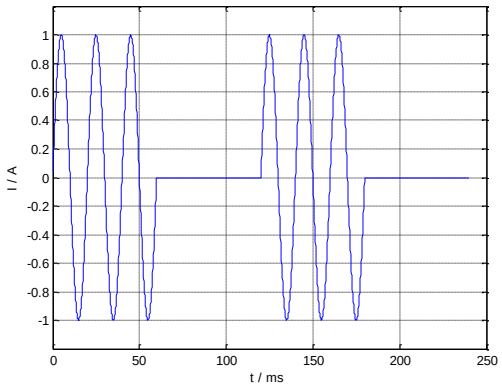


Figure 124: Example for the pulse pattern for injection with 50 Hz component

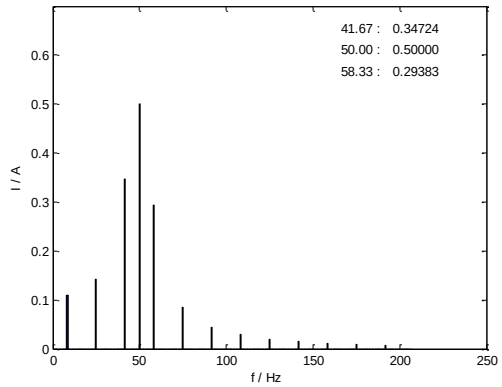


Figure 125: Frequency spectrum for injection with 50 Hz component

The main disadvantage of injecting with a 50 Hz component in the injection current is that the biggest part of this current is 50 Hz. This is clearly visible in Figure 125. The grid parameters are calculated using the current injection on the two adjacent frequencies 42 Hz and 58 Hz. Based on the size of the grid, the injected current may be too small to calculate the parameters correctly.

This can be prevented by rotating the phase of the injected current by 180° in the off time shown in Figure 124.

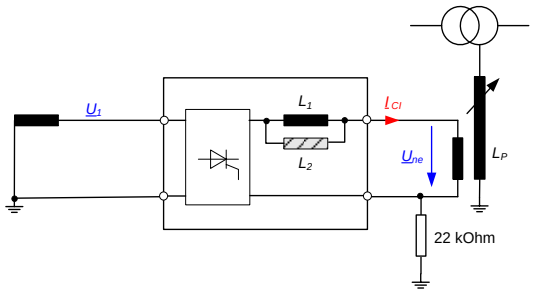


Figure 126: Simplified current injection diagram with only two frequencies (without 50 Hz)

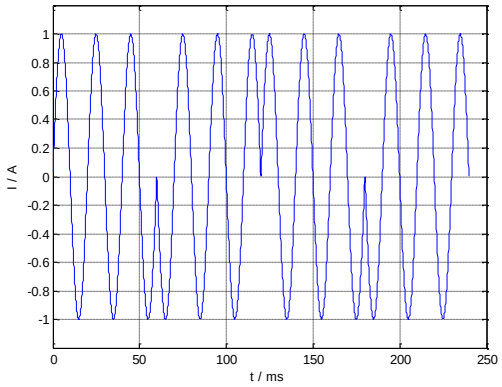


Figure 127: Example for the pulse pattern for injection without 50 Hz component

This activation shows that a direct earth connection to the P-coil's power auxiliary winding and a phase shift of 180° in the current injection can result in increased currents (and even short circuits). This is why the coil's auxiliary winding may not be directly earthed when this method is used.

The current injection cabinets that we deliver already contain the 22 kOhm resistor displayed in Figure 126. This guarantees the connection with the earth potential.

Note:

The coil's power auxiliary winding must not be earthed in this case. The 22 kOhm resistor displayed in Figure 126 is always delivered with the cabinet. Note that when the circuit in Figure 123 (with direct earthing of the **p**ower **a**uxilliary **w**inding) is used that the **earth** in the current injection cabinet is **on the same connection** as the earth for the PAW!

This has the advantage of having a higher current at the frequencies that are used to calculate the grid parameters.

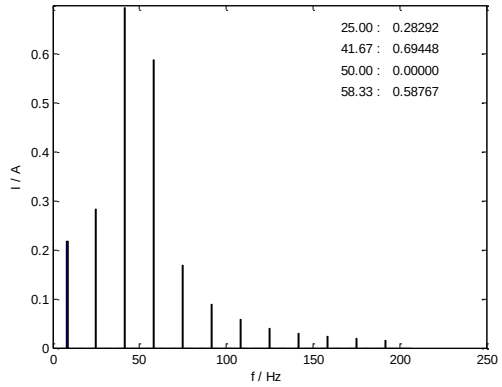


Figure 128: Frequency spectrum for injection without 50 Hz component

Figure 128 shows the frequency spectrum using the pulse pattern in Figure 127. Note that the 50 Hz component is no longer there.

The power of the current injection can be regulated any which way. The next figure shows the reduced current injection through phase angle control.

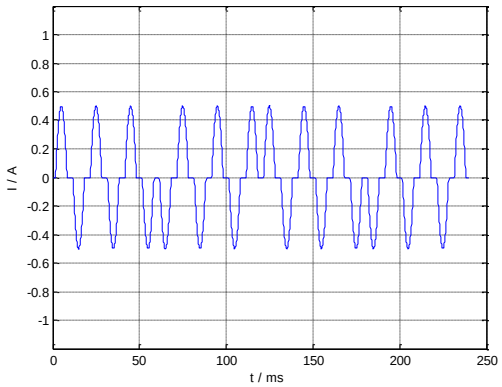


Figure 129: Example for a pulse pattern with reduced power

13.4 Configuration of the current injection controller (CIC)

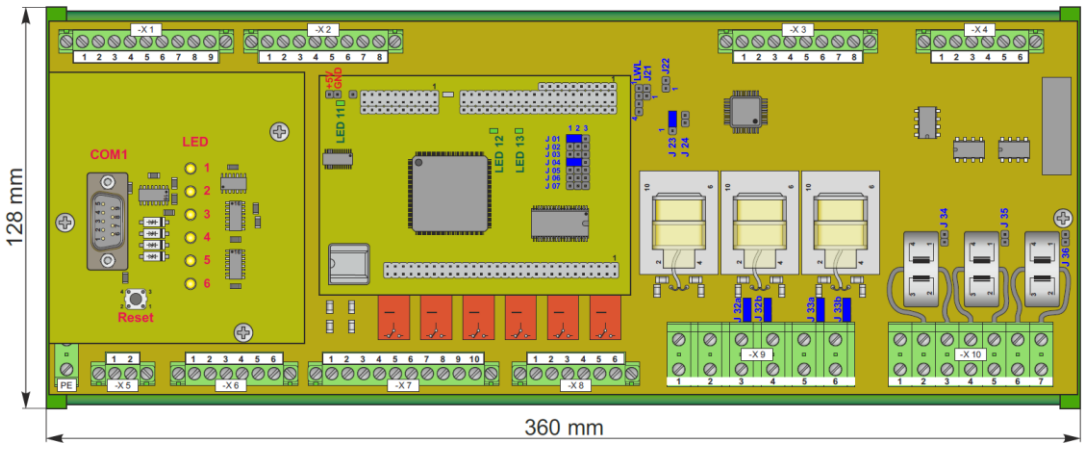


Figure 130: Dimensions of the current injection controller and position of all components

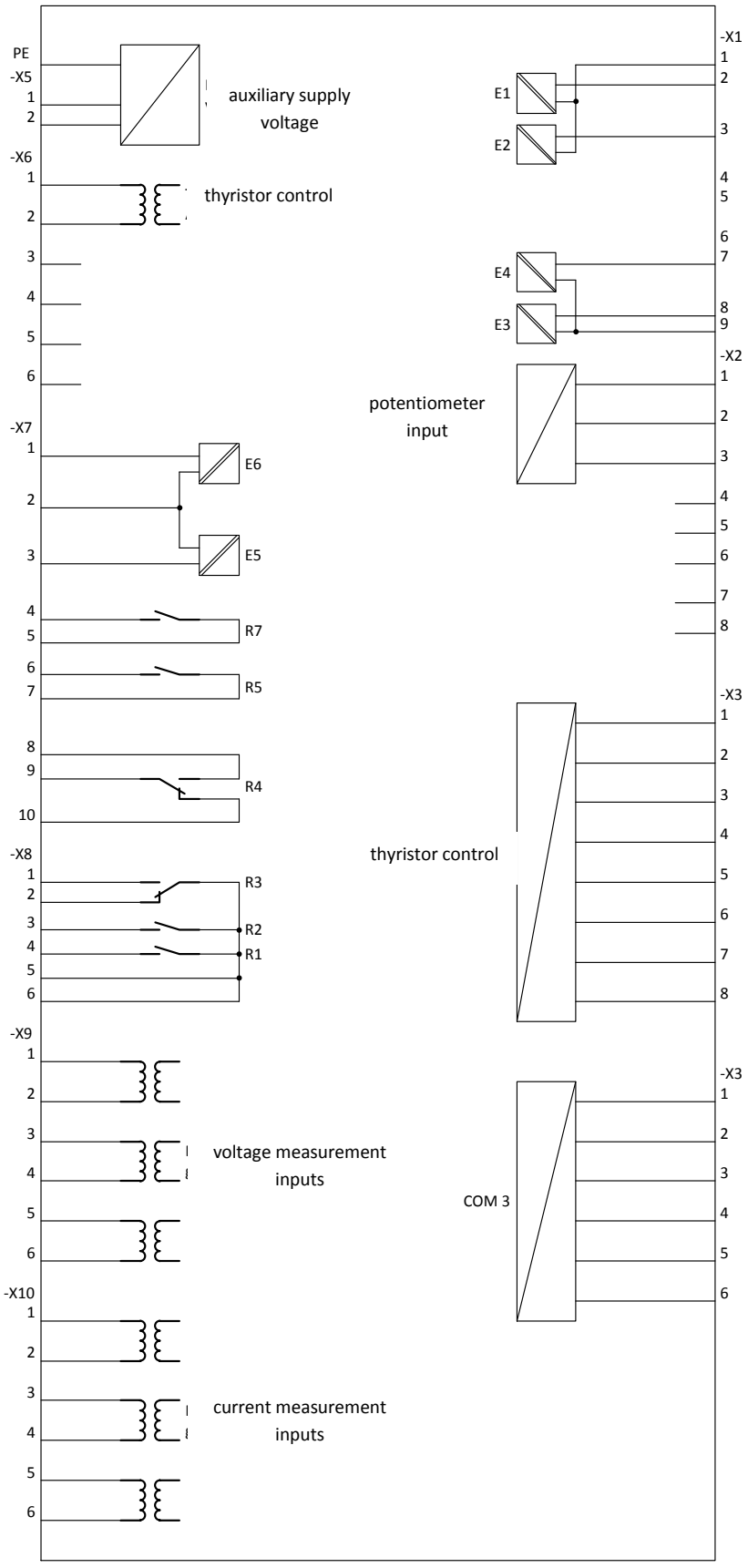


Figure 131: Terminal configuration of the CIC

13.5 Selecting the right measurement points for Uen when injecting current

The algorithm uses the measurement of the zero sequence voltage (Uen) and the injected current Ici to calculate the grid parameters.

The small algorithm (Uns, Ici - in the parameterization) can be used for most applications.

In this case, Uns corresponds to Une and also describes the zero sequence voltage. The zero sequence voltage can be tapped from the coil (Uns) or 'behind' the transformer from the busbar's open delta winding (specified here by Uod) if it always corresponds to the zero sequence voltage across the coil.

Measurement points for the different algorithms:

Measurement point	Algorithm Uod,Ici	Algorithm Uns,Ici	Algorithm Uns, Uod, Ins, If	Comment
$\underline{U}_{sync}$	☑	☑	☑	Synchronization voltage
$\underline{U}_{NS}$ (Une)		☑	☑	Zero sequence voltage on P-coil
$\underline{U}_{0D}$	☑		☑	Zero sequence voltage on open delta winding (on busbar)
$\underline{I}_{CI}$	☑	☑	☑	Injection current
$\underline{I}_{0\_S}$			☑	Current through the P-coil
$\underline{I}_{0\_fix}$			☑	Current through an additional fixed coil

Note:

The Uns, Uod, Ins, If algorithm was initially developed for the ENEL feature together with an EDC-Sys. It is not needed for standard applications.

13.5.1 Impact of the P-coil's design on the results of current injection

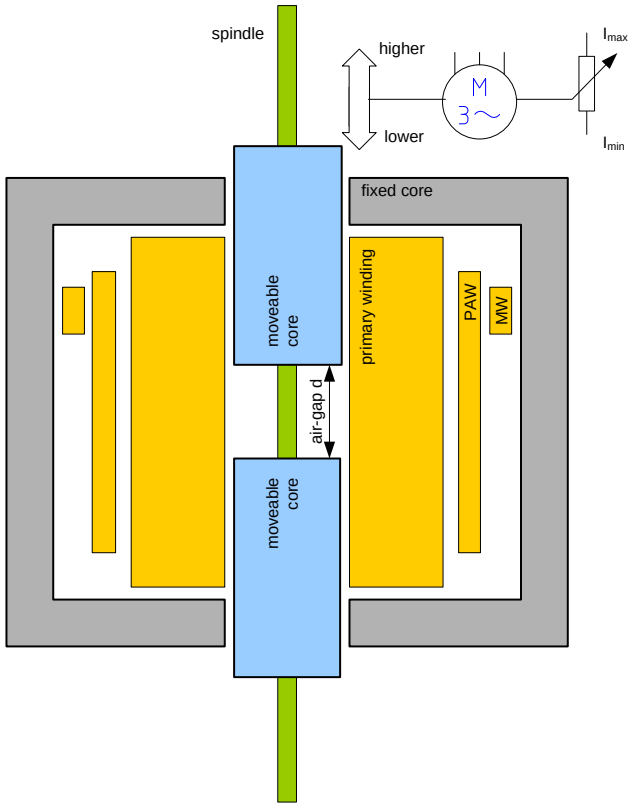


Figure 132: Basic design of a continuously adjustable P-coil

PAW - Power auxiliary winding

W - Winding

P-coil with PAW

In this case, the P-coil functions as a transformer. The accuracy of the results strongly depends on a constant conversion ratio between the PAW and the main winding. The ratio between the secondary current injection and the primary measured current value should stay the same regardless of the coil/plunger position.

In addition, the measurement of the zero sequence voltage should reflect the real value on the primary side and not just the voltage on the PAW.

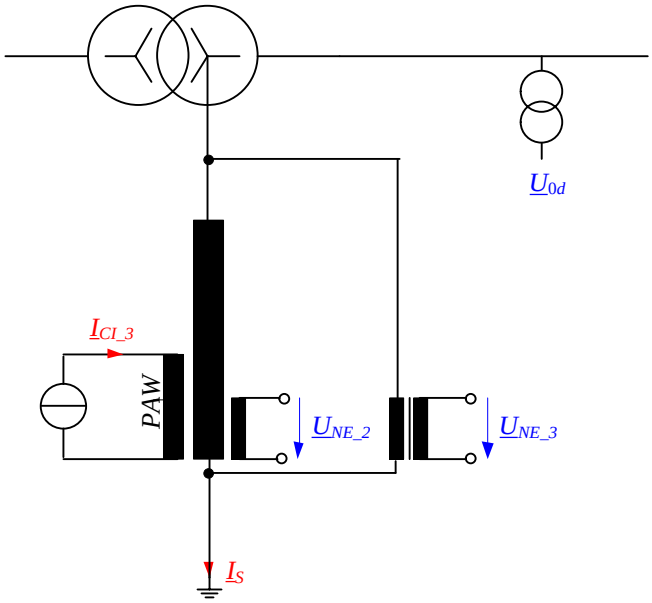


Figure 133: Possible measurement points on the P-coil with PAW

The below is a list of possible combinations and their score:

Combination of the measurement points:	Usual measurement accuracy				Score*)
	I_{CI_3}	U_{NE_2} U_{NE3}	I_S		
I_{CI3} , U_{NE2}		±10%	--		5
I_{CI3} , U_{NE3}		±3%	--		3
I_{CI3} , U_{0d}		±3%	--		3
I_S , U_{NE2}		±10%	±3%	Bad condition for I_S	8
I_S , U_{NE3}		±3%	±3%	Bad condition for I_S	7
I_S , U_{0d}		±3%	±3%	Bad condition for I_S	7

*) A score of 1 represents the best solution to record the measured values. A score of 10 represents the worst case and should not be used!

P-coil without PAW

Older coils may not be equipped with a power auxiliary winding.

In this case, a single-phase transformer can be used and connected in parallel to the P-coil's main winding.

Requirements for the features of the single-phase transformer

The transformer's output can be set up for 10 A on the secondary side. The same nominal value of 500 V used for the P-coil's normal PAW should be used for the conversion ratio for the secondary side.

The short-circuit impedance should be as small as possible.

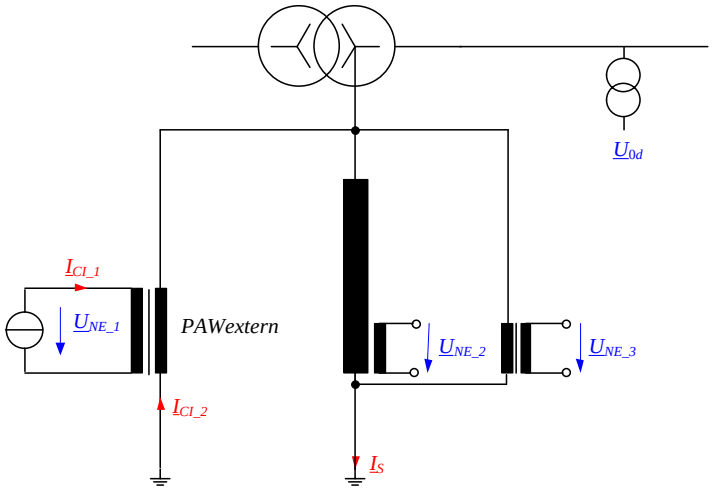


Figure 134: Possible measurement points on the P-coil without PAW

The below is a list of possible combinations and their score:

Measure-ment points:	Usual measurement accuracy					Score*)
	$\underline{Z}_{Tr}$	$\underline{I}_{CI\_2}$ /$\underline{I}_{CI\_1}$	$\underline{U}_{NE\_2}$ (I_{pos})	$\underline{I}_S$		
$\underline{I}_{CI1}$, $\underline{U}_{NE1}$			--	--	Not usable	10
$\underline{I}_{CI1}$, $\underline{U}_{NE2}$	--		±10%	--		8
$\underline{I}_{CI1}$, $\underline{U}_{NE3}$	--		±3%	--		5
$\underline{I}_{CI1}$, $\underline{U}_{0d}$	--		±3%	--		5
$\underline{I}_{CI2}$, $\underline{U}_{NE1}$		--	--	--		-
$\underline{I}_{CI2}$, $\underline{U}_{NE2}$	--	±3%	±10%	--		2
$\underline{I}_{CI2}$, $\underline{U}_{NE3}$	--	±3%	±3%	--		1.5
$\underline{I}_{CI2}$, $\underline{U}_{0d}$	--	±3%	±3%	--		1
$\underline{I}_S$, $\underline{U}_{NE1}$		--	--	--		--
$\underline{I}_S$, $\underline{U}_{NE\_2}$	--	--	±10%	±3%	Bad condition for $\underline{I}_S$	8
$\underline{I}_S$, $\underline{U}_{NE\_3}$	--	--	±3%	±3%	Bad condition for $\underline{I}_S$	6
$\underline{I}_S$, $\underline{U}_{0d}$	--	--	±3%	±3%	Bad condition for $\underline{I}_S$	6

*) A score of 1 represents the best solution to record the measured values. A score of 10 represents the worst case and should not be used!

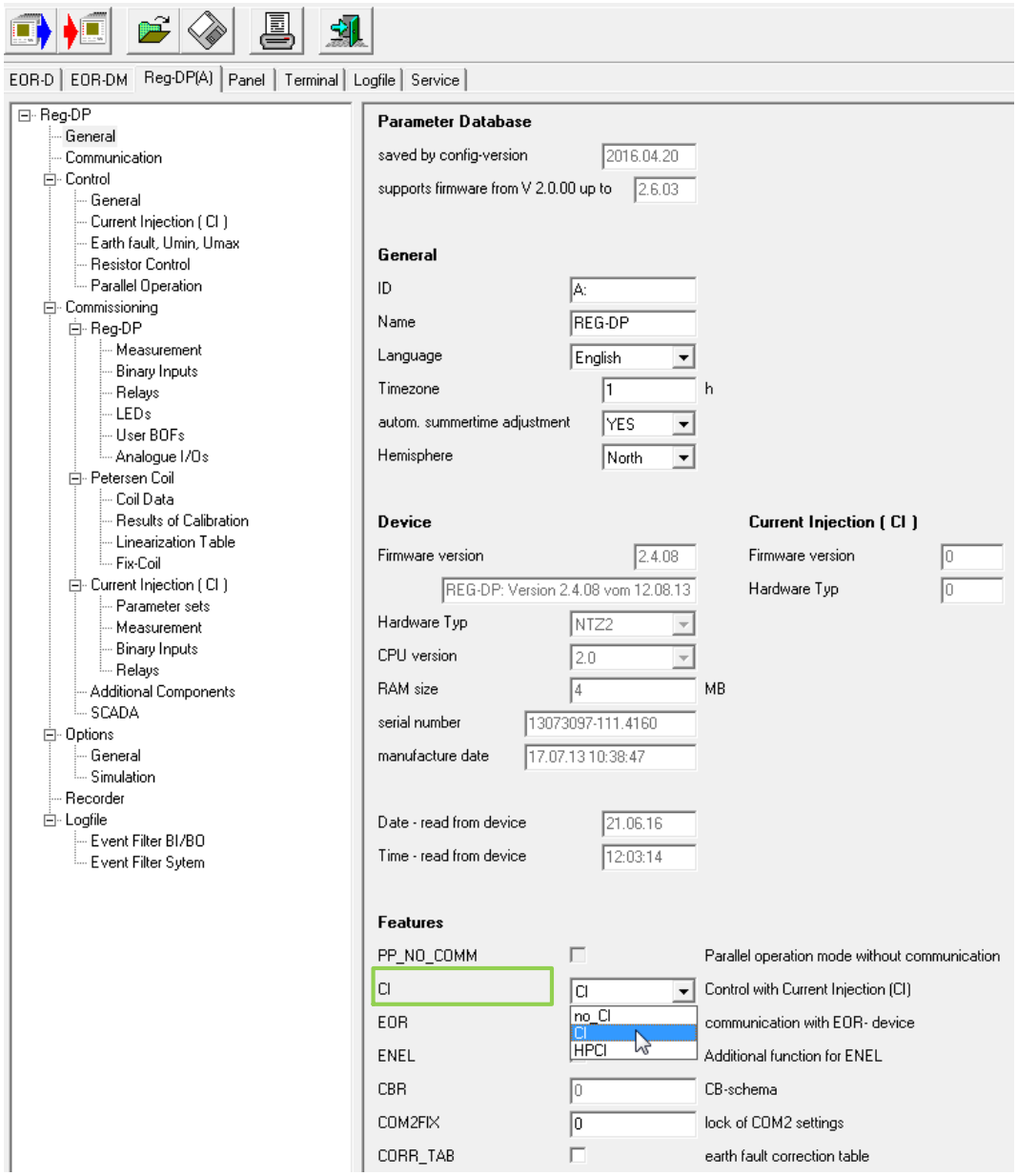
13.6 Enabling current injection in the REG-DP/ REG-DPA firmware

CAUTION! These operating instructions are based on the REG-DP/ REG-DPA running firmware > v 2.4.08.

13.6.1 Enabling CI using parameterization in WinEDC

Load the current parameter file from the REG-DP/ REG-DPA that is to be extended with current injection.

For classic current injection, select the CI feature in WinEDC. The CI feature is activated after the parameters have been sent to the REG-DP.



13.6.2 Enabling CI in the WinEDC terminal

Alternatively, the CI feature can be enabled in WinEDC.

Enter the command: feature ci = 1

Press ENTER to confirm.

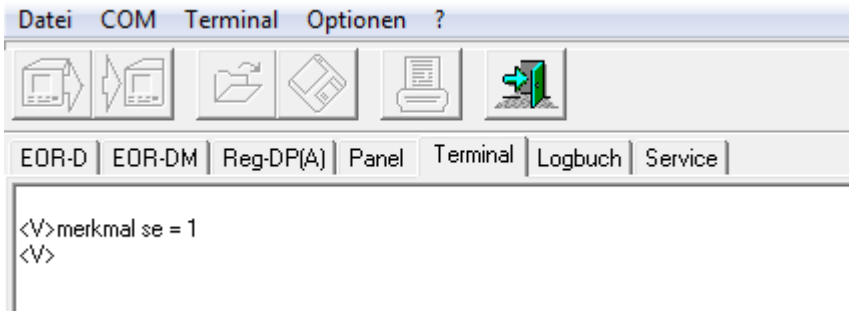


Figure 135: Enabling the CI feature in WinEDC's Terminal program

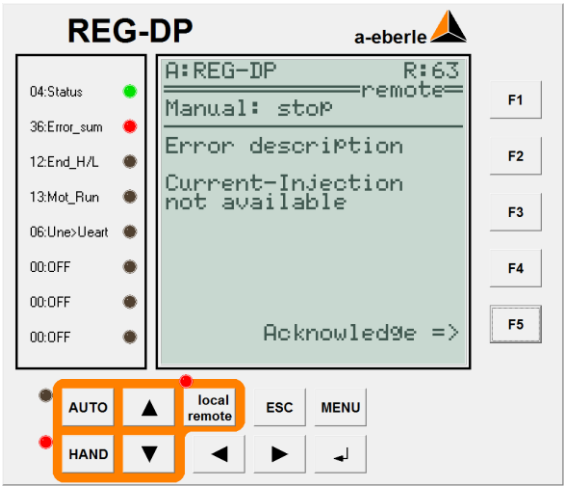
13.7 Testing communication between current injection and the REG-DP/ REG-DPA

To use current injection, the CI feature must be enabled. This is described in Chapter 13.6.

If the COM3 connection to the REG-DP/ REG-DPA does not exist or is faulty, an error will display on the regulator as soon as the CI feature is enabled.

The error is indicated directly on the regulator by the illumination of the error LED and on the 'Troubleshooting' screen.

The following error message displays:



Current injection not available

If the communication to the current injection controller is available, the error message will disappear.

The correct connection between the regulator (COM3) and the CIC's COM3 (current injection controller) is as follows:

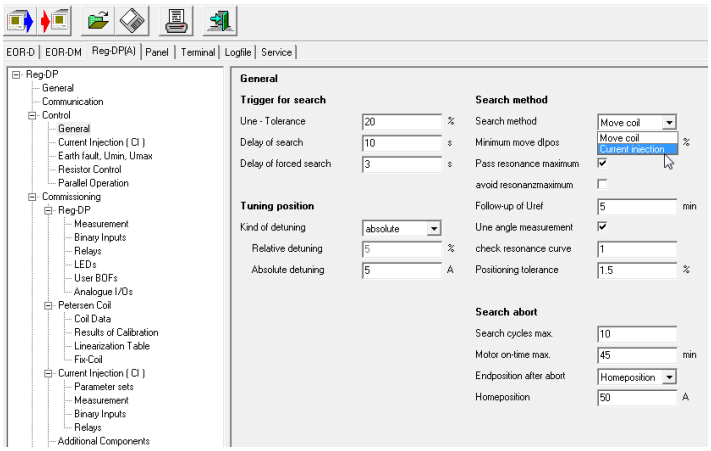
REG-DP/ REG-DPA		CIC
Tx+	<=>	Rx+
Tx -	<=>	Rx -
Rx+	<=>	Tx+
Rx -	<=>	Tx -

13.8 Parameterizing current injection in WinEDC

If the CI feature is enabled in WinEDC, additional current injection parameters will be displayed and can be changed.

13.8.1 Parameters in the Regulation menu

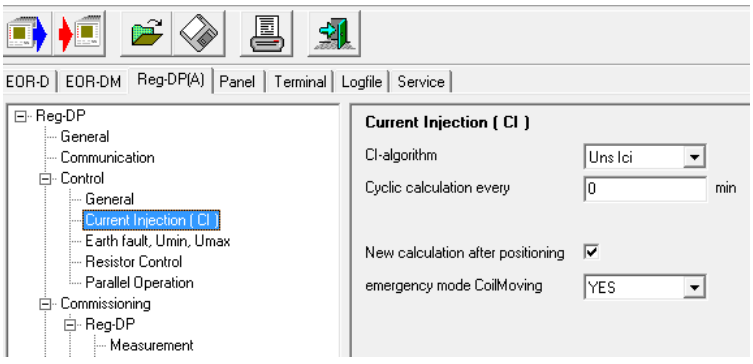
13.8.1.1 Menu item General



Select CurrInject as the search parameter.

Current injection will be used to determine the resonance curve

13.8.1.2 Menu item Current injection



This is where the basic parameters are set that are used to determine the grid parameters by including current injection in the calculation.

- CI algorithm

Settings:

Uns Ici:	Default algorithm to calculate the grid parameters
Uns Uod Is If:	Extended algorithm, this parameter is only used with the ENEL feature and is useful in combination with EDC-Sys

Default setting: Uns Ici

- cycl. Stimulate all

If the zero sequence voltage or the resonance curve is extremely flat, a relative change in the zero sequence voltage that is caused by a switching operation will have very little impact on the Une.

It is therefore meaningful to stimulate the current injection to calculate/check the grid parameters at regular intervals. Example every 60 min

Default setting: 0 min (= inactive)

- New search after positioning

If the checkbox for this parameter is checked, the REG-DP/ REG-DPA will perform a control measurement after successful tuning to check the resonance curve again. If the value is the same, the coil will stay in this position.

Default setting: active

- Emergency operation 'Move coil'

If the communication to the current injection controller fails,

the REG-DP/ REG-DPA can switch to classic regulation by moving the coil

Settings:

YES:	The REG-DP/ REG-DPA is allowed to move the coil to determine the resonance curve if current is not injected.
NO:	The REG-DP/ REG-DPA is **not allowed** to move the coil to determine the resonance curve if current is not injected The regulator goes into alarm state. If it stays in alarm state for more than 60s, the regulator will go into error state and switch to MAN.

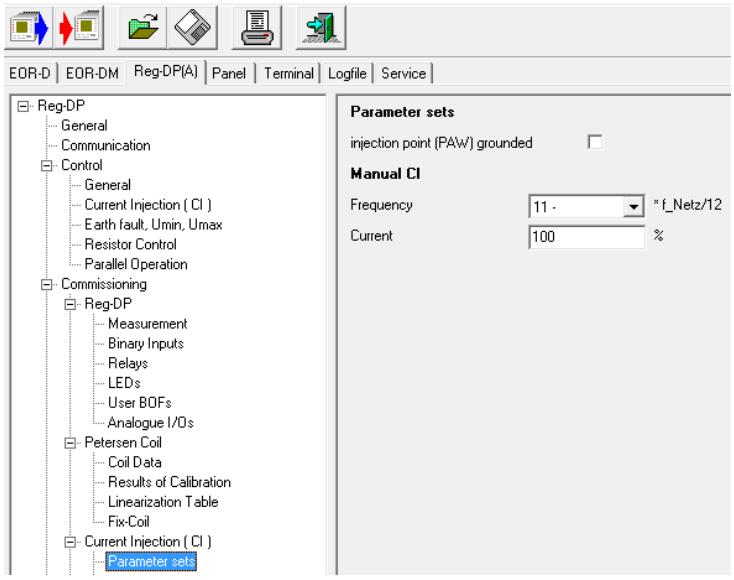
Default setting: YES

13.8.2 Parameters in the Commissioning menu

All of the other parameters that are needed to ensure that the current injection functions properly are set here.

13.8.2.1 Subsequent item Current injection

- Parameter sets



  - Injection location (PAW) earthed

This parameter refers to the current injection feature described in Chapter 13.3 to inject a measurement signal with or without 50 Hz component.

If the parameter is enabled, the REG-DP/ REG-DPA will assume that the PAW is directly earthed. In this case, an injection without 50 Hz component is not possible.

In this case, the measurement signal to calculate the grid parameter will get smaller

Default setting: NOT active (= not earthed)

- Manual CI

The parameters for manual current injection can also be set. This point is only interesting during commissioning. This is where the measured values can be checked using the WinEDC service screen and the manually startable current injection.

- Frequency

Settings:

Value	Description	Corresponds to frequencies		
6-	Two frequencies	25Hz		75Hz
8-	Two frequencies	33.3Hz		66.7Hz
10-	Two frequencies	41.7Hz		58.3Hz
11-	**Two frequencies (default)**	**45.8Hz**		**54.2Hz**
12+50 Hz	Pure 50 Hz current injection		50 Hz	
11+50 Hz	Three frequencies	45.8Hz	50 Hz	54.2Hz
10+50 Hz	Three frequencies	41.7Hz	50 Hz	58.3Hz
8+50 Hz	Three frequencies	33.3Hz	50 Hz	66.7Hz
6+50 Hz	Three frequencies	25Hz	50 Hz	75Hz

- Current

The amplitude of the manual current injection is set here.

Setting range: 0% .. 100 %

Default value: 100 %

- Measuring

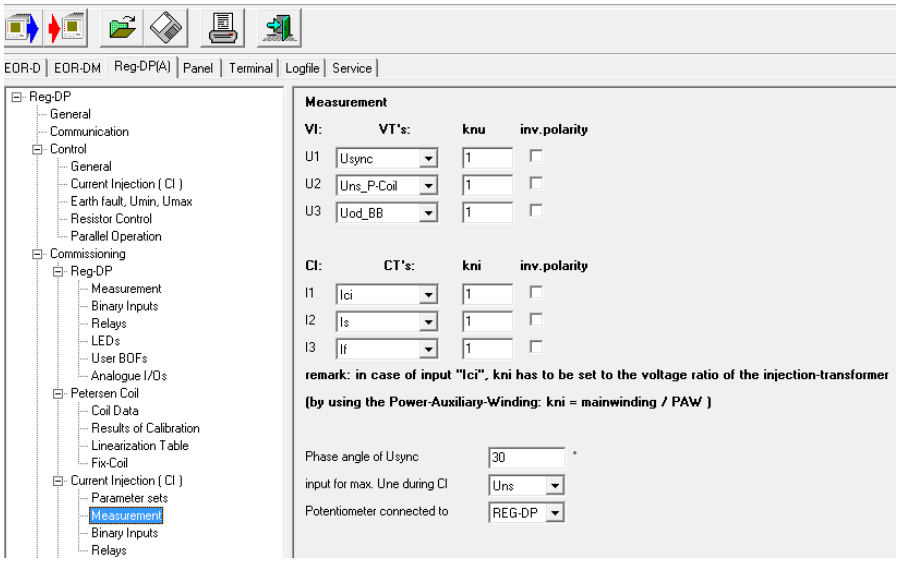


Figure 136: Setup of the measurement channels for current injection

The figure shows the default settings for the measurement inputs at the current injection controller for the 'Uns Ici' algorithm.

Current injection has three measurement channels for voltage and current.

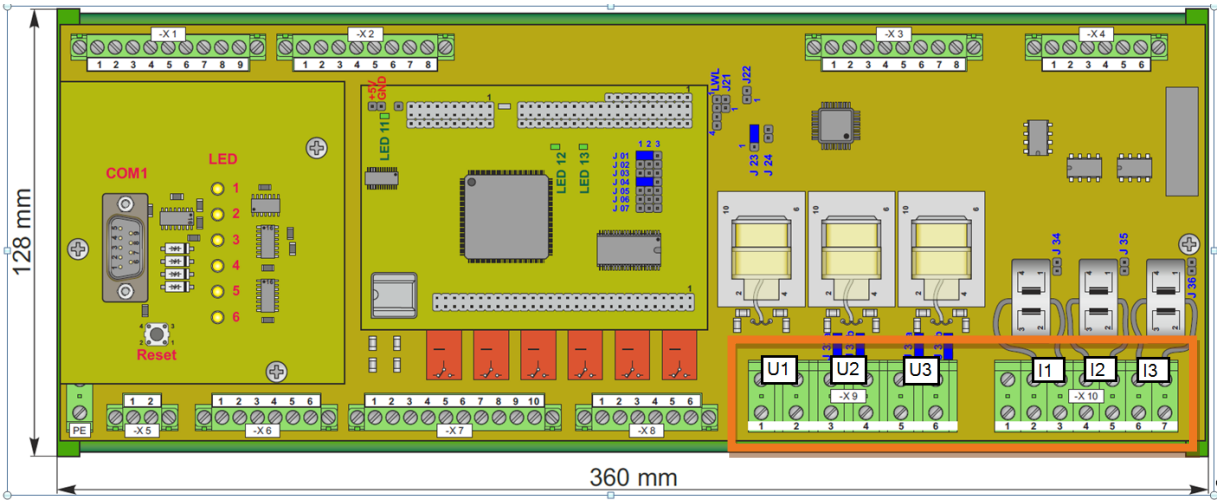


Figure 137: Position of measurement channels U1, U2, U3, I1, I2 and I3 at the Current injection controller (CIC)

- CI voltage measurement inputs

Settings:

Setting	Description
OFF:	Measurement input not used
Usync	Synchronisation voltage This is the reference voltage to determine the winding for the other five measurement channels. (usually 230 V AC)
Uns_Coil	Zero sequence voltage directly on the P-coil (usually 100 V) = U_{NE}
Uod_Grid	Zero sequence voltage measured directly on the busbar using the delta winding (usually 100 V)
Uci	Voltage measured directly where the current is injected. Can be up to 500 V.

The transformer factor must be defined for each input.

Default allocation for voltage channels

Measurement channel	Default allocation and settings
U1	Usync Knu = 1
U2	Uns_Coil Ex.: 20 kV coil → 12 kV nominal voltage/100 V Knu = 120
U3	OFF: Not used

- CI current measurement inputs

Settings:

Setting	Description
OFF:	Current measurement input not used
Ici	Current injected at PAW - wired in CI cabinet by default to current channel 1
Is	Current through the P-coil (only needed for the 'Uns Uod Is If' algorithm)
If	Current through the fixed coil (only needed for the 'Uns Uod Is If' algorithm)

Default allocation for current channels

Measurement channel	Default allocation and settings
I1	Ici Ex.: 20 kV coil → 12 kV nominal voltage/500 V power auxiliary winding (PAW) Kni = 24
I2	OFF: Not used
I3	OFF: Not used

In the example, the coil's nominal voltage is 12 kV, the transformer's nominal value is 100 V and the PAW's nominal voltage is 500 V.

The conversion ratio knu for the value Uns_Coil is 120.

Because the current is injected at the PAW, the ratio 12000 V/500 V = 24 for the current transformer factor (kni) can be set there. The current Ici is already measured on the secondary side by the current injection controller. Because the phase is the only thing that is important at U-Sync, knu = 1 can be used here.

- Phase U-Sync

The value is determined during commissioning by testing the polarity of the current and voltage channels.

The reason for this is that the synchronization voltage Usync at the REG-DP/ REG-DPA may not have the same phase as the synchronization voltage at the current injection controller.

However, the same zero sequence voltage is measured on both devices. The absolute value and especially the phase must be the same at both measurement inputs.

Values in increments of 15° can be entered.

Default value: 30°

- Measurement point for max. Une by CI

This is where the measurement point is defined at which the value of the zero sequence voltage is monitored when current is injected.

CAUTION! When using the UnsIci algorithm, Uns is the only setting that makes sense!

Setting	Description
Uns	Zero sequence voltage directly on the P-coil
Uod	Zero sequence voltage directly on the busbar
Uci	Voltage measured directly where the current is injected (usually the PAW).

- Pot connection at

The REG-DP/ REG-DPA and the current injection controller each have the possibility to connect the potentiometer information. The REG-DP/ REG-DPA only has to be told which of the two devices the information is connected to.

Setting	Description
REG-DP (Default)	The P-coil's position signal is connected to the REG-DP's potentiometer input
CI	The P-coil's position signal is connected to the current injection controller's potentiometer input

- Binary inputs

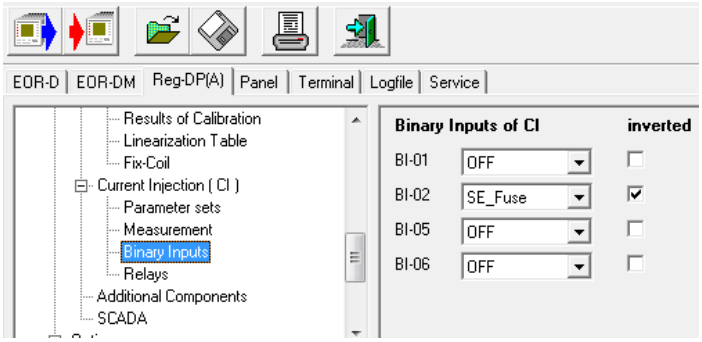


Figure 138: Configuration of inputs 1, 2, 5 and 6 in standard current injection cabinets

Binary input 2 is configured with the auxiliary contacts on the circuit breakers in the current injection.

The REG-DP/ REG-DPA receives a message if one of the fuses Q1 or Q2 blows. The REG-DP/ REG-DPA sends the summary error (BOF 38)

- Relay

This is where the available relays and LEDs for current injection are parameterized.

The functions that can be associated with the relays and LED 3 are the same as those in Chapter 11.4.1.2.

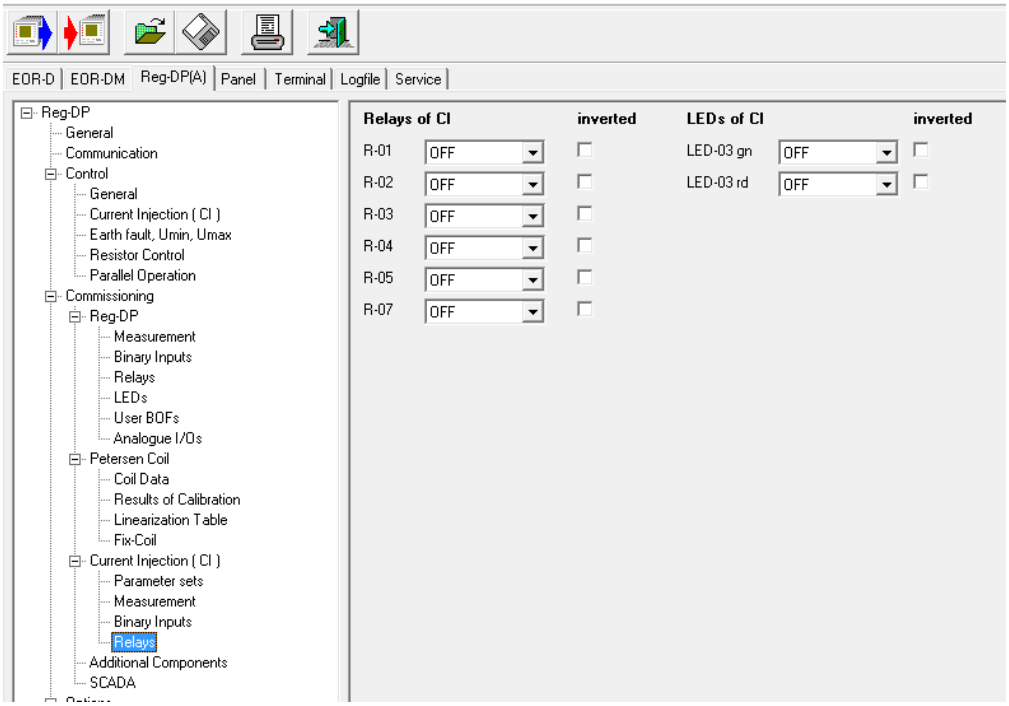
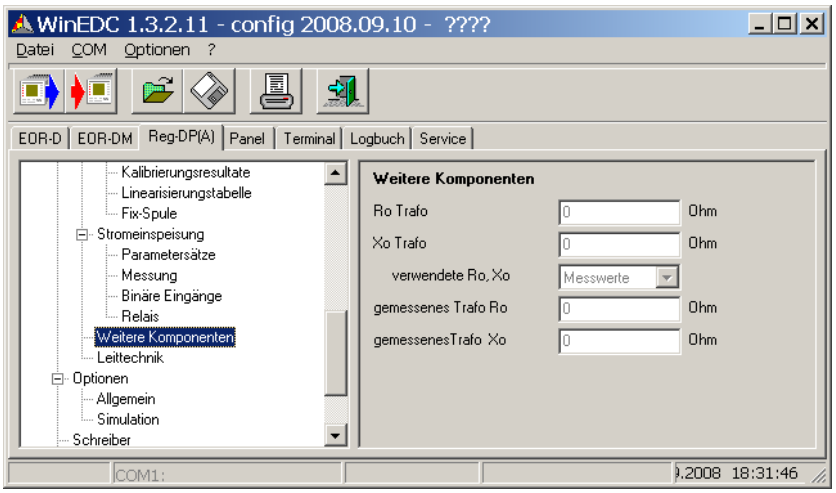


Figure 139: Parameter menu current injection relays and LEDs

13.8.2.2 Other Components



The values displayed here are read-only and cannot be changed.

13.9 Testing the polarity of the measurement channel

Once the parameters have been set, they have to be sent to the REG-DP/ REG-DPA. The polarity of the used measurement channels can then be tested.

CAUTION!

When commissioning current injection, the assumption is that the coil that is regulated by the REG-DP/ REG-DPA is already in the grid. The coil must be in the grid at the latest for the next polarity test so realistic results can be achieved.

13.9.1 Testing using the WinEDC service screen

For the following test, the P-coil must be connected to the grid and positioned at the actual resonance point. The regulator must also be running in MAN mode.

The point can be determined by moving the regulator manually and is where the zero sequence voltage peaks across the coil's whole adjustment range. Another option is to reset the regulator to the 'Move coil' option and start a tuning process.

On WinEDC's service screen, the REG-DP/ REG-DPA screen is expanded with the additional current injection functions.

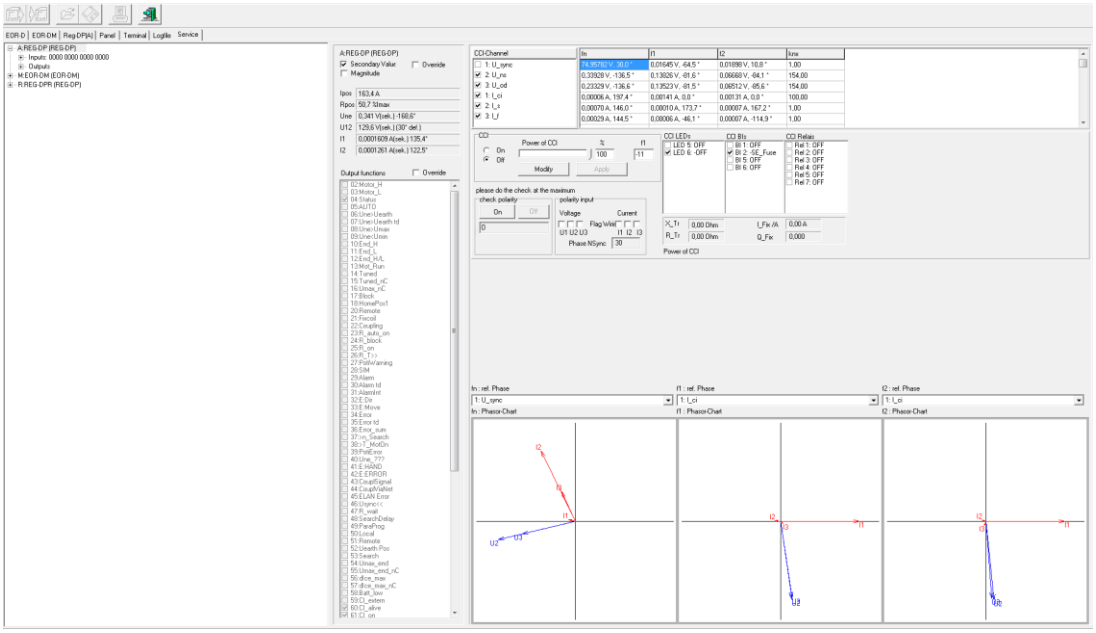
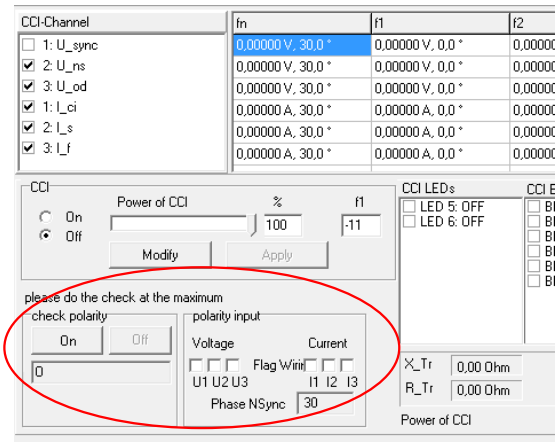


Figure 140: Service screen with current injection

If the aforementioned conditions are met, press the ON key in the highlighted field to start the test.



The automatic test consists of checking the plausibility of the measurement channels' polarity.

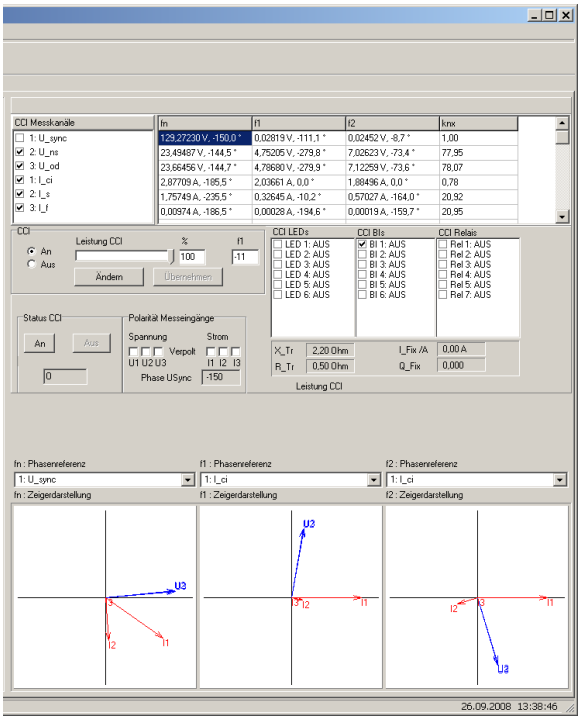
If the polarities are not plausible, 'Phase Usync' is used to synchronize both of the Une phases and correct the measured values while reversing the polarity of as few inputs as possible.

Measurement channels with a polarity that has clearly been reversed can be reconnected and the polarity test repeated.

The view shown in the section on WinEDC's service screen for frequencies f1 and f2 for the voltage indicators is correct. They must be opposite Ici in the first and fourth Quadrant of the vector diagram.

If current is injected, the corresponding pointers will be visible in the lower area.

The field fn stands for the signals of the fundamental frequency (50 Hz), and frequencies f1 and f2 for the signals with which the current injection performs the calculations.

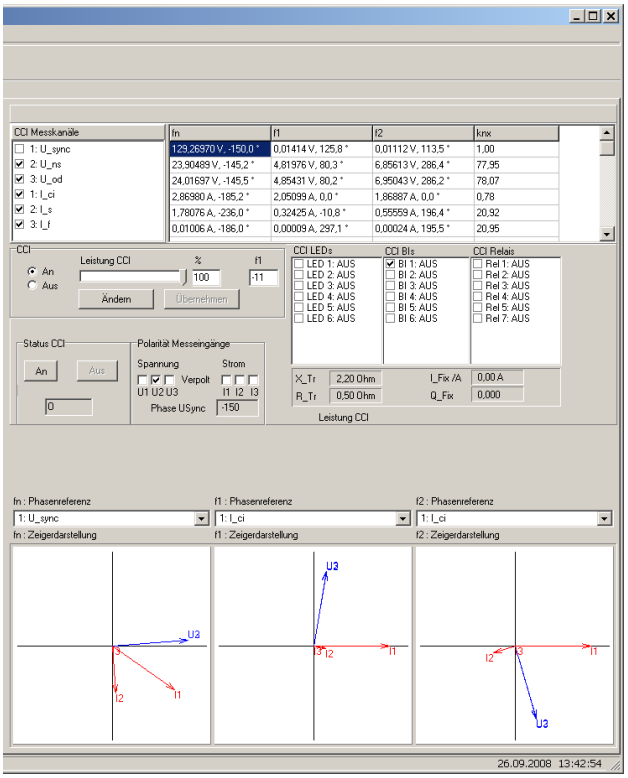


If, for example, the phase of Uen on the REG-DP/ REG-DPA and Uen on the current injection controller (CIC) are different, the phase of the U-sync-Une$_{DPA}$ input is automatically rotated until the absolute value and the phase match each other.

Une for the current injection controller and for the REG-DP/ REG-DPA must always be measured at the same spot.

In the example, Une (Uns) is connected to channel 2 on the current injection controller.

If the polarity of this channel is reversed, an automatic test will detect it and correct it.



The values for Une (Uns) on the current injection controller can be viewed in the second line (in red).

The reversed polarity on channel U2 is displayed under 'Polarity measurement inputs'.

Current injection is still on after the test has finished and must be switched off by pressing the 'OFF' key.

The test can be stopped at any time by pressing the 'OFF' key.

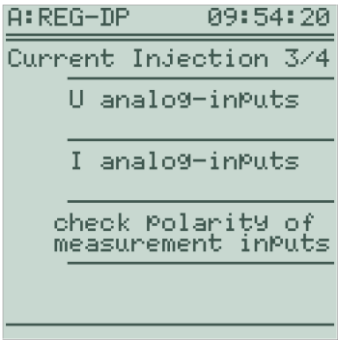
Current injection is also switched off when you exit the service screen.

13.9.2 Testing on the REG-DP/ REG-DPA

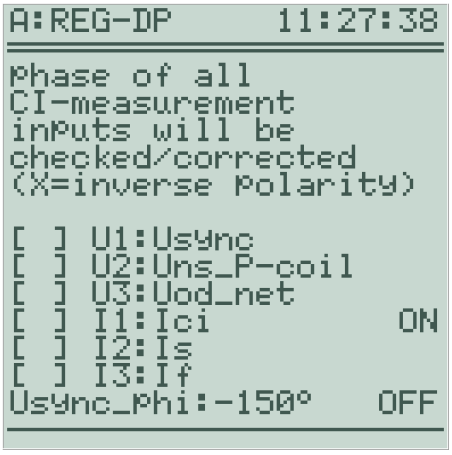
The automatic polarity test for the measurement channels for the current injection described in Chapter 13.9.1 can also be performed directly on the REG-DP/ REG-DPA.

One of the Commissioning menu's submenus is 'Current injection'. Here, you can select automatic testing.

Press **<MENU><F3><F5><F1> <F5>** to access the sub menu 'Current injection'.



The option ‘Test polarity of measurement inputs’ is on screen 3 of 4 as shown in the above figure.



Press F4 to access this function.

After the test has finished successfully, the message 'Polarity test successfully completed' displays. The value for Usync_phi and the polarity of the channels is now set and can be queried.

Note:

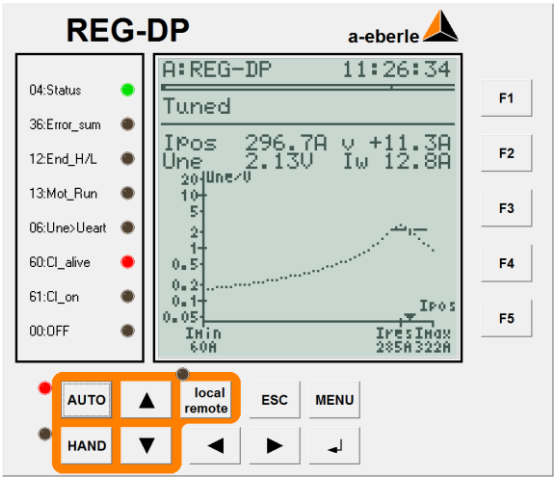
In contrast to the test, current injection is switched off through the WinEDC service screen following a successful test. The test can be aborted at any time by pressing F5.

13.10 Completing the commissioning of current injection

After a successful polarity test, the regulator can be set to AUTO mode and the resonance curve calculated.

Note:

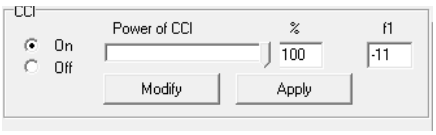
If the regulation parameter is still set to 'Move coil', set it back to 'Current injection'.



The calculated resonance curve and the value for Ires are displayed on the REG-DP/ REG-DPA.

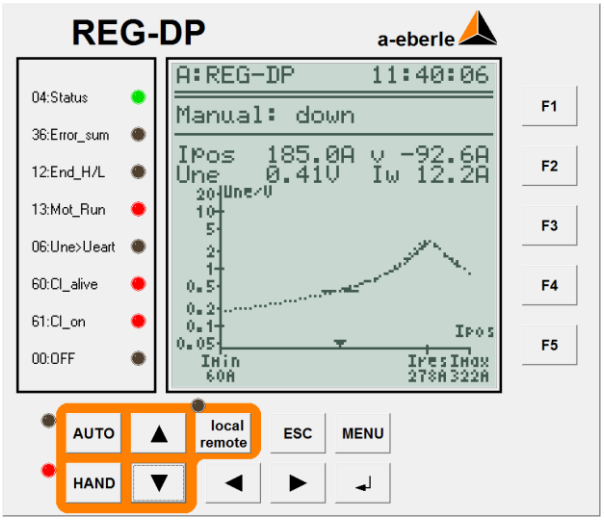
13.11 Verifying the correct calculation across the P-coil's whole adjustment range

- The REG_DP(A) must be set to MAN!
- Select **manual current injection** on the WinEDC service screen.
- Enter 100% for the power and press the 'Accept' key.



- Current injection is now continuous and new resonance curves are constantly calculated.
- Move the coil manually (using the Higher and Lower keys on the device) from the upper to the lower end switch.

During the adjustment, the calculated value for Ires and Iw should be as good as constant.



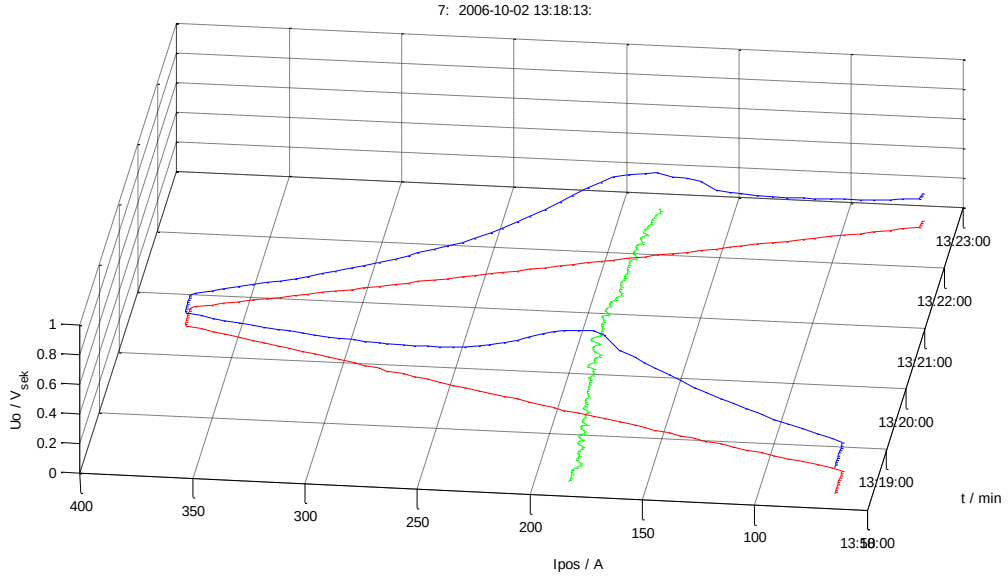


Figure 141: Calculated resonance point (green) across the whole adjustment range

The values can be slightly different at the upper and lower end switch points, because the magnetic coupling between the PAW and the main winding is slightly worse there.

The values should not deviate more than 10%, at the most 20% of the calculated value at the resonance point.

13.11.1 Enabling manual current injection directly on the REG-DP/ REG-DPA

Current injection can also be manually enabled on the REG-DP/ REG-DPA.

Pressing F1 takes you to the measured values screens, which includes the measured values for current injection.

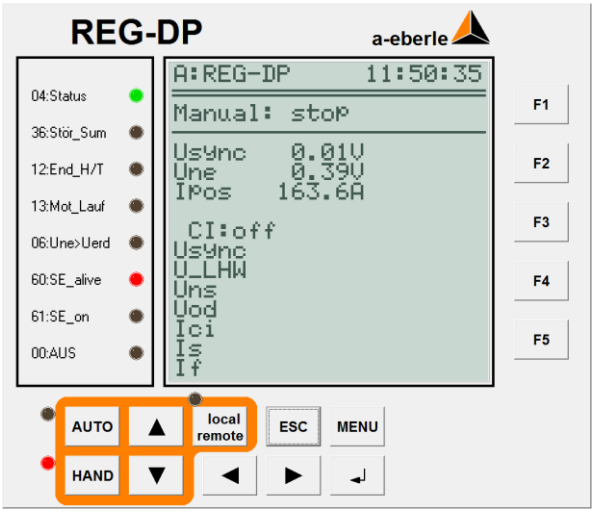
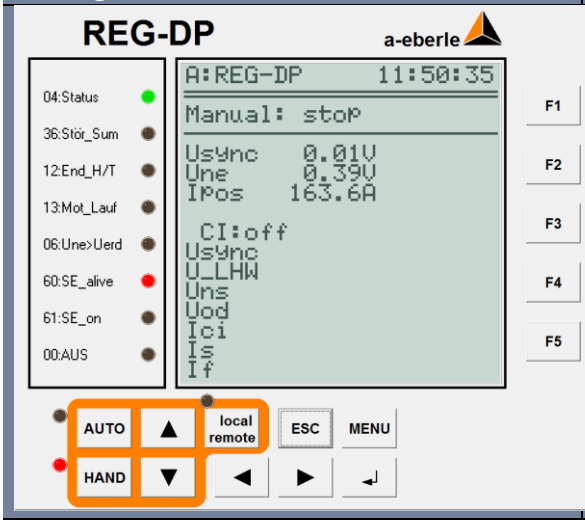
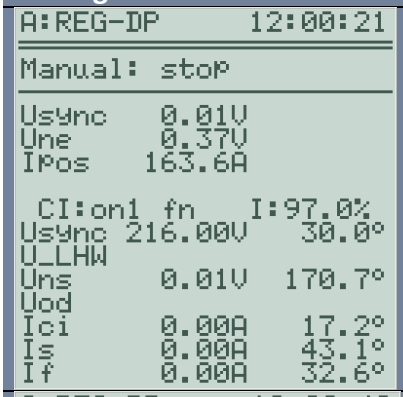
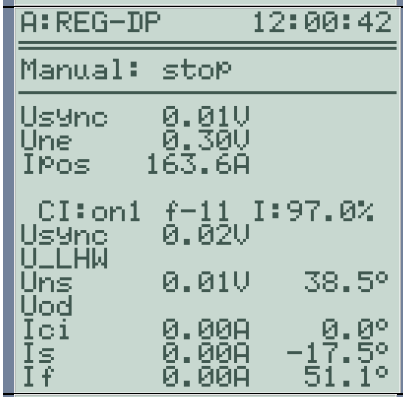
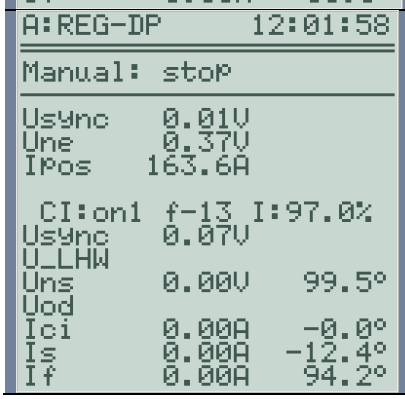


Figure 142: Start screen 3 – current injection not active

Setting	Description
	F1- Browse through screens F2 – Increase power (maximum 100%) F3 – Reduce power Increment 1% F4 – Browse through the measured values fn = Fundamental frequency fx = Depends on the pattern fx = Depends on the pattern F5 – Switch manual current injection ON and OFF

Setting	Description
	**F3 – Reduces power to 97%** **fn = Fundamental frequency Measured values**
	**f-11 = Measured values for the selected frequency** **F4 to switch displays**
	**f-13 = Measured values for the selected frequency** **F4 to switch displays**

13.11.1.1 The meaning of the LEDs on the current injection controller

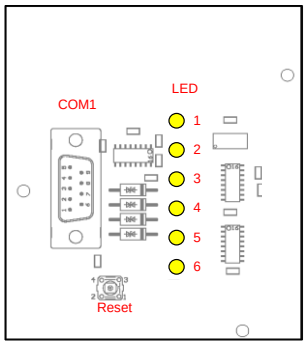


Figure 143: Meaning of the LEDs on the current injection controller CIC

LED	Function	Status ok	Status error
1	Usync measurement << 15 V at terminals X9:1-2	0	RED
2	Usync for thyristors 220 VAC << 30 V at terminals X6:1-2	0	RED
3		0	
4	Current injection active	GREEN	
5	PLL synchronized	GREEN	
6	Status current injection controller (CIC)	GREEN flashing	

The below tables describe the states for each of the LEDs in detail:

Usync V	Usync_Thyristor V	LED 1	LED 2
> 30	> 45	0	0
> 30	< 30	0	RED
< 15	> 45	RED	0
< 15	< 30	RED	RED

The meaning of the LED on the DSP board:

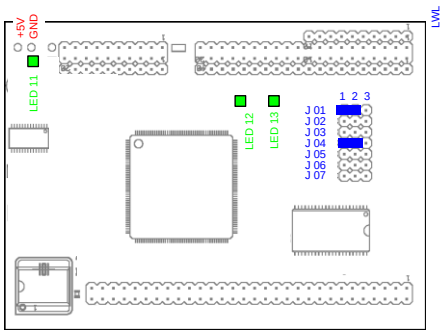
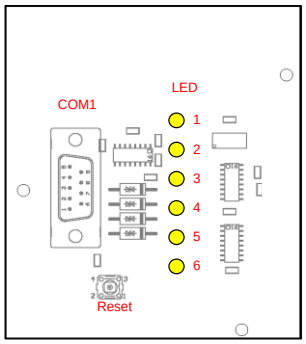


Figure 144: Meaning of the LEDs on the DSP board for current injection controller

LED	Function	Status ok	Status error
11	+ 5 V DC	GREEN	
12	DSP status	GREEN flashing	

13	-	-	

13.11.1.2 Reset button and COM1 interface on the controller



The COM1 interface is only used to update firmware. All parameters are set through the REG-DP/ REG-DPA.

The reset button is also used to put the controller into bootloader mode so the firmware can be loaded.

14. Commissioning the HPCI

You can operate a REG-DP/ REG-DPA either with classic current injection or High Power Current Injection (HPCI).

Figure 145: The structure of a dual HPCI – for two REG-DP/ REG-DPA or two P-coils

Once the REG-DP/ REG-DPA has been commissioned, additional steps must be taken to commission the current injection. The easiest way to commission current injection is to work through the steps in the sequence of the chapters they are discussed in.

General

Features of HP current injection:

- Two frequencies to calculate the grid parameters
- Switches off or reduces the current injection when the coil moves

- Fast calculation; takes place within a filter cycle (240 ms)
- Works on very symmetrical grids
- Calculation results immune to 50 Hz unbalance and crosstalk from the 50 Hz positive sequence system on the zero sequence system
- Cyclical current injection for the constant monitoring of changes in the grid
- Creates a pulse signal when an earth fault occurs to help locate the earth fault
- Recognizes the generated pulse signal in the detection relays EOR-D, EOR-3D and EOR-1D

14.1 Regulating the P-coil with HPCI - The basics of current injection

The basics of current injection with HPCI are the same as for classic current injection, which is described in Chapter 13.1.

14.2 Connecting the HP current injection

The time and effort needed to wire the new HPCI is pretty much the same as for classic current injection. The differences are as follows:

- Separate connection for the supply voltage for the electronics and the power supply to the power unit (fuse Q1 and Q2)
- Power supply to the two-phase power unit (L1, L2, N) for automatic switching
- Connection to the power auxiliary winding with bigger cross-section because it's needed for pulsing (min. 25 mm2)

14.2.1 Design of the HPCI

Each HPCI in a control cabinet consists of three components.

- Control unit

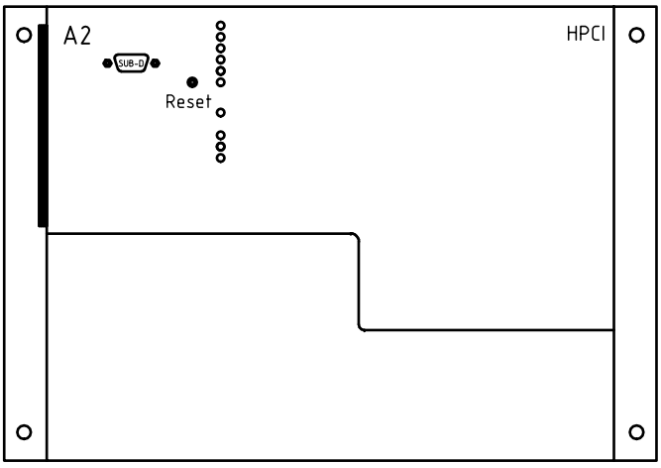


Figure 146: Control unit (HPCI module)

- Inductor shelf

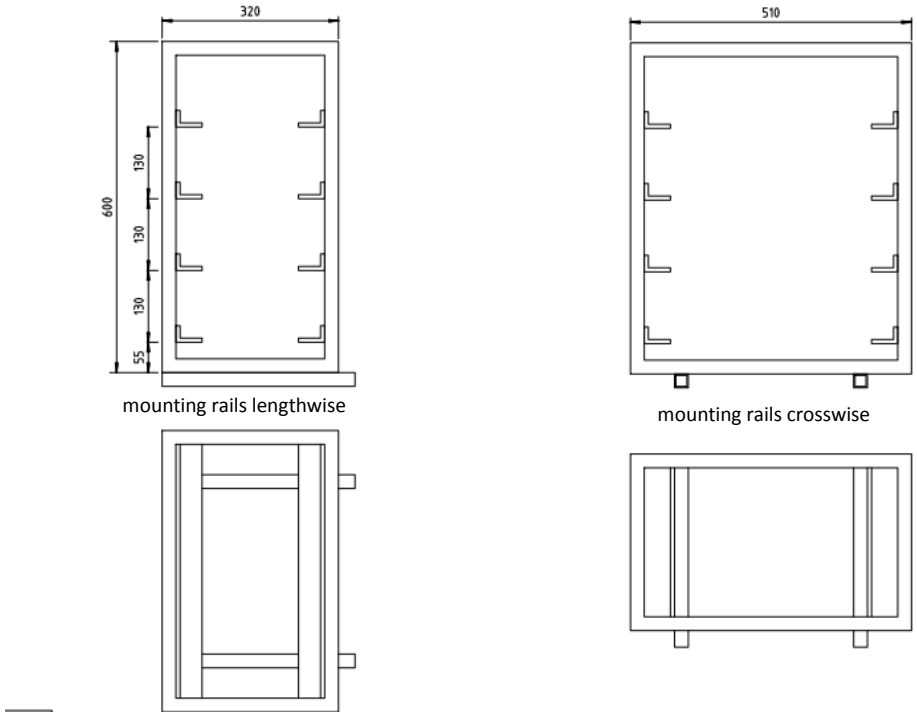


Figure 147: Dimensions for the inductor shelf (without inductors)

- Inductors – the quantity depends on the desired power – four inductors are the norm

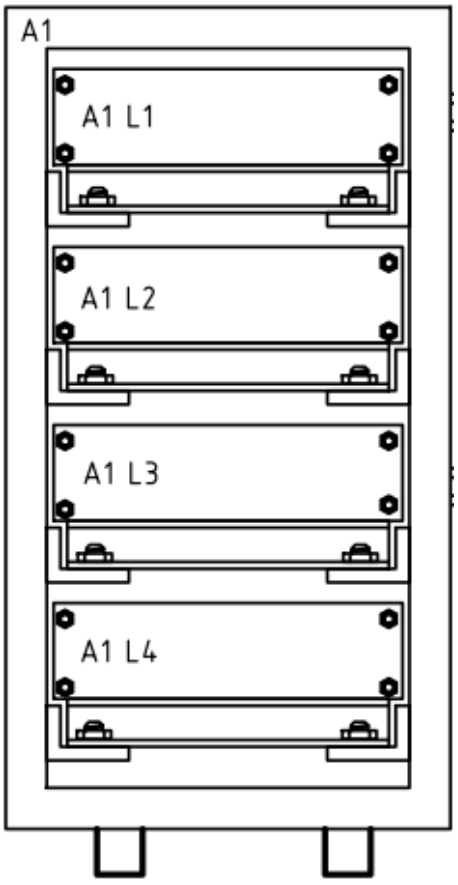


Figure 148: Inductor shelf (incl. inductors)

Figure 149: Design of HPCI control cabinet with two systems

14.2.2 Connections to HPCI

Connection to the power auxiliary winding must be at least 25 mm²!

The connection to the P-coil's power auxiliary winding has a separate fuse for each inductor. 40 A fuses are used. Based on the pulse pattern, up to 100 A can flow when an earth fault occurs.

The right choice of measurement points such as zero sequence voltage and the measurement of the current injected when HPCI is used is the same as for classic current injection and is described in Chapter13.2.

Only five connections are needed to install/retrofit HPCI.

Connection	Notes
Supply voltage (400 V/230 V AC, L1, L2, N)	Fused internally with 20 A (internally over Q2) CAUTION: Do not use an FI circuit breaker! Use an isolating transformer (S = 2.5 kVA) instead Use a 2.5 mm² cable
Supply voltage (230 V AC , L1-N)	Fused internally with 3 A (internally over Q1) CAUTION: FI fuse can be used!
U_{NE}	Measurement of zero sequence voltage Ideal of a voltage transformer that is not measuring in the same magnetic circuit as the power auxiliary winding. Separate voltage transformer in the coil External voltage transformer Measurement of open delta winding on the busbar
PAW On the power auxiliary winding	Use a connection cable that is at least 25 mm²
COM3 connection to REG-DP/ REG-DPA	4-wire RS-485 connection Use a shielded and twisted 2x2 core cable Small signal line!

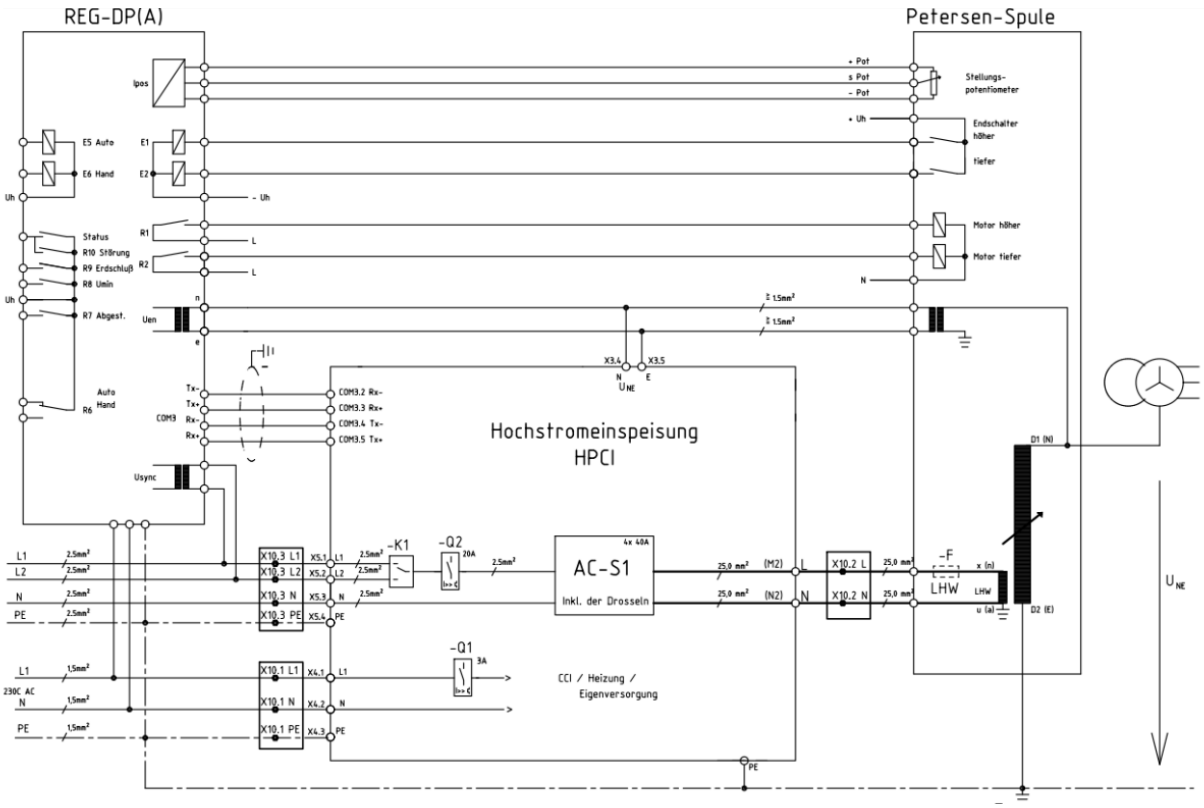


Figure 150: Connecting the HPCI between the REG-DP/ REG-DPA and the P-coil

14.2.3 Standard control cabinets for HPCI

14.2.3.1 Indoor installation (single)

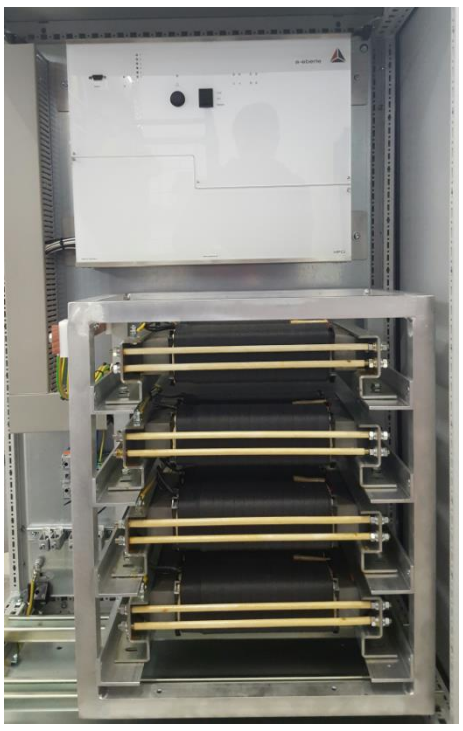


Figure 151: Current injection in control cabinet for indoor installation

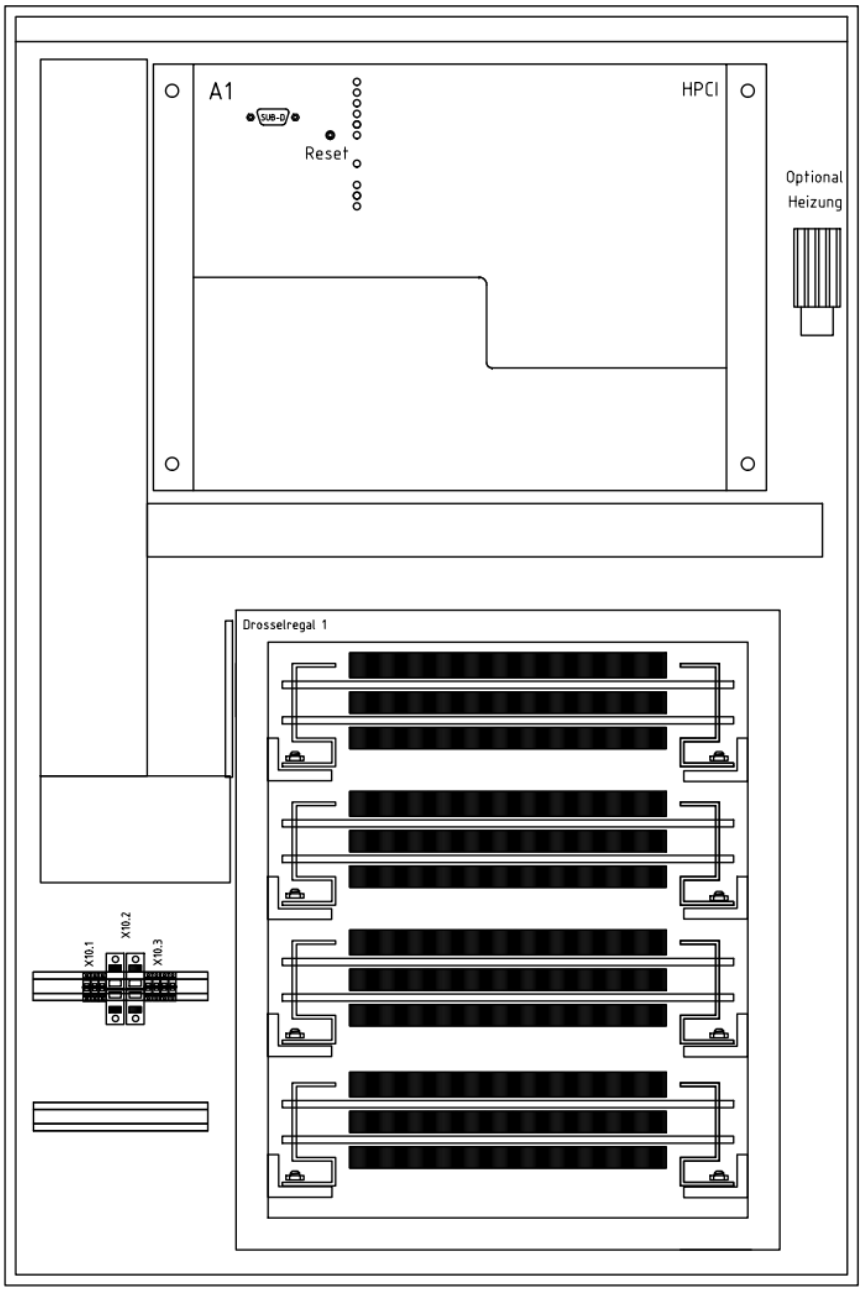


Figure 152: Dimensions: WxHxD = 800 mm x 1200 mm x 500 mm (dimensions without base)

14.2.3.2 Indoor installation (double)

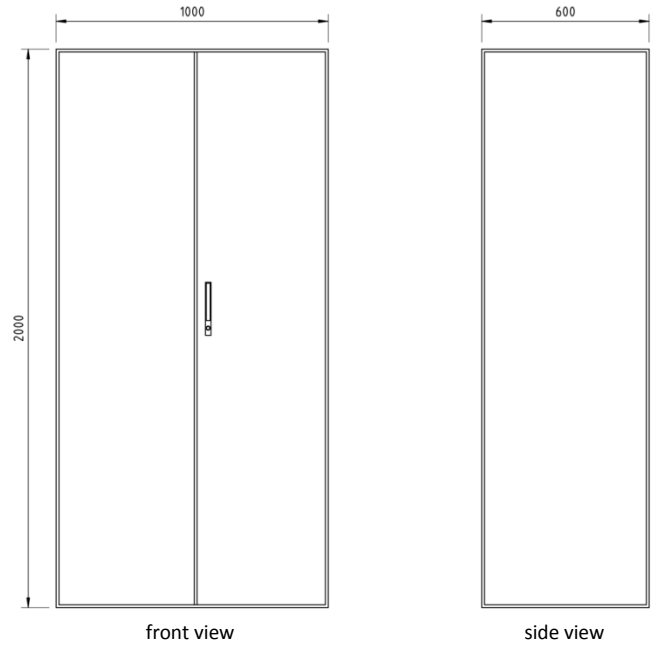


Figure 153: Current injection dimension drawing in control cabinet for outdoor installation

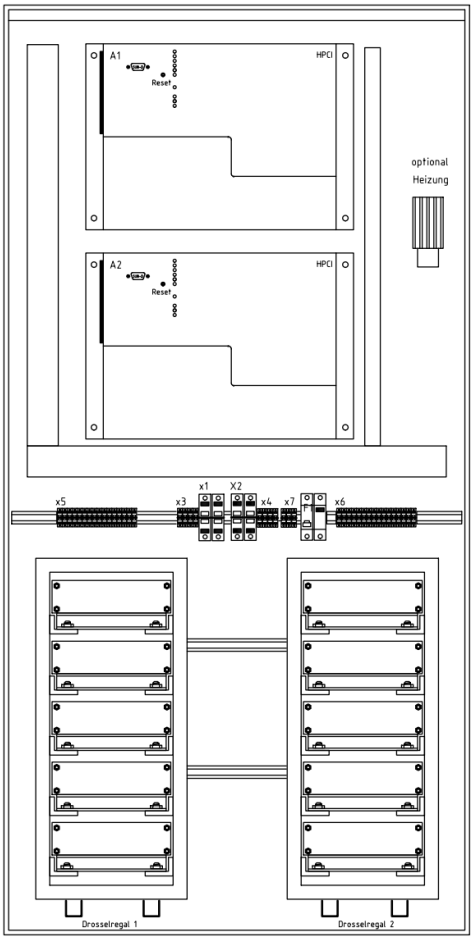


Figure 154: Inside of control cabinet for HPCI double

14.3 Current injection with two frequencies to calculate the grid capacity (with HPCI)

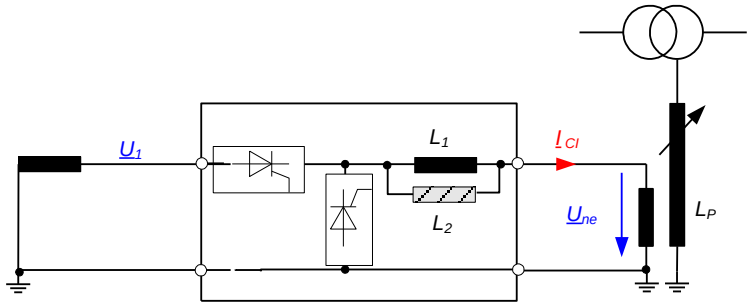


Figure 155: Simplified current injection diagram with three frequencies for HPCI

The below figure shows the progression of the injected current for the activation displayed in Figure 155: . In this case, the power auxiliary winding is earthed directly on the coil.

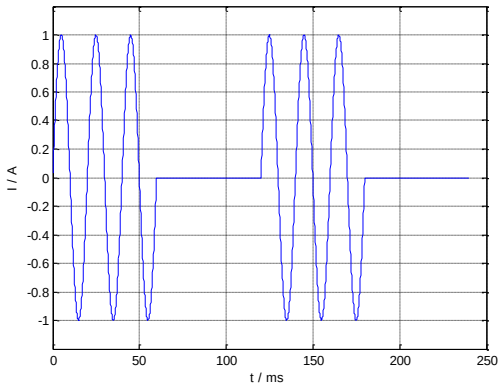


Figure 156: Example for the pulse pattern; Generation of two frequencies

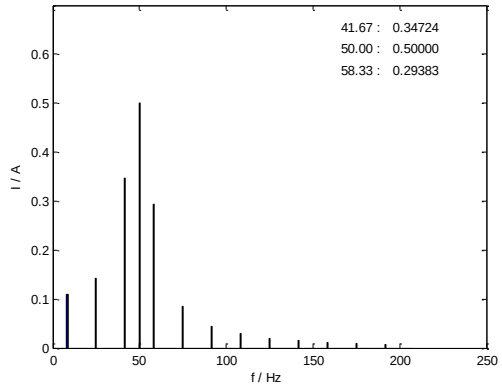


Figure 157: Frequency spectrum for injection with 50 Hz component

The grid parameters are calculated using the current injection on the two adjacent frequencies 42 Hz and 58 Hz. The power of the current injection unit for the part to compute the network capacitance is sufficient for 800 A of capacitive current in a 20 kV system.

Automatic power adjustment!

The current version of the HPCI can adjust the power automatically. On smaller grids, the HPCI 'learns' and reduces the injection power accordingly. The impact on the zero sequence voltage remains at an optimal ratio to the exact calculation of the grid's capacity.

14.3.1 Automatic power adjustment and phase switching L1-L2

Basically, current injection impacts the zero sequence voltage.

Based on the absolute value and phase of the natural zero sequence voltage, injecting high-power current can increase the zero sequence voltage. There are two states that can be automatically improved by applying different HPCI measures:

- Very symmetrical and 'small' grids (grid size < 50 A capacitive current)
  - The measure here would consist of automatically adjusting the power (reducing the injection power). The HPCI learns how high the impact is and reduces the power accordingly
- Overhead transmission grids with higher natural unbalance and therefore higher zero sequence voltage (> 5% UNE)
  - The measure here could consist of switching the phase (L1 or L2) that is used for injection. This can actually reduce the zero sequence voltage during injection.

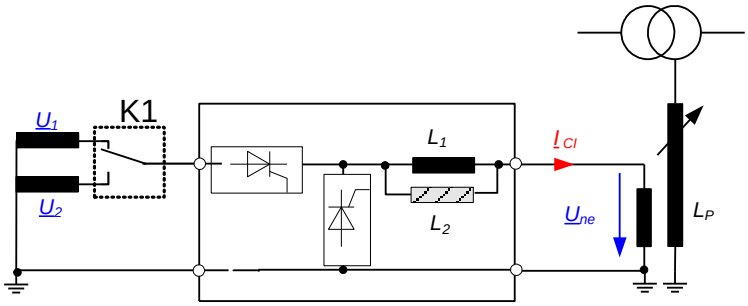


Figure 158: Switching the injection phase (L1 or L2) automatically through relay K1

14.4 Configuration of the HPCI module

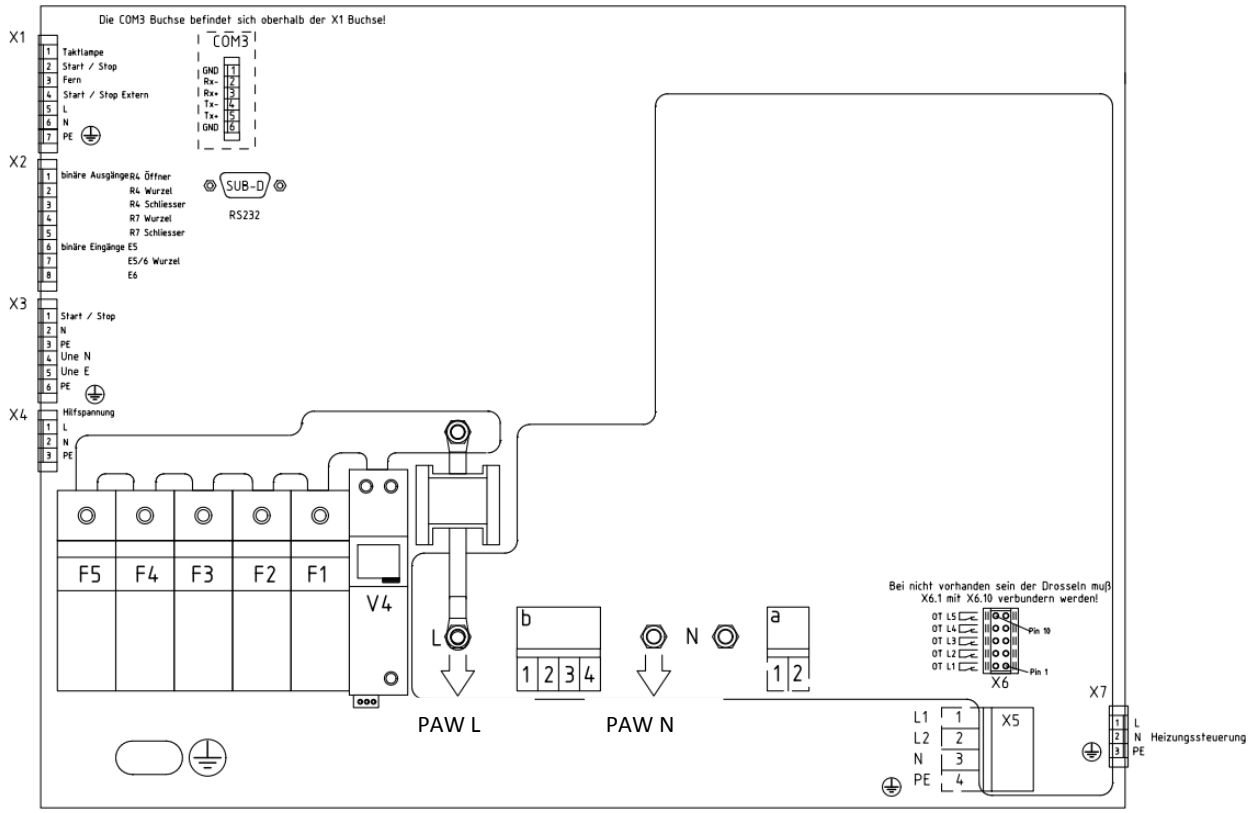


Figure 159: HPCI module; Position of the main terminals and components

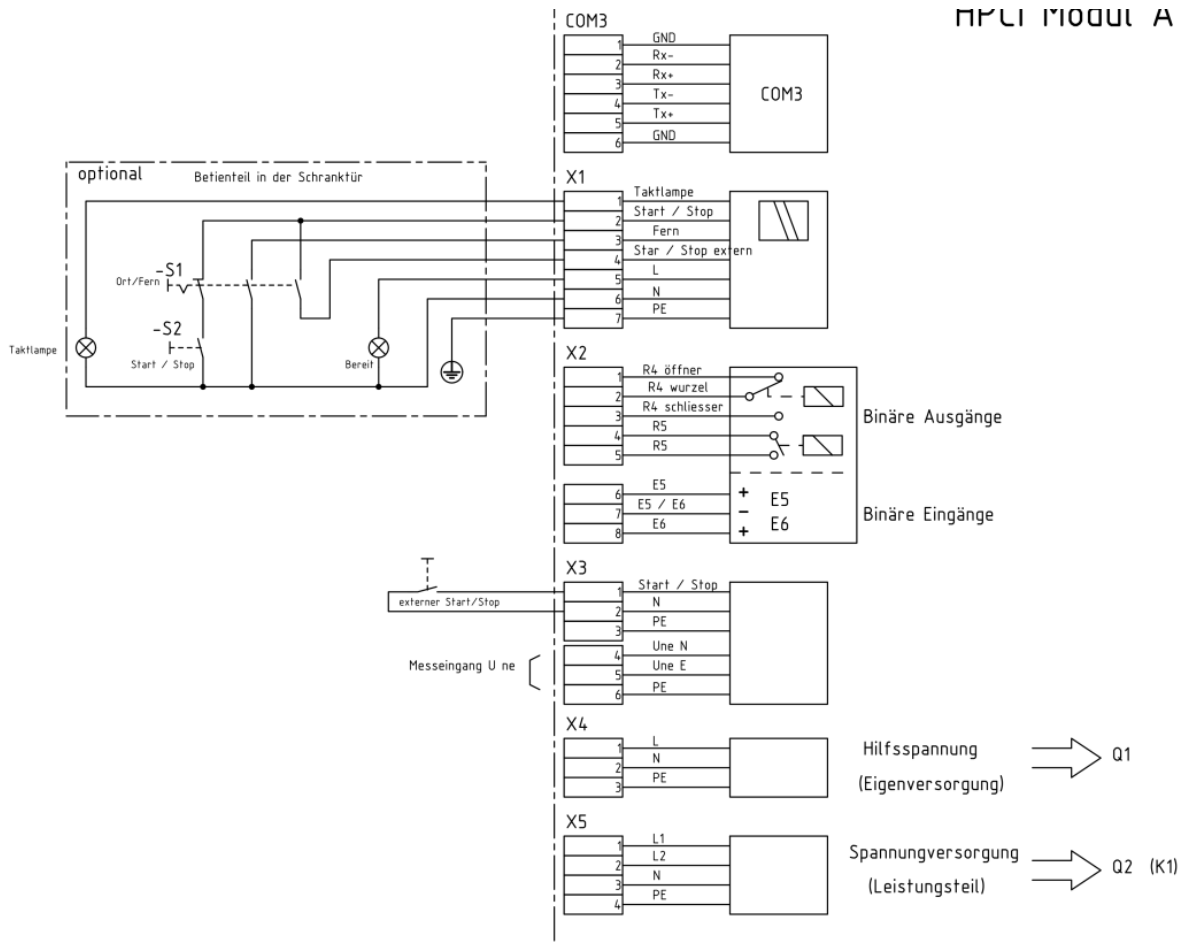


Figure 160: HPCI module terminal left cabinet side

Clamp X1	Description	Meaning
X1:1	Pulse lamp	Voltage signal for external pulse lamp **230 V AC**
X1:2	Start / Stop	Input for Start / Stop impulse pulsing for on-site operation Position of the selector switch is **local** The locking must be realized with an external circuit (as shown in Figure 160:)
X1:3	Remote	Input for Remote-function The HPCI can be controlled via external switches or from the REG-DP(A)
X1:4	Start / Stop external	HPCI accepts remote commands to start/stop the pulsing Via terminal X3:1 and X3:2 with an external switch Via the REG-DP(A) and ist COM 3 port (SCADA)
X1:5	L	Voltage supply for external control unit **DANGER** — **Terminal is energized with 230V AC!**
X1:6	N	Neutral conductor for 230 V AC supply of the external control unit

Clamp X1	Description	Meaning
X1:7	PE	Protective earth conductor of the 230 V AC supply for external control unit

Clamp X2	Description	Meaning
X2:1	R4 NC	Break contact relay R4 (change over contact); free programmable
X2:2	R4 contact	Common contact relay R4
X2:3	R4 NO	Make contact relay R4 (change over contact) ; free programmable
X2:4	R5 contact	Common contact relay R5
X2:5	R5 NO	Make contact relay R5, free programmable
---	---	---
X2:6	E5	Binary input 5, free programmable
X2:7	E5 / E6	Common of binary input 5 and 6
X2:8	E6	Binary input 6, free programmable

Clamp X3	Description	Meaning
X3:1	Start / Stop	Voltage supply for external button (phase conductor)
X3:2	N	Voltage supply for external button (neutral conductor)
X3:3	PE	External connection for protective earth conductor
X3:4	**Une N**	Measuring input for Une, connecting N
X3:5	**Une E**	Measuring input for Une, connecting E
X3:6	PE	Earthing connection for Une measuring, if used

Clamp X4	Description	Meaning
X4:1	L	Auxiliary voltage supply HPCI Module Phase (L); 230 V AC 50 Hz Fused internally with a 3 A fuse (Q1)
X4:2	N	Auxiliary voltage supply HPCI Module neutral conductor (N)
X4:3	PE	Auxiliary voltage supply HPCI Module protective earth conductor (PE)

Clamp X5	Description	Meaning

Clamp X5	Description	Meaning
X5:1	L1	Voltage supply power unit HPCI Module Phase (L1), 230 V AC 50 Hz Fused internally with a 20 A fuse (Q2)
X5:2	L2	Auxiliary voltage supply HPCI Module (L2), 230 V AC 50 Hz Fused internally with a 20 A fuse (Q2)
X5:3	N	Auxiliary voltage supply HPCI Module neutral conductor (N)
X5:4	PE	Auxiliary voltage supply HPCI Module protective earth conductor (PE)

Measurement points for the different algorithms:

Measu-rement point	Uns,Ici algo-rithm	Comment
$\underline{U}_{sync}$	☑	Synchronization voltage
$\underline{U}_{NS}$ (UNE)	☑	Zero sequence voltage on P-coil
$\underline{U}_{0D}$		Zero sequence voltage on open delta winding (on bus-bar)
$\underline{I}_{CI}$	☑	Injection current

14.4.1 Impact of the P-coil's design on the results of current injection

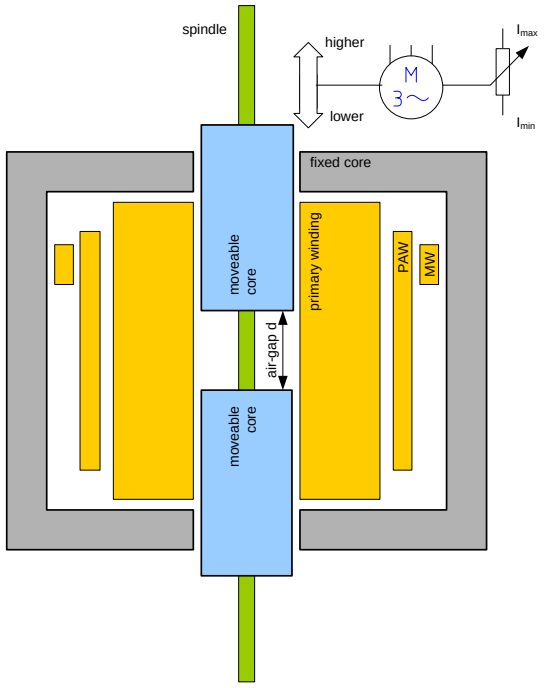


Figure 161: Basic design of a continuously adjustable P-coil

PAW - Power auxiliary winding

W - Winding

P-coil with PAW

In this case, the P-coil functions as a transformer. The accuracy of the results strongly depends on a constant conversion ratio between the PAW and the main winding. The ratio between the secondary current injection and the primary measured current value should stay the same regardless of the coil/plunger position.

In addition, the measurement of the zero sequence voltage should reflect the real value on the primary side and not just the voltage on the PAW.

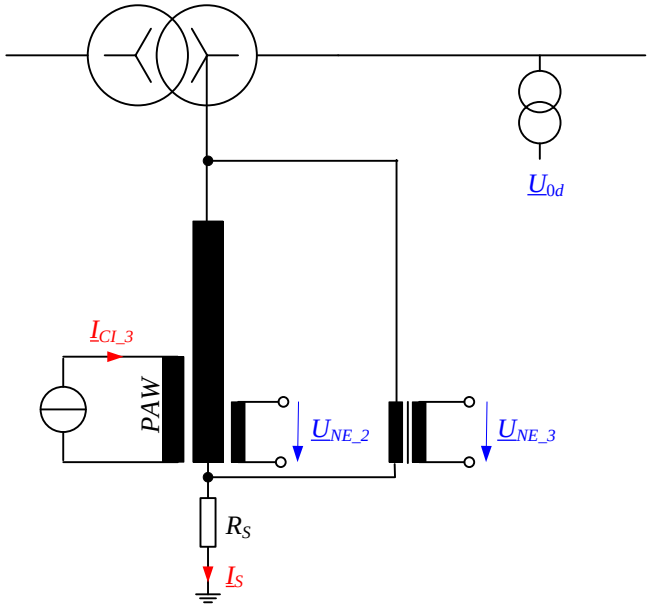


Figure 162: Possible measurement points on the P-coil with PAW

The below is a list of possible combinations and their score:

Combination of the measurement points:	Usual measurement accuracy				Score*)
	$\underline{I}_{CI\_3}$	$\underline{U}_{NE\_2}$ $\underline{U}_{NE3}$	$\underline{I}_S$		
$\underline{I}_{CI3}$, $\underline{U}_{NE2}$	☑	±10%	--		5
$\underline{I}_{CI3}$, $\underline{U}_{NE3}$	☑	±3%	--		3
$\underline{I}_{CI3}$, $\underline{U}_{0d}$	☑	±3%	--		3

*) A score of 1 represents the best solution to record the measured values. A score of 10 represents the worst case and should not be used!

P-coil without PAW

Older coils may not be equipped with a power auxiliary winding.

In this case, a single-phase transformer can be used instead and connected in parallel to the P-coil's main winding.

CAUTION	**Observe the power requirements on the power auxiliary winding!** Secondary nominal voltage 500 V AC Secondary nominal voltage continuous: 100 A Nominal voltage primary side = line-to-earth-voltage for the nominal voltage (Medium voltage side) The short-circuit impedance should be as small as possible.

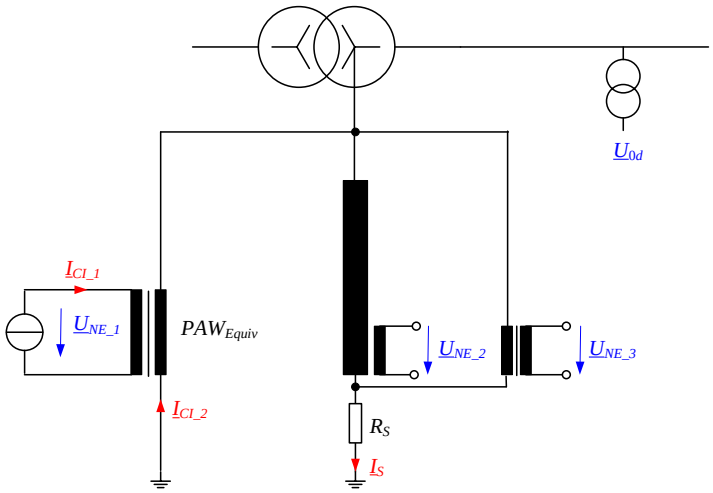


Figure 163: Possible measurement points on the P-coil without PAW

The below is a list of possible combinations and their score:

Measure-ment points:	Usual measurement accuracy				Score*)
	$\underline{I}_{CI\_2}/\underline{I}_{CI\_1}$	$\underline{U}_{NE\_2}$ (I_{pos})	$\underline{I}_S$		
$\underline{I}_{CI1}$, $\underline{U}_{NE1}$	☑	--	--	Not usable	10
$\underline{I}_{CI1}$, $\underline{U}_{NE2}$	☑	±10%	--		3
$\underline{I}_{CI1}$, $\underline{U}_{NE3}$	☑	±3%	--		2
$\underline{I}_{CI1}$, $\underline{U}_{0d}$	☑	±3%	--		2

*) A score of 1 represents the best solution to record the measured values. A score of 10 represents the worst case and should not be used!

14.5 Enabling HPCI in the REG-DP/ REG-DPA firmware

Firmware requirement!

- These operating instructions are based on the REG-DP/ REG-DPA running firmware > v 2.5.05.
- and **config_dp 2015_10_16** (or newer) for the WinEDC software

14.5.1 Enabling HPCI using parameterization in WinEDC

Load the current parameter file from the REG-DP/ REG-DPA that is to be extended with current injection.

Select the HPCI feature in WinEDC. The HPCI feature is active after the parameters have been sent to the REG-DP.

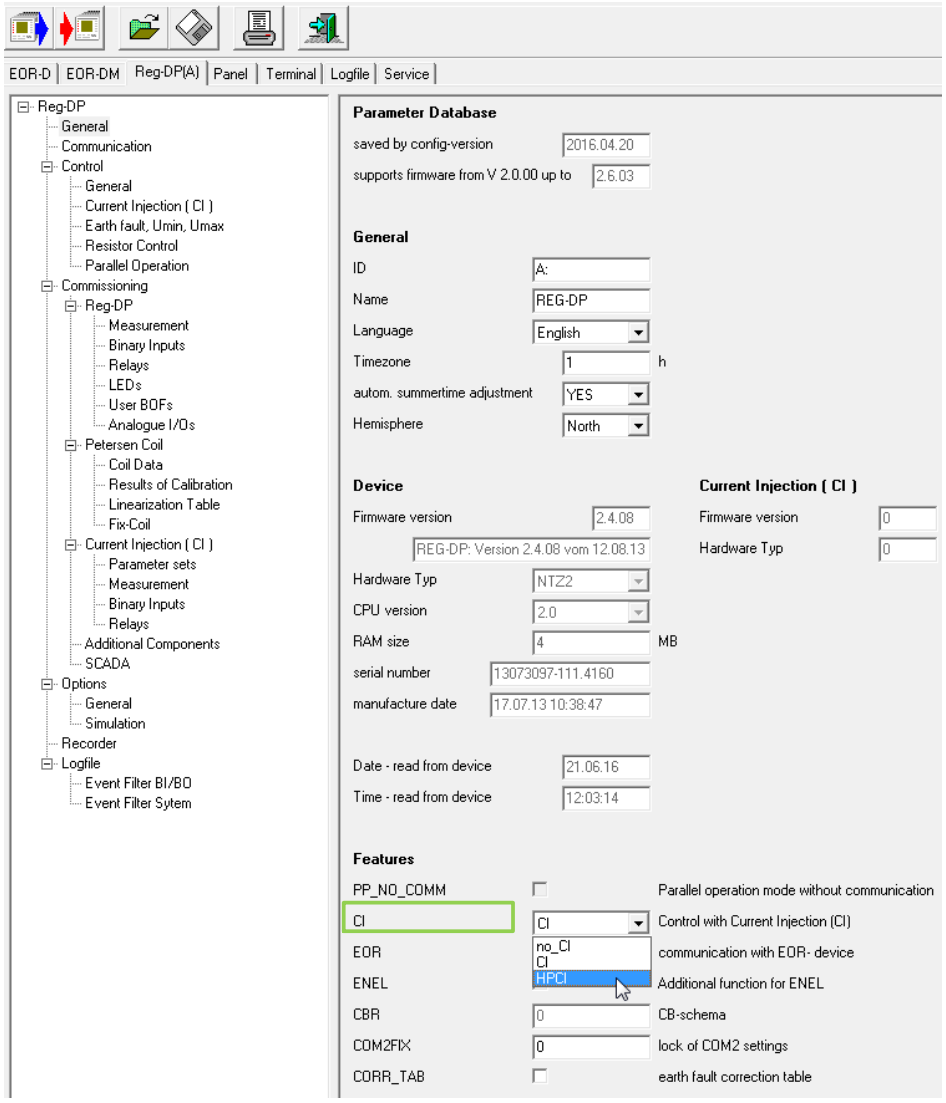


Figure 164: Enabling the HPCI feature in WinEDC

14.5.2 Enabling HPCI in the WinEDC terminal

Alternatively, the HPCI feature can be directly enabled in WinEDC

by entering the command: feature CI = 2

Press ENTER to confirm.

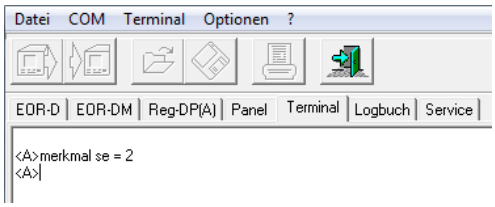


Figure 165: Enabling the HPCI feature in WinEDC's Terminal screen

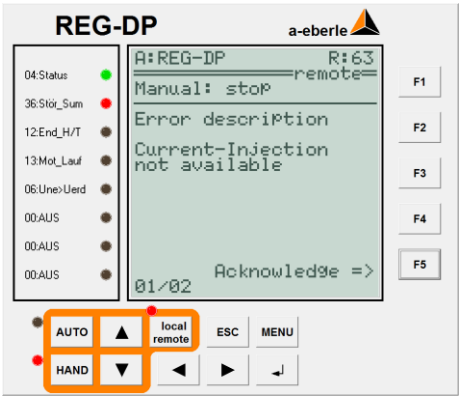
14.6 Testing communication between the HPCI module and REG-DP/ REG-DPA

To use current injection, the HPCI feature must be enabled. This is described in Chapter 1.1.

If the COM3 connection between REG-DP/ REG-DPA does not exist or is faulty, an error will display on the regulator as soon as the HPCI feature is enabled.

The error is indicated directly on the regulator by the illumination of the error LED and on the 'Troubleshooting' screen.

The following error message is displayed:



Message: Current injection not available

If the communication to the current injection controller is available, the error message will disappear.

The correct connection between the regulator (COM3) and the CIC's COM3 (current injection controller) is as follows:

REG-DP/ REG-DPA	CIC

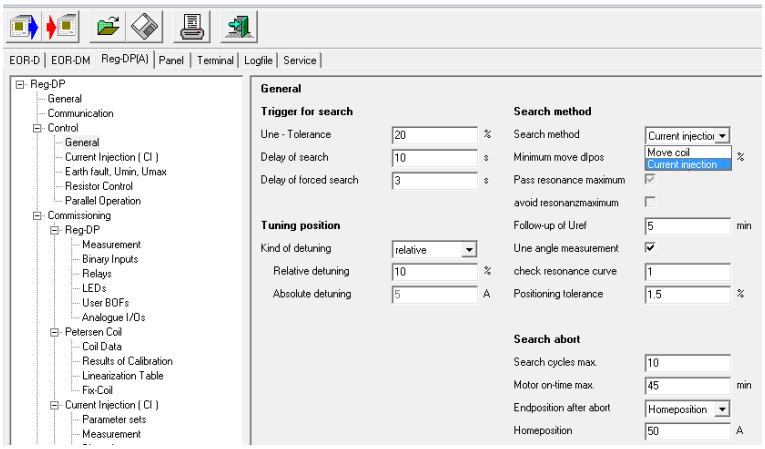
Tx+	<=>	Rx+
Tx -	<=>	Rx -
Rx+	<=>	Tx+
Rx -	<=>	Tx –

14.7 Parameterizing current injection in WinEDC

Enabling the HPCI feature in WinEDC displays additional current injection parameters that can be changed.

14.7.1 Parameters in the Regulation menu

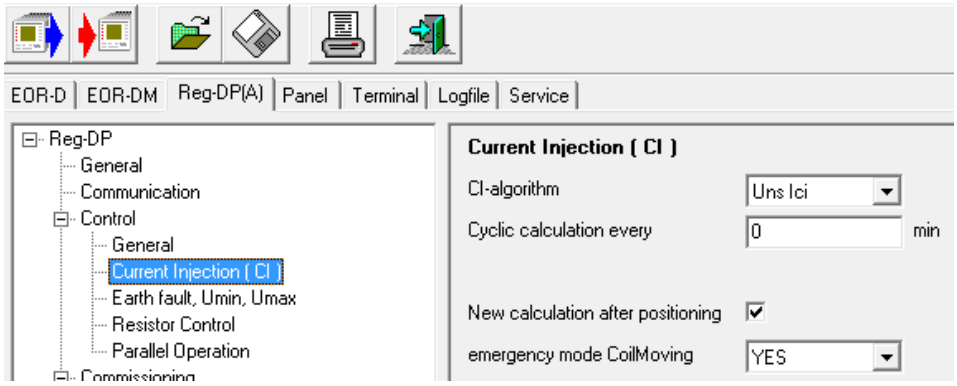
14.7.1.1 Menu item General



Select CurrInject as the search parameter.

Current injection will be used to determine the resonance curve

14.7.1.2 Menu item Current injection



This is where the basic parameters are set that are used to determine the grid parameters by including current injection in the calculation.

- CI algorithm

Settings:

Uns Ici: Default algorithm to calculate the grid parameters

Uns Uod Is If: Not possible for HPCI!

Default setting: Uns Ici

- cycl. Stimulate all

If the zero sequence voltage or the resonance curve is extremely flat, a relative change in the zero sequence voltage that is caused by a switching operation will have very little impact on the Une.

It is therefore meaningful to stimulate the current injection to calculate/check the grid parameters at regular intervals. Example every 60 min

Default setting: 0 min (= inactive)

- New search after positioning

If the checkbox for this parameter is checked, the REG-DP/ REG-DPA will perform a control measurement after successful tuning to check the resonance curve again. If the value is the same, the coil will stay in this position.

Default setting: active

- Emergency operation 'Move coil'

If the communication to the current injection controller fails,

the REG-DP/ REG-DPA can switch to classic regulation by moving the coil.

Settings:

YES: The REG-DP/ REG-DPA is allowed to move the coil to determine the resonance curve if current is not injected.

NO: The REG-DP/ REG-DPA is **not allowed** to move the coil to determine the resonance curve if current is not injected The regulator goes into alarm state. If it stays in alarm state for more than 60s, the regulator will go into error state and switch to MAN.

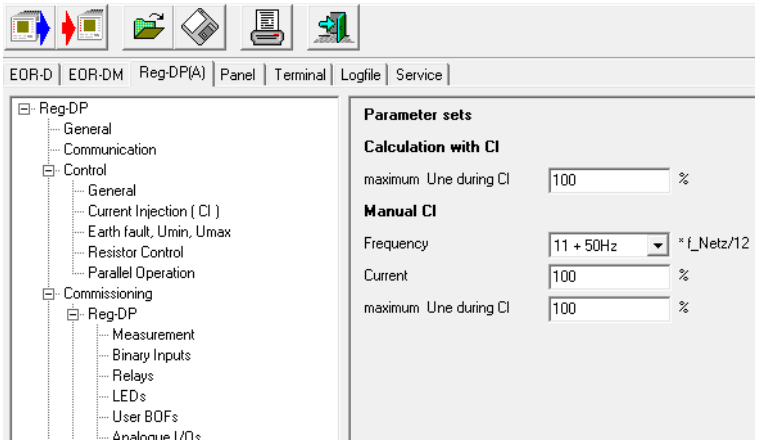
Default setting: YES

14.7.2 Parameters in the Commissioning menu

All of the other parameters that are needed to ensure that the current injection functions properly are set here.

14.7.2.1 Subitem Current injection

- Parameter sets



- Manual CI

The parameters for manual current injection can also be set. This point is only interesting during commissioning. This is where the measured values can be controlled using the WinEDC service screen and the manually startable current injection.

- Frequency

Settings:

Value	Description	Corresponds to frequencies		
12+50 Hz	Pure 50 Hz current injection		50 Hz	
11+50 Hz	Three frequencies (default)	45.8Hz	50 Hz	54.2Hz
10+50 Hz	Three frequencies	41.7Hz	50 Hz	58.3Hz
8+50 Hz	Three frequencies	33.3Hz	50 Hz	66.7Hz
6+50 Hz	Three frequencies	25Hz	50 Hz	75Hz

- Current

The amplitude of the manual current injection is set here.

Setting range: 0% .. 100 %

Default value: 100 %

- Measuring

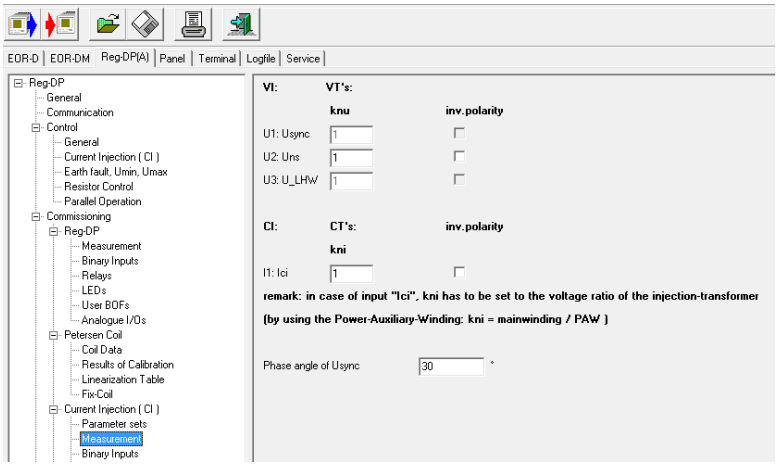


Figure 166: Setup of the measurement channels for HPCI

In contrast to classic current injection, HPCI only has two measurement channels. The transformer factors also have to be set.

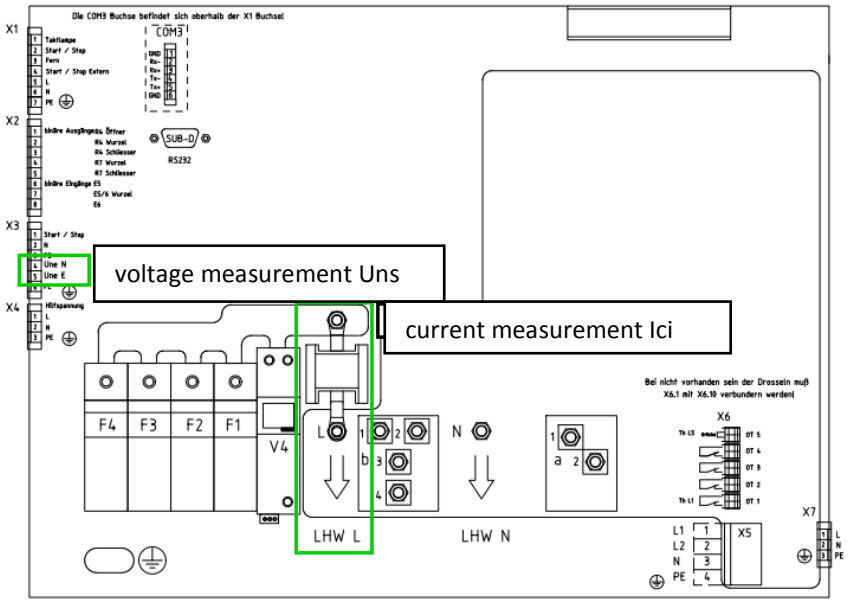


Figure 167: Position of the measurement channels for Uns (U_{NE}) and Ici

- CI voltage measurement inputs

Setting:

Setting	Description
Uns_Coil	Zero sequence voltage (usually 100 V) = U_{NE}

The transformer factor must be defined for each input.

Configuration of voltage channel 2

Measurement channel	Default allocation and settings
U2	Uns_Coil Ex.: 20 kV coil → 12 kV nominal voltage/100 V Knu = 120

- CI current measurement inputs

Current transformer in HPCI module

The current through the power auxiliary winding is measured directly on the HPCI with a 200/1 A current transformer. This transformer factor is integrated in the HPCI's firmware.

Setting for current input:

Setting	Description
Ici	Current injected at PAW - wired in CI cabinet by default to current channel 1

Default allocation of current channels

Measurement channel	Default allocation and settings
I1	Ici Ex.: 20 kV coil → 12 kV nominal voltage/500 V power auxiliary winding (PAW) Kni = 24

In the example, the coil's nominal voltage is 12 kV, the transformer's nominal value is 100 V and the PAW's 500 V.

The conversion ratio knu for the value Uns_Coil is then 120.

Because the current is injected at the PAW, the ratio 12000 V/500 V = 24 for the current transformer factor (kni) can be set there. The current Ici is already measured on the secondary side by the current injection controller.

- Phase U-Sync (parameter is hidden)

The value is determined during commissioning by testing the polarity of the current and voltage channels.

The reason for this is that the synchronization voltage Usync at the REG-DP/ REG-DPA may not have the same phase as the synchronization voltage at the current injection controller.

However, the same zero sequence voltage is measured on both devices. The absolute value and especially the phase must be the same at both measurement inputs.

Values in increments of 15° can be entered.

Default value: 30°

- Binary inputs

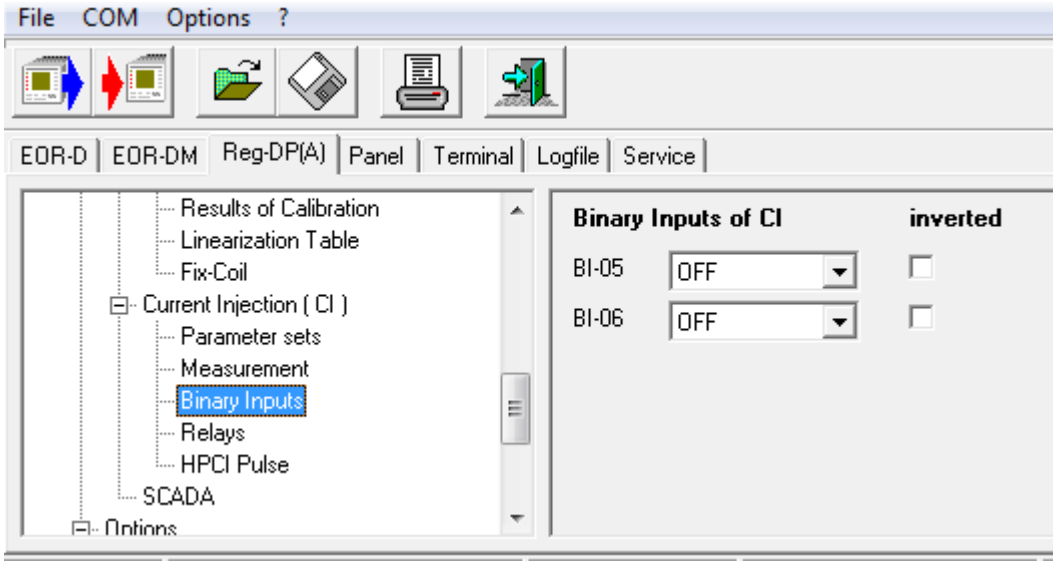


Figure 168: Binary inputs 5 and 6 can be used for HPCI

Binary input 2 is configured with the circuit breakers' auxiliary contacts in the current injection.

The REG-DP/ REG-DPA receives a message if one of the fuses Q1 or Q2 blows. The REG-DP/ REG-DPA sends the summary error (BOF 38)

- Relay

This is where the freely available relays and LEDs for HPCI are parameterized.

The functions that can be associated with the relays and LED 3 are the same as those in Chapter 11.4.1.2.

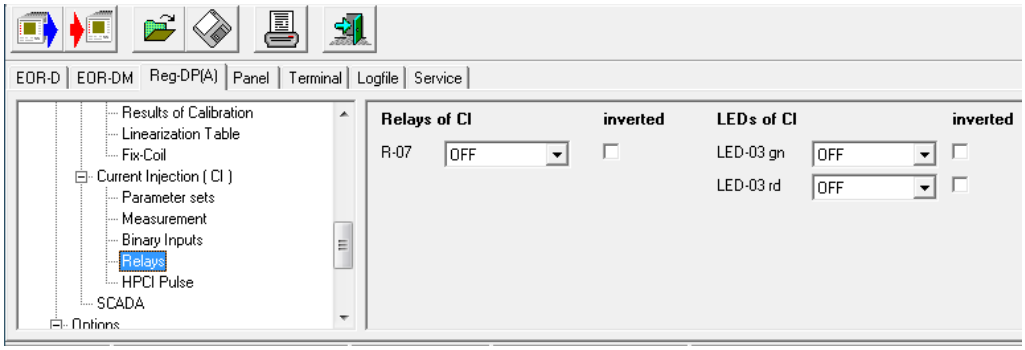


Figure 169: Parameter menu HPCI relays and LEDs

14.8 Testing the polarity of the measurement channel

Once the parameters have been set, they have to be sent to the REG-DP/ REG-DPA. The polarity of the used measurement channels can then be tested.

Note:

When commissioning current injection, the assumption is that the coil that is regulated by the REG-DP/ REG-DPA is already in the grid. The coil must be in the grid at the latest for the next polarity test so realistic results can be achieved.

14.8.1 Testing using the WinEDC service screen

For the following test, the P-coil must be connected to the grid and positioned at the actual resonance point. The regulator must also be running in MAN mode.

The point can be determined by moving the regulator manually and is where the zero sequence voltage peaks across the coil's whole adjustment range. Another option is to reset the regulator to the 'Move coil' option and start a tuning process.

On WinEDC's service screen, the REG-DP/ REG-DPA screen is expanded with the additional current injection functions.

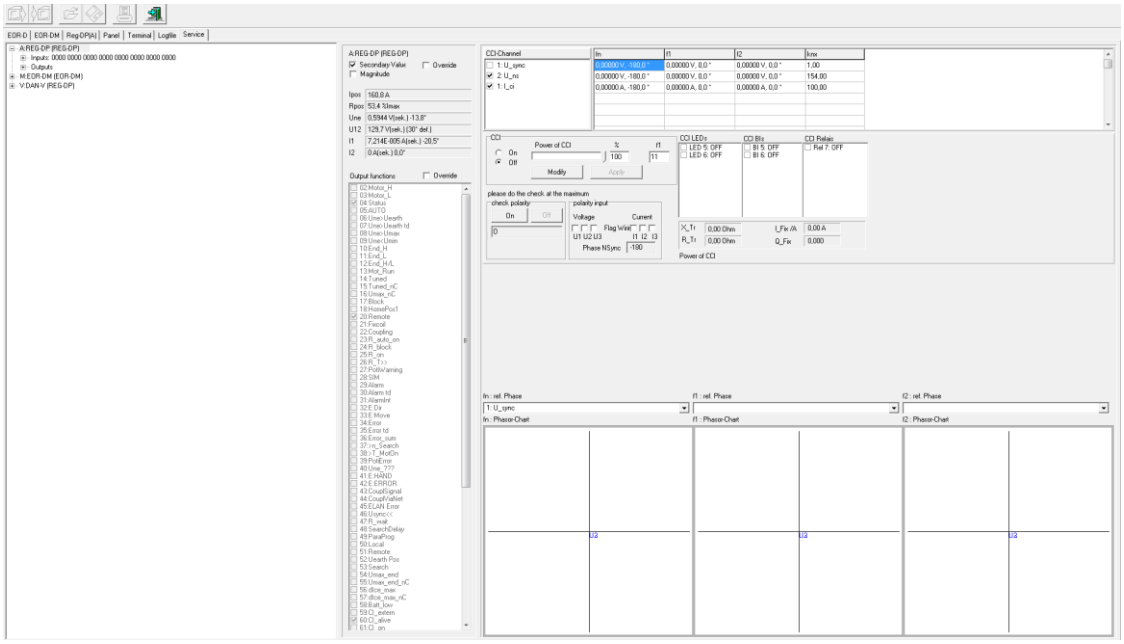
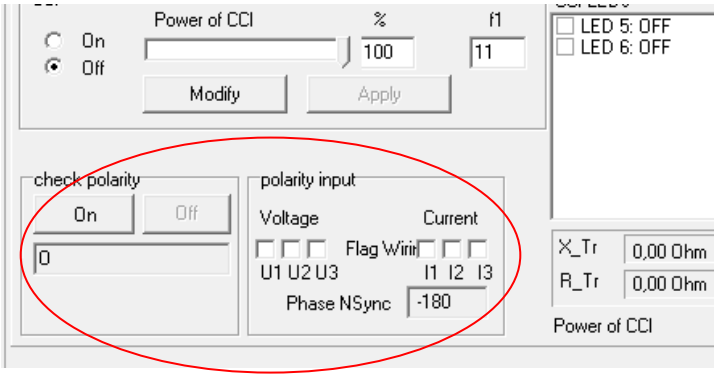


Figure 170: Service screen with current injection

If the aforementioned conditions are met, press the ON key in the highlighted field to start the test.



The automatic test consists of checking the plausibility of the measurement channels' polarity.

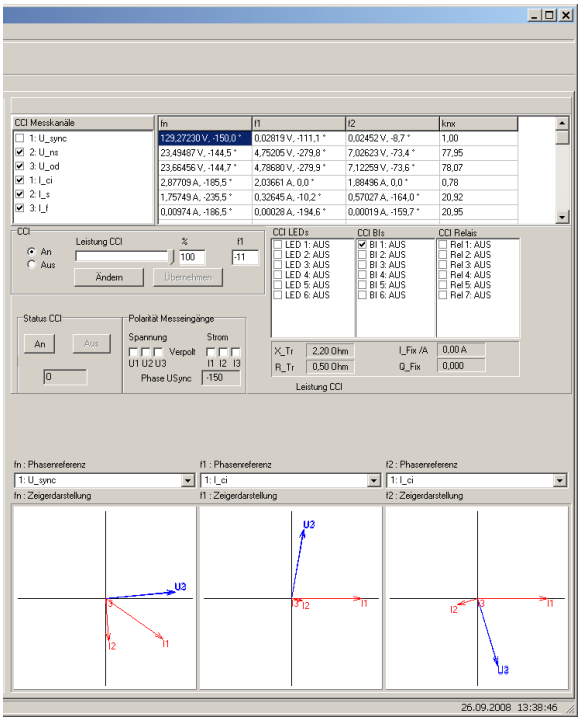
If the polarities are not plausible, 'Phase Usync' is used to synchronize both of the Une phases and correct the measured values while reversing the polarity of as few inputs as possible.

Measurement channels with a polarity that has clearly been reversed can be reconnected and the polarity test repeated.

The view shown in the section on WinEDC's service screen for frequencies f1 and f2 for the voltage indicators is correct. They must be opposite Ici in the first and fourth Quadrant of the vector diagram.

If current is injected, the corresponding pointers will be visible in the lower area.

The field fn stands for the signals of the fundamental frequency (50 Hz), and frequencies f1 and f2 for the signals with which the current injection performs the calculations.

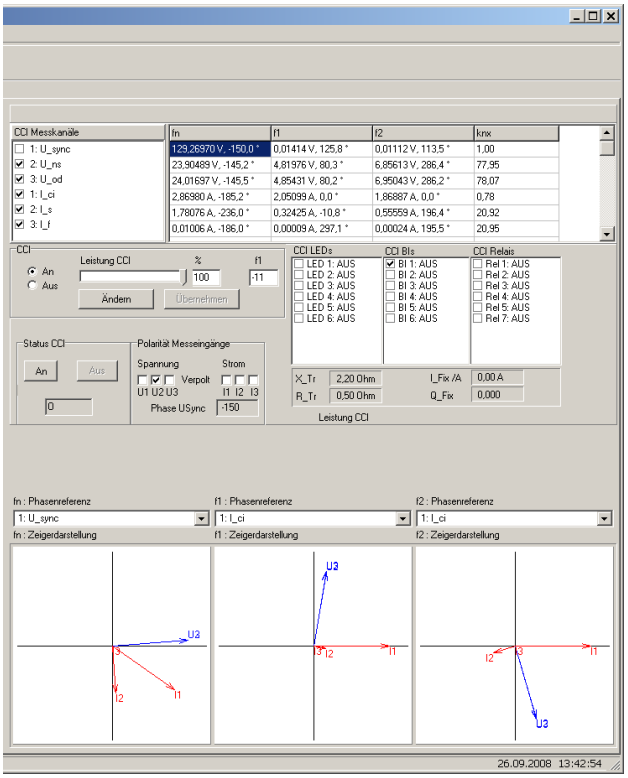


If, for example, the phase of Uen on the REG-DP/ REG-DPA and Uen on the current injection controller (CIC) are different, the phase of the U-sync input is automatically rotated until the absolute value and the phase match each other.

Une for the current injection controller and for the REG-DP/ REG-DPA must always be measured at the same spot.

In the example, Une (Uns) is connected to channel 2 on the current injection controller.

If the polarity of this channel is reversed, an automatic test will detect it and correct it.



The values for Une (Uns) on the current injection controller can be viewed in the second line (in red). The reversed polarity on channel U2 is displayed under 'Polarity measurement inputs'.

Current injection stays on after the test has finished and must be switched off by pressing the 'OFF' key.

The test can be stopped at any time by pressing the 'OFF' key.

Current injection is also switched off when you exit the service screen.

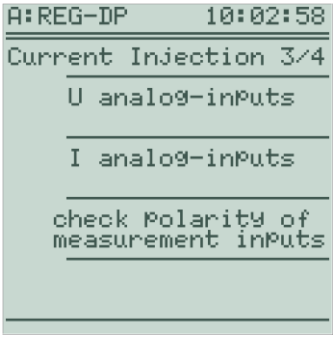
Une_{DPA} and Une_{CIC160}

14.8.2 Testing directly on the REG-DP/ REG-DPA

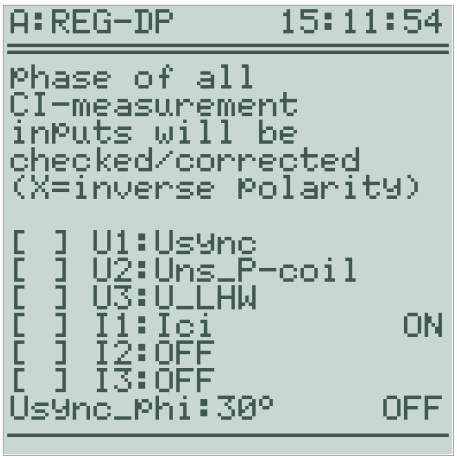
The automatic polarity test for the measurement channels for the current injection described in Chapter 13.9.1 can also be performed directly on the REG-DP/ REG-DPA.

One of the Commissioning menu's submenus is 'Current injection'. You can select 'Test polarity of measurement inputs' here.

Press **<MENU><F3><F5><F1> <F5>** to access the sub menu 'Current injection'.



The option 'Test polarity of measurement inputs' is on screen 3 of 4 as shown in the above figure.



Press F4 to access this function.

After the test has finished successfully, the message 'Polarity test successfully completed' displays. The value for Usync_phi and the polarity of the channels is now set and can be queried.

Note:

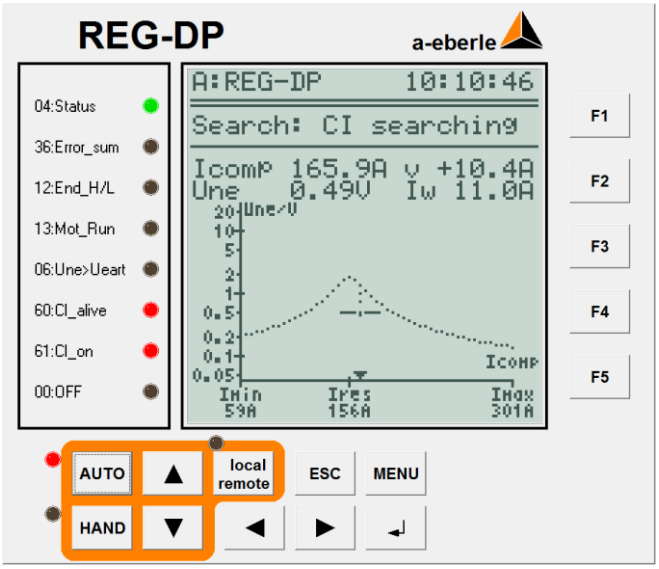
In contrast to the test, current injection is switched off through the WinEDC service screen following a successful test. The test can be aborted at any time by pressing F5.

14.9 Completing the commissioning of current injection

After a successful polarity test, the regulator can be set to AUTO mode and the resonance curve calculated.

Note:
If the regulation parameter is still set to 'Move coil', set it back to 'Current injection'.

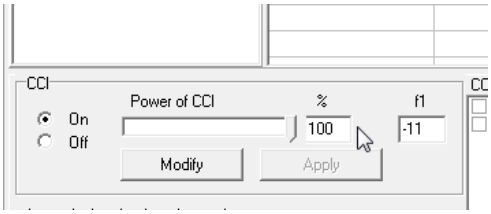
The calculated resonance curve



and the value for Ires are displayed on the REG-DP/ REG-DPA.

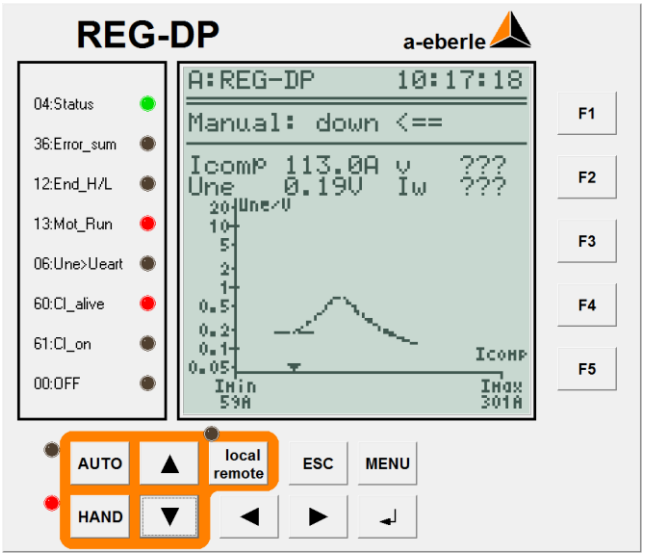
14.10 Testing the correct calculation across the P-coil's whole adjustment range

- The REG_DP(A) must be set to MAN!
- Select **manual current injection** on the WinEDC service screen.
- Enter 100% for the power and press the 'Accept' key.



- Current injection is now continuous and new resonance curves are constantly calculated.
- Move the coil manually (using the Higher and Lower keys on the device) from the upper to the lower end switch.

During the adjustment, the calculated value for Ires and Iw should be as good as constant.



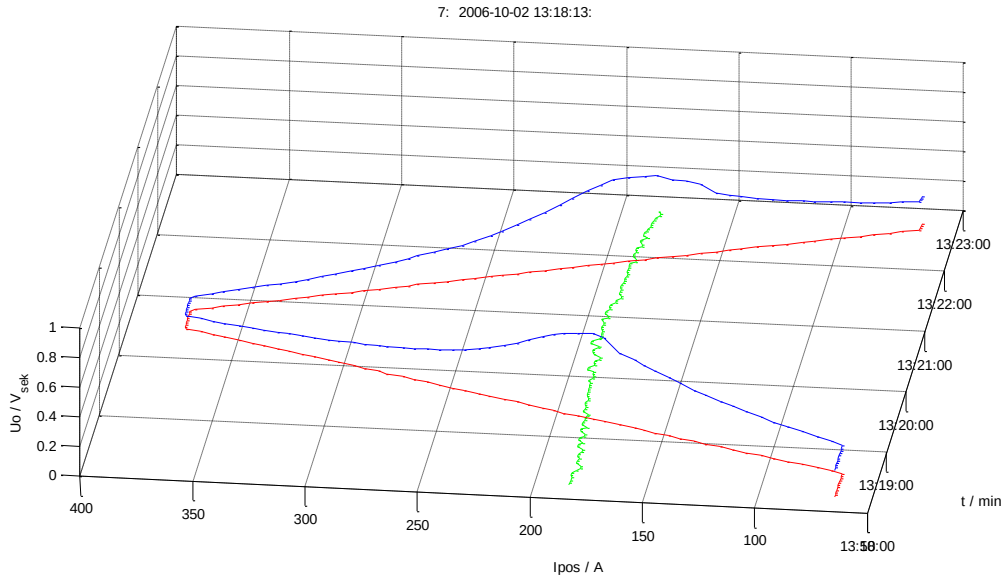


Figure 171: Calculated resonance point (green) across the whole adjustment range

The values can be slightly different at the upper and lower end switching points, because the magnetic coupling between the PAW and the main winding is slightly worse there.

The values should not deviate more than 10%, at the most 20% of the calculated value at the resonance point.

14.10.1 Enabling manual current injection directly on the REG-DP/ REG-DPA

Current injection can also be manually enabled on the REG-DP/ REG-DPA.

Pressing F1 takes you to the measured values screens, which includes the measured values for current injection.

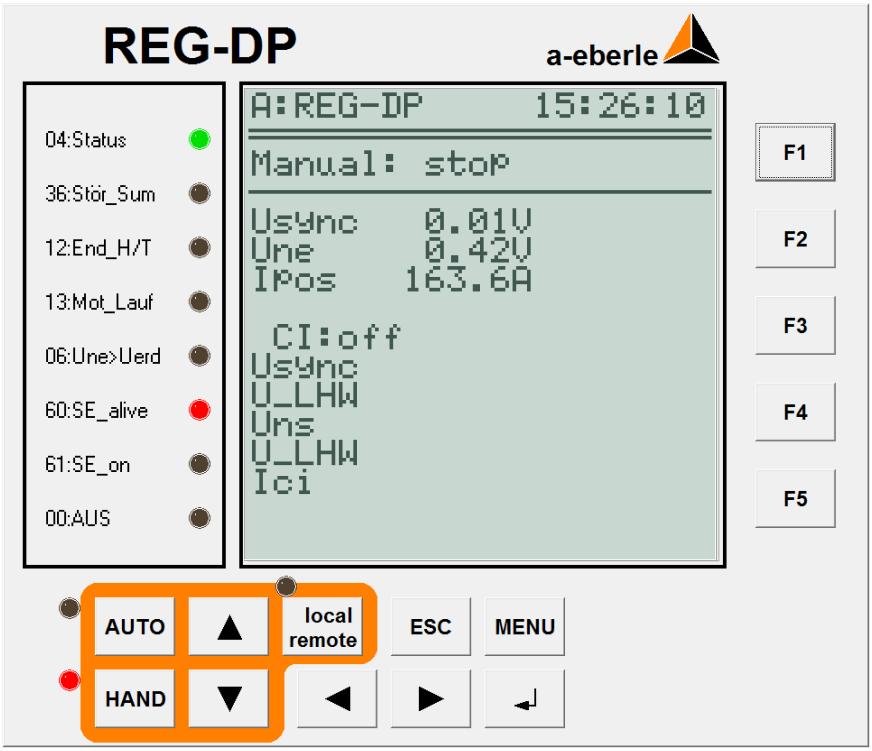
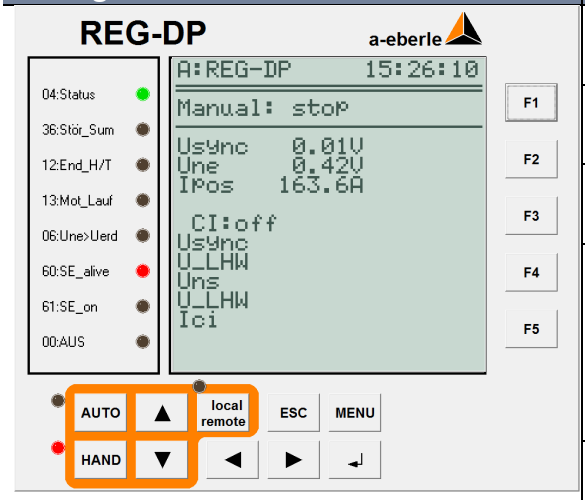
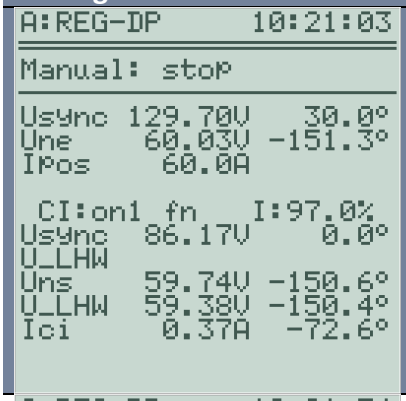
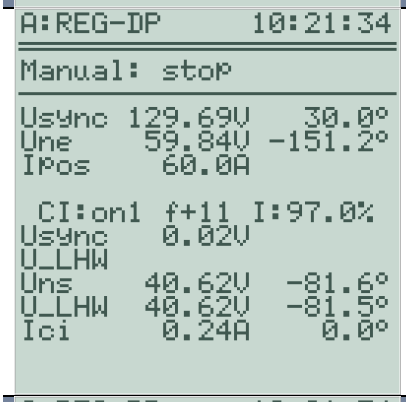
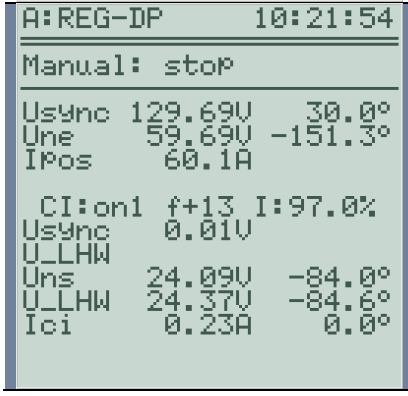


Figure 172: Start screen 3 – current injection not active

Setting	Description
	**F1- Browse through screens**
	F2 – Increase power (maximum 100%)
	F3 – Reduce power Increment 1%
	F4 – Browse through the measured values **fn = Fundamental frequency** **fx = Depends on the pattern** **Fy = Depends on the pattern**
	F5 – Switches manual current injection ON and OFF

Setting	Description
	**F3 – Reduces power to 97%** **fn = Fundamental frequency Measured values**
	**frequency** **F4 to switch displays**
	**f-13 = Measured values for the selected frequency** **F4 to switch displays**

14.11 LED Configuration of the HPCI module

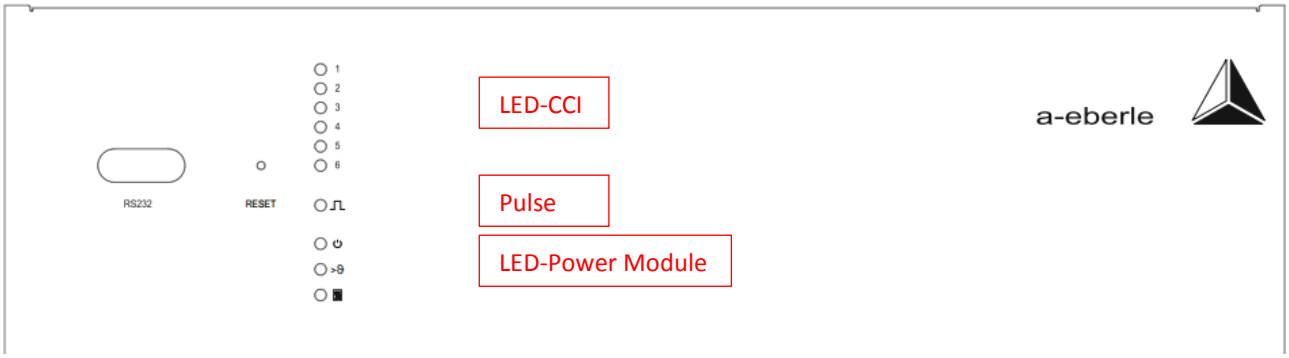


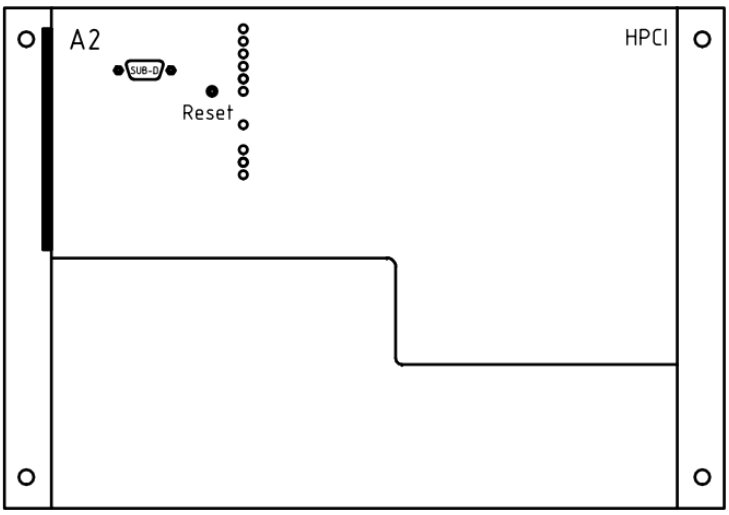
Figure 173: LED Configuration of the HPCI module

LED - CCI	function	status ok	status error
1	U 1 < 195 V status not ok U1 > 200 V status ok	0	RED
2	U1 – U3 < 35 V status not ok (pulsing is blocked) U1 – U3 status ok (pulsing can be enabled)	0	RED
3		GREEN	
4	HPCI searching for the resonance curve is ready ORANGE = HPCI searching is blocked	GREEN	 ORANGE
5	Pulse locating with HPCI is possible Pulse locating with HPCI is blocked	GREEN	 ORANGE
6	Status HPCI Controller (CCI) error = RED other errors = ORANGE, if: - DP Firmware is too old - CCI is not calibrated - wrong CCI type - voltage L1 is too small - communication between HPCI and REG-DP is interrupted	GREEN flashing	 RED flashing ORANGE flashing

Pulse	function	status ok	status error
LED	signals pulsing	GREEN flashing (classic pulse) GREEN (fast pulse)	not available

LED – power module	function	status ok	status error
	Power power section of HPCI is connected to the supply voltage	GREEN	RED
ϑ	Excess temperature in power section of HPCI (OR) - thyristors - heat sink - chokes	0	ORANGE
	Cooling fan is active (optional)	GREEN	
	Heating Switch cabinet heating is active (optional)	GREEN	

14.11.1 Reset button and COM1 interface at the HPCI module



The COM 1 interface is only needed in case of a firmware update. All of the parameters are configured at the REG-DP(A).

In case of firmware update, the reset button starts the bootloader mode that is necessary to load the firmware to the HPCI module.

15. Parameterizing the pulsing of HPCI

In addition to regulation with current injection, the HPCI can also be used to pulse during an earth fault. All of the settings are described here.

Classic pulse detection and fast pulse detection!

In the HPCI, the parameters can be set for classic pulsing (pattern 1 s to 1.5 s), fast pulsing (e.g., with 55 Hz) or a combination of both.

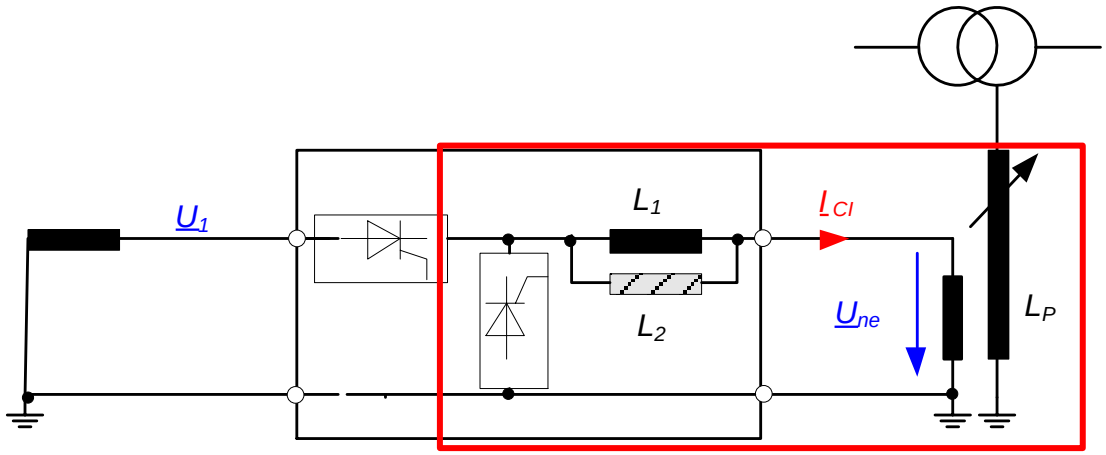


Figure 174: HPCI for pulse detection function – schematic diagram

15.1 How HPCI pulse works

The HPCI creates a pulse based on the pattern created by the set pulse ON and OFF time.

Inductors are used.

In contrast to a pulse cabinet with capacitors, the pulse-no-pulse-ratio can be inverted.

The additional inductors increase the P-coil's compensation capability. Switching on the inductors increases the inductive current from the P-coil.

15.2 Setting the HPCI pulse parameters in WinEDC

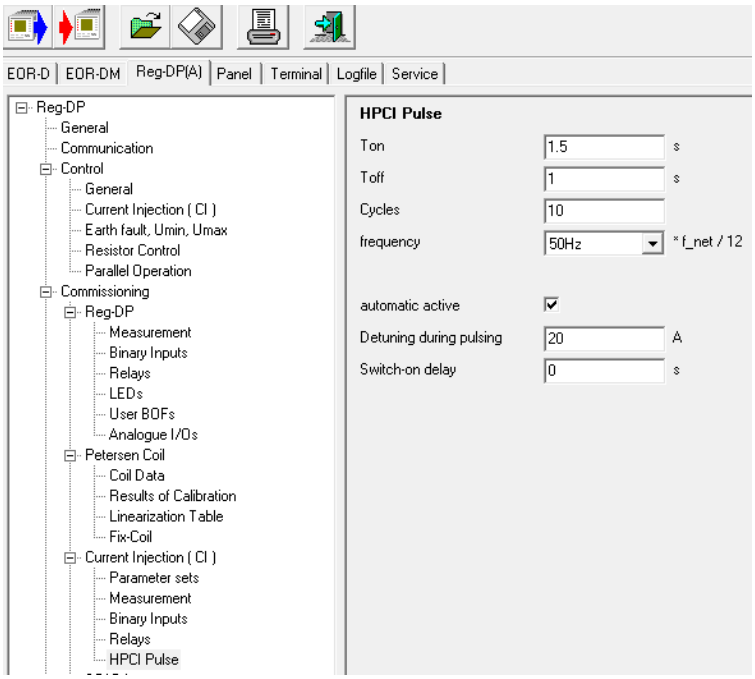


Figure 175: Overview of HPCI pulse parameters in WinEDC

Parameters	Description	Comment
T on	Switch-on time for the inductors	
T off	Off time	Inductors are switched off
Cycles	Number of repetitions	One cycle = T on + T off
Frequency	Frequency at T on	Default value 50 Hz corresponds to classic pulse
Active	Automatic when earth fault active	
Detuning when pulsing	Target detuning when pulsing	Target detuning compared with resonance point when pulsing. The coil is set back to its initial value at the end of the cycle time.
Switch-on delay	Time delay after earth fault to switch on the pulse cycle	This is where you determine when the cycle is activated. The delay time makes sense if pulsing is to occur only for a continuous earth fault.

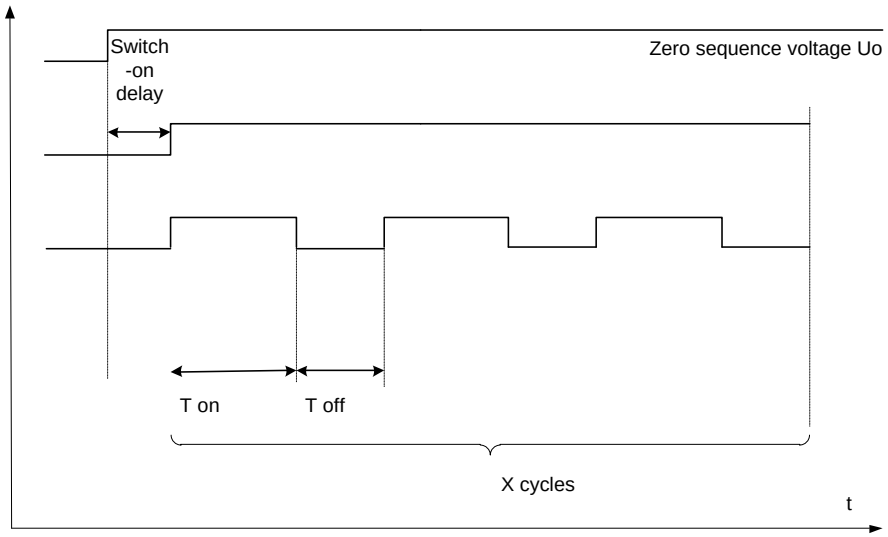


Figure 176: Flow chart for HPCI pulse setting

15.2.1 Replacing the classic pulse cabinet with HPCI

HPCI can replicate a classic pulsing signal.

Classic pulsing with inductors!

In contrast to the classic pulse cabinet, inductors are used instead of capacitors.

- The ratio between ON and OFF must be set to the opposite of that of a classic pulse cabinet in order to generate the same pulse pattern **(only important when unsymmetrical pulsing is used)**

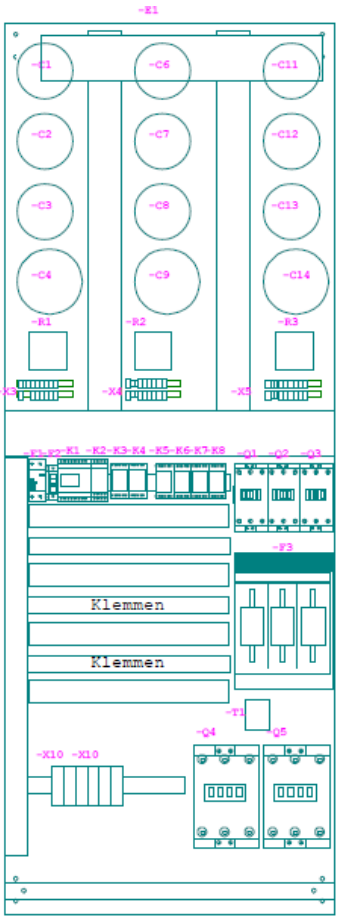


Figure 177: Classic pulse cabinet with capacitors (Height 2000 mm, Width 800 mm, Depth 600 mm)

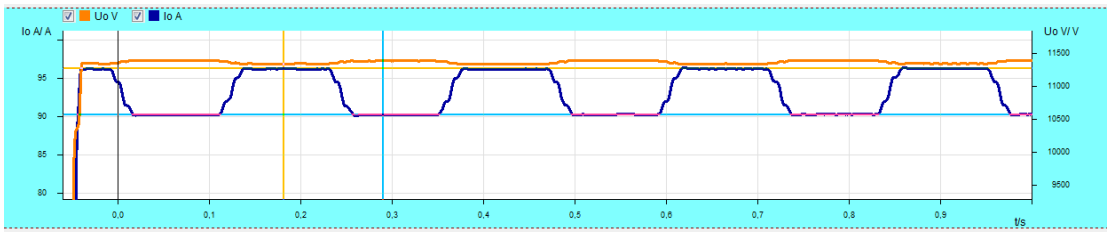


Figure 178: Example for pulse pattern generated with HPCI (fast pulsing)

16. SCADA system

Communication with SCADA system through external protocol cards!

For more information, see the opreating instructions for REG-P, REG-PE and REG-PED as well as the WinConfig software.

17. Maintenance/Cleaning

17.1 Cleaning instructions

Use a soft, slightly damp, lint-free cloth. Make sure no liquid gets in the housing. Do not use window cleaner, household cleaners, sprays, dissolvent, cleaners that contain alcohol, ammonia solutions or abrasive cleaning agents.

If the inside is very dirty due to improper use, it may be best to send the device to the manufacturer. Dust that accumulates on the printed circuit board can cause the insulation coordination to fail.

Dust is generally hygroscopic and can bridge creepage distances, which is why it is advisable to operate a device with housing with the housing closed.

NOTE!	**Do not clean the device with unsuitable products!** This can damage the surface of the device and remove markings ➲ Please follow the cleaning instructions described above.

17.2 Replacing a fuse

The REG-DP ™ has a replaceable microfuse (20 mm) that is fitted to printed circuit board 3 (power supply board, REG-NTZ) with an appropriate fuse holder. There is a replacement fuse on the back of printed circuit board 3.

Required fuse

Auxiliary voltage, feature H0/H1: Microfuse T1 L 250 V, 1 A (Order No. 582.1002)

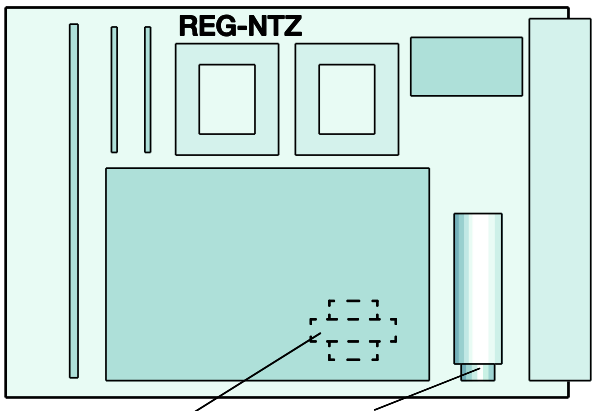
Auxiliary voltage, feature H2: Microfuse T2 L 250 V, 2 A(Order No. 582.1019)

DANGER!

Danger of electric shock!

Injury or death

➲ When replacing the fuse, disconnect the device from all power supplies (auxiliary voltage, control voltages).



17.3 Replacing the battery

Three versions of buffer battery are used in the REG-DP ™. Depending on the version and year of manufacture of the device, the batteries are used for different purposes (see case descriptions in this chapter). The battery is not actively used as long as the device is powered by auxiliary voltage. The battery serves as a backup if the auxiliary voltage fails.

In general, the battery voltage is monitored and an alarm set off (status relay or status/operating LED) or information (output function for weak battery) generated when the battery shows a low residual capacity. This means that the battery does not have to be replaced at regular intervals. Battery replacement can also be event-based.

The below delivery times are approximate. As a result of repairs, for example, old devices may need a new CPU circuit board. Please check the battery type in the device.

Regardless of the type of battery, the parameters should be saved as quickly as possible in the event of a battery failure and always before the device is disconnected from the supply voltage. This doesn't have to but can be done in devices equipped with MRAM. For more information on backing up and restoring parameters, see Chapter 10.2.3.6

⚠ DANGER!	**Danger of electric shock!** Injury or death ➲ When replacing the fuse, disconnect the device from all power supplies (auxiliary voltage, control voltages).

To replace the battery, first remove the plastic protective cover on the CPU board. Loosen the four screws and remove the cover. Once the battery has been changed, put the cover back on.

REG-DP devices with MRAM (from 05/2014)

These devices have a button cell battery to buffer the real-time clock. This means that no data are lost when the battery is removed. The time may have to be adjusted when the new battery is installed.

Required battery:

Lithium button cell 3 V Type CR1632 (order no. 570.0005)

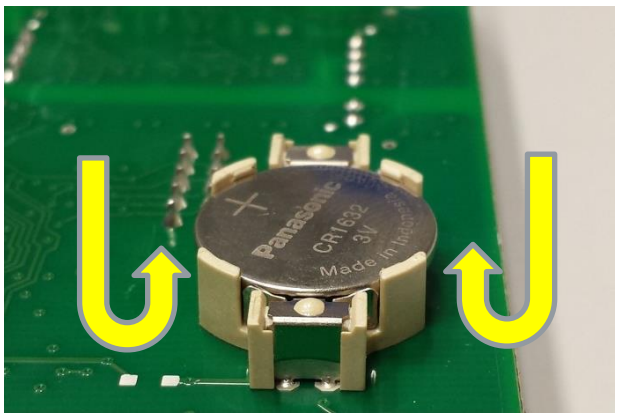
Service life:

When the REG-DP (no auxiliary voltage) is in storage > 6 years

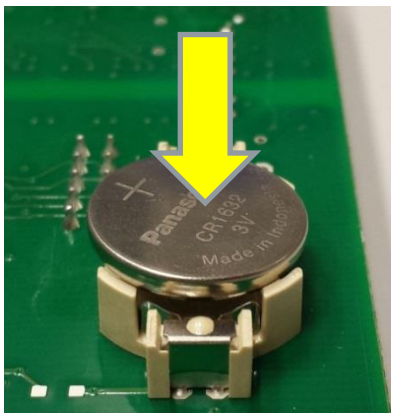
In operation at duty cycle > 50% > 6 years

The battery is installed on the outside of the CPU board in a suitable mount. To change the battery, pull the existing battery out of the holder and insert a new one. If you use tools to remove the battery, be careful not to damage the printed circuit board.

NOTE!	**Do not use pointed or sharp tools to remove the button cell!** Damage to the CPU circuit board ➲ Remove the button cell with your fingers and not with a tool. ➲ If you have to use a tool, do not use a screwdriver or similar pointed or sharp objects.



Remove the button cell



Insert the button cell

REG-DP device with SDRAM and plug-in battery (from 05/2009)

In these devices, the battery is a buffer for the SDRAM and the real-time clock. Parameters are lost when the battery is removed, which is why the devices have a dual connection for the buffer battery. This means that the new battery can be connected before the spent one is removed.

For safety reasons, it is recommended to back up the parameters for these devices.

Required battery:

Lithium 3 V or 3.6 V type CR14250 1/2AA with cable and connector (Order No. 570.0003 00

Service life:

When the REG-DP (no auxiliary voltage) is in storage > 6 years

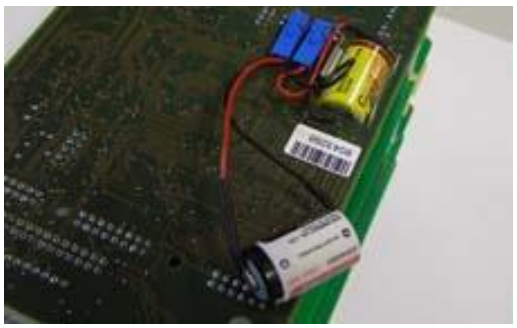
In operation at duty cycle > 50% > 10 years

Removing the battery erases the parameters!

- Connect the new battery before removing the spent one.
- Back up the parameters (see Chapter 10.2.3.6) before removing the battery.

There are two battery connection points on the back of the circuit board. To prevent losing the parameters, place the replacement battery in the empty connection point. Lift the battery that needs replacing and remove it carefully from the metal cover. You can then push the new battery into the metal cover.

Plug connection points and metal cover on the outside of the printed circuit board



Parallel plugged batteries

REG-DP device with SDRAM and soldered battery (before 09/2013)

In these devices, the battery is a buffer for the SDRAM and the real-time clock. Parameters are lost when the battery is removed, which is why the parameters have to be backed up before replacing the battery.

Parameters are lost on removal of the battery!

- ➲ Connect the new battery before removing the spent one.
- ➲ Back up the parameters (see Chapter 10.2.3.6) before removing the battery.

Required battery:

Lithium 3 V or 3.6 V type CR14250 1/2AA with soldering lugs (Order No. 570.0001)

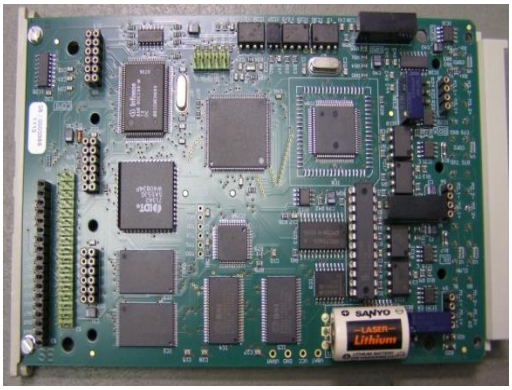
Service life:

When the REG-DP (no auxiliary voltage) is in storage > 6 years

In operation at duty cycle > 50% > 10 years

NOTE!	**Mechanical/thermal damage to the CPU circuit board!** Destruction of the conductor paths and/or the soldering pads ➲ It is recommended to have the battery changed in the factory. ➲ If the battery has to be replaced on-site, it must be replaced by trained and qualified personnel in compliance with EMC Directives.

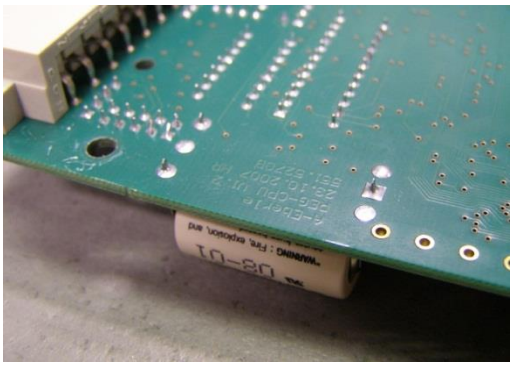
The following describes in detail how to replace a soldered battery with three soldering lugs with a battery with two soldering lugs. When using a soldering iron, it is imperative to comply with general safety rules. Ensure the work is carried out with the utmost care and by trained personnel only.



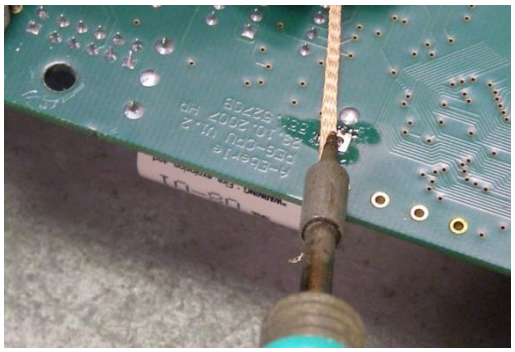
CPU circuit board with soldered battery – plan view

Soldered battery with three soldering lugs

Turn the device so that the three soldering joints are in front of you. Desolder the three soldering pins on the battery using a soldering iron. We recommend using desoldering tape to remove the solder from the pins. Often, a little bit of tin solder on the top side of the suction tape helps to suck up the tin solder from the soldering joint. It is not recommended to use a desoldering suction pump as it can damage the soldering pads on the circuit board.

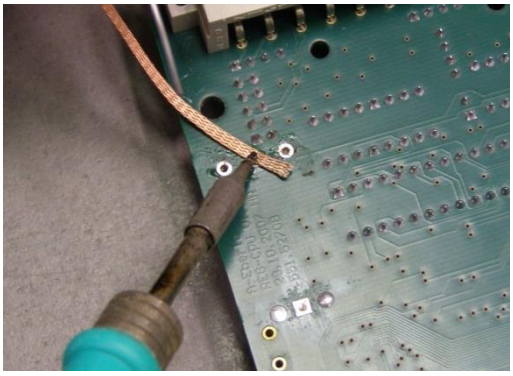


The soldered battery's soldering joints with three soldering lugs

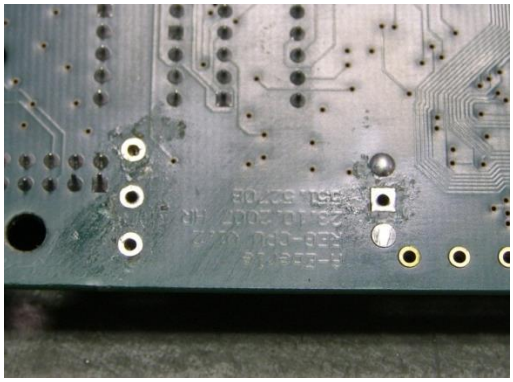


Desoldering with desoldering tape

To solder a soldered battery with two soldering lugs, the middle soldering point, which is between the two soldering lugs that have already been desoldered, must be freed from solder. Before inserting the battery with two soldering lugs, the middle of the three soldering pads on both the right and left side must be free of tin solder.

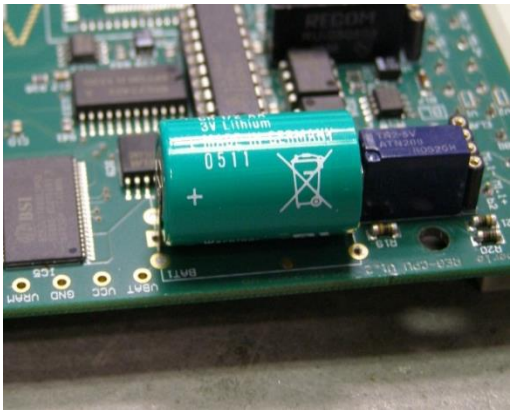


Desoldering the missing soldering pad for soldering batteries with two soldering lugs

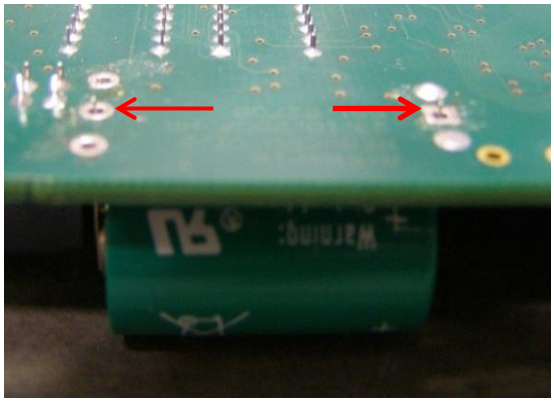


Soldering joints prepared for soldered battery with two soldering lugs

Plug the battery with two soldering lugs in the central soldering pads on the top side and make sure that the polarity of the battery is correct. On the underside of the CPU circuit board, the soldering pins on the two middle soldering pads must protrude.

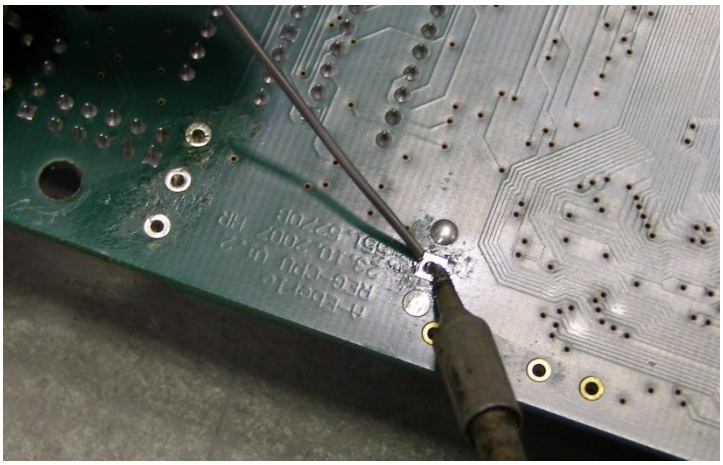


Soldered battery with two soldering lugs
– Check the polarity of the battery!



Inserted soldered battery with two soldering lugs

Solder the pins of the batteries to the circuit board and make sure that the battery is properly attached. Finally, securely place the plastic cover over CPU circuit board.



Soldering the soldered battery with two soldering lugs

18. Standards and laws

- IEC 61010-1/EN 61010-1
- CAN/CSA C22.2 No. 1010.1 -92
- IEC 60255-22-1/EN 60255-22-1
- IEC 61326-1/EN 61326-1
- IEC 60529/EN 60529
- IEC 60068-1/EN 60068-1
- IEC 60688/EN 60688
- IEC 61000-6-2/EN 61000-6-2
- IEC 61000-6-4/EN 61000-6-4
- IEC 61000-6-5/EN 61000-6-5 (in preparation)

19. Disposal

Disposal note for EU member states

To preserve and protect the environment, prevent pollution, and improve the recycling of raw materials, the European Commission has issued a directive according to which manufacturers must take back electrical and electronic devices so they can be properly disposed of or recycled.

The devices with this symbol may not be disposed of in the European Union together with normal solid household waste:

Special note for customers in Germany

The electronic devices manufactured by A. Eberle are intended for commercial use. These devices may not be disposed of at municipal recycling centres for electrical devices, but are taken back by A. Eberle.

If you have any questions, please contact us by phone or email:

+49-(0)911-628 108-0

info@a-eberle.de

If the device is not operated in the European Union, the national waste-disposal regulations in the respective country must be respected.

20. Product Warranty

The warranty period is three years starting from the delivery date.

21. Storage

The devices and spare components must be stored in rooms that are dry and clean.

The device and its replacement modules must be stored in a temperature -between -25°C to +65°C.

The relative humidity may not result in the creation of condensation or ice.

It is recommended to limit the storage temperature to -10 °C to +55 °C to prevent the electrolytic capacitors from ageing prematurely.

It is also recommended to connect the device to the auxiliary voltage every two years to condition the electrolytic capacitors. This should also be done before the device is commissioned. In extreme climatic conditions (in the tropics), this also 'preheats' the device and prevents condensation.

Before voltage is applied to the device for the first time, it should be left in the operating environment for at least two hours to equalise the temperature and prevent the creation of humidity and condensation.

22. Background programming (B-program)

22.1 The REG-L programming language

The REG-L (REG-Language) programming language was specifically developed to meet the needs of the REGSys system. The objective was to create a simple, goal-oriented dialogue language. REG-L has since been enhanced with commands for the P-coil regulator REG-DP.

The language is based on Forth and BASIC, which were specially developed for fast machine-oriented controls. Forth enables a simple concatenation of command sequences for new commands. Forth uses reverse Polish notation (RPN), which is also used in scientific calculators manufactured by Hewlett-Packard.

The regulator can be programmed from an ASCII terminal. The program lines are entered in the regulator as text and saved by pressing <Return>.

The program lines in the regulator are read by the interpreter and processed in the background at regular intervals.

The following are examples of available commands on the REG-DP/ REG-DPA. This list is also displayed by invoking the Help in terminal mode. (After the prompt with the regulator's address (in our Example <A>), a ? is entered and <Return> pressed)

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Software version:

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