DESIGNER'S HANDBOOK

# MDR-2

## Multi Differential Relay

4189340300J

# 1. General information

## 1.1 Warnings, legal information and safety

### 1.1.1 Symbols for hazard statements

**DANGER!**

**This highlights dangerous situations.**

If the guidelines are not followed, these situations will result in death, serious personal injury, and equipment damage or destruction.

**WARNING**

**This highlights potentially dangerous situations.**

If the guidelines are not followed, these situations could result in death, serious personal injury, and equipment damage or destruction.

**CAUTION**

**This highlights low level risk situation.**

If the guidelines are not followed, these situations could result in minor or moderate injury.

**NOTICE**

**This highlights an important notice**

Make sure to read this information.

### 1.1.2 Symbols for general notes

**NOTE** This highlights general information.

**More information**
This highlights where you can find more information.

**Example**

This shows an example.

**How to ...**
This gives a link to a video for help and guidance.

### 1.1.3 Legal information and disclaimer

DEIF takes no responsibility for installation or operation of the generator set or switchgear. If there is any doubt about how to install or operate the engine/generator or switchgear controlled by the Multi-line 2 unit, the company responsible for the installation or the operation of the equipment must be contacted.

**NOTE** The Multi-line 2 unit is not to be opened by unauthorised personnel. If opened anyway, the warranty will be lost.

**Disclaimer**

DEIF A/S reserves the right to change any of the contents of this document without prior notice.

The English version of this document always contains the most recent and up-to-date information about the product. DEIF does not take responsibility for the accuracy of translations, and translations might not be updated at the same time as the English document. If there is a discrepancy, the English version prevails.

### 1.1.4 Safety during installation and operation

When you install and operate the equipment, you may have to work with dangerous currents and voltages. The installation must only be carried out by authorised personnel who understand the risks involved in working with electrical equipment.

**DANGER!**

**Hazardous live currents and voltages**

Do not touch any terminals, especially the AC measurement inputs and the relay terminals, as this could lead to injury or death.

### 1.1.5 Electrostatic discharge awareness

Sufficient care must be taken to protect the terminal against static discharges during the installation. Once the unit is installed and connected, these precautions are no longer necessary.

### 1.1.6 Factory settings

The Multi-line 2 unit is delivered from factory with certain factory settings. These are based on average values and are not necessarily the correct settings for matching the engine/generator set in question. Precautions must be taken to check the settings before running the engine/generator set.

## 1.2 About the Designer's Handbook

### 1.2.1 General purpose

This Designer's Handbook includes function descriptions, a presentation of display unit and menu structure, the procedure for parameter setup and reference to parameter lists.

The general purpose of this document is to provide useful overall information about the functionality of the controller and its applications. This document also offers the user the information needed to successfully set up the parameters needed in the specific application.

**CAUTION**

**Lack of knowledge can be dangerous**

Read this document before starting to work with the controller and the genset to be controlled. Failure to do this could result in human injury or damage to the equipment.

### 1.2.2 Intended users

This Designer's Handbook is mainly intended for the panel builder designer. On the basis of this document and the Installation instructions, the panel builder designer will give the electrician the information he needs to install the controller, for example, detailed electrical drawings.

# 2. Preface

## 2.1 General data

### 2.1.1 Technical specifications

| | |
|---|---|
| Accuracy | 0.1 × IN < I < IN: 1 % of IN<br>IN < I: 1 % of I<br>(IN = 1 A or 5 A, I = measured value, secondary side of CT) |
| Operating temperature | -25 to 70 °C |
| Aux. supply | 12/24 V DC nominal (8 to 36 V DC operational), max. 11 W consumption<br>0 V DC for 10 ms when coming from at least 24 V DC |
| Frequency | 30 to 70 Hz |
| Measuring current | From current transformers …/1 A or …/5 A. Consumption max. 0.3 VA per phase. |
| Digital inputs | Input voltage 6 to 32 V DC. Impedance 2.4 kΩ, bi-directional. |
| Relay outputs | 250 V/8 A or 24 V DC/1 A. Refer to actual description of I/Os. |
| Safety | To EN 61010-1 installation category (over-voltage category) III, 600 V, pollution degree 2 |
| Galvanic separation | Between AC current and other I/Os: 3250 V AC – 50 Hz – 1 min. |
| EMC/CE | According to EN-61000-1/2/3/4 IEC 255-3 |
| Material | All plastic parts are self-extinguishing to UL94 (V1) |
| Climate | HSE, to DIN 40040 |
| Connections | AC currents: 4 $mm^2$ multi-stranded<br>Others: 2.5 $mm^2$ multi-stranded<br>Display: 9-pin SUB-D female<br>Service port: 9-pin SUB-D male |
| Response times | Response times are measured from end of period of measured current cycle<br>Differential current: <50 ms |
| Protection | Case: IP40<br>Terminals: IP20<br>Operator panel (option): IP40 (IP54 when mounted with gasket)<br>To IEC 529 and EM 60529 |
| Mounting | Base-mounted with six screws or DIN-rail mounted |
| Weight | Approx. 1 kg incl. packing |

# 3. Standard functions

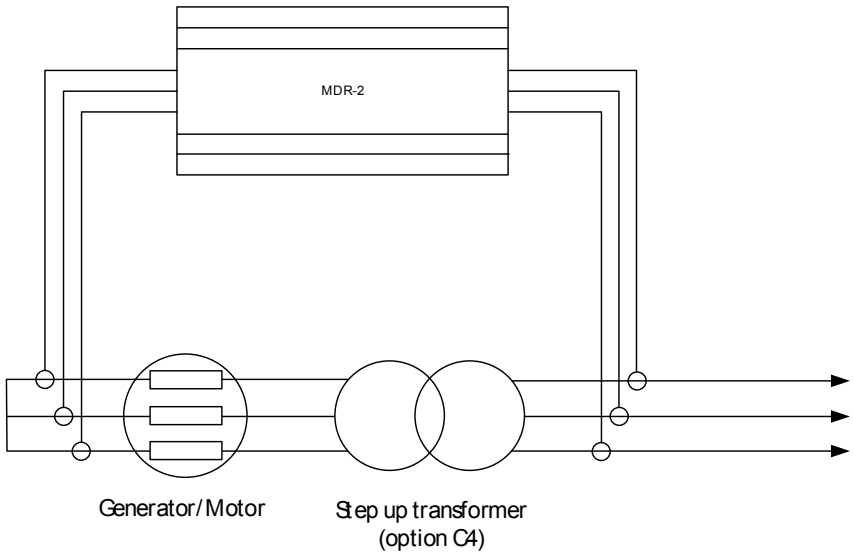
## 3.1 Differential current detection

The MDR-2 is primarily intended for protection of a generator or an electric motor against current leaks. This is accomplished by measuring the current on each side of the generator/motor and comparing these. If there is a difference (differential current), a leak is detected.

The differential current detection takes place in each phase.

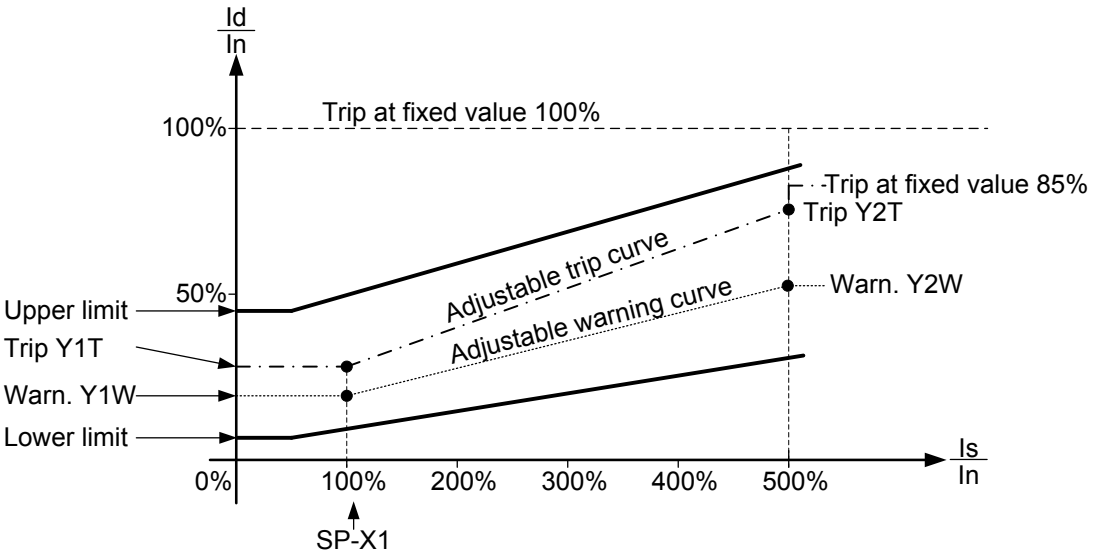
So, the differential current detection is based on:

| **Primary side (I1)** | | **Secondary side (I2)** |
|---|---|---|
| L1 | compared to | L1 |
| L2 | compared to | L2 |
| L3 | compared to | L3 |




### 3.1.1 Differential current tripping/warning

The pickup characteristics are defined using customisable curves.




The trip/warning pickup characteristics are shown above. They are a function of:

- Stabilisation current Is in relation to nominal current In (X-axis)
- Differential current Id in relation to nominal current In (Y-axis)

The lines marked "UPPER LIMIT" and "LOWER LIMIT" are the limits for the curves.

Max. values are:

- X1: 500 %
- Y1: 45 %
- Y2: 95 %

Min. values are:

- X1: 50 %
- Y1: 5 %
- Y2: 25 %

There are two sets of adjustable settings:

- Warning, set points Y1W and Y2W (can be disabled)
- Trip, set points SP-X1, Y1T and Y2T

The warning curve shares the SP-X1 value with the trip curve.

Both settings are with adjustable time delay (0.01 to 2.00 sec.)

## 3.2 Display

Front-mounted display with push-buttons and display of all measured values and alarms.

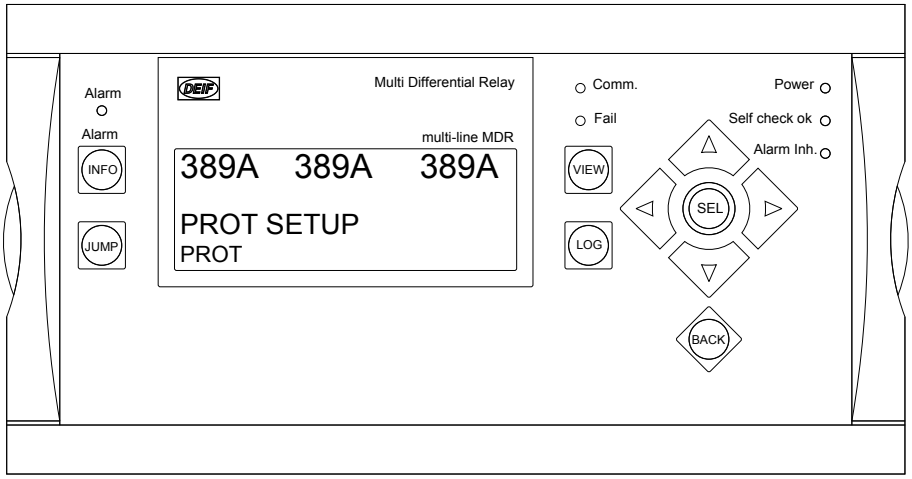
The following values can be read:

- Phase currents L1, L2, L3 primary side (I1)
- Phase currents L1, L2, L3 secondary side (I2)
- Phase currents are presented in actual current and % of nominal value

- Differential currents are presented in actual current and % of nominal value
- Stabilisation currents (average of I1 and I2 values, displayed for each phase)

The alarm and event log list can be read.

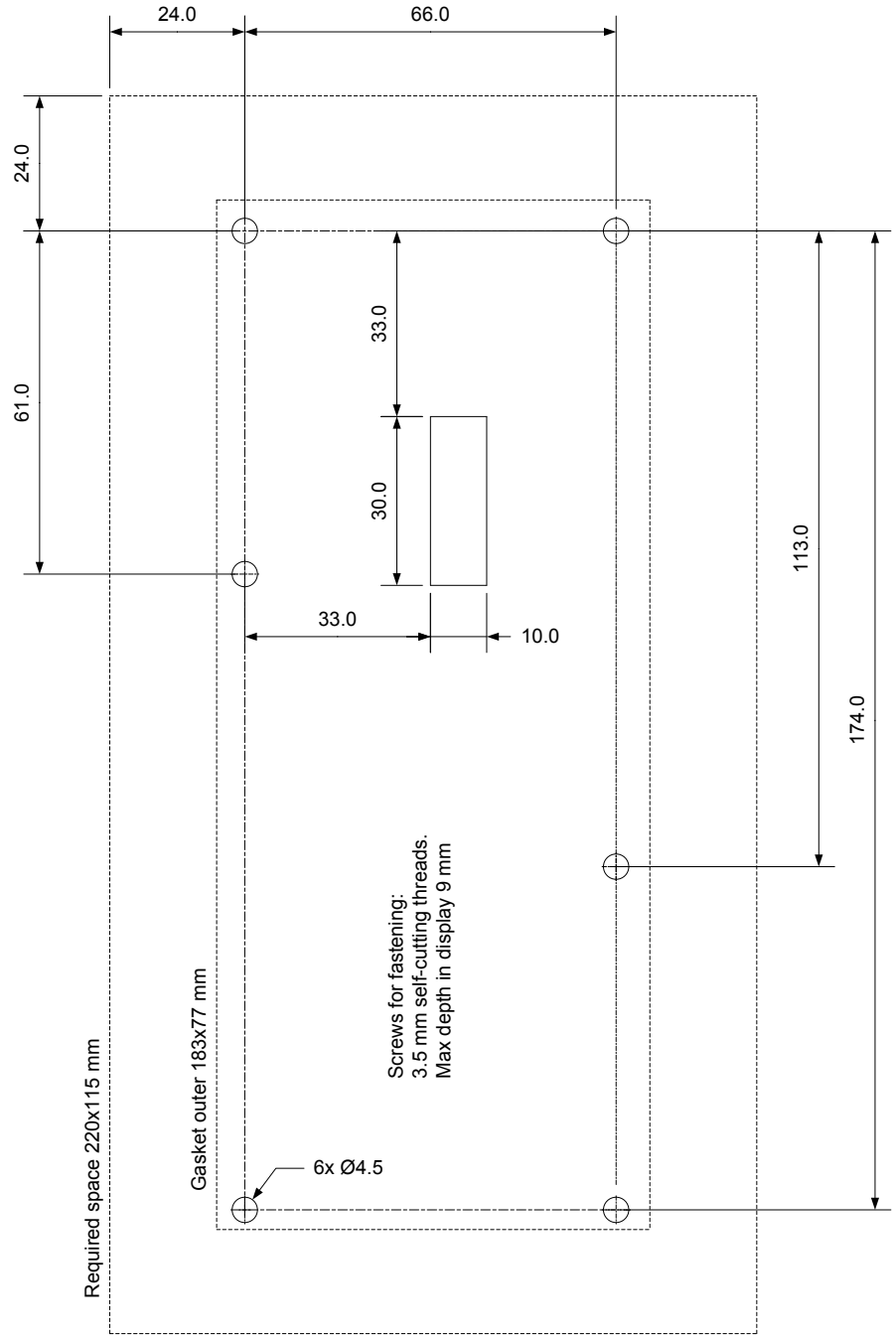
All parameter settings can be made via the display.



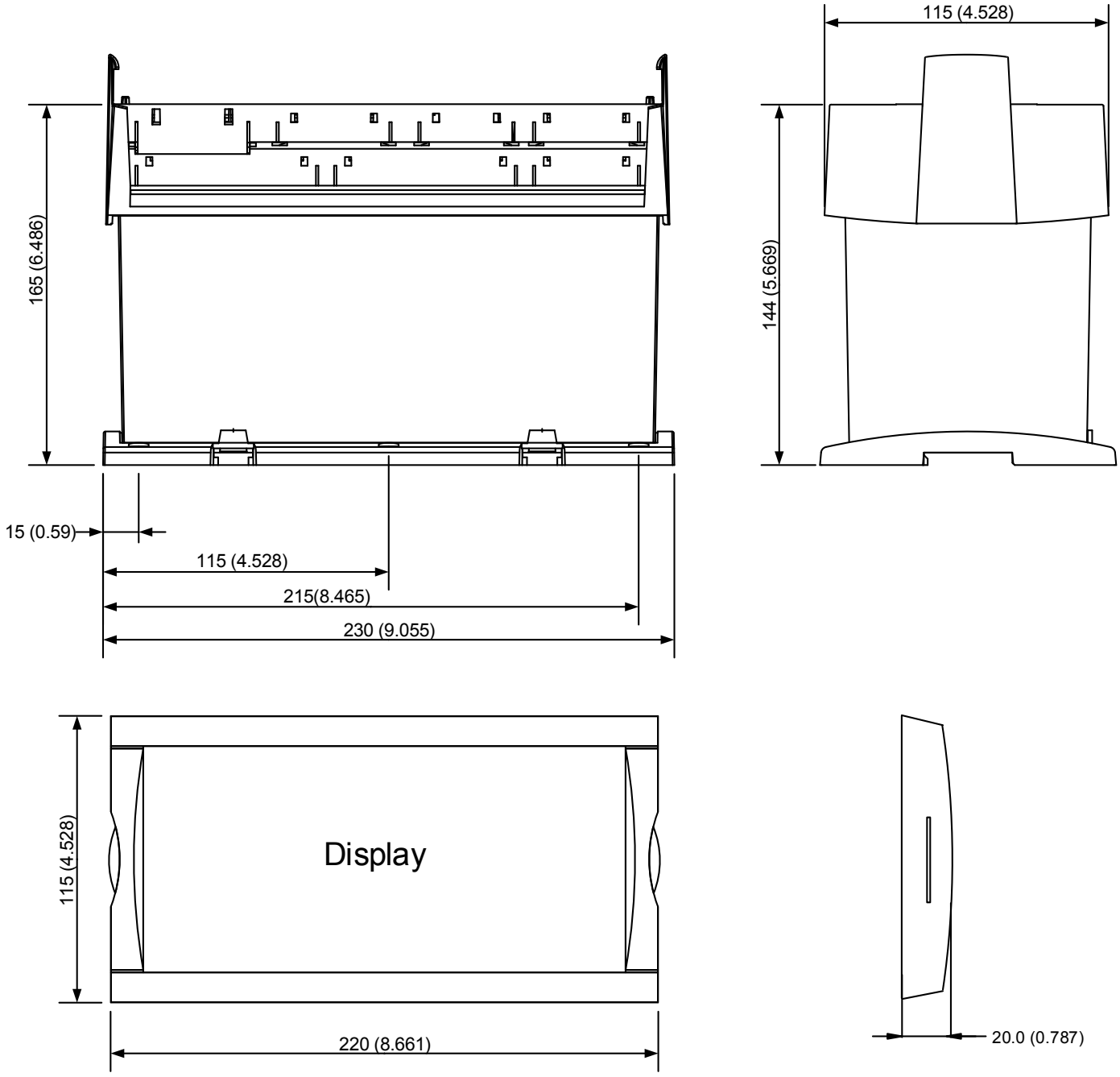

The push-buttons are:

| | |
|---|---|
| INFO: | Displays the alarm list. If no active alarms are present, the list will be empty. |
| JUMP: | Enables the user to jump directly to a specific setting instead of entering via the menu system. |
| VIEW: | Scrolls the readings in the upper line of the display (in the protection setting menu). |
| LOG: | Enters the log list. The log list contains max. 150 historical events/alarms, all with time and date. |
| SEL: | Selects the chosen menu/value (enter function). |
| △ ▽ | Up/down value buttons. Used for changing of settings, and so on. |
| ◁ ▷ | Move buttons. Moves the cursor (in the lower line of the display) during manoeuvring in the menus. |

### 3.2.1 Panel cutout for display



### 3.2.2 Unit dimensions in mm (inches)



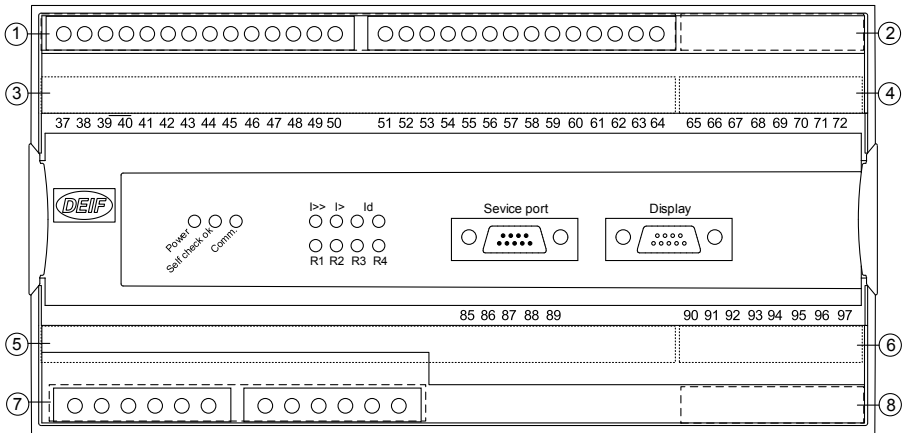
# 4. Hardware

## 4.1 Terminals and board slot positions

The Multi-line 2 housing is divided into board slot positions, some of which are standard (non-changeable) and some intended for options. The MDR-2 unit is divided like this:

| Slot | Slot type | Terminal | MDR-2 |
|---|---|---|---|
| Slot #1 | Power supply and digital I/O | 1-28 | Standard |
| Slot #2 | Not used | 29-36 | |
| Slot #3 | Not used | 37-64 | |
| Slot #4 | Not used | 65-72 | |
| Slot #5 | Not used | 84-89 | |
| Slot #6 | Not used | 90-97 | |
| Slot #7 | AC current measurement | 98-109 | Standard |
| Slot #8 | Not used | 126-133 | |

An overview of the terminals can be seen below. The slots are positioned in the unit as follows (seen from the top of the unit):




## 4.2 Base unit LED indicators

There are 11 LED indicators on the front of the base unit. The indications are:

| | |
|---|---|
| Power: | DC power is on |
| Self check OK: | The microprocessor watchdog status is OK. This relates to the "Status" relay output (normally energised) |
| Comm.: | Communication status: not used |
| I>>: | Option: short-circuit trip indication |
| I>: | Option: over-current trip indication |
| Id: | There are two LEDs. The left one is differential current warning, the right one is differential current trip |
| R1, R2, R3, R4: | Green by deactivated relay output, red by activated relay output |

**NOTE:**

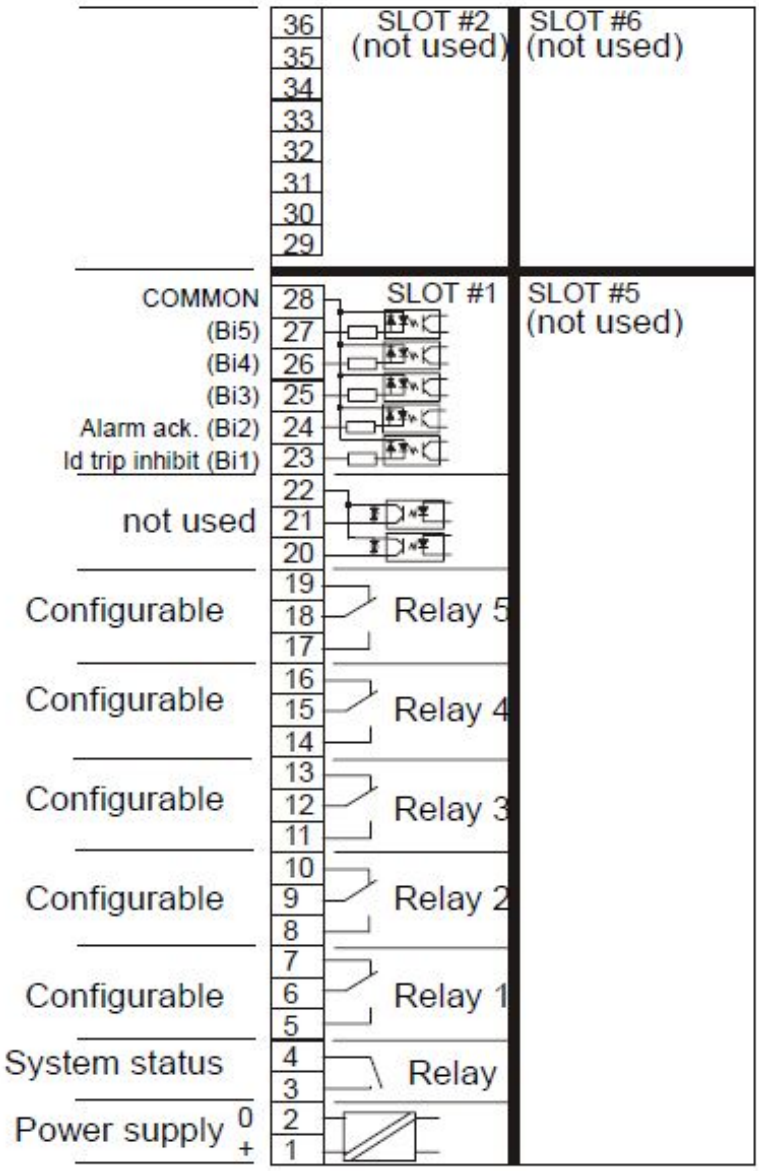
I>> and I> share the same LEDs.

I>>, I> and Id LEDs are turned off if the function is not chosen or inhibited.

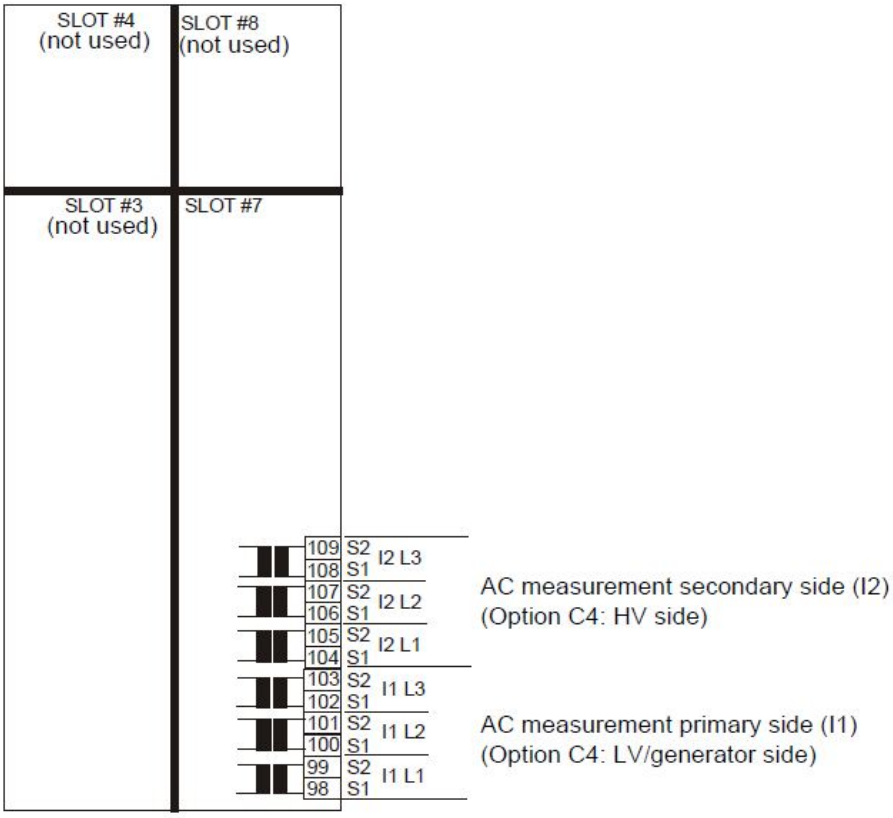
I>>, I> and Id LEDs can indicate status (yellow light) if the function is turned ON. Refer to the paragraph "Status LED".

## 4.3 Terminal strip overview

### 4.3.1 Slots #1, #2, #5 and #6



### 4.3.2 Slots #3, #4, #7 and #8




## 4.4 Terminal strip, explanation

For the relay outputs, the following terms will be used:

NO means Normally Open

NC means Normally Closed

Com. means common terminal for the relay in question

### 4.4.1 Slot #1, power supply and digital I/O

Standard board (always needed)

| Terminal | Function | Technical data | Description |
|---|---|---|---|
| 1 | +24 V DC | 24 V DC +20/-30 % | Power supply |
| 2 | 0 V DC | | |
| 3 | NC | Status relay<br>24 V DC/1 A | Normally closed relay, processor/power supply status supervision |
| 4 | Com. | | |
| 5 | NO | Relay 1<br>250 V AC/8 A | Configurable relay |
| 6 | Com. | | |
| 7 | NC | | |

| Terminal | Function | Technical data | Description |
|---|---|---|---|
| 8 | NO | Relay 2<br>250 V AC/8 A | Configurable relay |
| 9 | Com. | | |
| 10 | NC | | |
| 11 | NO | Relay 3<br>250 V AC/8 A | Configurable relay |
| 12 | Com. | | |
| 13 | NC | | |
| 14 | NO | Relay 4<br>250 V AC/8 A | Configurable relay |
| 15 | Com. | | |
| 16 | NC | | |
| 17 | NO | Relay 5<br>250 V AC/8 A | Configurable relay |
| 18 | Com. | | |
| 19 | NC | | |
| 20 | | Not used | |
| 21 | | | |
| 22 | | | |
| 23 | Digital input 1 | Optocoupler | Id trip inhibit (differential current trip inhibit) |
| 24 | Digital input 2 | Optocoupler | Alarm acknowledge |
| 25 | Digital input 3 | Optocoupler | |
| 26 | Digital input 4 | Optocoupler | |
| 27 | Digital input 5 | Optocoupler | |
| 28 | Com. | Common | Common for terminals 23 to 27 |

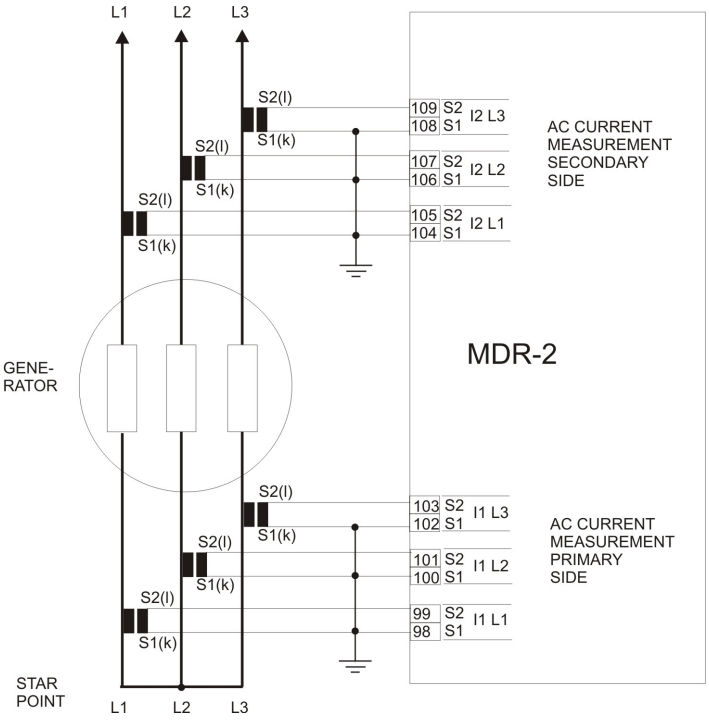
### 4.4.2 Slot #7, AC current measurement

| Terminal | Function | Technical data | Description |
|---|---|---|---|
| 98 | S1 (k) | I 1L1 | Primary side current measurements (I1) |
| 99 | S2 (l) | | |
| 100 | S1 (k) | I 1L2 | |
| 101 | S2 (l) | | |
| 102 | S1 (k) | I 1L3 | |
| 103 | S2 (l) | | |
| 104 | S1 (k) | I 2L1 | Secondary side current measurements (I2) |
| 105 | S2 (l) | | |
| 106 | S1 (k) | I 2L2 | |
| 107 | S2 (l) | | |
| 108 | S1 (k) | I 2L3 | |
| 109 | S2 (l) | | |

# 5. Wiring diagrams

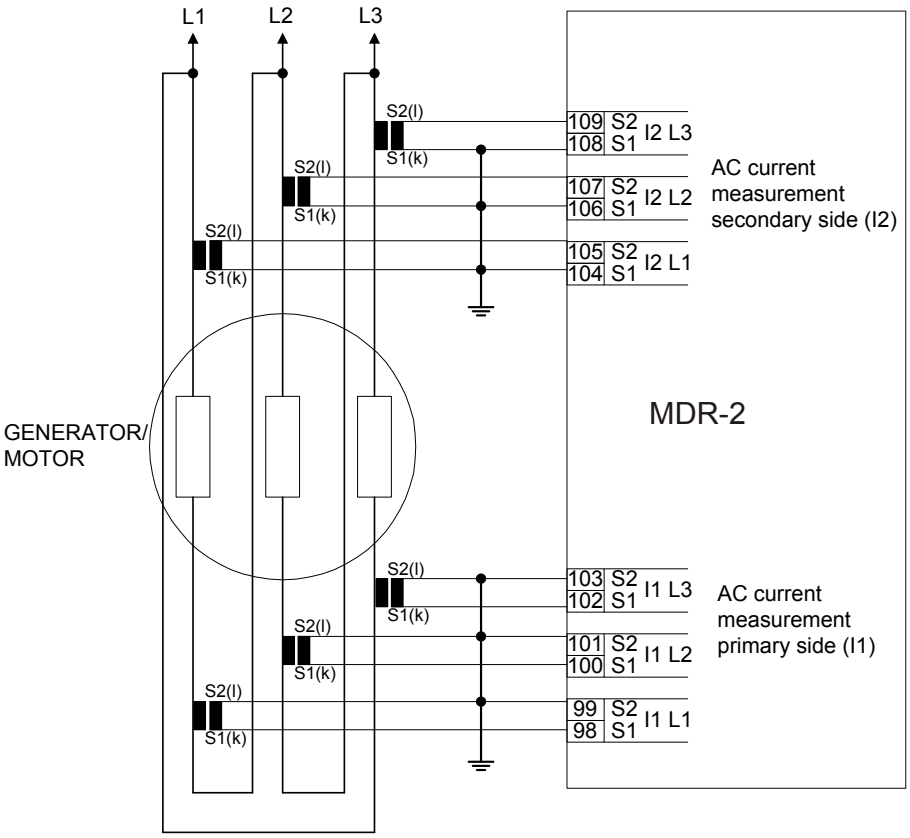
## 5.1 Coupling and connection

### 5.1.1 AC current measurements, star coupling



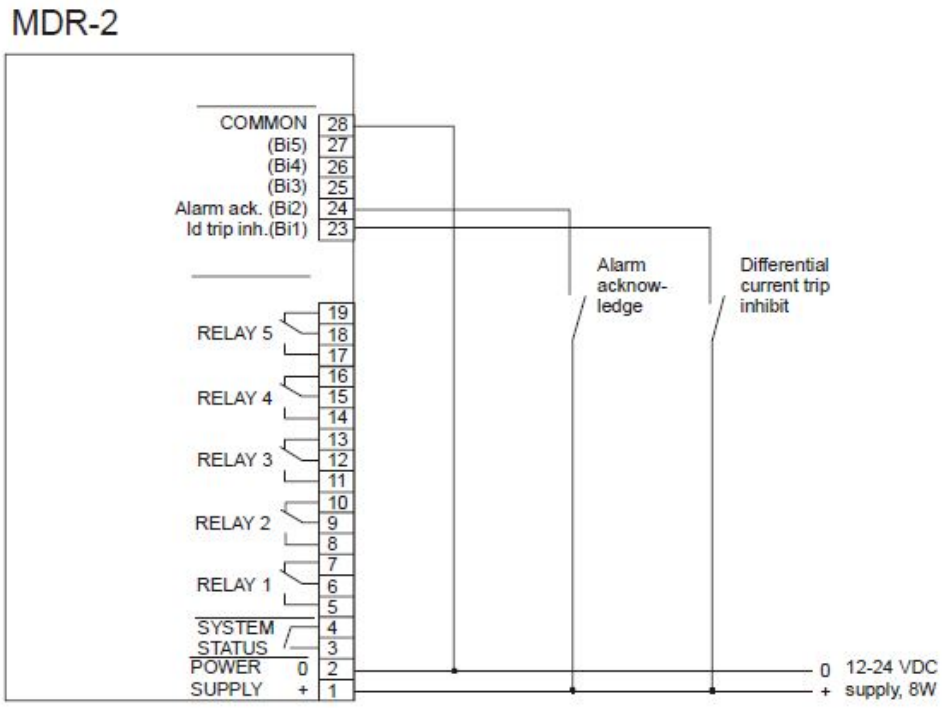

**NOTE** The ground connections can be connected to S1 or S2 as needed.

## 5.1.2 AC current measurements, delta coupling




**NOTE** The nominal current setting is to be the name plate current divided by √3.
**NOTE** The ground connections can be connected to S1 or S2 as needed.

## 5.1.3 DC connections, inputs and outputs




**NOTE** Alarms can be acknowledged by:

1. Using the display

2. Activating the alarm acknowledge input
3. Auto acknowledge. The use of this is selected in the setup menus.

# 6. Parameter programming

## 6.1 Programming

### 6.1.1 About programming

All settings can be programmed using the DEIF utility software for Multi-line 2 or via the display. All parameters are protected by a password.

In the following, the term "No." (number) refers to a specific number used for each setting. The first digit in the number indicates which group the setting belongs to.

### 6.1.2 Parameter setting method in display

The parameter setting menu is chosen by placing the cursor (underscore) under “PROT” (move the cursor with the buttons) in the lower line of the display and pressing “SEL”.

The following display appears:

```
Is      0       0      0%
1010 Diff. Current W
Setpoint          20.0%
Y1W  Y2W  DEL  OA  OB  EN
```

As it can be seen, the cursor is placed under “Y1W”.

If “SEL” is pressed, the setting of set point Y1W is entered (password-protected):

```
Is      0       0      0%
1011 Diff. Current W
  5.0…   20.0...   45.0%
RESET                SAVE
```

The value can now be changed with the  and  buttons.

When a value is to be stored, remember to move the cursor to "SAVE" and then press "SEL".

Explanations for the different possible setting are made in the next paragraphs.

**NOTE** In these displays, the "VIEW" button can be used to change the upper line reading.

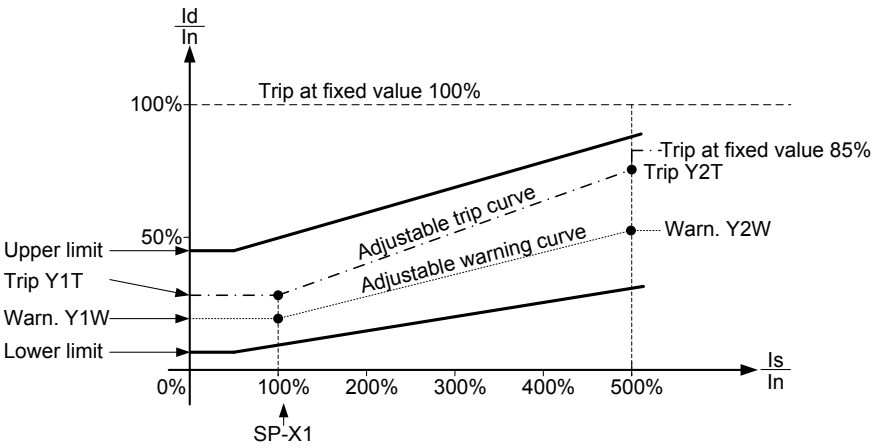
## 6.2 Differential current

### 6.2.1 Settings

The setting of differential current warning/trip is done by using five set points:

- Common for trip and warning is SP-X1 (placed under trip (curve 2) setting)
- Warning Y1W and Y2W

- Trip Y1T and Y2T




## 6.2.2 Warning (curve 1)

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 1010 | Diff. current warning | Selection display | - | - | - |
| 1011 | Diff. current warning | SP-Y value 1 warning, Y1W | 5 % | 45 % | 20 % |
| 1012 | Diff. current warning | SP-Y value 2 warning, Y2W | 25 % | 95 % | 55 % |
| 1013 | Diff. current warning | Delay | 0.01 s | 2.00 s | 0.10 s |
| 1014 | Diff. current warning | Relay output A | R0 (none) | R5 (relay 5) | R3 (relay 3) |
| 1015 | Diff. current warning | Relay output B | R0 (none) | R5 (relay 5) | R5 (relay 5) |
| 1016 | Diff. current warning | Enable | OFF | ON | ON |

## 6.2.3 Trip (curve 2)

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 1020 | Diff. current trip | Selection display | - | - | - |
| 1021 | Diff. current trip | SP-X value 1 warn/trip, X1 | 50 % | 300 % | 100 % |
| 1022 | Diff. current trip | SP-Y value 1 trip, Y1T | 5 % | 45 % | 25 % |
| 1023 | Diff. current trip | SP-Y value 2 trip, Y2T | 25 % | 95 % | 70 % |
| 1024 | Diff. current trip | Delay | 0.01 s | 2.00 s | 0.10 s |
| 1025 | Diff. current trip | Relay output A | R0 (none) | R5 (relay 5) | R4 (relay 4) |
| 1026 | Diff. current trip | Relay output B | R0 (none) | R5 (relay 5) | R5 (relay 5) |

## 6.2.4 Trip (fixed trip value)

The fixed trip value refers to tripping when the differential current is 100 % or more.

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 1030 | Diff. fixed limit trip | Selection display | - | - | - |
| 1031 | Diff. fixed limit trip | Delay | 0.01 s | 2.00 s | 0.05 s |

The relays (max. two) to be activated are chosen under Trip (curve 2).

### 6.2.5 Use of relay outputs

For each function (warning and trip), two relay outputs can be set (relay output A and B). For both of these, any of the relays available (standard: relay 1-5) can be used.

Due to the fact that tripping the generator breaker is insufficient in case of a differential current failure, a total generator shutdown must be carried out. Dependent on the AVR (Automatic Voltage Regulator) in question, the AVR should also be tripped, ensuring that the generator voltage is removed immediately. It is suggested to use for example relay output A to trip the breaker and relay output B to trip the AVR. Alternatively, if that is not possible, to shut down the engine.

The reason for this shutdown is to stop the damaging current flow caused by the internal failure (differential current).

If warning or trip messages are to be sent to an alarm system, it is suggested to use separate relays for each warning or trip alarm sent to the alarm system. This enables the alarm system to identify the cause of alarm.

## 6.3 Other settings

### 6.3.1 Status LED

This setting enables/disables the use of yellow light in the protection LEDs. When set ON, the LEDs for I>>, I> and Id will indicate an alarm status (yellow), if the alarm set point is exceeded, but the delay timer is still running. If the timer has run out (the alarm is triggered), the LED will be red.

| No. | Setting | | First setting | Second setting | Factory setting |
|---|---|---|---|---|---|
| 4300 | Status info via LED | Selection display | - | - | - |
| 4301 | Status info via LED | Show status | OFF | ON | OFF |

### 6.3.2 Auto acknowledgement of alarms

Automatic acknowledgement of alarms is activated by turning setting 4312 ON.

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 4310 | Auto acknowledge | Selection display | - | - | - |
| 4311 | Auto acknowledge | Delay | 0.10 s | 10.00 s | 2.00 s |
| 4312 | Auto acknowledge | Enable | OFF | ON | OFF |

### 6.3.3 Service menu

The service menu can only be entered using the "JUMP" push button. In this menu, status and timers can be seen (useful in commissioning situations).

| No. | Setting | | Min. setting |
|---|---|---|---|
| 4980 | Service menu | Selection display | - |
| 4981 | Service menu | Alarm | Shows remaining delay time |
| 4982 | Service menu | Digital input | Shows digital input status |
| 4983 | Service menu | Relay output | Shows relay output status |

# 6.4 Nominal settings

## 6.4.1 Nominal current

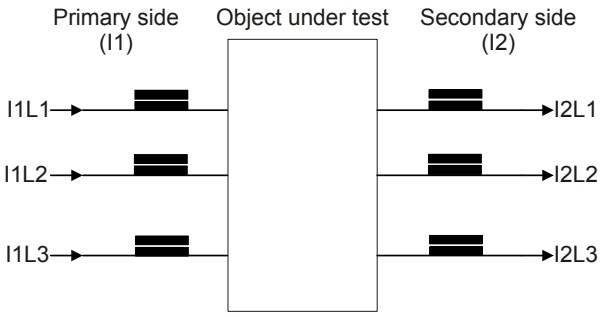
The nominal current is the nominal current of the generator.

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 4010 | Nominal settings | Selection display | - | - | - |
| 4011 | Nominal settings | Nominal frequency | 48 Hz | 62 Hz | 50 Hz |
| 4012 | Nominal settings | Nominal current | 1 A | 10000 A | 787 A |

**NOTE** If the generator/motor is delta-coupled, the nominal current setting is to be the name plate current divided by √3.

## 6.4.2 Current transformers

The six current transformers are to be placed like this:




The object under test can be:

- A generator

- An electric motor

Transformer ratio for current measurements I1L1, I1L2, I1L3, I2 L1, I2L2 and I2L3.

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 4020 | Trafo ratio | Selection display | - | - | - |
| 4021 | Trafo ratio | Current prim. | 5 A | 10000 A | 1000 A |
| 4022 | Trafo ratio | Current sec. | 1 A | 5 A | 1 A |

## 6.4.3 Date and time (internal clock)

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 4100 | Date and time | Selection display | - | - | - |
| 4101 | Date and time | Year | Factory setting is random. Time and date must be set during commissioning. | | |
| 4102 | Date and time | Month | | | |
| 4103 | Date and time | Date | | | |
| 4104 | Date and time | Hour | | | |
| 4105 | Date and time | Minute | | | |

### 6.4.4 Power supply (battery) under-voltage alarm

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 4220 | Battery low V | Selection display | - | - | - |
| 4221 | Battery low V | Set point | 8.0 V | 24.0 V | 18.0 V |
| 4222 | Battery low V | Time | 0.00 s | 10.00 s | 1.00 s |
| 4223 | Battery low V | Relay output A | R0 (none) | R5 (relay 5) | R0 (none) |
| 4224 | Battery low V | Relay output B | R0 (none) | R5 (relay 5) | R0 (none) |
| 4225 | Battery low V | Enable | OFF | ON | ON |

### 6.4.5 User password for programming via display

The user password can only be entered using the "JUMP" push-button on the display.

| No. | Setting | | Min. setting | Max. setting | Factory setting |
|---|---|---|---|---|---|
| 4971 | User password | Setting | 0 | 32000 | 2000 |

### 6.4.6 Language selection

| No. | Setting | | Setting | Factory setting |
|---|---|---|---|---|
| 4230 | Language | Selection display | - | - |
| 4231 | Language | English | 0 | 1 |
| | | Deutsch | 1 | - |
| | | Français | 2 | - |
| | | Español | 3 | - |