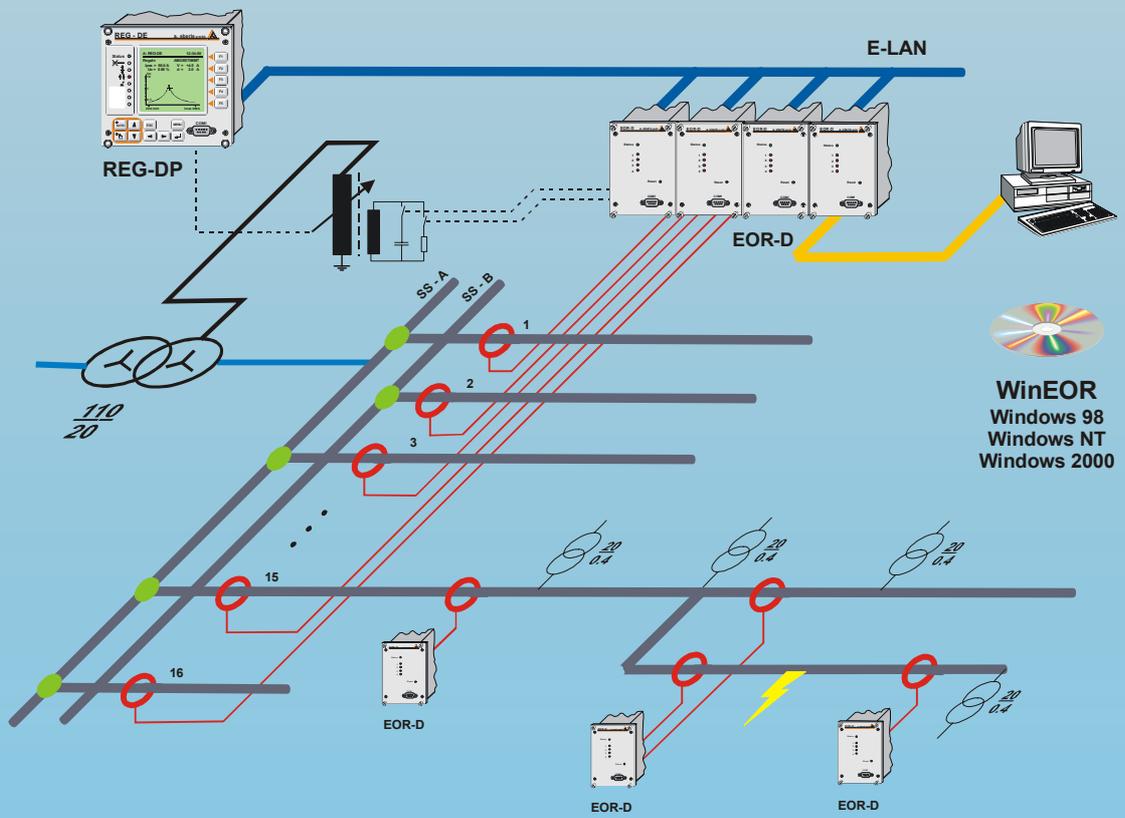


Earth Fault Locating Relay

EOR - D

Supplied
Software Version:



Operating Manual

Issue: July 2007

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1 Warnings and Information

The EOR-D earth fault locating relay is exclusively designed for implementation in systems and equipment incorporating electrical energy technology on which only trained experts are permitted to carry out all required work. Experts are persons who are familiar with the installation, mounting, commissioning and operation of these types of products. Furthermore, experts have qualifications which comply with their field of work.

The EOR-D earth fault locating relay leaves the factory in a condition that fulfils all relevant safety regulations. To maintain this condition and to ensure safe operation, the following instructions and warnings in this Operating Manual must be observed.

- The EOR-D earth fault locating relay has been designed to comply with IEC 10110/EN61010 (DIN VDE 0411), degree of protection I, and was tested according to this standard before delivery.
- The REG-D earth fault locating relay must be earthed via a protective earth conductor. This condition is fulfilled when the voltage regulator is connected to an auxiliary voltage with a protective earth conductor (European power supply system). If the auxiliary voltage network does not have a protective earth conductor, an additional connection must be established from the protective earth conductor connection terminal to earth.
- The upper limit of the permissible auxiliary voltage U_{aux} may not be exceeded, neither permanently nor for a short period of time.
- Before changing the fuse, separate the EOR-D earth fault locating relay completely from the auxiliary voltage U_{aux} . The use of fuses other than those of the indicated type and nominal current is prohibited.
- A earth fault locating relay, which displays visible damage or clear malfunctioning must not be used and has to be secured against unintentionally being switched on.
- Maintenance and repair work on an opened EOR-D earth fault locating relay may only be carried out by authorised experts.

2 Scope of Supply

- 1 unit Earth fault locating system, comprising at least one EOR-D
- 1 unit Operating Manual in German, English, or other language
- 1 unit WinEDC operating software on CD
- 1 unit Removal tool

3 Locating the Earth Fault

To take advantage of the individual earth fault locating procedures in different earth fault situations, the following procedures

- Harmonic procedure
- Pulse locating
- Transient earth procedure
- Wattmetric procedure without increased residual active current
- Wattmetric procedure with increased residual active current

were combined in the user-programmable EOR-D earth fault locating relay. The messages of the individual locating procedures are freely selectable and combinable.

Features of the individual procedures:

Harmonic procedure

- The response threshold of the neutral earth voltage U_{en} can be set
- High sensitivity due to the comparative evaluation of the harmonic currents of the earth-faulted busbar section
- Compensation of the daily fluctuations of the harmonic currents using comparative evaluation
- Can also be used as single relay by evaluating angle information
- Suitable for isolated networks as $\sin\phi$ relay for the 0th harmonic current (50 Hz)

Pulse locating

- Dynamic adaptation of the response threshold of the sum current $3 \cdot I_0$
- The pulse pattern to be recognised can be freely programmed
- Resetting of the display via an external signal or automatically after a time interval
- Clocking can be controlled via the EOR-D
- It is also possible to locate the error location

Transient earth procedure

- The response threshold of the neutral earth voltage U_{en} can be set
- The response threshold of the sum current $3 \cdot I_0$ can be set
- Suppression of transient earth messages depending on a selectable minimum neutral earth voltage period
- Suppression of earth fault messages in direction of the busbar (optional)
- Resetting of the display by means of an external signal or automatically after a time interval
- Recording of the transient procedure

Wattmetric procedure without increased residual active current

- The response threshold of the neutral earth voltage U_{en} can be set
- The response threshold of the sum current $3 \cdot I_0$ can be set
- A preset phase angle correction is possible for the current transformer
- Suppression of earth fault messages in direction of the busbar (optional)
- Recording of the transient procedure

Wattmetric procedure with increased residual active current

- The response threshold of the neutral earth voltage U_{en} can be set
- The response threshold of the sum current $3 \cdot I_0$ can be set
- A preset phase angle correction is possible for the current transformer
- Suppression of earth fault messages in direction of the busbar (optional)
- Recording of the transient procedure

3.1 Response of a Compensated Medium-Voltage Network

A simplified equivalent circuit for the medium voltage network is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** This simplified equivalent circuit diagram neglects the majority of the following components:

- Impedances of the transformer
- Longitudinal impedance of the lines
- Couplings between the conductors
- The impedance of the earth return
- The discharge resistors of the conductors to earth

For further considerations, it is assumed that the load is linear and symmetrical. It is also assumed that the infeed voltage comes from a three-phase supply.

Fehler! Verweisquelle konnte nicht gefunden werden. shows that during proper operation that the currents in the neutral point of the three capacitances cancel each other out, assuming that the three capacitances to earth are the same value. The voltage distribution of the three phases is symmetrical to earth. Taking account of a symmetrical supply voltage, no neutral earth voltage U_{ne} can therefore be generated. The capacitances to earth therefore represent an additional symmetrical capacitive load whose neutral point is earthed.

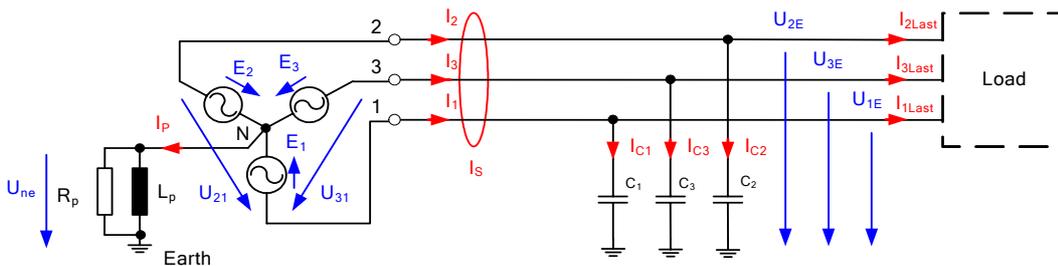


Figure 3.1: Simplified equivalent circuit diagram of the healthy compensated medium-voltage network

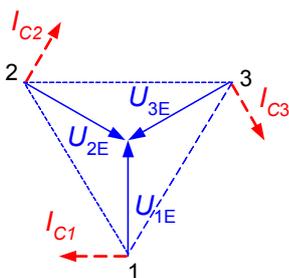


Figure 3.2: Currents and voltages in Figure 1.1 (without load)

However, if the three capacitances are not the same value, an asymmetrical voltage system occurs at the three capacitances and the neutral earth voltage U_{ne} results. This asymmetrical case can also be described as "high-resistance earth fault" with the fault impedance $Z_F = 1/\omega\Delta C$.

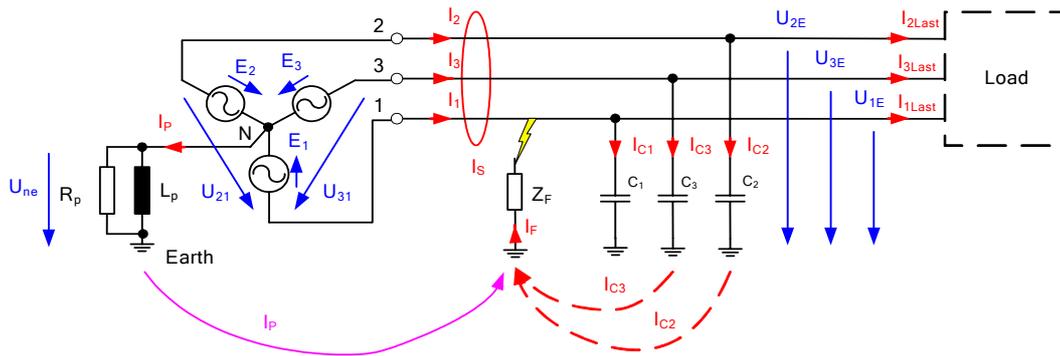


Figure 3.3: Simplified equivalent circuit diagram of the compensated medium-voltage network with single-pole earth fault

Fehler! Verweisquelle konnte nicht gefunden werden. shows the simplified equivalent circuit diagram when there is a single-pole earth fault. In case of a low-resistance earth fault ($Z_F = 0$), phase L1 is reduced to the earth potential and the two faultless conductors increase to the voltage $E_1 \cdot \sqrt{3}$. The voltage triangle remains; thus an "undisturbed transport" of energy to the load is possible, even during a single-pole earth fault.

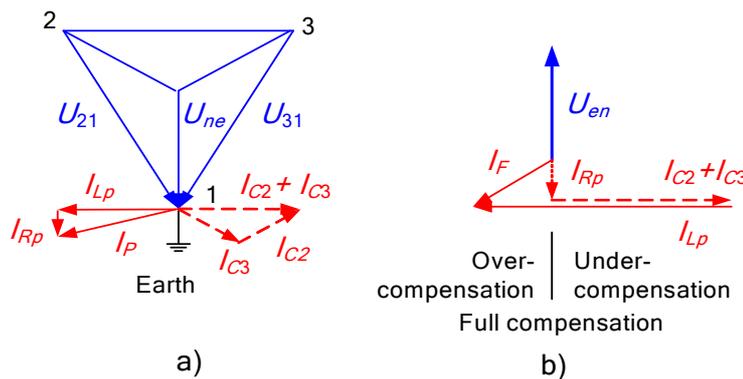


Figure 3.4: Vector diagrams for the single-pole earth fault according to Figure 3.3

The vector diagram for a low-resistance earth fault in phase 1 is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** Due to the low-resistance earth fault in phase 1, no current flows over capacity C_1 ; the capacity is short-circuited due to the earth fault. The currents over the two faultless phases is now $\sqrt{3}$ larger compared to the faultless network operation. The phase shift between the two currents is 120° and the geometric sum of the two currents is as high as the entire capacitive leakage current in the faultless network.

From the equivalent circuit diagram, it can be seen that U_{ne} receives the value of the phase voltage E_1 and drives an inductive current across the Petersen coil and the fault location. If the Petersen coil is set in such a way that the value of the inductive current corresponds to the value of the capacitive sum current across the fault location, these two reactive currents cancel each other out at the fault location and a very small active component remains. In this case, the term full compensation is used. If over-compensation occurs, the inductive current is greater than the capacitive current. In the event of under-compensation, the inductive current is less than the capacitive current. (See **Fehler! Verweisquelle konnte nicht gefunden werden.** b).

In a dead earth fault, the sum current, which is measured in the transformer plant at the earth-faulted feeder and which flows across the fault location, can be influenced by adjusting the Petersen coil. The sum current in the healthy feeders is solely determined by their line capacitances and is not influenced by a change in the Petersen coil.

Using Kirchhoff's laws, the following equations can be listed:

$$0 = I_P + I_1 + I_2 + I_3 \tag{1}$$

$$V_{ne} Y_P = I_P \tag{2}$$

$$(E_1 + V_{ne}) Y_1 = I_1 \tag{3}$$

$$(E_2 + V_{ne}) Y_2 = I_2 \tag{4}$$

$$(E_3 + V_{ne}) Y_3 = I_3 \tag{5}$$

$$Y_P = G_P + \frac{1}{j\omega L_P} \tag{6}$$

$$Y_1 = (G + \Delta G) + j\omega(C + \Delta C) \tag{7}$$

$$Y_2 = Y_3 = G + j\omega C. \tag{8}$$

$$V_{ne} = - \frac{Y_1 + a^2 Y_2 + a Y_3}{Y_P + Y_1 + Y_2 + Y_3} E_1. \tag{11}$$

$$V_{ne} = - \frac{Y_U}{Y_U + Y_W + j(B_C - B_L)} E_1 = - \frac{Y_U}{Y_U + Y_O} E_1 \tag{14}$$

$Y_U = \Delta G + j\omega \Delta C$ Asymmetry at the fault location

$Y_W = 3G + G_P$ Wattmetric component of Y_O

$B_C = \omega 3C$ Capacitive component of Y_O

$B_L = \frac{1}{\omega L_P}$ Inductive component of Y_O

The single-pole equivalent circuit diagram shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** can be drawn using equation (14). This equivalent circuit diagram applies to both the low-resistance and the high-resistance earth fault.

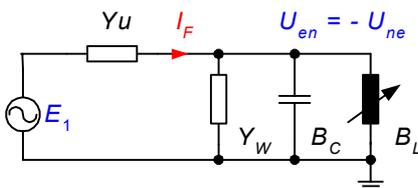


Figure 3.5: Single-pole equivalent circuit diagram for the single-pole asymmetry

The curve of the neutral earth voltage for a healthy network with a "natural capacitive asymmetry" is shown in **Fehler! Verweisquelle konnte nicht gefunden werden..**

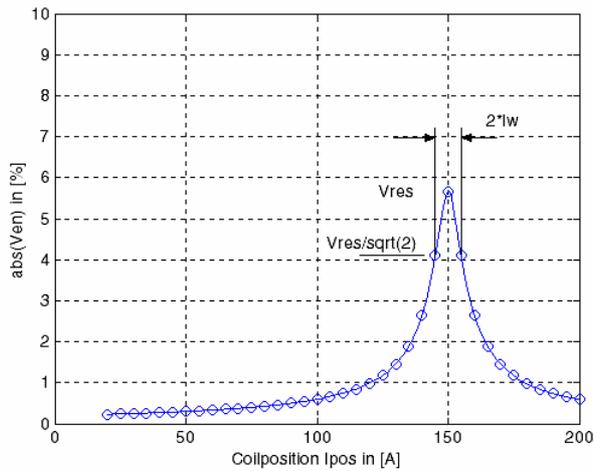


Figure 3.6: Resonance curve of the healthy network operation ("high-resistance asymmetry: $Y_U = \omega \Delta C$ ")

The network can be described by the following three parameters:

- U_{res} Maximum voltage of the resonance curve
- I_{res} Associated current of the Petersen coil for U_{res}
- I_w Wattmetric current across the fault location in the event of a low-resistance earth fault

3.2 Harmonic Procedure

The harmonic currents and voltages of the healthy network are considered in **Fehler! Verweisquelle konnte nicht gefunden werden.** The prerequisites for this are symmetrical longitudinal impedances (transformer, line) and symmetrical capacitances between the conductor and earth. Couplings between the conductors are likewise assumed to be symmetrical. Due to non-linear loads in the network, harmonic currents occur in the individual phases. Because there is no connection to earth in the load, the sum of the load currents equals zero at any point in time. On the other hand, these harmonic currents cause voltage drops along the longitudinal impedances of the network (line-longitudinal impedances, transformer impedances). The distortions of the conductor-earth voltages occur in such a way that the currents also neutralise themselves via the line capacitances in the neutral point of the capacitances (earth). As a result of this, when the earth capacitances are symmetrical, no harmonic current flows in the healthy network via the earth or via the Petersen coil, even if the phase-to-phase voltages and the phase currents contain large harmonic currents.

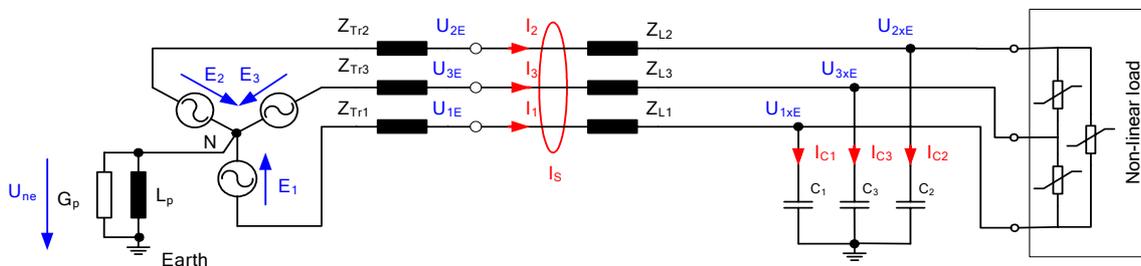


Figure 3.7: Simplified equivalent circuit diagram of the healthy network

The situation for the harmonic currents changes due to an earth fault (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

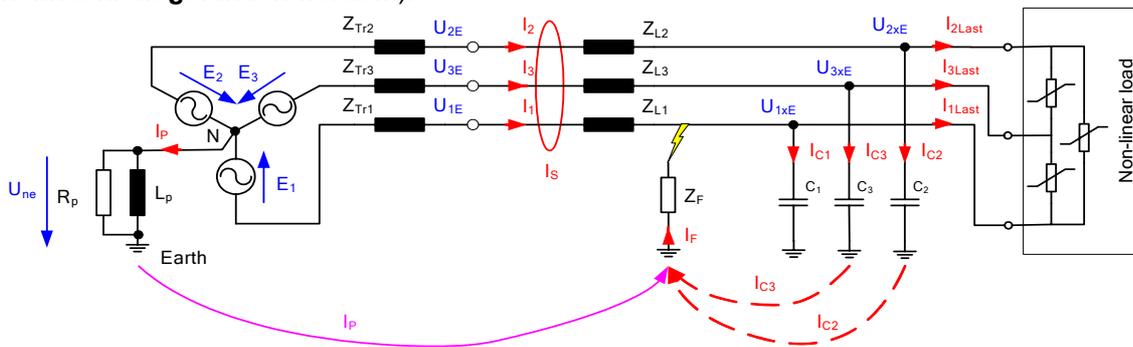


Figure 3.8: Simplified equivalent circuit diagram in the case of a single-pole earth fault

Due to the "low-resistance short-circuit" of phase L1, the distorted phase-to-phase voltage is present at the healthy phases L2 and L3. This distorted voltage provides a capacitive fundamental current of 50 Hz, which is compensated by the Petersen coil as described previously. Furthermore, the voltage components contained in the harmonic also generate an additional harmonic current across the fault location. In this case, it must be taken into consideration that the admittance of the capacitance with a certain frequency increases linearly, i.e. the voltage amplitude for the 5th harmonic results in a five-fold current. In contrast to this, the current is subjected to a 5 times higher impedance in the Petersen coil which in turn reduces the value by a

factor of 5. Therefore, harmonics in the compensated network can be seen as an "isolated neutral system" to a first approximation.

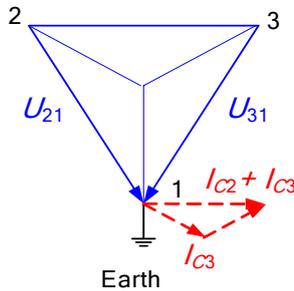


Figure 3.9: Vector diagram of the capacitive currents (also applies to harmonic currents)

The simplified equivalent circuit diagram for a transformer substation with three feeders and a single-pole earth fault in phase 1 of line A is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** Only the harmonic currents in the individual phases are plotted. It can be seen that the value of the current at the output with an earth fault is the sum of the harmonic currents of the other outputs. This applies to every order of the harmonic.

The **distortion of the phase-to-phase voltage** on the busbar of the transformer substation is significant for the procedure. This distorted phase-to-phase voltage generates the harmonic currents to earth **in the healthy feeders**. Only the sum of these harmonic currents of the healthy feeders can be measured in the earth-faulted feeder.

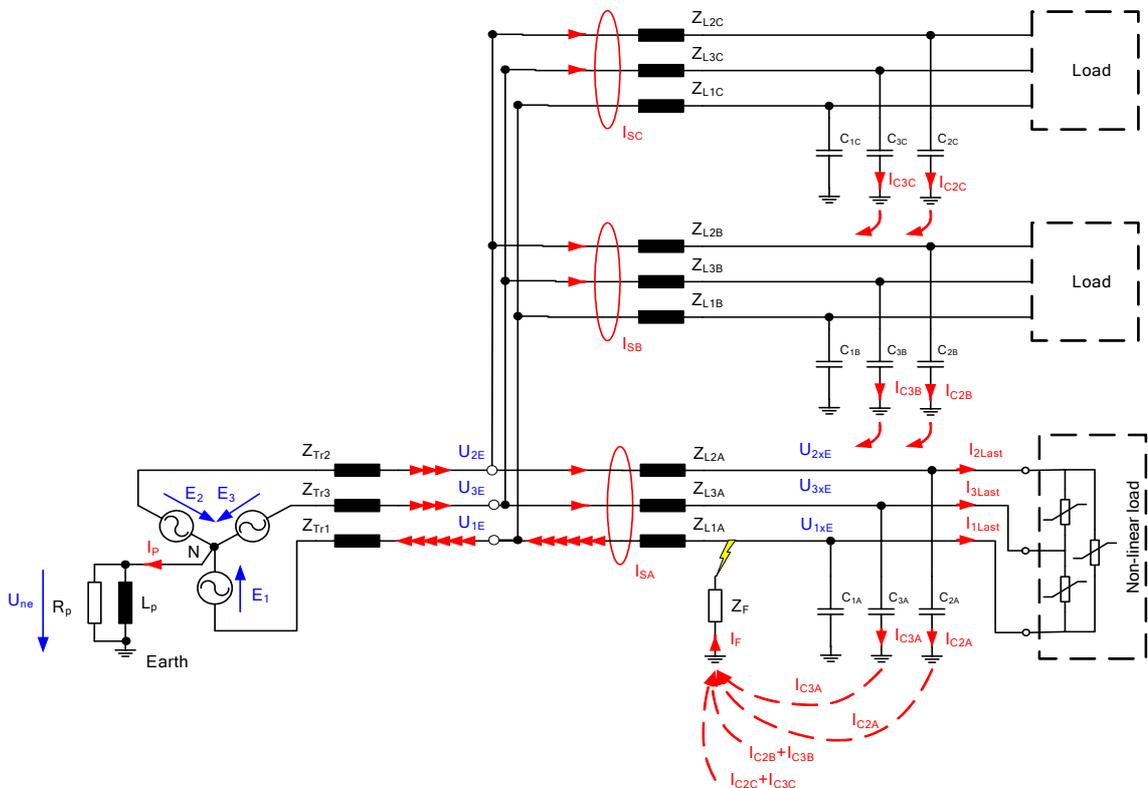


Figure 3.10: Network with three feeders and a single-pole earth fault in L1 of line A.

For the harmonic relay, it must be ensured that, on the one hand, the largest harmonic current is measured in the earth-faulted feeder and that, on the other hand, the phase position of the harmonic current is rotated by 180° compared to the healthy feeders. The current associated with

the harmonic is capacitive in healthy feeders and inductive in the earth-faulted feeder, see **Fehler! Verweisquelle konnte nicht gefunden werden.** Therefore the relay only needs to correctly detect the direction of the current relative to the associated harmonic voltage. Phase angle errors of the current and voltage transformers hardly have any effect compared to the wattmetric procedure.

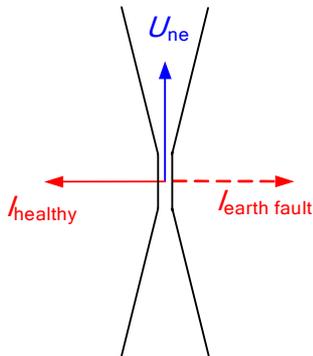


Figure 3.11: Selectable limit ranges for earth fault detection

The harmonic procedure is a **stationary locating procedure**.

If switching is carried out for rings, the display of the earth-faulted feeder moves with it as soon as the disconnection point is behind the fault location.

For rings, the feeder with the greatest current is displayed. This is the shortest electrical distance from the busbar to the fault location.

For **isolated networks**, no current flows across the neutral point even at 50 Hz. This means that the harmonic relay in the isolated neutral system can be used directly for 50 Hz. In this case, you have the advantage that the "0th harmonic voltage" is available at the full value of 100%.

Limits of the harmonic procedure:

- **Network with only two feeders:**
If only a numeric evaluation of the harmonics takes place, the feeder cannot be selectively determined from the comparison of the amounts. This is because harmonic currents that flow into an feeder come out at other feeders. The two currents have the same value but different directions.
=>
By measuring the direction of the harmonic currents, it is possible to make a selective assertion about the earth-faulted feeder.
- **No harmonic exists:**
The procedure cannot be applied if no harmonic exists in the network.

The setting of the relay sensitivity is relatively non-critical, because a comparative measurement of the individual feeders is carried out. The relay always displays the greatest harmonic current and, in the case of only two feeders, the direction is also evaluated.
- **Very high-resistance errors**
If the neutral earth voltage does not exceed a settable limit value, the harmonic currents that flow across the error location are very small.

3.3 Harmonic Procedure with Ripple Control Systems

The harmonic procedure requires that sufficient harmonics are present in the network.

If there are only a small number of harmonics, the situation can be improved by supplying a defined harmonic, for example using a ripple control system. Normally, the ripple control system is designed to generate a harmonic voltage of approx. 1%. This harmonic voltage is available in the network under consideration and can also be used for locating the earth fault.

Therefore, a freely definable frequency can also be set in the relay, for example 217 Hz

The duration of the supplied ripple control frequency can be freely defined, for example 6s. The result of the locating and its display can be saved in the relay. The saved data can be retained until the earth fault is gone or until the next "pulse" of the ripple control system.

If the ripple control system is activated via these "6 second pulses", the earth fault display does not immediately move with the earth fault, if the earth fault moves from one feeder to the next due to switching actions. The last known status is saved until the next request. After the switching of the feeders, a new request must be started with a "6 second pulse".

3.4 Pulse Locating

A pulsating current is generated via the clocking device, which is usually connected to the auxiliary power winding of the Petersen Coil. This pulsating current can only be measured as far as the fault location. The network must be set so that it is over-compensated by a certain amount. A change in the current towards full compensation results from adding capacitors. In this way, the sum current is reduced in the faulty feeder and increased in the healthy feeders.

The pulse locating principle can be seen in the following figure.

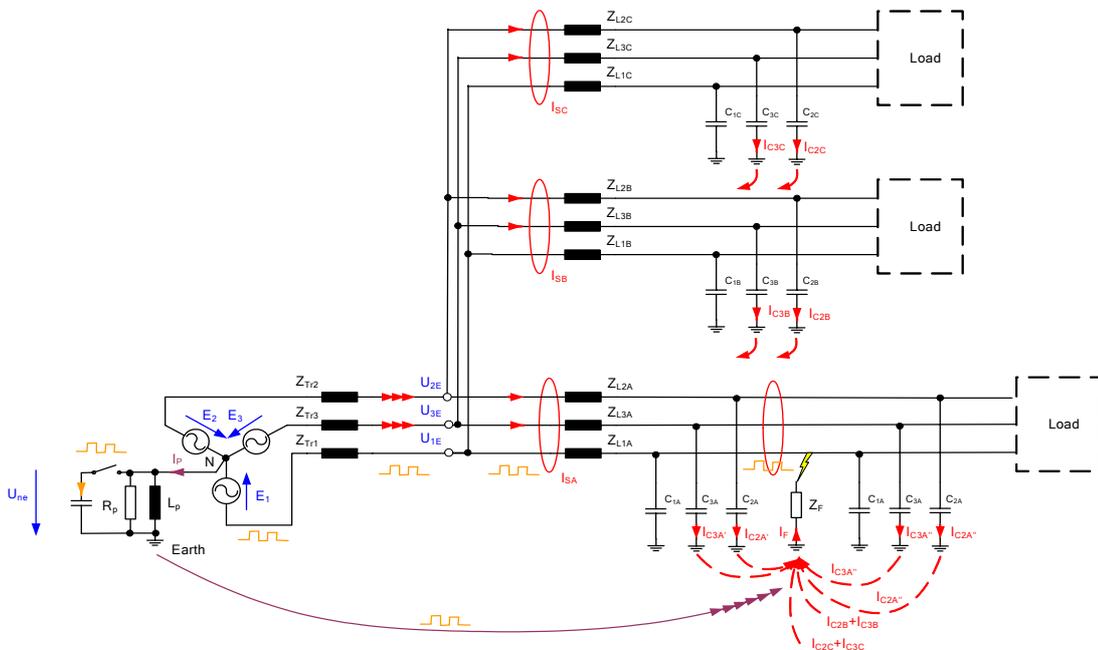


Figure 3.12: Principle of pulse locating

In pulse locating, a capacitor with a frequency of approx. 0.5 Hz is connected at a neutral point. The residual current across the neutral point changes due to this detuning value. For low-

resistance faults, this current can only flow across the fault location. The voltage between the faulty conductor and earth remains constant, and the capacitive currents in the healthy feeders also remain constant. A change to the residual current with a frequency of 0.5 Hz is therefore only detected at the earth-faulted feeder.

For high-resistance earth faults, a coupling to the healthy feeders takes place. If the change of the current across the fault location changes the impedance Z_F also alters. As a result the neutral earth voltage U_{NE} changes along with the voltage between the healthy conductors and earth. This leads to a change in the capacitive currents between the healthy conductors and earth as well. Due to this connection, the healthy and faulty conductors cannot be distinguished for **symmetrical clocking** and high-resistance earth faults.

The remedy comes in the form of **asymmetrical clocking**. For this type of clocking, the capacitor is activated for 1 second and deactivated for 1.5 seconds (pulse-to-pause ratio 1:1.5). This pattern can be repeated as often as required. It can easily be shown that, in the event of over-compensation, the resulting current changes in the healthy feeder are the inverse of the change in the faulty feeder. In this way, you get a criterion for distinguishing between the faulty and healthy feeders even for high-resistance transfer resistances in the faulty conductor.

3.5 Transient Earth Fault Procedure

The earth fault is made up of three events, the effects of which overlap each other.

The following assumptions are made for future considerations:

- The network is configured as a radial network
- The supply comes from only one side
- Earth fault in phase 1

The sections are explained using **Fehler! Verweisquelle konnte nicht gefunden werden.:**

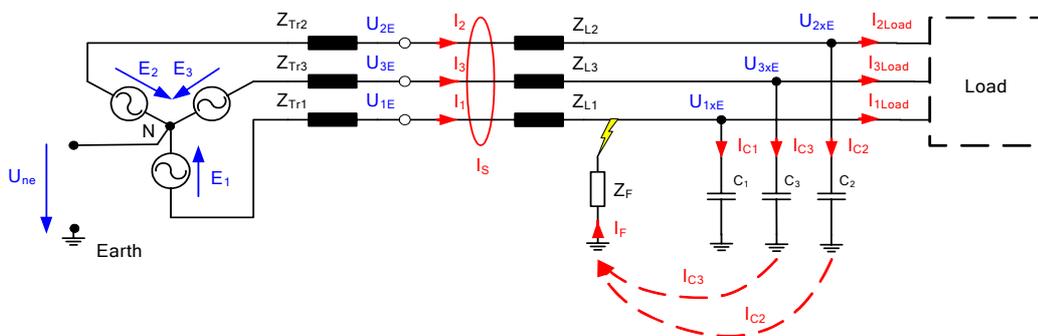


Figure 3.13: The equivalent circuit diagram of an earth-faulted network

The following overlapping events can be distinguished:

- Discharging of the faulty conductor via earth
- Charging of the healthy conductors via earth.
- Stationary steady state

The individual events are considered in detail in the following sections.

3.5.1 Discharging the Faulty Conductor via Earth

The following are critical for the course of the discharging:

- Capacity of phase 1 to earth
- Charge status of capacity of phase 1
- Line impedance Z_{L1} to and in the other feeders
- Impedance of the error location itself, or the earthing

The transformer and the loads represent very high impedance and can be disregarded for these considerations. Likewise, the two healthy conductors play no role. Phase L1 can be considered to be a high-resistance closed chain conductor. The healthy spur lines represent a parallel circuit, whereby the equivalent longitudinal impedance of the healthy conductors is lower in resistance and the capacity is greater.

The very high-frequency transient procedure depends on the lengths of the cables; the frequency is higher for shorter cables. It is normally >10 kHz.

The transient frequency of a line consisting of a single-core cable with $\epsilon_r = 4$ is estimated using:

$$f_E = \frac{37500}{l} \left[\frac{Hz}{km} \right] \quad (3.1)$$

The amplitude of the maximum discharge oscillation (earth fault in the voltage maximum) is dependent upon the length of the conductors for the single-conductor cable described above and can be written as:

$$\hat{I}_{ZE} = 250 \hat{I}_{CE} \quad (3.2)$$

When an earth fault occurs in the zero point of the voltage:

$$\hat{I}_{ZE} = \frac{1}{3} \hat{I}_{CE} \quad (3.3)$$

where

$$I_{CE} = 3 \omega C_E E_1 \quad (3.4)$$

3.5.2 Charging the Healthy Conductors via Earth.

The following are critical for the course of the charging:

- Capacity of phase 2 and 3 to earth
- Charging condition of the capacity of the phases
- Charging voltage ($E_1 + E_2$, $E_1 + E_3$)
- Leakage inductance of the infeed transformer
- Line impedance Z_{L1} from the error location to the infeed transformer
- Impedance of the error location itself, or the earthing

The distribution transformers or the loads are only considered when they have high-resistance and can be disregarded in the first approximation. The load essentially acts as an additional

attenuation of the charging oscillation. If the distribution transformer is not loaded, the line is essentially only loaded with the very high main inductance of the transformer.

The relatively low-resistance leakage inductance of the infeed transformer remains as a limiting element of the charging oscillation and, for errors that are far away, the inductance from the transformer to the error location is the limiting element.

Any existing delta connection of the transformer can be converted into the equivalent star connection.

For the star connection, the charging procedure corresponding to the equivalent circuit applies as shown in **Fehler! Verweisquelle konnte nicht gefunden werden..**

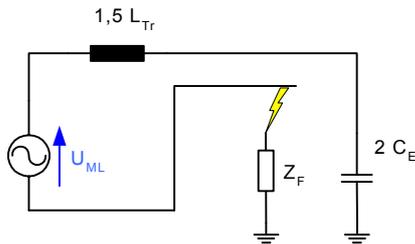


Figure 3.14: Equivalent circuit diagram for the charging procedure

The following formulas:

$$L_{equiv} = 1.5 L_{Tr} \quad (3.5)$$

$$C_{equiv} = 2 C_E \quad (3.6)$$

The frequency of the charging oscillation results for

$$f_A = \frac{1}{2\pi} \sqrt{\frac{1}{L_{equiv} C_{equiv}}} = \frac{1}{2\pi} \sqrt{\frac{1}{3 L_{Tr} C_E}} \quad (3.7)$$

This formula for the frequency of the charging oscillation also applies if the inductance of the line from the error location to the transformer is added to the inductance of the transformer L_{Tr} . This makes the frequency lower. An error that is far away provides a lower charging frequency than an earth fault near a busbar.

Estimation of the leakage inductance via the short circuit voltage and the nominal apparent power of the transformer:

$$X_{Tr} = \omega L_{Tr} = \frac{u_s U_n^2}{100 S_{Tr n}} \approx \frac{u_k U_n^2}{100 S_{Tr n}} \quad (3.8)$$

The initial amplitude of the charging current is therefore:

$$\hat{I}_{ZA} = 2 \omega C_E \hat{U}_{ML} c_\varphi = \frac{2}{3} \hat{I}_{CE} c_\varphi \quad (3.9)$$

The influence of the switching instant (angle φ) is taken into consideration in the amplitude factor

(in the formula, $f = 50 \text{ Hz}$ is used):

$$c_\varphi = \sqrt{\cos^2 \varphi + \left(\frac{f_A}{f}\right)^2 \sin^2 \varphi} \tag{3.10}$$

At the maximum earth-conductor voltage of the faulted conductor ($\varphi = 90^\circ$),

$$\hat{I}_{ZA} = 0.667 \hat{I}_{CE} \frac{f_A}{f} \tag{3.11}$$

For the zero point of the earth-conductor voltage of the faulted conductor ($\varphi = 0^\circ$), $c=1$ and

$$\hat{I}_{ZA} = 0.667 \hat{I}_{CE} \tag{3.12}$$

The following figure shows a network with a cable from the busbar to the infeed transformer and three feeders at the busbar. The individual charging currents are plotted in the individual phases.

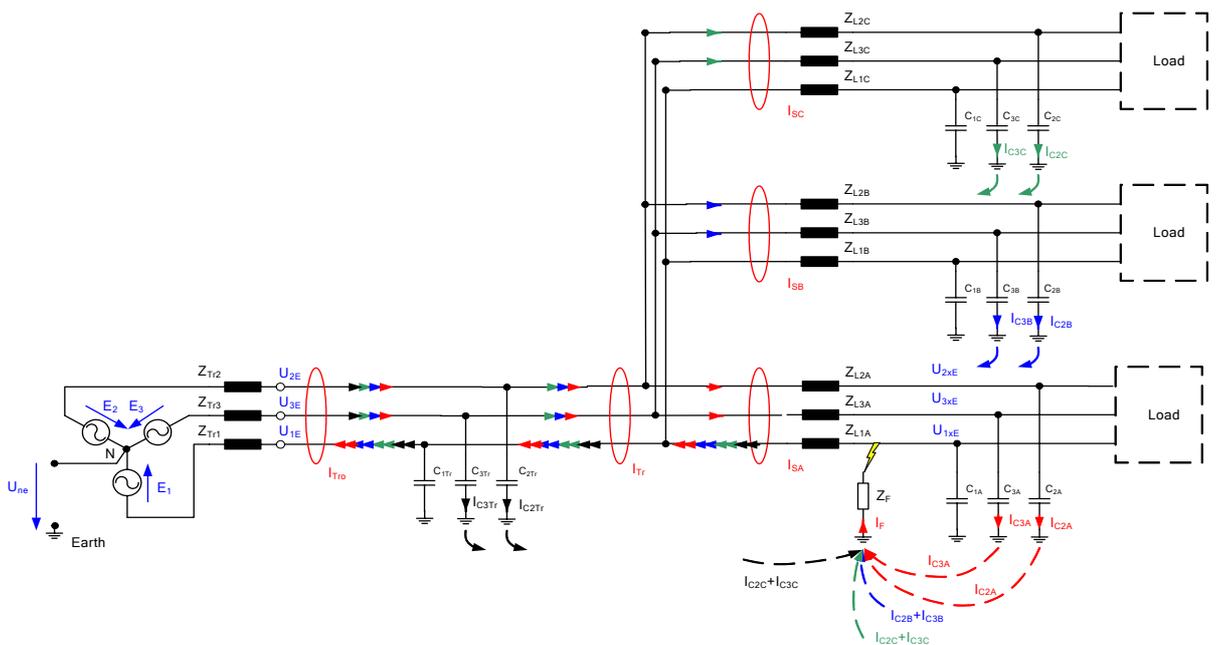


Figure 3.15: Network with feeder cable from the transformer to the busbar and three feeders

The figure shows that the sum of all the charging currents of the healthy phases flows as the charging current in the earth-faulted feeder. The charging current of its own phase cannot be measured as a neutral current. The above outgoing cables have shown that the peak value of the charging current at least adopts the value $0.667 \cdot I_{CE}$ of the remainder of the network (remainder of the network = total network minus earth-faulted feeder).

Transitional earth fault relays evaluate the charging process. The high-frequency discharging oscillations are filtered out.

3.5.3 Stationary Transitioned Earth Fault

In the steady state, the 50 Hz component of the capacitive current of the network flows across the error location in an isolated network. The phase L_1 is kept to the earth potential by the earth fault and the two phase-to-phase voltages U_{21} and U_{31} drive the earth fault currents via the capacitances C_2 and C_3 . These earth fault currents must be added as complex vectors according to Fehler! Verweisquelle konnte nicht gefunden werden..

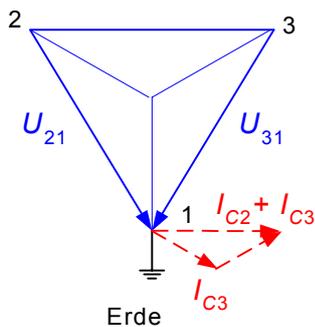


Figure 3.16: Vector diagram for the earth fault currents

This component also includes the harmonic currents that are primarily generated by the distortions in the phase-to-phase voltage. It must be taken into consideration that the admittance of the capacitors increases and the resistance decreases as the ordinal number increases. Due to the decreased resistance, the current becomes greater for a constant excitation voltage. The currents increase proportional to the order of the harmonic to a first approximation (disregarding the longitudinal inductances, resistances in ohms, etc.).

3.6 Wattmetric Procedure without Increased Active Residual Current

The theory of symmetrical components has been used to calculate a wide range of parameters in 3-phase systems for decades.

The zero system is the most important aspect for the earth fault locating process.

In the zero system, all of the components that can divert the current to earth are grouped together.

In the event of a single-pole earth fault in a compensated network, it is important to note that the fault location is not current-free, even when there is full compensation.

With the aid of the Petersen coil, the capacitive current can be compensated, but the "active residual current" remains. This current flows from the Petersen coil through the faulty feeder, the fault location, earth, and back to the Petersen coil.

Petersen coils become warm in the event of an earth fault. This clearly shows that active power is present in the Petersen coil during an earth fault.

In general, the output of Petersen coils lies between 40 kW and 80 kW (Important: this applies independently of the voltage levels!).

For a 20 kV network, the result is that a voltage of 11.5 kV ($20 \text{ kV}/\sqrt{3}$) is present across the Petersen coil during an earth fault.

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

$$I = P/U$$

$$I = 50\text{kW}/11.5\text{kV}$$

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

All of the isolating ohmic resistors act in parallel to the Petersen coil. These resistors can reduce the total resistance, thereby increasing the active residual current.

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

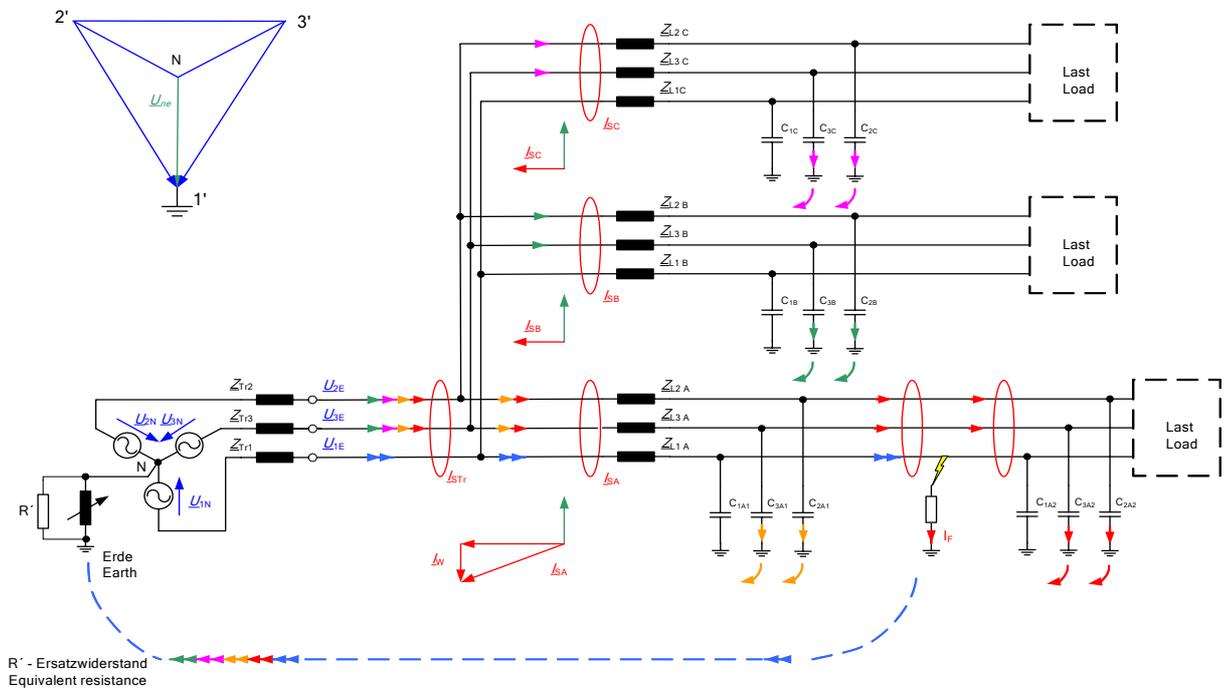


Figure 3.17: Schematic of active residual current procedure

Important information:

Active residual current detection can only be used in compensated systems

Only work with core balance transformers due to the problem of incorrect angles in HolmGreen circuits

For distributed coils, you must ensure that no Petersen coil is allowed to work on the faulty wire

3.7 Wattmetric Procedure with Increased Active Residual Current

The fundamental construction of Petersen coils has not changed over the last few decades.

The electrical power loss of Petersen coils, which were produced 50 years ago, also lay between 40 kW and 80 kW.

In those days, the coils almost exclusively compensated open line systems.

The ICE of an open line network is approximately 20 to 30 times smaller than that of a cable network of the same size.

For this reason, the ratio between I_w and ICE in the days of open line networks was much more favourable than in the cable network.

In order to create comparable ratios in regard to locating, you can switch-in an active resistance parallel to the Petersen coil, which considerably increases the active residual current for the duration of the measurement.

In this way, the erroneous angles of the HolmGreen transformer sets that are often used in open line networks can also be compensated.

The active residual current increase can also be used if the network was not originally compensated (small industrial networks, power plant networks, etc.).

However, with the active residual current increase, you must also ensure that no Petersen coils are on the faulty wire.

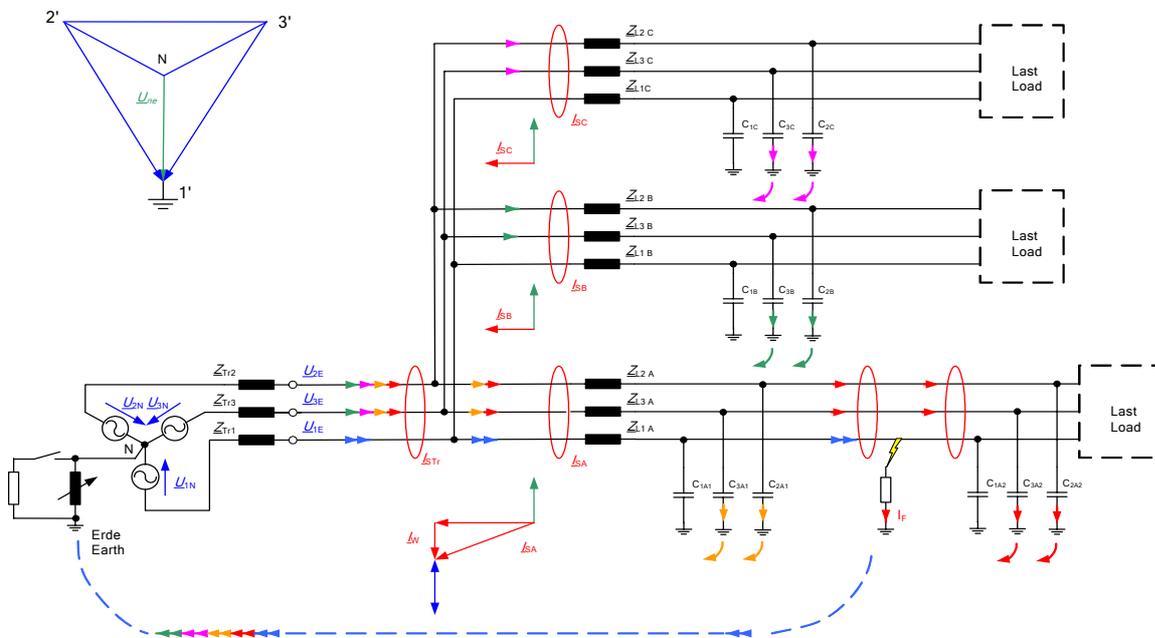


Figure 3.18: Principle of active residual current increase

3.8 Busbar Configurations

The most frequently encountered configurations of transformer stations and substations are:

- Single busbar operation
- Dual busbar operation with longitudinal coupling
- Dual busbar operation with bus coupling and 2 disconnectors and a circuit breaker per feeder
- Dual busbar operation with duplex circuit breaker (coupling can take place in any feeder)

It is important that an unambiguous assignment of U_0 and I_0 per feeder is required. This can be done in different ways depending on the busbar configuration:

- Measuring the neutral earth voltage and the residual current per feeder
- Measuring the neutral earth voltage at the busbars and assigning via the station configuration
- Measuring the neutral earth voltage at the busbar and switching through the neutral earth voltage via auxiliary contacts of the circuit breakers and disconnectors

A grouping of the earth-faulted feeders is required to compare the individual feeders. In the case of an earth fault, only the feeders located in the same earth fault section should be compared to each other.

In the case of the station configuration, the grouping can be determined directly from the position of the circuit breakers and disconnectors.

If, however, the neutral earth voltage and the residual current per feeder are provided to the relay, the grouping takes place by means of comparing the neutral earth voltages of the individual feeders. The earth fault is detected via a threshold value being exceeded at a feeder. The complex vector of this neutral earth voltage is measured. All feeders at which the same or approximately the same neutral earth voltage is measured at this point in time are grouped together and used for the comparative evaluation.

The locus of the vector in the complex plane is defined as shown in Fig. 3.11. The radius r of the circle can be parameterised via software.

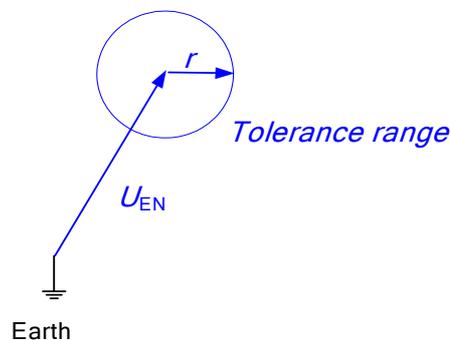


Figure 3.19: Grouping by comparing the neutral earth voltage

4 Technical Characteristics

4.1 Electrical Data

4.1.1 Regulations and Standards

IEC 1010 / EN61010 (VDE 0411)
 CAN / CSA - C 22.2 No. 1010.1 - 92 1010.1 - 92
 VDE 0110
 IEC 255-4
 EN 55011 : 1991
 EN 50082 - 2 : 1995
 IEC 688 -1
 IEC 529
 EN 50178 / VDE 0160 / 11.94 (currently draft)
 VDE0106 TEIL 100
 DIN 40050



4.1.2 AC Voltage Input (U_{ne1} ... U_{ne4} , U_{sync})

Neutral earth voltage U _{NE}	0.1 V to 120 V
Synchronisation voltage U _{sync}	100 to 250 V
Curve shape	Sinusoidal
Frequency range	45 ... 2500 Hz
Internal consumption	$\leq U_{\text{nominal}}^2 / 20 \text{ k}\Omega$
Overload capacity	$U_{\text{nominal}} * 1.2$

4.1.3 AC Current Input (I_{o1} ... I_{o4})

Current range	1 A / 5 A (selectable using software)
Frequency range	45 ... 2500 Hz
Internal consumption	$\leq 0.5 \text{ VA}$
Overload capacity	10 A continuous $60 I_{\text{nominal}}$ for 1 s $30 I_{\text{nominal}}$ for 10 s 500 A for 5 ms

4.1.4 Binary Inputs

Inputs E1 ... E16

Input voltage	48 V...230 V AC/DC
Curve shape, permissible	Rectangular, sinusoidal
H – Level	$> 35 \text{ V}$
L – Level	$< 25 \text{ V}$
Signal frequency f _s	$\text{DC} \leq f_s \leq 60 \text{ Hz}$
Input resistance	$\geq 47 \text{ k}\Omega$
Electrical isolation	Optocoupler, all inputs isolated from each other

4.1.5 Relay Outputs

Relay R1 ... R12, incl. status

Max. switching frequency	≤ 1 Hz
Electrical isolation	Isolated from all device-internal potentials
Contact load	250 V AC, 5 A (cosφ = 1.0) 250 V AC, 3 A (cosφ = 0.4) 220 V DC, 55 W (L/R = 0 ms) 110 V DC, 55 W (L/R = 0 ms) 60 V DC, 55 W (L/R = 0 ms) 30 V DC, 150 W (L/R = 0 ms)
No. of switching operations	> 10 ⁵ electrical
Status relay	Relay with change-over contact

4.1.6 Reference Conditions

Reference temperature	23 °C ± 1 K
Input parameters	1 V, 5 V, 20 V, 100 V
Auxiliary voltage	H = Hn ± 1%
Frequency	50 Hz...60 Hz
Curve shape	Sine, form factor 1.1107
Load for analogue output	Rn = 4 V / Y2 ± 1%
Other	IEC 688 - Part 1

4.1.7 Electrical Safety

Degree of protection	I
Degree of pollution	2
Overvoltage category	II, III

III	II
Input circuits of the current and voltage transformers Power supply	Control circuits, Analogue inputs, Analogue outputs, ELANs, COMs

Nominal isolation voltages

50 V	230 V
E-LAN, COM1 - COM3, Time synchronisation	Voltage inputs, Current inputs, Power supply, Binary inputs (E1 ... E16), Relay outputs (R1 ...R12), status relay

4.1.8 Electromagnetic Compatibility

The device conforms to the emitted interference and interference immunity requirements specified in EN 55011: 1991, EN 50082-2: 1995

Interference emissions

According to EN 55011
Limit Class A Group 1

Interference immunity

Electrostatic discharges
according to EN 61000-4-2

Discharge in air 8 kV
Contact discharge 4 kV

Electromagnetic fields
conform to ENV 50140, ENV 50204

80 MHz...1000 MHz 10 V/m
Radio frequency range 10 V/m
900 MHz \pm 5 MHz 10 V/m
 pulse-modulated

Fast transient interferences (bursts)
According to EN61000-4-4

Supply voltage 230 V AC, 2 kV
Data cables 2 kV

Conducted interferences
According to EN 50141

0.15 MHz...80 MHz U_{eff} = 10 V
Radio frequency range U_{eff} = 3 V

Magnetic fields according to EN 61000-4-8

50 Hz fields 30 A/m

Climatic stability

Temperature range
Function (housing) -10 °C...+50 °C
Function (plug-in module) -10 °C...+60 °C
Transport und storage -25 °C...+65 °C

4.1.9 Power Supply

Feature	H1	H2
AC	85 ... 264 V	
DC	88 ... 280 V	18 .. 72 V
Power consumption	≤ 15 VA	≤15 VA
Frequency	50Hz / 60Hz	
Miniature fuse	T2 250 V	T2 250 V

The following applies to all features:

Voltage interruptions ≤ 80 ms do not cause a fault or loss of data.

4.1.10 Display, Status, Reset

Status display: LED, green

Earth-faulted feeder: LED with three colours (red, green, and the combination colour orange)

Function monitoring (Status)

The battery, processor cycles (Watchdog), operating voltage and the communication with other EOR-Ds are all monitored in every device.

A reset button is located on the front of the EOR-D. It can only be operated using a tool.

4.2 Mechanical Design

4.2.1 Plug-In Module

Front panel	Aluminium, RAL 7035 light grey
Height	3 U (128.5 mm)
Width	18 TE (91.4 mm)
Weight	≤ 1.5 kg
Degree of protection	
Plug-in module	IP00
Socket	IP00
connector	
Mounting	Conforms to DIN 41494 Part 5
Plug-in connectors	DIN 41612

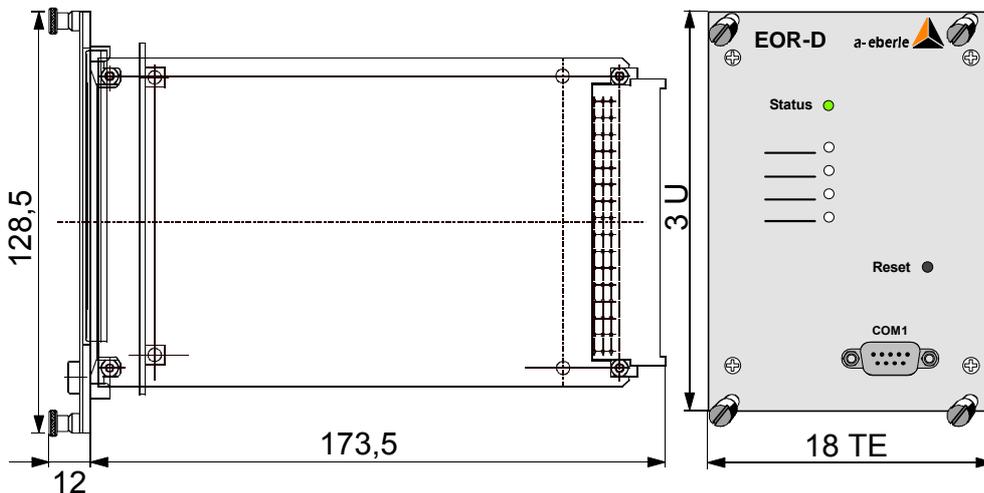


Figure 4.1: Dimensions

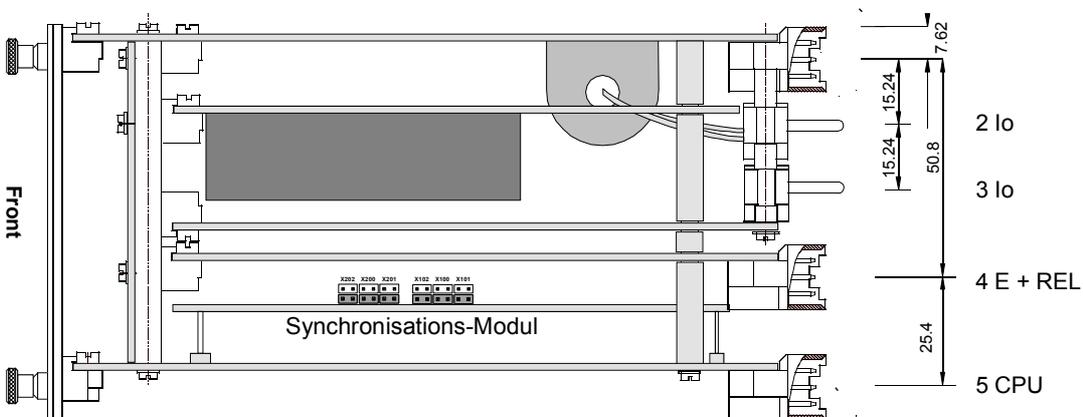


Figure 4.2: Location of the circuit boards and blade connectors (top view)

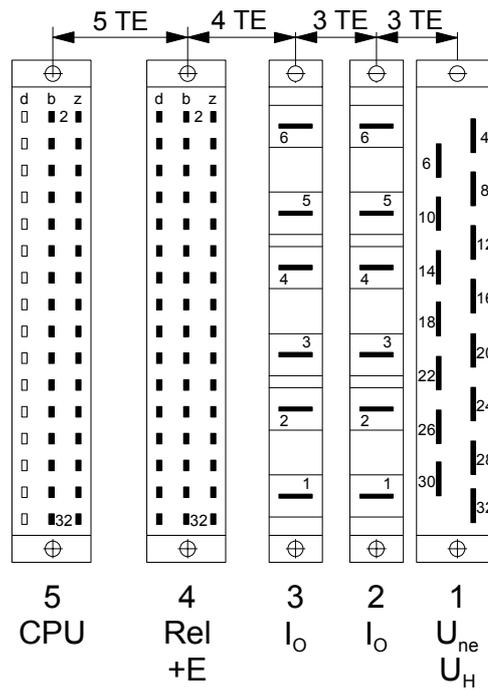


Figure 4.3: Location of the socket connectors (view from behind)

4.2.2 Contact Assignment of the Plug-In Module

4.2.2.1 Contact assignment of the socket connectors

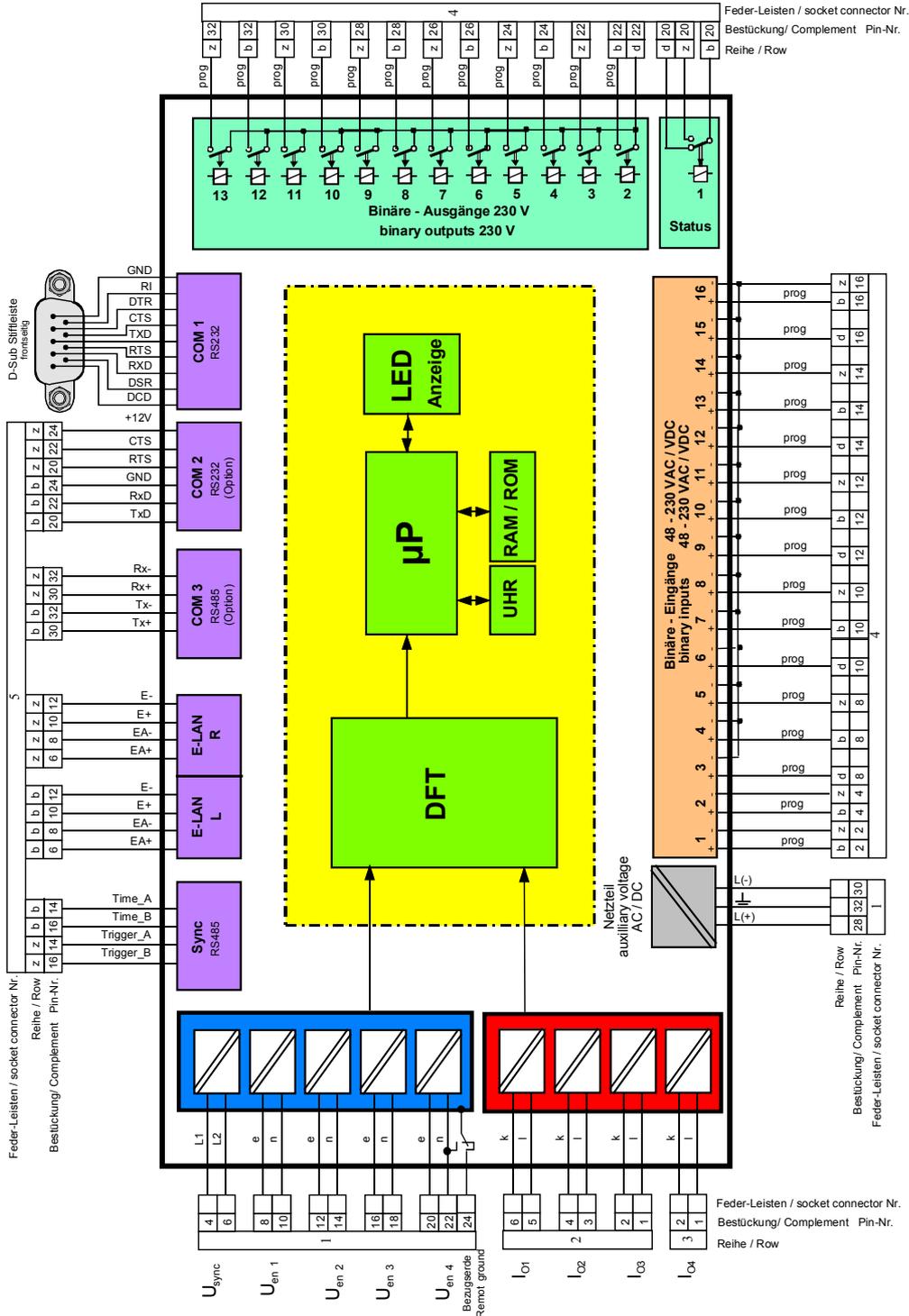


Figure 4.4: Contact assignment of the socket connectors

4.2.2.2 Socket Connector 1: U_{en} , U_{Sync} and Auxiliary Voltage

Function	Designation	Assignment	Pin
Reference voltage (AC)	U_{sync}	L1	4
		L2	6
Neutral earth voltage 1 (AC)	U_{en1}	e	8
		n	10
Neutral earth voltage 2 (AC)	U_{en2}	e	12
		n	14
Neutral earth voltage 3 (AC)	U_{en3}	e	16
		n	18
Neutral earth voltage 4 (AC)	U_{en4}	e	20
		n	22
Reference earth	GND		24
			26
Auxiliary voltage (AC/DC)	U_H	L (+)	28
		L (-)	30
		PE	32

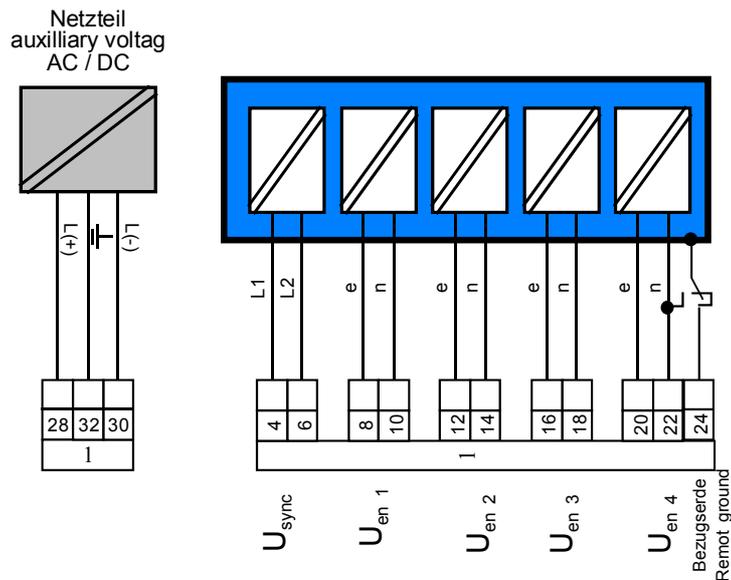


Figure 4.5: Socket Connector 1: Neutral earth voltage U_{en1} ... U_{en4} , U_{sync} and auxiliary voltage

As standard the power supply unit of the EOR-D is designed for 88 V to 230 V AC and DC. However, other voltage ranges can also be supplied.

The inputs of the neutral earth voltages U_{en1} ... U_{en4} can be used for a measurement value up to 110 V.

The synchronisation voltage U_{sync} (100 V to 250 V) is used as reference voltage to measure the phase angle both for the neutral earth voltages U_{en1} ... U_{en4} and for the sum currents I_{o1} ... I_{o4} . The variables are used for locating in some calculation procedures. The phase-to-phase voltage U_{12} , for example, can be used as the synchronisation voltage. Other synchronous voltages which are not influenced by a single-pole earth fault can also be used. The synchronisation input is designed for a nominal voltage up to 230 V AC, but a voltage of 50 V AC is sufficient.

The 230 V AC internal consumption can also be used as the synchronisation voltage. Voltages of up to 400 V conductor-conductor can also be used. However, in this case the voltage transformer must not be earthed.

The synchronisation voltage is internally converted into a square wave signal. No special requirements need to be observed except for the required minimum value and the synchronicity with the 50 Hz voltage. An internal PLL circuit (phase-locked loop) is synchronised by this synchronisation voltage. The system is not affected by interruptions in the synchronisation voltage that last only a few seconds, e.g. when an EB transformer is switched to a different busbar. The PLL is only active if a synchronisation voltage is present. If no signal is detected, the last setting is used.

4.2.2.3 Socket Connectors 2 + 3: Current Inputs

Socket connector 2:

Function	Designation	Assignment	Pin
Sum current I _{o1} (AC)	I _{o1}	k	6
		l	5
Sum current I _{o2} (AC)	I _{o2}	k	4
		l	3
Sum current I _{o3} (AC)	I _{o3}	k	2
		l	1

Socket connector 3:

Function	Designation	Assignment	Pin
			6
			5
			4
			3
Sum current I _{o4} (AC)	I _{o4}	k	2
		l	1

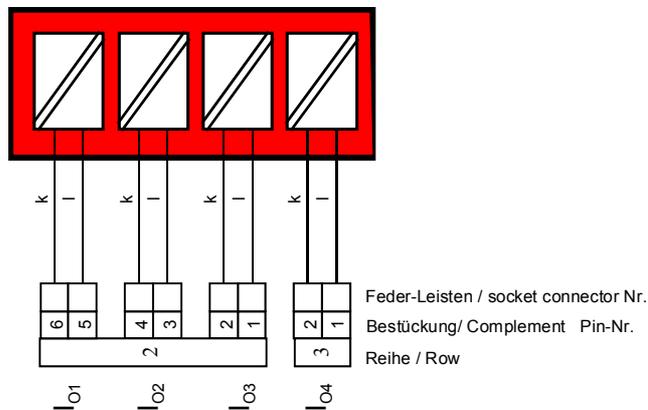


Figure 4.6: Socket connectors 2 + 3: current inputs

The current inputs can be changed to 5 A using software.

4.2.2.4 Socket Connector 4: Binary Inputs and Relay Outputs

Function	Polarity	Pin	Function	Polarity	Pin	Function	Polarity	Pin			
		d2	Free progr.	E1	+	b2	Free progr.	E1	-	z2	
		d4	Free progr.	E2	+	b4	Free progr.	E2	-	z4	
		d6				b6				z6	
Free progr.	E3	+	d8	Free progr.	E4	+	b8	Free progr.	E5	+	z8
Free progr.	E6	+	d10	Free progr.	E7	+	b10	Free progr.	E8	+	z10
Free progr.	E9	+	d12	Free progr.	E10	+	b12	Free progr.	E11	+	z12
Free progr.	E12	+	d14	Free progr.	E13	+	b14	Free progr.	E14	+	z14
Free progr.	E15	+	d16	Free progr.	E16	+	b16	Pol. E3..E16	-	z16	
		d18				b18				z18	
Status relay	NC contact	+	d20	Pol. status relay	Pol	-	b20	Status relay	NO contact	+	z20
Pol. BI 2..13	-	d22	Free progr.	BA2	+	b22	Free progr.	BA3	+	z22	
		d24	Free progr.	BA4	+	b24	Free progr.	BA5	+	z24	
		d26	Free progr.	BA6	+	b26	Free progr.	BA7	+	z26	
		d28	Free progr.	BA8	+	b28	Free progr.	BA9	+	z28	
		d30	Free progr.	BA10	+	b30	Free progr.	BA11	+	z30	
		d32	Free progr.	BA12	+	b32	Free progr.	BA13	+	z32	

E Binary input
 BA Binary output
 Pol. Polarity

Binary inputs:

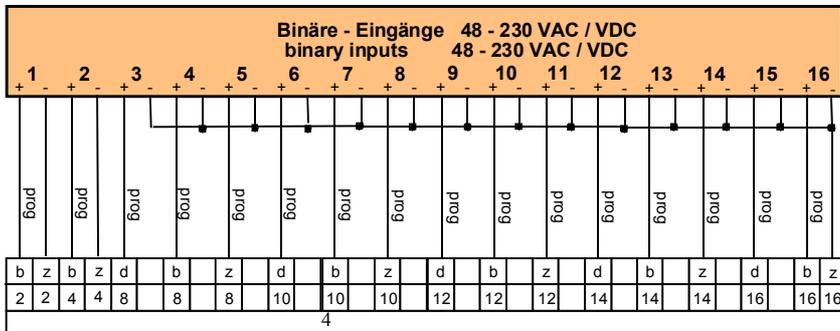


Figure 4.7: Socket connector 4: binary inputs

The binary inputs 1 and 2 are designed with two-poles. The inputs 3 to 16 refer to one single ground point (z16). They are so-called "inputs connected to common potential" and are mainly required for the station configuration.

Relays:

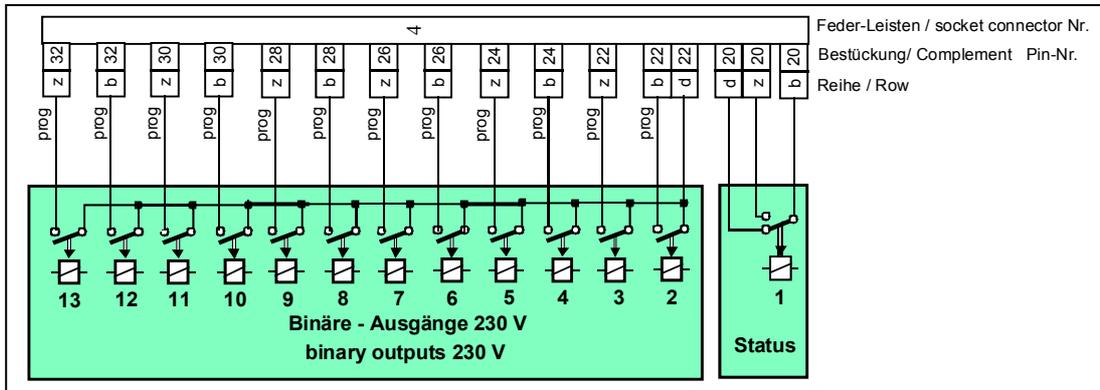


Figure 4.8: Socket connector 4: binary outputs BO

The relays can be parameterised as required using the software.

R1 ... R13: Status	Floating relay contacts
Load capacity:	250 V AC, 5A, $\cos\phi = 1$

4.2.2.5 Socket Connector 5: Interfaces

Function		Pin	Pin	
E-LAN	Left EA +	b6	z6	Right EA +
	Left EA -	b8	z8	Right EA -
Synchronisation (in preparation)	Left E +	b10	z10	Right E +
	Left E -	b12	z12	Right E -
	Time_A	b14	z14	Trigger_A
	Time_B	b16	z16	Trigger_B
COM 2 (RS232)		b18	z18	
	TxD	b20	z20	RTS
	RxD	b22	z22	CTS
COM 3 (RS485)	GND	b24	z24	+12 V
	3.1 -	b28	z28	3.2 -
	Tx +	b30	z30	Rx +
	Tx -	b32	z32	Rx -

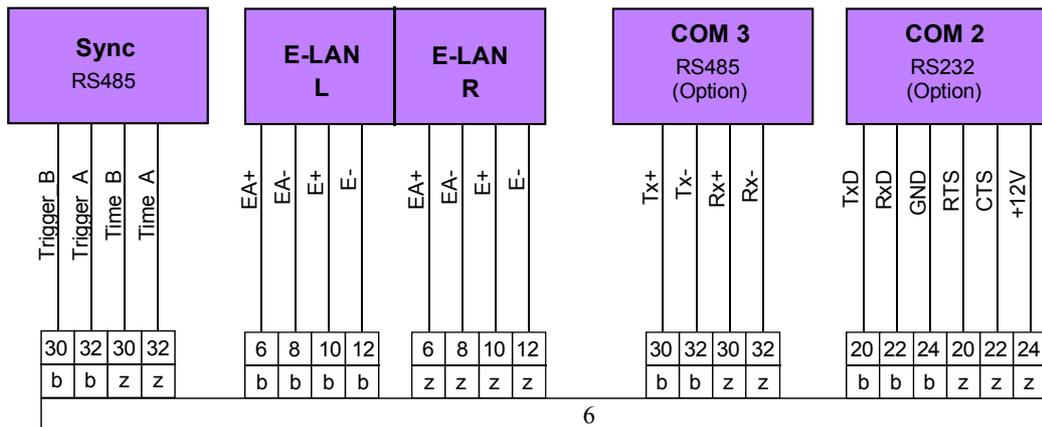


Figure 4.9: Socket connector 5: Communication COM 2, COM 3, E-LAN, time synchronisation

COM 2 interface (optional)

The COM 2 serial interface can be used to connect the control system to higher-level control devices. The **REG-P/PM** or **REG-PE** module is addressed over this interface. This module is used for the connection of an earth fault locating system using the IEC870-5-101 / 103, 61850 protocol.

COM 3 Interface (RS485) (optional)

Up to 15 interface modules (BIN-D, ANA-D) can be connected to this interface in any combination in order to increase the number of inputs and outputs.

E-LAN (Energy - Local Area Network)

Each EOR-D has 2 identical E-LAN interfaces, via which the devices (and other RegSys devices) can communicate with each other.

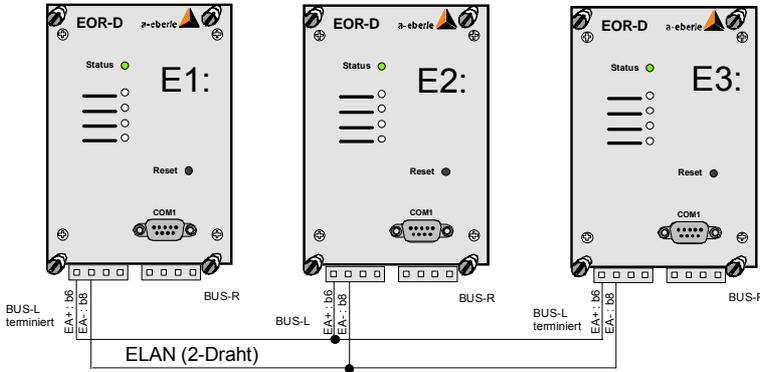


Figure 4.10: Example configuration for three EOR-Ds with ELAN two-wire connection

The E-LAN can be used to link up to 255 E-LAN stations (EOR-D, REG-DP/DPA, REG-D, MMUD, PAN-D). All bus stations can thus communicate with each other or be centrally controlled (see WinREG operating manual for selection and details).

Characteristics of the E-LAN

- 255 bus stations can be addressed
- Multimaster structure
- Integrated repeater function
- Can be operated as a bus, open ring or combination of bus and ring
- Log based on SDLC/HDLC framework
- Transfer rate 62.5 Kbit/s and 115 Kbit/s
- Telegram length 10... 30 bytes
- Average throughput approx. 100 telegrams at 62.5 Kbit/s

Each one of these interfaces also functions with either a 2-wire line or 4-wire transmission technology (RS485).

Socket connector 6					
BUS-L Terminal	BUS-R Terminal	Function	2-wire		4-wire
b6	z6	EA+	"Input +" and "Output +"		"Output +"
b8	z8	EA -	"Input -" and "Output -"		"Output -"
b10	z10	E+	No function		"Input +"
b12	z12	E -	No function		"Input -"

A 2-wire line is normally used, because this is the only system that allows one bus configuration with several stations on the same bus line. To do so, the integrated terminating resistance of the **first** and the **last** stations on the bus line must be switched on (selection: "**terminated**").

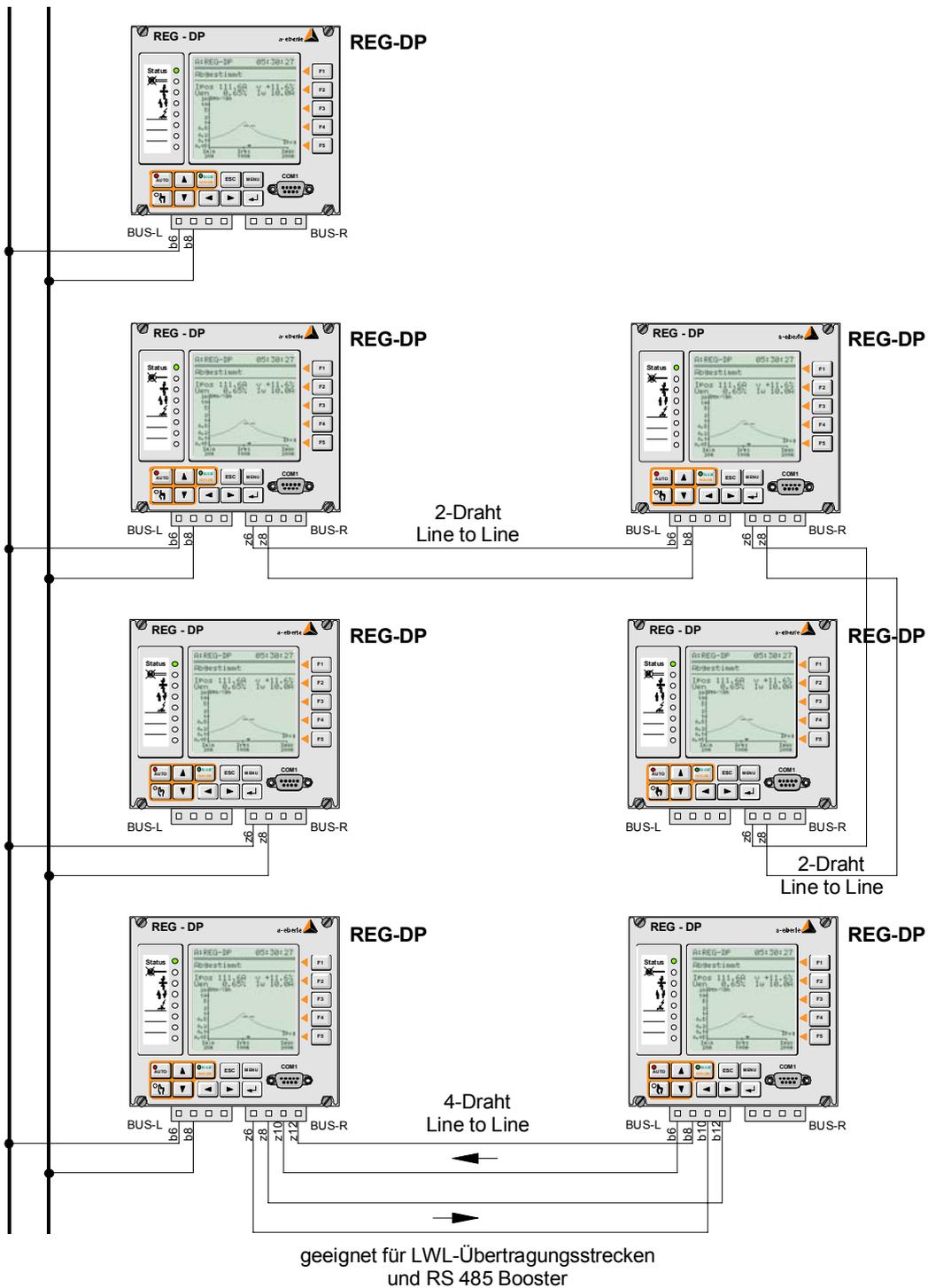
For long transmission distances >1000 m or in the event of a booster (amplifier for increasing the signal level for very long transmission distances) 4-wire transmission technology must be used. The required terminating resistances will be automatically activated (the selection "**terminated**" is no longer required).

Caution:

Normal functioning of the bus would be impossible without a terminating resistance due to the reflections which would then appear on the end of each line.

For further configuration information, see in Chapter "Commissioning".

2-Draht BUS



*

Figure 4.11: Possible E-LAN connection using REG-DP as an example

4.2.2.6 COM1 Serial Interface

Function	Pin
DCD	1
Rx	2
Tx	3
DTR	4
GND	5
DSR	6
RTS	7
CTS	8
RI	9

The serial interface COM 1 is on the device front and is used to connect a PC, terminal or modem.

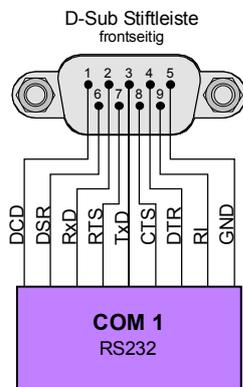
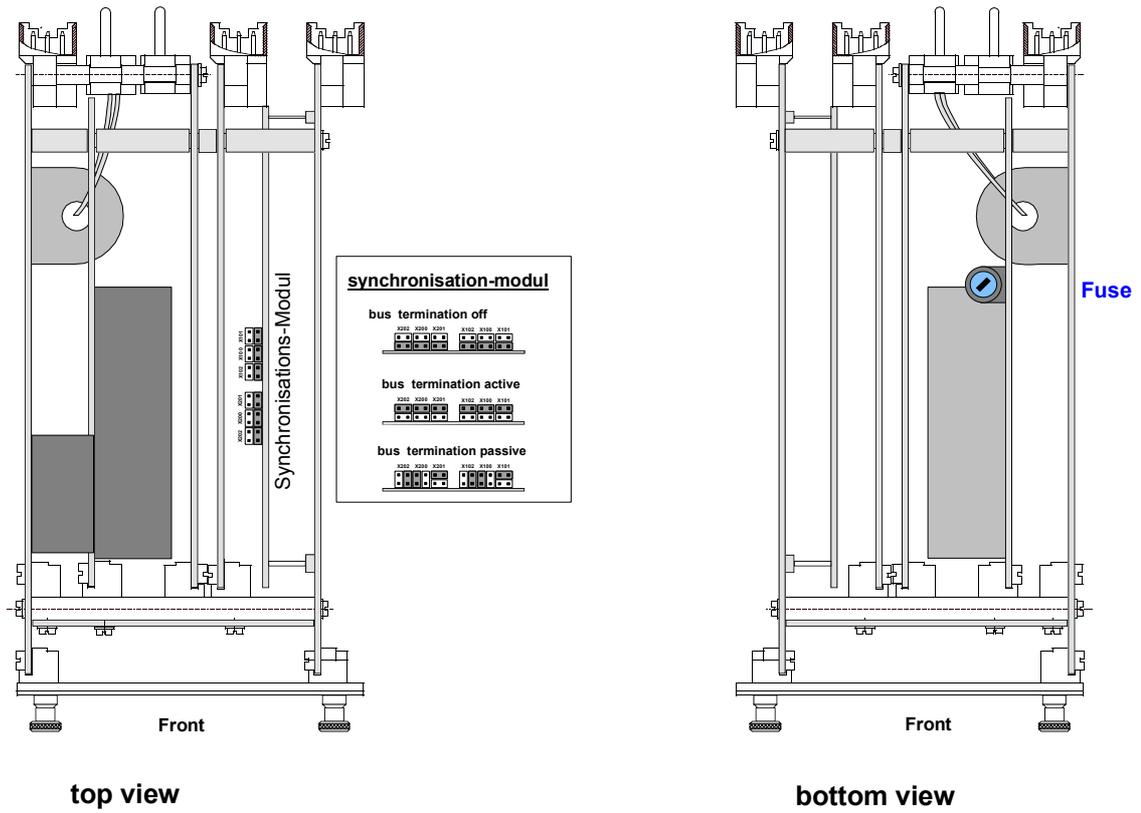


Figure 4.12: COM1 Serial interface



5 Commissioning

OVERVIEW:

The following points should be carried out during commissioning:

- Check the wiring
- Test the power supply
- Install the “WinEDC” parameterisation software
- Set/test COM connection to the PC
- Set/test ELAN connection between the EOR-Ds
- Firmware update, if required
- Load the parameter set with a station configuration
- Test the voltage and current measurement inputs
- Test the digital inputs, outputs and LEDs
- Test the communication to the SCADA system

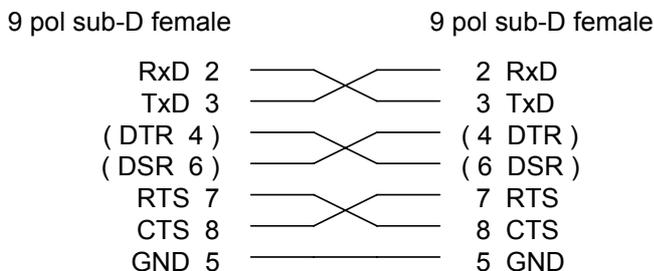
5.1 Installing the “WinEDC” parameterisation software

Installation is not necessary. The supplied EXE file (WinEDC_Vxy.exe) and the parameterisation database (config_dp_xy.mdb; only for REG-DP) must be copied to a common, freely selectable directory.

5.2 Setting/Testing the COM Connection to the PC

Physical connection

Connect the PC and EOR- D to the supplied “zero modem” cable.

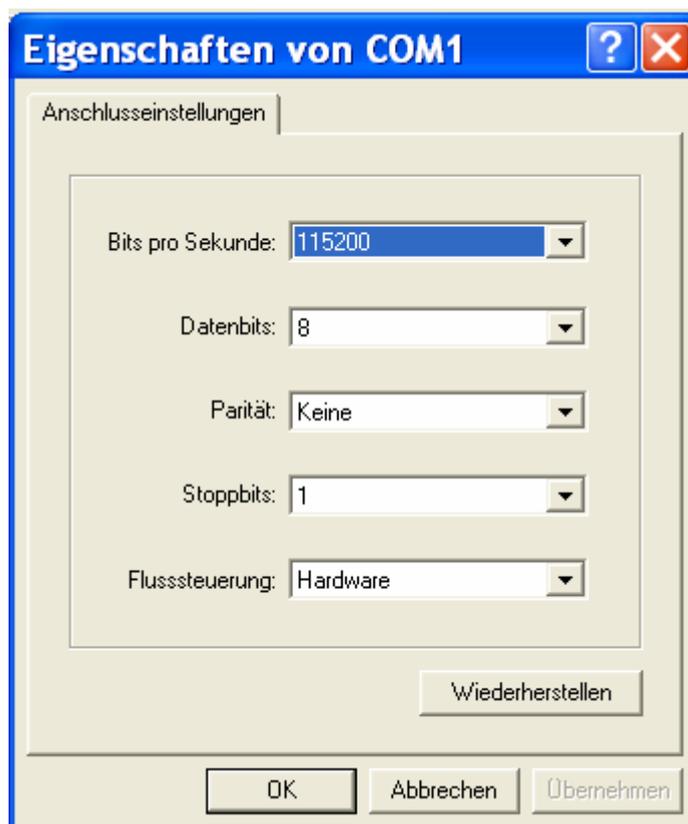
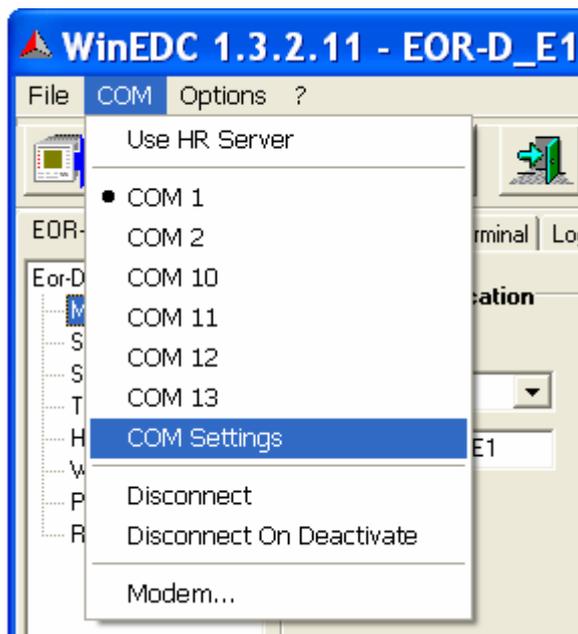


Zero modem cable for the PC (WinEDC) ⇔ EOR-D connection

Adapting the COM port of the PC to the parameters of the EOR-D.

Delivery condition of the EOR-D:

- Mode: Standard;
- Baud: **115200**;
- Parity: none;
- Handshake: **RTS/CTS (= “Hardware”)**

**Note:**

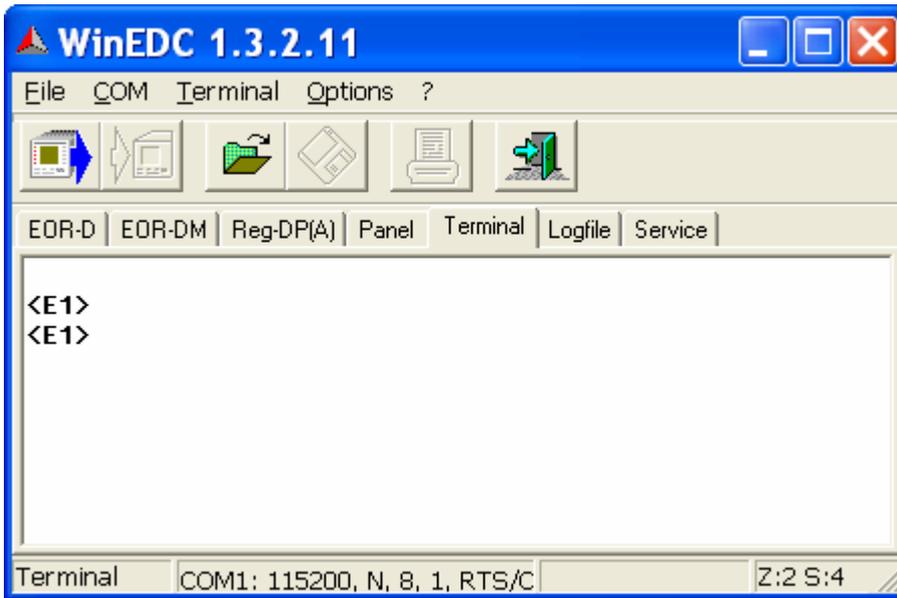
The interface settings are not changed for a firmware update.

A reset of all of the parameters (sysreset=590) switches the EOR-D to:

Mode: Standard; Baud: **9600**; Parity: none; Handshake: **Xon/Xoff**

After this, the communication to the directly connected device should be checked:

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

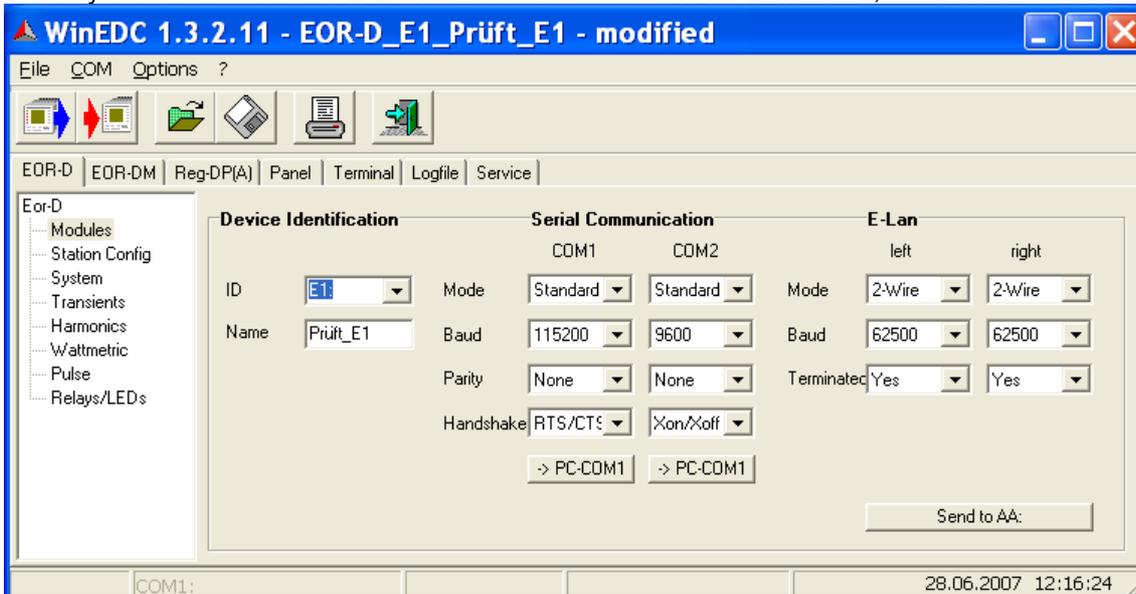


5.3 Setting/Testing the Communication between the EOR-D Devices via the E-LAN

Only necessary if several devices are present.

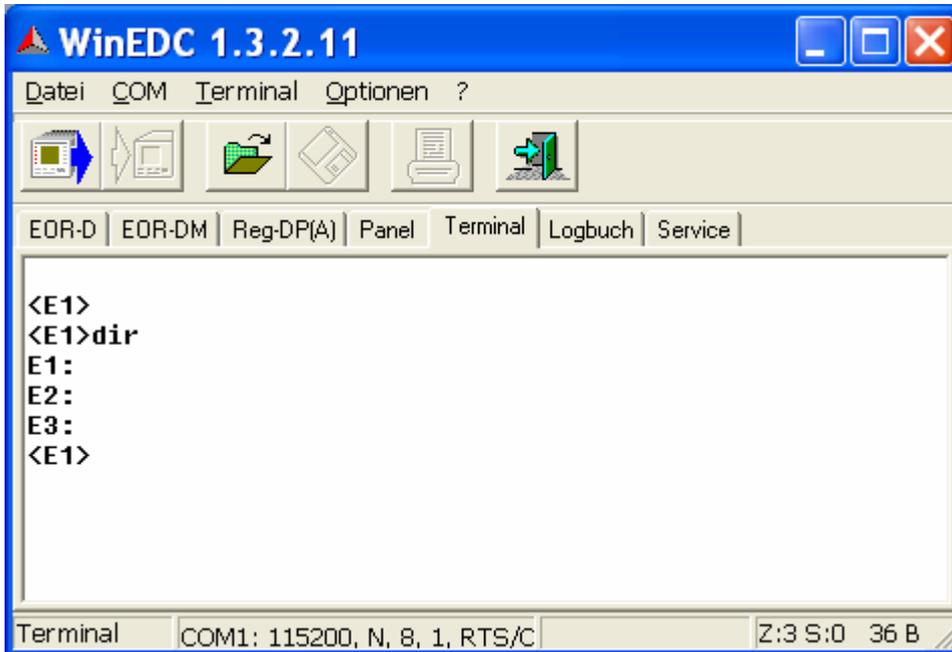
The interface parameters must be set identically for all devices (see parameterisation)
 The two outermost devices must be “terminated” (for cable lengths under 10 m, any two devices can be “terminated”). Unused E-LAN interfaces must also be “terminated.”

Delivery condition of the two E-LAN interfaces on the EOR-D: 2-wire / 62,500 Baud / terminated



Now connect the cable of the COM1 port to all EOR-D. Enter the correct device ID (e.g. E1:) on the WinEDC parameterisation screen “EOR-D - module”, set all E-LAN parameters (observe correct termination!) and use the “Send to AA:” button to send the settings to the connected device.

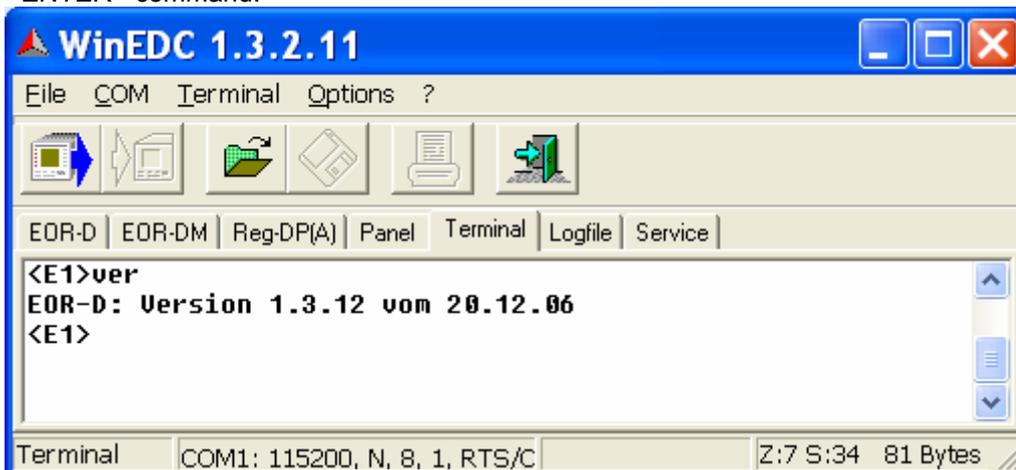
After this, the communication between the devices should be checked:
On the WinEDC – Terminal screen, all of the devices must report with their ID when “dir” <ENTER> is entered.



5.4 Firmware Update (If Required)

This section can be skipped if no firmware update is required.

The version of the connected EOR-D can be queried in the WinEDC Terminal using the “ver” <ENTER> command:



All EOR-Ds that are connected via the E-LAN must have the same firmware version. Test this in the WinEDC terminal with the “all,ver&” <ENTER> command, for example:

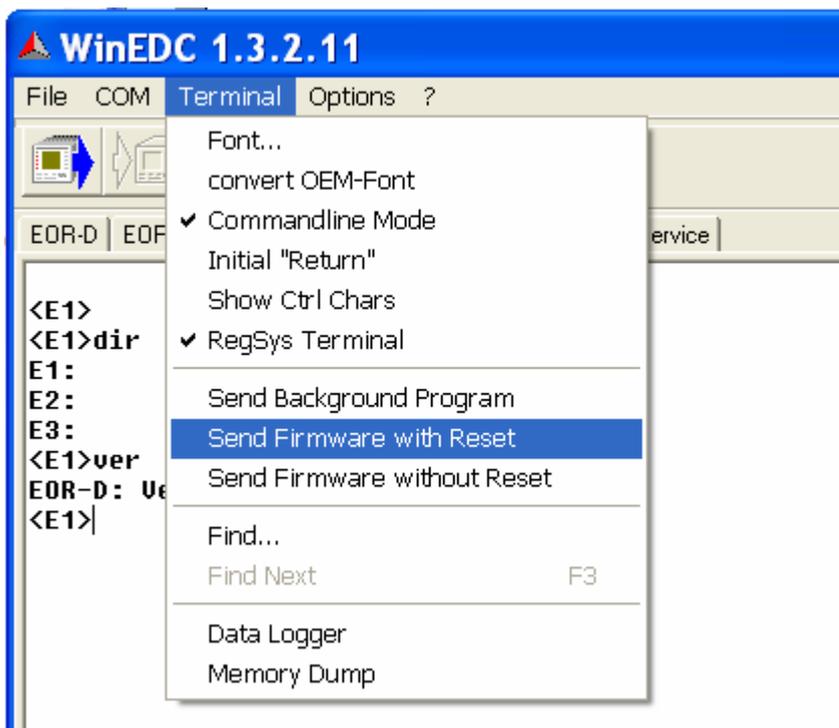
```
<E1>all,ver& <ENTER>
E1:EOR-D: Version 1.3.14 vom 21.06.07
E2:EOR-D: Version 1.3.14 vom 21.06.07
E3:EOR-D: Version 1.3.14 vom 21.06.07
<E1>
```

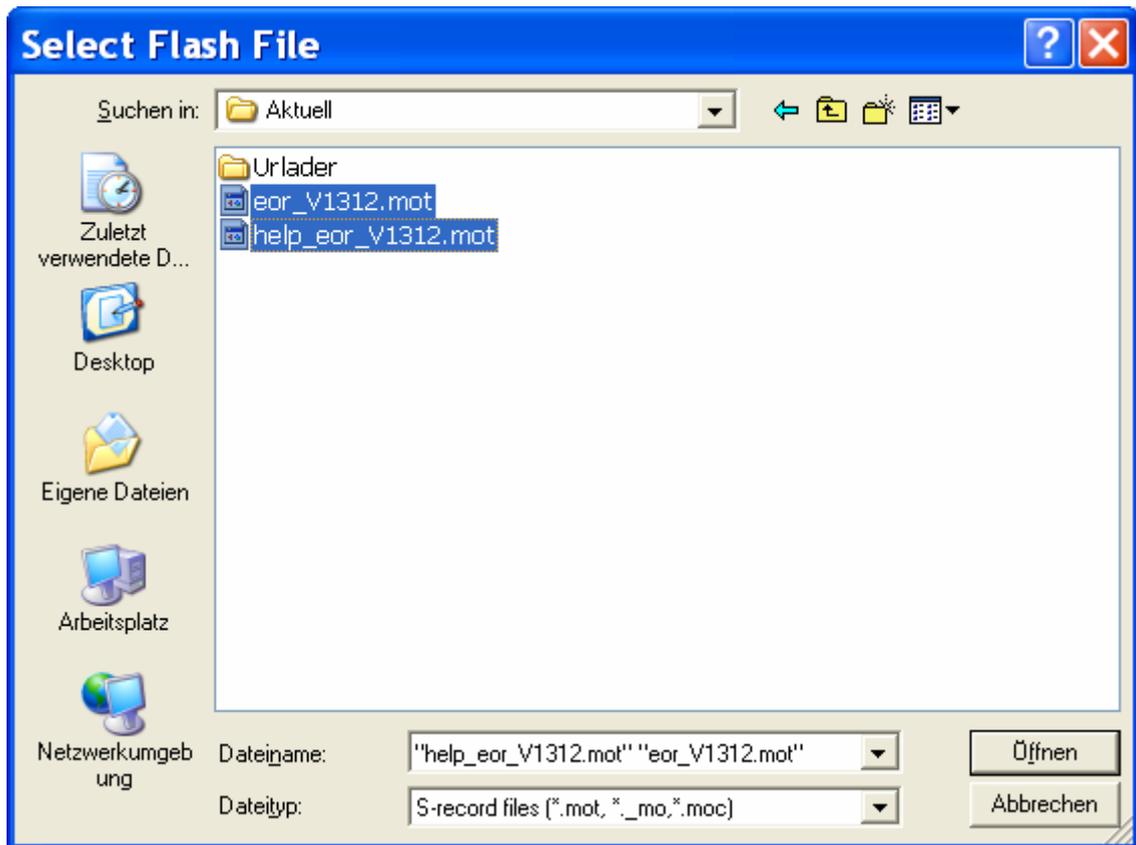
If an update is required, the following steps must be carried out:

Important information:

- In this case, the zero modem cable must be plugged directly into the EOR-D to be loaded.
- For the firmware update, the COM1 port on the PC must always be set to:
Mode: Standard; Baud: **115200**; Parity: none; Handshake: **RTS/CTS**

- Put device in “bootstrap loader” mode
Press the reset key on the EOR-D for approx. 10 seconds. This puts the device in “bootstrap loader” mode. All LEDs remain lit as long as the reset button is pressed. Once the EOR-D is switched to “bootstrap loader” mode, the green LED of the status display begins to flash.
Note: The EOR-D can be taken out of “bootstrap loader” mode and put back into normal mode at any time by pressing the reset key again for 10 seconds
- Load firmware into the device
On the WinEDC –Terminal screen, select the menu item “Terminal” – “Send firmware with reset” and select the two files eor_Vxy.mot (firmware) and help_eor_Vxy.mot (REG-L – online documentation) in the following dialog.





- Repeat the steps for all devices

Comments

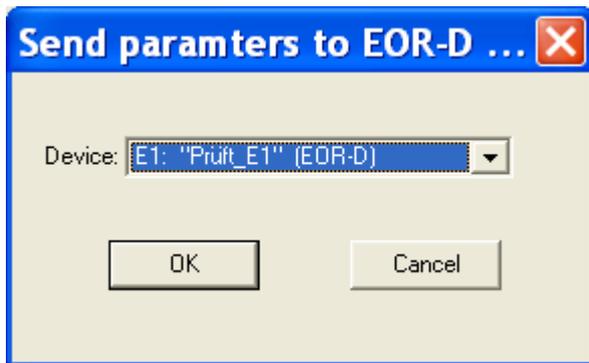
- *.mot and *.moc files are equivalent files (*.moc: compressed format)
- After the update, the EOR-D automatically exits the “bootstrap loader” mode
- During a firmware update to a newer version, all of the parameters will remain to their former settings. In WinEDC – Terminal, you can set all of the parameters to their default values using the “sysreset=590” command.
- After an **update to an older version**, all of the parameters must be set to their default values. To do this, enter the command “sysreset=590” in WinEDC Terminal!

5.5 Loading the Parameter Set

The complete parameter set is described in the next section!

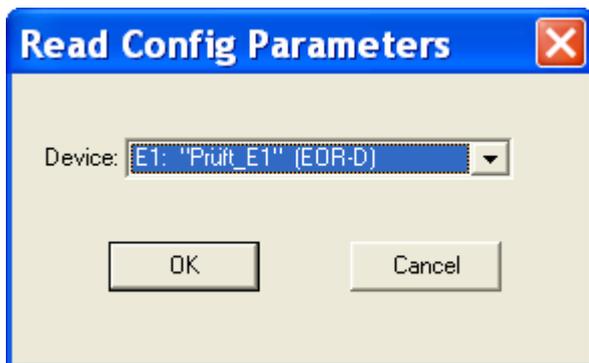
5.5.1 Loading the Parameter Set into the Device(s) using the “Send” Button.

(alternatively using the menu: File - Send)



5.5.2 Reading the Parameter Set from the Device Using the “Get” Button.

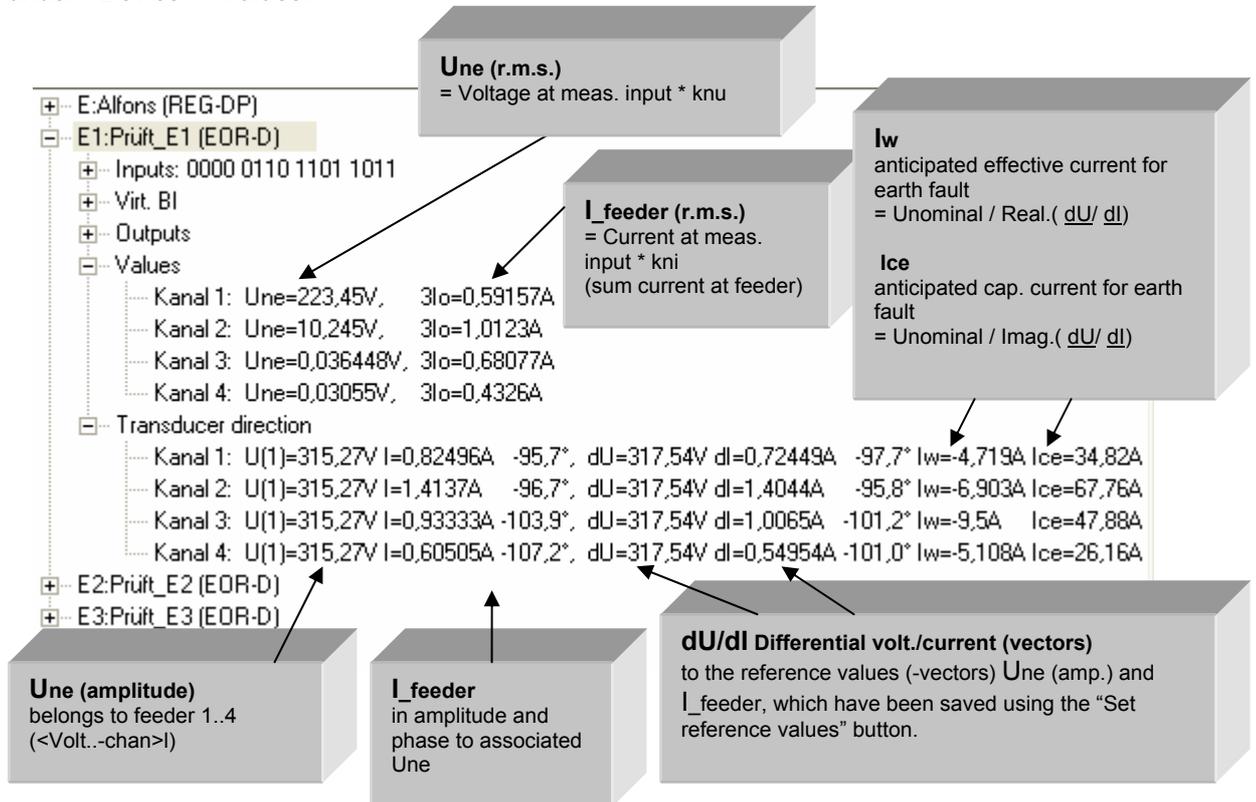
(alternatively using the menu: File - Get)



5.6 Testing the Voltage and Current Measurement Inputs

The WinEDC – Service screen is used for checking all of the important measurement values and some of the derived values.

The r.m.s. value of the 4 voltage channels and 4 current channels is displayed in the left window under <Device> - Values.



Note

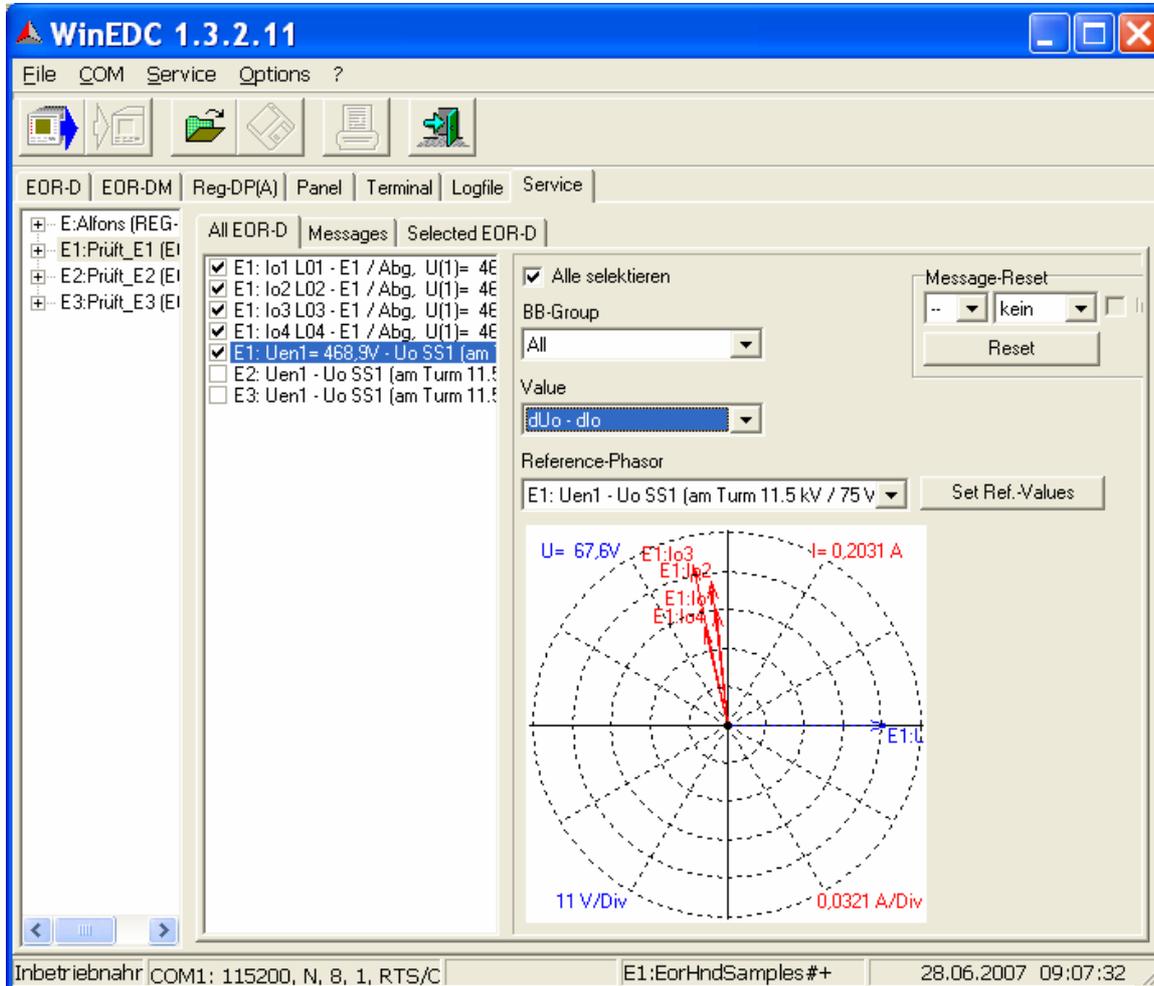
The current measurement can be checked by feeding an additional defined current through each cable-type current transformer.

5.6.1 Transformer Direction Test

In the healthy network, the feeders in the zero system should be considered to be capacitors. All currents must therefore lead (approx. -90°) the associated neutral earth voltage (same group). See vector diagram.

Inaccuracies that occur with small neutral earth voltages can be avoided via differential measurement:

- In the "variable" field, select " $dU_o - dI_o$ "
- The Petersen coil is adjusted so that the neutral earth voltage is at a maximum (position at resonance point).
- Press the "Set reference values" button. This saves the measurement values of the zero sequence voltage and values of the residual currents and uses them as reference values.
- Then the Petersen coil is adjusted so that a clear change to the neutral earth voltage results.
- The current should lead the voltage again in a capacitive manner (approx. -90°) for the displayed vectors dU_o and dI_o



Special case: for feeders with E-coils, the direction of the current turns around if the inductivity on this feeder dominates.

5.6.2 Checking the Synchronisation Voltage

The synchronisation voltage cannot be measured directly as a value. The input signal is immediately converted to a square signal internally.

The synchronisation should therefore be checked using a multimeter directly at the device input. It is possible to make an indirect measurement by observing a U_{ne} voltage. The vector must not rotate, i.e. the angle measurement of the 50 Hz components should be stable if the neutral earth voltage is in the range of a few %.

5.7 Testing the Digital Inputs, Outputs and LEDs

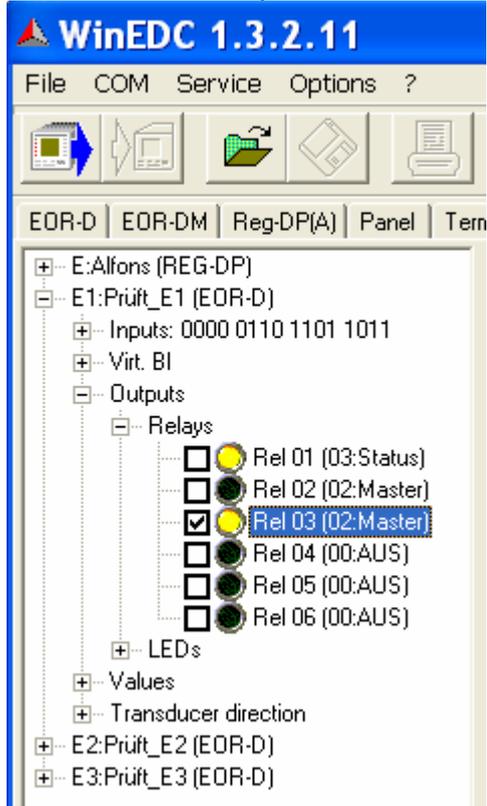
5.7.1 Checking the Relay Outputs

The messages from the relay to the control room or the SCADA system can be checked using the WinEDC – Service screen.

The current states of the relays are displayed in the left window under <Device> - “Outputs” – “Relays.”

An activated relay is displayed with a yellow circle.

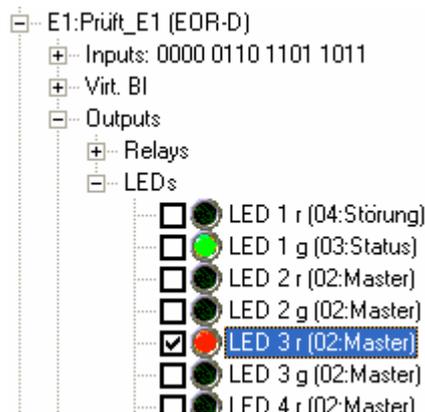
The status of the relay can be inverted by clicking on the checkbox in front of it.



Important: After carrying out the test, the inversion must be undone (the relays reset automatically when the service screen is closed).

5.7.2 Testing the LEDs

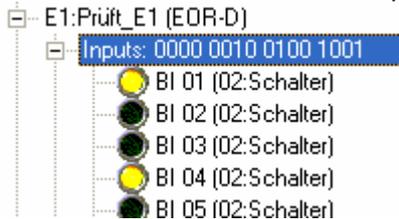
Functions in the same way.



5.7.3 Testing the Binary Inputs

The current states of the binary inputs are displayed in the left window under <Device> - "Inputs."
A active signal level is displayed with a yellow circle.

In addition, all states are also displayed as binary code (BI 1 far right, etc.).



5.8 Testing the Communication to the SCADA System

All present locating messages are displayed on the WinEDC – Service screen – messages (in the right window). Additional messages can be simulated by clicking the mouse. These messages are also output via relays and LEDs and are sent to the SCADA system.

Note

The parameterset in WinEDC and in the device must be the same (synchronize, by reading parameter from device), so that the messages can be displayed correctly.

Autom. generation ...
 activated: the messages simulated by the "override" are also considered in the locating messages.
 deactivated: Deactivating also ends the override.

Override mode/Override (OVR)
 Activates if a message is simulated by mouse click.
 End OVR:
 - After the OVR resid. time (10 min)
 - When exiting the page or
 - By pressing the "Stop OVR" button

All EOR-D Messages Selected EOR-D

Device: E1:Prüft_E1 Master Id: E1: Message-Reset: none [Inv] Override mode (OVR): 575 balance time (OVR)

Status: Master [Reset] [Stop OVR]

autom. Generieren von Ortungsmeldungen

Io-Channel:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Transient forward																										
Transient backward																										
Harmonic forward																										
Harmonic backward																										
Pulse																										
Wattmetric forward			X																							
Wattmetric backward			1																							
Localization #1																										
Localization #2			X																							
Localization #3																										
Localization #4																										

	Global	BB1	BB2	BB3	Grp1	Grp2	Grp3	Grp4	U1	U2	U3
Earthfault signal	X	X			X					X	
Transient signal											
Harmonic signal											
Pulse signal											
Wattmetric signal	X	X			X						

Simulated message in override
 Simulated by mouse click
 0: message off
 1: message on

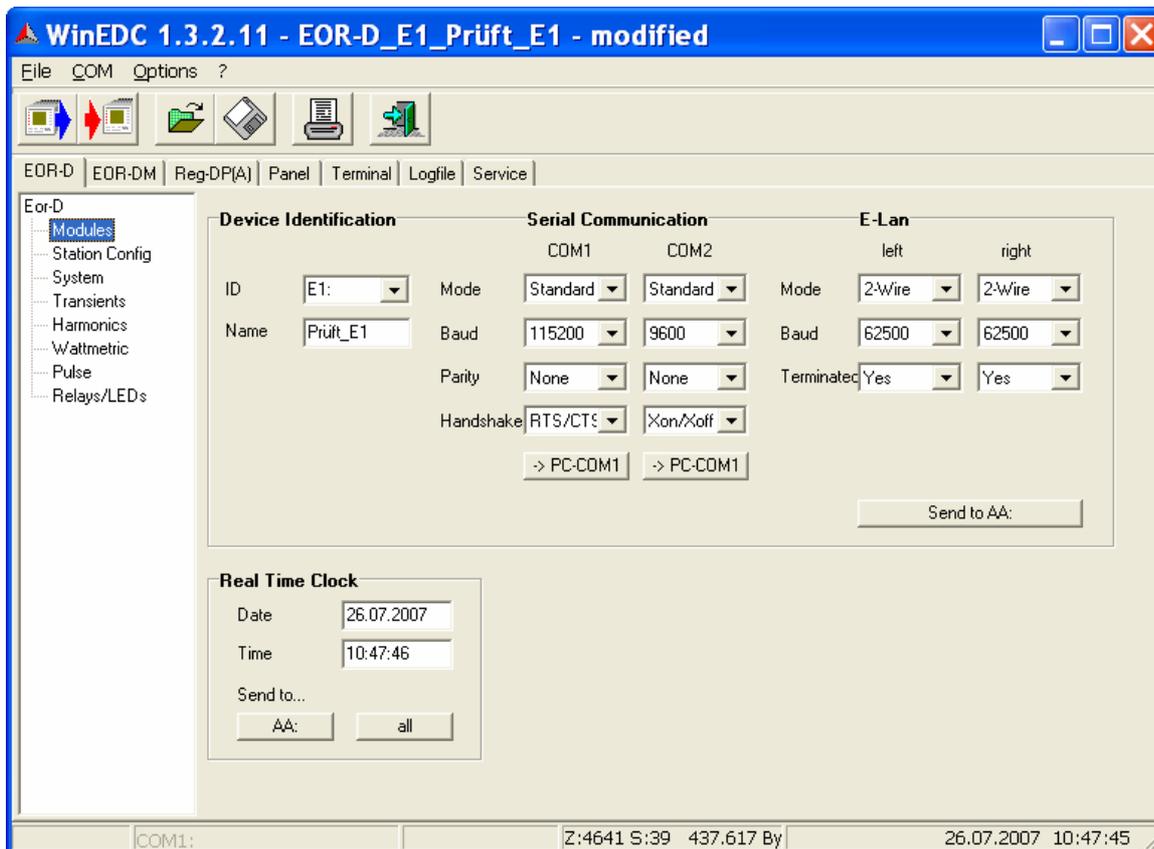
Messages from the device
 X: generated by the device, e.g. earth fault on feeder 3:
 - Wattmetric forward has been detected
 - Message is also linked in "Localization #2" message
 - Feeder attached to SS1; in group 1; associated to Une1

6 EOR-D Parameterisation with WinEDC

In general:

All parameters are set as primary values!

6.1 Screen “Modules”



ID

ID (address) of an EOR-D for unambiguous distinguishing of several EOR-Ds that work together on one E-LAN.

In all, up to 255 addresses can be assigned: A:, A1:, A2:, ...A9:, B:, B1:, ...B9:, C:, , Z4

Note: The IDs of all existing devices are also automatically read from the station configuration.

New: Delivery condition: E1:

Name

In addition to the unique ID, each device have its own assigned name.

The name can be entered or changed on the “Modules” and “System” parameterisation screens.

New: Delivery condition: EOR - D

Serial port

Each EOR-D has two COM ports (COM 1 on the front, COM 2 only accessible via the terminals), via which the devices can communicate with the PC, modem, COM server, etc. The port parameters must be the same on the EOR-D and on the PC etc.

Delivery condition:

Mode: Standard; Baud: 115200; Parity: none; Handshake: RTS/CTS

“->PC-COM1” button

Adapts the EOR-D settings for the PC port, which is used for the communication.

ELAN

Each EOR-D has 2 identical E-LAN interfaces, via which the devices (and other RegSys devices) can communicate with each other.

Mode / Baud

Set the same for all devices.

Delivery condition: 2-wire / 62,500 Baud

Terminated

To prevent reflections at the ends of the cables of the E-LAN, the E-LAN terminals that are at the beginning and end of the bus must be terminated with a resistance that corresponds to the impedance of the cable.

The resistances are already built into the device and are activated via built-in relays.

Delivery condition: terminated

“Send to AA” button

All of the settings described above are sent to the directly connected device.

Important: If the parameters of the port used (e.g. COM1) have been changed, the communication to the connected device can abort. Use the “->PC-COM 1” button.

Date/Time

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

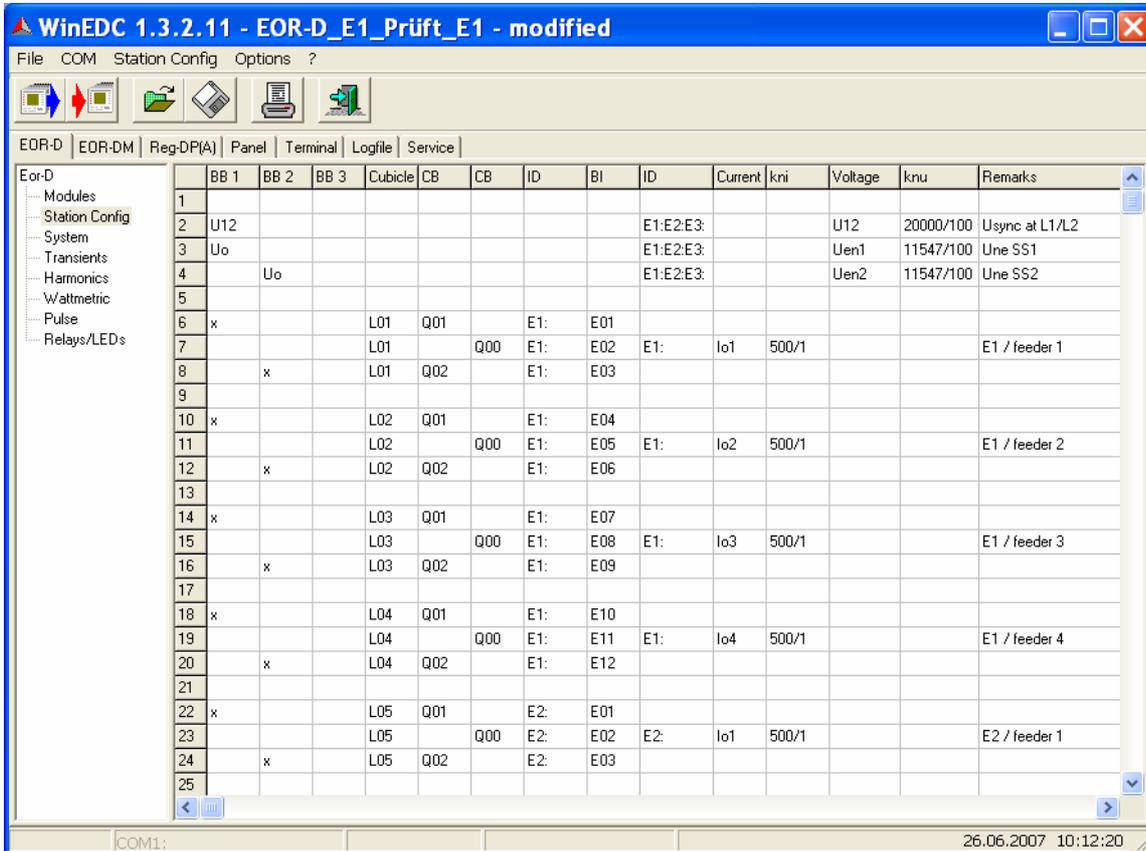
“Send to AA” button

Sends the PC data and PC time to the directly connected device

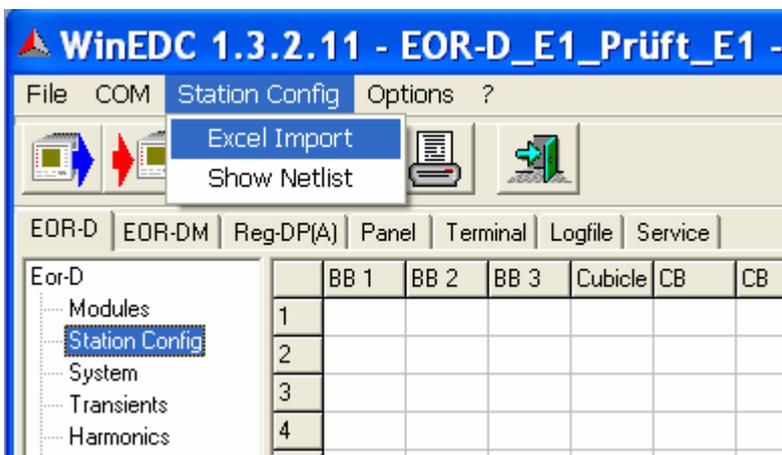
“Send to all” button

Sends the PC data and PC time to all connected devices

6.2 Screen “Station Config”



This section describes the basic EOR-D commissioning procedure based on three different configuration examples of a network. The configuration of all EOR-D inputs is implemented via the so-called station configuration. This normally takes place in an Excel table, which can be imported into the WinEDC parameterisation software after it is created. Subsequent changes are possible in WinEDC, but major changes are best dealt with in Excel (better editing capabilities).



Important: When importing, Excel must already be opened with the appropriate station configuration table.

The structure of this Excel table is based on the single-pole equivalent station configuration of the busbar.

The zero sequence voltage and the residual currents of all feeders are connected at the measurement inputs of the EOR-D. The binary input channels report the switch positions per cell/feeder to the EOR-D. It is possible to assign several feeders to a certain zero sequence voltage by means of the information on the position of the disconnectors and the circuit breakers. This assigning is called "grouping."

The two following figures show the one-line equivalent station configuration of the system on the right and the corresponding Excel display on the left.

The following always applies:

The current and zero sequence voltage of an feeder must be measured in the same device!

In other words the voltage measurements on the busbar must be distributed to all the devices; but no device ID is necessary for voltage measurements per feeder.

When loading the station configuration (together with the remaining parameters) into the devices, the IDs of the devices must agree with the IDs in the station configuration, otherwise the loading process is aborted.

Example configuration A:

- Measurement of the zero sequence voltage per busbar section
- Reporting of the switch position is available
- Grouping directly from the station configuration via the switch position is possible

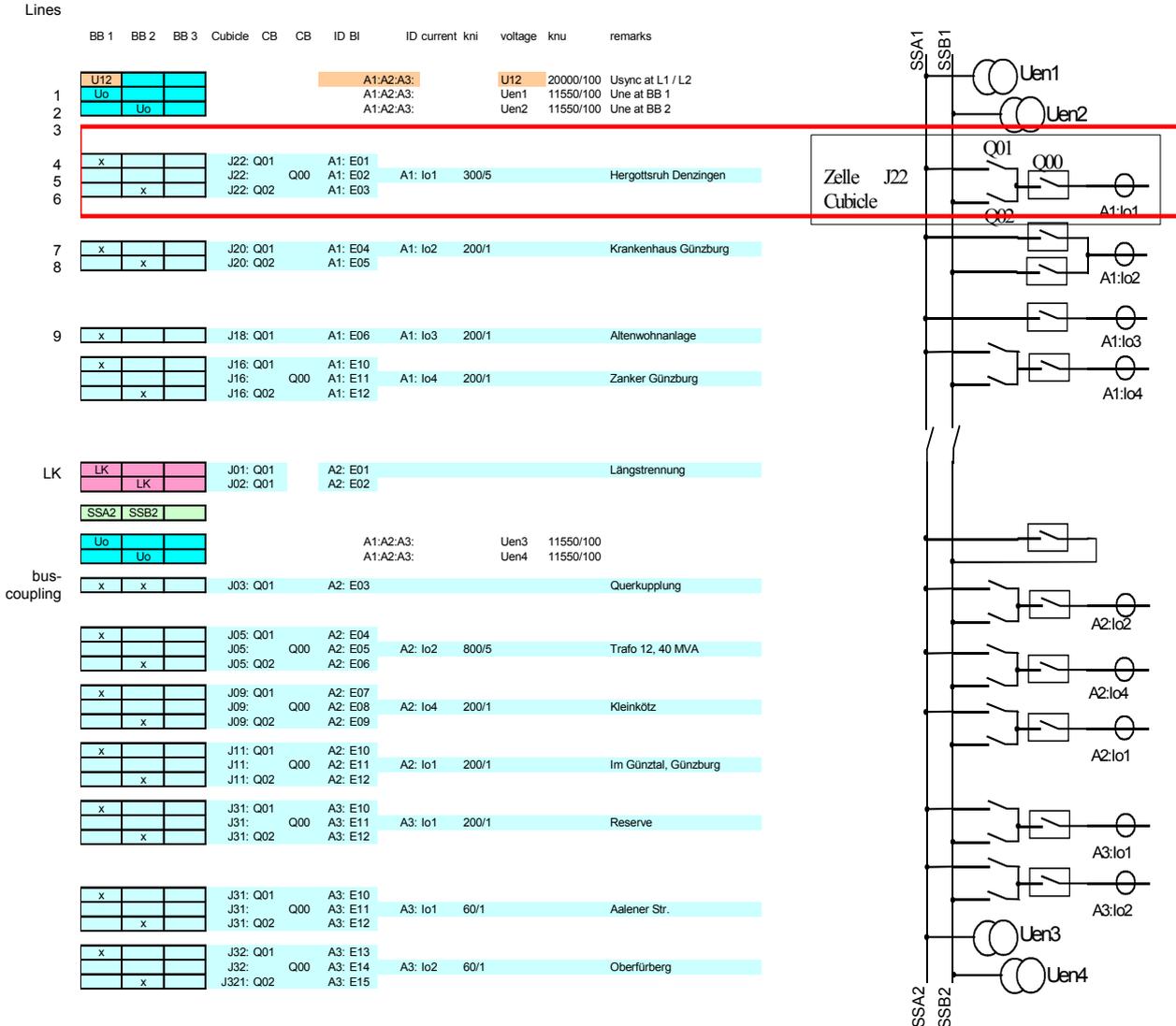


Figure 6.1: Example configuration A

Explanations of configuration A

1st Line:

Usync (=U12) is measured by devices A1:, A2: and A3: via measurement input Usync (=U12). knu is not analysed here!

2nd Line:

Zero sequence voltage. Une on busbar 1 (SS1) is measured by the devices with addresses A1, A2 and A3 with the measurement input Une1 (=Uen1). "knu" defines the conversion factor (here $20 \text{ kV}/\sqrt{3} / 100\text{V}$).

Please note: The nominal value of the secondary side of the transformer has a fixed value of 100 V!

3rd Line:

same as 2nd line

4th – 6th Line:

The first feeder is equipped with two disconnectors and a circuit breaker.

The designation of cell "J22" is the same for all of the switches of this feeder.

The switch designation (Q00...Q02) is not analysed.

The disconnector position for SS1 is reported to the device with address A1: via binary input E01.

The circuit breaker position is sent to the earth fault locating relay with address A1: via binary input E02 and the disconnector position is sent to the SSB2 busbars via the binary input E03.

The sum current Io1 of the feeder is measured with a transformer ratio of 300/5.

The "comment" for the feeder is not analysed.

7th and 8th line

The second feeder - a duplex feeder - can be coupled with two circuit breakers.

Coupling of the two busbars is possible via this feeder at any time.

9th Line:

The third feeder is permanently assigned to a busbar, but it can be connected or disconnected via a circuit breaker at any time.

"LK" lines

Describes the longitudinal coupling with reference to the binary inputs used.

Longitudinal couplings are only reported to one device; the information (longitudinal coupling closed or open) is communicated to the entire system via E-LAN.

After each longitudinal coupling, a definition for the neutral earth voltage measurement on the busbars is required again. Please see lines 2 and 3.

Bus coupling

In the case of a bus coupling, the lines for both busbars are designated with an "x."

Column SS3

the 3rd busbar is not needed in this example

Example configuration B:

- Reporting of the zero sequence voltage per feeder
- **Switch positions are not available** => The groups are formed via the zero sequence voltages

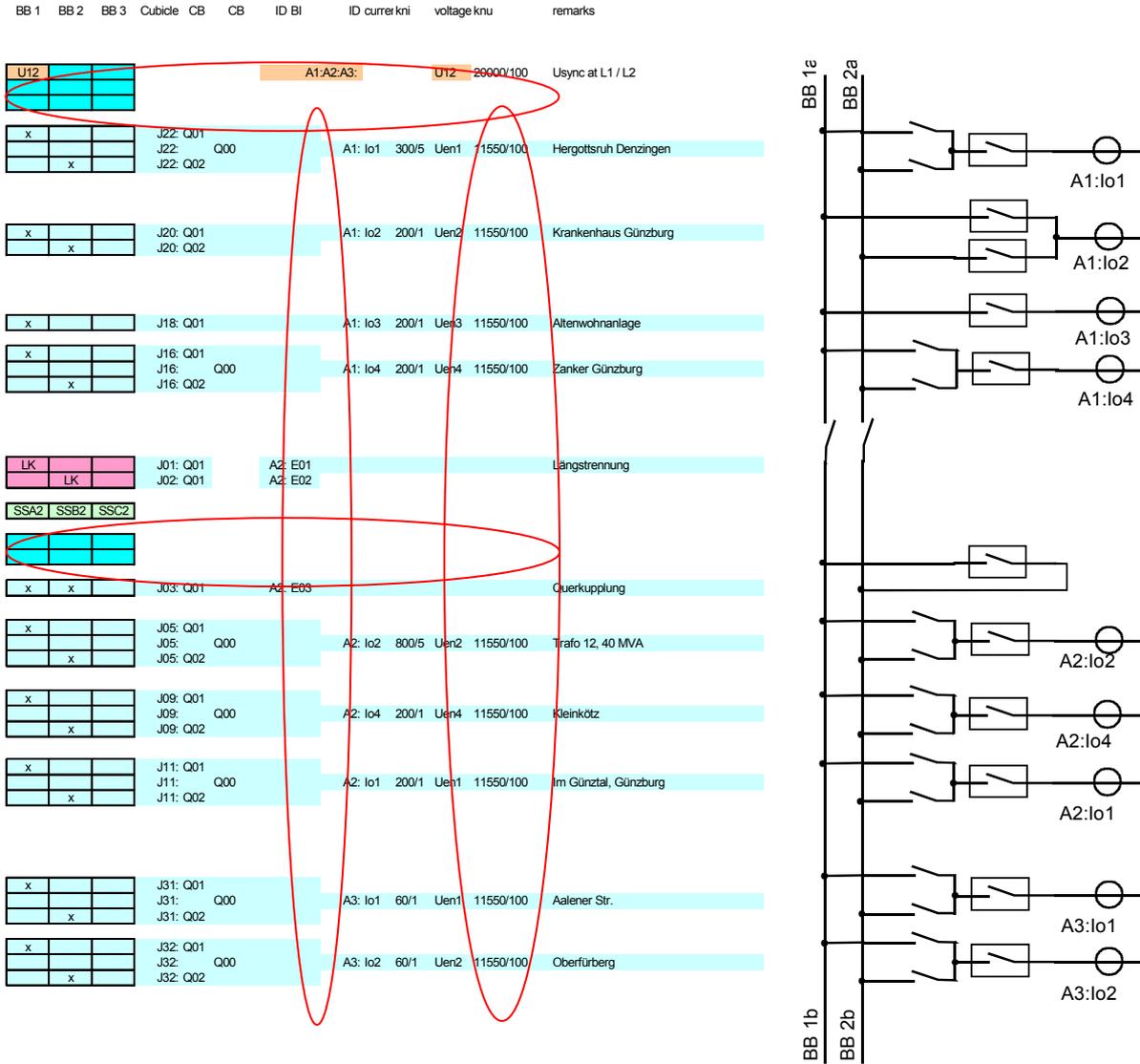


Figure 6.2: Example configuration B

Differences to example A:

- The switch positions are not reported to the individual EOR-Ds
- The zero sequence voltage U_{ne} is measured at each feeder (see “voltage” column / “knu”)

Explanation of the columns of the two Excel displays:

Column	Function
SS1, SS2, SS3	Three busbars with longitudinal couplings LK can be shown. Connected feeders are marked with an x. The measurement points are marked by Uo or by U12.
Cell	Designation of the cell, which is used. When reading-in the station configuration, all lines are grouped together into one feeder with the same cell designation.
Switch	Type and assignment of the switches or disconnectors (only for documentation)
ID BI	ID (address) and binary input of the module to which the auxiliary contact of the station configuration is connected.
ID current	ID and channel of the EOR-D for measurement of the residual current of the feeder
kni	Transformation ratio of the current transformer
Volt	Assignment of the channel of the voltage measurement
knu	Transformation ratio of the voltage transformer
Comments	Comments (not evaluated during the conversion)

Example configuration C:

- Reporting of the zero sequence voltage per feeder
- **Station configuration is not available** => Grouping via the zero sequence voltage.
- **Feeders permanently assigned to a busbar**

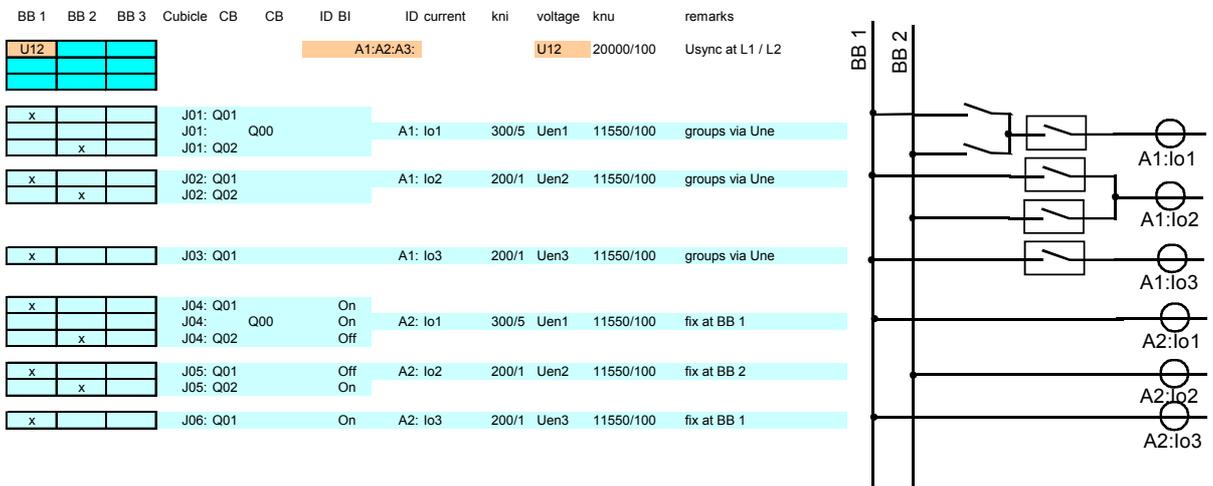
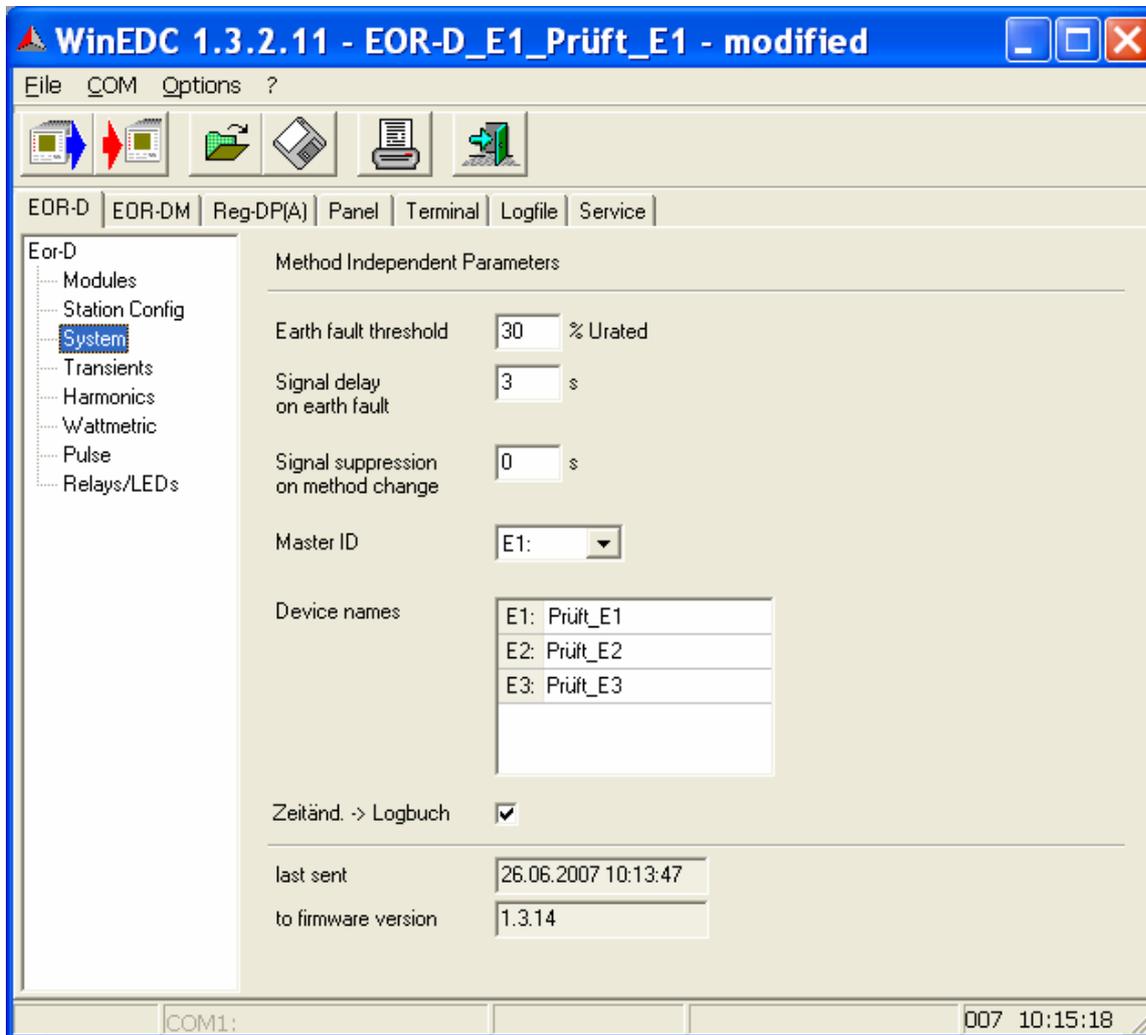


Figure 6.3: Example configuration C:

The feeders of cells J04, J05 and J06 are permanently assigned to a busbar. No wiring of the switch position is necessary. A disconnect or switch-over to another busbar is no longer detected by the relay. The associated current in the feeder is taken into consideration during grouping if the switch status is "ON".

6.3 Screen “System”



Earth fault threshold

The analyses of all locating procedures only become active if the zero sequence voltage exceeds the set limit value. The 1st harmonic (50 Hz) is used for monitoring.

The overshooting of the zero sequence voltage is detected. In the case of “Grouping without station configuration”, now, all feeders are tested to see whether their zero sequence voltages are within a tolerance range around the detected “earth fault.” If this is the case, this feeder is added to the earth-faulted group. Next comes a comparative analysis of the residual currents of this earth-faulted group.

If, however, the grouping is done via the station configuration, the groups are generated every time a binary input changes. The assignment to the group is already known when the earth fault occurs and the comparison operation of the currents can take place immediately.

Default: 30 %

Signal delay on earth fault

An earth fault (message and logfile entry) is only reported if the earth fault threshold is exceeded for longer than the specified time.

Default: 0 s

Signal suppression on method change

A pause in messaging if a switch-over from one locating procedure to another takes place on any output channel (relay, LED).

Default: 0 s

Master ID

The master ID determines which of the available EOR-D modules is working as "master." The list of possible devices is defined by the station configuration.

Delivery condition: E1:

Device names

In addition to the unambiguous ID, a name can be assigned to each module. The device name can be input on the "Module" and "System" parameterisation screens.

New: Delivery condition: E1:EOR-D

Time change -> Logfile

This parameter determines whether time changes are reported into logfile or not. Entry in the logfile does not make sense if the device is cyclically synchronised.

Default: activated

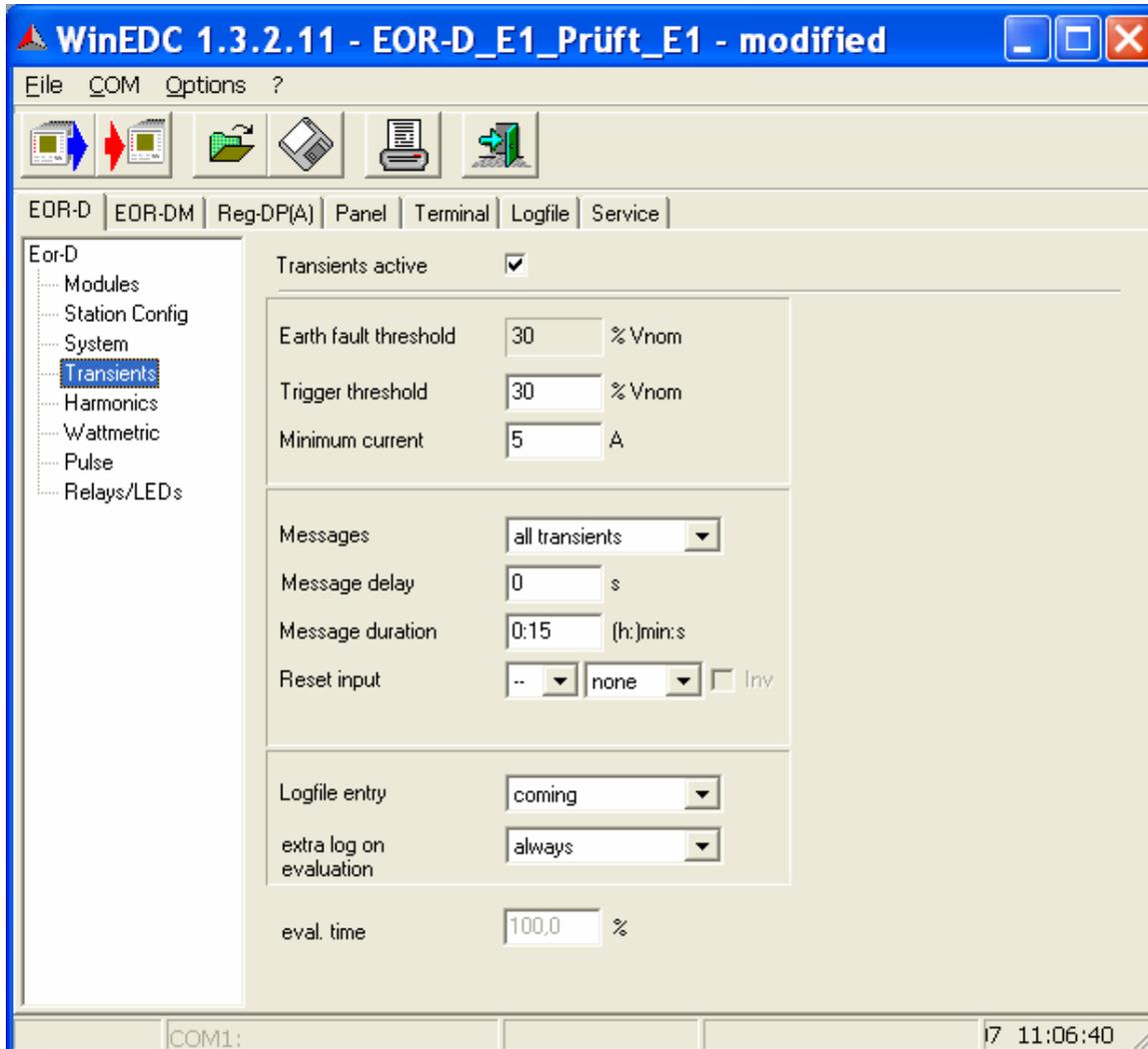
Last sent

Time at which the parameter set was last written to the device.

To firmware version

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

6.4 Screen “Transients”



Transients active

Activation of the transient earth fault procedure.

Default: activated

Earth fault threshold

Uniformly set on the “System” screen for all procedures.

Trigger threshold

The analysis of the transient earth fault procedure only becomes active if the zero sequence voltage exceeds the specified limit value.

The following cases are supported:

- Grouping via the station configuration
- Fixed assignment of the residual currents to a neutral earth voltage
- Grouping via the zero sequence voltage

If the transient earth fault procedure is used in combination with other procedures, the same trigger threshold should be used as that for the other procedures.

If different thresholds are used, the situation could arise where the earth fault transient earth fault procedure activates and the other procedures (optimised for detailed locating) cannot be used because the trigger levels for the zero sequence voltage have not yet been reached.

Default: 30%

Minimum current

If the zero sequence voltage has exceeded the threshold value, a minimum current must also flow before the device can start the locating algorithm.

The minimum value of the healthy residual network (expressed in A) is specified with this parameter.

Default: 10 A

Messages

Selection options:

All transients	all transient earth faults are reported
only cont. faults	only transient earth faults which become a long-term earth fault are reported (“earth fault message delay”)

Message delay

Transient earth faults will be reported, after the delay time that is set here.

Default: 0 s

Message duration

The transient earth fault message is automatically reset after this time.

If another locating procedure is already active at this point in time, a switch-over to this procedure takes place.

Default: 15 s

Reset input

A reset can be carried out at any time via a binary input or the SCADA system. The input signal can be inverted via the “Inv.” flag.

Default: none

Logfile entry

This parameter is used to select which events of the earth fault incident are entered in the logfile. Each entry contains at least the date, time, feeder and type of event.

Selection options:

None	No logfile entry
coming	Entry when a message appears
going	Entry when a message disappears
coming/going	Entry when a message appears and disappears

Whether or not the messages are output to the SCADA system depends on the corresponding configuration on the parameterisation screen "Relay/LED."

extra log on evaluation

Selection options:

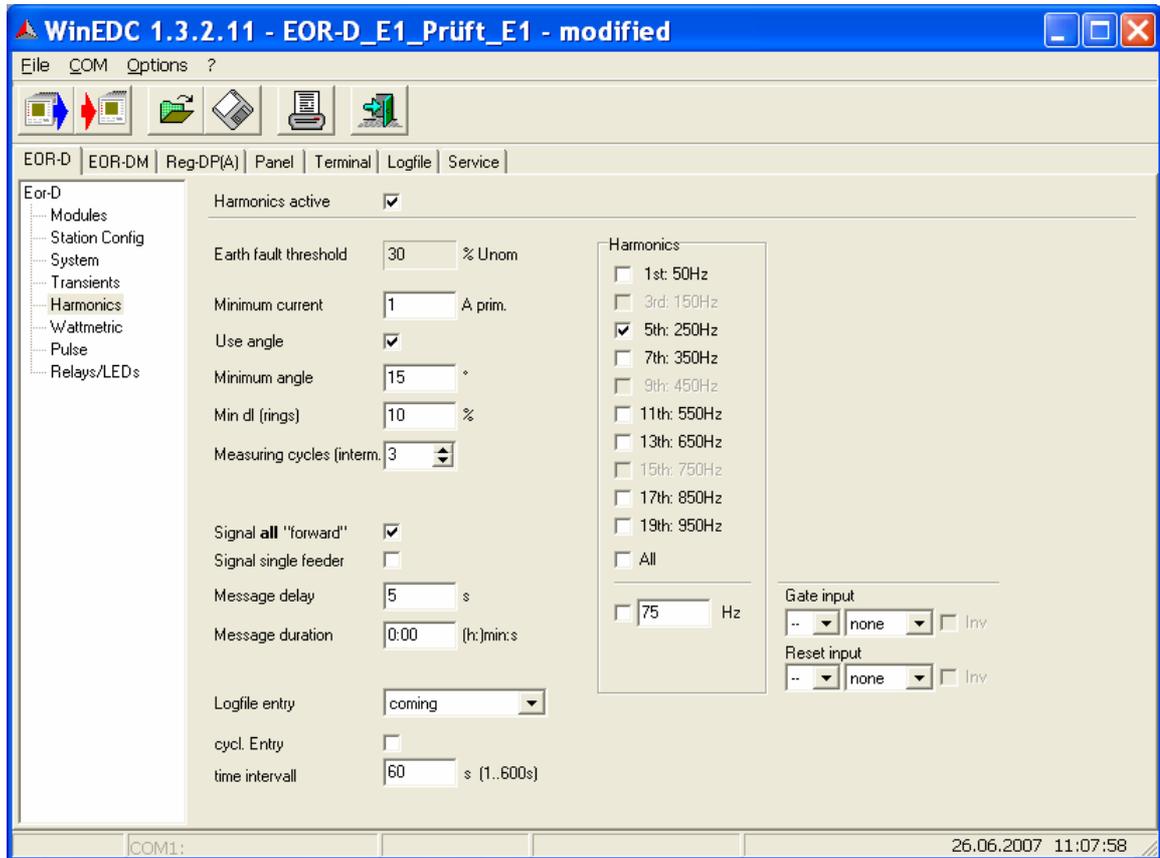
None	Entry is only made if the transient earth fault is reported. The Eval-transient earth fault messages are not entered All triggerings are entered. Eval transient earth fault: Trigger threshold has triggered, qu-evaluation not yet carried out Transient earth fault: Result of the qu-evaluation has provided valid results.
If message	
Always	

eval. time

This parameter cannot be changed.
(for further use)

Default: 100%

6.5 Screen “Harmonics”



Harmonics active

Activation of the harmonic procedure.

Default: activated

Earth fault threshold

Uniformly set on the “System” screen for all procedures.

Minimum current

The minimum current suppresses a forward or backward message being displayed for small currents which probably only occur due to interference faults. In addition, a minimum angle can also be defined. Currents that lie within this defined range do not cause an indication.

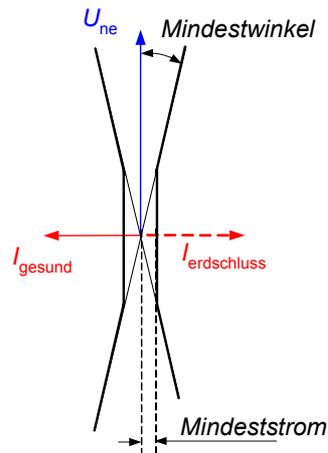


Figure 6.4: Minimum current and minimum angle

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

$$I_{250} = I_{50} \frac{\omega_{250}}{\omega_{50}} \frac{U_{250}}{U_{50}} \quad (6.1)$$

Example:

$$\begin{aligned} I_{50} &= 100 \text{ A} \\ \omega_{250} / \omega_{50} &= 5 \\ U_{250} &= 2\% \end{aligned}$$

Applying these to the equation (5.1) results in: $I_{250} = 100 \text{ A} * 5 * 0.02 = 10 \text{ A}$

Default: 1 A

Use angle

If this function is activated, the angle information is taken into consideration when determining the earth-faulted feeder.

If this function is deactivated, only the largest harmonic current is used as a selection criterion. In configurations with only two feeders, false indications are bound to occur, because the current that is flowing in the direction of the busbar is approximately the same as the current flowing in the faulty wire. Using the angle information, the faulty wire can accurately be distinguished from the healthy wire even in a setup with only two wires.

Default: activated

Minimum angle

In addition to the minimum current, a minimum angle can also be parameterised in order to take angle errors of the current and voltage transformers into consideration.

Default: 15°

Min dl (rings)

If feeders are connected to rings, all of the feeders that are connected to the earth-faulted feeder will indicate in the forward direction. (Note: The parameters “Report all forward” and “Use angle” must be activated in this case)

If the analysis of the angle information is deactivated, only the largest current can be analysed. If the error lies in the middle of two feeders, it can cause oscillations in the indication of the “largest earth fault current.” This oscillating indication is suppressed by the “minimum dl” hysteresis.

Default: 10%

Measureing cycles (interm.)

To reduce the number of messages during intermittent earth faults, the measurement cycles specified here must at least result in the same earth fault direction before the earth fault message is sent.

Default: 3

Signal all “forward”

Activated: For rings, all of the feeders for the fault location are displayed
Deactivated: For rings, only the feeder that has the shortest electrical path to the fault location is displayed. Of all the forward directions, only the feeder on which the largest current is measured is displayed.

Default: activated

Signal single feeder

A healthy network is needed “behind” the EOR-Ds to detect a current in the forward direction. If, however, only one feeder is available, no harmonic current can be measured. If this function is activated, an earth fault message is output even if the EOR-D only detects a single feeder in the earth faulted group via the station configuration or via the grouping.

Default: deactivated

Message delay

If an earth fault is detected, the message is only sent after this set message delay.

Default: 1 s

Message duration

The analysis of the zero sequence voltage and the residual currents is done cyclically. Switchovers in the network are therefore immediately taken into consideration, i.e. when the earth fault switches to another feeder, the display of the earth-faulted feeder immediately updates.

The earth fault display goes out as soon as the the zero sequence voltage undershoots the set limit value. The message of the earth-faulted feeders can be extended using this parameter.

Default: 0 s

Logfile entry

This parameter is used to select which events of the earth fault incident are entered in the logfile. Each entry contains at least the date, time, feeder and type of event.

Selection options:

None	No logfile entry
coming	Entry when a message appears
going	Entry when a message disappears
coming/going	Entry when a message appears and disappears

cycl. entry

The harmonic currents can be entered in the logfile cyclically for an earth fault.

Default: deactivated

Note: This function is reserved for special cases and can only be activated after consultation with A. Eberle.

Time interval

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

Default: 60 s

Note: This function is reserved for special cases and can only be activated after consultation with A. Eberle.

Harmonics

The frequencies to be monitored can be defined in this range.

For isolated networks, there are advantages to use only the 1st harmonic (50 Hz).

Up to three frequencies can be specified.

If "All" is activated, the relay itself searches for and evaluates the three largest harmonics (excluding the 1st harmonic).

Default: only 5.: 250 Hz

Gate input

A ripple control signal can also be used for generating harmonic voltages. The ripple control system is normally only switched on for a few seconds during the earth fault. The locating of the earth-faulted feeder takes place during this “enabling.” At the end of this enabling, the forward and backward directions that are detected at this point in time are saved. The duration of the saving depends on the parameters “message duration”, “Reset input”.

The enabling pulse can be provided to a binary input of the device or via the SCADA system. The input level can also be inverted. The following parameters can be set:

- Relay ID
- Binary input
- Inversion

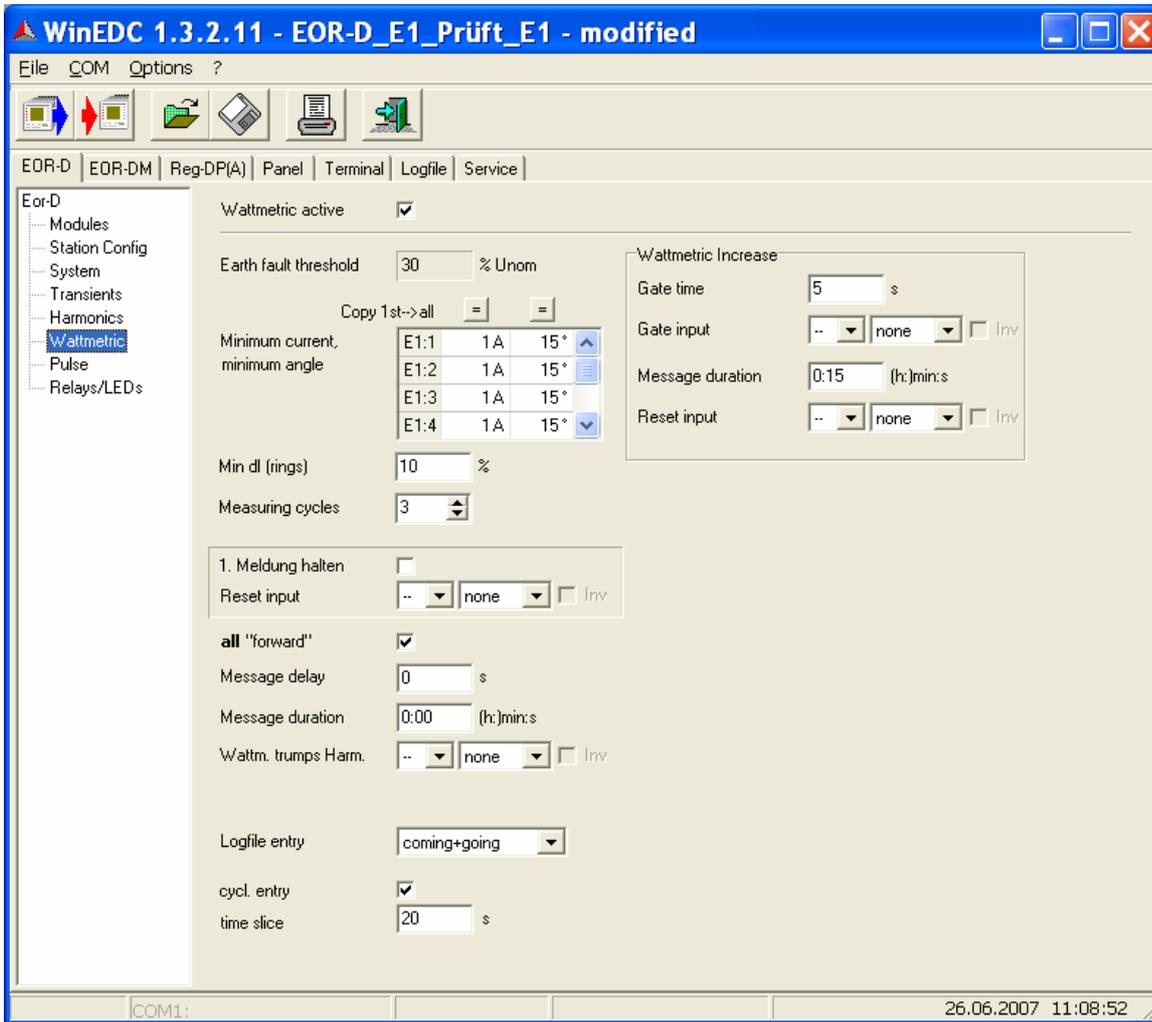
Default: None

Reset input

The messages saved with “Gate input” can be reset here. After that, a cyclic analysis and indication of the neutral earth voltage and the residual currents of the feeders is carried out. The system can be reset either via a binary input or via the SCADA system.

Default: none

6.6 Screen “Wattmetric”



Wattmetric active

Activation of the wattmetric procedure.

Default: deactivated

Earth fault threshold

Uniformly set on the “System” screen for all procedures.

Minimum current, minimum angle

Left column:

The minimum resistive component of the sum current for each feeder can be set separately.

Right column:

The minimum angle between the sum current and a purely capacitive current ($= 90^\circ$ to U_{en}) for each feeder can be separately set here.

All of the values can be set to be the same using the "=" buttons. This copies the values of the first line into the other fields.

Defaults: 1 A primary / 15°

Min dl (rings)

If feeders are connected to rings, all of the feeder that are connected to the earth-faulted feeder will indicate in the forward direction in the case of an earth fault. (Note: The parameters "all forward" must be activated in this case)

If the fault lies in the middle of two feeders, it can cause oscillations in the indication of the "largest watt residual current." This fluctuating indication is suppressed by the "minimum dl" hysteresis.

Default: 10%

Measurement cycles

To reduce the number of messages in case of intermittent earth faults. The specified minimum number of measurement cycles must point in the same earth fault direction before the earth fault message is output.

Default: 3

Keep 1st message

Activated: If an earth fault changes (without an earth fault interruption) to a different feeder (via switching actions), the feeder that is no longer earth-faulted continues to be displayed. The messages remain until they are reset by the reset input or until the earth fault disappears.

Deactivated: Only the currently earth-faulted feeders are always displayed.

Default: deactivated

Reset input

The messages saved with "keep 1st message" can be reset.

The reset can be initiated via a binary input or via the SCADA system.

Signal level =1 extinguishes all wattmetric messages. The currently earth-faulted feeders are displayed again if signal level drops =0.

Default: none

all “forward”

Activated: For rings, all of the feeders to the fault location are displayed
Deactivated: For rings, only the feeder that has the shortest electrical path to the fault location is displayed. Of all the forward directions, only that feeder with the largest wattmetrical current is displayed.
This parameterisation can lead to false indications if the path to the fault is electrically shorter via the healthy wire.

Default: activated

Message delay

If an earth fault is detected, the detected feeder is only indicated after this message delay.

Default: 1 s

Message duration

The wattmetric earth fault message is automatically reset after this time. If another locating procedure is already active at this time, a switch-over to this procedure takes place.

Default: 0 s

Wattm. trumps Harm.

The priority of the indication can be changed via a binary input. Normally, the harmonic procedure is displayed so long as the minimum current is exceeded. Via this binary input, a switch-over to the wattmetric procedure from the harmonic procedure takes place, independently of the current minimum current.

Default: none

Logfile entry

This parameter is used to select which events of the earth fault incident are entered in the logfile. Each entry contains at least the date, time, feeder and type of event.

Selection options:

None	No logfile entry
coming	Entry when a message appears
going	Entry when a message disappears
coming/going	Entry when a message appears and disappears

cycl. entry

The wattmetric currents can be entered in the logfile cyclically for an earth fault.

Default: deactivated

Note: This function is reserved for special cases and can only be activated after consultation with A. Eberle.

Time slice

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

Default: 60 s

Note: This function is reserved for special cases and can only be activated after consultation with A. Eberle.

Wattmetric increase

An increase of the watt residual current can be used to improve the indication of the wattmetric procedure. An enabling input ("Gate input") lets the EOR-D know, that the watt residual current increase is active. A measurement window is enabled by the rising edge of the enabling signal. Messages are saved at the end of the measurement window.

Gate time

The length of the measurement window for the wattmetric increase.

Default: 5 s

Gate input

The locating of the earth-faulted feeder takes place during this "enabling." At the end of this enabling, the forward and backward directions that are detected at this point in time are saved and output.

The enabling pulse can be initiated either via a binary input or via the SCADA system. Only the rising edge of the pulse is analysed. The input level can also be inverted. For this reason, the following parameters can be set:

- EOR-D ID
- Binary input
- Inversion

Default: none

Message duration

The wattmetric earth fault message is automatically reset after this time. If another locating procedure is already active at this time, a switch-over to this procedure takes place.

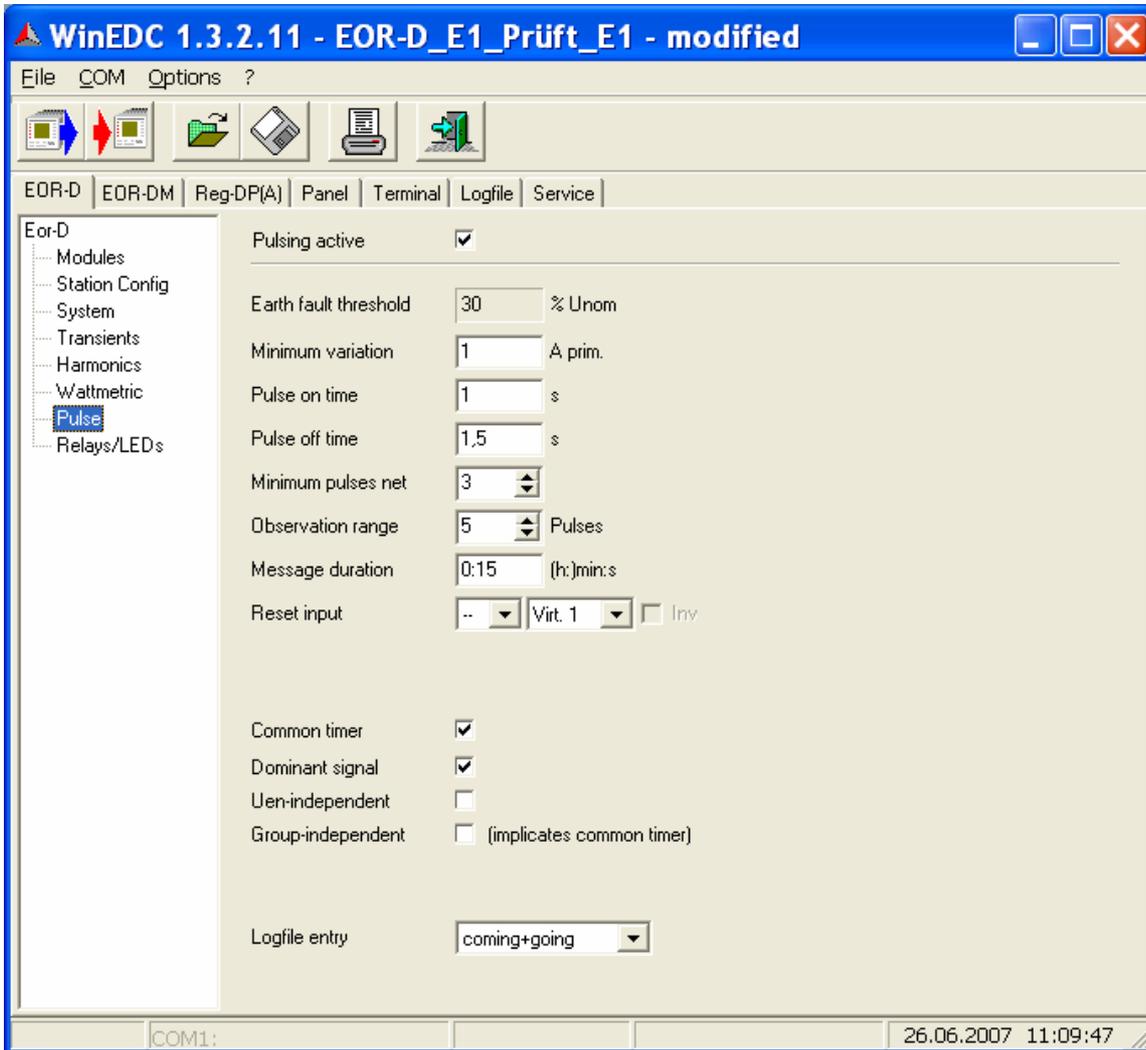
Default: 15 s

Reset input

The messages, saved with the "Gate input", can be reset here. After that, the usual cyclic analysis and indication with the wattmetric procedure is carried out. The reset input can be initiated via a binary input or via the SCADA system.

Default: none

6.7 Screen “Pulse”



Pulsing active

Activation of the pulse locating procedure.

Default: deactivated

Earth fault threshold

Uniformly set on the “System” screen for all procedures.

Minimum variation

This parameter determines the minimum current change of the pulse pattern required for detection.

Note: This value results from earth fault engineering. The clocking pulse power must be adapted to the network value.

Default: 1 A primary

Pulse-on time

Switch-on time of the detuning capacitor.

Default: 1 s

Pulse-off time

Pause time of the detuning capacitor. The capacitor is switched off during this time.

Default: 1.5 s

Minimum pulses net

Number of pulses that must be detected as “correct” within the “observation range”.

Default: 3

Observation range

The device searches for a pulse pattern in the past few seconds (moving observation range).
The length of the observation range = $n * (\text{switch-on time} + \text{switch-off time})$ in [s]
That is, why the observation range determines the minimum number of pulses that must be sent from the clock device.

Default: 5

Message duration

Once enough pulses have been detected as “correct” in the observation range, the earth fault message is sent. The message continues to be kept after the clocking (sufficient number of cycles no longer visible in the observation range) until the automatic reset time has elapsed. The message is also saved if the neutral earth voltage has already become smaller than the earth fault threshold.

Default: 15 s

Reset input

The Messages can be reset by a “binary input” or via the SCADA system (virtual input).
Default: none

Common timer

The automatic resetting of the pulse locating messages of all groups is controlled by a common timer.

Deactivated:
each group works with its own timer, i.e. with chronologically arranged earth faults in separate groups, the messages are set in succession and deleted after the respective reset time.

Activated:
all groups work with a shared timer, i.e. all pulse locating messages are deleted together (after the reset time for the last group has elapsed).

default: activated

Dominant signal

When this parameter is activated, the pulse locating overrides the other locating procedures. In this case, all of the locating messages from all of the groups in this system are reset and only the result of the pulse locating is output. It also makes sense to activate the “shared timer.”

Default: activated

Uen - independent

Message, even if the earth fault threshold is not yet exceeded, or even without the neutral earth voltage being measured by the EOR-D (detailed locating in substations)

Default: deactivated

Group - independent

Every message will be output, even if no grouping was possible.

Default: deactivated

Logfile entry

This parameter is used to select which events of the earth fault incident are entered in the logfile. Each entry contains at least the date, time, feeder and type of event.

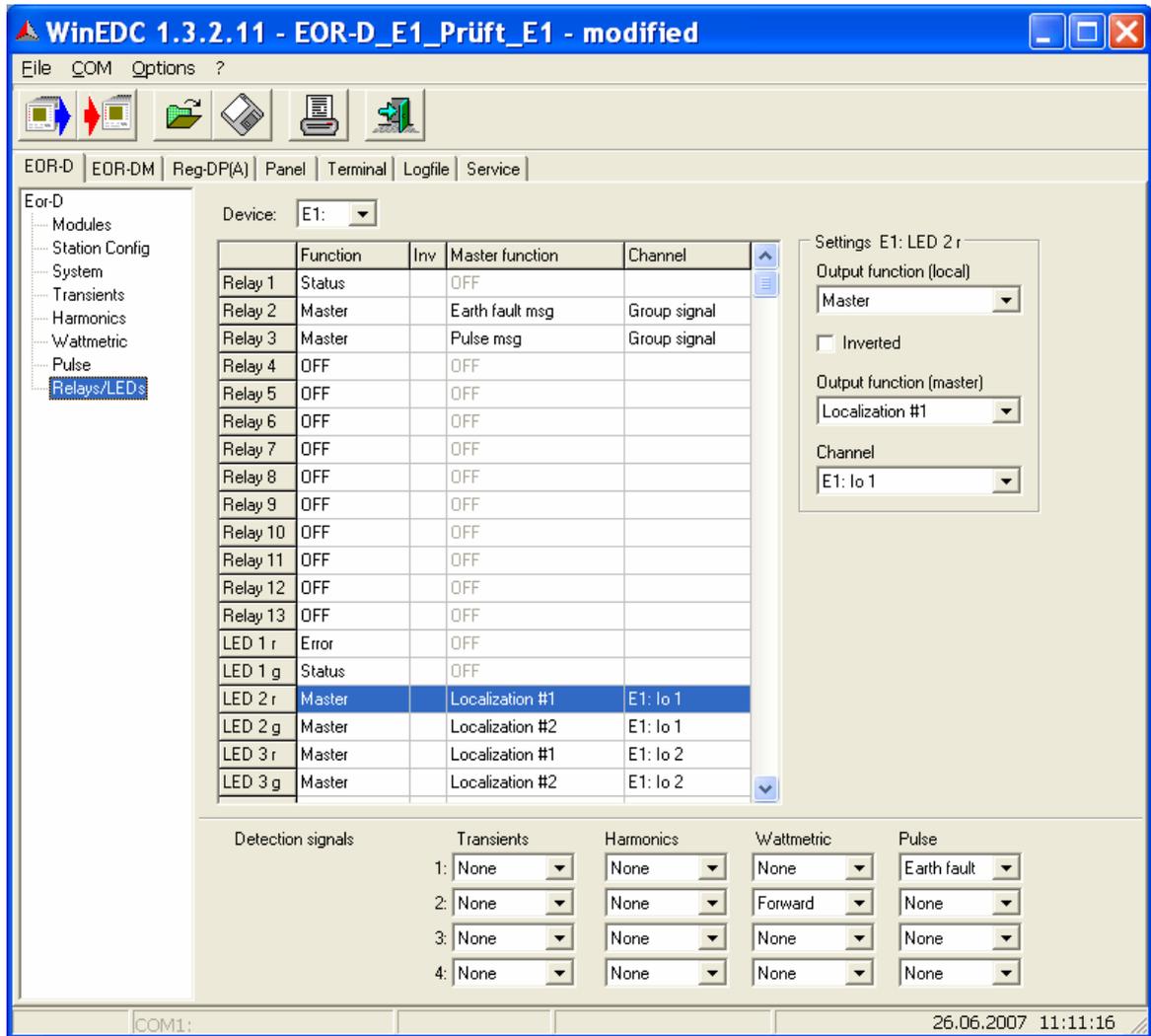
Selection options:

None	No logfile entry
coming	Entry when a message appears
going	Entry when a message disappears
coming/going	Entry when a message appears and disappears

6.8 Screen “Relays/LEDs”

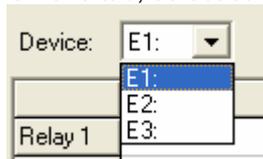
The messages via LEDs and the relays available to individual EOR-Ds can be configured via the “Relays/LED” tab.

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



Device

On this tab, select successively each EOR-D:



There are 13 relays and 5 two-coloured LEDs for each EOR-D (only 5 relays for older devices) Different messages can be linked to each relay and LED colour.

The locating results can be output in the form of four group messages.

These group messages can be assigned to each relay and/or each LED.

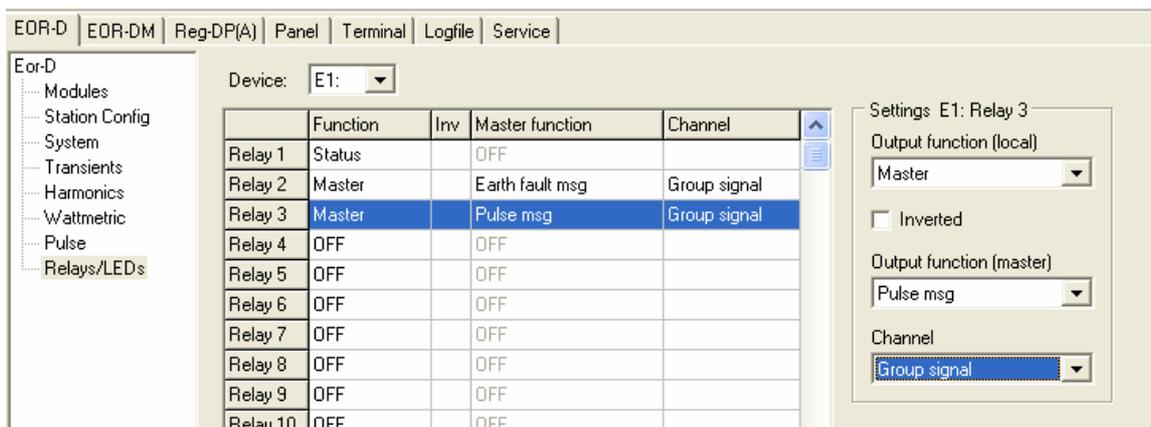
Detection signals	Transients	Harmonics	Wattmetric	Pulse
1:	None	None	None	Earth fault
2:	None	None	Forward	None
3:	None	None	None	None
4:	None	None	None	None

The following options are available for the individual locating procedures:

Procedure		Function
Harmonic	Off	None
	Forward	Only forward messages
	Backward	Only backward messages
	Both	Forward and backward directions are linked.
Transient earth fault	Off	None
	Forward	Only forward messages
	Backward	Only backward messages
	Both	Forward and backward directions are linked.
Pulse locating	Off	
	Earth fault	The earth fault is behind the measurement point
Wattmetric	Off	None
	Forward	Only forward messages
	Backward	Only backward messages
	Both	Forward and backward directions are linked.

Functions can be assigned to the individual relays or LEDs. The current setting of the relay/LED is displayed in the table.

The functions for the relays or LEDs are assigned using the four editing fields on the top right.



The screenshot shows the EOR-D configuration software interface. At the top, there are tabs for EOR-D, EOR-DM, Reg-DP(A), Panel, Terminal, Logfile, and Service. On the left, a tree view shows the configuration structure: Eor-D, Modules, Station Config, System, Transients, Harmonics, Wattmetric, Pulse, and Relays/LEDs. The main area displays a table for Device: E1:

	Function	Inv	Master function	Channel
Relay 1	Status		OFF	
Relay 2	Master		Earth fault msg	Group signal
Relay 3	Master		Pulse msg	Group signal
Relay 4	OFF		OFF	
Relay 5	OFF		OFF	
Relay 6	OFF		OFF	
Relay 7	OFF		OFF	
Relay 8	OFF		OFF	
Relay 9	OFF		OFF	
Relay 10	OFF		OFF	

On the right, the 'Settings E1: Relay 3' panel is visible, showing configuration options for the selected relay:

- Output function (local): Master
- Inverted
- Output function (master): Pulse msg
- Channel: Group signal

Settings:

Output function (local):

Output function	Description
Off	Relay is not used
Prog	Relay is activated by a background program
Master	The output function of the master determines the status of the relay
Status	Status message of the EOR-D: Status messages are only internal faults of the CPU, not EORSys system faults
Error	a detected error is output via the relay
Status & - Error	OR-linking of "Status" and the inverted "Error" function
ELAN L	Communication via E-LAN left
ELAN R	Communication via E-LAN right
ELAN error	Communication error on the E-LAN
Master lost	No connection to the master via the ELAN
Master error	Error of the master, locating not possible!
Slave(s) lost	No connection to the slave via the ELAN

Inverted:

The message is output with inverse polarity.

Master Output function (Master):

The locating algorithms are executed in the master and its output functions are designated as "master output functions." These "master output functions" are listed in the following table.

Master output function	Description
Off	
Transient forward	
Transient backward	
Harmonics forward	
Harmonics backward	
Pulse forward	
Wattmetric forward	
Wattmetric backward	
Localization #1	Self-defined locating message 1
Localization #2	Self-defined locating message 2
Localization #3	Self-defined locating message 3
Localization #4	Self-defined locating message 4
Earth fault msg	
Transient msg	
Harmonic msg	
Pulse msg	
Wattmetric msg	

Channel:

The "Channel" column defines the locating message of which feeder should be outputted.

Examples for parameterizing the relays in master E1:

	Function	Inv	Master function	Io	Description
Relay 1	Status				Status message from device E1:
Relay 2	Master		Transient earth fault forward	E1:Io1	At relay 2 from device E1: the earth fault message of the transient earth fault algorithm is output for forward direction in the EOR-D E1: Channel 1
Relay 3	Master		Harmonics Forward	E2 :Io1	At relay 3 from device E1: the earth fault message of the harmonic algorithm is output for forward direction in the EOR-D E2 : Channel 1

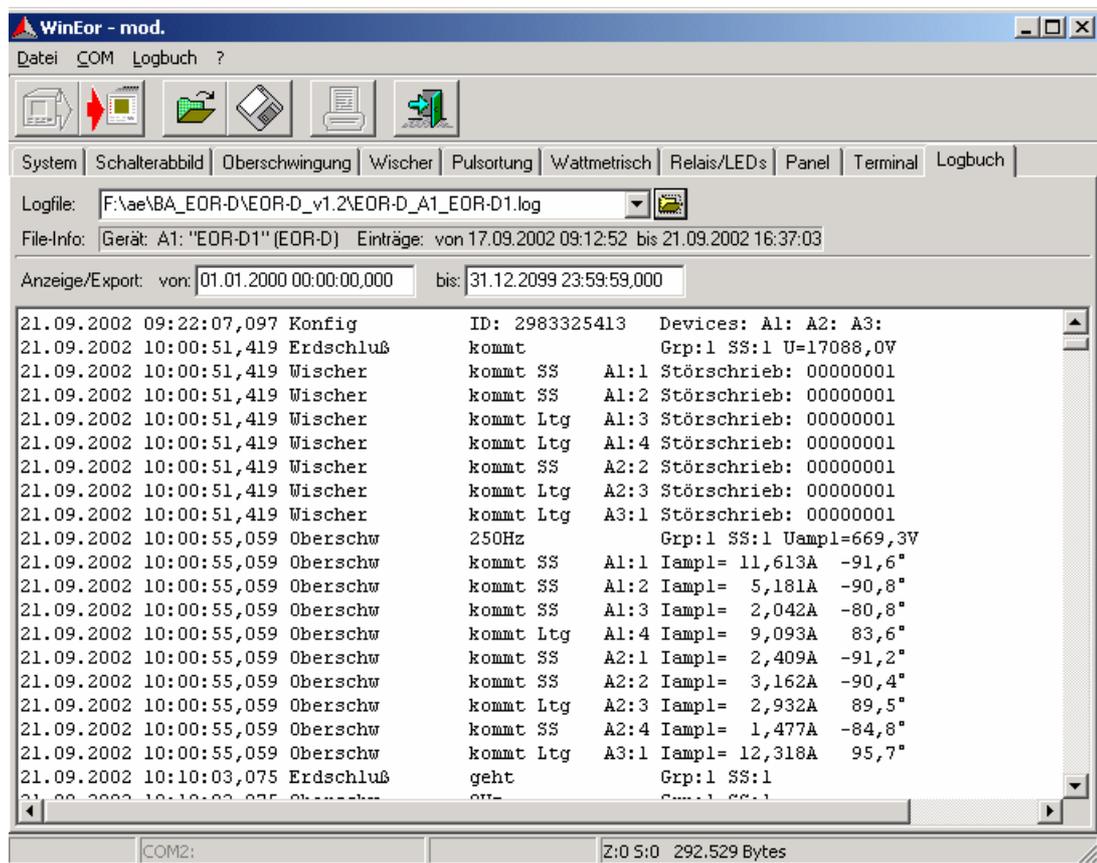
Note: It is possible, to output any earth fault (e.g. detected on feeder 1 of EOR-D E2:) on any relay or LED, on any EOR-D, in a device-independent manner.

7 Logfile

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

- Configuration changes (additionally every 24h)
- Changes of the feeder groups (additionally every 24h)
- Earth fault messages
- All messages of the locating procedures with additional information
- Binary input functions
- Setting the real-time clock
- Pauses in operations/resets
- Fault messages
- Up to 4 configurable voltages with harmonics (hourly)

The logfile can be read, displayed, archived and exported in a different format using WinEOR:



Menu items:

Font...

sets the character set for the text field and for the terminal window. A non-proportional font is recommended, because otherwise the tabular display will be lost.

Get from device...

Gets **the logfile** from the device and adds it to the current logfile. The device has a ring buffer of 1280 records. The previous last record of the file in the device has already been overwritten, a gap in the recording occurs.

First, a dialogue box appears for selecting the device. The device to which the current logfile belongs is suggested. In the event that no logfile is open, a logfile whose name is made up of the device name, device ID and device type is suggested. However, the name can also be freely selected. If the selected file and the selected device do not match, the program issues a warning.

Caution: Ignoring the warning can cause data to be lost!

This step may be required, e.g. if the ID or name of the device has changed.

Get fault record...

Gets a **set of sampling values** from a device. Every device has space for the last two transient earth fault events. The fault records are identified via an ID, which is saved in the logfile during a transient earth fault event.

First, a dialogue box appears for selecting the device and the fault record and for entering the filename for the fault record. The fault records are saved as .csv text files; the files can be opened using Excel and displayed as follows:

- Mark A2:I2050,
- Start the Chart wizard,
- Select "XY Scatter".

The values are saved as integers in mV or mA.

Split file...

The logfile is split into two files. The program ensures data consistency during this.

First, a dialogue box for entering the location to split the file and the new filenames appears.

An overlap of 5 records at the end of the file is recommended, i.e. the entirety of the current file is contained in the "old" file and the "new" file contains the last 5 records of the current file.

Export>Text

Saves the entire contents of the text window to a file.

Export>CSV (Excel)

Saves the data currently displayed in an Excel-compatible .csv file. When selecting the time interval for this, it must be considered that an Excel sheet can hold a maximum of 65,536 lines.

Updating (F5)

Refreshes the displayed text.

8 Maintenance

8.1 Changing the Fuse

Caution!

It is essential that the EOR-D voltage regulator is disconnected from the power supply before changing the fuse!

Required fuse:

Miniature fuse T (time-lag) 250 V, 2 A

You will find the fuse holder on the underside of circuit board 1

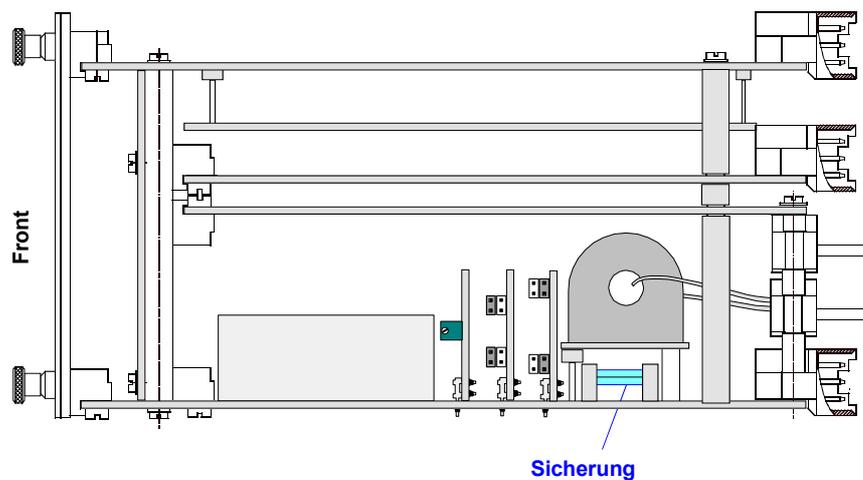


Figure 8.1: Changing the fuse on circuit board 1

8.2 Changing the Battery

Caution!

Before changing the battery, you must disconnect EOR-D from the power supply!

Required battery:

Lithium 3 V with soldering lugs type VARTA AA-6127

Service life

When stored > 6 years

In operation with a switch-on duration > 50%, the service life is > 10 years

We recommend having the battery changed in the factory.