



## Operating instructions

### Earth fault detection relay



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## 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 physical injury
- **Caution** warns of property damage

#### Structure of the warnings

 Signal word	Nature and source of the danger  Prevention measure.
--	--

### 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
  1. List level 2

## **1.4 Other applicable documents**

For the safe and correct use of the EOR-D, 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**

- EOR-D hardware in housing B01 (19" slide-in device)
- Null modem cable (RS-232) to communicate with the WinEDC software.
- CD with current operating software, firmware, manual 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 EOR-D datasheets.



### 3. Safety instructions

The earth fault detection relay EOR-D met all of the relevant safety requirements when it left the factory. To ensure that it continues to meet them and function as it is supposed to, 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 that needs servicing 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 EOR-D earth fault detection relay 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 system). 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  $U_h$  may not be exceeded continuously or even momentarily.
-  The EOR-D earth fault detection relay must be completely disconnected from the auxiliary voltage  $U_h$  before changing the fuse. The fuse may only be replaced with a fuse of the same type and rated current.
-  An EOR-D earth fault detection relay 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 EOR-D.

## **4. Technical specifications**

Please read the current datasheet. It contains all of the standards that the device meets.

## **5. Intended use**

The EOR-D earth fault detection relay is intended solely for use in power engineering installations and facilities in which 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 EOR-D earth fault detection relay is manufactured in accordance with IEC 10110/EN61010 (DIN VDE 411), Safety class I and tested against this standard before it leaves the factory.

## 6. Applications

The EOR-D earth fault detection relay is a component of the REGSys™ measurement, control, regulator and recording system.

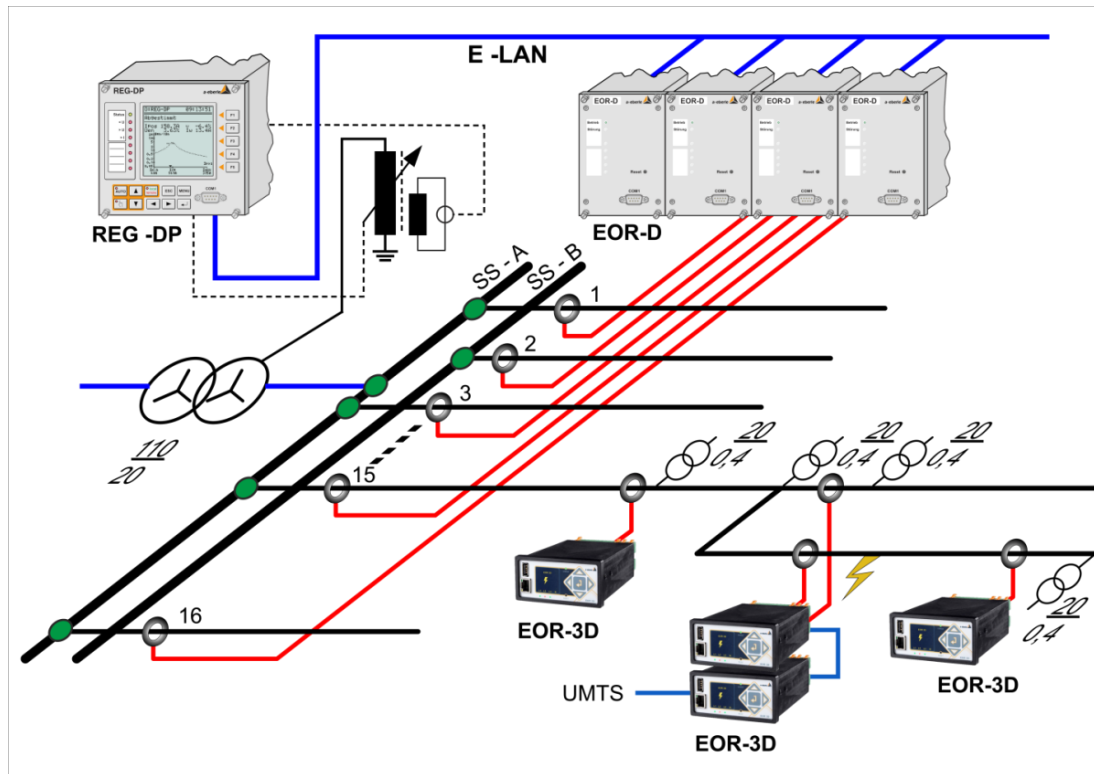


Fig. 1: EORSys™ EOR-D

The EOR-D earth fault detection relay is a component of the EORSys detection system and is therefore easy to connect to the REG-D voltage regulator and the REG-DP P-coil regulator.

A key feature of the EORSys and the REGSys™ is that all of the components that are connected through an E-LAN communication bus can be parameterized and connected to the SCADA system through the same interface. All of the measured values and parameters on all of the connected devices can be accessed, read out and changed by the SCADA system. Interfaces in accordance with IEC 60870-5-104, IEC 60870-5-103, IEC 60870-5-101, IEC 61850 (Ed. 1 and 2) and DNP 3.0 are available.

## 6.1 Definitions

REG-DP(A)	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 <sub>NE</sub> '	Large index for primary quantities
'U <sub>ne</sub> '	Small index for secondary quantities
HPCI	High-power current injection (for regulation and location detection)

## 6.2 Earth fault detection

In order to benefit from the advantages of each of the earth fault detection methods in every earth fault situation, the following methods

- Harmonics
- Pulse detection
- Transient
- Wattmetric without residual current increase
- Wattmetric with residual current increase

have been combined into the freely programmable earth fault detection relay **EOR-D**. The messages for the individual detection methods are freely selectable and combinable.

### Features of each of the methods:

#### Harmonics

- The trigger threshold for the zero sequence voltage  $U_{en}$  is parameterizable
- High sensitivity through the comparative evaluation of the harmonic current in the faulty busbar section
- Compensation of the daytime harmonic current fluctuations through the comparative evaluation
- Also suitable as individual relay by evaluating the angle information
- Suitable for isolated grids as  $\sin\phi$  relay for the fundamental frequency (50 Hz)

#### Pulse detection

- Dynamic adaptation of the trigger threshold for total current  $3 \cdot I_0$
- The pulse pattern to be detected is freely programmable
- Indicator is reset by an external signal or automatically at the end of a time period
- Clocking can be controlled by the EOR-D
- 'Depth detection' up to the faulty section is possible

#### Transient

- The trigger threshold for the zero sequence voltage  $U_{en}$  is parameterizable
- The trigger threshold for total current  $3 \cdot I_0$  is parameterizable
- Suppression of transient message based on a selectable minimum duration of the zero sequence voltage (transition to continuous earth fault)
- Suppression of earth fault messages in direction of the busbar (optional)
- Indicator is reset by an external signal or automatically at the end of a time period
- Recording of the transient process (error log for transients)

#### Wattmetric without residual current increase

- The trigger threshold for the zero sequence voltage  $U_{en}$  is parameterizable
- The trigger threshold for total current  $3 \cdot I_0$  is parameterizable for each outgoing circuit
- A fixed angle correction can be set for the current transformer
- Suppression of earth fault messages in direction of the busbar (optional)

#### Wattmetric with residual current increase

- The trigger threshold for the zero sequence voltage  $U_{en}$  is parameterizable
- The trigger threshold for total current  $3 \cdot I_0$  is parameterizable
- A fixed angle correction can be set for the current transformer
- Suppression of earth fault messages in direction of the busbar (optional)

### 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 pole-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  $X_C$ .

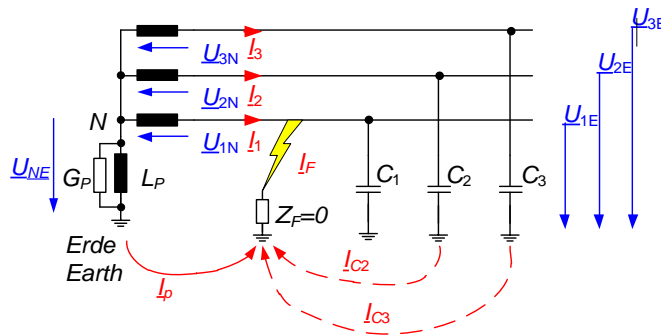


Fig. 2: Equivalent circuit of an earthed grid with P-coil and single pole-to-earth fault

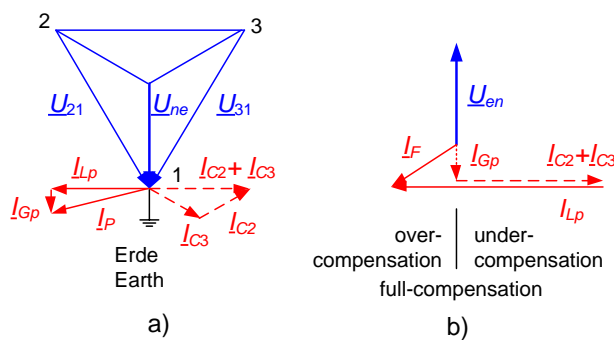


Fig. 3: a) Vector diagram with earth fault in phase L1 (transistor  $0 \Omega$ )  
b) Impact of different tuning positions on fault current  $I_F$

$L_p, G_p$	P-coil (inductance and conductance)
$C_1, C_2, C_3$	Line-to-earth capacitance
$Z_F$	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 capacitance and conductance are symmetrical
- All unbalances are allocated to Line 1
- For first observations, no load current is flowing

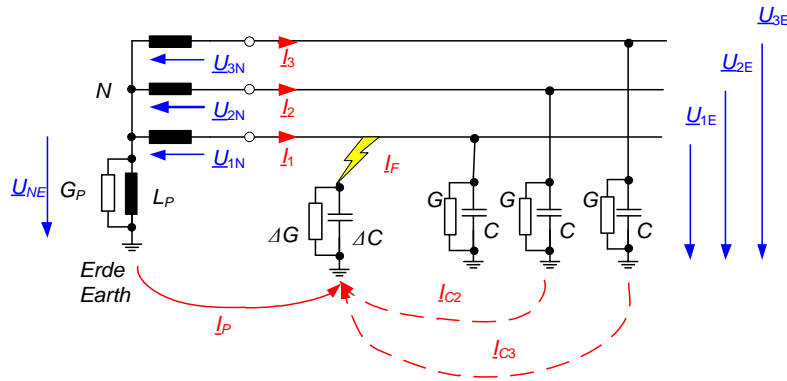


Fig. 4: Simplified equivalent circuit

For the equivalent circuit in **Fehler! Verweisquelle konnte nicht gefunden werden.**, 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  $120^\circ$  against each other. This can be used by the rotation operator  $\underline{a} = e^{-j120^\circ}$  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

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

with

$$\underline{Y}_U = \Delta G + j\omega\Delta C$$

unbalance at the faulty section

$$\underline{Y}_W = 3G + G_p$$

Watt-metric component of  $\underline{Y}_O$

$$\underline{B}_C = \omega 3C$$

Capacitive component of  $\underline{Y}_O$

$$\underline{B}_L = \frac{1}{\omega L_p}$$

Inductive component of  $\underline{Y}_O$

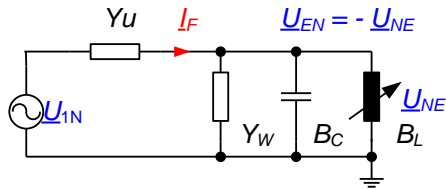


Fig. 5: Single-phase equivalent circuit for single-pole unbalance

The equivalent circuit for equation (1.14) is displayed in **Fehler! Verweisquelle konnte nicht gefunden werden.** This circuit is valid for low-impedance single-pole faults as well as grids with a natural capacitive unbalance under the abovementioned assumptions.

## 6.3 Harmonics method

Fig. 6 displays the current and voltage harmonics in the healthy grid. The prerequisite is symmetrical series impedance (transformer, line) and symmetrical line-to-earth capacitance. The links between the conductors are also assumed to be symmetrical. Non-linear loads on the grid create harmonic currents in the individual phases. Since the load has no connection to earth, the sum of the load currents is zero at all times. On the other hand, these harmonic currents create voltage drops along the grid's series impedance (line-series impedance, transformer impedance). The distortions in the line-to-earth voltage are so strong that the currents cancel themselves out across the line capacitance in the capacitance's neutral point (earth). This is why harmonic current does not flow across the earth or the P-coil in a healthy grid with balanced earth capacitance even if the line-to-line voltage and the phase currents contain big harmonic currents.



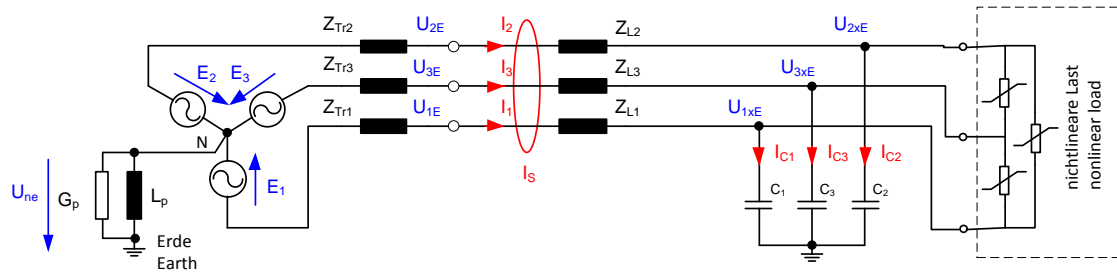


Fig. 6: Simplified equivalent circuit of a healthy grid

An earth fault changes the situation for the harmonic currents (see Fig. 7).

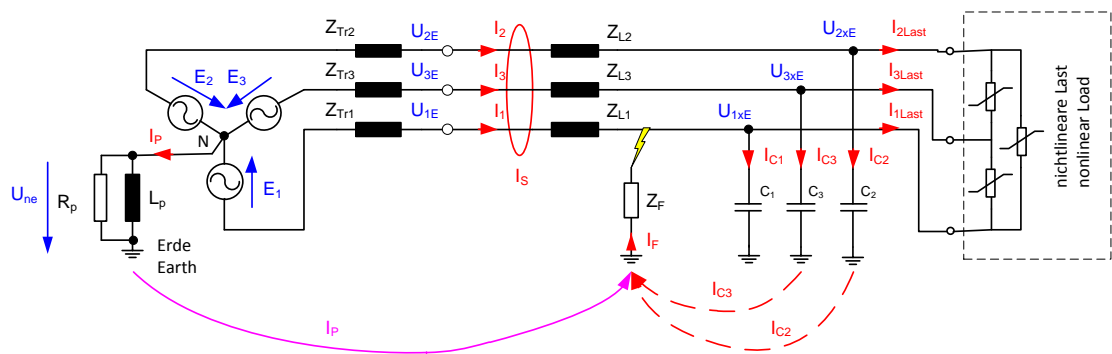


Fig. 7: Simplified equivalent circuit when a single-line-to-earth fault occurs

Because of the 'low impedance short circuit' in phase L1, the line-to-line voltage on the healthy phases L2 and L3 will be distorted. On the one hand, this distorted voltage supplies a capacitive fundamental frequency current of 50 Hz, which, as described above, is compensated by the P-coil. The harmonic components contained in the line-to-line voltage create an additional harmonic current across the faulty section. Bear in mind that the capacitive conductance increases in line with the frequency, meaning that the same voltage amplitude, e.g., for the fifth harmonic, will supply five times more current. On the other hand, the current through the P-coil will be reduced to 1/5 because of the P-coil's five-time higher impedance. For the harmonics, the earthed grid can be considered as an 'isolated grid' in first-order approximation.

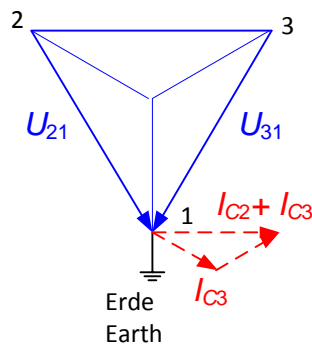


Fig. 8: Vector diagram of the capacitive currents (also applies to harmonic currents)

Fig. 9 displays the simplified equivalent circuit of a substation with three outgoing circuits and a single pole-to-earth fault in phase 1 of line A. Only the harmonic currents in each of the phases are shown. It is clear that the sum of the other outgoing circuits' harmonic currents are flowing through the faulty outgoing circuit. This is valid for each of the harmonic orders.

Key for this method is the **distortion of the line-to-line voltage** on the substation's busbar. This distorted line-to-line voltage creates the harmonic currents to the earth **in the healthy outgoing circuits**. Only the sum of these harmonic currents in the healthy outgoing circuits can be measured in the faulty outgoing circuit.

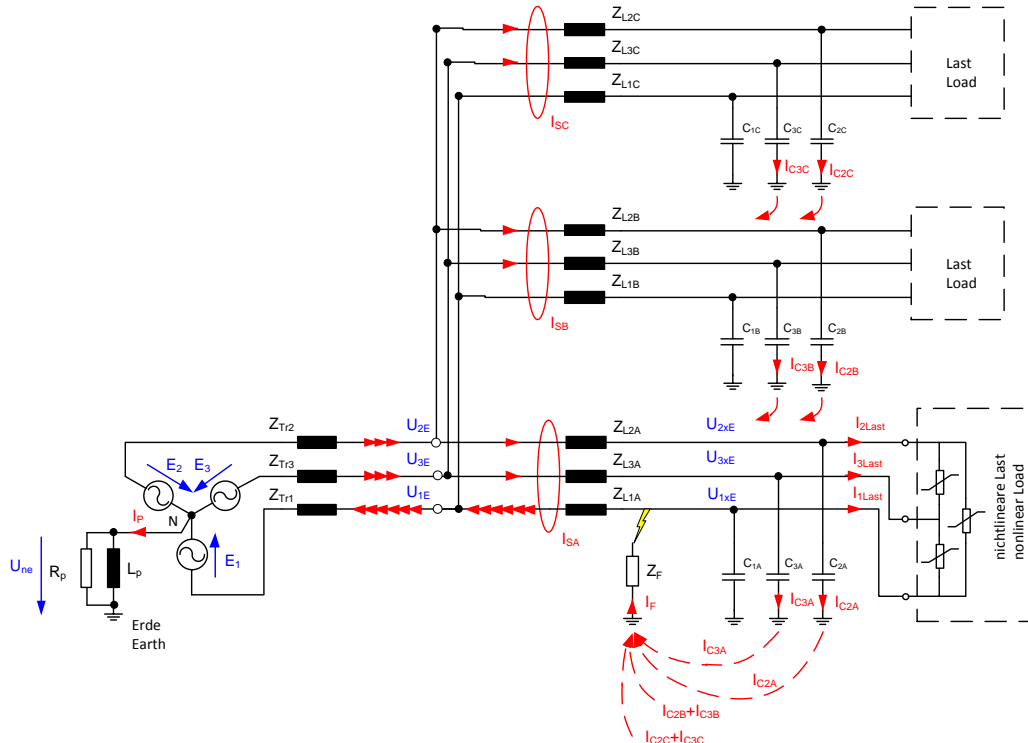


Fig. 9: Grid with three outgoing circuits and a single-pole-to-earth fault in L1 of line A.

It must be noted for the harmonic relay, on the one hand, that the biggest harmonic current is measured in the faulty outgoing circuit and that, on the other hand, the phase of the

harmonic current is rotated 180° against the healthy outgoing circuits. In relation to a harmonic, the corresponding harmonic current in healthy outgoing circuits is capacitive and in faulty outgoing circuits inductive. See Fig. 10. So all the relay really has to do is correctly determine the direction of the current in relation to the harmonic voltage. Compared with the wattmetric method, angle errors generated by the current and voltage transformers hardly have an impact.

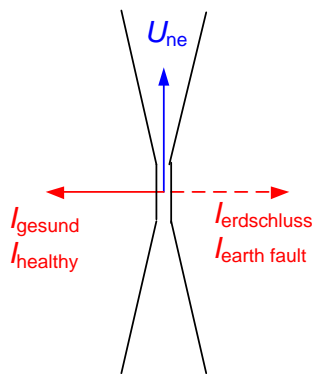


Fig. 10: Selectable thresholds for earth fault detection

The harmonics method is a **steady-state detection method**.

If switchovers are performed on rings, the indicator of the faulty outgoing circuit will move with them as soon as the sectioning point is behind the faulty section.

The outgoing circuit with the biggest current is displayed for rings. This is the electrically shortest distance from the busbar to the faulty section.

For **isolated grids** the condition that no current is to flow out of the neutral point is already reached for 50 Hz. This is why the harmonics relay can be used for 50 Hz in isolated grids. The advantage here is that 100% of the '0 harmonic voltage' is available.

#### Limitations of the harmonics method:

- **Grid with only two outgoing circuits:**

If harmonics are evaluated only by their absolute value, it will not be possible to selectively determine the outgoing circuit by comparing the absolute values because harmonic currents flowing into one outgoing circuit flow out through the other outgoing circuit. The absolute values of both currents are the same but have different directions.

=> Measuring the direction of the harmonic currents enables a selective statement to be made on the faulty outgoing circuit.

- **No harmonics present:**

This method cannot be used if there are no harmonics on the grid.

The sensitivity of the relay is not very critical because a comparative measurement is performed for each outgoing circuit. The relay always shows the biggest harmonic current and the direction is also evaluated when there are only two outgoing circuits.

- **Very high impedance fault:**

If the zero sequence voltage does not exceed a settable limit value, the harmonic currents flowing across the faulty section are very small.

## 6.4 Harmonics method with ripple control systems

The harmonics method assumes that the grid has enough harmonics.

Injecting a specific harmonic - for example, with a ripple control system - improves the situation if the harmonics are low. The ripple control system is usually designed to create a harmonic voltage of ca. 1%. This harmonic voltage is available in the observed grid and can be used to detect the earth fault.

A freely definable frequency can also be set in the relay, e.g., 217 Hz

The duration of the injection of the ripple-control frequency is freely definable, e.g., 6s. The detection results can be stored and displayed in the relay. The data can remain stored until the earth fault has been eliminated or until the next ripple control system's next 'impulse'.

If the ripple control system is activated by the '6s impulse', the earth fault indicator will not immediately move with it when switching operations move the earth fault from one outgoing circuit to another. The last detected state is stored until the next request. A new request for a '6s impulse' must be made after the outgoing circuits have switched over.

## 6.5 Pulse detection

A clock system, which is normally connected to the P-coil's power auxiliary winding, creates a pulsating current that can be measured all the way to the faulty section. The grid must be set to overcompensate by a certain absolute value. Switching on capacitors changes the current toward full compensation. This decreases the total current in the faulty outgoing circuit and increases it in the healthy outgoing circuits. Only the 200 ms mean values of the total current (only 50 Hz component) are evaluated.

The below figure displays the basics of pulse detection.

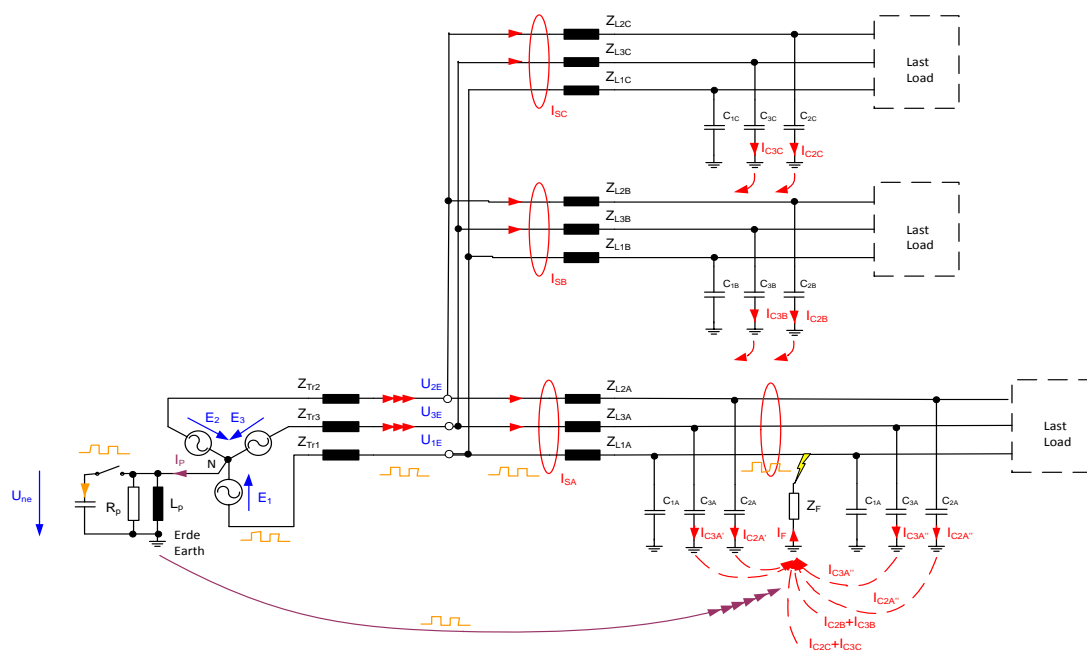


Fig. 11: *The basics of pulse detection*

**Unbalanced clocking** is a good workaround. With this type of clocking, the capacitor is switched on for 1 second and switched off for 1.5 seconds (switch-on/switch-off ratio 1/1.5). This pattern can be repeated as often as desired. It is easy to demonstrate that the resulting current changes for overcompensation in the healthy outgoing circuit are the inverse of the change in the faulty outgoing circuit. This creates a criterion for high impedance transistors in the faulty line so a distinction can be made between the faulty and the healthy outgoing circuits.

## 6.6 Transient earth fault method

- The grid is switched as a radial system
- Injection is one-sided only
- Earth fault in phase 1

[illegible]

## Applications

The following overlapping processes are distinguished:

- Discharging of the defective line to earth
- Charging of the defective line to earth
- Steady-state vibration

The following sections discuss each of the processes in detail.

### 6.6.1 Discharging of the defective line to earth

Important for the discharge process are:

- Conductivity of phase 1 to earth
- Charging state of the conductivity of phase 1
- Low line impedance  $Z_{L1}$  to and in the other outgoing circuits
- Impedance of the faulty section itself or the earthing

The transformer and the loads have a very high impedance and are negligible for the observations. The two healthy lines are also irrelevant. Phase L1 can be considered as a high impedance closed lattice network. The healthy single feeders are switched in parallel, which reduces the impedance and increases the capacitance of the equivalent series impedance on the healthy lines. The very high-frequency transient process depends on the length of the cables and its frequency gets higher as the cables get shorter. It is usually in the range of  $>10$  kHz.

A line's transient frequency consisting of a single core cable with  $\epsilon_r = 4$  is estimated with:

$$f_E = \frac{37500}{l} \left[ \frac{Hz}{km} \right] \quad (1.1)$$

The amplitude of the maximum discharge oscillation (earth fault in the voltage maximum) depends on the length of the above-described single core cable:

$$\hat{I}_{ZE} = 250 \hat{I}_{CE} \quad (1.2)$$

When the earth fault occurs in the voltage's zero point:

$$\hat{I}_{ZE} = \frac{1}{3} \hat{I}_{CE} \quad (1.3)$$

with

$$I_{CE} = 3 \omega C_E E_1 \quad (1.4)$$

## 6.6.2 Charging of the defective line to earth

Key for the charging process are:

- Capacitance of phase 2 and 3 to earth
- Charging state of the phases' capacitance
- Charging voltage (  $E_1 + E_2$ ,  $E_1 + E_3$  )
- Leakage inductance from the injection transformer
- Line impedance  $Z_{L1}$  from the faulty section to the injection transformer
- Impedance of the faulty section itself or the earthing

The distribution transformers or the loads are only considered at a high impedance and can be neglected in the first approximation. The load essentially functions as an additional damping on the charge oscillation. If the distribution transformer is not loaded, the line is essentially only loaded with the transformer's very high main inductance.

The charge oscillation's limiting element remains the injection transformer's relatively low impedance leakage inductance, and, if the faults are very far away, the transformer's inductance to the faulty section.

A possible transformer delta connection can be converted to the equivalent wye connection.

The charging process for the wye connection is displayed in the equivalent circuit in Fig. 13.

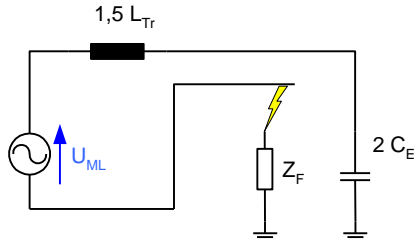


Fig. 13: Equivalent circuit for the charging process

The following formulas:

$$L_{ers} = 1,5 L_{Tr} \quad (1.5)$$

$$C_{ers} = 2 C_E \quad (1.6)$$

The frequency of the charge oscillation is reached from

$$f_A = \frac{1}{2\pi} \sqrt{\frac{1}{L_{ers} C_{ers}}} = \frac{1}{2\pi} \sqrt{\frac{1}{3 L_{Tr} C_E}} \quad (1.7)$$

This formula for the charge oscillation frequency also applies when the inductance of the transformer  $L_{Tr}$  is added to the inductance of the line from the faulty section to the transformer. It reduces the frequency. An earth fault that is very far away delivers a lower charge frequency than an earth fault that is closer to a busbar.

Estimation of the leakage impedance over the impedance voltage and the transformer's rated apparent power:

$$X_{Tr} = \omega L_{Tr} = \frac{u_s U_n^2}{100 S_{Tr n}} \approx \frac{u_k U_n^2}{100 S_{Tr n}} \quad (1.8)$$

The initial amplitude of the changing current is reached from:

$$\hat{I}_{ZA} = 2 \omega C_E \hat{U}_{ML} c_\varphi = \frac{2}{3} \hat{I}_{CE} c_\varphi \quad (1.9)$$

The impact of the switching moment (angle  $\varphi$ ) is taken into account by the amplitude factor (in the formula,  $f = 50$  Hz):

$$c_\varphi = \sqrt{\cos^2 \varphi + \left( \frac{f_A}{f} \right)^2 \sin^2 \varphi} \quad (1.10)$$

In the maximum of the earth-line voltage of the faulty line ( $\varphi = 90^\circ$ )

$$\hat{I}_{ZA} = 0.667 \hat{I}_{CE} \frac{f_A}{f} \quad (1.11)$$

For the zero point of the earth-line voltage of the faulty line ( $\varphi = 0^\circ$ )  $c_\varphi=1$  and

$$\hat{I}_{ZA} = 0.667 \hat{I}_{CE} \quad (1.12)$$

The next figure displays a network with a cable from the busbar to the injection transformer and three outgoing circuits on the busbar. Each of the charging currents are displayed in each of the phases.

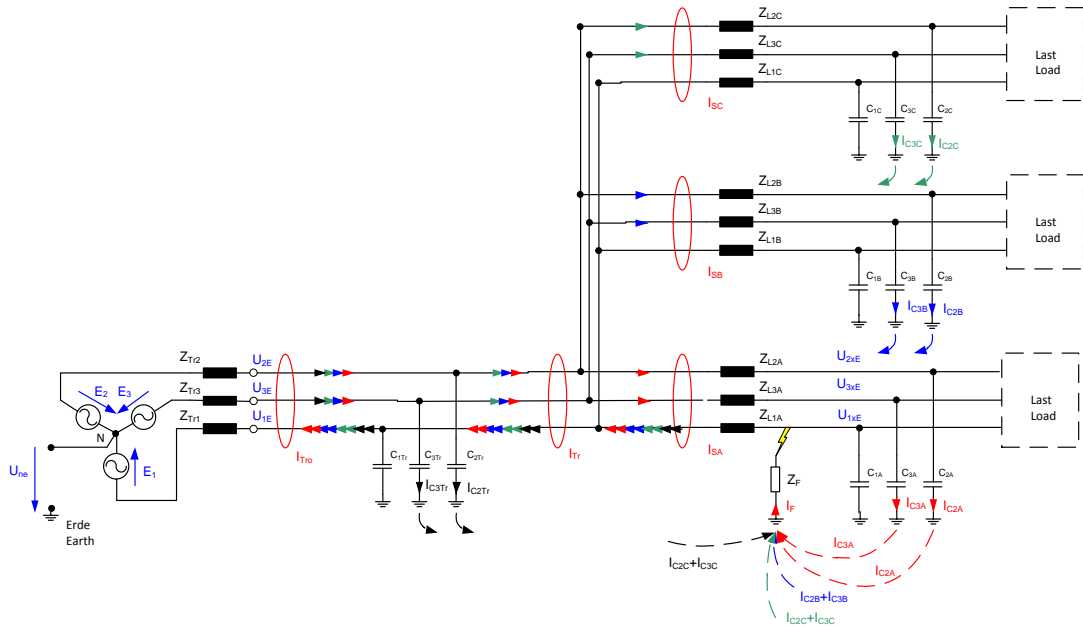


Fig. 14: Grid with power supply line from transformer to busbar and three outgoing circuits



The figure shows that the sum of all of the charging currents in the healthy phase flow through the charging current in the faulty outgoing circuit. A phase's charging current cannot be measured as residual current. The above derivations have shown that the peak value of the charging current takes on at least the value  $0.667 \cdot \hat{I}_{CE}$  of the remaining grid (remaining grid = total grid minus faulty outgoing circuit).

Transient relays evaluate the charging process. The high frequency discharge oscillations are filtered out.

### 6.6.3 Steady-state earth fault

In a steady state, the 50 Hz component of an isolated grid's capacitive current flows across the faulty section. The earth fault keeps phase  $L_1$  in earth potential and both line-to-line voltages  $U_{21}$  and  $U_{31}$  drive the earth fault currents across capacitance  $C_2$  and  $C_3$ . These earth fault currents must be added as complex vectors.

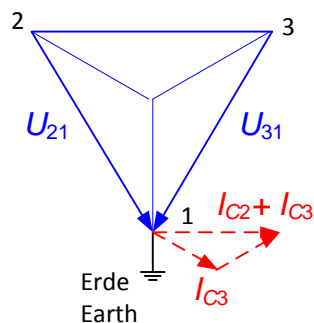


Fig. 15: Vector diagram for the earth fault currents

The component also includes the harmonic currents that are essentially created by the distortions in the line-to-line voltage, whereby it is important to note that the conductance of the capacitors increases or the resistance decreases as the harmonic order increases. Due to the decreased resistance, the current increases for the same excitation voltage. In the first approximation (disregarding the series inductances, ideal resistors, etc.), the currents increase in proportion to the harmonic order.

## 6.7 Wattmetric without residual current increase

The symmetrical component method has been used for decades to calculate the different parameters in three-phase systems.

The zero sequence system is the most interesting for the detection of earth faults.

The zero sequence system combines all of the components that could conduct the current to earth.

In the case of a single-pole earth fault in an earthed grid, the faulty section is not current free even with full compensation.

The P-coil can compensate the capacitive current but the residual current remains and flows from the P-coil across the faulty outgoing circuit, the faulty section and through the earth back to the P-coil.

P-coils get warm when an earth fault occurs, which clearly shows that active power is present in the P-coil when an earth fault occurs.

In general, the P-coil has a power of 40 kW to 80 kW (Important: this does not depend on the voltage levels!).

For a 20 kV grid, the voltage across the P-coil when an earth fault occurs is 11.5 kV ( $20 \text{ kV}/\sqrt{3}$ ).

Together with the resistance the residual current is calculated to be approximately:

$$I = P/U$$

I=50 kW/11.5 kV

$$I = 4.3 \text{ A}$$

All of the isolating ideal resistors that reduce the total resistance and can therefore increase the residual current are working at the same time as the P-coil.

The residual current generally lies in the range of 5 A to 10 A.

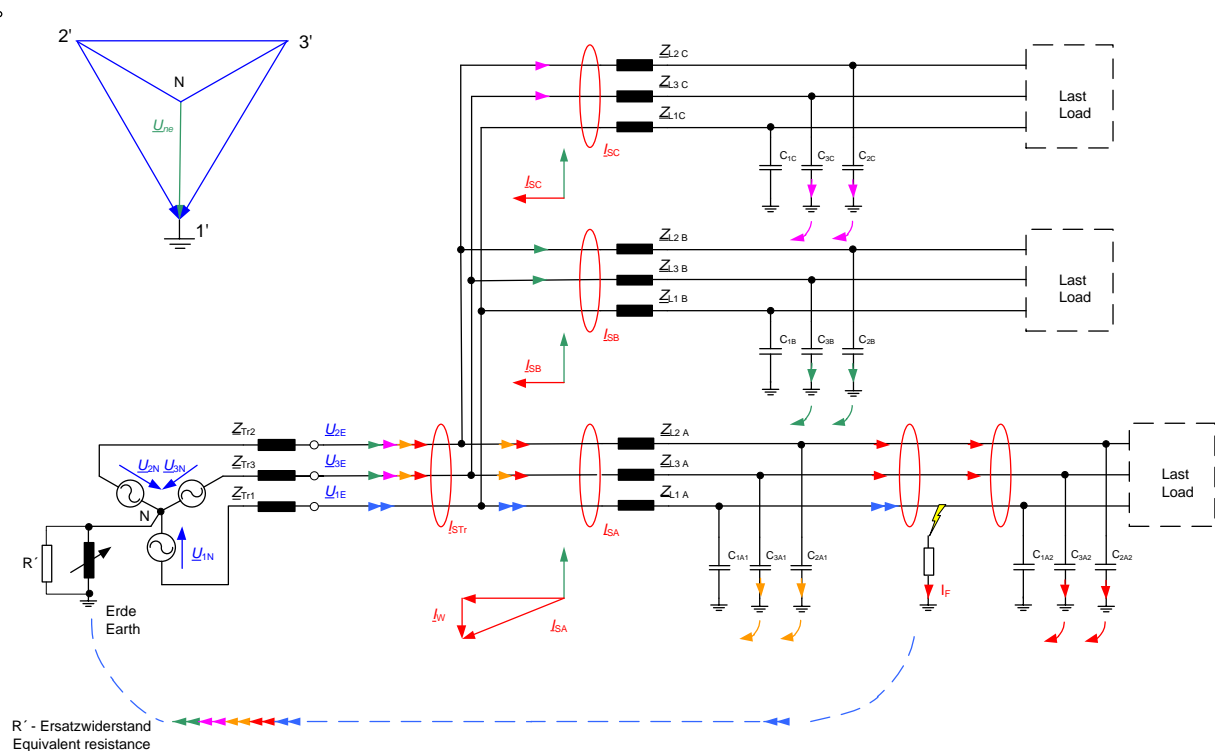


Fig. 16: Basics of the residual current method

**Important notes:**

- Residual current logging can only be used in earthed systems
- Due to phase shift issues with holmgreen circuits, only work with cable type current transformers.
- For distributed coils, note that P-coils are not allowed to be operating on the faulty line.

## 6.8 Wattmetric with residual current increase

The design of the P-coil has not changed in the last few decades.

The electrical power loss of P-coils that were manufactured 50 years ago are also between 40 kW and 80 kW.

Back then, the coils almost exclusively compensated overhead transmission grids.

The  $I_{CE}$  of an overhead transmission grid is about 20 to 30 times smaller than that of a similarly large cable network.

This is why the ratio between  $I_w$  and  $I_{CE}$  was better than in cable networks in the days of overhead power lines.

In order to achieve similar detection ratios, an active resistance can be added alongside the P-coil to increase the residual current for the duration of the measurement.

This also enables the phase shifts created by holmgreen transformer sets, which are frequently used in overhead transmission lines, to be compensated.

The residual current can also be increased if the grid was not originally compensated (small industrial grids, power plant networks, etc.)

but you must ensure that no P-coils are on the healthy line.

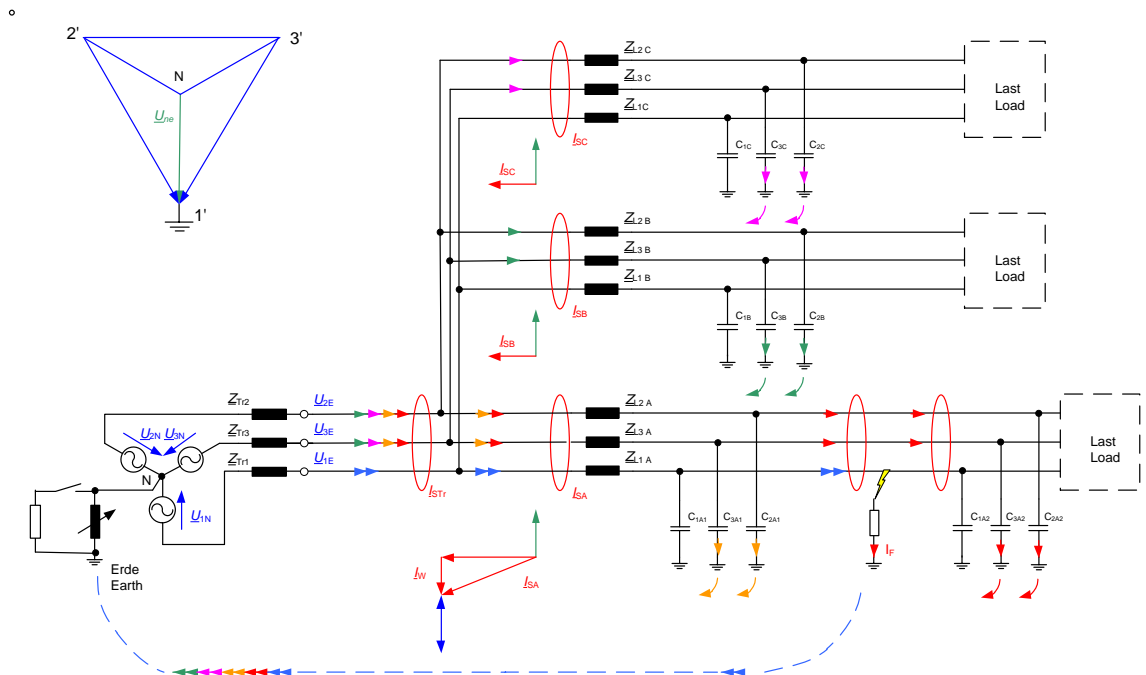


Fig. 17: Basics of residual current increase

## 7. Technical specifications EOR-D

**See the latest EOR-D datasheet for the technical specifications. The current versions of all of our documents can be downloaded from our website [www.a-eberle.de](http://www.a-eberle.de).**

You can also request a copy by sending an email to [info@a-eberle.de](mailto:info@a-eberle.de) .

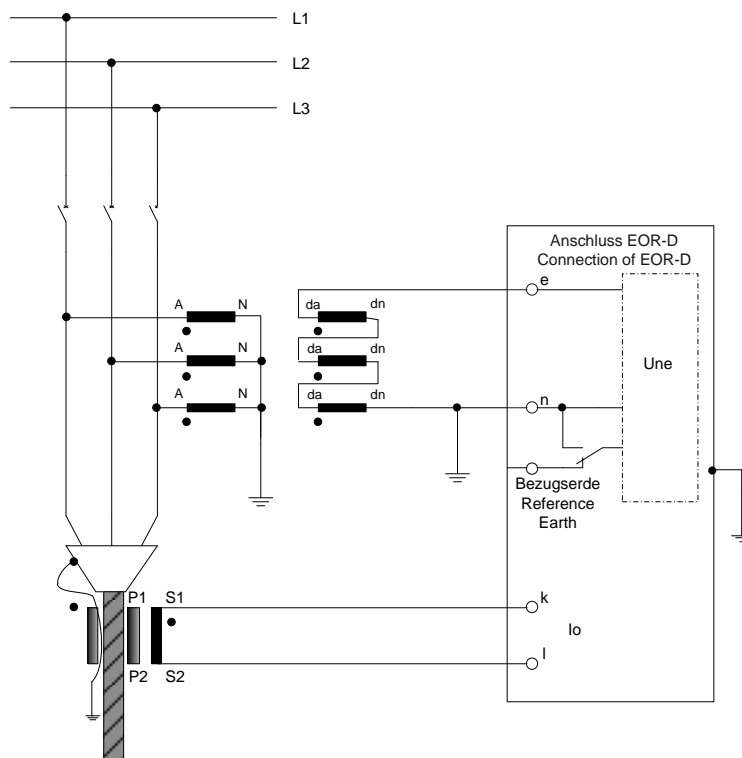


The datasheet with the connection instructions and these operating instructions are important documents that ensure the safe operation of the EOR-D.

## 8. Connecting the measurands to the EOR-D

### 8.1 Connecting the zero sequence voltage

The zero sequence voltage is connected through the voltage transformer's open delta winding. The zero sequence voltage can be connected to the EOR-D according to the following circuit diagrams. All four voltage channels must be connected in the same way.



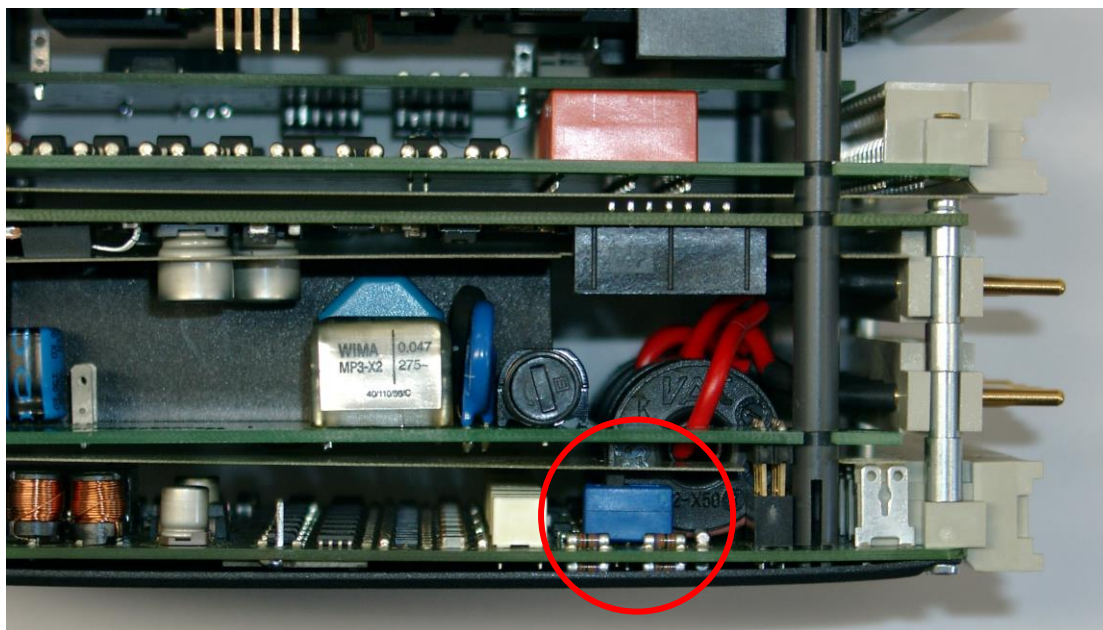
**Fig. 18: Connecting the zero sequence voltage and total current**



If the fourth voltage channel is used as reference potential, the earthed line (da or dn) must be connected to voltage input 'n'.

### 8.1.1 Reference earth

The reference earth MUST be connected because it is the reference potential for the voltage measurement inputs. Not connecting the reference earth will result in faulty measurements.



*Fig. 19: Position switch for reference earth*

If the position of the switch in the red circle is towards the front of the panel as shown in Fig. 19, the reference earth must be connected with pin 24 as shown in Fig. 20.

If the switch is set towards the female multipoint connectors (meaning to the right), the reference earth must be connected to pin 22 on the fourth voltage channel.

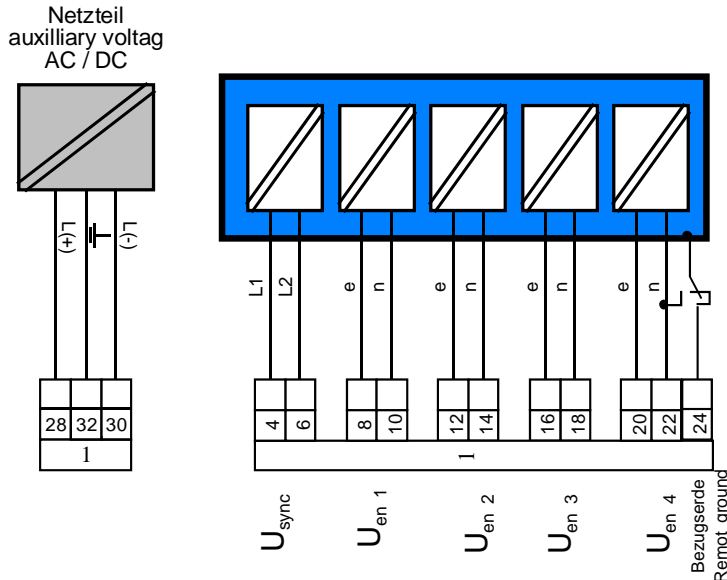


**Default:** Switch for reference earth towards front panel (and therefore independent of the fourth voltage channel)

**Note:**

EOR-D devices up to April 2006 do not have this selection switch. The reference potential is therefore set to the fourth voltage channel.

## 8.2 Synchronization voltage $U_{\text{sync}}$



*Fig. 20: Female multipoint connector 1: Zero sequence voltage  $U_{\text{en1}}$  to  $U_{\text{en4}}$ ,  $U_{\text{sync}}$  and auxiliary voltage*

The power supply for the EOR-D is equipped standard for 88 V to 230 VAC and VDC. Other voltage ranges are also available.

The inputs for the zero sequence voltage  $U_{\text{en1}}$  to  $U_{\text{en4}}$  can be used up to a rated value of 100 V.

The synchronization voltage  $U_{\text{sync}}$  (100 V to 250 V) is used as the reference voltage to measure the phase for the zero sequence voltages  $U_{\text{en1}}$  to  $U_{\text{en4}}$  and the total currents  $I_{o1}$  to  $I_{o4}$ . A few calculation methods use the quantities for detection. The line-to-line voltage  $U_{12}$ , for example, can be used as the synchronization voltage. Other voltages that are 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 230 VAC but a voltage of 50 VAC is sufficient.

The 230 VAC auxiliary circuit can also be used as synchronization voltage. Voltages up to 400 V line-to-line can also be used but the voltage transformer may not be earthed.

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) and interruptions in the synchronization voltage in the seconds range have no effect, for example, on switching over the internal transformer to another busbar. The PLL is inactive until there is a need for synchronization voltage. If a signal is not detected, the last setting is used.



Because the EOR-D supports up to four busbar sections, up to four synchronization voltages can be connected to the device. Bear in mind that only one synchronization input should be live, which is why there should be one selection circuit in each of the busbar sections for the synchronization voltage.

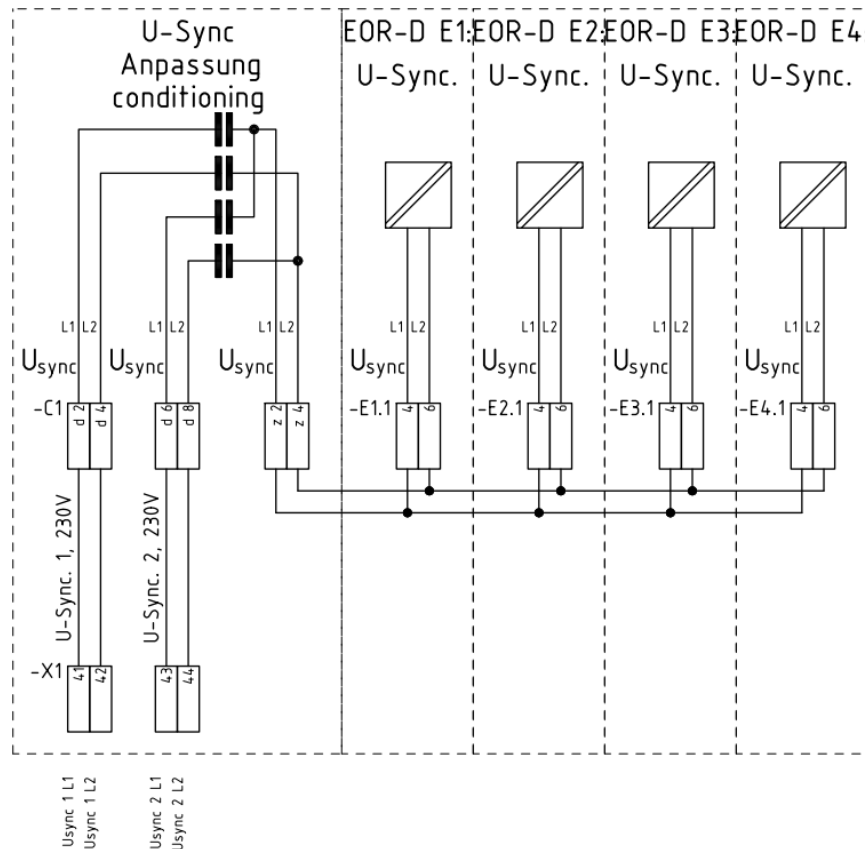


Fig. 21: U-Sync modification for two busbar sections



## 8.3 Total current

The total current measured at the outgoing circuit is used in the earth fault detection method. The total current can either be connected through a cable type current transformer or a holmgreen circuit on the phase current transformer.

The connection through a cable type current transformer is preferred because the summation ( $3I_0 = I_{L1} + I_{L2} + I_{L3}$ ) is performed over the magnetic field. The connection is carried out according to **Fehler! Verweisquelle konnte nicht gefunden werden.**

Another way of reaching the total current would be to use a holmgreen circuit. This has the disadvantage that the transformer errors of each of the phase current transformers are added, which results in a higher inaccuracy.

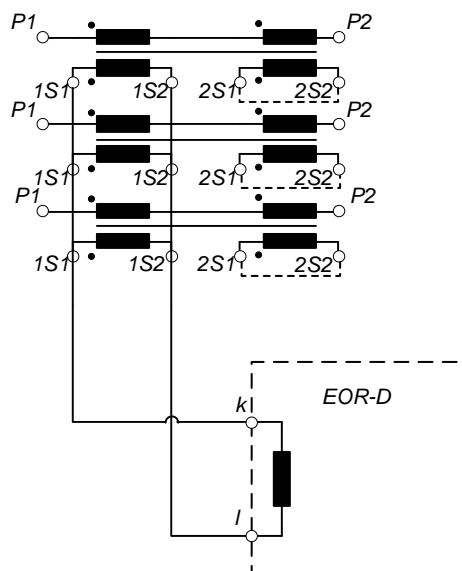


Fig. 22: Holmgreen circuit



### Information!

The following applies to all of the circuit diagrams for the current transformer: **P1 is positioned with its direction of installation towards the busbar**

## 9. E-LAN

### E - LAN ( Energy - Local Area Network )

Each EOR-D has two equal E-LAN interfaces through which the devices (and other RegSys devices) can communicate with each other.

The E-LAN can connect a maximum of 255 E-LAN participants (EOR-D, REG-DP/DPA, REG-D, MMU-D, PAN-D). All of the participants can communicate with each other or be controlled centrally (for selection and details, see the operating instructions for WinEDC).

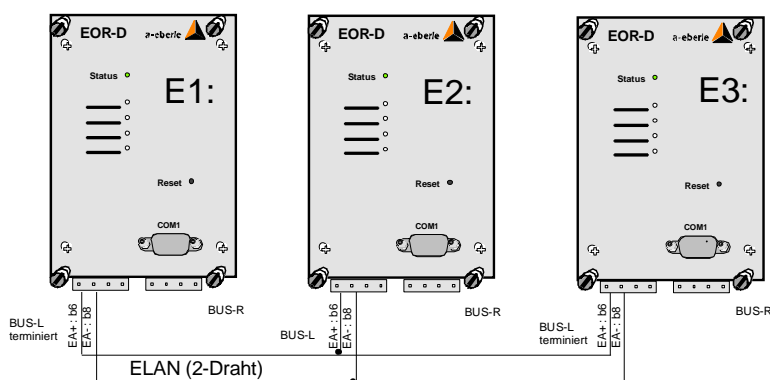


Fig. 23: Configuration example for three EOR-Ds with two-wire E-LAN connection

**E-LAN LEFT** indicates 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 Ter- minals	Bus-R Ter- minals	Function	2-wire	4-wire
b6	z6	IO+	'Input +' and 'Output +'	'Output +'
b8	z8	IO -	'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**').

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).

#### 2-Draht BUS

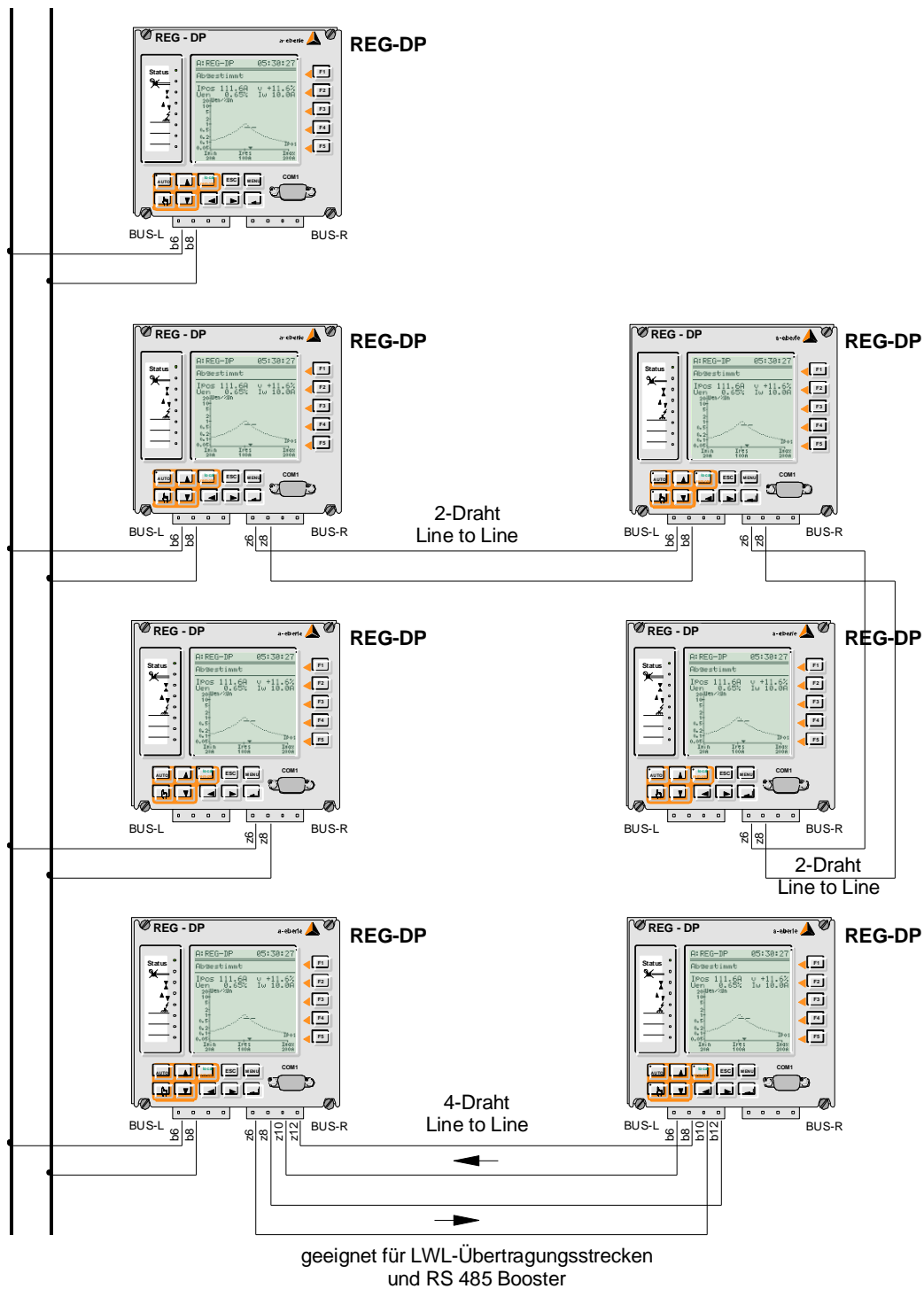


Fig. 24: Networking options with E-LAN

## 10. Commissioning

### OVERVIEW:

The following steps should be performed during commissioning:

- Check the wiring
- Check the power supply
- Install WinEDC parameterization software
- Configure/test COM connection to PC
- Configure/test the E-LAN connection between the EOR-Ds
- Update firmware, if necessary
- Load parameter set with switching scheme
- Check the voltage and current measurement inputs
- Check the digital inputs, outputs and LEDs
- Check the communication with the SCADA system

### 10.1 WinEDC Parameterization Software

A CD with the current version of the WinEDC parameterization software is shipped with the EOR-D.

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



#### Information!

The parameter database config\_dp\_xy.mdb is only needed for REG-DP.

### 10.1.1 Function keys in WinEDC

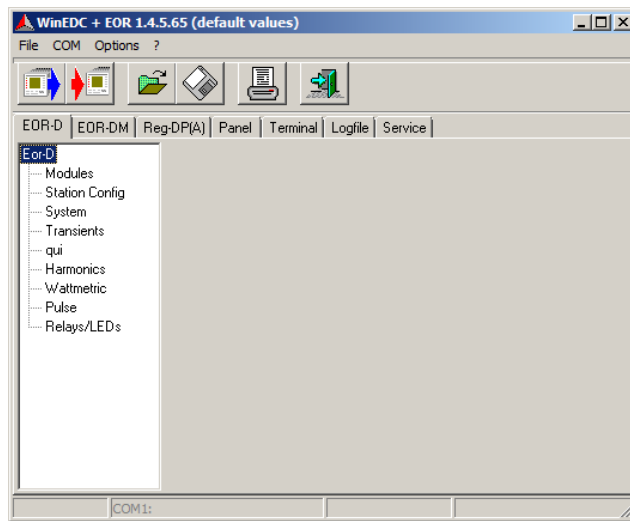


Fig. 25: : WinEDC operating software interface



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)

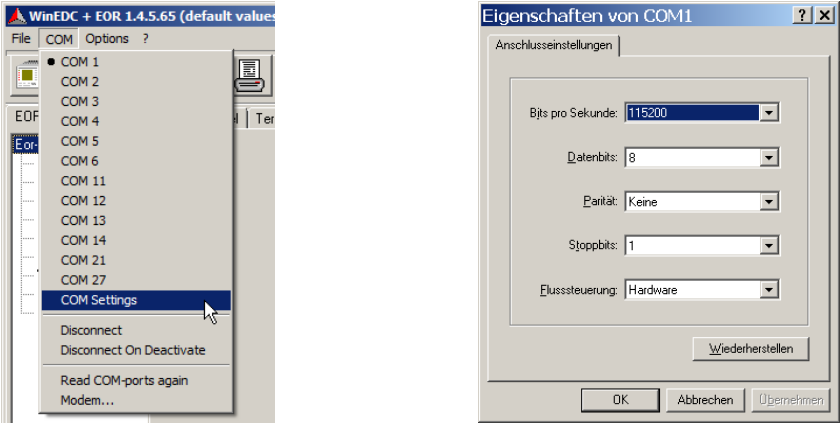
Exit WinEDC

10.1.2 Connecting the WinEDC software to the EOR-D

You will need a null modem cable to connect the EOR-D to the PC. The interface speed for the serial connection must be the same for the EOR-D and WinEDC.

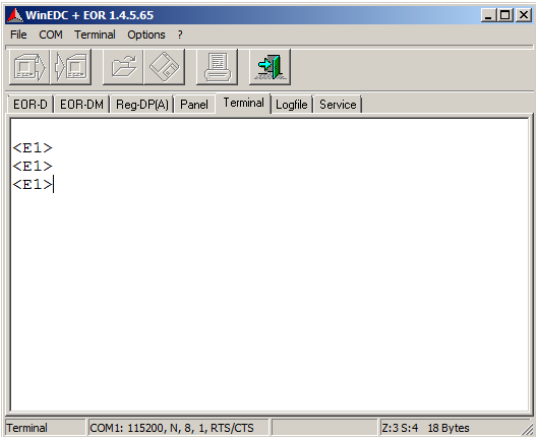
Delivery state of the EOR-D:	Physical connection
<ul style="list-style-type: none"><li>● Mode: Default;</li><li>● Baud: 115200;</li><li>● Parity: None;</li><li>● Handshake: RTS/CTS (= Hardware)</li></ul>	<div>9 pol sub-D female</div> <div>9 pol sub-D female</div> <div><div>RxD 2</div><div>TxD 3</div><div>( DTR 4 )</div><div>( DSR 6 )</div><div>RTS 7</div><div>CTS 8</div><div>GND 5</div></div> <div><div>2 RxD</div><div>3 TxD</div><div>( 4 DTR )</div><div>( 6 DSR )</div><div>7 RTS</div><div>8 CTS</div><div>5 GND</div></div>

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



The EOR-D 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.



### 10.1.2.1 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.

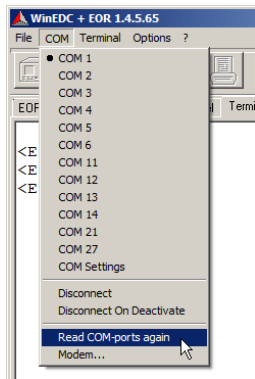


Fig. 26: Re-importing COM interfaces

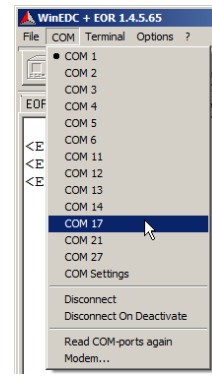


Fig. 27: COM 17 visible after re-import



#### Notes:

The interface settings do not change when the firmware is updated.

By resetting **all** of the parameters (sysreset=590.1), the EOR-D changes to:

- Mode: Default;
- Baud: 9600;
- Parity: None;
- Handshake: Xon/Xoff

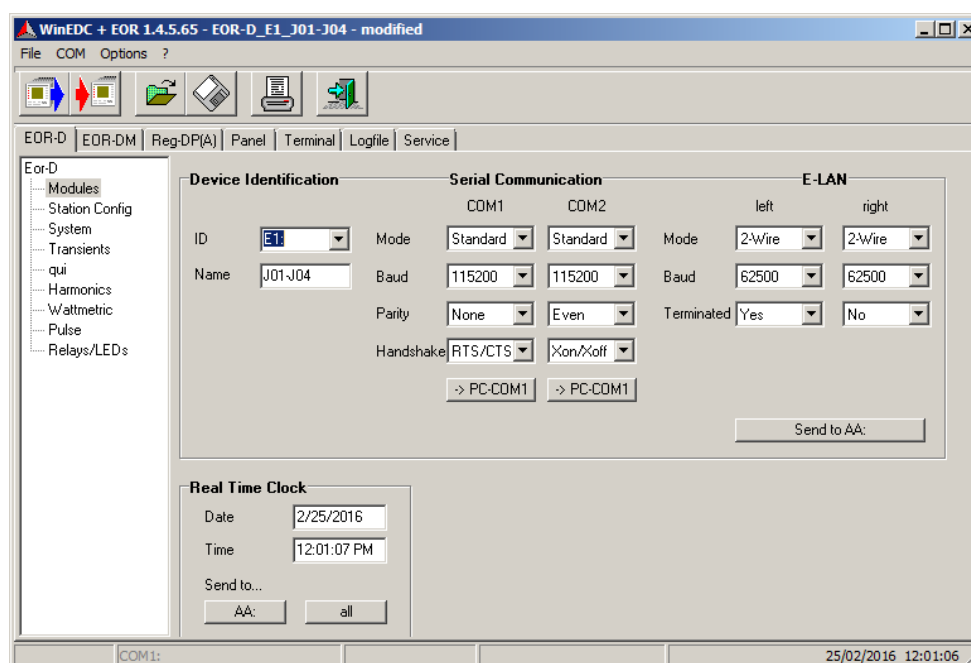
Note that any parameters or background programs that are stored on the device are deleted!

Communication with the directly connected device should be tested:

In the WinEDC terminal screen, the EOR-D must answer with its ID (e.g. <E1>) every time ENTER is pressed.

### 10.1.3 Configure/test communication between the EOR-D devices through the E-LAN

- The interface parameters must be the same for all devices (master and slave(s)) (see parameterization).
- **Only one** device may/must be terminated on the E-LAN.
- Unused E-LAN interfaces must also be terminated.



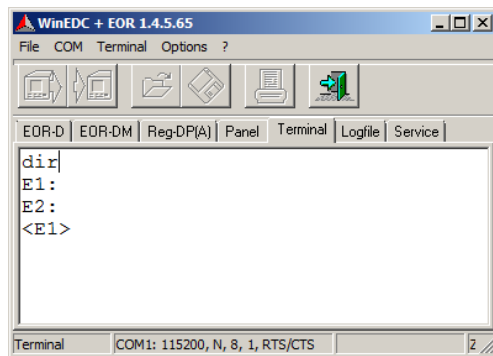
Connect the serial cable to the COM1 interface of the first EOR-Ds. In the WinEDC parameter screen 'EOR-D - Module', enter the correct device ID (e.g. E1:), configure all E-LAN parameters accordingly (pay attention to correct termination!) and press 'Send to AA:' to send the settings to the connected device.

This process must be repeated for each EOR-D that needs to be parameterized.

Communication with the directly connected device should then be tested:

In the WinEDC terminal screen, all of the devices should answer with their device ID after entering the 'dir' command and pressing <ENTER>.





### 10.1.4 REG-L commissioning commands

Alternatively, the interfaces can be configured by entering REG-L commands in the terminal screen.

The following is a list of useful REG-L commissioning commands.

REG-L com-mand	Description	Example
dirn	Displays all devices connected in the E-LAN with their name and ID	<B>dirn B:REG-DP
all,ver&	Displays the firmware version of all devices in the E-LAN	<B>all,ver& B:REG-DP: Version 2/4/07 from 12/07/12
all,systest&	Number of main iterations (main = 318 loop/s); transmission errors in the E-LAN are counted in BL or BR	<B>all,systest& B: Main = 1295 loops/s B: ECS-LAN TxRep: BL= 0, BR= 0; ESCC2: BL= 0, BR= 0
all,errstat&	Creates a list of set system error flags	B>all,errstat& B:No errors

REG-L command	Description	Example
all,status&	Creates a list of internal device information, e.g., relay, battery, COM interfaces, E-LAN settings etc.	B:Station : B:REG-DP [REG] B:REG-DP : Software V2.4.07 (12/07/12) B:Interval : 15 m (time) B:Format(0) : 32 channels, 476 entries (5.0 days), 0 used B:Tariff : T1 (program) B:Relay : R1:- R2:- R3:- R4: R5:- R6:- B:24 V Output : OK B:LithiumBat. : OK B:StatusRelay : 1 (OK), coupled B:Max.L-Level : 0 B:COM1 : 115200 baud, parity: Off, handshake: Xon/Xoff, ECL B:COM2 : 57600 baud, parity: Even, handshake: Xon/Xoff, ECL B:COM3 : -- B:BUS-L : 62K5 baud (2W+), users-L: 0(0), total: 1 B:BUS-R : 62K5 baud (2W+), users-R: 0(0)
All,setcoms&	Displays COM settings for all E-LAN devices	B:SetCOM1 = ECL/115200/P-/XON B:SetCOM2 = ECL/57600/PE/XON B:SetCOM3 = 19200 B:SetLanL = 2W+/62K5 B:SetLanR = 2W+/62K5
all,sysSN	Displays the device numbers	<B>all,sysn& B:SysSN = 10062642-111.4160
all,hlist*& all,plist*& all,qlist*&	Displays the H, P and Q rows	
setkenn = A:	Changes the ID of the device that is connected to the COM1 interface through the PC	<B>setkenn = A: <A>

### 10.1.5 Example: Changing the interface speed of the COM1 interface

REG-L command	Description	Example
setcoms	Display current interface configuration	<pre>&lt;E1&gt;setcoms SetCOM1 = ECL/115200/P-/RTS SetCOM2 = ECL/115200/P-/RTS SetCOM3 = 19200 SetLanL = 2D+/62K5 SetLanR = 2D+/62K5</pre>
	Copy the row for the COM1 settings and paste them at the prompt	<pre>&lt;E1&gt;SetCOM1 = ECL/115200/P-/RTS</pre>
	Change COM1 settings as needed and press <ENTER> to confirm	<pre>&lt;E1&gt;SetCOM1 = ECL/57600/P-/RTS</pre>

### 10.1.6 Updating EOR-D firmware with WinEDC

You will not have to update the firmware if you start using the EOR-D 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](http://www.a-eberle.de) and update the EOR-D first.

#### 10.1.6.1 Querying the firmware version with WinEDC

Entering the command 'ver' and pressing <ENTER> after the connection to the EOR-D has been established displays the firmware's version number.

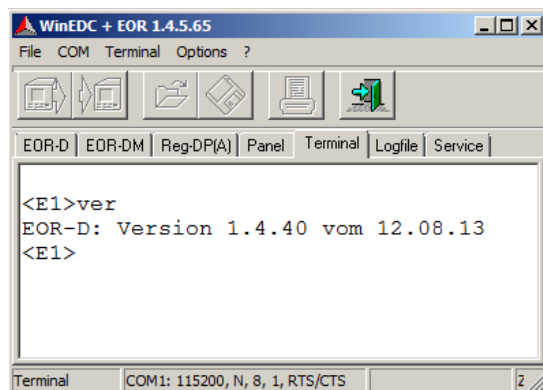


Fig. 28: Querying the firmware version



**Important notes:**

All EOR-Ds that are connected through the E-LAN must be on the same firmware version. You can test this by entering the following commands in the WinEDC terminal screen:

```
<E1>all,ver& <ENTER>
E1:EOR-D: Version 01/03/2014 from 21/06/2007
E2:EOR-D: Version 01/03/2014 from 21/06/2007
E3:EOR-D: Version 01/03/2014 from 21/06/2007
<E1>
```

### 10.1.6.2 Selecting the right firmware file

The current firmware version can be downloaded from our 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 EOR-D
 <b>Firmware EOR-D</b> für Geräte ab Mai 2009 for devices as of May 2009 para dispositivos como el de Mayo 2009	 eor_1440_UNI.moc  help_eor_1440_UNI.moc
 <b>Firmware EOR-D</b> für Geräte vor Mai 2009 for devices before May 2009 para dispositivos realizado antes de Mayo 2009	 eor_1440.moc  help_eor_1440.moc



**Note:** You can use the same firmware with the file extension \_UNI on all devices by updating the EOR-D bootloader (at least bootloader v 2.12).

10.1.6.3 Updating firmware

- Put the EOR-D into bootloader mode for the firmware update



**Important notes:**

In this case the null modem cable must be connected directly to the EOR-D that the firm-ware is to be installed on.

When updating firmware, the COM1 interface on the PC must always be set to:

- Mode: Default;
- Baud: 115200;
- Parity: None;
- Handshake: RTS/CTS



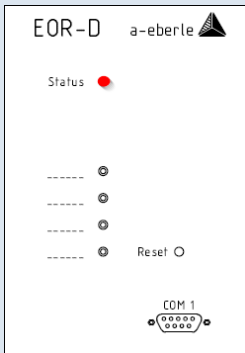
Press and hold the reset button on the EOR-D for approx 10 s to put the device into bootloader mode. All LEDs are illuminated as long as the reset button is pressed. As soon as the EOR-D has switched into bootloader mode, all of the LEDs on the selected EOR-D start to flash. Release the reset button. The status LED is red.

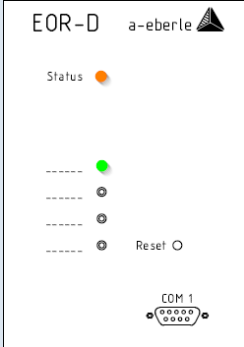

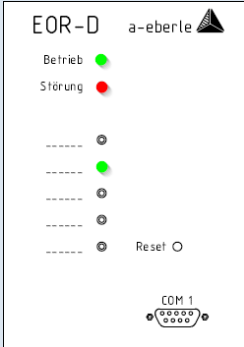


**Note:**

You can press and hold the Reset button for 10 s at any time to take the EOR-D out of boot-loader mode and put it back into normal mode.

Depending on the front panel and the bootloader, the EOR-D will behave as follows in boot-loader mode:

Versions	Behaviour in boot-loader mode	Firmware
Old front and boot-loader V1.xx 	Status LED is red	eor_Vxxx.moc help_eor_Vxxx.moc

Versions	Behaviour in boot-loader mode	Firmware
<p>Old front and boot-loader V2.xx</p> 	Status LED is orange, first outgoing circuit LED is green	<p>eor_Vxxx_UNI.moc help_eor_Vxxx_UNI.moc</p>
<p>New front and boot-loader V1.xx</p> 	Error LED is red	<p>eor_Vxxx.moc help_eor_Vxxx.moc</p>
<p>New front bootloader V2.xx</p> 	Operation LED is green; Error LED is red; First outgoing circuit LED is green	<p>eor_Vxxx_UNI.moc help_eor_Vxxx_UNI.moc</p>



### Important notes:

Files for two **bootloader versions** are currently delivered.

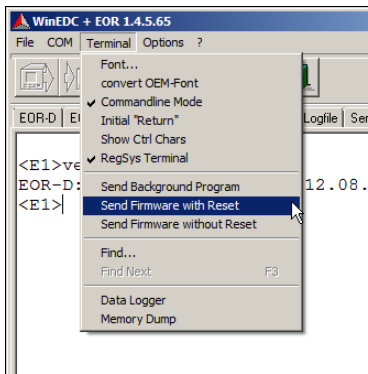
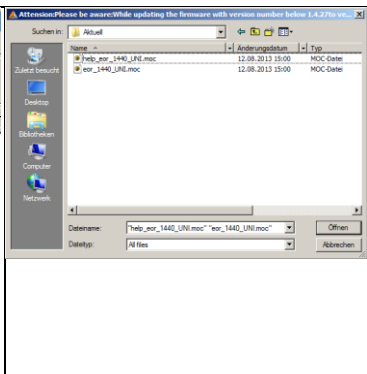
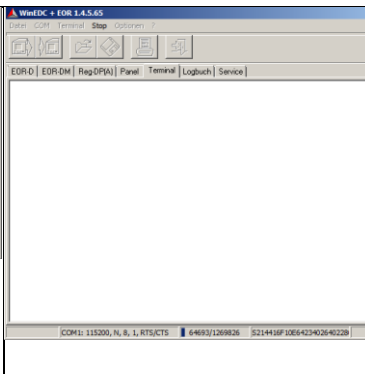
All EOR-Ds that were delivered after March 2009 left the factory with the new bootloader. For the new bootloader from version 2.10 the files with the extension **\_UNI** must be used

This creates the following combinations:

- Loading FW.moc on device with bootloader 1.xx => ok
- Loading FW.moc on device with bootloader 2.xx => Error message: 'Wrong version'
- Loading FW\_UNI.moc on device with bootloader 1.xx => Abort without error message
- Loading FW\_UNI.moc on device with bootloader 2.xx => ok

- Firmware is updated


With the EOR-D in bootloader mode, perform the following steps:

		
<p>Select the function 'Update firmware update with reset'</p>	<p>Select the directory in which the firmware and the 'Help' are stored</p>	<p>The progress of the update is displayed at the bottom of the screen.</p>



### Note:

If the EOR-D firmware is updated from a version < 1.4.x, a sysreset = 590 must be performed. Note that all of the parameters and the background program must be reloaded.

 Repeat the steps for all of the other EOR-D devices

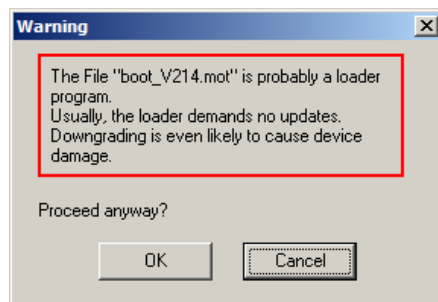
### 10.1.7 Updating the bootloader

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(A), REG-D(A), PAN-D, EOR-D, PQI-D and DMR-D)



*Fig. 29: Press OK to confirm warning message during bootloader update*



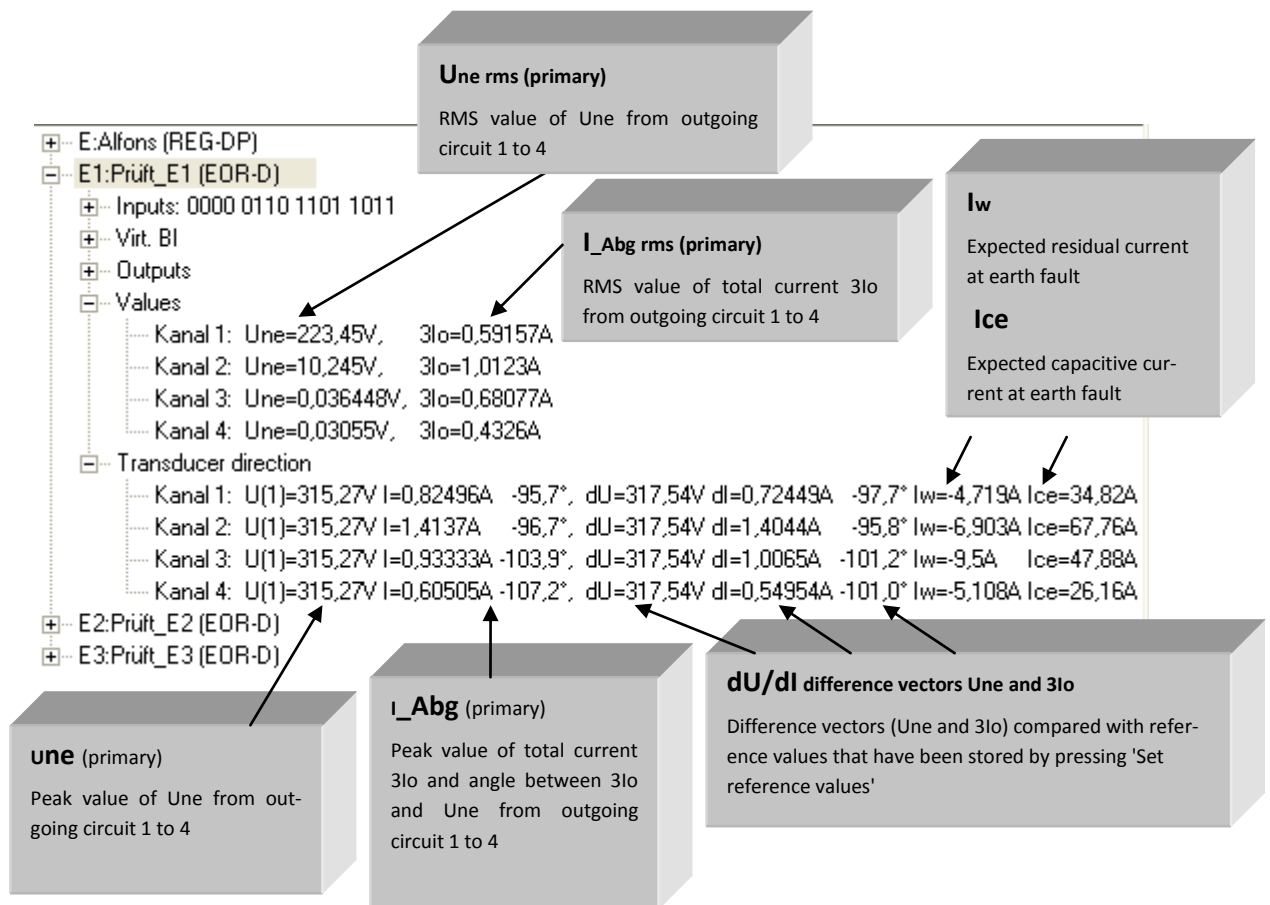
The new bootloader is visible:

- When the EOR-D is in bootloader mode, the LEDs are illuminated, viewed from the top:
  - For devices with separate status and error message (front panel with 7 LEDs)
    - red (status)
    - green (error)
    - red (1st outgoing circuit)
  - or for devices with joint status and error message (front panel with 5 LEDs)
    - orange (status + error )
    - red (1st outgoing circuit)
- Query the version through the serial interface in terminal mode `ver <ENTER>` PQI-D 2.xx Bootloader
- \*.mot and \*.moc files are equal (\*.moc: compressed format)
- The EOR-D automatically leaves bootloader mode when the update has finished
- No parameters are lost when the firmware is updated to a new version. Entering the command 'sysreset=590' in the WinEDC terminal screen resets all of the parameters to their default values.
- When updating an older version, all of the parameters must be reset to their default values by entering the command 'sysreset=590' in the WinEDC terminal window and restoring the previously backed up parameters on the EOR-D.

## 10.2 Check the voltage and current measurement inputs

All of the important measured quantities as well as some derived quantities can be tested in the connected EOR-Ds from the WinEDC service screen.

The RMS value for the four voltage and four current channels is displayed in the left pane under <Device> - Values.



### Note

For the EOR-D, the current measurement is the reference vector, meaning that the phase is displayed here as  $U_{en}$  compared with  $3I_o$ . This results in angles of  $-90^\circ$  for capacitive outgoing circuits.

The current measurement can be verified by injecting a defined current into each cable type current transformer.

### 10.2.1 Transformer polarity test

In a healthy grid, the outgoing circuits in a zero sequence system are to be considered as capacitors.

All of the currents must therefore lead (ca.  $-90^\circ$ ) the associated zero sequence voltage (same group). See vector diagram in Fig. 30.

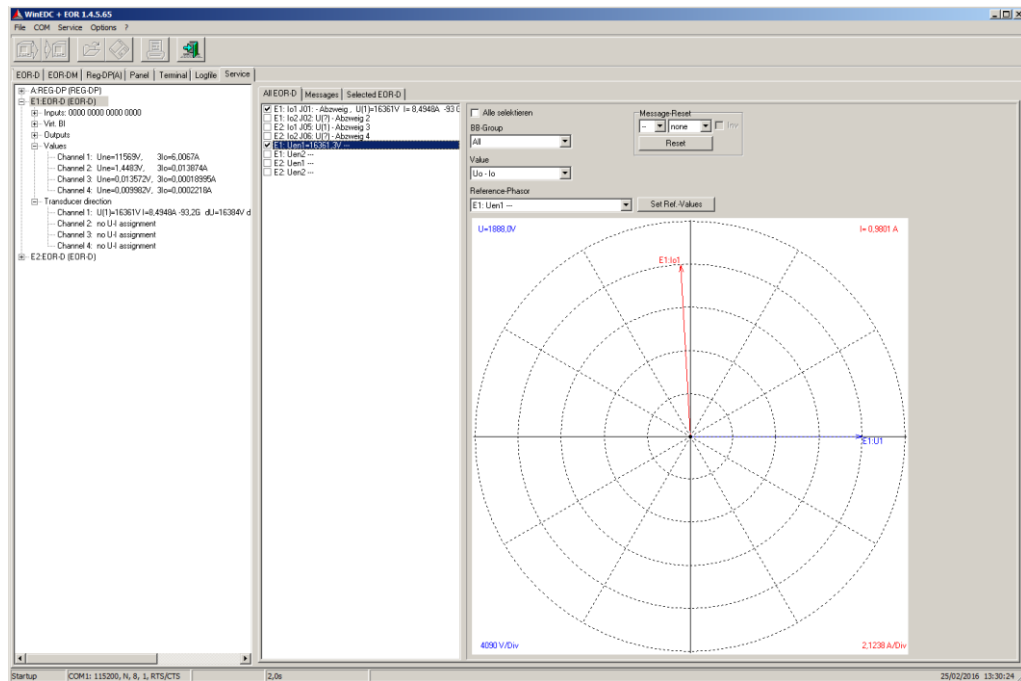


Fig. 30: Using a vector diagram to test the polarity of the transformer

Inaccuracies that arise from small zero sequence voltages can be avoided with a differential measurement:

- In the 'Variable' field, select ' $dU_0 - dI_0$ '
- The P-coil is adjusted so that the zero sequence voltage is at a maximum (position at resonance point).
- Press 'Set reference values' to save the measured values for the zero sequence voltage and residual currents and use them as reference values.
- The P-coil is then adjusted to produce a clear change in the zero sequence voltage.
- For the displayed vectors for  $dU_0$  and  $dI_0$ , the current must lead as a capacitance (ca.  $-90^\circ$ )



#### Note

For outgoing circuits with P-coils, the current changes direction when the inductance on this outgoing circuit is predominant

## 10.2.2 Testing the synchronization voltage

The synchronization voltage cannot be measured directly as a value. The input signal is immediately internally converted into a square wave.

A multimeter should therefore be used to check the synchronization voltage directly at the device input.

An indirect measurement can be made by observing a  $U_{ne}$  voltage. The vector may not rotate, i.e. the angle measurement of the 50 Hz components should be stable if the zero sequence voltage is in the range of a few %.

## 10.3 Check the digital inputs, outputs and LEDs

### 10.3.1 Testing the relay outputs

The messages from the relay to the control room or the SCADA system can be tested in the WinEDC service screen.

The current states of the relays are displayed in the left window under <Device> - 'Outputs' – 'Relay'.

An energized relay displays with a yellow circle.

The state of the relay can be inverted by checking the checkbox in front of it.

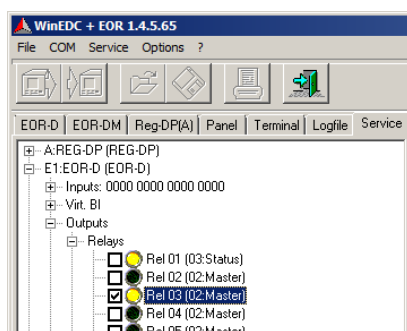


Fig. 31: WinEDC service screen Test Relay



**CAUTION**

After carrying out the test, the inversion must be undone or the relays automatically reset when the service screen is exited.

### 10.3.2 Testing the LEDs

Just like the relays, the state of the LEDs can be inverted by checking the checkbox in front of it.

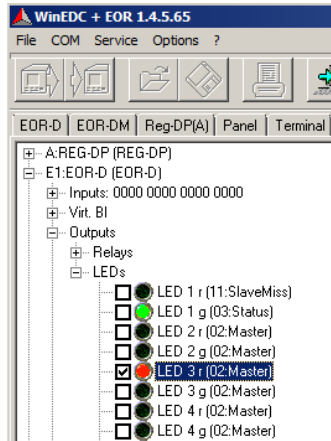


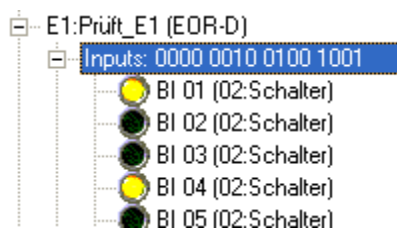
Fig. 32: WinEDC Test LEDs

### 10.3.3 Testing the binary inputs

The current states of the binary inputs are displayed in the left window under <Device> - 'Inputs'.

An active signal level displays with a yellow circle.

All of the states are also displayed at the top of the list as binary codes (BI 1 far right, etc.).



## 10.4 Check the communication with the SCADA system

All current detection messages are displayed on the WinEDC service screen 'Detection messages' (in the right window). Additional messages that are also output through relays and LEDs and are sent to the SCADA system can be simulated by clicking the mouse.

**autom. Generieren von Ortungsmeldungen**

activated: simulated by the "Override" The messages are also taken into account in the localization messages.

deactivated: Disabling, also the "Override" is terminated.

**Message Reset**

Exit OVR mode

**Override mode (OVR)**

is activated when with a mouse click a message is simulated

Exit OVR mode:

- after OVR-balance time (10 min)
- leaving the Service page
- pressing button "Stop OVR"

**simulated message in OVR mode**

simulation with mouse click

0: message off

1: message on

**Messages from the device**

X: generated by the device

e.g. earth fault in feeder:

- Transient forward detected
- Message is also associated to localization 2 message
- Feeder depends on BB1 in group1; Associated Une1

**Caution**, when multiple methods are active:

The localization/collective messages display for each group only the method with the highest priority.

**Priorities:**

1. Transient method (qu2)
2. Intermittent method (qui)
3. Harmonic method
4. Wattmetric method
5. Pulse method



### Note

To ensure that the messages are displayed correctly, the same parameter set must be used in WinEDC and on the devices.

## 11. Parameterizing EOR-D with WinEDC

### General

All of the parameters are set as primary values.

### 11.1 'Module' screen

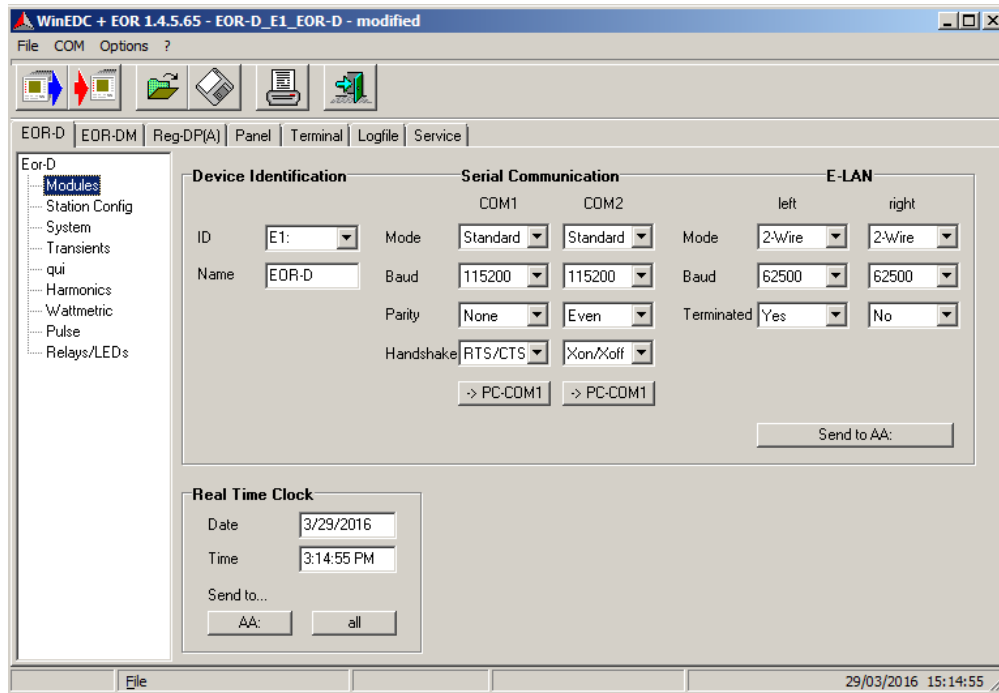


Fig. 33: WinEDC 'Module' parameter screen

#### 11.1.1 Device identification

##### Identification

Address (ID) of the EOR-D on the bus (E-LAN). Every EOR-D 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 (:).

##### Name

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 logfile and error logs.



#### Note:

The IDs for all existing devices are also read automatically from the switching scheme.

*New: Delivery state: E1:*

## 11.1.2 Serial interface

### COM1/COM2

Each device must have a unique name in addition to a unique ID. The name can be entered or changed on the 'Modules' and 'System' parameterization screens.

*New: Delivery state: EOR-D*

### Serial interface

- 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-COM1 button

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.

### 11.1.3 E-LAN

#### Mode

There are two modes:

- 2-wire
- 4-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 section. Meaningful speeds are:

- 62 500
- 125 000



#### Note:

For 2-wire connections, the speed can be increased to a maximum of 125000 baud.

#### Terminated

If an EOR-D is at the beginning or end of a bus section, the bus must be closed/terminated at that point with a resistor (characteristic impedance). The required resistors are already in the EOR-D and are switched on and off through a relay. All of the bus sections have to be terminated for 4-wire connections. For 2-wire connections, termination depends on the structure of the bus: select YES (for closed/terminated) or NO (for not closed/not terminated).

#### 11.1.4 <Send to AA:>

##### 'Send to AA' button

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



**CAUTION**

##### **Caution!**

If the parameters of the used interface (e.g., COM 1) have changed, communication with the connected device can be disrupted. Click the ->PC-COM1 button

##### Date/time

The date and time of the connected PC are displayed in the respective fields.

##### 'Send to AA' button

Sends the date and time of the PC to the directly connected device.

##### 'Send to AA' button

Sends the date and time of the PC to all of the connected devices.

## 11.2 'Station config' screen

The creation and configuration of the switching scheme is an important part of parameterizing the EOR-D. The following points are defined in the switching scheme:

- Available EOR-D devices with ID (master/slave devices)
- Transformation ratios of the voltage and current transformers
- Allocation of current channels to a zero sequence voltage
- Management of the earth fault groups

The zero sequence voltage and the residual currents for all of the outgoing circuits are connected to the EOR-D's measurement inputs. The binary input channels report the switch positions for each cell/outgoing circuit to the EOR-D. The information on the position of the disconnectors and the circuit breakers enable several outgoing circuits to be allocated to a specific zero sequence voltage. This allocation is called 'grouping'.

Groups are created on the EOR-D through the switching scheme, meaning that all of the outgoing circuits that are allocated to a zero sequence voltage can create a group. These groupings are used to evaluate an earth fault according to the steady-state earth fault method. This is the only way that an earth fault message can be output with a correct switching scheme.

### 11.2.1 The basics of a switching scheme

All of the EOR-D's inputs are configured through the switching scheme. This is usually done in an Excel table that is imported in the WinEDC parameterization software after the switching scheme has been created. The scheme can be changed later in WinEDC, but major changes should be made in Excel (better editing capabilities).

The basics of creating a switching scheme are displayed in the respective substation configuration.

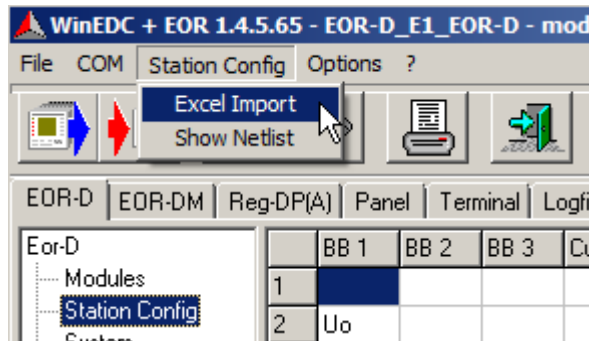


Fig. 34: Import Excel switching scheme into EOR-D



When importing, the appropriate switching scheme table must be open in Excel. The structure of this Excel table is based on the busbar's single-pole equivalent circuit.

● **The following always applies:**

The current and zero sequence voltage of an outgoing circuit must always be measured in the same device! In other words the voltage measurements on the busbar must be distributed to all of the devices. No device ID is required for voltage measurements that are performed for each outgoing circuit.

When loading the switching scheme (together with the other parameters) into the devices, the device IDs must match the IDs in the switching scheme or the loading process will be aborted.

### 11.2.1.1 Configuration parameters

This section describes each of the elements that are needed to create the switching scheme. An example is used to explain the basic creation and function (grouping and channel allocation) of the switching scheme.

BB1	BB2	BB3	Cell	Switch	ID	BI	ID	Current	Kni	Voltage	Knu	Comment
BB_A	BB_B	BB_C										
U12							E1:			U12	20000/100	
Uo							E1:			Uen1	11547/100	
	Uo						E1:			Uen2	11547/100	
x			J01: Q01		E1: E01							
x			J01: Q0		E1: E02	E1: Io1	60/1					Hospital
x			J02: Q02		E1: E03							

Fig. 35: Example configuration of a switching scheme

#### Explanation of the columns in the Excel spreadsheet

Column	Function
BB1, BB2, BB3	Substation configurations with up to three busbars (BB) with longitudinal couplings (LC) and transverse couplings can be replicated in the switching scheme. Outgoing circuits that are connected to the respective busbar are indicated by an 'x'. Measuring points must be marked as follows: Zero sequence voltage: U <sub>0</sub> Synchronization voltage: U <sub>12</sub>
Cell	This column stores the description of the respective functional unit. The description of the cell must match that of an outgoing circuit's switchgear. When evaluating the switching scheme, all of the rows with the same cell description are combined into one outgoing circuit.
Switch	The switchgear for the respective functional unit is described in this column. The value entered in this field is for information purposes only and is not used in evaluations.
ID BI	ID (address) and binary input of the EOR-D module to which the switchgear's auxiliary contact is connected.
ID current	ID and current channel of the EOR-D module for the measurement of the residual current (total current) at the outgoing circuit
kni	Transformation ratio of the current transformer
Voltage	Allocation of the voltage measurement to the voltage channel of the EOR-D module
knu	Transformation ratio of the voltage transformer  <div data-bbox="539 1167 616 1240" data-label="Image"> </div> The nominal value of the secondary side of the transformer has a fixed value of 100 V!
Comment	Comment, e.g., to describe the outgoing circuits. (Comments are not evaluated)

## 11.2.2 Switch configuration

The below shows the basic structure of several functional unit configurations in the EOR-D's switching scheme.

### 11.2.2.1 Configuration 2 disconnector/1 circuit breaker

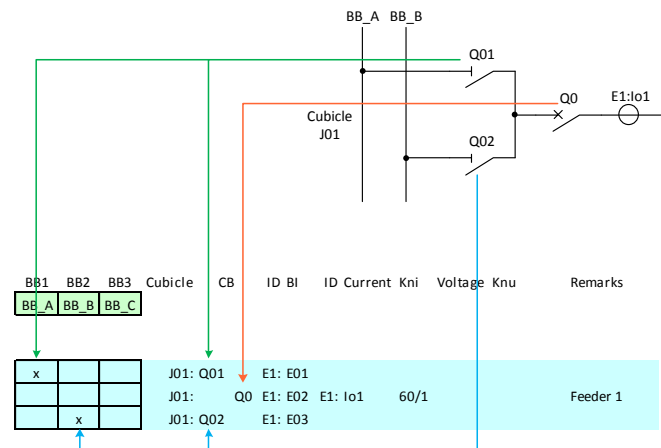


Fig. 36: Change switch from equivalent circuit to switching scheme

### 11.2.2.2 Configuration 2 circuit breaker (duplex substation)

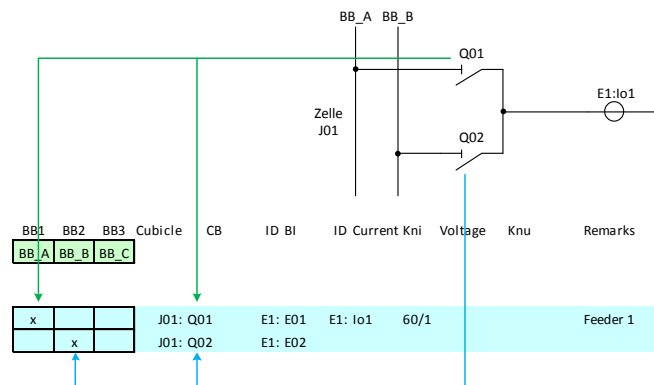
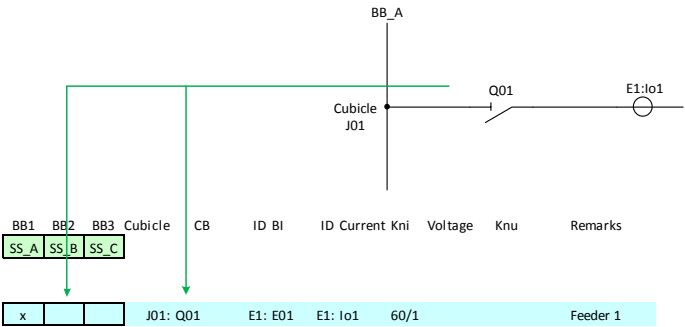
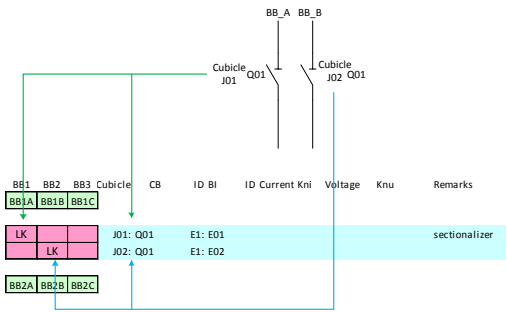


Fig. 37: Change switch from equivalent circuit to switching scheme

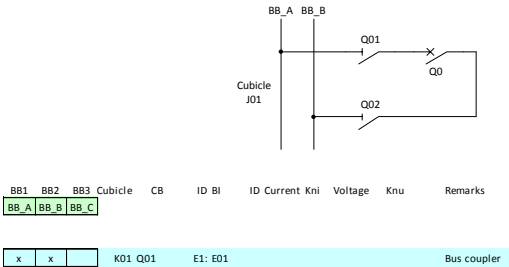
11.2.2.3 Configuration 1 circuit breaker



11.2.2.4 Disconnecter (isolating switch)



11.2.2.5 Transverse coupling





### 11.2.3 Position message

In order to combine the outgoing circuits into one earth fault group when an earth fault occurs, the EOR-D must be able to allocate the outgoing circuits to the right busbar.

There are several ways to allocate the outgoing circuits to the respective busbars.

#### 11.2.3.1 Reading in position messages for each binary input on the EOR-D

In this configuration, the position messages from the respective switchgear are wired to a binary input on the EOR-D. The respective EOR-D (ID) and the binary input (BI) for the corresponding position message are entered in the switching scheme.

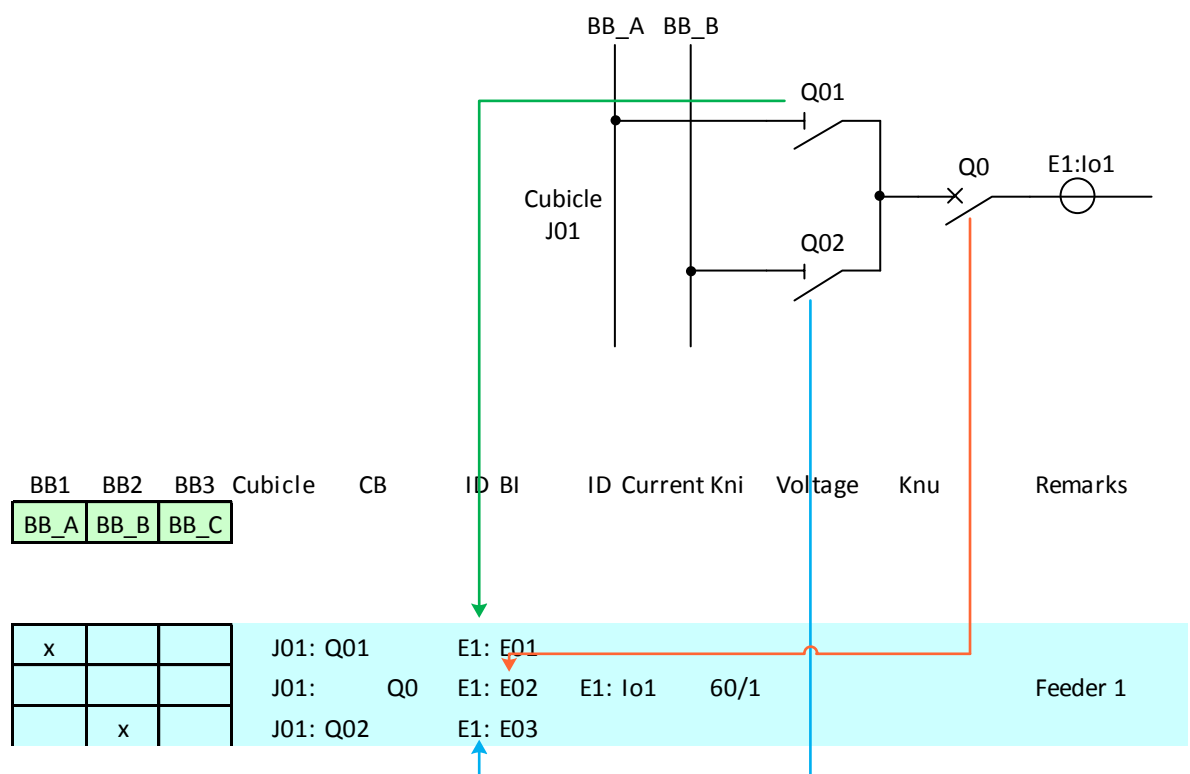


Fig. 38: Switch position message through binary input

**Fehler! Verweisquelle konnte nicht gefunden werden.** shows an example of the how this type of switch feedback is used. Here, switch Q01 of binary input 1 (E01) is allocated to device E1: (EOR-D). So that the outgoing circuit to BB\_A is detected, BI E1:E01 (Q1) and E1:E02 (Q0) must receive an ON feedback message.

11.2.3.2 Fixed position message in the switching scheme

In this configuration, the position messages (ON or OFF) are fixed directly in the switching scheme.

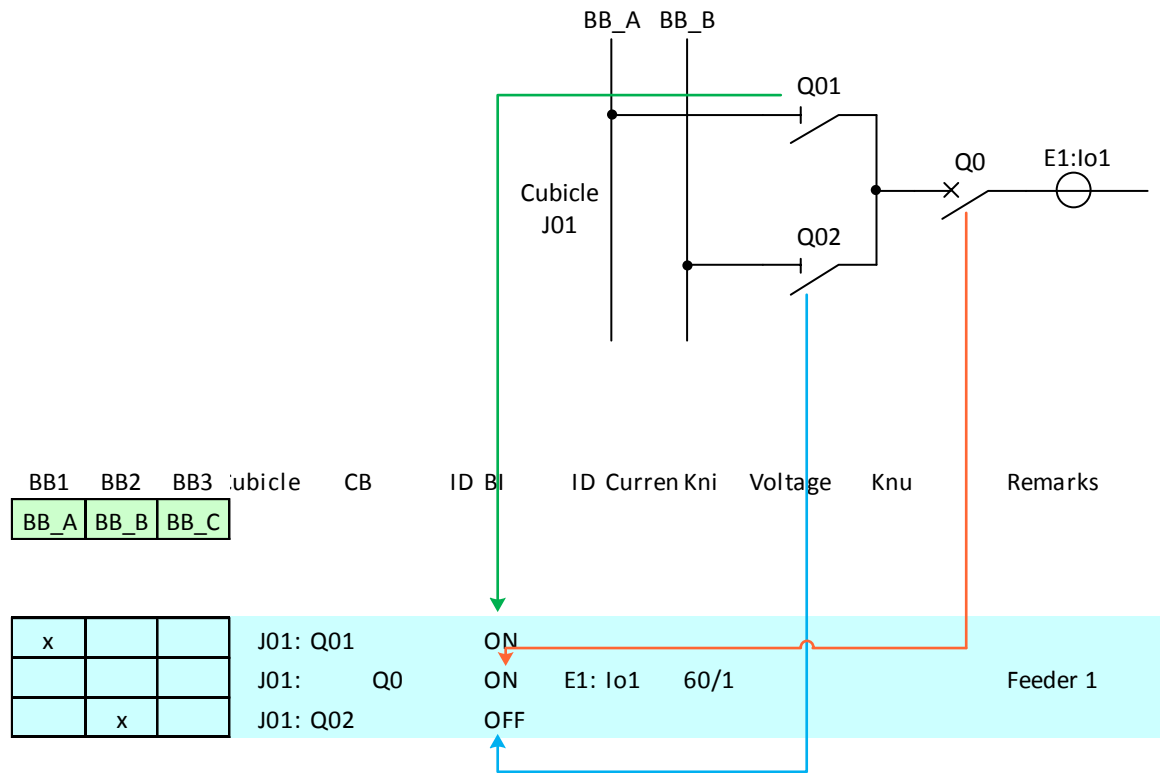


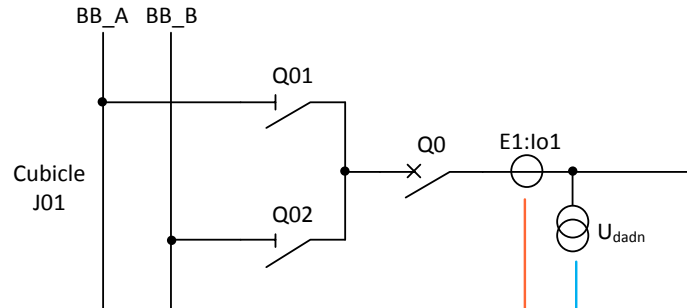
Fig. 39: Fixed ON or OFF switch feedback message

To define a fixed switch position, ON or OFF is entered for the respective switching state in the BI column instead of the binary input. The ID column can remain empty.

The relay won't detect a switch-off or switchover to the other busbar. The related current in the outgoing circuit is taken into account during grouping if the switching state is 'ON'.

### 11.2.3.3 No switch position message

In this configuration, a group is only created when an earth fault occurs. The total current and the zero sequence voltage must be measured separately on each outgoing circuit. The current channels are always allocated to the zero sequence voltage on the same channel.



BB1	BB2	BB3	Cubicle	CB	D BI	ID Current Kni	Voltage	Knu	Kommentar
BB_A	BB_B	BB_C							
x			J01: Q01						
			J01: Q0			E1: Io1	60/1 Uen1	11547/100	Feeder 1
	x		J01: Q02						

## 11.2.4 Creating the switching scheme

This section describes each of the steps that are taken to create a switching scheme for the EOR-D.

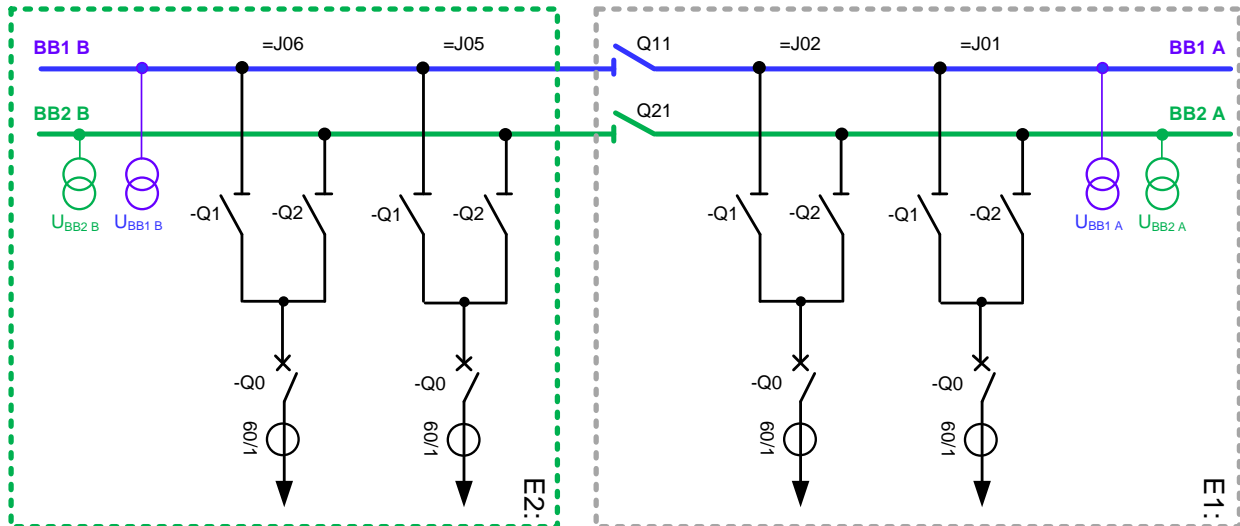


Fig. 40: Example configuration

### Configuration:

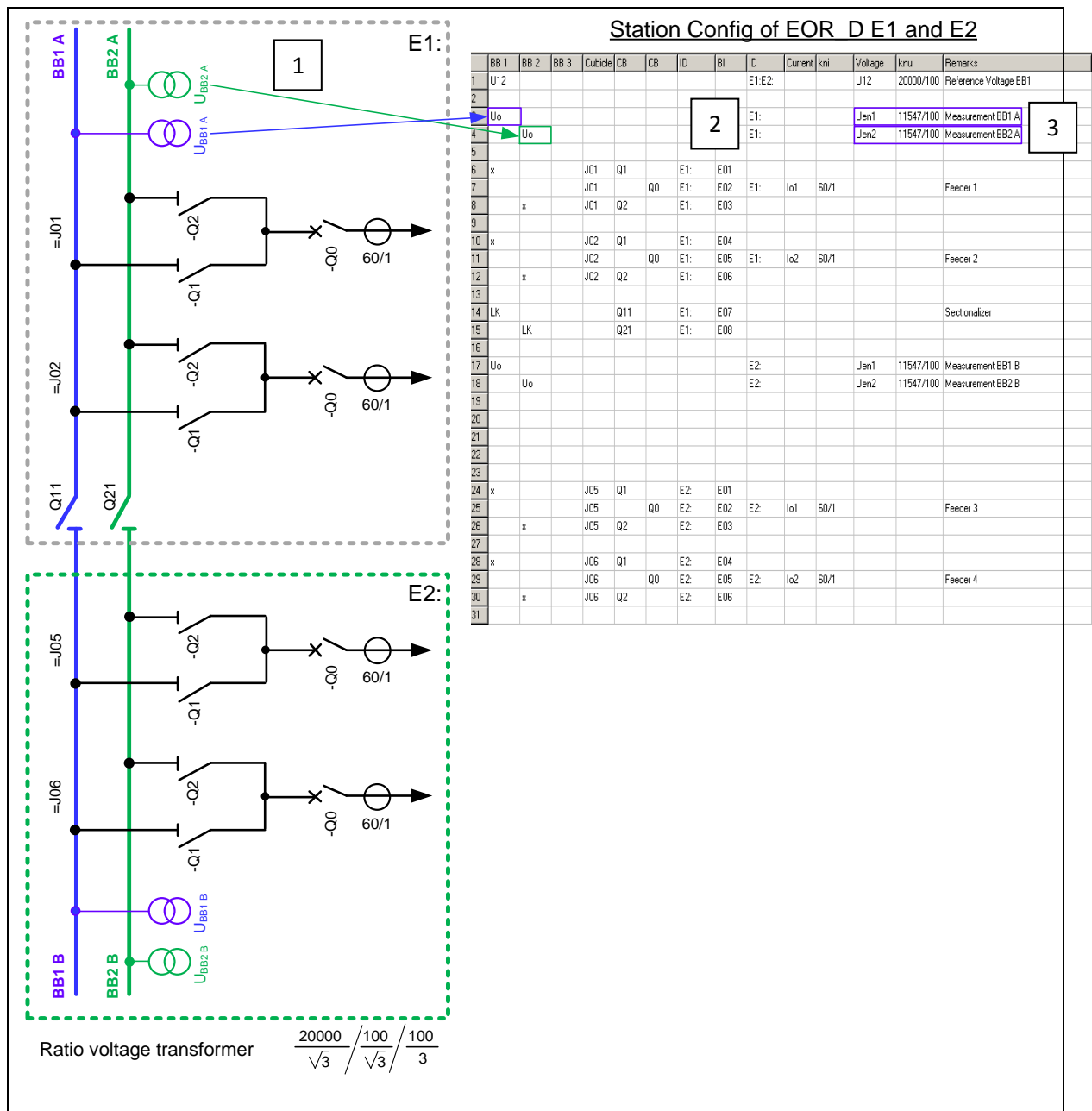
- Switch position message is available

### Step 1: Measure zero sequence voltage

First, you have to determine where the zero sequence voltage will be measured

- busbar
- for each outgoing feeder

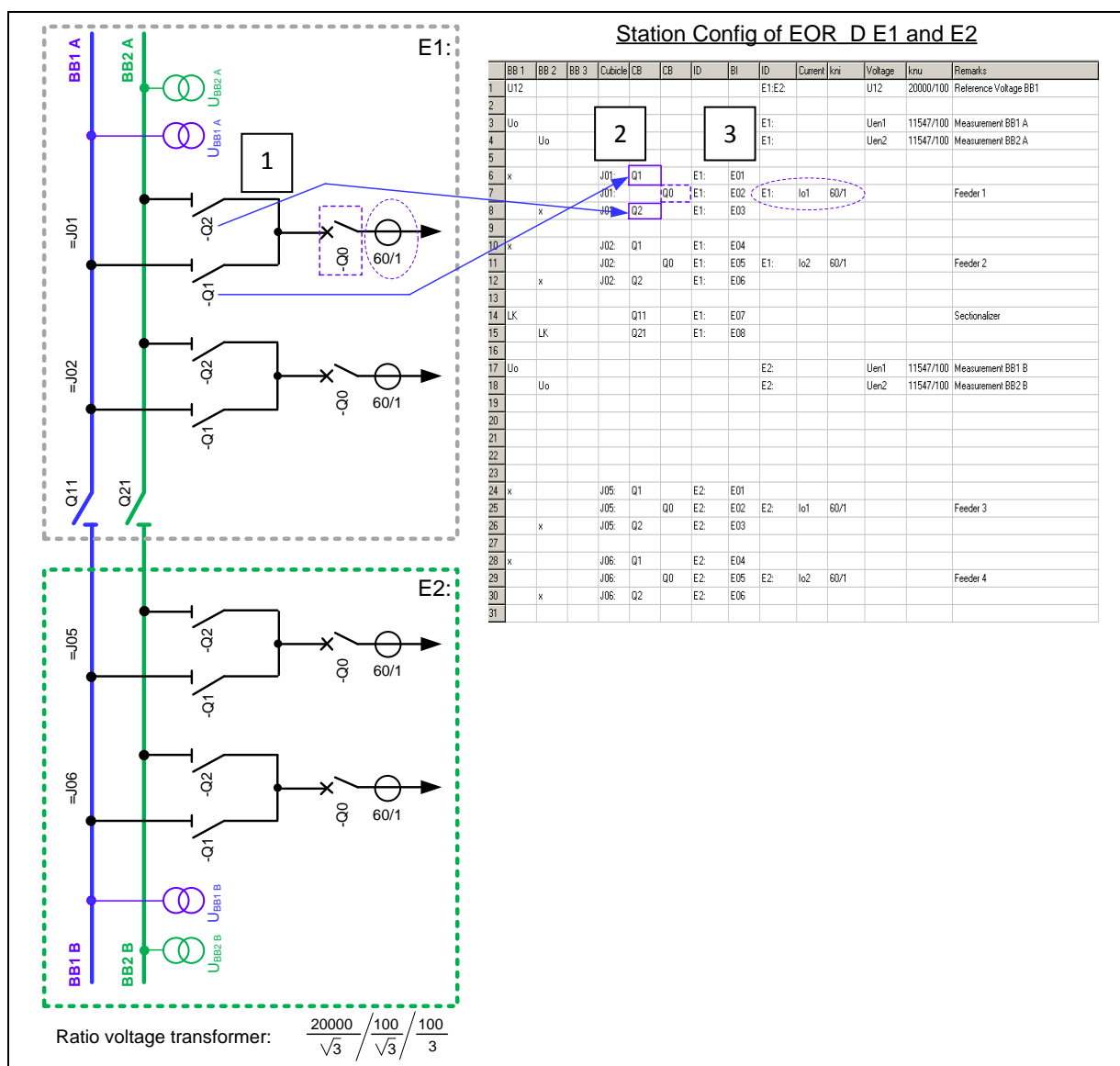
The example configuration shows that the switchgear consists of a double busbar. The zero sequence voltage is measured at the respective busbar. Accordingly, the first rows in the switching scheme can be created as follows:



1. Allocate the zero sequence voltage measurement to both busbars
2. Enter all of the IDs of the available EOR-D devices. Because device E1: is the only device that is responsible for the top busbar section in this example, only the ID for E1: is entered. Accordingly, device E2: must be entered after the switch disconnector (Q11, Q12).
3. Allocate the measurement channel on the EOR-D (Uen1 or Uen2) and enter the transformation ratio of the voltage measurement (zero sequence voltage).

## Step 2 – n: Entering the outgoing feeders

The next step consists of entering the other lead fields



1. Allocate the outgoing lines to both busbars (column BB1 und BB2)
2. Enter cell and switch descriptions
3. Allocate the binary inputs on the EOR-D for switch feedback messages. In the example, the feedback from switch Q01 (RM ON/OFF) is expected on device E1: binary input 1.
4. Allocate the EOR-D current channel to the feeder panel
  - Enter ID and current channel (Io1 - Io4)
  - Enter the transformation ration of the current transformer (transformation ratio of the cable type current transformer or transformation ratio of the phase current transformer in holmgreen mode)

## 11.2.5 Configurations

This section describes the commissioning process for the EOR-D based on three different grid configuration examples.

### Example configuration A:

- Measurement of zero sequence voltage
- Switch position message is available
- Grouping directly from the switching scheme through switch position is possible

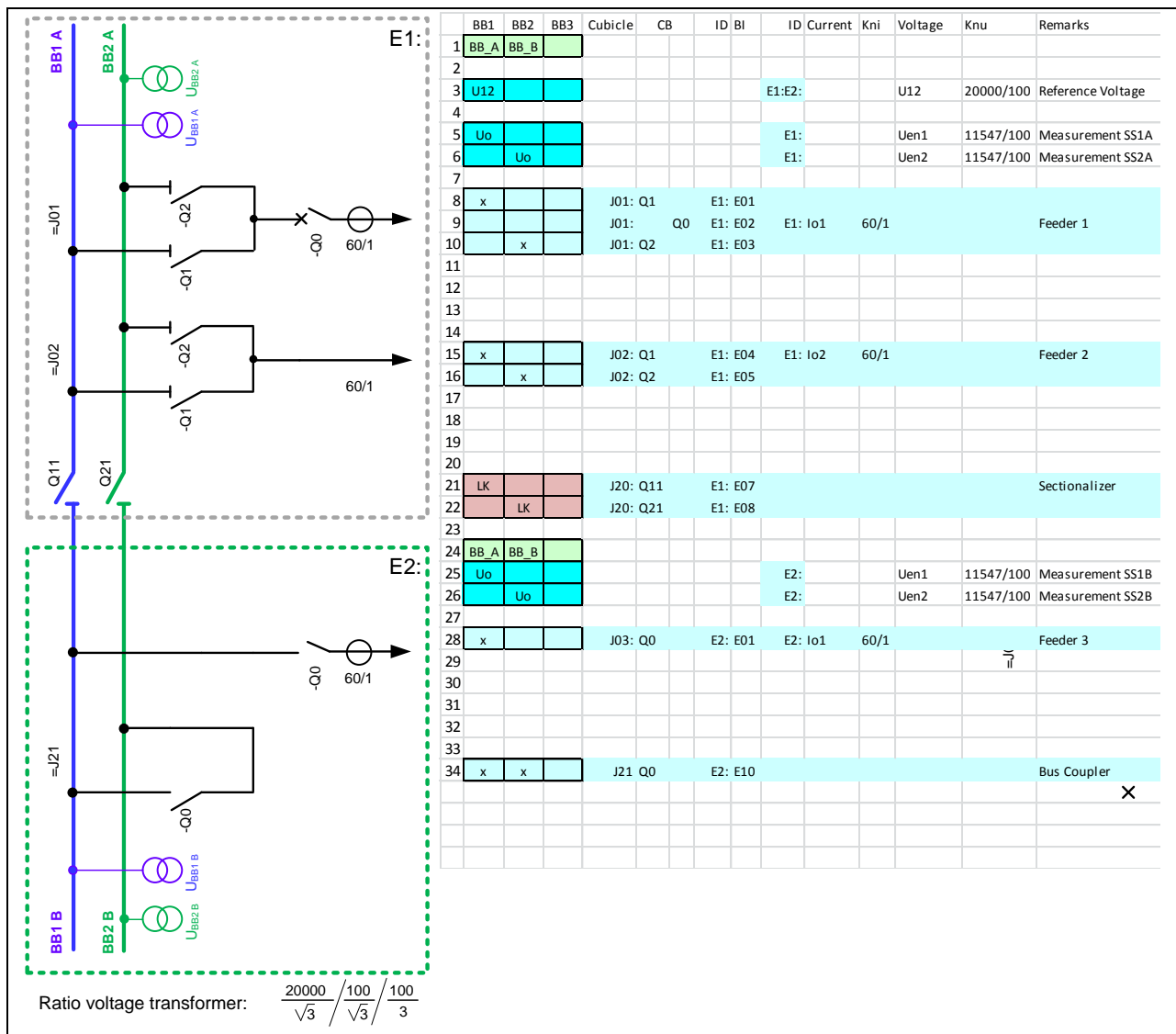


Fig. 41: Example configuration A; Excel table vs single-pole equivalent circuit

### Explanation for configuration A:

Row	Function
3	Definition of the reference voltage
5	Zero sequence voltage $U_{ne}$ on busbar 1 (BB1) is measured by the devices with the addresses A1, A2 and A3 with measurement input $U_{ne1}$ ( $=U_{en1}$ ). 'knu' defines the transformer factor (here $20 \text{ kV}/\sqrt{3}/100 \text{ V}$ ).
6	Same as row 5
8 - 10	The first outgoing circuit is equipped with two disconnectors and a circuit breaker. The description of cell 'J01' is the same for all of this outgoing circuit's switches. The switch descriptions (Q0...Q2) are not evaluated. The position of the disconnector for BB1 is reported to the device with address E1: through binary input E01. The position of the circuit breaker is sent to the earth fault detection relay with address E1: through binary input E02. The position of the disconnector for busbar SSB2 is sent through binary input E03. The total current $I_{o1}$ for the outgoing circuit is measured with a transformation ratio of 60/1. The 'Comments' for the outgoing circuit are not evaluated.
15 - 16	This outgoing circuit is a duplex output - can be connected with two circuit breakers. The two busbars can be connected at any time through this outgoing circuit.
21 - 22	Describes the disconnector with reference to the used binary inputs. The disconnector is only signalled to one device at a time; the information whether the disconnector will be open or closed is communicated system-wide through the E-LAN. The zero sequence voltage measurement must be redefined on the busbar after every disconnection. See rows 5 and 6.
28	The third outgoing circuit has a fixed allocation to a busbar but can be connected/disconnected at any time through a circuit breaker.
34	In the event of a transverse coupling all of the cells for both busbars are indicated by an 'x'.
BB3	The third busbar is not needed in this example
ID current	Enter the device ID and the current channel to which the measured total current is fed here.
kni	Transformation ratio of the current transformer
Volt	Allocation of the voltage measurement channel
knu	Transformation ratio of the voltage transformer
Comment	Comment (is not evaluated with the conversion)





### Example configuration C:

- Measurement of zero sequence voltage per outgoing circuit
- **Switching scheme is not available** => Groups are created through the zero sequence voltages
- **Permanently allocated outgoing circuits to a busbar**

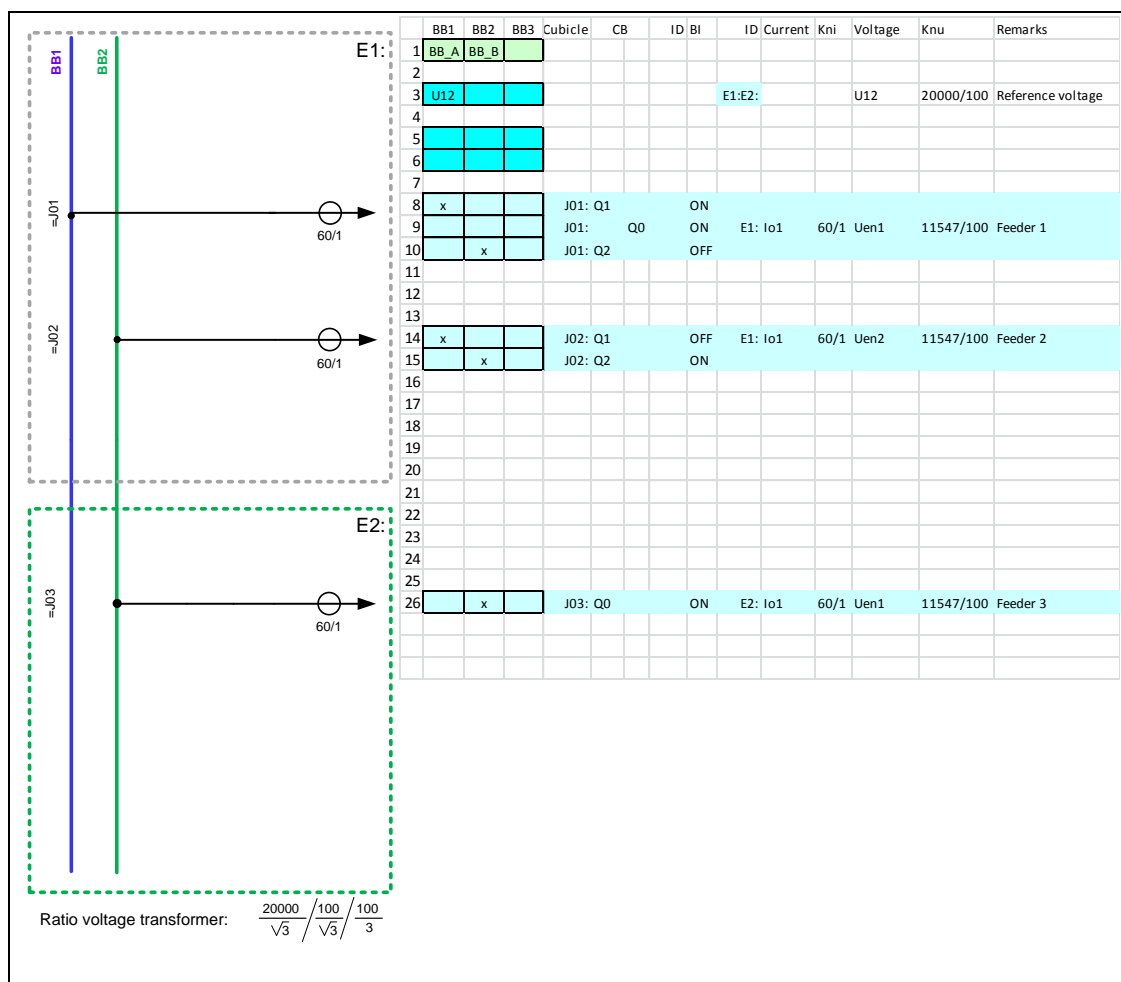
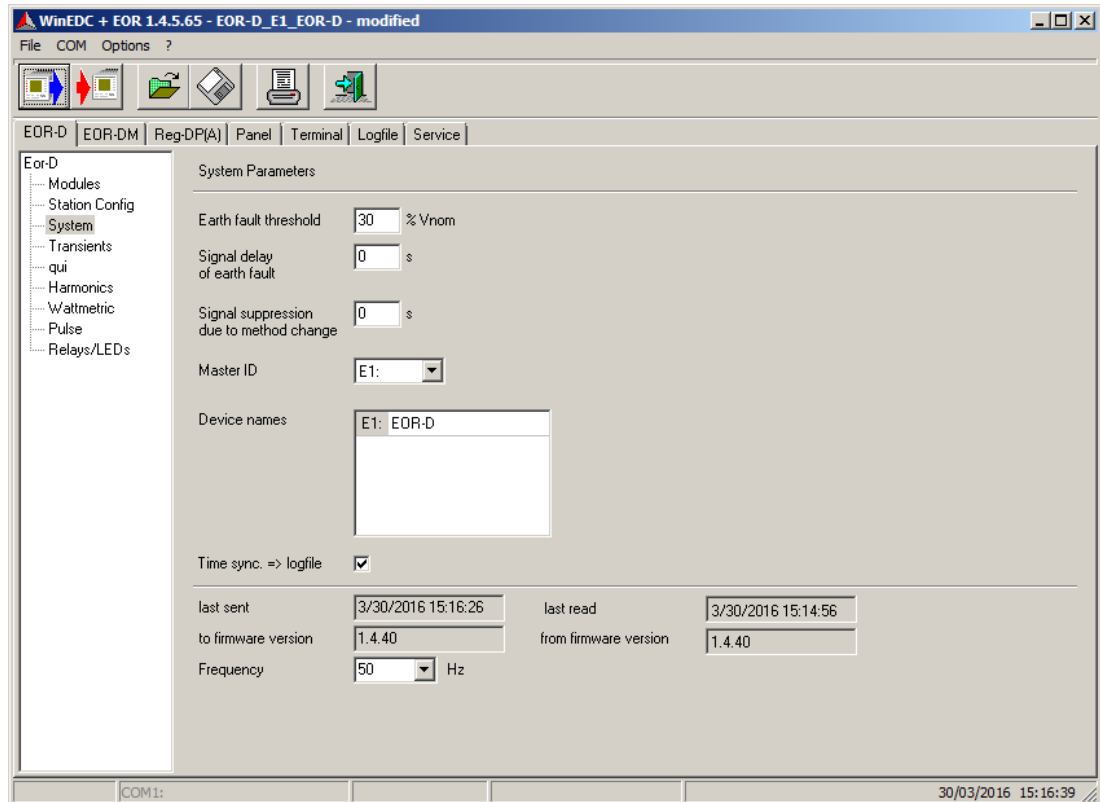


Fig. 43: Example configuration C

The outgoing circuits for cells J01, J02 and J03 are permanently allocated to a busbar. The switch position doesn't have to be wired. The relay won't detect a switch-off or switchover to the other busbar. The related current in the outgoing circuit is taken into account during grouping if the switching state is 'ON'.

## 11.3 System screen



### ● Earth fault threshold

The evaluations of all of the detection methods remain inactive until the zero sequence voltage has exceeded the set threshold value. The first harmonic order (50Hz) is used for monitoring. For 'Grouping without switching scheme', the system detects when a zero sequence voltage is exceeded. The next step then consists of checking whether the zero sequence voltage of all of the outgoing circuits is within a tolerance range around the detected earth fault voltage. If this is the case, the outgoing circuit is added to the fault group. Then a comparative evaluation is done of the residual currents for the faulty group in relation to the first voltage in the group.

If the groups are created through the switching scheme, the groups will be recreated every time a binary input changes. The assignment to the group is already known when the earth fault occurs and the comparison of the currents can start immediately.

The operate value is indicated as a percentage and refers to the secondary nominal voltage (100 V) of the transformation ratio of the voltage transformer specified in the switching scheme.

- **Signal delay on earth fault**

A general earth fault (message and logfile entry) is only evaluated if the threshold for the zero sequence voltage is exceeded for longer than the specified time.

*Default value: 0 s*



**Note:**

Does not affect the delay time that can be set for each of the methods.

- **Message delay on method change**

A pause in messaging when a switchover from one detection method to another takes place on any output channel (relay, LED).

**Example:**

If all of the detection methods for an outgoing circuit are supposed to be output on the same relay, it will not be possible to distinguish them. If a distinction is desired, the relay will drop out for the set time. The following is then displayed for the following method.

Display sequence:

1. Transient method
2. Harmonics method
3. Wattmetric method
4. Pulse detection method

*Default value: 0 s*

- **Master ID**

The master ID determines which of the available EOR-D modules is the 'master'.

Because an EOR-D can only monitor up to four outgoing circuits it makes sense to link several EOR-Ds to one system. EOR-Ds that are connected through the E-LAN can be combined into one system.

The list of possible devices is defined by the switching scheme.

*Delivery state: E1:*



**Note:**

A master system makes sense because several EOR-Ds can be combined into one system and the parameters only have to be sent to the master device.

- **Device names (substation name)**

Each module must have a unique name in addition to a unique ID.

The name of the device can be entered or changed on the 'Modules' and 'System' parameterization screens.

It makes sense to use the substation as name (max 8 characters and only characters that can be used in Windows file names are allowed). When downloading error logs and logfiles, a file name consisting of the device's ID and name is automatically generated.

*Delivery state: E1:EOR-D*

- **TimeChg -> Logfile**

This parameter determines whether time changes are entered in the logfile. It doesn't make sense to record time changes in the logfile if the device is cyclically synchronized because the logfile would only contain the timestamps and not the interesting information.

- **last sent**

Time at which the parameter set was last sent to the device

- **to firmware version**

Firmware version of the device to which the parameter set was sent

- **Nominal frequency**

The nominal frequency (50 Hz or 16.7 Hz) is selected here

The selection is entered in WinEDC's registry so that the value is available the next time it is needed.

This setting is transferred to the device during the send process.

The frequency that was actually selected is not displayed until the parameters are read out.





If the frequencies don't match, a sysreset = 0 must be performed to reboot the EOR-D after the parameter has been sent. The reboot process transfers the frequency to the signal processor where it is activated.

This parameter enables each device to be parameterized on site for 50 Hz or 16.7 Hz.



**Note:**

The system does not have to be reset from firmware version 1.4.34. The EOR-D automatically resets the system after the parameters have been changed or sent.

Parameter	Settings	Default setting
Earth fault threshold	0 to 100% Unenn	30%
Signal delay on earth fault	0 to 60 s	0 s
Signal suppression on method change	0 to 60 s	0 s
Master ID	Select the device ID defined in the switching scheme	E1:
Device names	editable device name.	EOR-D
TimeChg -> Logfile	 <b>Activated</b>  <b>Deactivated</b>	Activated
Nominal frequency	 <b>16.7Hz</b>  <b>50Hz</b>	50 Hz

## 11.4 Transient screen (qu2 method)

### 11.4.1 Functional description

The qu2 method (transient earth fault) evaluates the charging process of the two healthy lines when an earth fault occurs.

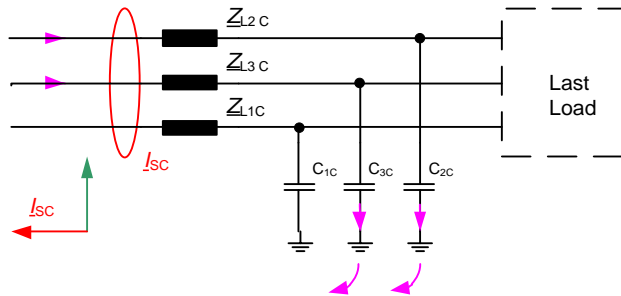


Fig. 44: Charging process fault-free outgoing circuit

The curve of the zero sequence voltage can be described in a simplified manner by the following equation:  $u_0(t) = \frac{1}{C} \int_0^t i_o(\tau) d\tau$ . It shows that a voltage cannot be created until a current flows on the line-to-earth capacitance. This creates a current that leads the voltage by  $90^\circ$ . The integrated value of the current can be interpreted here as the applied charge  $q$ . This means that the voltage in a fault-free outgoing circuit is proportional to the charge. Plotting  $u_0$  and  $q$  against in a diagram will always yield a straight line with a positive gradient for the fault-free outgoing circuit.

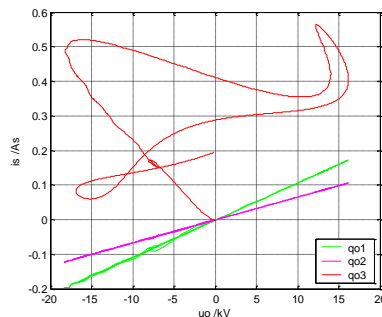


Fig. 45: Direction evaluation qu2 method

Based on the fault resistance, the faulty outgoing circuit will yield a straight line with a negative gradient or the direction evaluation will be based on the rotation (corresponds to the surface or the curvature of the curve)

Fault-free output: Straight line with positive gradient

Faulty output: Straight line with negative gradient or rotation

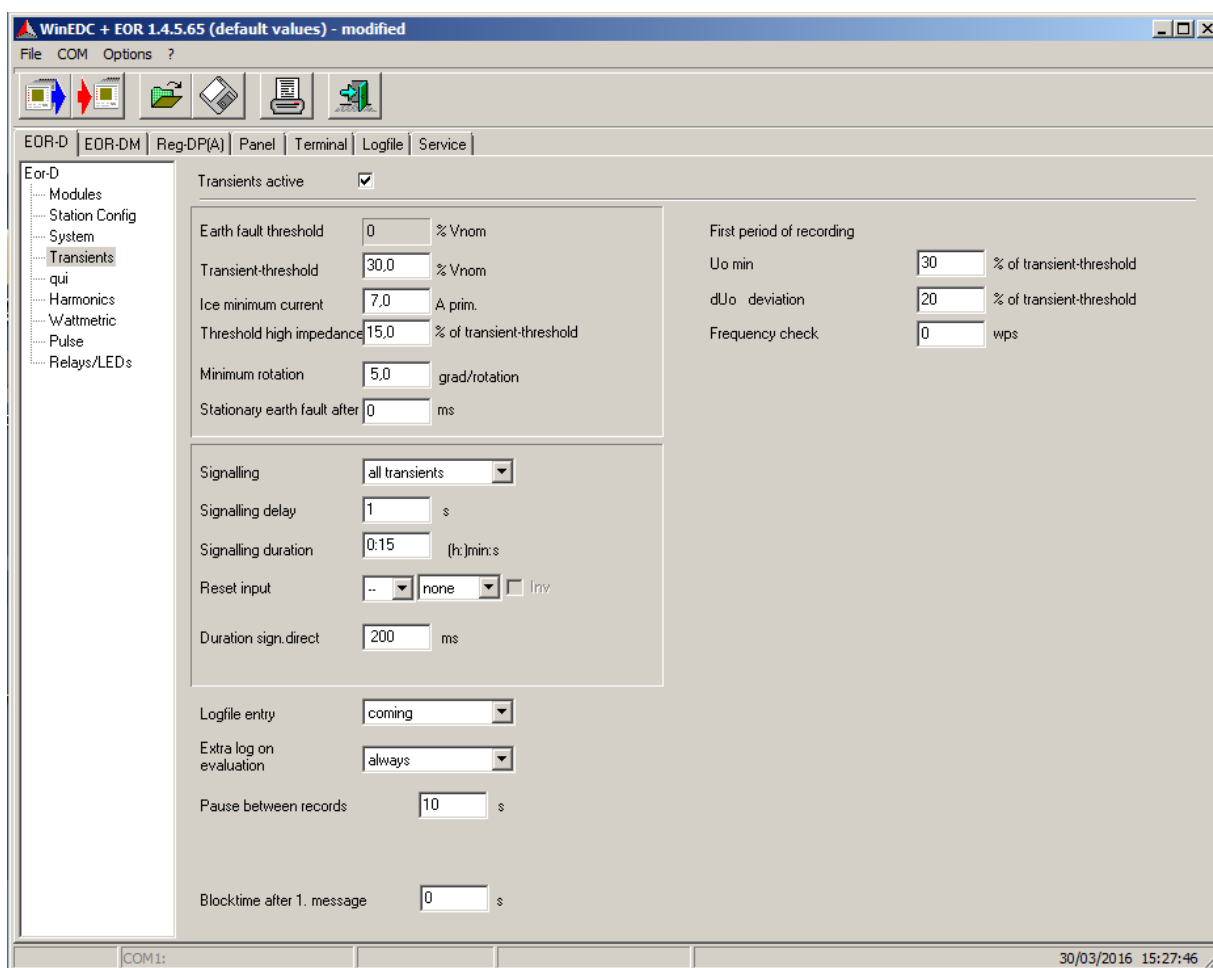


Fig. 46: Parameters qu2 method

## 11.4.2 Setting instructions

### ► Description of the parameters in the qu2 method (transient earth fault)

#### Transient active

Activates the qu2 method

#### Earth fault threshold

Uniformly set on the System screen for all methods.



### Trigger threshold

The evaluation of the transient processes of the zero sequence voltage and the residual currents starts as soon as the zero sequence voltage exceeds the set limit value.

The following cases are supported:

- Grouping through the switching scheme
- Fixed allocation of the residual currents to a zero sequence voltage
- Grouping through the zero sequence voltage

If the transient earth fault method is used in combination with other methods, the same trigger threshold should be used as that for the other methods. If different thresholds are used and the transient earth fault method, for example, is activated, it can happen that the other methods (optimized for pinpointing) cannot be used because the trigger levels for the zero sequence voltage have not yet been reached.

### Ice min

If the zero sequence voltage has exceeded the threshold, a minimum current must flow before the device sends a message. This parameter specifies the minimum size of the remaining healthy grid (expressed in A\_primary). This corresponds to the grid's line-to-zero capacitance, which is in the 'backbone' of the relay and specified in Ampere\_primary.

The operate value can be estimated from the isolated earth fault current:



**Note:** Rule of thumb

$$I_{CE\_min} = \frac{5}{100} * I_{CE}$$

### High impedance threshold

Threshold for the detection of high impedance earth faults.

This threshold is applied to the voltage after linearization around the operating point.

### Minimum rotation

This setting determines which evaluation method is used for the qu algorithm for the direction decision. If the rotation is bigger than the value entered here, the rotation will be used for the direction decision. Otherwise the gradient is used to evaluate the direction of the faulty section.

$$\frac{rot}{grad} > Minimum\ rotation \rightarrow direction\ is\ fixed\ by\ the\ rotation$$

$$\frac{rot}{grad} < Minimum\ rotation \rightarrow direction\ is\ fixed\ by\ the\ gradient$$

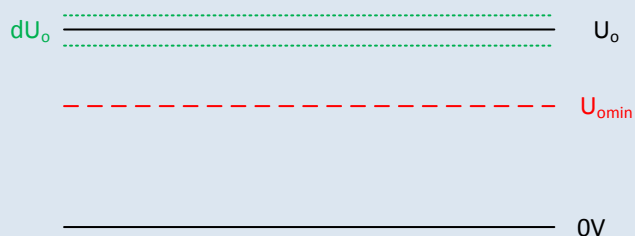
## 1. Recording period

For the linearization around the operating point it is important whether the earth fault occurred before or in the first period of the recording. The two settings  $U_{o\_min}$  and  $dU_o$  are used to determine this.

If the zero sequence voltage is smaller than  $U_{o\_min}$  throughout the first recording period, linearization can be performed immediately.



If, on the other hand,  $U_o$  is bigger than  $U_{o\_min}$  throughout the first recording period, linearization can only be performed if the voltage remains constant during this period or the variation of  $U_o$  is smaller than the value set for  $dU_o$ .



## Continuous earth fault after

The system detects a continuous earth fault when the zero sequence voltage stays above the trigger threshold for longer than the set time.

Options:

- |             |  |
|-------------|--|
| 0           | No continuous earth fault detection  |
| 60 ... 1000 | Minimum time for $U_{ne} > U_{trigger \text{ threshold}}$ to detect a continuous earth fault |

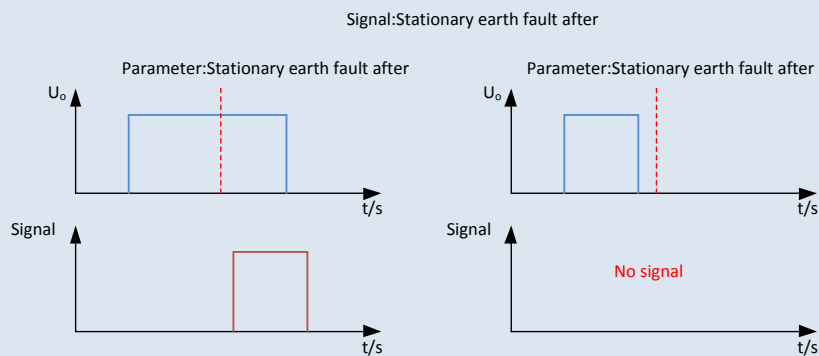
## Messages

The options can be used to determine whether all of the transient earth faults (meaningful in cable networks) or only the transient earth faults that turn into continuous earth faults are reported (meaningful in overhead transmission grids).

The zero sequence voltage must be present for longer than defined in the 'Message delay' parameter.

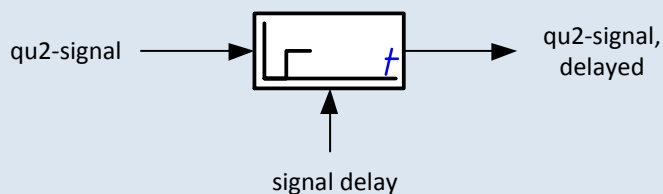
Options:

0	No continuous earth fault detection
60 ... 1000	Minimum time for $U_{ne} > U_{\text{trigger threshold}}$ to detect a continuous earth fault



## Message delay

Transients are not reported until the delay set in this parameter has lapsed. This only applies to the 'slow message'. The fast, direct message is not affected by this parameter.



### Message extension

The transient earth fault message is held for the time set in the parameter. The transient information is automatically reset at the end of the set time. If a different detection method is already active, the system switches over to it.



#### Note:

$t_{verl,max} = 3 \text{ h}$   
 $t_{verl} = 0 := \text{continuous}$

### Reset input

A reset can be performed at any time through a binary input or the SCADA system. The input signal can be inverted by checking the 'Inv' flag.

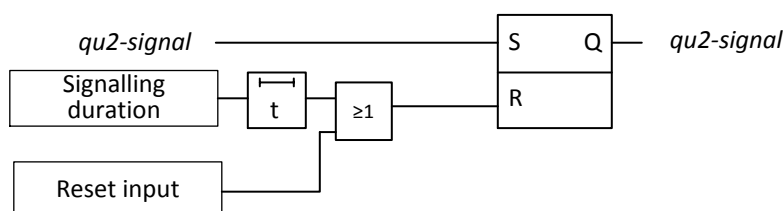


Fig. 47: Message behaviour EOR-D

### Direct message duration

This parameter sets the duration of the fast direct message. The result of the qu2 algorithm is sent to the module's relay for the time entered here. The set time has a precision of 20 ms.



#### Note:

This only applies to the relays on their own module

### Logfile entry

This parameter determines which earth fault events are entered in the logfile. Each entry contains at least a date, time, outgoing circuit and event type.

Options:

None	No logfile entry
<b>coming</b>	Entry when a message is coming
going	Entry when a message is going
coming/going	Entry when a message is coming or going

For the transient method, only the coming message is interesting because information about an earth fault is contained in the rising edge. The duration of the display is only a setting for the visualization or for the detection through the SCADA system.

The configuration on the 'Relay/LED' parameter screen determines whether the messages are output to the SCADA.

### extra log on evaluation

#### Options:

None	No additional evaluation of the qu2 method is entered in the logfile.
when message	An additional entry for the qu2 evaluation is only made when a transient is reported
always	All triggers are entered.

**qu2\_transient:** Trigger threshold was reached, qu2 evaluation has already been performed.

The direction towards the earth fault is entered in the logfile as follows (**Fehler! Verweisquelle konnte nicht gefunden werden.**):

L ... fault is in the direction of the line

B ... fault is in the direction of the busbar

- ... direction could not be determined

Ice Result of qu2 algorithm (gradient) The calculated current is equal to the outgoing circuit's capacitive current

Forward : gradient <  $-I_{ce,min}$

Backward : gradient <  $I_{ce,min}$

Rotation : Rotation result of the qu2 algorithm

**Transient:** Additional criteria might have to be met so that the message can be sent through the relay or the SCADA system.

**Earth fault duration:** Criteria for a continuous earth fault were also met.

2015-04-15 11:40:59,634	qu2_transient:	E1:	1:L	2:-	3:-	4:-	Error log: 04202859
2015-04-15 11:40:59,634	Ice	E1:	-24.43	0.00	0.00	0.00	
2015-04-15 11:40:59,634	Rotation	E1:	-4.29	0.00	0.00	0.00	
2015-04-15 11:41:01,127	Transient is coming line	E1:1	Error log:04202859				

Fig. 48: Evaluation of the qu2 algorithm in the logfile

### Pause between error entries

Transient earth faults during the set pause do not create an error entry. The evaluation of the direction of the earth fault and the corresponding event entries in the logfile are not affected.

### 11.4.3 Parameter

Parameter	Settings	Default setting
Transient active	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	Yes
Trigger threshold	0 to 100% Unenn	30%
Ice Minimum current	0 to 200A	10A
High impedance threshold		30%
Minimum rotation	0 to 10000 0 :Evaluation through rotation is switched off. Only the evaluation based on the gradient is active.	5
Continuous earth fault after	0 to 1000 ms	0 ms
Messages	<ul style="list-style-type: none"> <li>▶ all transients</li> <li>▶ only transients with CE</li> </ul>	all transients
Message delay	0 to 60 s	1 s
Signal extension	0 to 64800 s	15min
Reset input	0 to 255	None
Direct message duration	0 to 1000 ms	200 ms
Uo min	0 to 100%	30%
dUo	0 to 100%	20%
Logfile entry	<ul style="list-style-type: none"> <li>▶ None</li> <li>▶ Coming</li> <li>▶ Going</li> <li>▶ Both</li> </ul>	Coming
extra log on evaluation	<ul style="list-style-type: none"> <li>▶ None</li> <li>▶ Always</li> <li>▶ When message</li> </ul>	Always
Pause between error entries	2 to 1000 s	10 s

## 11.5 qui screen

### 11.5.1 Functional description

The qui method uses the transient method for restriking faults. Important is that the zero sequence voltage remains above the trigger threshold. The increase in the zero sequence voltage caused by the restriking fault represents only a fraction of the maximum zero sequence voltage. This method displays correctly when grid switchovers are performed during the restriking fault. The earth fault indicator tracks the fault.

**Intermittent faults** occur on isolated grids. In this case, overvoltages up to 3.5 times the nominal voltage can occur.

**Restriking faults** occur in the cable. In this case, extremely high overvoltages cannot occur because the flashover distance is determined by the distance between the inner conductor and the screen.

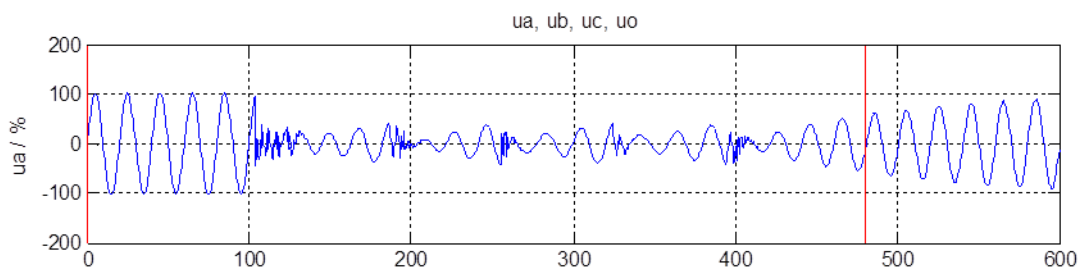


Fig. 49: Line-to-earth voltage  $U_{L1}$

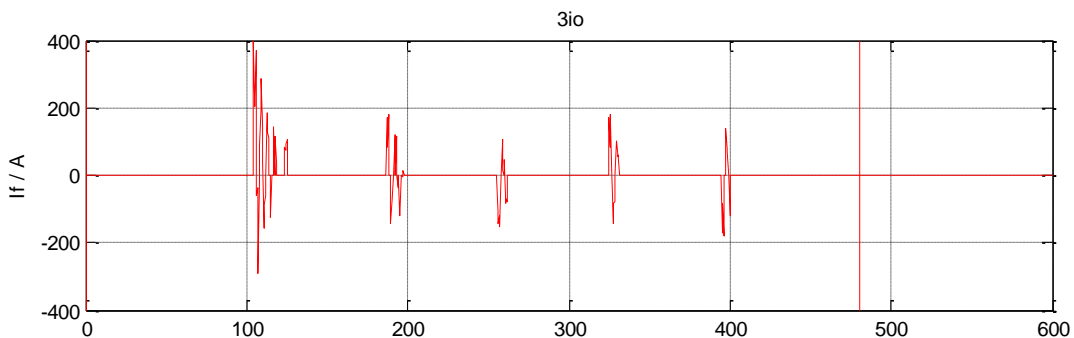


Fig. 50: Fault current

**Fehler! Verweisquelle konnte nicht gefunden werden.** shows the behaviour of a restriking fault. The line-to-earth voltage  $U_{L1}$  is not zero during the entire earth fault. The fault current itself extinguishes after a few milliseconds when it crosses the zero point. The grid considered here is a compensated grid, meaning that the line-to-earth voltage  $U_{L1}$  increases only very slowly. The line-to-earth voltage increases to a value of 2 - 6 kV until the faulty section is restruck. The restriking voltage depends on different parameters and also varies during the earth fault.

We take care of it.

Measurement value recordings in power control systems normally determine a mean value for the voltage over 200 - 1000 ms. This does not enable a restriking fault to be detected. This type of fault would therefore always be detected as a high impedance, steady-state earth fault.

## 11.5.2 Setting instructions

### ► Description of the parameters in the qu2 method

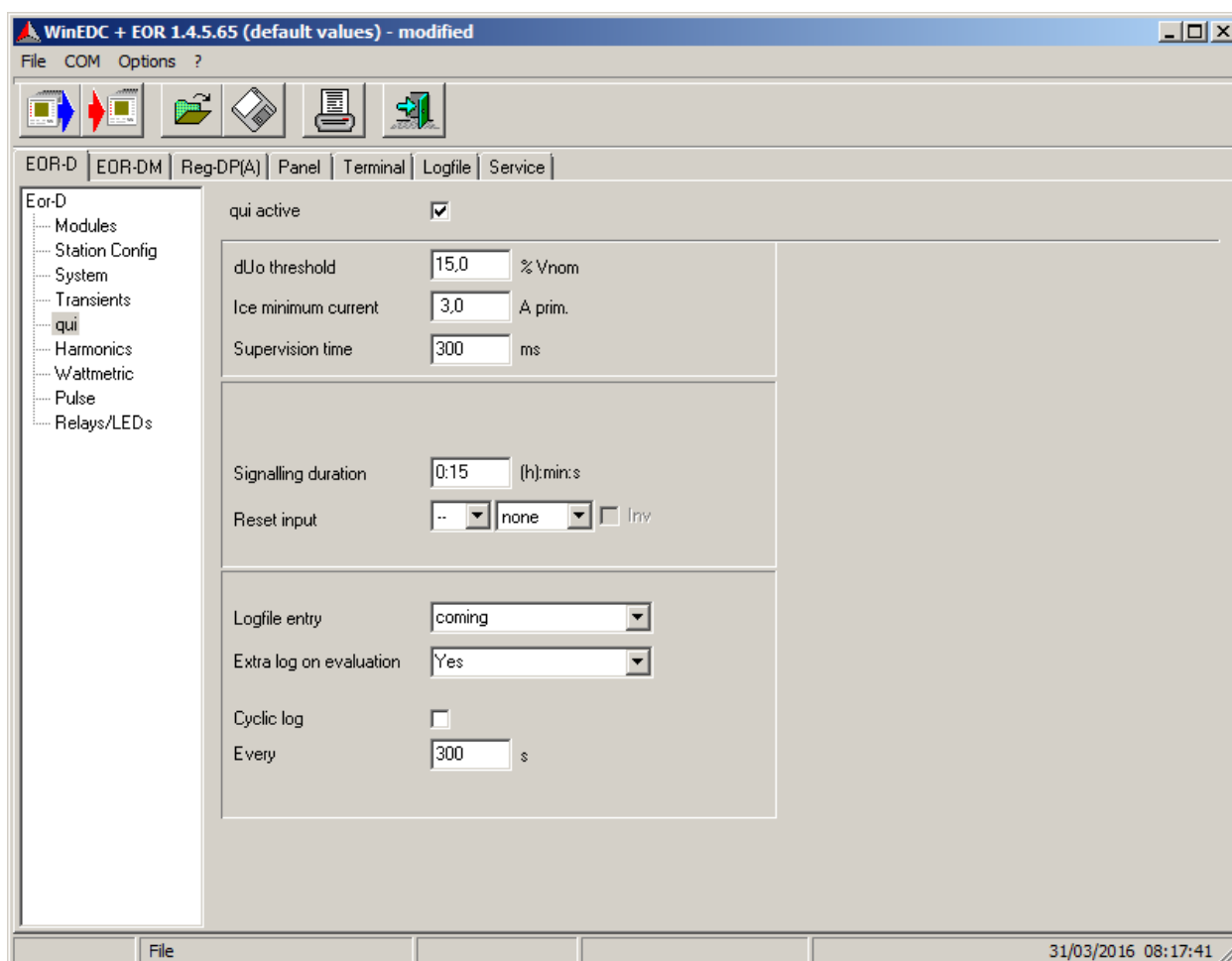


Fig. 51: Parameter in the qu2 method

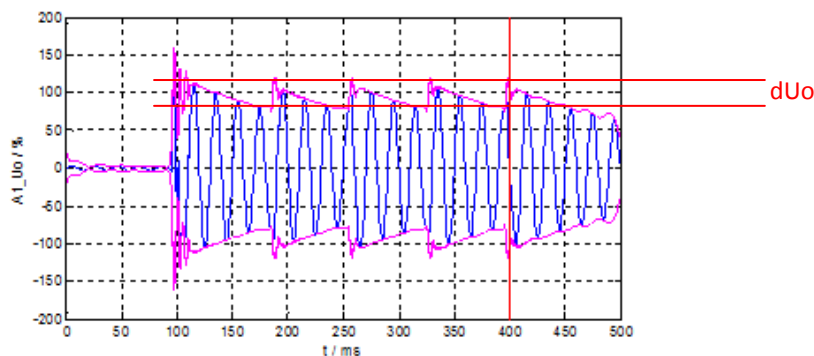


### qui active

Activates the qui method (intermittent earth fault)

### Trigger threshold dUo

The trigger for the qu2 algorithm (transient) is used to detect the earth fault. Restriking and intermittent faults are detected by a change in the zero sequence voltage during the earth fault. This parameter sets the minimum amount by which the zero sequence voltage must change during the earth fault in order to detect a restriking earth fault.



### Ice min

Minimum current so that a direction decision or message can be output.

### Observation range

This parameter sets the moving observation range. All of the ignition impulses that occur in this observation range are counted. More than two ignition impulses must be within the observation range in order for them to display.

### Message extension

The transient information is automatically reset after the set time. If a different detection method is already active, the system switches over to it.



#### Note:

maximum settable time is 3 h

### Reset input

A reset can be performed at any time through a binary input or the SCADA system. The input signal can be inverted by checking the 'Inv' flag.

### Logfile entry

This parameter determines which earth fault events are entered in the logfile. Each entry contains at least a date, time, outgoing circuit and event type.

#### Options:

None	No logfile entry
coming	Entry when a message is coming
going	Entry when a message is going
coming/going	Entry when a message is coming or going

The configuration on the 'Relay/LED' parameter screen determines whether the messages are output to the SCADA.

### extra log on evaluation

#### Options:

Yes	An additional entry is made in the logfile when the direction of the earth fault changes
No	No additional entries are made

### Cyclical logfile entry

During an earth fault, the evaluations of the qui method are cyclically entered in the logfile according to the set time, making it a lot easier to reconstruct the fault.

### Time interval

Time interval for the cyclical entry of the evaluation using the qui method

### 11.5.3 Parameter

Parameter	Settings	Default setting
qui active	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	Off
Trigger threshold dUo	0 to 100% Unenn	15%
Ice Minimum current	0 to 200A	3A
Monitoring window	0 to 1000 ms	600 ms
Message extension	0 to 64800 s	15min
Reset input	0 to 255	None
Logfile entry	<ul style="list-style-type: none"> <li>▶ None</li> <li>▶ Coming</li> <li>▶ Going</li> <li>▶ Both</li> </ul>	Coming
extra log on evaluation	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul>	Always
cyclical logfile entry	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul>	No
Time interval	1 to 600 s	300 s

## 11.6 Harmonics screen

### 11.6.1 Functional description

The harmonics method enables the evaluation of the following frequencies in EOR-D:

Frequency	Application
50 Hz (fundamental frequency)	for isolated grids -> $\sin(\varphi)$ method
150 Hz (3rd harmonic)	isolated and compensated grid
250 Hz (5th harmonic)	
Free frequency (ripple-control frequency)	

When looking, for example, at the 5th harmonic, an earthed grid in approximation can be considered as an isolated grid because the P-coil's impedance increases by a factor 5 ( $X_{ESP} = \omega L_{ESP}$ ). This is why the reactive power method can be used to detect the earth fault or determine the direction. A disadvantage is that the 250 Hz zero sequence voltage does not have a value of 100%, but is subject to daytime load fluctuations. This can be avoided by injecting defined frequencies (e.g., ripple control system).

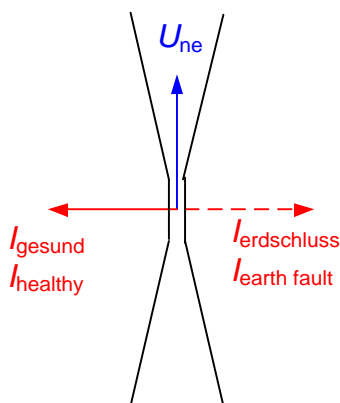


Fig. 52: Direction evaluation harmonics method (OV\_250,OV\_fx1)

## 11.6.2 Setting instructions

### ► Description of the parameters in the harmonics method

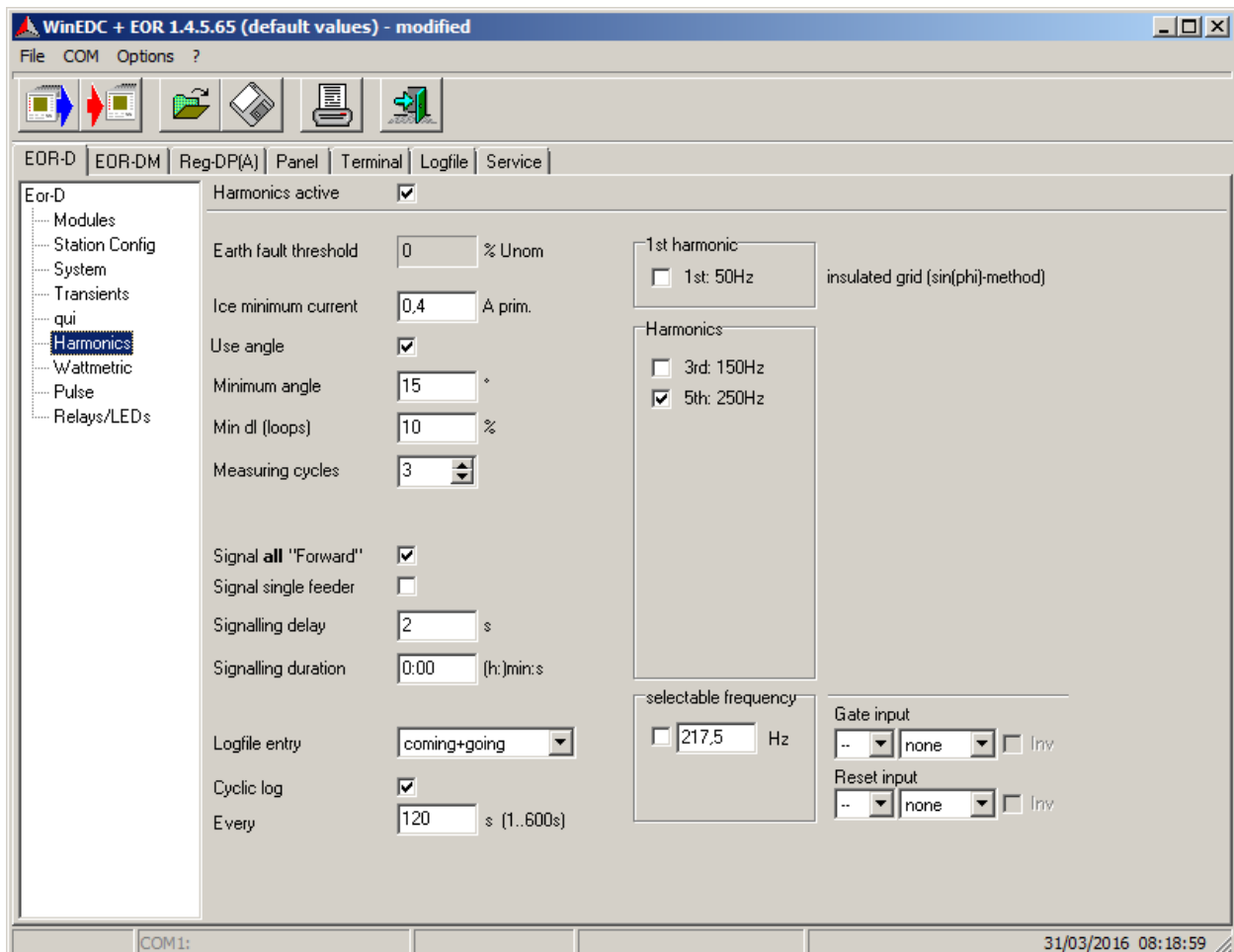


Fig. 53: Parameters in the harmonics method

#### Harmonics active

Activates the harmonics method

#### Earth fault threshold

Uniformly set on the System screen for all methods.

### Ice Minimum current

The minimum current suppresses a forward or backward indication caused by small currents that may have been created by interference. A minimum angle can also be defined. Currents that are within this defined range do not produce an indication.

The minimum current for 250 Hz can be estimated using the following equation:

$$I_{250} = I_{50} \frac{\omega_{250}}{\omega_{50}} \frac{U_{250}}{U_{50}} * \text{Earth fault threshold (in \%)}$$

Example:

$$I_{50} = 100 \text{ A}$$

$$\omega_{250} / \omega_{50} = 5$$

$$U_{250} = 2\%$$

Earth fault threshold: Default value = 30%

Used in equation (5.1) yields  $I_{250} = 100 \text{ A} * 5 * 0.02 * 0.3 = 3 \text{ A}$

### Use angle

If this function is enabled, the angle information is taken into account when determining the faulty outgoing circuit.

If this function is disabled, only the biggest harmonic current is used as selection criterion. This will result in faulty indications for configurations with only two outgoing circuits because the current flowing in the direction of the busbar will be approximately the same as that flowing in the faulty line. The angle information enables the faulty line to be distinguished from the healthy line even in a two-line configuration.

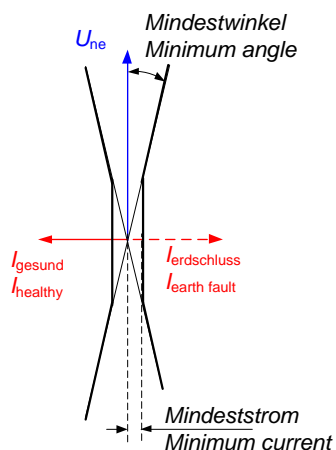


Fig. 54: Minimum current and minimum angle

### Minimum angle

In addition to the minimum current, a minimum angle can be parameterized to consider voltage transformer and current transformer angle errors.

### Minimum dl (rings)

When outgoing circuits are connected into rings, all of the outgoing circuits that are connected to the faulty outgoing circuit will indicate a forward direction in the event of an earth fault.



**Note:**

The parameters 'Signal all forward' and 'Use angle' must be enabled in this case

### Measurement cycles

In order to reduce the number of messages, at least the measurement cycles defined here must yield the same earth fault direction before an earth fault message is output.

### Signal all forward

- |           |  |
|-----------|--|
| active:   | For rings, all of the outgoing circuits to the faulty section are displayed.   |
| disabled: | For rings, only the outgoing circuit with the electrically shortest route to the faulty section is displayed. Of all of the forward directions, only the outgoing circuit is displayed on which the biggest current is measured. |

### Signal single feeder

In order to detect a forward-flowing current, a healthy grid is needed behind the EOR-D. But if only one outgoing circuit is available, the harmonic current cannot be measured. If this function is enabled, an earth fault message will also be output if the EOR-D only recognizes one outgoing circuit in the faulty group through the switching scheme or the grouping.



**Note:**

This parameter must be disabled when a secondary test is performed for the harmonics method with a feeder panel.

### Message delay

When an earth fault is detected, the message is not output until this delay has lapsed.

### Message extension

The evaluation of the zero sequence voltage and the residual currents are performed cyclically. Grid switchovers are therefore considered immediately, meaning that when the system switches over to a different outgoing circuit when an earth fault occurs, the faulty circuit is immediately indicated.

The earth fault indicator extinguishes as soon as the zero sequence voltage falls below the set limit value. This parameter extends the time the indicator for the faulty outgoing circuit displays.

### Logfile entry

This parameter determines which earth fault events are entered in the logfile. Each entry contains at least a date, time, outgoing circuit and event type.

#### Options:

None	No logfile entry
coming	Entry when a message is coming
going	Entry when a message is going
coming/going	Entry when a message is coming or going

The configuration on the 'Relay/LED' parameter screen determines whether the messages are output to the SCADA.



### Cycl entry

When an earth fault occurs, harmonic currents can be cyclically entered in the logfile. This provides an overview of the height of the harmonics on the grid and makes it a lot easier to reconstruct the fault.

### Time interval

Time interval for the cyclical entry of the harmonic currents in the logfile.

### Harmonics

This is where the frequencies to be monitored are defined. The fundamental frequency (50 Hz) can be used for isolated grids. This corresponds to the familiar zero reactive power directional relay or the  $\sin(\varphi)$  method for 50 Hz.

### Gate input

A ripple control signal can also be used to create the harmonic voltage. The ripple control system is usually switched on only for a few seconds during an earth fault. The location of the earth fault is detected during this 'enabling' (gate). All of the forward and backward directions that were detected at this time are saved after this 'enabling'. How long the data are stored depends on the Message extension and Reset input parameters.

The frequency of the ripple control system is entered in the field below 'Harmonics' Example 275 Hz

The 'enabling' impulse can come through a binary input on the EOR-D or through the SCADA system. The input level can also be inverted. The following parameters can be set:

- EOR-D ID
- Binary input
- Inversion

### Reset input

The messages that were saved by the gate input are reset here. The output circuits' zero sequence voltage and residual currents are cyclically evaluated and indicated again. The system can be reset at any time through a binary input or the SCADA system.



#### Note:

If an EOR-D ID is not entered for the gate input or reset input parameters, there are 255 virtual binary inputs the user can use. Virtual binary inputs are either set by a background program or a SCADA protocol.

### 11.6.3 Parameters

Parameter	Settings	Default setting
Harmonics active	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	Off
Ice Minimum current	0 to 100A	0.4A
Use angle	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	Yes
Minimum angle	0° to 90°	15°
Minimum dI (rings)	0 to 100%	10%
Measurement cycles	0 to 100	3
Signal all forward	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul>	Yes
Signal single feeder	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul>	No
Signal delay	1 to 60 s	2 s
Message extension	0 to 10800 s	0 s
Fundamental frequency	▶ 50Hz	disabled
Harmonics	<ul style="list-style-type: none"> <li>▶ 150Hz</li> <li>▶ 250Hz</li> </ul>	250Hz
Free frequency	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul> 50 to 2500 Hz	No  217.5 Hz
Gate input	0 to 255	None
Reset input	0 to 255	None

Parameter	Settings	Default setting
Logfile entry	<ul style="list-style-type: none"> <li>▶ None</li> <li>▶ Coming</li> <li>▶ Going</li> <li>▶ Both</li> </ul>	Both
cyclical entry	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul>	Yes
Time interval	1 to 600 s	120 s

## 11.7 Wattmetric screen

### 11.7.1 Functional description

The  $\cos(\phi)$  method projects the measured total current  $I_0$  to the zero sequence voltage  $U_0$ . The active component is then calculated from the total current. The direction of the active current is determining for the earth fault message in forward or backward direction.

When using this method, it is also important that the measured sizes  $I_0$  and  $U_0$  are accurately measured. The accuracy of the angle of the current transformer and the voltage transformer are of particular importance.

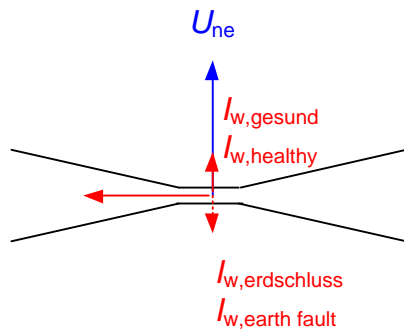


Fig. 55: *Direction evaluation  $\cos(\phi)$  method*

## 11.7.2 Setting instructions

### ► Description of the parameters in the cos(phi) method

The screenshot shows the WinEDC software interface for configuring the EOR-D module. The 'Wattmetric' option is selected in the left-hand menu. The main window displays various configuration parameters for the Wattmetric active method.

**Wattmetric active:** ☐

**Earth fault threshold:** 30 % Unom

**Copy 1st->all:** ☐ ☐

Minimum current primary,	minimum angle
E1:1 1 A 15 °	
E1:2 1 A 15 °	
E1:3 1 A 15 °	
E1:4 1 A 15 °	

**Min dl (loops):** 10 %

**Measuring cycles:** 3

**Retain 1st signal:** ☐

**Reset input:** -- none ☐ Inv

**All "Forward":** ☒

**Signalling delay:** 1 s

**Signalling duration:** 0:00 (h:min:s)

**Wattm. outweighs Harm.:** -- none ☐ Inv

**Logfile entry:** coming+going

**Cyclic log:** ☐

**Every:** 60 s

**Wattmetric Increase:**

**Gate time:** 5 s



**Gate input:** -- none ☐ Inv

**Message duration:** 0:30 (h:min:s)

**Reset input:** -- none ☐ Inv

The status bar at the bottom right shows the date and time: 31/03/2016 08:28:31.

Fig. 56: Parameters cos(phi) method

Cos(phi) active	
Activates the cos(phi) method	
Earth fault threshold	
Uniformly set on the System screen for all methods.	
Minimum current primary and minimum angle	
Minimum current primary	Minimum angle
<p>The minimum resistive component of the total current can be set separately for each outgoing circuit.</p> <p>Minimum resistive component of the total current in the outgoing circuit. The following formula is used to estimate the operate value:</p> <p>Rule of thumb:  <math display="block">I_{w,min} = 0.25 \cdot 0.03 \cdot I_{CE,Netz}</math> </p> <p>The entire active component for the grid can then be estimated with 3% of <math>I_{CE,Netz}</math> or, for example, read directly from the P-coil. The operate value is then obtained by multiplying it by a safety factor (fA=25%).</p>	<p>The minimum angle of the total current compared with a pure capacitive current (= 90° compared with Uen) can be set separately for each outgoing circuit.</p> <p>If an accurate cable type current transformer is used, the angle error for this transformer can be entered. Class 1 transformers with an angle accuracy of 120" are recommended. If they are used, the minimum angle can be set to 2°.</p>
<div>  <b>Note:</b> Use the '=' buttons to set all of the fields to the same value by copying the values in the first row to the other fields.         </div>	
Minimum dl	
<p>When outgoing circuits are connected into rings, all of the outgoing circuits that are connected to the faulty outgoing circuit will show a forward direction in the event of an earth fault.</p> <p>If the error is somewhere between two outgoing circuits, the indicator for the biggest residual current can oscillate. This oscillating indicator is suppressed by the 'Minimum dl' hysteresis.</p>	
<div>  <b>Note:</b> The parameter 'all forward' must be enabled in this case.         </div>	

### Measurement cycles

In order to reduce the number of messages for intermittent earth faults, at least the measurement cycles defined here must indicate the same earth fault direction before an earth fault message is output.

### Keep 1st message

- ▶ **active:**  
If an earth fault switches over to other outgoing circuits without interrupting the earth fault (through switching operations), the outgoing circuits that are no longer faulty will continue to display. The message will continue to display until they are reset by the gate input or until the earth fault is extinguished.
- ▶ **disabled:**  
Only the currently fault outgoing circuits are displayed.

### Reset input

The messages saved by 'Keep 1st message' can be reset. The system can be reset through a binary input or the SCADA system.

Signal level =1 deletes all wattmetric messages. The current messages aren't reset until signal level = 0.

### all forward

- ▶ **active:**  
For rings, all of the outgoing circuits to the faulty section are displayed.
- ▶ **disabled:**  
For rings, only the outgoing circuit with the electrically shortest route to the faulty section is displayed. Of all of the forward directions, only the outgoing circuit with the biggest active current is displayed. This parameter setting can result in faulty indications if the route to the fault through a healthy line is electrically shorter.

### Message delay

When an earth fault is detected, the detected outgoing circuit is not displayed until this delay has lapsed.

### Message extension

The wattmetric earth fault message is automatically reset after the set time. If a different detection method is already active, the system switches over to it.

#### Wattm trumps harm

A binary input is used to change the priority of the indication. The harmonics method is usually displayed so long as the minimum current is exceeded. The binary input selected here switches from the harmonics method to the wattmetric method independently of the current minimum current.

#### Logfile entry

This parameter determines which earth fault events are entered in the logfile. Each entry contains at least a date, time, outgoing circuit and event type.

Options:

None	No logfile entry
coming	Entry when a message is coming
going	Entry when a message is going
coming/going	Entry when a message is coming or going

The configuration on the 'Relay/LED' parameter screen determines whether the messages are output to the SCADA.

#### Cycl entry

When an earth fault occurs, the residual currents can be cyclically entered in the logfile.

#### Time interval

Time interval for the cyclical entry of the residual currents in the logfile.

### 11.7.2.1 Residual current increase

A residual current increase can be used to improve the indication of the wattmetric method. An 'enabling' (gate) input is used to tell the EOR-D when the residual current increase is active. The rising edge of the 'enabling' signal opens a measurement window. The current measurement results are saved when the measurement is completed.

#### Measurement window

Length of the measurement window for a residual current increase.



### Gate input

The location of the earth fault is detected during this 'enabling' (gate). All of the forward and backward directions that were detected at this time are saved and output at the end of this 'enabling'.

The 'enabling' impulse can be initiated through a binary input or the SCADA system. Only the rising edge of the impulse is evaluated. The input level can also be inverted, which is why the following parameters can be set:

- EOR-D ID
- Binary input
- Inversion

### Message extension

The wattmetric earth fault message is automatically reset after the set time. If a different detection method is already active, the system switches over to it.

### Reset input

The messages that were saved by the gate input are reset here. The wattmetric method then resumes its normal cyclical evaluation and indication. The reset input parameter is triggered by a binary input or the SCADA system.



**Note:**

If an EOR-D ID is not entered for the reset input parameter, there are 255 virtual binary inputs the user can use. Virtual binary inputs are either set by a background program or a SCADA protocol.

### 11.7.3 Parameters

Parameter	Settings	Default setting
Wattmetric active	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	Off
Minimum current	0 to 100A	1A
Minimum angle	0° to 90°	0°
Minimum dI (rings)	0 to 100%	10%
Measurement cycles	1 to 100	3
Keep 1st message	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul>	No
Reset input	0 to 255	None
Signal all forward	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul>	Yes
Message delay	0 to 60 s	2 s
Message extension	0 to 10800 s	0 s
Wattm trumps harm	0 to 255	None
Logfile entry	<ul style="list-style-type: none"> <li>▶ None</li> <li>▶ Coming</li> <li>▶ Going</li> <li>▶ Both</li> </ul>	Both
cyclical entry	<ul style="list-style-type: none"> <li>▶ No</li> <li>▶ Yes</li> </ul>	Yes
Time interval	1 to 600 s	120 s

### 11.7.3.1 Watt residual current increase

Parameter	Settings	Default setting
Measurement window	0 to 300 s	5 s
Gate input	0 to 255	None
Message extension	0 to 10800 s	15 s
Reset input	0 to 255	None

## 11.8 Pulse detection screen

### 11.8.1 Functional description

A clock system, which is normally connected to the P-coil's power auxiliary winding, creates a pulsating current that can be measured all the way to the faulty section. By toggling capacitors, there is a current change towards full compensation. In this way, the total current at the faulty output is reduced and increased at the fault-free outputs.

Pulse detection consists of switching on a capacitor with a frequency of ca. 0.5Hz at a neutral point. This detuning changes the residual current across the neutral point. For low impedance faults, this current can only flow across the faulty section. The voltage on the healthy line-to-earth remains constant, which is why the capacitive currents in the healthy outgoing circuits remain constant. This is why changing the residual current in a 0.5 Hz rhythm can only be measured at the faulty outgoing circuit.

High impedance earth faults create a link to the healthy outgoing circuits. The change in current across the fault section caused by impedance  $Z_f$  changes the zero sequence voltage  $U_{0e}$  and hence the voltage on the healthy line to earth. This also results in a change in the capacitive current in the healthy line to earth. As a result of this correlation, the faulty and the healthy lines cannot be distinguished in the event of symmetrical clocking and high impedance earth faults.

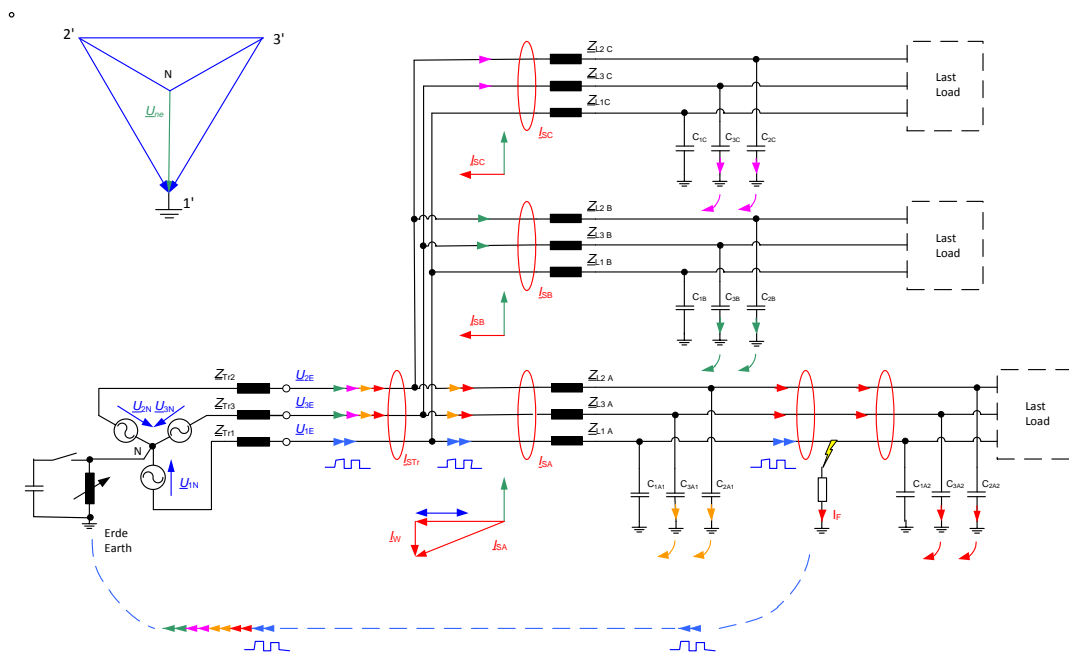


Fig. 57: Pulse locating principle

Help is provided by asymmetric pulsing. In this type of pulsing, the capacitor is switched on for 1 second and off for 1.5 seconds (pulse interval ratio 1:1.5). This pattern can be repeated as often as necessary. It can easily be shown that with over-compensation the resulting current changes in the fault-free output are the inverse of the change in the faulty output. Consequently, even for high-resistance transition resistances in the faulty conductor, a criterion for differentiating between the faulty and fault-free conductors exists.

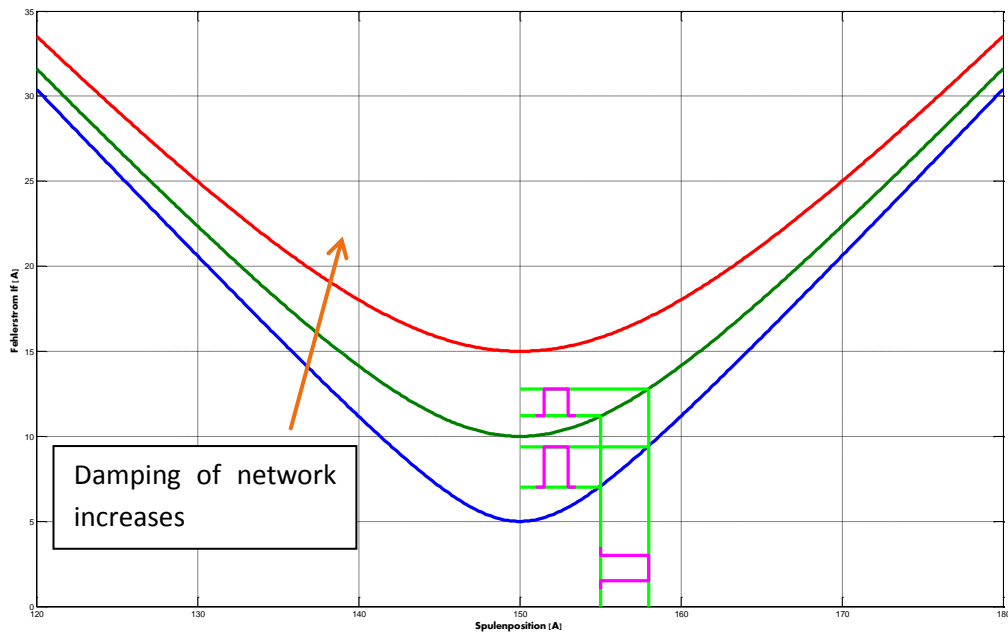


Fig. 58: Timing pulse with different attenuation  $\triangleq I_w$

**Fehler! Verweisquelle konnte nicht gefunden werden.**clarifies again the influence of attenuation on the transferred pulse current. As the damping increases (V curve is flatter) the transferred pulse decreases. This is why suitable detuning must be selected when pulse detection is used.

► Description of the parameters in the pulse detection method

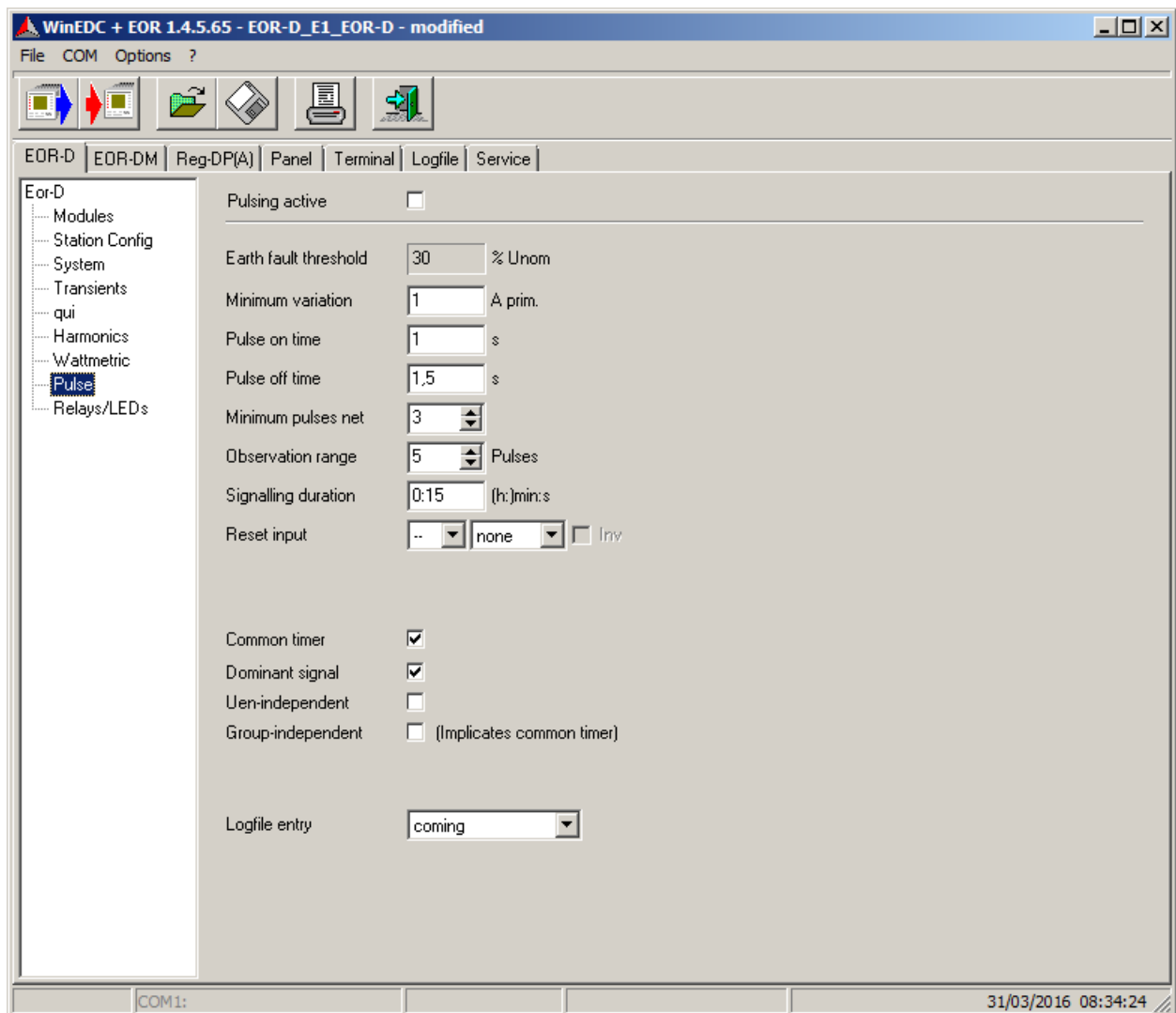


Fig. 59: Pulse detection parameters

## 11.8.2 Setting instructions

### Pulse detection active

Activates the pulse detection method.

### Earth fault threshold

Uniformly set on the System screen for all methods.

### Minimum variation

This parameter sets the minimum current change in the pulse pattern required for detection.



#### Note:

This value is produced during earth fault engineering work. As part of the work, the clock pulses must be adapted to the size of the grid.

### Pulse on time

Switch-on time for the detuning capacitor.

### Pulse off time

The clock's off time. The capacitor is switched off during this time.

### Minimum pulses net

Number of impulses that must be recognized as 'correct' in the observation range.

### Observation range

The device searches for the pulse pattern in the last few seconds (moving observation range).

Length of the observation range =  $n * (\text{switch-on time} + \text{switch-off time})$  in [s]

At the same time, the observation range determines the minimum number of impulses that must be sent by the clock.

### Message extension

The earth fault messages are output as soon as enough impulses have been recognized as 'correct' in the observation range. The message is held after pulsing (insufficient clocking visible in the observation range) until the automatic reset time has lapsed.

The messages are also saved when the zero sequence voltage is already smaller than the earth fault threshold.

### Reset input

The messages can be reset early through a binary input or the SCADA system (virtual input).

### Common timer

The automatic reset of the pulse detection messages for all groups is triggered by a common timer.

▶ **active:**

All of the groups work with the same timer, meaning that all of the pulse detection messages are deleted at the same time (when the reset time has also lapsed for the last group).

▶ **disabled:**

Each group works with its own timer. For time-staggered earth faults in separate groups, this means that the messages are set in succession and deleted after the respective reset time.

### Dominant signal

When this parameter is enabled, pulse detection overwrites the other detection methods. In this case, all of the detection messages from all of the groups in this system are reset and only the result of the pulse detection is output. In this case, it makes sense to enable the common timer.

### Uen-independent

A message is generated even if the earth fault threshold has not yet been exceeded or without having to measure the zero sequence voltage from the EOR-D (depth detection in substations).

### Group-independent

Each message is output even if groups could not be created.

### Logfile entry

This parameter determines which earth fault events are entered in the logfile. Each entry contains at least a date, time, outgoing circuit and event type.

Options:

None	No logfile entry
coming	Entry when a message is coming
going	Entry when a message is going
coming/going	Entry when a message is coming or going

The configuration on the 'Relay/LED' parameter screen determines whether the messages are output to the SCADA.



### 11.8.3 Parameter

Parameter	Settings	Default setting
Pulse detection active	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	Off
Minimum variation	0 to 10A	1A
Pulse on time	0 to 10 s	1 s
Pulse off time	0 to 10 s	1.5 s
Minimum pulses net	2 to 10	3
Observation range	2 to 10	5
Signal extension	0 to 10800 s	15 s
Reset input	0 to 255	None
common timer	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	Yes
Dominant signal	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	Yes
Uen-independent	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	No
Group-independent	<ul style="list-style-type: none"> <li>▶ Yes</li> <li>▶ No</li> </ul>	No
Logfile entry	<ul style="list-style-type: none"> <li>▶ None</li> <li>▶ Coming</li> <li>▶ Going</li> <li>▶ Both</li> </ul>	Both

## 11.9 Relays/LEDs screen

The messages that are sent to the LEDs and relays that are available to each of the EOR-Ds are configured on the 'Relays/LEDs' screen.

Comment: If the EOR-D units are operated with additional interface components (e.g., BIN-D), the additional inputs/outputs can only be addressed through the background program.

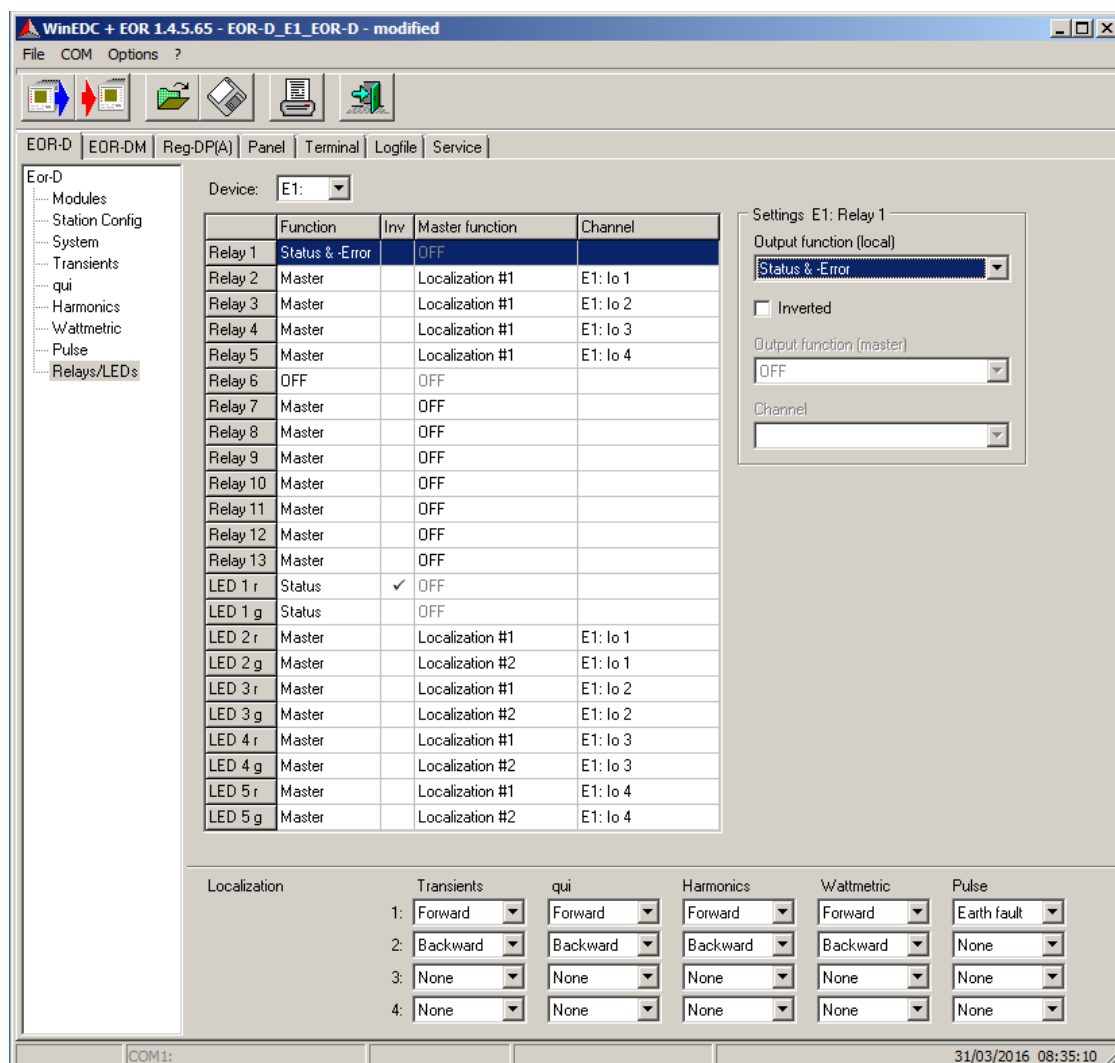


Fig. 60: Relay and LED configuration

## Device

The devices that are configured in the switching scheme can be selected from the device list.

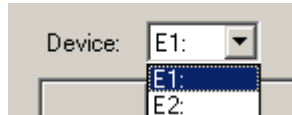


Fig. 61: Select device

Each EOR-D has a maximum of 13 relays (older devices only have 5), as well as 5 bicolour LEDs. Which relay is really available depends on how the EOR-D is wired to the terminal strips of the module rack or housing

Different signals can be assigned to each relay and LED colour.

The detection result can be output in the form of four collective messages, which can be allocated to each relay and/or LED.

The messages from the different earth fault detection methods are linked by an OR statement.

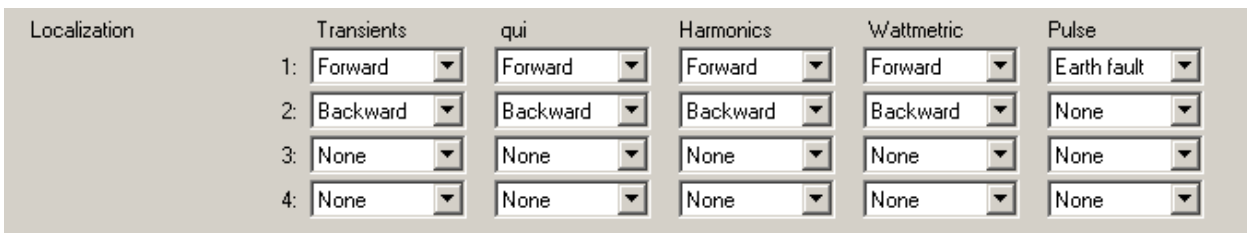


Fig. 62: Detection message configuration

The following options are available for each of the detection methods:

Method		Function
Transient (qu2)	Off	None
	Forward	only forward messages
	Backward	only backward messages
	Both	Forward and backward messages are linked
qui	Off	None
	Forward	only forward messages
	Backward	only backward messages
	Both	Forward and backward messages are linked
Harmonics	Off	None
	Forward	only forward messages
	Backward	only backward messages
	Both	Forward and backward messages are linked
Wattmetric	Off	None
	Forward	only forward messages
	Backward	only backward messages
	Both	Forward and backward messages are linked
Pulse detection	Off	
	Earth fault	Earth fault is behind the measuring point

Other output functions can be allocated to each of the relays or LEDs. The current settings for the relays/LEDs are displayed in the table.

The four edit fields in the top right are used to allocate a function to a relay or LED.

Relay	Function	Inv	Master function	Channel
Relay 1	Status & -Error	OFF		
Relay 2	Master		Localization #1	E1: Io 1
Relay 3	Master		Localization #1	E1: Io 2
Relay 4	Master		Localization #1	E1: Io 3
Relay 5	Master		Localization #1	E1: Io 4
Relay 6	Master		Harmonic forward	E2: Io 1
Relay 7	Master		OFF	
Relay 8	Master		OFF	
Relay 9	Master		OFF	

Settings E1: Relay 6

Output function (local)  
Master

☐ Inverted

Output function (master)  
Harmonic forward

Channel  
E2: Io 1

Fig. 63: Relay configuration

## Settings:

### 11.9.1 Output function (local):

Output function	Description
Off	Relay is not used
Prog	Relay is activated by a background program
Master	Output function on the master determines the state of the relay
Status	Status message on the EOR-D Status messages are only internal CPU errors, they are not EORSys failures
Failure	A detected failure is output through the relay
Status and failure	OR link for status and no error message Monitoring of all of the EOR-Ds specified in the parameter (incl slaves) The relay status can be used as OR link
E-LAN left	Communication over E-LAN left
E-LAN right	Communication over E-LAN left
E-LAN Error	Communication error on the E-LAN
Master lost	No connection over E-LAN to master
Error on master	Error on master, detection not possible!
Slave lost	No connection over E-LAN to slave
Transient Io1 forward	Fast direct transient message (qu2) on local module
Transient Io2 forward	Fast direct transient message (qu2) on local module
Transient Io3 forward	Fast direct transient message (qu2) on local module
Transient Io4 forward	Fast direct transient message (qu2) on local module
Transient Io1 backward	Fast direct transient message (qu2) on local module
Transient Io2 backward	Fast direct transient message (qu2) on local module
Transient Io3 backward	Fast direct transient message (qu2) on local module
Transient Io4 backward	Fast direct transient message (qu2) on local module

#### ► Inverse:

The message is output inverted.

## 11.9.2 Master output functions:

The detection algorithms are performed in the master and its output functions designated as master output functions. The below table lists the master output functions.




**Note:**

Because data for the master output functions have to be requested from the slaves over the ELAN, are then evaluated centrally in the master device and sent back to the slaves to be output, there is always a minimum time delay of 1 to 2 s. The more slaves, the higher the time delay.

Output function	Description
Off	No message
Transient forward	Transient earth fault message forward
Transient backward	Transient earth fault message backward
Harmonics Forward	Harmonics message forward
Harmonics Backward	Harmonics message backward
Pulse detection forward	Pulse detection message
Wattmetric Forward	cos(phi) message forward
Wattmetric Backward	cos(phi) message backward
Detection message 1	User-defined detection message 1
Detection message 2	User-defined detection message 2
Detection message 3	User-defined detection message 3
Detection message 4	User-defined detection message 4
Earth fault message	General earth fault message
Transient message	Collective message from the transient method (All outgoing circuits forward and backward)
Harmonics message	Collective message from the harmonics method (All outgoing circuits forward and backward)
Pulse detection message	Collective message pulse detection (All outgoing circuits)
Wattmetr message	Collective message from the cos(phi) method (All outgoing circuits forward and backward)
qui message:	Collective message from the qui method (All outgoing circuits forward and backward)
qui forward	Intermittent earth fault forward
qui backward	Intermittent earth fault backward

**Channel:**

The Channel column determines the outgoing circuit from which the defined detection message is output.

Channel	Description
<ul style="list-style-type: none"> <li>Io1</li> <li>Io2</li> <li>Io3</li> <li>Io4</li> </ul>	Selection of the outgoing circuit for the respective message  <b>Note:</b> Only available for targeted messages
<ul style="list-style-type: none"> <li>Collective message</li> </ul>	General collective message from the respective method
<ul style="list-style-type: none"> <li>Busbar 1</li> <li>Busbar 2</li> <li>Busbar 3</li> </ul>	Collective message from affected busbar
<ul style="list-style-type: none"> <li>Group 1</li> <li>Group 2</li> <li>Group 3</li> <li>Group 4</li> </ul>	Groups 1 to 4 are each allocated to a zero sequence voltage. A group message is generated for a group when an earth fault occurs in one of its outgoing circuits.
<ul style="list-style-type: none"> <li>Master U1</li> <li>Master U2</li> <li>Master U3</li> <li>Master U4</li> </ul>	A master message is generated as soon as the zero sequence voltage reaches its threshold on voltage channel U1 to U.

#### Examples for the parameterization of the relay in master E1

	Function	Inv	Master function	Io	Description
Relay 1	Status				Status message from device E1:
Relay 2	Master		Transient forward	E1:Io1	The earth fault message of a transient algorithm in forward direction on relay 2 of device E1: is output to EOR-D E1: channel 1.
Relay 3	Master		Harmonics Forward	E2:Io1	The earth fault message of the harmonics algorithm in forward direction on relay 3 of device E1: is output to EOR-D E1: channel 1.

**Note:** An earth fault that is detected on outgoing circuit 1 of EOR-D E2: can be output device-wide to any relay or LED on another EOR-D.

## 12. Logbook

The following events are recorded in the master EOR-D:

- Configuration changes (in addition every 24 h)
- Changes to outgoing circuit groups (in addition every 24 h)
- Earth fault messages
- All messages from the detection methods with additional information
- Binary input functions
- Setting of the real-time clock
- Operation interruptions/resets
- Error messages
- Up to four configurable voltages with harmonics (hourly)

WinEDC can read out, display, archive and export the logfile in a different format:

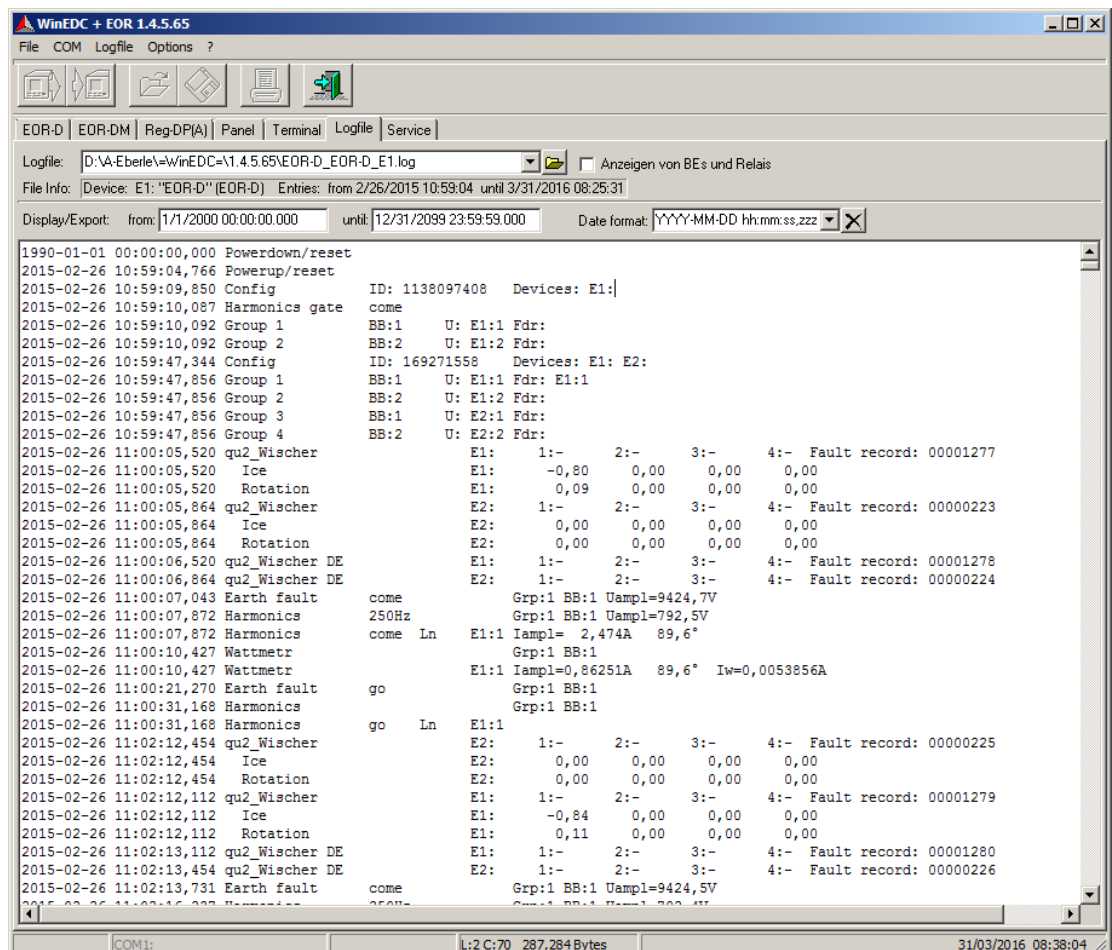


Fig. 64: Logfile EOR-D



## 12.1 Logfile events

### Reset

The 'Reset' event is displayed as two events: 'End operation' (PowerDown) and 'Restart operation' (PowerUp).

2015-12-01 09:03:59,806 PowerDown/Reset

2015-12-01 09:04:09,578 PowerUp/Reset

### Configuration change

The 'Config' event is recorded every time the configuration of the device changes and in addition every 24 h. The Config ID enables you to immediately recognize a parameter change. The list of all of the system's devices is also displayed.

2015-12-01 08:58:23,226 Config ID: 1949468442 Devices: E1:

### Grid change

The following is displayed for each group:

- The busbars that are connected to the group's outgoing circuits providing that the information is available
- The voltage input that is used to monitor the earth fault for this group
- The list of current inputs (=outgoing circuits) that belong to the group

When groups are created through Uen, the outgoing circuits that belong together can only be determined for a continuous earth fault which is why 'Groups (empty)' is usually displayed here

The 'Grid change' event is recorded every time the grid topology changes and in addition every 24 h.

2015-09-02 13:34:45,441 Group 1 BB:1 U: E1:1 Outg: E1:2 E2:2 E2:3 E2:4 E3:1  
 2015-09-02 13:34:45,441 Group 2 BB:2 U: E1:2 Outg: E1:1 E1:3 E1:4 E2:1

### Earth fault coming/going

The affected group(s), busbar(s) and zero sequence voltage are displayed in the logfile. Uampl is the measured zero sequence voltage at the time that the earth fault is detected and can deviate from the steady-state measurements.

2015-11-30 12:56:09,386 Earth fault coming Grp:1 BB:1 Uampl=8159,1V  
 2015-11-30 12:56:52,738 Earth fault going Grp:1 BB:1

### Transient detection message

The direction message and the number of the error log that recorded the transient is entered for each outgoing circuit.

2015-09-02 13:36:03,825 Transient going Ltg E2:4  
 2015-09-02 13:36:16,508 Transient coming Ltg E2:4 error log: 00000016

### Transient evaluation message

The event shows an error entry trigger on the respective device. The device ID, evaluation results, direction information and the error log number are displayed

2015-04-15 11:40:59,634 qu2\_transient E1: 1:L 2:- 3:- 4:- Error entry: 04202859

2015-04-15 11:40:59,634 Ice E1: -24.43 0.00 0.00 0.00

2015-04-15 11:40:59,634 Rotation E1: -4.29 0.00 0.00 0.00

### Harmonics detection message

The first row displays the frequency of the affected groups and busbars that was used for the evaluation as well as the voltage amplitude for the evaluated frequency.

The direction message (if available) is also displayed for each of the group's outgoing circuits as well as the current amplitude and the angle of the evaluated frequency.

2015-12-01 09:59:45,290 Harmonics 250 Hz Grp:1 BB:1 Uampl=325,6V

2015-12-01 09:59:45,290 Harmonics coming Ltg E1:1 Iampl= 7,034A 90.8°

2015-12-01 09:59:48,422 Harmonics going Ltg E1:1

### Wattmetric detection message

The first row displays the affected groups and busbars.

The direction message (if available) is also displayed for each of the group's outgoing circuits as well as the current amplitude and the angle of the fundamental frequency.

2015-04-08 10:32:53,620 Wattmetr Grp:1 SS:1,2

2015-04-08 10:32:53,620 Wattmetr coming BB E1:1 Iampl=70,606A -0,1° Iw=70,606A

2015-04-08 10:32:53,620 Wattmetr coming Ltg E1:2 Iampl=70,683A 179,8° Iw=-70,682A

2015-04-08 10:35:31,260 Wattmetr going BB E1:1

2015-04-08 10:35:31,260 Wattmetr going Ltg E1:2

### Pulse detection message

The message 'coming' and the current amplitude and angle of the fundamental frequency are displayed for each outgoing circuit.

2015-12-01 12:09:36,227 Pulse detection coming E1:1 Iampl50= 8,177A -0,8°

### Transient reset

Reset input for the transient method


2015-12-01 12:16:59,589 Transient Reset coming

2015-12-01 12:17:02,539 Transient Reset going

<b>Harmonics reset</b>		
Reset input for the harmonics method		
2015-12-01 12:16:59,159	Harmonics Gate	coming
2015-12-01 12:17:02,193	Harmonics Reset	going
<b>Harmonics gate input</b>		
Gate input for the harmonics method (free frequency)		
2015-12-01 12:16:59,159	Harmonics Gate	coming
2015-12-01 12:17:02,193	Harmonics Gate	going
<b>Wattmetric reset</b>		
Reset input for the wattmetric method		
2015-12-01 12:16:59,160	Wattm Reset	coming
2015-12-01 12:17:02,193	Wattm Reset	going
<b>Wattmetric trumps harmonics</b>		
Priority input for the wattmetric method		
2015-12-01 12:16:59,161	Wattm Priority	coming
2015-12-01 12:17:02,193	Wattm Priority	going
<b>Trigger residual current increase</b>		
Gate input for the residual current increase		
2015-12-01 12:16:59,161	Residual curr Rst	coming
2015-12-01 12:17:02,195	Residual curr Rst	going
<b>Reset residual current increase</b>		
Reset input for the message extension for the residual current increase		
2015-12-01 12:16:59,161	Residual curr Rst	coming
2015-12-01 12:17:02,195	Residual curr Rst	going
<b>Reset pulse detection</b>		
Reset input for the pulse detection method		
2015-12-01 12:09:45,210	Pulse detect Reset	coming
2015-12-01 12:09:49,777	Pulse detect Reset	going

## 12.1.1 Error messages

Status errors	
Internal errors are reported as status errors. The error type is displayed in the logfile as a hex-coded number behind the status error.	
ErrStat-01: Selftest error	0000 0001
ErrStat-02: ROM error	0000 0002
ErrStat-03: RAM error	0000 0004
ErrStat-04: EEPROM-A error	0000 0008
ErrStat-05: EEPROM-B error	0000 0010
ErrStat-06: User error A	0000 0020
ErrStat-07:	0000 0040
ErrStat-08: Internal batt error	0000 0080
ErrStat-09:	0000 0100
ErrStat-10:	0000 0200
ErrStat-11: Uv outage	0000 0400
ErrStat-12:	0000 0800
ErrStat-13:	0000 1000
ErrStat-14: COM1 Comm error	0000 2000
ErrStat-15: COM2 Comm error	0000 4000
ErrStat-16: COM3 Comm error	0000 8000
ErrStat-17: LAN Comm error	0001 0000
ErrStat-18:	0002 0000
ErrStat-19:	0004 0000
ErrStat-20:	0008 0000
ErrStat-21: LAN/L error	0010 0000

ErrStat-22: LAN/R error	0020 0000
ErrStat-23: LON error	0040 0000
ErrStat-24:	0080 0000
ErrStat-25:	0100 0000
ErrStat-26:	0200 0000
ErrStat-27:	0400 0000
ErrStat-28:	0800 0000
ErrStat-29: Batt almost spent	1000 0000
ErrStat-30:	2000 0000
ErrStat-31:	4000 0000
ErrStat-32:	8000 0000
2015-12-01 13:04:34,376 Status error	coming 00000020
2015-12-01 13:04:37,065 Status error	going
<b>Slave error</b>	
The error message 'Slave missing' is triggered when the master is no longer able to communicate with one or more slaves.	
<div>  <b>Note:</b> Please note: The master is a function, not a device. In the device with the master ID, both the master and the slave functions are active, meaning that 'Slave missing' can be displayed with the master ID.         </div>	
2015-02-24 17:06:37,630 Slave missing	coming E2:
2015-02-24 17:42:24,625 Slave missing	coming E2:

## Master error

The error message 'Master missing' is triggered when the slave has not heard from its master for more than 10 s.



### Note:

Please note: The master is a function, not a device. In the device with the master ID, both the master and the slave functions are active, meaning that 'Master missing' can be displayed with the master ID.

2015-02-25 15:17:12,414 Master missing coming

2015-02-25 15:17:14,207 Master missing going

## Configuration error

The error message 'Config error' is triggered when the master cannot find all of the configured slaves after it has been booted or reconfigured. The list of missing slaves is displayed.

After a configuration error, the master will attempt to find all of the slaves every 3 min.



### Note:

Detection does not work until the configuration message has been cleared.

2015-12-02 07:48:20,433 Config error coming E2:

2015-12-02 07:51:20,049 Config error going

## E-LAN errors

These error messages are generated when communication between the devices is no longer possible.

- 00010000 : E-LAN communication error in background program, e.g., addressed ID is not present.
- 00100000 : E-LAN error left, physical (hardware) error on E-LAN left, e.g., missing line, missing termination resistors, address collision (double ID)
- 00200000 : E-LAN error right

2014-10-23 16:39:47,206 E-LAN error coming 00200000

2014-10-23 16:42:53,675 E-LAN error going

## 12.2 Menu items under logfile:

### Font...

sets the font for the text field, e.g., in the terminal window. We recommend choosing a monospaced font because the tables will not display properly otherwise.

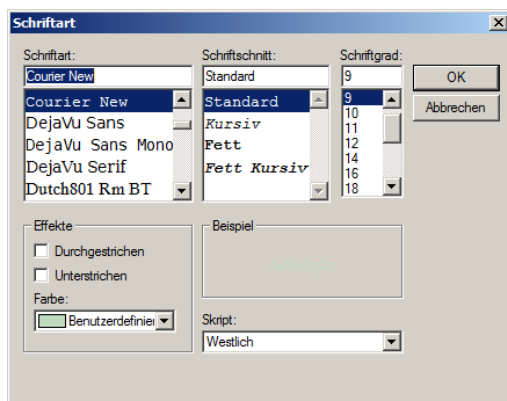
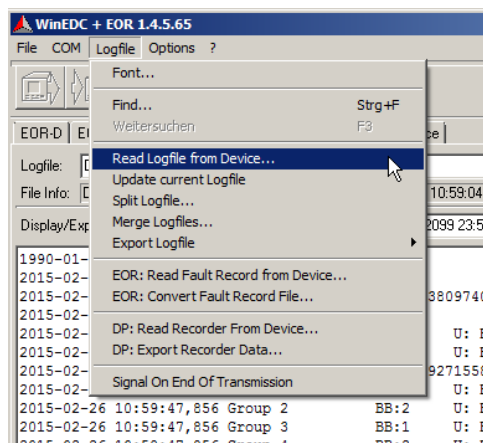


Fig. 65: Logfile fonts

### 12.2.1 Get logfile from device...

Gets the **logfile** from the device and adds it to the current logfile. The device has a circular buffer of 1280 records. If the previous last record



in the file on the device was already overwritten, there will be a gap in the recording.

Fig. 66: Get logfile

A dialogue field displays on the device. The device to which the current logfile belongs is suggested. If a logfile is not open, a logfile whose name is generated from the device name, ID and type is suggested. It is also possible to give the file a user-defined name. If the selected file and the selected device do not match, the program generates a warning.



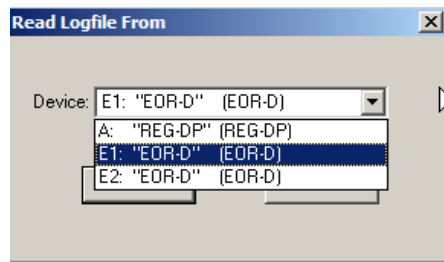


Fig. 67: Select device



CAUTION

### Caution!

Ignoring the warning can result in data loss!

The warning may have to be ignored if the name or ID of the device has changed.

## 12.2.2 EOR: Get error log...

Gets a **set of sampling values** from the device. Each device has space for the last two transient events. The error logs are identified by an ID that is stored in the logfile together with the transient event.

A dialogue box for the selection of the device and error log is displayed as well as a field to enter the name under which the error log is to be stored.

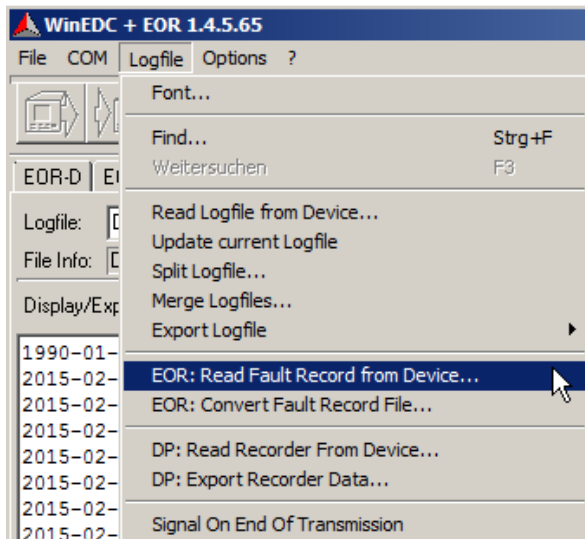


Fig. 68: Get error log

- 1) Select device
- 2) Select available error logs on the EOR-D device
- 3) Not used for the EOR-D
- 4) Select target directory
- 5) All of the error logs on the device (master and slave(s)) are loaded
- 6) Error logs that are already in the target directory are not overwritten

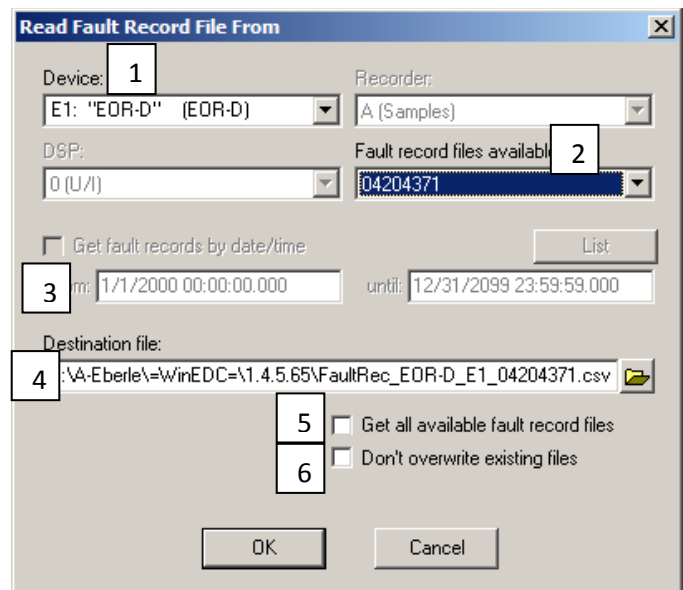


Fig. 69: Select error log

The error logs that are read out of the EOR-D are stored as Comtrade and cs files. The csv files can be opened in Excel and displayed as a diagram. The sampling values are stored as integers in V or A.

### 12.2.3 EOR: Convert error log

A csv file can be converted to a comtrade file.

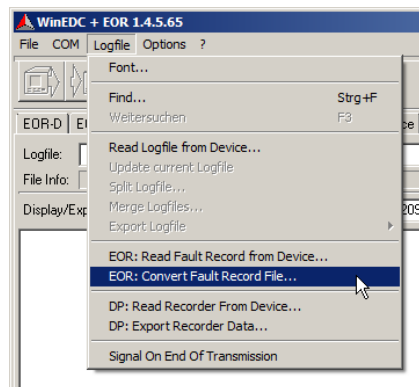


Fig. 70: Convert error log

## 12.2.4 Split logfile...

The logfile is split into two files. The program guarantees data consistency. A dialogue box displays in which the separation points and the new file name are entered.

The system suggests an overlap of 5 records between the two files, meaning that the last 5 records in the 'old' file (the original file that is being split) are the same as the first 5 records in the 'new' file (the second file that contains the datasets that were originally in the 'old' file).

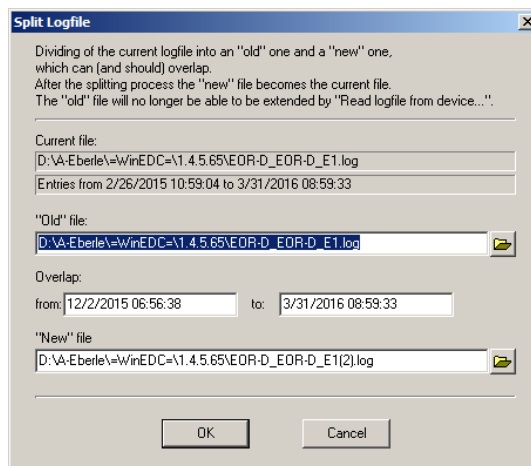


Fig. 71: Split logfile

## 12.2.5 Export logfile

- >Text

Saves the full contents of the text window to a new file.

- >CSV (Excel)

Saves the data that were just displayed in a table in a csv file. Bear the time interval in mind, as an Excel sheet cannot contain more than 65536 rows.

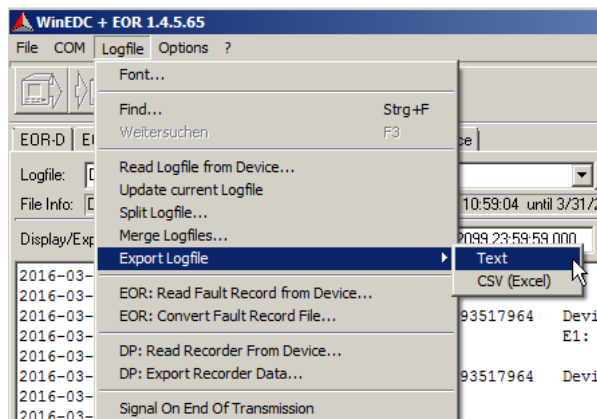


Fig. 72: Export logfile

### 12.2.6 Signal upon completion

An acoustic signal is emitted when the system has finished reading out a logfile or error log.

### 12.2.7 Refresh (F5)

Updates the displayed text.

## 13. Maintenance/Cleaning

### 13.1 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.

## 13.2 Replacing a fuse

The EOR-D has a replaceable microfuse (20 mm). This 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)



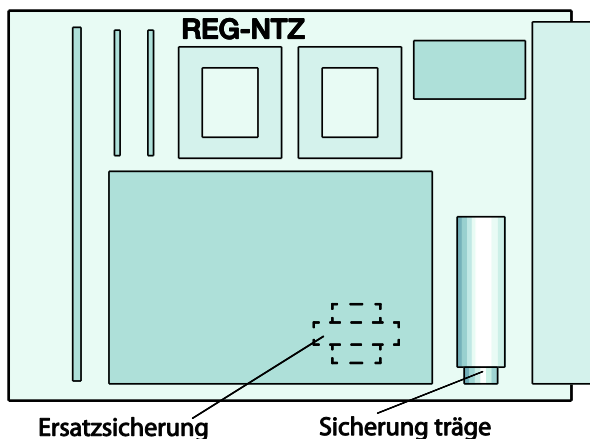
**DANGER!**

**Danger of electric shock!**

Injury or death



When replacing the fuse, disconnect the device from all power supplies (auxiliary voltage, control voltages).




### 13.3 Replacing the battery

Three versions of buffer battery are used in the EOR-D. 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.

 <b>DANGER!</b>	<p><b>Danger of electric shock!</b></p> <p>Injury or death</p> <p>➡ When replacing the fuse, disconnect the device from all power supplies (auxiliary voltage, control voltages).</p>
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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.

### EOR-D 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 EOR-D (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.

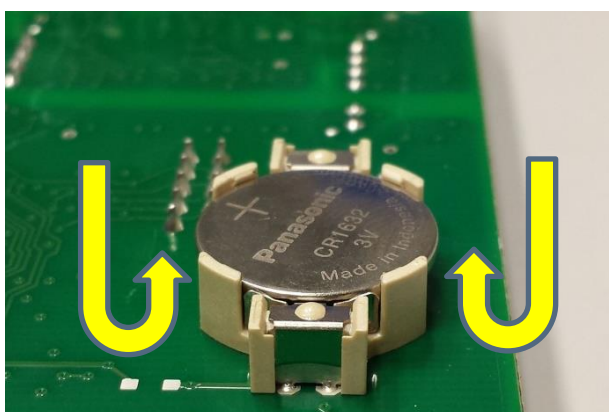


Fig. 73: Remove the button cell

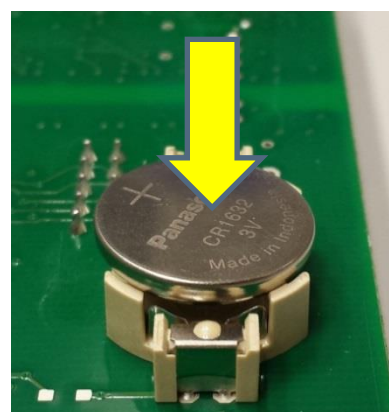


Fig. 74: Insert the button cell



### EOR-D 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 EOR-D (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 by downloading them before changing 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.



Fig. 75: Plug connection points and metal cover on the outside of the printed circuit board



Fig. 76: Parallel plugged batteries

### **EOR-D 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.



#### **Removing the battery erases the parameters!**

- ➡ Connect the new battery before removing the spent one.
- ➡ Back up the parameters by downloading them before changing 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 EOR-D (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!**

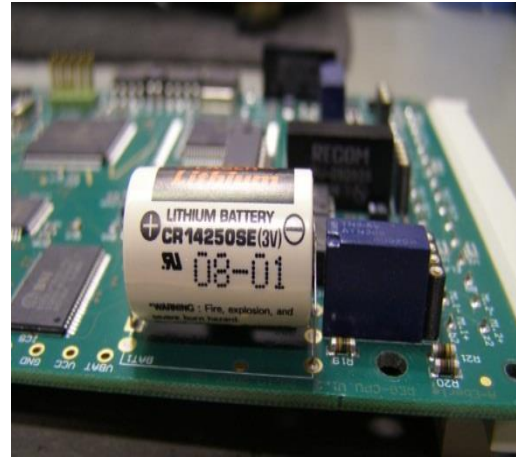
Destruction of the conductor paths and/or the soldering pads

- ➡ 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.

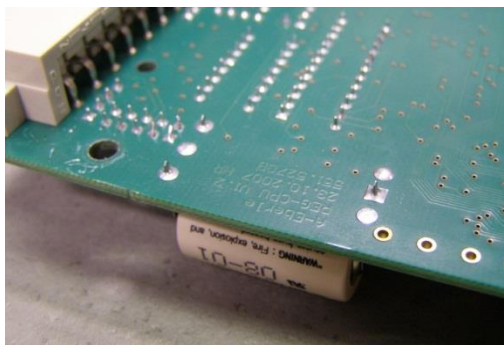


*Fig. 77: CPU circuit board with soldered battery – plan view*

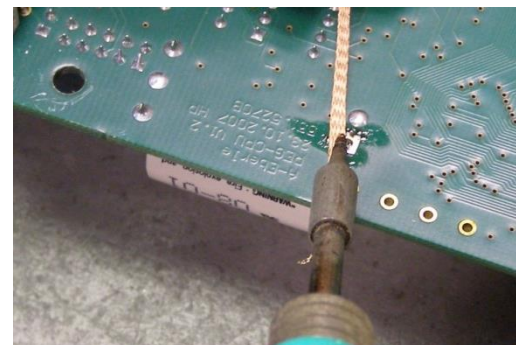


*Fig. 78: Soldered battery with three soldering lugs*

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.

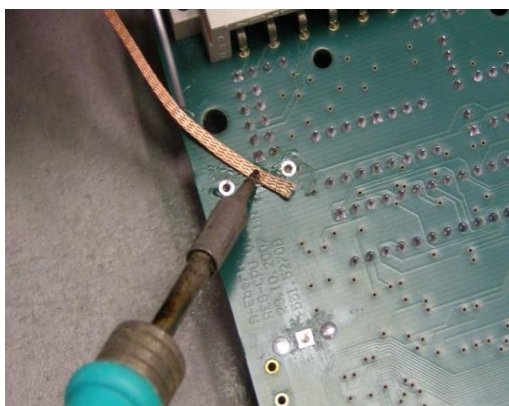


*Fig. 79: The soldered battery's soldering joints with three soldering lugs*

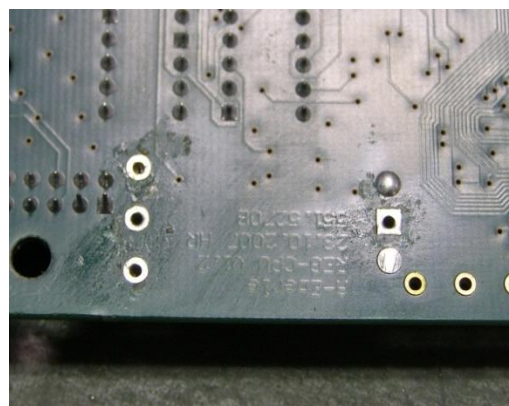


*Fig. 80: Desoldering with desoldering tape*

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.

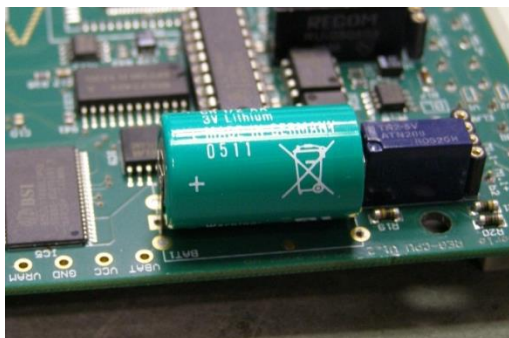


*Fig. 81: Desoldering the missing soldering pad for soldered batteries with two soldering lugs*

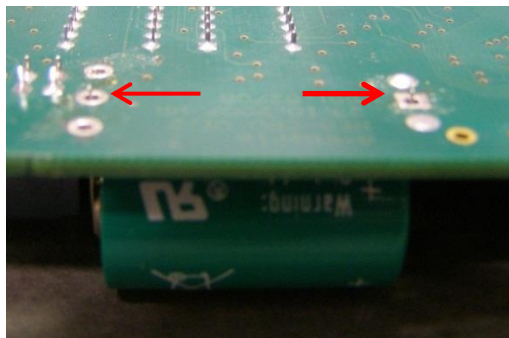


*Fig. 82: Desoldering with desoldering tape*

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.

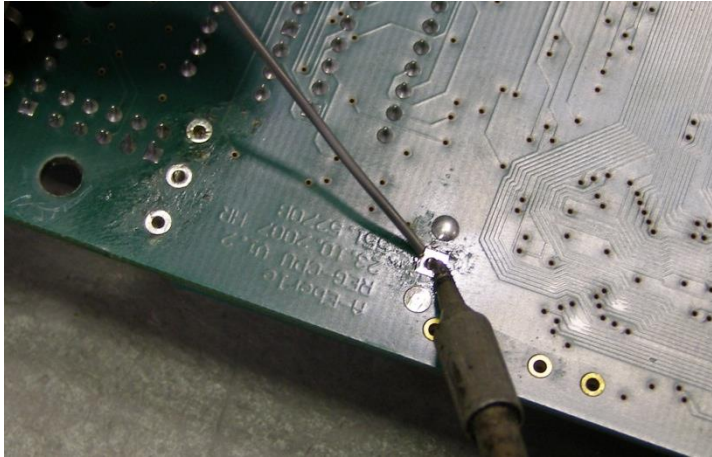


*Fig. 83: Soldered battery with two soldering lugs:  
Check the polarity of the battery!*



*Fig. 84: 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.



*Fig. 85: Soldering the soldered battery with two soldering lugs*

## 14. 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



## 15. 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](mailto: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.

## **16. Product Warranty**

The warranty period is three years starting from the delivery date.



## 17. 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.

## 18. Important ECL commands

**<A1>setcom1** ; Query COM1 parameters  
SetCOM1 = ECL/115200/P-/RTS

**<A1>setcom1 = ECL/115200/P-/RTS** ; Set COM1 parameters  
SetCOM1 = ECL/115200/P-/RTS

**<A1>all,setcom1&** ; Query all COM1s on the network  
A1:SetCOM1 = ECL/115200/P-/RTS  
A2:SetCOM1 = ECL/115200/P-/RTS  
A3:SetCOM1 = ECL/115200/P-/RTS

**<A1>all,setlanl&** ; Query all E-LAN\_Left on the network  
A1:SetLanL = 2D+/62K5  
A2:SetLanL = 2D/62K5  
A3:SetLanL = 2D+/62K5

**<A1>all,setlanr&** ; Query all E-LAN\_Right on the network  
A1:SetLanR = 2D+/62K5  
A2:SetLanR = 2D/62K5  
A3:SetLanR = 2D+/62K5

**<A1>all,kenn&** ; Query all IDs, for dir  
A1:  
A2:  
A3:

**<A1>all,station&** ; Query all names on the network  
A1:Station = EOR-D  
A2:Station = EOR-D  
A3:Station = EOR-D

**<A1>status**

Station	A1:EOR-D [REG]
EOR-D	Software V1.0.24 (01/07/02)
Interval	15 m (time)
Format (0)	32 channels, 476 entries (5.0 day), 0 used
Tariff	T1 (Program)
Relay	R1:* R2:- R3:- R4:- R5:- R6:-
24 V output	OK
Lithium-Bat	OK
StatusRelay	1 (OK), coupled
Max. L-Level	0
COM1	115200 baud, parity: Off, protocol: RTS/CTS, ECL
COM2	9600 baud, parity: Off, protocol: Xon/Xoff, ECL
COM3	--
BUS-L	62K5 Baud (2D+), participant-L: 2(2), total: 3
BUS-R	62K5 Baud (2D+), participant-L: 0(0)

[illegible]

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Software version:

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Subject to change without notice.