



# Operating Manual

## Digital Transformer Monitoring Relay



**PRELIMINARY**

Firmware version 3.25

**NOTICE:**

Please note that these operating instructions may not always contain the latest information concerning the device. Should you require a more recent version of these instructions or have any questions about the product or how to use it, please contact the REGSys<sup>TM</sup> Support on: +49 (0)911 628108-101 or via email at: [regsys-support@a-eberle.de](mailto:regsys-support@a-eberle.de).

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## Table of Contents

<b>1.</b>	<b>Overview .....</b>	<b>7</b>
1.1	Target group.....	7
1.2	Warnings .....	7
1.3	Tips .....	8
1.4	Other symbols.....	8
1.5	Applicable documentation.....	8
1.6	Storage .....	8
<b>2.</b>	<b>Safety instructions .....</b>	<b>9</b>
<b>3.</b>	<b>Intended use.....</b>	<b>10</b>
<b>4.</b>	<b>Scope of Delivery .....</b>	<b>10</b>
<b>5.</b>	<b>Description for the Transformer Monitoring Relay .....</b>	<b>10</b>
5.1	Thermal model of the transformer .....	12
5.2	Transformer moisture assessment .....	17
5.2.1	Monitoring Parameters.....	18
5.2.2	Temperatures.....	18
5.2.3	Oil relative saturation .....	18
5.2.4	Load Current .....	19
5.2.5	Determination of water content in oil .....	19
5.2.6	Determination of water content in cellulose.....	19
5.3	Determination of Bubble Formation Temperature .....	24
5.3.1	Risk of bubble formation and oversaturation.....	25
<b>6.</b>	<b>Main menu .....</b>	<b>26</b>
6.1	Monitor .....	26
6.1.1	Oil temperatures (TC/Transformer).....	30
6.1.2	Winding currents and winding temperature .....	30
6.2	Service life .....	31
6.2.1	Operating hours (1).....	31
6.2.2	Operating hours (2).....	33
6.2.3	Service life consumption.....	33
6.3	Transducer mode .....	36
6.4	Basic Recorder function with three channels .....	37
6.5	Additional Recorder function.....	40
6.6	PQIView.....	41
6.7	Logbook (Eventlog) .....	42

<b>7.</b>	<b>SETUP .....</b>	<b>45</b>
7.1	SETUP 1 .....	45
7.1.1	Transformer Parameters.....	45
7.1.2	Basis of the control .....	47
7.1.3	Temperature limits .....	47
7.2	SETUP 2 .....	48
7.2.1	Calculation .....	48
7.2.2	Fan assignment .....	49
7.2.3	Number of fans .....	49
7.2.4	Current measurement .....	50
7.3	SETUP 3 .....	52
7.3.1	Oil temperature (TC) .....	52
7.3.2	Oil level (TC) .....	53
7.3.3	Oil level (transformer) .....	53
7.4	SETUP 4 .....	54
7.4.1	Oil temperature (Alarm) .....	54
7.4.2	Oil temperature (Trip).....	55
7.4.3	Winding temperature (Alarm) .....	55
7.4.4	Winding temperature (Trip).....	56
7.5	SETUP 5/6/7 .....	56
7.5.1	Water in Oil content .....	57
7.5.2	Gas in Oil (Total gas in Oil) content .....	57
7.5.3	H2 (Hydrogen) in Oil content.....	58
7.5.4	CO (Carbon Monoxide) in Oil content .....	58
7.5.5	CO2 (Carbon Dioxide) in Oil content.....	59
7.5.6	C2H2 (Acetylene) in Oil content .....	59
7.5.7	C2H4 (Ethylene) in Oil content .....	60
7.5.8	C2H6 (Ethane) in Oil content .....	60
7.5.9	CH4 (Methane) in Oil content.....	61
7.6	SETUP 8 .....	61
7.6.1	Analogue inputs and outputs.....	61
7.6.2	Binary inputs and outputs .....	67
7.7	SETUP 9 .....	71
7.7.1	Transformer service life .....	71
7.7.2	Tap changer service life .....	72
7.7.3	Oil pumps .....	72

7.7.4	Fans .....	73
7.8	SETUP 10 .....	73
7.8.1	Max. Winding temperature .....	73
7.8.2	Time to max. temperature .....	73
7.9	SETUP 11 Bubble Module .....	74
7.10	SETUP 12 .....	74
7.10.1	Voltage and current transformer installation .....	75
7.10.2	RS232 .....	76
7.10.3	E-LAN (Energy - Local Area Network).....	77
7.11	SETUP 13 .....	78
7.11.1	General.....	78
7.11.2	Functions:.....	80
7.11.3	State .....	80
<b>8.</b>	<b>Download of a background program (h-code) .....</b>	<b>81</b>
<b>9.</b>	<b>Download of firmware and Bootloader .....</b>	<b>83</b>
<b>10.</b>	<b>Increasing the system's hardware resources .....</b>	<b>85</b>
10.1	Additional inputs and outputs .....	85
10.2	COM3/Modbus (RTU Master) Converter.....	86
<b>11.</b>	<b>Temperature measurement .....</b>	<b>87</b>
11.1	Accuracy considerations .....	87
<b>12.</b>	<b>Maintenance and power consumption.....</b>	<b>89</b>
12.1	Fuse replacement.....	89
12.2	Battery replacement .....	90
12.3	Power consumption REG-DMA .....	91
<b>13.</b>	<b>Notes on storage .....</b>	<b>91</b>
<b>14.</b>	<b>Notes on cleaning .....</b>	<b>91</b>
<b>15.</b>	<b>Disposal .....</b>	<b>92</b>
<b>16.</b>	<b>Product Warranty .....</b>	<b>92</b>
<b>17.</b>	<b>Technical Data .....</b>	<b>93</b>
17.1	Technical Specifications .....	93
17.2	Mechanical configuration .....	97
17.3	Terminal configuration .....	102
17.4	Terminal configuration Level II .....	105
17.5	Terminal configuration Control system Level II .....	107
17.6	Block diagram - Characteristics D0, D1, D4, D7, D9 .....	109
17.7	Block diagram - Characteristics D2, D3, D5, D6, D8 .....	110

17.8	Network .....	111
17.9	Serial interfaces .....	111
17.10	A.Eberle Toolbox Parameterization and configuration software .....	113
17.11	Order specifications .....	114
<b>18.</b>	<b>Index .....</b>	<b>120</b>

# 1. Overview

This User Manual is a summary of the information needed for the installation, putting into operation and operation of the Moisture Assessment Module of the REG-D(A).

Read the User Manual entirely and do not use the product unless you have comprehended well the material.

## 1.1 Target group



The User Manual is intended for skilled technicians as well trained and certified operators.

The contents of this User Manual must be accessible to people tasked with the installation and operation of the system.

## 1.2 Warnings


### Structure of the warnings


Warnings are structured as follows:


 <b>SIGNAL WORD</b>	<p><b>Nature and source of the danger.</b></p> <p>Consequences in the event of non-observance.</p> <p> Actions to avoid the danger.</p>
--	--

### Types of warnings

Warnings are distinguished by the type of danger they are warning against:

 <b>DANGER!</b>	Warns of an immediately impending danger that can result in death or serious injuries when not avoided.
--	---

 <b>WARNING!</b>	Warns of a potentially dangerous situation that can result in death or serious injuries when not avoided.
---	---

 <b>CAUTION!</b>	Warns of a potentially dangerous situation that can result in fairly serious or light injuries when not avoided.
---	--

<b>NOTICE:</b>	Warns of a potentially dangerous situation that results in material or environmental damage when not avoided.
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## 1.3 Tips



Tips on the appropriate use of the device.

## 1.4 Other symbols

### Instructions

Structure of the instructions:

- ➡ Instructions for an action.
- ↪ Indication of an outcome, if necessary.

### Lists

Structure of unnumbered lists:

- List level 1
- List level 2

Structure of numbered lists:

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

## 1.5 Applicable documentation

For the safe and correct use of the product, observe the additional documentation that is delivered with the REG-DMA as well as the relevant standards and laws.


## 1.6 Storage


Store the user manual, including the supplied documentation, readily accessible near the REG-DMA.



## 2. Safety instructions

- ➔ Follow the operating instructions.
- ➔ Regularly instruct staff in all relevant issues regarding occupational safety, the operating instructions and, in particular, the safety instructions they contain.
- ➔ Ensure that the device is only operated if in perfect condition. Never use a damaged device (physically damaged or malfunctioning).
- ➔ Ensure that only qualified personnel operate and service the device.
- ➔ Connect and use the device only as specified.
- ➔ Operate the device only with the recommended accessories.
- ➔ Ensure that the device is only operated in its original condition.
- ➔ Ensure that the device is not operated outside of its design limits (see technical data).
- ➔ Do not install or operate the device in environments where explosive gases, dust or vapours may be present (i.e. that generally do not meet the requirements mentioned in the technical data).
- ➔ Clean the device only with cleaning products that comply with the manufacturer's specifications.
- ➔ Use only spare parts and auxiliary materials that have been approved by the manufacturer.
- ➔ Maintenance and repair of a REG-DMA Monitoring relay must only be carried out by authorised, qualified personnel and must meet EMC directives.

 <b>DANGER!</b>	<p><b>Electric shock!</b></p> <p>Injury or Death</p> <ul style="list-style-type: none"> <li>➔ Disconnect the device from all life circuits like aux. supply, measurement circuits and so on before you work on the hardware.</li> <li>➔ The connected circuits may not exceed the device's safety category (e.g. measurement inputs: CAT III / 300V).</li> <li>➔ The REG-DMA is a Safety Class I device. The device must be connected to the system's earth system by a protective earth before it is put under voltage.</li> </ul>
--	---

 <b>WARNING!</b>	<p><b>Damage of the current transformers!</b></p> <ul style="list-style-type: none"> <li>➔ Short circuit the current transformer before removing the terminal connections from the device</li> </ul>
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### 3. Intended use

The product is intended solely to monitor power transformers.

### 4. Scope of Delivery

REG-DMA according to characteristics

Mounting material (wall bracket, in-panel terminals, DIN-rail adapter (only for Characteristic B1))

Brush sealing

User Manual

Null modem cable and/or mini USB cable

CD (Operating instructions; A. Eberle Toolbox)

### 5. Description for the Transformer Monitoring Relay

Power transformers are key components of an electrical supply grid. The failure of a transformer not only has major economic consequences for the energy supplier, it can also lead to serious losses for consumers. For this reason, it makes sense to monitor the transformer as closely as possible, to record its 'temperature curve' (the thermal image) and to collect information about the current load and the expected remaining service life as well as the moisture content of the oil and the paper. This task can - based on IEC standards - be solved by electronic measuring and computing facilities.

This manual describes the main functions and the various steps to monitor the transformer.

The winding's hot-spot temperature is determined by the current that runs through the windings and the oil temperature. The latter can be fed into the REG-DMA as a mA signal or directly as a PT100 signal. Appropriate input modules are available for both types of signals. The appropriate analogue input channels must be available in order to record the fill levels and other quantities such as humidity, H<sub>2</sub> or the oil's CO content.

Monitoring consists of monitoring the transformer's main parameters. The oil temperature is recorded in addition to the current. The hot-spot temperature is determined from the oil temperature and the current in accordance with IEC 60354 or IEC 60076 and extrapolated to the transformer's service life consumption. Up to six cooling stages can be activated depending on the oil or winding temperature. The system monitors the operating times of the fan and controls the individual fan groups so that as balanced an operating time as possible is achieved over the whole operating life. If desired, individual fans can also be permanently assigned to a specific cooling stage. Additional alarms such as Buchholz pre-warning and/or Buchholz triggering can be fed into the monitoring system as binary signals, displayed and sent to a SCADA system for further processing (see Figure 1).

The following protocols are available:

- IEC 60870-5-101
- IEC 60870-5-103
- IEC 60870-5-104
- DNP 3.0
- IEC 61850
- LON (on request)
- MODBUS
- PROFIBUS
- SPABUS

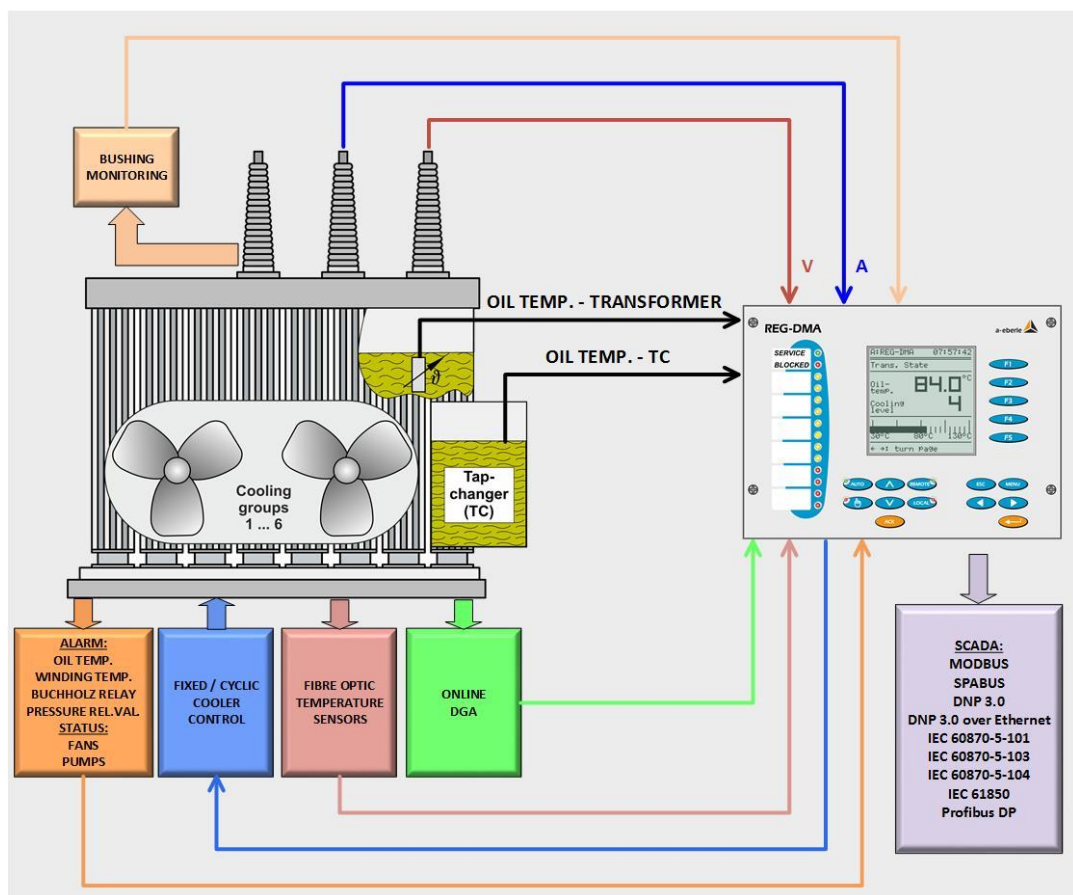


Figure 1: Signal diagram

## 5.1 Thermal model of the transformer

The thermal situation in the transformer can be displayed in a graphic (see Figure 2). Please note that it is a simplified view of a complex situation. The 'simplification' is based on the following assumptions:

- the oil temperature in the tank increases linearly from the bottom to the top
- the average temperature of the winding is linearly parallel to the oil temperature with a constant temperature differential  $g_r$  increasing from bottom to top
- the hot-spot temperature (P) is higher than the temperature of the winding at the upper (hot) end of the winding. The increase in temperature between the hot spot in the winding and the oil temperature at the top of the tank is specified as constant  $H_{gr}$  (hot spot at top oil gradient). Studies have shown that the factor H can vary between 1.0 and 2.1 based on the size, short-circuit impedance and winding design of the transformer.

The abbreviations used in the diagram are explained below. Measured values are indicated by a solid square (■), calculated values are indicated by a solid point (●).

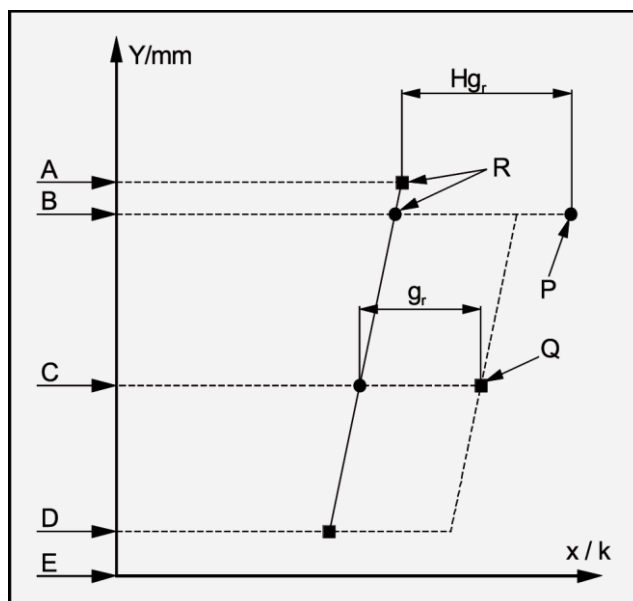


Figure 2: Thermal model based on IEC

- A Temperature of the top oil layer
- B Temperature in the transformer tank at the upper end of the winding
- C Temperature of the tank's oil at the centre of the winding
- D Temperature at the lower end of the winding
- E Represents the bottom of the tank
- P Hot-spot temperature
- Q Average winding temperature
- R Points that are assumed to be at the same temperature

X X-axis of the graph shows the temperature

Y Y-axis indicates the relative position of the individual points

The basic version has only one current input to determine the hot-spot temperature. Three currents can also be measured through an optional Aron circuit (hardware Characteristic M2).

In most cases, this configuration will produce acceptable results because one can assume that the transformer has a more or less uniform load.

For this general operating condition:  $I_1 \sim I_2 \sim I_3$

The hot-spot temperature is calculated and the cooling equipment controlled according to the model shown in Figure 3.

The operating current and the oil temperature are the most important measurements for the estimation and calculation of the hot spot and the hot-spot temperature  $\Theta_h$ . The REG-DMA records up to three oil temperatures that can be used for the calculation. Each of the measured oil temperatures is fed into the equation together with the current and the characteristics of the transformer in order to obtain a thermal image of the transformer. This enables the service life consumption of the insulation and the hot-spot temperatures to be calculated.

The transformer's temperature can be controlled by connecting fans in six stages, two oil pumps and a heater. The fans can be controlled manually (MAN) or automatically (AUTO). If the fans are controlled manually (the REG-DMA is in MAN mode), the 'Up Arrow' and 'Down Arrow' buttons are used to control the fans' stages. The outputs used to control the fans and the inputs used to feed the temperature signals into the controller can be set up at a later stage in the menu-driven configuration.

A default configuration is supplied that may occasionally require a few minor changes. If additional analogue inputs or outputs and/or additional binary inputs or outputs are required for the REG-DMA's monitoring system, interface modules (ANA-D and BIN-D) can be connected through the device's COM 3 port. This increases the hardware resources for the basic unit.

If the information provided by the system is used properly, the function can significantly increase the transformer's availability using comparatively few resources.

Block diagram of the hot-spot calculation and the cooling stage control

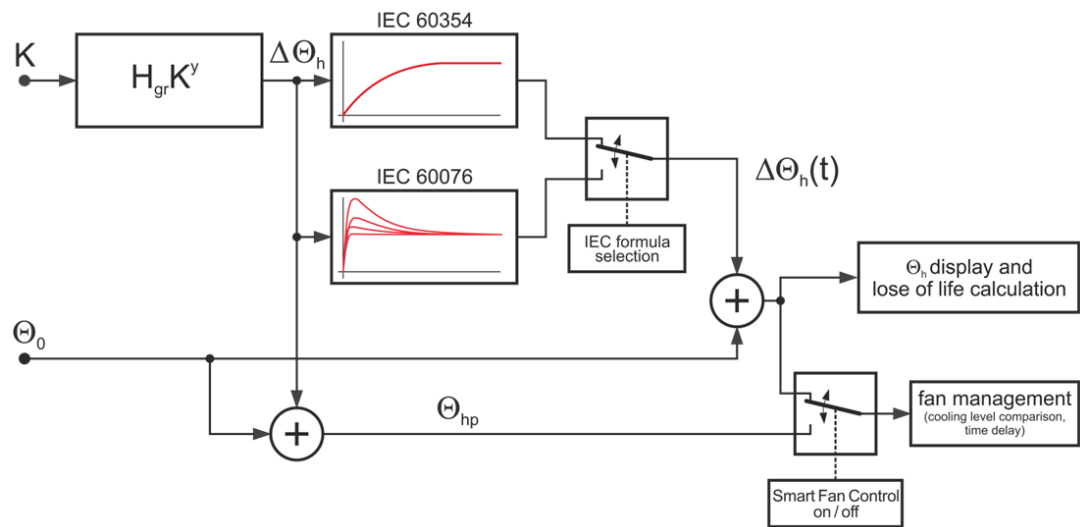


Figure 3: Block diagram

$K$  : Load factor =  $I / I_N$   
 $\Theta_0$  : Oil temperature (measured)  
 $H_{gr}$  : Hot-spot to top-oil gradient  
 $\Delta\Theta_h$  : Hot-spot temperature increase  
 $\Theta_h$  : Hot-spot temperature  
 $\Theta_{hp}$  : Expected hot-spot temperature  
 $Y$  : Winding exponent

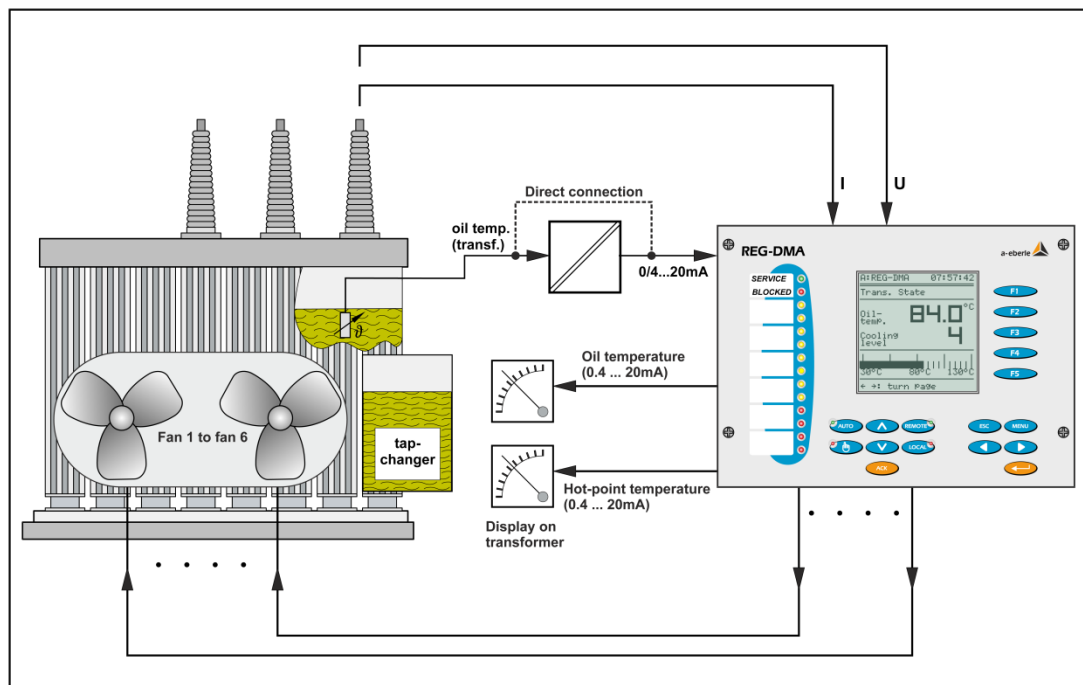


Figure 4: Oil temperature measurement diagram

If a temperature transducer has already been allocated to measure the oil temperature, the oil temperature can be fed into the controller as mA input. If necessary, the PT100 temperature sensors can also be connected directly in a three-wire circuit.

If remote temperature gauges are used, both the hot-spot temperature and the oil temperature can be provided as mA output.

The oil or hot-spot temperature function enables up to six groups of fans, two oil pumps and a heater to be connected.

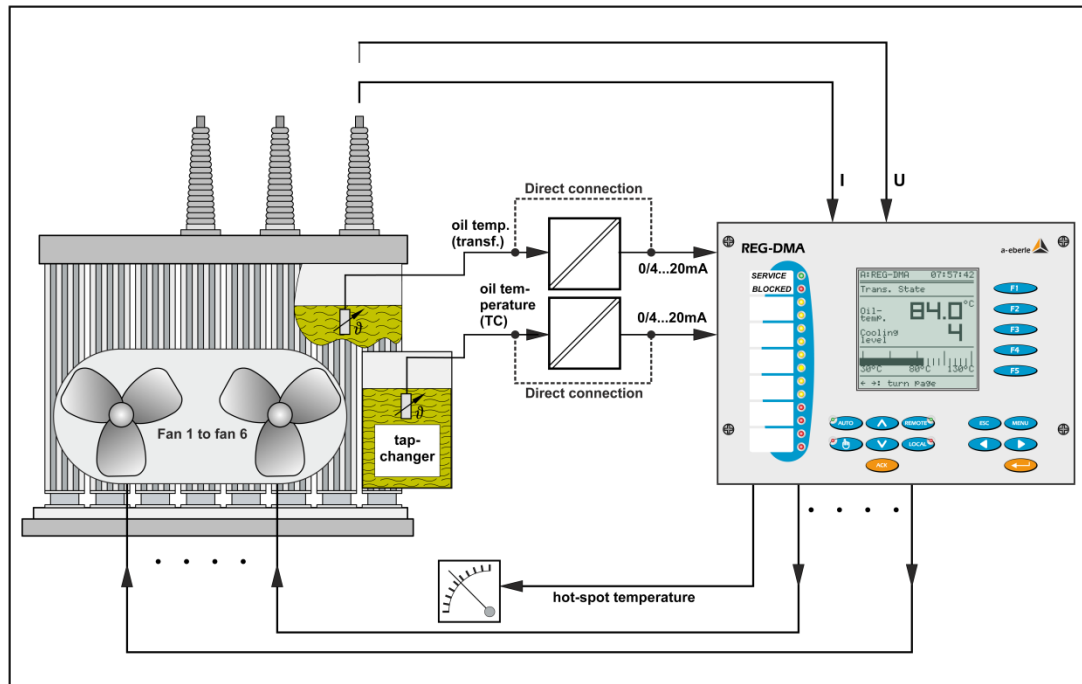
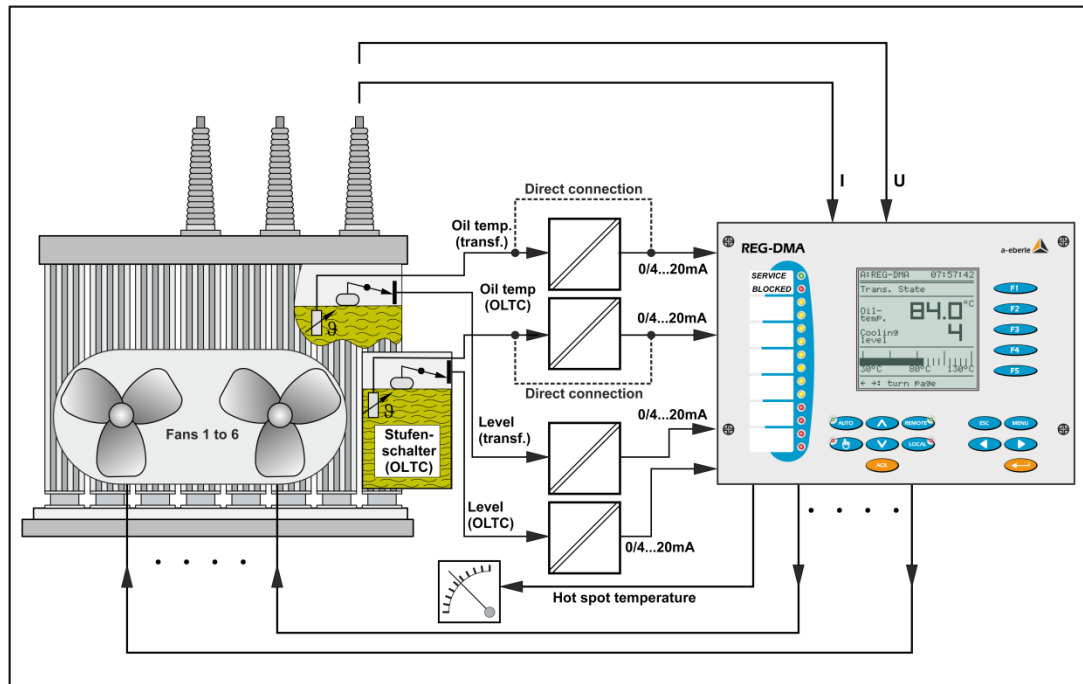


Figure 5: Diagram of the oil temperature measurement in the tap changer

If the oil temperature in the tap changer vessel is also to be recorded, a second mA or PT100 input must be available.



*Figure 6: Fill level determination diagram*

The fill levels of the transformer and/or tap changer can also be recorded and fed into the controller. The information can be displayed on the Control unit's screen and if necessary transferred to a SCADA system through a serial interface (Figure 1).



## 5.2 Transformer moisture assessment

Excessive moisture is detrimental for transformer operation. It affects dielectric integrity of liquid/paper system, insulation life and transformer loading capability. Moisture is a major cause of many failures and can lead to partial discharges, bubble formation, dielectric breakdown and deterioration of insulating liquid and paper.

Therefore, continuous online monitoring of water in transformers is increasingly becoming one of the essential parameters to monitor for their life and safety.

Measurement of water dissolved in oil is usually carried out with proven on-line technology based on extensive use of moisture in oil sensors. The majority of such sensors used for moisture in oil monitoring are relative humidity sensors, which respond to a change of relative humidity (RH) in the oil in a same fashion as they respond to the change in relative humidity in the air. RH sensors are normally based on the thin film polymer capacitive material. When used in liquid, the relative humidity is called relative saturation (RS) and it is measured in percentage. There are other moisture parameters of interest, which could be directly measured or determined from RS reading and temperature at the point of measurement. Among the most frequently used parameters are: a) moisture content of oil in parts per million (PPM) and b) water activity.

In most moisture-in-oil instruments a conversion from RS to PPM is performed using a built-in formula incorporating the so-called solubility coefficients. The formula is only valid for an average new mineral oil and may not be adequate for a service aged oil and other insulating liquids like silicon and ester. A high level of error may be introduced by not considering actual water in oil solubility characteristic.

About 99% of all water present in a conventional transformer is concentrated in solid insulation and it is known as water-in-paper. Therefore determination of moisture in paper is of primary importance. However, in present practice, moisture in the solid insulation cannot be directly measured, but is inferred by the moisture measurement in oil. Moisture in cellulose insulation is not distributed evenly and varies considerably from top to bottom. Another consideration is that moisture in pressboard barriers can be significantly higher than moisture in winding paper because of the temperature difference between these two elements. The top of the winding is the hottest part while the bottom part of pressboard barriers is at the coolest temperature of the bottom oil. Because of water absorption characteristics of oil and paper in regards to temperatures, the water content in the barrier can be significantly higher than the water content in the winding paper. It is important to understand that no single value of moisture content of solid insulation can be derived when estimating from a reading of a single moisture-in-oil sensor. Moisture in solid insulation is distributed unevenly and there is always a range of moisture values attributed to a particular solid insulation element.

Moisture continuously migrates from paper to oil and back due to temperature variations. This dynamic process is taken into account when estimating moisture content of solid insulation.

Moisture equilibrium diagrams have been extensively used for determination of water content of solid insulation. However, a great care should be exercised when applying moisture equilibrium diagrams to infer moisture in solid insulation. Most of the time, thermodynamic equilibrium cannot be obtained and therefore direct use of equilibrium diagram can result in high error level. There is an extensive literature on use and misuse of moisture equilibrium charts, which should be consulted before utilizing the theory of moisture equilibrium.

There is a strong correlation between moisture in oil and moisture in solid insulation predominantly adsorbed on the surface of the conductor paper and pressboard barriers. Various algorithms have been developed to devise moisture available for exchange between oil and different parts of the solid insulation. However, a good judgment should be used when applying any of these algorithms as there are always assumptions and limitations, which should be carefully considered.

During a rapid temperature decrease (e.g. an unexpected shutdown) relative saturation of water in oil increases rapidly. At a low temperature after sudden change the accuracy of RS measurement is compromised by the fact that dynamic response is slower at low temperatures than at high temperatures and underestimation of saturation point may occur. Technical specifications of the moisture sensors should be carefully examined to adequately consider temperature effects on accuracy of relative saturation measurement.

A moisture assessment algorithm, which is incorporated in the transformer moisture assessment module, uses smart analytical tools (e.g. neuro-fuzzy computing) to better account for uncertainties and nonlinearities of water in the transformer oil/paper system.

### 5.2.1 **Monitoring Parameters**

### 5.2.2 **Temperatures**

A temperature at the location of relative saturation sensor must be continuously measured for calculation of absolute water content in oil (WCO).

It is beneficial to have the measurement of another temperature at different location, such as top oil temperature, in order to predict relative saturation at that point too. Top oil temperature is normally provided and should be used for calculation of distribution of moisture in cellulose barrier insulation.

### 5.2.3 **Oil relative saturation**

The relative saturation (RS) of water in oil is measured to predict the water in paper activity and then to estimate the water content in cellulose insulation, which corresponds to the level of water activity. The RS is also measured to estimate an inception temperature for the bubble formation and to estimate the risk of oversaturation of oil with water.

#### 5.2.4 Load Current

Load current monitoring is necessary for determination of temperatures at which bubbles may form. The load current must be measured on the most loaded windings. Load current is one of the inputs to the hot-spot temperature model, thus is normally available for use.

#### 5.2.5 Determination of water content in oil

The Water content in oil is determined in the TMM according to the formula:

$WCO = RS * WCO^s$ , where

$WCO^s = \exp(A+B/T)$ ,

where **WCOs** – water content in oil at the maximum water saturation expressed in parts per million (ppm);

**RS** – relative saturation of water in oil measured by moisture sensor (%);

**A** and **B** are the solubility coefficients, which could be entered during configuration step.

**T** - temperature in Kelvin at the RS sensor location.

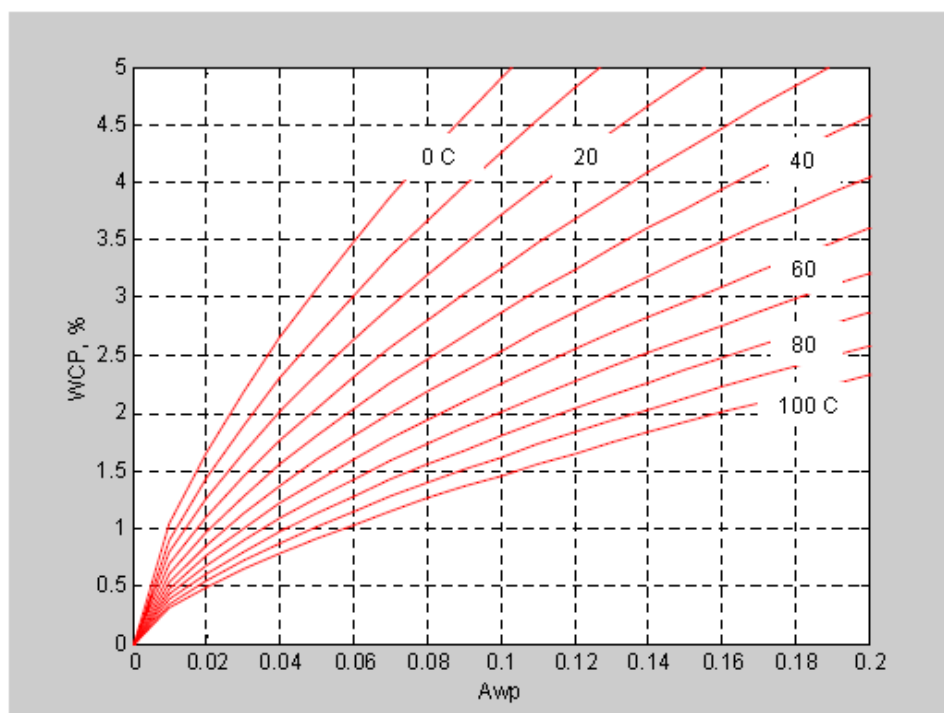
#### 5.2.6 Determination of water content in cellulose

A method for moisture assessment of transformer insulation in a core-type transformer, with a conservator oil preservation system (COPS), is based on the concept of water-in-paper activity.

The concept of water activity is not new and has been known for more than 100 years. Water activity as a parameter is being successfully utilized in pharmaceutical, food and paper production industries. When applied to modeling of water migration between cellulose (solid) and oil (liquid) dielectric the water activity is seen as an equilibrium relative saturation of water in oil, in the vicinity of solid insulation.

This method evaluates the so-called 'active' moisture content in solid insulation. The word 'active' is associated with the term of water-in-paper activity ( $A_{wp}$ ) – a new concept introduced in [Roizman & Davydov 2005] to reflect free water available for exchange between the transformer oil and paper.

The relationship between the 'active' water content of paper (WCP, %) as a function of  $A_{wp}$  and the oil temperature is shown in Figure 1.



*Figure 1*

*Moisture Equilibrium Curves Relating Water-in-Paper Activity to the 'Active' Water Content of Paper*

Numerically  $A_{wp}$  is equal to  $RS_{eq}/100$ , where  $RS_{eq}$  is the percentage oil relative saturation at moisture equilibrium in a paper-oil insulation system. Thus, the water-in-paper (WIP) algorithm incorporates the following steps:

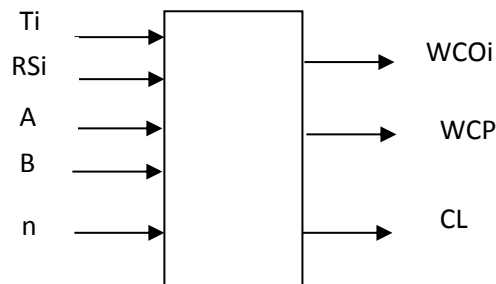
1. Evaluation of true oil relative saturation ( $RS_{true}$ ) in a transformer
2. Evaluation of the water-in-paper activity ( $A_{wp}$ ) for the certain period of time
3. Evaluation of the confidence level for each  $A_{wp}$
4. Evaluation of the 'active' water content of paper insulation ( $WCP_A$ ) as a function of  $A_{wp}$  and temperature.

Some of the advantages of the moisture module/model are:

- The model employs moisture assessment based on intelligent water activity concept and is unique in a way that it uses fundamental physical-chemical principles in order to estimate moisture state of a whole paper/oil insulation
- The model uses new bubble evaluation method, which is not implemented in other models/methods

- For moisture in paper the model uses relationship between water-in-paper activity and water-in-paper by dry weight while most other systems use ppm/wcp(%) equilibrium relationship, which is less accurate
- The model does not use the measured  $A_w$  by the sensor, but rather estimate it by applying intelligent inference system
- The model provides necessary inputs for other diagnostic models such as aging and drying and therefore is ready to be integrated in full scale diagnostic and monitoring.

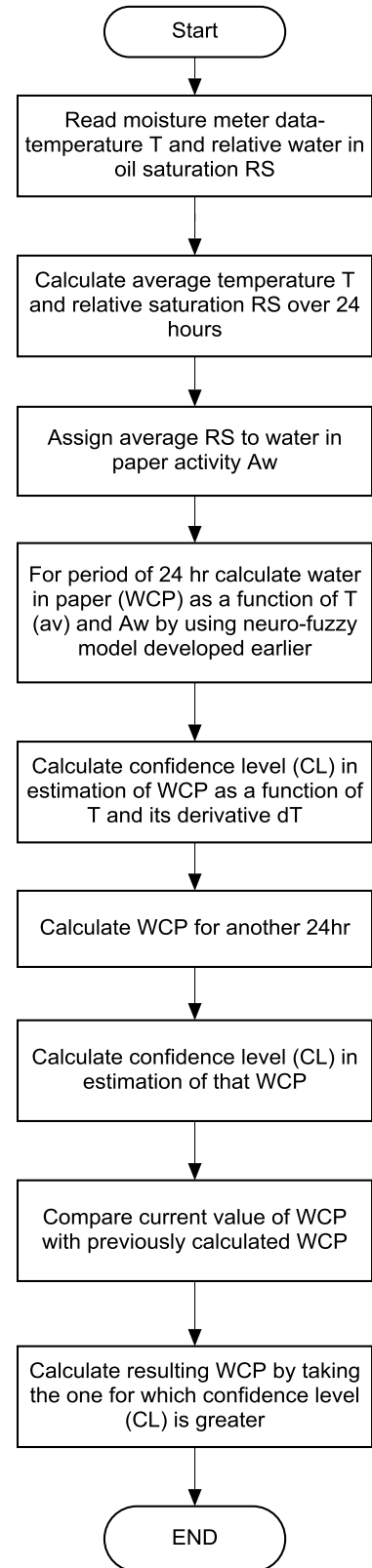
A more detailed description of the algorithm is presented as a block diagram as depicted in Figure 2



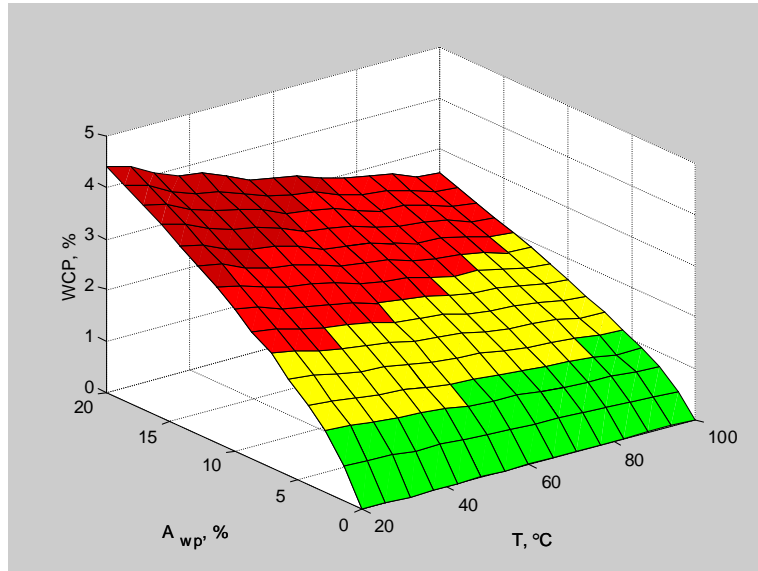
**Figure 2**  
*Block diagram of the WCP system identification*  
where,

**Ti** – temperature of the oil sample as seen from the moisture sensor tip at  $i^{\text{th}}$  moment of time  
**RS<sub>i</sub>** – relative saturation measured by the moisture sensor  
**A, B** – water in oil solubility coefficients  
**n** – sampling interval in minutes  
**k** – number of sample pairs  
**WCO<sub>i</sub>** – water content in oil at  $i^{\text{th}}$  moment of time  
**WCP** – active water content in paper  
**CL** – confidence level of WCP determination  
**dT** – rate of change in  $T$  °C

The algorithm (inputs to outputs) has been outlined in a flow chart sense (adjacent).



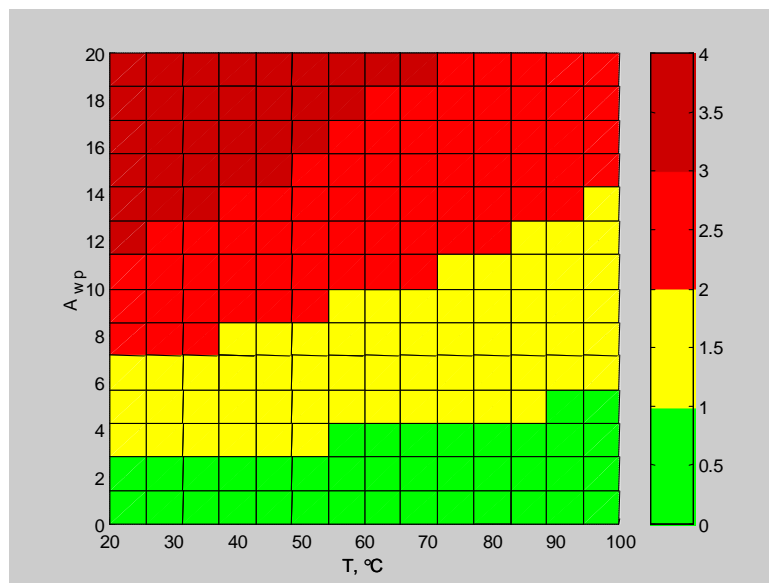
TMM uses neuro-fuzzy computing to evaluate the consistency of the moisture sensor output, to assess the water content in paper (WCP) and to alert the user when insulation condition requires attention.



*Figure 3*  
*Membership function surface for  $WCP=f(A_{wp}, T)$*

First, fuzzy logic rules were developed from experimental data. Then the rule base was fine-tuned using artificial neural network (ANN) algorithms. The resulting membership function for the WCP is shown in Figure 3.

Figure 4 shows the fuzzy mapping of A<sub>wp</sub> and T into %WCP, presented as a two-dimensional color chart in Figure 4.



*Figure 4*  
*Color Chart (Fuzzy Mapping Awp and T into WCP)*

It can be seen from this chart that all values of WCP are distinguished by color. For example, the green area corresponds to WCP of less than 1%; the yellow area of the chart corresponds to the range from 1% to 2% in WCP, etc. To fine-tune the fuzzy inference system ANN has been used.

The diagnostic value of WCP is supported by the Confidence Level (CL), which takes values between 0 and 1. In the simplest case the CL depends on the oil temperature in the vicinity of solid insulation and rate of change of this temperature.

The fuzzy inference system ANN training data set was formed from measured values of temperature, relative saturation and WCP for differently conditioned test coils. Test coils were manufactured from a wound copper conductor wrapped with Kraft paper and wound pressboard to represent material and insulation mass ratio of real transformer. For instance several coils (five of which depicted below) were conditioned and used for approximating a function of T and Aw to work out the WCP.



Each coil with known WCP was placed in a glass tank and subjected to temperature change in steps and response of RS was recorded. Resulting data set was used to generate neuro-fuzzy inference system for estimation of WCP. Utilising the property of neural networks and fuzzy systems as universal function approximators, the adaptive neuro-fuzzy inference model was created. Two approaches were used to fine tune neuro-fuzzy model, which as expected both approaches had very similar outcomes:

1. All data was used as a training set and
2. Some coils were used for training the network and the rest of the coils were utilized for validation.

### 5.3 Determination of Bubble Formation Temperature

The key dissolved gases within the mineral oil of a transformer are the following:

- Nitrogen: From the external atmosphere or from a gas blanket over the free surface of the oil
- Oxygen: From the external atmosphere
- Water: From moisture absorbed in cellulose insulation or from thermal decomposition of the cellulose
- Carbon dioxide: From thermal decomposition of cellulose insulation
- Carbon monoxide: From thermal decomposition of cellulose insulation

Other gases may be present in very small amounts as a result of oil or insulation decomposition by overheated metal, partial discharges, or arcing and sparking, but these normally make an insignificant contribution to the summation of gas partial pressures within the oil.

The fundamental equation governing bubble formation is:

$$P_{int.} = P_{ext.} + ( 2 \sigma / R_B )$$

Where,

- P<sub>int</sub> = internal pressure
- P<sub>ext</sub> = external pressure.
- R<sub>B</sub> = Radius of bubble
- σ = Surface tension

It is known that the following factors affect bubble formation:

- Average active water content (water content of paper at the interface with the oil)
- Moisture content of water in oil at the interface with the paper effected by the bubble formation
- Capillary property of paper
- Gas content in paper
- Surface tension of oil
- Gradient of temperature rise
- Static pressure in the liquid above the bubble formation area
- Dissolved gas content in oil
- Type of oil preservation system
- Electric stress in the active part

However, one of the most important factors, often overlooked, is the rate of temperature change and/or the temperature difference between the winding and surrounding oil.

It is generally agreed that at 2% moisture in paper (corresponding to an aged transformer) the bubble evolution temperature is slightly above 140 °C. At 0.5% moisture level the bubble evolution temperature is above 200 °C. In other words, even at the 180 °C hot-spot condition bubbles will not be produced from very dry insulation.



T.V. Oommen was able to find a good approximation of the hot spot temperature as a function of moisture and gas content and the total external pressure (atmospheric plus oil head). The equation is given below:

$$\Theta_{bubble} = \left[ \frac{6996.7}{22.454 + 1.4495 \ln W_{WP} - \ln P_{pres}} \right] - \left[ \left( \text{EXP}^{(0.473 W_{WP})} \right) \left( \frac{V_g^{1.585}}{30} \right) \right] - 273$$

Where:

- $P_{pres}$  = Total pressure, mm mercury (torr.)
- $V_g$  = Gas content of oil, % (v/v)
- $W_{WP}$  = Per cent by weight of moisture in paper (dry basis)
- $\Theta_{bubble}$  = Temperature for bubble evolution, °C

Despite that the above equation does not consider all the factors affecting bubble incipient temperature the expression is recognized as the most reliable model.

This model is used for calculation of bubble formation temperature along with temperature gradient consideration in the current version of TMAM.

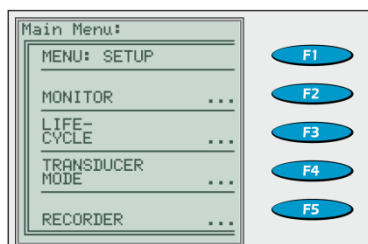
### 5.3.1 Risk of bubble formation and oversaturation

The risk of gas bubble formation can be evaluated by calculating a probability of bubble occurrence. This is achieved by continually measuring or predicting hot-spot temperature and calculating the probability of predicted bubble temperature.

Oversaturation of oil with water can occur when a transformer undergoes a sudden decrease in load. Once it happens a sharp increase in RS may cause relative saturation to reach 100%, dramatically reducing insulation liquid dielectric strength. This is a dangerous situation and must be avoided whenever possible.

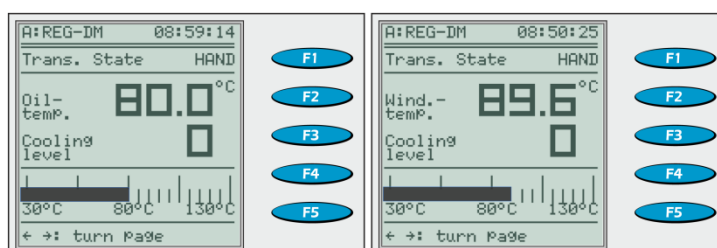
The moisture algorithm predicts a risk of oversaturation by continuously calculating saturated water content in oil at the temperature of interest and compares this value to the value of water content as measured by RS sensors at the beginning of sudden change of temperature. If these two values become equal there is a high risk of oversaturation.

## 6. Main menu



The main menu can be accessed from the Monitor, Service life and Transducer screens as well as from the Setup screen by pressing the <Menu> button.

### 6.1 Monitor



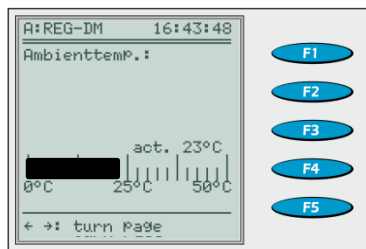
The Monitor's basic screen shows either the oil temperature or the winding temperature as decimal values and a bar graph. The current cooling stage is also displayed. The displayed winding temperature is the highest of the three calculated winding temperatures.

The oil temperature is displayed whenever the oil temperature is selected to regulate the temperature, the fan or the oil pump control. The winding temperature is displayed when either the 'Smart Fan Control' (SFC) or the winding temperature is selected as the basis for the temperature control.

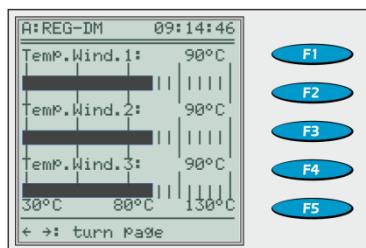
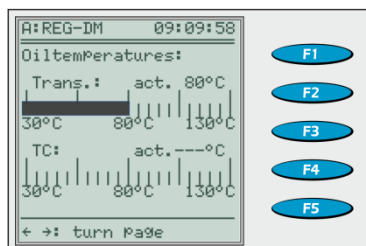
Based on the model, transformers are equipped with several fan groups. Since the fans are similar in terms of their cooling performance, a greater cooling performance is achieved by running several fans at the same time. Cooling stage 3 means that three groups of fans are working at the same time. Cooling stage 1 means that one group of fans is working.

The fans can be controlled manually or automatically. For manual control, the REG-DMA must be set to MAN. The orange up arrow and down arrow buttons are used to gradually activate or deactivate the cooling stages. When the REG-DMA is in AUTO mode, the fan is controlled automatically.

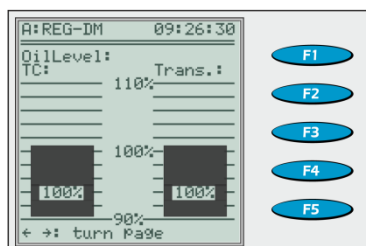
Press '→' to access the next screen and display the ambient temperature.



Press '→' to access the next two screens. These screens display either the oil temperature for the transformer and the tap changer or the hot-spot temperature of all three windings.

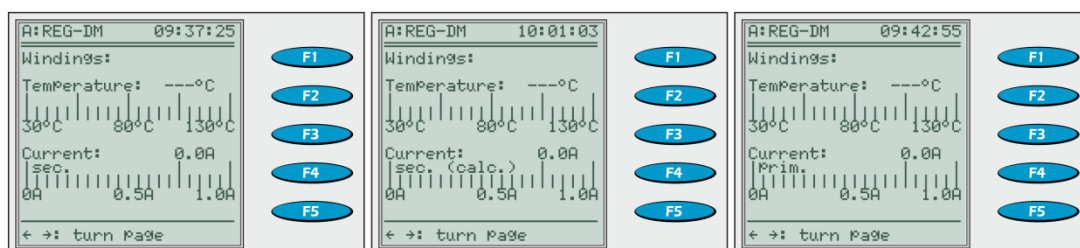


Press '→' to access the next screen and display the fill levels for the transformer tanks and the TC vessel (TC ⇒ tap changer ⇒).

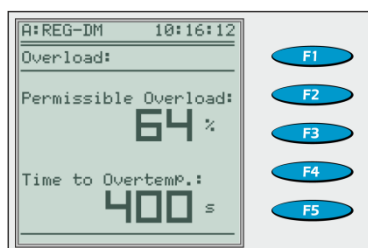


The oil level in the transformer and the tap changer can only be displayed if the controller is supplied with the corresponding sensor data from the transformer and the tap changer. In the simplest case, the fill level is supplied to the controller as an analogue signal. Scaling is done from the menu. The bar flashes when the limits are exceeded. In addition the level alarm is available as relay and LED output function as well as SCADA indication. A black non-flashing column indicates that the 'fill level is OK'.

Press '→' to access the next screen and display the winding temperature and the secondary current that is currently flowing. Based on the settings for the current transducer connection and the Characteristics 'Three winding' and 'M2', the current shows the actual measured secondary value, the calculated secondary value, or the primary value (see also Chapter 7.2.4).



Press '→' to access the next screen and display the possible overload and the time within which the over temperature will be reached.



### Possible overload

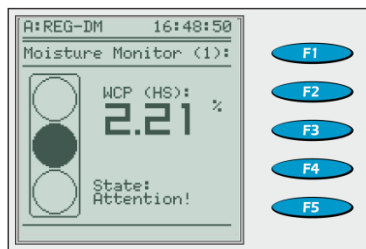
This screen provides information about the transformer's load capacity. It indicates the load that the transformer can carry as a percentage without exceeding the maximum winding temperature at the end of the window (Time to max temperature).

### Time to over temperature

This screen displays the time after which the maximum winding temperature will be reached at the current load.

Two dashes are displayed if the temperature limit is not reached at the current load. The same applies when the temperature limit has already been reached or exceeded.

Press '→' to access the next screen and display the Moisture Monitor (1).



The Moisture Monitor (1) screen shows the estimated water in paper content both as a numerical value and a traffic light.

The limits for the traffic light in the standard setting are as followed:

Green (lower circle):  $0 \leq Wcp < 1$

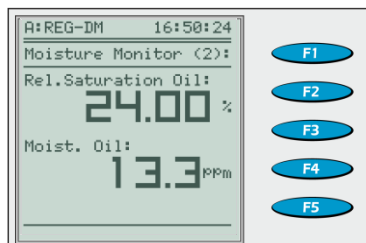
Yellow (middle circle):  $1 \leq Wcp < 4$

RED (upper circle):  $4 \leq Wcp$

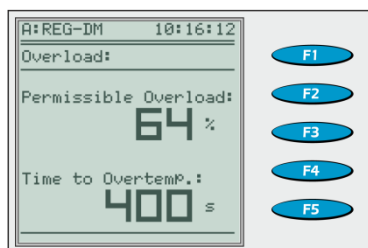
The thresholds for the traffic light can be adjusted, therefore please contact the REGSys support (+49(0)911/628108-101 or [regsys-support@a-eberle.de](mailto:regsys-support@a-eberle.de))

In accordance to the traffic light the Status of the water in paper content is indicated as text message (Normal, Attention!, Critical!!).

Press '→' to access the next screen and display the Moisture Monitor (2) that shows the relative saturation of the oil provided by the sensor and the calculated moisture in oil content expressed in ppm.



Press '→' to access the next screen and display the Moisture Monitor (3).



The Moisture Monitor (3) screen shows the estimated Bubbling temperature, the Bubbling safety margin and a traffic light for the Bubbling temperature. The Bubbling safety margin shows the temperature difference between the Bubbling temperature ( $\Theta_{\text{bubble}}$ ) and the Hot-spot temperature ( $\Theta_{\text{h}}$ ). If the Safety margin becomes small the Hot spot temperature is very close to the estimated bubble formation temperature. That means bubble formation can happen. In addition the bubble safety margin traffic light indication takes the estimated steady state Hot spot temperature  $\Theta_{\text{hp}}$  into account.

The limits for the traffic lights are as follows:

Green (lower circle), low risk:  $(\Theta_{\text{bubble}} - \Theta_{\text{h}}) > 10 \text{ K}$  and  $(\Theta_{\text{bubble}} - \Theta_{\text{hp}}) > 10 \text{ K}$

Yellow (middle circle), medium risk:  $(\Theta_{\text{bubble}} - \Theta_{\text{h}}) > 10 \text{ K}$  and  $(\Theta_{\text{bubble}} - \Theta_{\text{hp}}) < 10 \text{ K}$

RED (upper circle), high risk:  $(\Theta_{\text{bubble}} - \Theta_{\text{h}}) < 10 \text{ K}$

The traffic light indication has a hysteresis of 1 Kelvin.

### 6.1.1 Oil temperatures (TC/Transformer)

The oil temperatures can be displayed either as bars or alphanumerically. The maximum temperature for the transformer and tap changer can be specified in the setup. If the temperature in the tap changer vessel is needed, it must be fed into one of the controller's analogue inputs as a mA value.

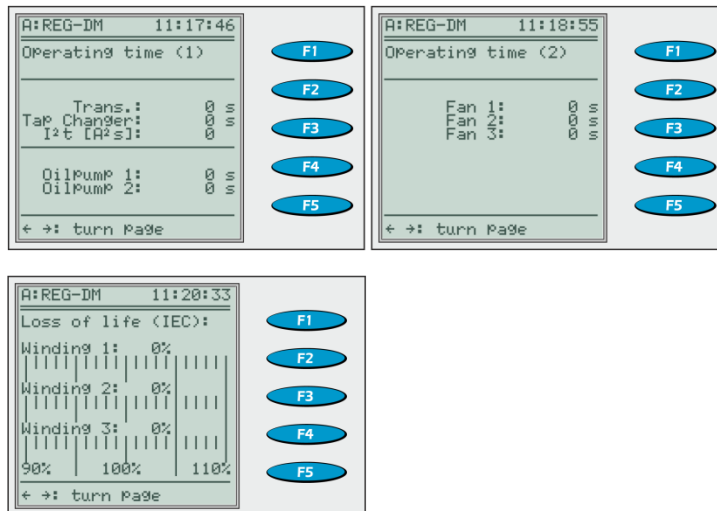
### 6.1.2 Winding currents and winding temperature

The 'Windings' display mode provides information about the actual current flowing through the windings, as well as the hot-spot temperature, which is determined from the current and the oil temperature. The values displayed correspond to the largest current and the highest winding temperature.

## 6.2 Service life

The 'SERVICE LIFE' menu, which combines all of the service lives (transformer, fan, pump), is accessed from the 'MONITOR' main menu by pressing <F2>.

Press <ESC> to return to the MONITOR main menu from any menu. The number of times <ESC> needs to be pressed depends on the menu level you are at.



### 6.2.1 Operating hours (1)

'Operating hours 1' displays the accumulated operating hours for the transformer (transformer under voltage), the tap changer and the oil pump. The operating hours for the transformer and the tap changer are different because only the hours that the motor is in operation are measured for the tap changer. The 'Operating light time' is used as an indicator of the tap changer's operating hours. This means that the service life counter is only active for the tap changer if a binary input is configured as 'Operating light' (07:Operate).

The counter value does not change if an input is configured but no operating light connected. If a binary input is not configured, the program uses the operating light's maximum time in the Controller's SETUP 5 menu (Functions..., F1).

In this case, the tap changer's service life counter is incremented by the preset time when the controller transmits a control command.

The transformer's operating hours are recorded by default if a voltage on the secondary page is set to 'Transformer in operation'.

This approach can produce incorrect results (see Figure 7) based on the location of the voltage transducer.

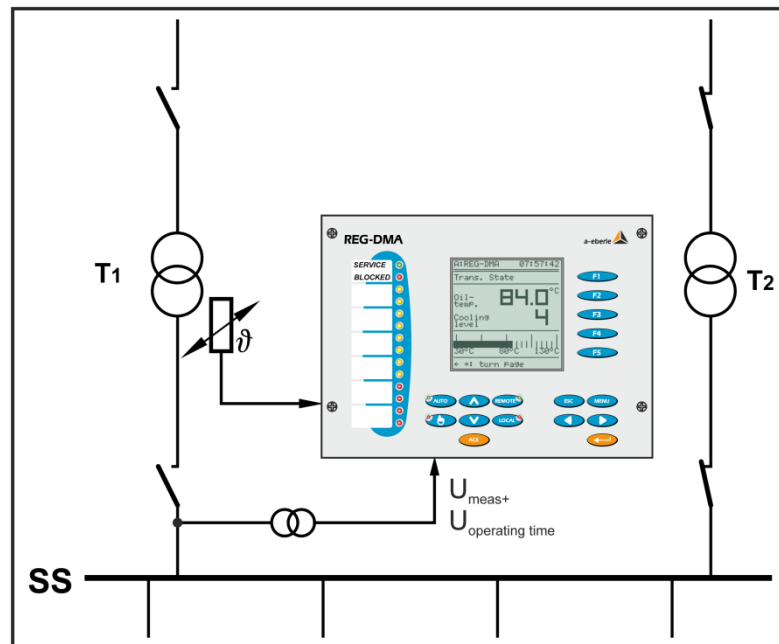


Figure 7: Diagram showing the operating hours through the secondary voltage

In any case, measuring the primary voltage of the transformer will produce correct results. The firmware characteristic 'Three winding' can be used to activate a second voltage channel that measures the primary voltage. The second voltage input is always present and in principle available for this task when the controller is equipped with hardware Characteristic 'M9'. In all other cases, the regulator – if the primary voltage is to be measured – must be sent in for modification.

If software Characteristic 'Three winding' is activated (only possible in combination with hardware Characteristic M9), the operating hour count is derived from the primary voltage.

If the characteristic 'Three winding' is not activated, the operating hours are derived from the transformer's secondary voltage, which - as mentioned above - can produce incorrect results based on the location of the voltage transducer.

Figure 7 shows an application in which two transformers are fed from a bus bar.

If the voltage transducer is installed close to the bus bar, the controller will still measure a voltage if the secondary voltage of transformer T1 is switched off because the bus - and thus the voltage transducer - is supplied through the second active transformer T2.

Figure 8 displays the secondary control voltage, while the voltage for the operating hour count is tapped from the primary voltage transducer. This version records the operating hours correctly.



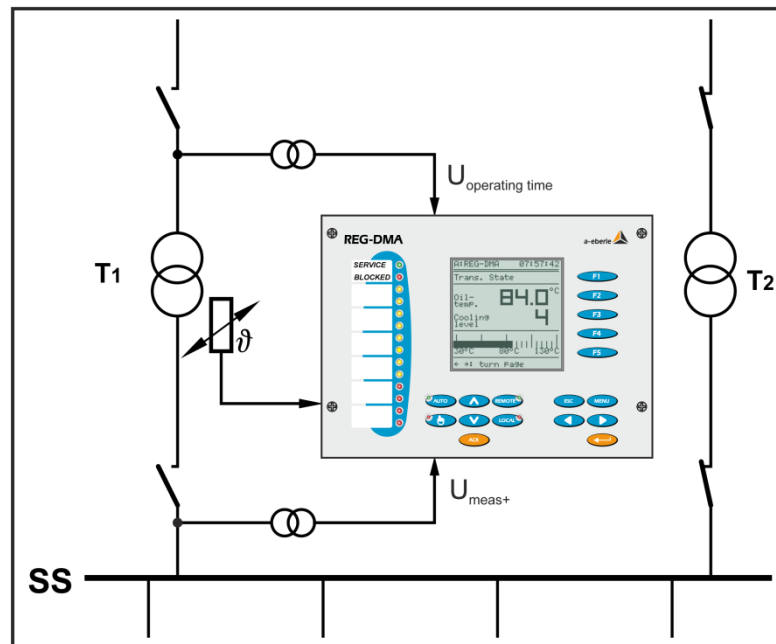


Figure 8: Diagram showing the operating hours through the primary voltage

The value  $I^2t$  is used to estimate the contact erosion in the tap changer. Two parameters are needed to determine this value. One is the current in the electric arc and the other the time 't' during which the arc is discharged. Current 'I' is the current that is flowing at the time of the changeover, whereas time 't' can be entered for a specific tap changer. It should be noted that the changeover time is very difficult to determine accurately and is also not constant over the life of the changer. But the accumulation of  $I^2t$  provides a way to capture the qualitative condition of the tap changer. If time 't' is set to 1, the sum of product  $I^2t$  is only  $I^2$ .

If the oil pumps are controlled by the controller, the operating time of the pump is totalled and displayed in the menu. The oil pumps are controlled by fixed assigned output relays.

### 6.2.2 Operating hours (2)

The operating times of the fan and the oil pump are listed under 'Operating hours (2)'.

The fans are controlled according to an algorithm that always adds the fan with the smallest total operating time.

This ensures that all the fans are more or less evenly loaded. A specific output can also be allocated to a specific cooling group in each menu.

### 6.2.3 Service life consumption

The service life consumption information is derived from the equations specified in IEC 60354 and IEC 60076.

The service life consumption should not be confused with the operating hours described earlier. The 'Operating hour' log file only counts the time during which the transformer is under voltage, while the service life consumption takes thermal ageing into account.

The relative thermal ageing of the insulation as a factor of temperature and time is determined by the Arrhenius equation:

$$\text{Operational life span} = e^{(\alpha+\beta)/T}$$

$\alpha$  and  $\beta$  : Constants that are determined by tests on the insulators

$T$  : Thermodynamic temperature in K

In the 80... 140°C temperature range, the Arrhenius equation can be replaced with the slightly simpler Montsinger relationship.

$$\text{Life expectancy} = e^{-P\Theta}$$

$P$  : Constant

$\Theta$  : Temperature in °C

According to scientific publications, a transformer's service life consumption doubles in the 80 to 140°C range when the temperature increases by about 6 K.

Another equation can be used to determine the relative service life consumption at temperature  $\Theta_h$  relative to the normal service life consumption at temperature  $\Theta_{hN}$ .

$$V = \frac{\text{Service life consumption at } \Theta_h}{\text{Service life consumption at } \Theta_{hN}} \quad (1)$$

$$V = 2^{(\Theta_h - \Theta_{hN})/6} = e^{0,693(\Theta_h - \Theta_{hN})/6}$$

The value  $\Theta_{hN}$  was specified for a transformer according to CEI/IEC 354/VDE 0532 Part 1/11.71 at 98°C. This temperature corresponds to the operation of a transformer with nominal output at a coolant temperature of 20°C when the hot-spot temperature is 78 K, i.e. 13 K above the average over temperature of 65 K. These temperature conditions correspond to the normal ageing of the insulation.

The following equation can be derived in common logarithms from equation (1) with  $\Theta_{hN} = 98^\circ\text{C}$ .

$$V = \text{Relative service life consumption} = 10^{(\Theta_h - 98)/19,93} \quad (2)$$

This relationship is shown in the below table:

$\Theta_h$ in °C	Relative service life consumption
80	0.125
86	0.25
92	0.5
98	1.0
104	2.0
110	4.0
116	8.0
122	16.0
128	32.0
134	64.0
140	128.0

**Example:**

10 hours at 104°C and 14 hours at 86°C consume  $(10 \text{ h} \times 2) + (14 \text{ h} \times 0.25) = 23.5$  hours during an operation period of 24 hours.

Note that the service life consumption is negligible below 80°C.

When the load and ambient temperature are constant, the relative service life consumption is calculated with the relationship  $V \times t$ . 't' is the time under load and V is the relative service life consumption from equation (1).


More commonly, when the operating conditions are not constant, the transformer's service life consumption is calculated according to the following equation:

$$L = \frac{1}{t} \int_{t_1}^{t_2} V dt \quad \text{or} \quad L = \frac{1}{N} \sum_{n=1}^N V$$

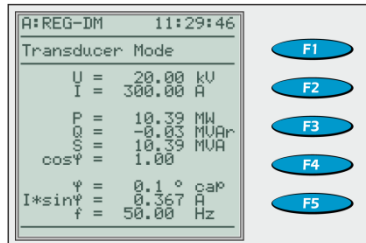
n : Number of a time interval

N : Total number of the same time intervals

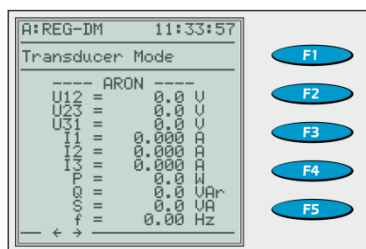
## 6.3 Transducer mode

 In the Monitor's basic screen, press <Menu> and then <F3> to access the Transducer.

This is where the current voltage, current, power and power factor are displayed.



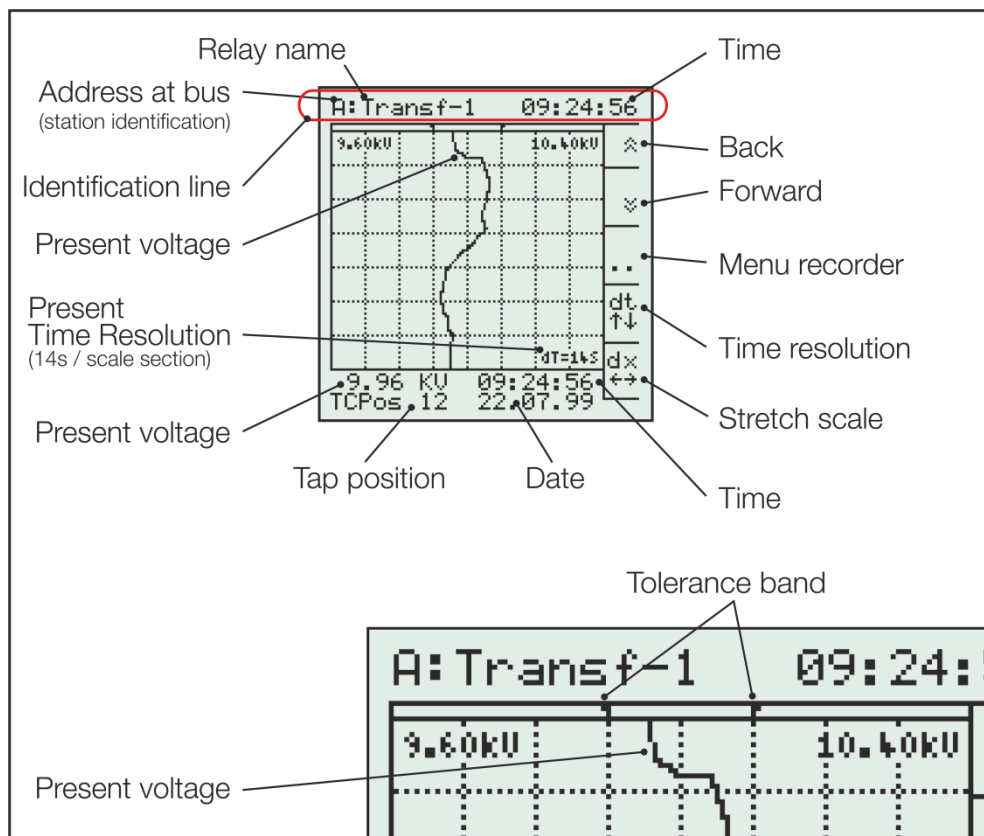
If your REG-DMA is equipped with Characteristic M2, you will have access to the menu that displays the voltage, current and power measured in the Aron circuit. Please note that the transducer's voltage and current must be set to ARON (see also Chapter 7.10.1) when the transducer is installed to ensure that the Aron measurement is correct.



## 6.4 Basic Recorder function with three channels

The chronological sequence of up to two selectable measured quantities is continuously displayed as a line chart. The time grid for the recording is adjustable. The current date and time (timestamp) are also recorded. This enables correlated data to be queried by date and time. The average storage time for a channel is about six weeks. A total of three channels can be recorded.

The keyboard or the operating software can be used to retrieve and display the stored values.



### Displaying recorded data

In the first recorder menu (F3), menu item 'Dual display' (F4) is used to toggle the recorder display between single-channel display and dual-channel display. The left and right arrow keys are used to toggle between the displayed channels.

Use 'dx' (F5) to change the value range displayed for the active channel. The value of the left channel is changed in dual display mode. Use F1 and F2 to move the displayed curve to the left or the right. Use F4 to zoom into the scale. Use F5 to zoom out. Use F3 to change the scale.

- Manual: Use F1, F2, F4 and F5 to change the graphic
- Auto Setup: One-time automatic adjustment of the display to the value range measured to date

- Upper limit ...: Enables a fixed end value to be entered for the scale (upper limit)
- Lower limit ...: Enables a fixed start value to be entered for the scale (lower limit)
- Lower limit = 0: Sets the start value of the scale to zero

Use F4 to select the recorder's feed rate. You can choose from five different times: 14 s, 1 min, 2 min, 5 min, 10 min. The 'dt' values related to the time that must pass before a division is depicted. Seven available divisions are displayed on the screen. This enables a maximum time domain of 7 x 10 min (70 min) to be displayed on the screen. The shortest time domain with the highest optical resolution is 7 x 14 s (98 seconds).

### Operation

Press F1 and F2 to access historical data in the Recorder's menu. You can view the timestamp for a specific event by pressing F1 and F2 to browse the voltage-time-diagram back to the time reference line (beginning of the grid (top)) and then at the bottom of the grid, time, date, voltage and tap position.

'HIST' is displayed at the bottom of the grid when historical data are displayed. Press ESC to exit the screen at any time. Press F3 to open the Recorder-1 menu.

Under 'Scroll' you can set the number of lines displayed on the screen when searching with F1 and F2 in recorder mode. This accelerates the search process. You can also switch to 'Dual display' or 'MMU display' in the Recorder-1 menu. Press F3 to open the Recorder-2 menu. The menu point 'Time search' enables you to specify a specific search date and time. You can choose the type of display under 'Channel display'.

Pressing F3 to return to recorder mode displays the time line-diagram for the selected time.

The Recorder-1 and Recorder-2 menus display the current storage level as a percentage and number of days.



#### Note:

The recorder is running in demo mode if DEMO is displayed in the left of the grid when the recorder is in normal display mode. In this operating mode, the recorder records measured values for a time domain of 4 to 6 hours. The oldest values are overwritten at the end of this period. Data cannot be read out in demo mode!

## Parameterization

The channels are parameterized in the recorder's Setup, which is accessed from the Recorder's basic screen by pressing F3 and F5.

Pressing F3 starts or stops recording the measured values.

## Number of channels

The number of channels specifies the number of channels to record. A total of three channels can be recorded.

The following parameters are accessed by pressing F1 in the Recorder's Setup menu.

## Allocation

This is where you define which measured quantity is recoded on which channel. If the measured quantity is scaled with a factor, it is displayed in front of the F3 button.

Function	Value range	Scaling*	Description
U	0...150 V	KNU	Voltage
I**	+/- 10A	KNI	Current
PHI	+/- 180°	1	Phase angle Phi
U1	+/- 3200 V	KNU 1	Voltage U1
U2	+/- 3200 V	KNU 2	Voltage U2
OilTp-TR	+/- 3200°C	1	Transformer oil temperature
WindTemp	+/- 3200°C	1	Winding temperature
A1_ANA	Selectable	1	Analogue channel 1
A2_ANA	Selectable	1	Analogue channel 2
A3_ANA	Selectable	1	Analogue channel 3
A4_ANA	Selectable	1	Analogue channel 4
A5_ANA	Selectable	1	Analogue channel 5
A6_ANA	Selectable	1	Analogue channel 6
...			
AMAX_ANA***	Selectable	1	Analogue channel max.

\* Scaling is used for the display. This means that specific values are stored, for example, as secondary values and scaled for display by this value.

\*\* The current is recorded relative to the nominal value (1/5 A) set. This means that the value 1 A is recorded if 5 A are flowing for a 5A transducer. The effective transducer factor (5 x KNI) is used for the display.

This behaviour must be taken into account when setting the absolute deviation.

\*\*\* The number of analogue channels available in the recorder depends on the number of analogue channels it has. The max number of channels is 32. The max number of channels for Characteristic S2 are 64.

The function that is allocated to the analogue function is contained in the name in the allocation menu. For example, if analogue channel 4 is allocated output function oSP (output of the active setpoint), the description is A4\_oSP.

### **Step distance**

The step distance parameter determines the value range that is recorded and the number of decimals the values are stored with. For the measured quantities U, I, Phi, U1, U2, OilTp-Tr and WindTmp, the range of values is fixed and automatically set when the measured quantity is selected. When an analogue channel is recorded, the value range for the measured quantities is not fixed, which is why the step distance can be selected. The step distance determines the number of decimals used to record the measured values. Because each of the recorder channels can record  $\pm 32000$  values, setting the number of decimal places defines a specific value range (step distance 0.01 -> value range  $\pm 320.00$ ; step distance 0.1 -> value range  $\pm 3200.0$ ). The available range of values is displayed in front of the F3 button.

### **Absolute deviation**

The absolute deviation defines a dead band for the recording of the measured values. This means that a new value is only recorded when the change to the last recorded value is greater than the absolute deviation. This parameter enables the storage space to be reduced for measured values that strongly fluctuating.

### **Deleting recorded data**

Recorder data can be deleted in the menu 'Setup-10\General-2' by pressing F4 'Delete recorder'.

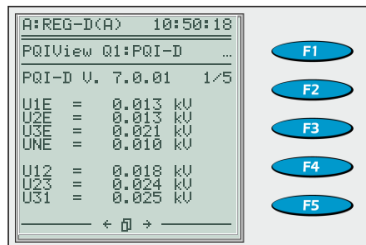
## **6.5 Additional Recorder function**

The additional Recorder function has a total of 4 recorders, each with 64 channels. The recording interval can be set separately for each recorder. The data can only be parameterized and viewed with the A. Eberle Toolbox software. The stored values cannot be displayed on the REG-DMA's screen.



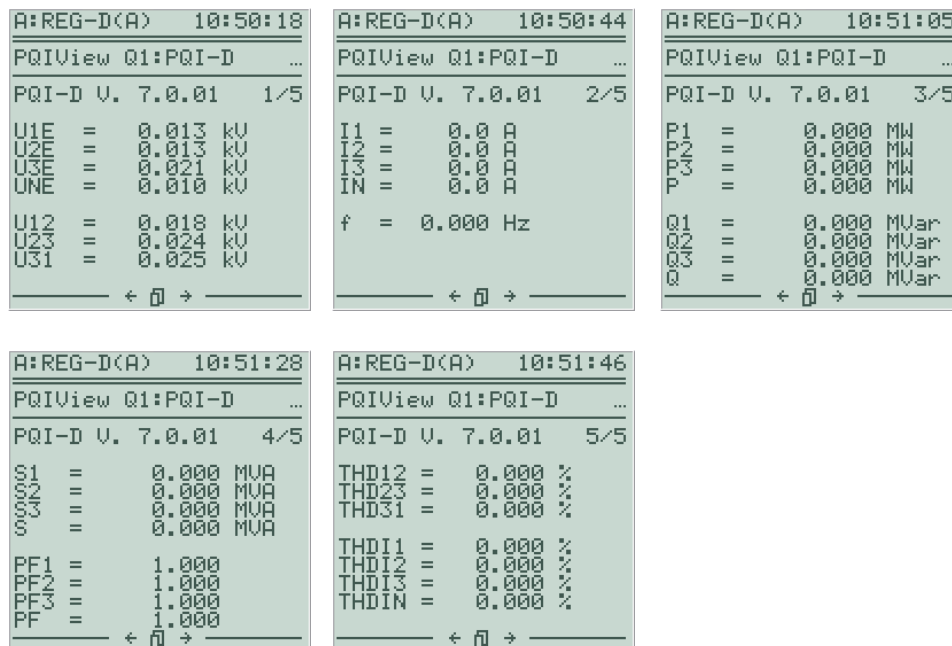
## 6.6 PQIView

The PQIView mode shows measurement values from a PQI-D(A) power quality interface that is connected to the same ELAN network like the REG-DMA is.



If there is more than one PQI-D(A) available on the ELAN network the F1-key can be used to switch the display to another device. The F2 to F5-keys are used to go through the different pages of the PQIView. The number and style of the different pages of the PQIView depends on the type of the connected PQI-D(A)s.

PQI-D View displays for UI-devices (devices with voltage and current measurement):



PQI-D View displays for UU-devices (devices with voltage measurement only):

A:REG-D(A) 10:53:20 PQIView Q2:PQI-D ... PQI-D U. 4.0.07 1/3 U1E_1 = 0.000 kV U2E_1 = 0.000 kV U3E_1 = 0.000 kV UNE_1 = 0.000 kV  U12_1 = 0.000 kV U23_1 = 0.000 kV U31_1 = 0.000 kV ← □ →	A:REG-D(A) 10:53:42 PQIView Q2:PQI-D ... PQI-D U. 4.0.07 2/3 U1E_2 = 0.000 kV U2E_2 = 0.000 kV U3E_2 = 0.000 kV UNE_2 = 0.000 kV  U12_2 = 0.000 kV U23_2 = 0.000 kV U31_2 = 0.000 kV ← □ →	A:REG-D(A) 10:54:08 PQIView Q2:PQI-D ... PQI-D U. 4.0.07 3/3 THD12_1 = 0.000 % THD23_1 = 0.000 % THD31_1 = 0.000 %  THD12_2 = 0.000 % THD23_2 = 0.000 % THD31_2 = 0.000 %  f = 0.000 Hz ← □ →
---	---	---

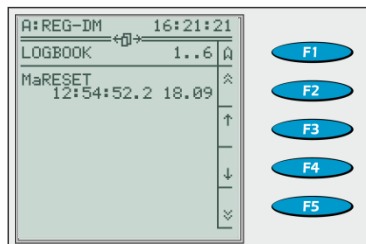


#### Device not available

If there is no PQI-D(A) connected to the ELAN network the following message is shown:  
“PQIView is not able to display PQ data, because no PQI-D(A) could be found on E-LAN”

## 6.7 Logbook (Eventlog)

The REG-DMA is equipped with a event log functionality that is able to record up to 511 event. The Logbook enables you to do a post mortem analysis of the things happening around the monitored power transformer. If the max. number of events is reached the oldest event will be overwritten.



[illegible]

The following system events are always logged. A configuration is not possible.

Event	Logbook text	Description
<b>Time Restore</b>	RTC=RAMt RTC=EEPt RTC=RBUt RTC=2000	The time information of the REG-DMA was found invalid after a power On. Therefore the time was reset to the best available backup.  Timebackup sources: RAMt = Restore from the RAM (MRAM) EEPT = Restore from the EPROM RBUt = Restore from a RAM-image in the flash memory 2000 = The time was set to 01.01.2000 0:00:00
<b>Master Reset</b>	MaRESET	All parameters of the device were reset to default values and the RAM was initialised.

It's also possible to log the status of the binary inputs, binary outputs and LEDs of the REG-DMA. These events are not logged as standard because of the limited memory of the logbook. The logging of these events can be switched on and off via the AE Toolbox software. Hereby it's possible to define if the I/O should trigger an event when it becomes active or inactive or both.

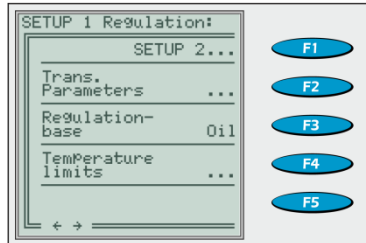
In addition to the standard events generated by the firmware of the REG-DMA it's possible to do customer and application specific event via background program (h-code). This customer specific events are free definable and consist of up to 8 characters (e.g. „Costum\_1“).


The Logbook can be checked and cleared directly on the Display of the REG-DMA and with the Software AE Toolbox. The AE Toolbox is also able to store the events of the logbook on the PC.

## 7. SETUP

 Press <Menu> twice to access Setup from the Monitor's basic screen.

### 7.1 SETUP 1




 Use the <F2...F4> keys to access the individual submenus.

#### 7.1.1 Transformer Parameters



... several sets of parameters

A parameter set can be specified for each cooling stage. The number of menus depends on how many cooling stages/fans the transformer has. The number of cooling stages can be set for each menu.

 Press <F1> to access the next set of cooling stage parameters.


#### Rated current

The winding's rated current can be different for each type of cooling. Please note that primary values are also used for the rated current when measuring the primary current.


The rated current displayed in this menu must not be confused with the rated value of the current that is used to measure tasks in the controller (SETUP 5, F2 et seqq).

There, the rated current is configured as 1 A or 5 A. For transformer monitoring, the nominal value of the current is the maximum current a transformer can be subjected to with a specific cooling.

The current can be displayed in a range from 0...3000 A.

 Press <F2> to enter the corresponding rated current.

 Use <F1...F5> to enter the appropriate values.

 Press <Enter> to confirm the entry.

### Thermal time constant for the winding

The thermal time constant is a transformer-specific parameter and can generally be taken from the transformer's data sheet.

Value range: 0..50000 s

You may need to contact the manufacturer.

The time constant for the winding is the time that would elapse until the hot spot reaches the steady-state final value multiplied by five.

Example:

With a time constant of 3000 seconds, it is assumed that after  $5 \times 3000 \text{ s} = 15,000 \text{ s}$ , meaning about 4 hours, the steady-state final value of the hot-spot temperature will be reached.

The number of submenus is determined in proportion to the number of predefined cooling stages. 'Cooling stage 0' means that there is no cooling at all. 'Cooling stage 0 (oil pump)' only appears when one of the two cooling types is configured ON/OF or ON/OD. The parameters for each of the cooling stages (fan group) are set for the transformer in the 'Cooling stage 1,2,...' menus.

### Hot-spot temperature increase $H_{gr}$

The hot-spot temperature increase (Hot-Spot Incr.) is a transformer-specific parameter and can generally be taken from the transformer's data sheet.

You may need to contact the manufacturer.

If manufacturer data is not available for ' $H_{gr}$ ', use the values specified in the standard.

The standard indicates that different values should be used for the hot-spot temperature ' $H_{gr}$ ' based on the type of cooling used for medium and large power transformers.

Type of cooling	ON...	OF...	OD...
$H_{gr}$	26 K	22 K	29 K

A value of 23 K is suggested for distribution transformers with cooling type ONAN.

### Winding exponent $y$

Winding exponent ' $y$ ' is a transformer-specific parameter and can generally be taken from the transformer's data sheet.

You may need to contact the manufacturer.

If no manufacturer data is available for ' $y$ ', it is recommended to use the values specified in the standard.

The standard indicates that different values should be used for winding exponent ' $y$ ' based on the type of cooling used for medium and large power transformers.

Type of cooling	ON...	OF...	OD...
$y$	1.6	1.6	2.0

An exponent of 1.6 is suggested for distribution transformers with cooling type ONAN.

### 7.1.2 Basis of the control

Different reference temperatures can be chosen for the connection of the individual fans. Because the temperature for the oil and the winding are related in terms of their formula, both temperatures can be used as base temperature.

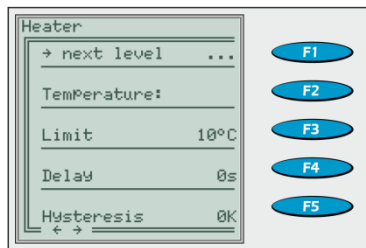
In order to accommodate their own business philosophy, users can select which rule they use.

 Press <F3> in <SETUP 1/Control> to choose the desired base.

The following choices are available:

- Oil (the oil temperature determines the limit values)
- Winding (the winding temperature determines the limits)
- SmrtCtrl (Smart fan control): In this operating mode, the estimated winding temperature is calculated and used to control the cooling.


### 7.1.3 Temperature limits





..... several sets of parameters

Individual limit values can be configured for each cooling stage, the heating and the oil pumps. The number of menus depends on how many cooling stages are configured and whether a cooling mode with forced circulation is selected (see the section 'SETUP 3').

The respective cooling stage is activated when the temperature exceeds the specified limit.

 Use function keys <F1...F5> to set the limit in the range of -30°C to 200°C.

 Press <Enter> to confirm the chosen limit.

 Press <F1> to access the next set of cooling stage parameters.

#### Switching delay

To force the fan to run quietly, the temperature must exceed the defined limit for a configurable time before it is switched on.

The switching delay can be set in the range of 0...900 s.

Use the switching delay to adjust the sensitivity of the fan controls. In suppressed short temperature increases that can be caused by interference during transmission.


### Hysteresis

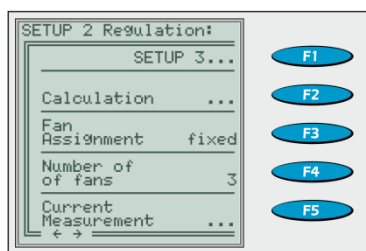
If the temperature were to fluctuate around the set limit value, it would be impossible to prevent the fan repeatedly switching on and off without specifying the hysteresis.

Since this behaviour would degrade the effectiveness of the whole system, a hysteresis in the range of a few Kelvin is recommended.

The hysteresis can be set in the range of 0...30 K.

## 7.2 SETUP 2

 SETUP 2 is accessed by pressing the '→' arrow or <F1> in SETUP 1.



### 7.2.1 Calculation

#### Type of air cooling (outer cooling medium)

The following options are available:

- AN: Stands for Air Natural, meaning that the transformer does not have any fans and that air is moved by convection.
- AF: Stands for Air Forced, meaning that the transformer has fans

#### Limited oil flow

The following options are available:

- Yes
- No

This parameter is used in accordance with IEC 60076. It takes into account that the transformer has a limited oil flow by design. The manufacturer can tell you if the transformer has a limited oil flow as described in the standard.

#### Type of oil cooling (inner cooling medium)

The following options are available:

- ON: Stands for ONAN or ONAF cooling
- OF: Stands for OFAF or OFWF cooling
- OD: Stands for ODAF or ODWF cooling



- ON/OF: Stands for switching between ON and OF cooling. In this case, at least one controllable oil pump is available:
- ON/OD: Stands for switching between ON and OD cooling. In this case, one device to steer the oil and at least one controllable oil pump are available.

The 'Transformer parameters' and 'Temperature limits' menus each have two additional parameter tabs for the oil pumps when cooling modes ON/OF and ON/OD are activated.

#### **IEC Formula**

The following options are available:

- IEC 60354
- IEC 60076

The parameter determines the algorithm used to calculate the hot-spot temperature.

### **7.2.2 Fan assignment**

To enable users to assign a specific fan to a cooling stage or let the system decide which fan to activate for a cooling stage, the Transformer Monitoring Module offers the choice between:

- fixed
- and
- cyclical

If the parameter 'fixed' is chosen to assign fans to a specific cooling stage, fan 1 will always be switched on for cooling stage 1. Over a long period of operation, this setting will result in a high operating time and thus wear of fan 1, whereas that of the higher cooling stages will be very small.

If 'cyclical' is chosen for the fan assignment, the controller decides which fan is switched on in proportion to the total operating time of each cooling stage. Over the service life, this algorithm achieves a more or less equal operating time for all fans.

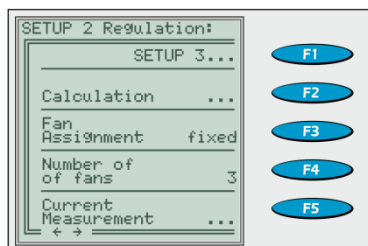
### **7.2.3 Number of fans**

As the number of fan groups varies by transformer type, the current number can be entered in the menu. As a result, this setting will be adjusted in all menus in which fan control and fan service life parameters are configured.

There are a total of six fan cooling groups that are identified in the menu by the numbers 1: to 6:.

## 7.2.4 Current measurement

A transformer's hot spot is affected by a number of transformer parameters (Hgr,  $\gamma$ , time constant) and by the two measured quantities oil temperature and current through the winding. Different sources to measure the current are available for different applications. The necessary settings can be made in the 'Current Measurement' setup.



### Transducer connection

The current used to calculate the hot-spot temperature is selected in the 'Transducer connection' submenu. The effect of this parameter depends on the characteristic 'Three winding' and 'M2'. Please see the below note.

### Ratio of the power transformer

In order to determine the primary current when measuring the secondary current, the power transformer's conversion ratio is used to convert the measured current to primary current. This parameter is also used to calculate the secondary current for the Monitor's 'Windings' screen when the primary current is measured.

### Tap changer switching time

The value  $I^2t$  is used to record the quality of the contact load in the tap changer. The current used to calculate  $I^2t$  is taken from the continuous measurement of the current, while the switching quantity 't' is a tap-changer specific value.

If detailed information about the tap changer is not available, sufficiently good results will be achieved with a switching time in the range of 0.02 to 0.06 s.

👉 Press <F5> to enter the switching time for the tap changer.

👉 Press <Enter> to confirm the entry.

## **Influence of the 'Three winding' and 'M2' characteristics and the 'Transducerconnection' parameter on the current consumption**

### **Measurement of the winding current:**

- Without M2 and Three winding:
  - Prim.: Secondary value (calculated from the primary value)
  - Sec.: Secondary value
- With M2 and without Three winding:
  - Prim.: Secondary value 3-phase (calculated from the primary value)
  - Sec.: Secondary value 3-phase
- Without M2 and with Three winding:
  - Prim.: Primary value (measured value on Transducer 2)
  - Sec.: Secondary value (measured value on at Transducer 1)
- With M2 and Three winding:
  - Prim.: Secondary value 3-phase (calculated from the primary value)
  - Sec.: Secondary value 3-phase

If the calculated or measured primary values are used for the current, the primary values must also be used for the settings in the Monitor!


### **Calculation of the $I^2t$ value:**

- Without M2 and Three winding:
  - Prim.: Primary value
  - Sec.: Primary value (calculated from the secondary value)
- With M2 and without Three winding:
  - Prim.: Max: primary value
  - Sec.: Max. primary value (calculated from the secondary value)
- Without M2 and with Three winding:
  - Prim.: Primary value directly at Transducer 2
  - Sec.: Primary value directly at Transducer 2
- With M2 and Three winding:
  - Prim.: Max: primary value
  - Sec.: Max. primary value (calculated from the secondary value)

The calculated primary value is determined from the measured secondary current and the transformer's conversion ratio.

'Prim.' and 'Sec.' refer to the setting of the 'Transducer connection' parameter.

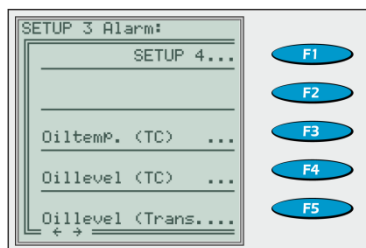
## 7.3 SETUP 3

 SETUP 3 is accessed by pressing the '→' arrow or <F1> in SETUP 2.

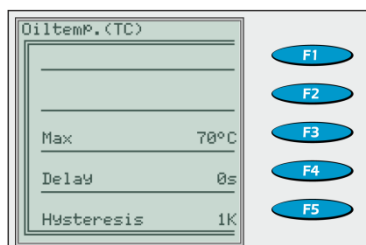
Use <F2...F5> to access other submenus in which limits, switching delays and hystereses can be selected.

Since the logic of the submenus is the same, the description of the individual screens is short. However, the hardware requirements must be met so that the controller can receive the measured quantities, which are usually supplied by external transducers as mA signals.

The total number of eight analogue channels (order characteristics E + C) can be expanded at any time with analogue interface cards (ANA-D) (see chapter 8 'Increasing the system's hardware resources').



### 7.3.1 Oil temperature (TC)



#### Maximum value

Defines the switch-on point for the alarm signal.

Setting range: 0...150°C

#### Switching delay

Defines the switch-on delay for the alarm signal.

Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...30 K

### 7.3.2 Oil level (TC)

Oillevel(TC)	
Min	95%
Max	105%
Delay	0s
Hysteresis	1%

F1

F2

F3

F4

F5

#### Minimum value

Defines the switch-on point for the 'Oil level too low' alarm signal.

Setting range: 0 ... 150%

#### Maximum value

Defines the switch-on point for the 'Oil level too high' alarm signal.

Setting range: 0 ... 150%

#### Switching delay

Defines the switch-on delay for the alarm signal.

Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for both switching points.

Setting range: 1 ... 30%

### 7.3.3 Oil level (transformer)

Oillevel(Trans.)	
Min	95%
Max	105%
Delay	0s
Hysteresis	1%

F1

F2

F3

F4

F5

#### Minimum value

Defines the switch-on point for the 'Oil level too low' alarm signal.

Setting range: 0 ... 150%

#### Maximum value

Defines the switch-on point for the 'Oil level too high' alarm signal.

Setting range: 0 ... 150%

#### Switching delay

Defines the switch-on delay for the alarm signal.

Setting range: 0...900 s

### Hysteresis

Defines the hysteresis for both switching points.

Setting range: 1 ... 30%

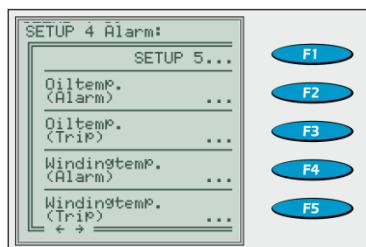
## 7.4 SETUP 4



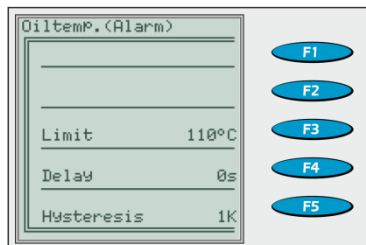
SETUP 4 is accessed by pressing the '→' arrow or <F1> in SETUP 3.

Use <F2...F5> to access other submenus in which limits, switching delays and hystereses can be selected.

Since the logic of the submenus is the same, the description of the individual screens is short.



### 7.4.1 Oil temperature (Alarm)



#### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...150°C

#### Switching delay

Defines the switch-on delay for the alarm signal.

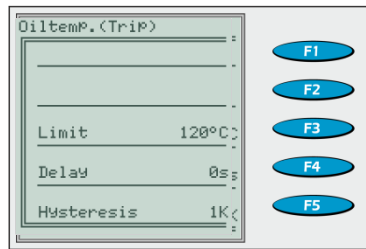
Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...30 K

## 7.4.2 Oil temperature (Trip)



### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...200°C

### Switching delay

Defines the switch-on delay for the alarm signal.

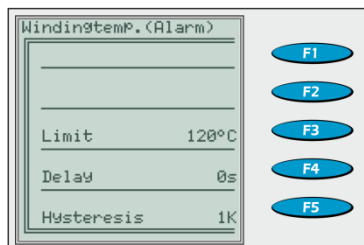
Setting range: 0...900 s

### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...30 K

## 7.4.3 Winding temperature (Alarm)



### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...200°C

### Switching delay

Defines the switch-on delay for the alarm signal.

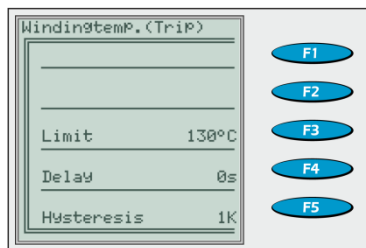
Setting range: 0...900 s

### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...30 K

#### 7.4.4 Winding temperature (Trip)



##### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...200°C

##### Switching delay

Defines the switch-on delay for the alarm signal.


Setting range: 0...900 s

##### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...30 K

### 7.5 SETUP 5/6/7

 SETUP 5/6/7 is accessed by pressing the '→' arrow or <F1> in SETUP 4/5/6.

Use <F2...F5> to access other submenus in which limits, switching delays and hysteresis can be selected.

Since the logic of the submenus is the same, the description of the individual screens is short. However, the hardware requirements must be met so that the the controller can receive the measured quantities, which are usually supplied by external transducers as mA signals.

The total number of eight analogue channels (order characteristics E + C) can be expanded at any time with analogue interface cards (ANA-D) (see chapter 8 'Increasing the system's hardware resources').



### 7.5.1 Water in Oil content

Water in Oil	
Limit	1000000 ppm
Delay	0 s
Hysteresis	100000 ppm

F1

F2

F3

F4

F5

#### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...1000000 ppm

#### Switching delay

Defines the switch-on delay for the alarm signal.

Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...100000 ppm

### 7.5.2 Gas in Oil (Total gas in Oil) content

Gas in Oil	
Limit	1000000 ppm
Delay	0 s
Hysteresis	100000 ppm

F1

F2

F3

F4

F5

#### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...1000000 ppm

#### Switching delay

Defines the switch-on delay for the alarm signal.

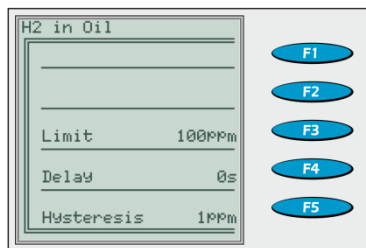
Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...100000 ppm

### 7.5.3 H2 (Hydrogen) in Oil content



#### **Limit value**

Defines the switch-on point for the alarm signal.

Setting range: 0...1000000 ppm

#### **Switching delay**

Defines the switch-on delay for the alarm signal.

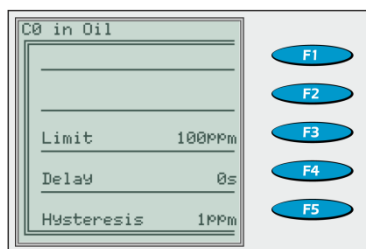
Setting range: 0...900 s

#### **Hysteresis**

Defines the hysteresis for the switching point.

Setting range: 1...100000 ppm

### 7.5.4 CO (Carbon Monoxide) in Oil content



#### **Limit value**

Defines the switch-on point for the alarm signal.

Setting range: 0...1000000 ppm

#### **Switching delay**

Defines the switch-on delay for the alarm signal.

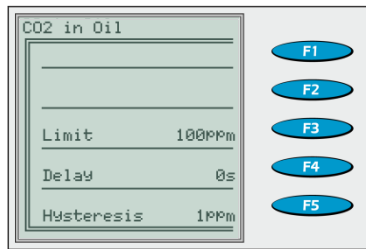
Setting range: 0...900 s

#### **Hysteresis**

Defines the hysteresis for the switching point.

Setting range: 1...100000 ppm

### 7.5.5 CO<sub>2</sub> (Carbon Dioxide) in Oil content



CO <sub>2</sub> in Oil	
Limit	100ppm
Delay	0s
Hysteresis	1ppm

F1  
F2  
F3  
F4  
F5

#### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...50000 ppm

#### Switching delay

Defines the switch-on delay for the alarm signal.

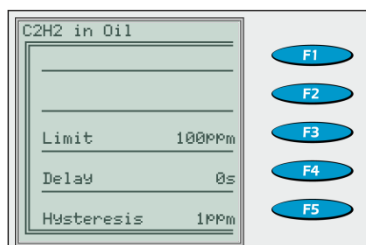
Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...5000 ppm

### 7.5.6 C<sub>2</sub>H<sub>2</sub> (Acetylene) in Oil content



C <sub>2</sub> H <sub>2</sub> in Oil	
Limit	100ppm
Delay	0s
Hysteresis	1ppm

F1  
F2  
F3  
F4  
F5

#### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...50000 ppm

#### Switching delay

Defines the switch-on delay for the alarm signal.

Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...5000 ppm

### 7.5.7 C<sub>2</sub>H<sub>4</sub> (Ethylene) in Oil content

C <sub>2</sub> H <sub>4</sub> in Oil	
Limit	1000ppm
Delay	0s
Hysteresis	1ppm

F1  
F2  
F3  
F4  
F5

#### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...50000 ppm

#### Switching delay

Defines the switch-on delay for the alarm signal.

Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...5000 ppm

### 7.5.8 C<sub>2</sub>H<sub>6</sub> (Ethane) in Oil content

C <sub>2</sub> H <sub>6</sub> in Oil	
Limit	1000ppm
Delay	0s
Hysteresis	1ppm

F1  
F2  
F3  
F4  
F5

#### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...50000 ppm

#### Switching delay

Defines the switch-on delay for the alarm signal.

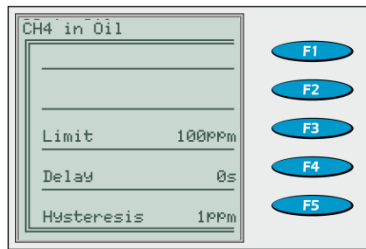
Setting range: 0...900 s

#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...5000 ppm

### 7.5.9 CH4 (Methane) in Oil content



#### Limit value

Defines the switch-on point for the alarm signal.

Setting range: 0...50000 ppm

#### Switching delay

Defines the switch-on delay for the alarm signal.


Setting range: 0...900 s

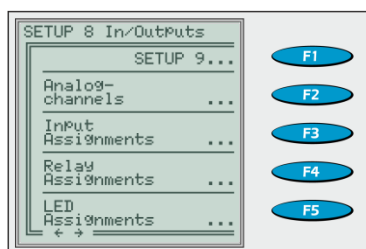
#### Hysteresis

Defines the hysteresis for the switching point.

Setting range: 1...5000 ppm

## 7.6 SETUP 8

 SETUP 8 is accessed by pressing the '→' arrow or <F1> in SETUP 7.



### 7.6.1 Analogue inputs and outputs

The physical parameters for the temperature (transformer, tap changer), fill level (transformer, tap changer), water content, gas in oil, etc. can be fed into the REG-DMA as mA signals.

Each REG-DMA can be configured with up to eight analogue channels that are available for analogue inputs, analogue outputs or PT100 modules. Note that two analogue channels are needed for one PT100 module.

The controller automatically detects the type of configuration in each slot and adaptively activates the relevant menus.

### Input and output functions

Input and output functions are used to assign a specific input or output to a particular measurement.

The following **input functions** are available:

Input function	Description
OFF	Switched off, no function
PROG	Programmable, analogue input is evaluated by the H program
iT_Oil	Oil temperature (transformer) when only one oil temperature is used
iT_Oil1	Oil temperature winding 1
iT_Oil2	Oil temperature winding 2
iT_Oil3	Oil temperature winding 3
iT_OilTC	Oil temperature (tap changer)
iOillevTC	Oil level (tap changer)
iOillevTr.	Oil level (transformer)
iWater	Water in oil content (relative saturation)
iGas	Total gas in oil content (e.g. from a DGA device)
iCO	CO in oil content (e.g. from a DGA device)
iH2	H <sub>2</sub> in oil content (e.g. from a DGA device)
iT_Wind	Winding temperature when only one winding temperature is used
iT_Wind1	Winding temperature 1
iT_Wind2	Winding temperature 2
iT_Wind3	Winding temperature 3
iTmpWSens	Oil temperature at the location of the moisture sensor
iCO2	CO <sub>2</sub> in oil content (e.g. from a DGA device)
iC2H2	C <sub>2</sub> H <sub>2</sub> in oil content (e.g. from a DGA device)
iC2H4	C <sub>2</sub> H <sub>4</sub> in oil content (e.g. from a DGA device)
iC2H6	C <sub>2</sub> H <sub>6</sub> in oil content (e.g. from a DGA device)
iCH4	CH <sub>4</sub> in oil content (e.g. from a DGA device)
iT_Amb	Ambient temperature

The following **output functions** are available:

Output function	Description
OFF	Switched off, no function
PROG	Programmable, analogue output controlled by the H program
oZero	Output 0 mA
o+FullRng	Output of the positive max. value
o-FullRng	Output of the negative max. value
oU	Active measurement voltage
oP	Active power

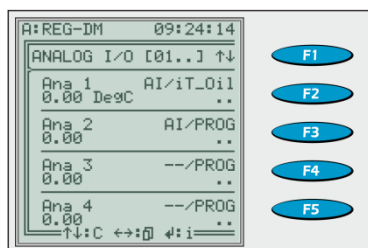
Output function	Description
oQ	Reactive power
oS	Apparent power
oU1	Measuring voltage at Transducer 1
oU2	Measuring voltage at Transducer 2
oI1	Current 1
oI2	Current 2
oI3	Current 3
oPHIDEG	Phase angle
oCOSPHI	cos (phi)
oFREQ	Frequency
oOilTemp	Oil temperature
oWindTemp	Hot-spot temperature of the winding
oT_Wind1	Hot-spot temperature winding 1
oT_Wind2	Hot-spot temperature winding 2
oT_Wind3	Hot-spot temperature winding 3
oArU12	Aron voltage U12
oArU23	Aron voltage U23
oArU31	Aron voltage U31
oArP	Aron active power:
oArQ	Aron reactive power
oArS	Aron apparent power
oMM_wco	Water in oil content
oMM_wcpmax	Water in paper content max.
oMM_cnf	Confidence of the water in paper content
oMM_cnfmx	Confidence of the water in paper content max.
oMM_WCPhs	Water in paper content at the hot spot temperature
oMM_Tbhs	Bubble Inception Temperature at hot spot location
oMM_Risc	Risc of bubble formation

The input function PROG is always selected when a non-standard measured quantity is used.

In principle, any arbitrary measured quantity that can be represented as an mA value can be fed into the controller, processed and displayed.

If necessary, limit values can of course be derived from such 'non-standard inputs' and output by relay. To do this, please contact the head office.

### Configuring the analogue channels



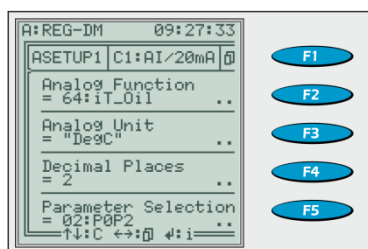
✎ Press <F2...F5> to select the channel that needs configuring.

✎ Use '→' to toggle between the analogue values.

Normalized values (relative to the nominal value of the channel), scaled values (with the parameterized scale and the unit), the real mA value, or the minimum and maximum values can be displayed. (Press F2...F5 to reset the min/max values)

The following Figures show the configuration of Channel 1. 4.. 20 mA is set to record the oil temperature 0... 100°C.

✎ Press <F2> to select Channel 1.



✎ Press <F2> to select the analogue channel.

✎ A list of all available functions displays:

✎ Use <F1, F2> and <F4, F5> to select the required function.

✎ Press <F3> to confirm the entry.

✎ Press <F3> to set the units for the scaled signal.

✎ Press <F4> to set the number of decimal places.

The aforementioned settings only affect how the values are displayed in the analogue main menu and not their processing or their display in the Monitor.

✎ Press <F5> to select the type of characteristic curve used to scale the mA signal.

The following options are available:

All: All parameters are available

Fac+Off: Scaling using factor and offset

POP2: Linear scaling

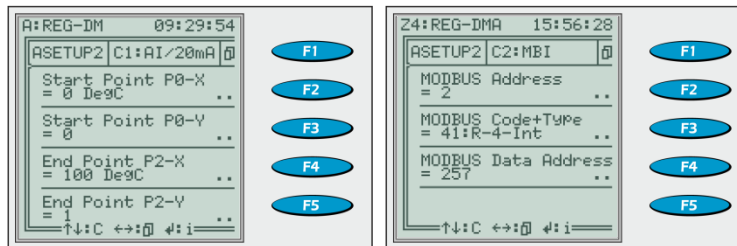
POP1P2: Scaling with a breakpoint

MODBUS: The according analogue channel gathers the data via MODBUS RTU \*

\* COM3/MODBUS converter necessary



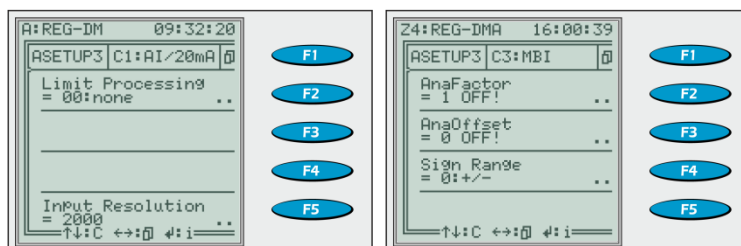
Our example uses input function 'IT\_oil'. The unit °C and two decimal places are selected automatically. A linear characteristic curve is used for scaling.



### *Analogue Setup 2 of analogue channels and MODBUS (right picture)*

- ✎ Press <F1> to access the ASETUP 2 menu.  
This is where the scaling is done.
- ✎ Press <F2> to set the start point for the measured quantities. In our example, 0°C (input without unit). In case of MODBUS please enter the MODBUS device address of the sensor unit here.
- ✎ Press <F3> to set the start point for the mA value. The value is input in standardized form, i.e. in relation to the module's nominal value. In our example, 0.2 (4 mA/20 mA = 0.2). In case of MODBUS please enter the MODBUS CODE and Type here.
- ✎ Press <F4> to set the start point for the measured quantity. In our example, 100°C (input without unit). In case of MODBUS please enter the MODBUS Data Address here.
- ✎ Press <F5> to set the end point for the mA value. The value is input in standardized form, i.e. in relation to the module's nominal value. In our example, 1 (20 mA/20 mA = 1).

The nominal value of the module displays at the top centre of the screen behind the channel number. There are two additional support points if you use the non-linear characteristic curve.



*Analogue Setup 3 of analogue channels with POP2 scaling and MODBUS (right picture)*

✎ Press <F1> to access the ASETUP 3 menu.

✎ Press <F2> to set the limit for the analogue channel (only without MODBUS).

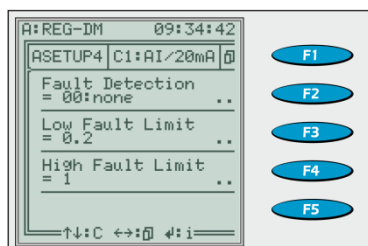
The following options are available:

- None: No limit
- High: Limit when the configured maximum value is exceeded
- Low: Limit when the configured minimum value is exceeded
- High+Low: Upper and lower limit

For example, if 'None' is selected, the characteristic curve is extended beyond the support points. In our example, this means that a current value of less than 4 mA results in an oil temperature lower than 0°C. If 'Low' is selected, a current value of less than 4 mA will result in an oil temperature of 0°C.

In case of MODBUS the parameters AnaFactor and AnaOffset can be used to scale the measured value delivered by the sensor unit via Modbus (e.g. multiplying with 0.1).

✎ Press <F5> to configure the resolution for an analogue input.



✎ Press <F1> to access the ASETUP 4 menu.

✎ Press <F2> to set the limit for the broken-wire detection.

The following options are available:

- None: No broken-wire detection
- High: Broken-wire detection when the maximum value is exceeded
- Low: Broken-wire detection when the minimum value is exceeded
- High+Low: Broken-wire detection when the minimum and maximum values are exceeded

✎ Use <F3> and <F4> to set the values for broken-wire detection (range in exceeded values). The input is a standardized value (e.g. 3.5 mA (at 20 mA rated current) -> 0.175).

This function is not available in case of MODBUS communication.

## 7.6.2 Binary inputs and outputs

The REG-DMA can recognize various control signals as a binary signal and output control signals through relay outputs.

### Binary input and output functions

The following **input functions** are available:

Input function	Description
00: OFF	OUT
01: PROG	Input is used by the H program
02: Auto	Auto
03: Man	Man
04: ManAuto	Man, Auto, pulse controlled
05: BuchAlm	Buchholz alarm
06: BuchTrip	Buchholz trigger
07: BuchTC	Tap changer Buchholz alarm
08: OpLamp	Operating lamp signal
09: LR_AH	REG-LR Auto/Man
10: LR_STAT	REG-LR Status
11: LR_LR	REG-LR Local/Remote
12: Higher	Increase cooling stage by one stage (only in Remote)
13: Lower	Decrease cooling stage by one stage (only in Remote)
14: LRHigher	Increase cooling stage by one stage (only in Local)
15: LRLower	Decrease cooling stage by one stage (only in Local)

The 'Buchholz Alarm' and 'Buchholz Trigger' signals must be supplied to the controller by a separate Buchholz relay and can then be transmitted to a higher-level control system through a corresponding SCADA.

The following **output functions** are available:

The output functions are available for relays, as well as for LEDs.

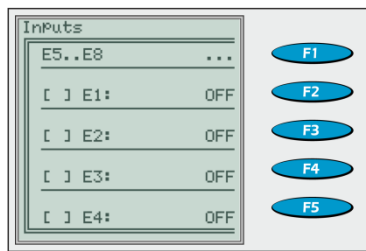
Output function	Description
00: OFF	No function
01: PROG	Output is used by the H program
02: ON	ON
03: Heating	Heating on
04: Oil pump	Oil pump 1 on
05: Cooling 1	Fan group 1 on
06: Cooling 2	Fan group 2 on
07: Cooling 3	Fan group 3 on
08: Cooling 4	Fan group 4 on
09: Cooling 5	Fan group 5 on
10: Cooling 6	Fan group 6 on
11: OlAlarm	Oil temperature alarm
12: WndAlarm	Winding temperature alarm
13: WndAusl	Winding temperature trip
14: T_OITC	Alarm TC oil temperature
15: Water	Water limit exceeded
16: Gas	Gas limit exceeded
17: OlstTC+	High oil level in TC
18: OlstTC-	Low oil level in TC
19: OlstTr+	High oil level in transformer
20: OlstTr-	Low oil level transformer
21: Buchalm	Buchholz alarm
22: BuchTrip	Buchholz trigger
23: BuchTC	Tap changer Buchholz alarm
24: ELAN-L	Communication on the E-LAN-L
25: ELAN-R	Communication on the E-LAN-L
26: ELAN-Err	ELAN error
27: AUTO	Automatic operation
28: OpLamp	Operating lamp signal
29: AnaFlt1	Fault analogue channel 1
30: AnaFlt2	Fault analogue channel 2
31: AnaFlt3	Fault analogue channel 3
32: AnaFlt4	Fault analogue channel 4
33: AnaFlt5	Fault analogue channel 5
34: AnaFlt6	Fault analogue channel 6
35: TOIErr	Error oil temperature measurement collectively
36: TOI1Err	Error oil temperature measurement 1
37: TOI2Err	Error oil temperature measurement 2
38: TOI3Err	Error oil temperature measurement 3

Output function	Description
39:Olump2	Oil pump 2 on
40:CO	CO limit value exceeded
41:H2	H2 limit value exceeded
42:TWndErr	Error winding temperature collectively
43:TWnd1Err	Error winding temperature 1
44:TWnd2Err	Error winding temperature 2
45:TWnd3Err	Error winding temperature 3
46:Local	Local mode
47:Remote	Remote mode
48:CO2	CO <sub>2</sub> in oil content exceeds the limit
49:C2H2	C <sub>2</sub> H <sub>2</sub> in oil content exceeds the limit
50:C2H4	C <sub>2</sub> H <sub>4</sub> in oil content exceeds the limit
51:C2H6	C <sub>2</sub> H <sub>6</sub> in oil content exceeds the limit
52:CH4	CH <sub>4</sub> in oil content exceeds the limit
53:WCP_Norm	Water content paper normal (lower circle of the traffic light)
54:WCP_Warn	Water content paper attention (middle circle of the traffic light)
55:WCP_Alm	Water content paper critical (upper circle of the traffic light)
56:Bbl_Norm	Bubbling safety margin normal (lower circle of the traffic light)
57:Bbl_Warn	Bubbling safety margin attention (middle circle of the traffic light)
58:Bbl_Alm	Bubbling safety margin critical (upper circle of the traffic light)
101:Inp-01	Binary input 1
102:Inp-02	Binary input 2
...	
126:Inp-26	Binary input 26
127:Inp-27	Binary input 27

A specific control function (e.g. 'Oil pump' or 'Fan group') is assigned to a specific relay output in the Controller menu.

The configuration process is described using examples.

### Configuring the binary inputs and outputs



The current function assignments are displayed on the right side of the screen.

- ✎ The <F2...F4> keys are used to select an input.
- ✎ The <F1> key is used to scroll inputs four at a time.  
Selecting an input displays the list of available input functions.
- ✎ The <F1, F2> and <F4, F5> keys are used to select the desired function.
- ✎ Press <F3> to confirm the selection.

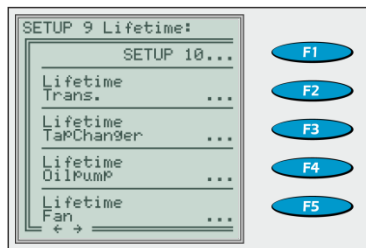
The same procedure applies to the relay and LED functions.

## 7.7 SETUP 9

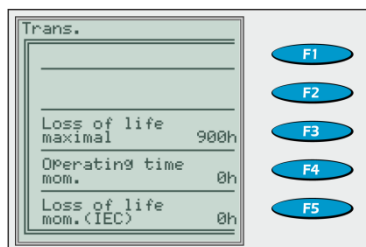
👉 SETUP 9 is accessed by pressing the '→' arrow or <F1> in SETUP 9.

The maximum service life and the currently elapsed operating hours for the different equipment are entered in the 'Service life' submenu. This must be done when the monitoring system is installed on a transformer that is already in service.

This menu can also be used to set the 'Service life' parameter when individual devices are replaced.



### 7.7.1 Transformer service life



#### Maximum operating hours

Press <F3> to enter the expected maximum service life (see the manufacturer's data).

Setting range: 0...999999 h

#### Current operating hours

This is where the current operating hours for the transformer (see the section 'Operating hours (1)') are adjusted. This setting is important if the system is not installed at the same time as the transformer. Adjustments may also need to be made in conjunction with revisions.

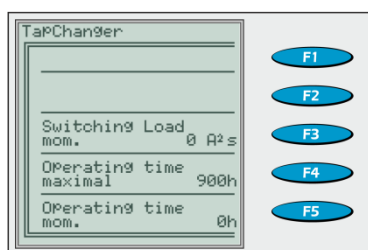
Setting range: 0...999999 h

#### Current operating hours (IEC)

This is where the IEC-based operating hours are adjusted.

Setting range: 0...999999 h

### 7.7.2 Tap changer service life



#### Switching load

This is where the current switching load for the tap changer is adjusted.

Setting range: 0...9000000 A<sup>2</sup>s

#### Maximum operating hours

Press <F4> to enter the expected maximum service life (see the manufacturer's data).

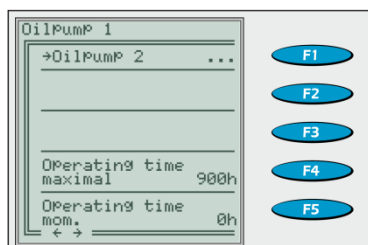
Setting range: 0...999999 h

#### Current operating hours

The 'Current operating hours' parameter is important if the system is not installed at the same time as the tap changer. Both parameters may need to be adjusted in conjunction with revisions.

Setting range: 0...999999 h

### 7.7.3 Oil pumps



... several pages

#### Maximum operating hours


Press <F4> to enter the expected maximum service life (see the manufacturer's data) for the oil pumps.

Setting range: 0...999999 h

#### Current operating hours

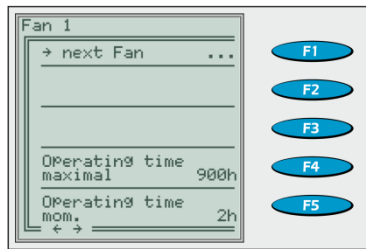
The 'Elapsed operating hours' parameter is important if the system is not installed at the same time as the transformer and the oil pump. Both parameters may need to be adjusted in conjunction with revisions.

Setting range: 0...999999 h

 Press <F1> to toggle between oil pump 1 and 2.



## 7.7.4 Fans



..... several sets of parameters

The number of parameter sets is based on the number of fans used.

### Maximum operating hours

The 'Elapsed operating hours' parameter is important if the system is not installed at the same time as the transformer and the fan groups. Both parameters may need to be adjusted in conjunction with revisions.


Setting range: 0...999999 h

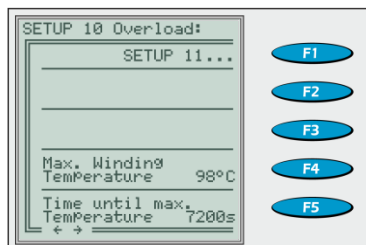
### Current operating hours

Press <F5> to enter the current age of the fans.

Setting range: 0...999999 h

## 7.8 SETUP 10

 SETUP 10 is accessed by pressing the '→' arrow or <F1> in SETUP 9.



The overload parameters are set in Setup 8.


### 7.8.1 Max. Winding temperature

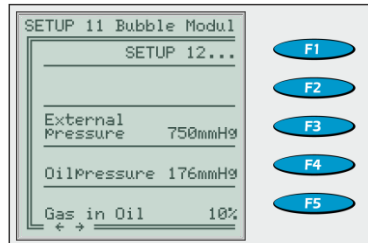
The parameter 'Max. winding temperature' specifies the limit value for the winding temperature used to calculate the overload. The default value is 98°C.

### 7.8.2 Time to max. temperature

The parameter 'Time to max. temperature' specifies the time it takes to reach the maximum winding temperature. For example, a setting of 7200 s means that the possible overload is calculated so that the maximum winding temperature is reached after 2 h = 7200 s.

## 7.9 SETUP 11 Bubble Module

 SETUP 11 is accessed by pressing the '→' arrow or <F1> in SETUP 10.



### External pressure (default: 750 mmHg)

Atmospheric pressure on the transformer.


### Oil pressure (default: 176 mmHg)

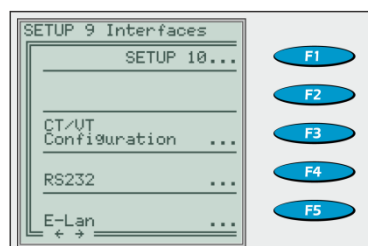
Oil head pressure of the Hot spot location.

### Gas in Oil (default: 10 %)

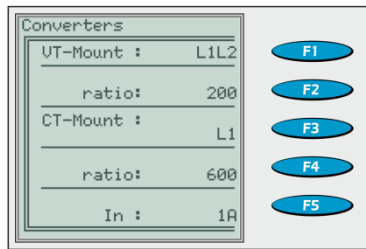
Total gas in oil content. The bubble formation temperature depends on the gas in oil content. Therefore the gas in oil content is necessary to calculate the bubbling formation temperature. The parameter “Gas in Oil” is only used if no measurement value of the gas in oil content is available. The measured gas in oil content can be received via mA-signal or Modbus. Thereby it's possible to use the total gas in oil content (analogue input function 69) or the summation of the individually measured gases (analogue input functions 75...79).

## 7.10 SETUP 12

 SETUP 12 is accessed by pressing the '→' arrow or <F1> in SETUP 11.



### 7.10.1 Voltage and current transformer installation



Converters	
UT-Mount :	L1L2
ratio:	200
CT-Mount :	L1
ratio:	600
In :	1A

F1 F2 F3 F4 F5

This is where the data of the voltage and current transformers are entered. If Characteristic 'Three-windings' is active, two KNU and two KNI are available. If Characteristic 'M2' is active and the measurement is to be done by the Aron circuit, the parameters 'VT-Mount' and 'CT-Mount' must be set to 'ARON'.

The factor KNU is calculated by dividing the primary nominal value by the secondary nominal value of the VT (e.g.  $132\text{KV}/110\text{V} = 1200$ ).

The factor KNI is calculated by dividing the primary nominal value by the secondary nominal value of the CT (e.g.  $2500\text{A}/5\text{A} = 500$ ).

The parameter 'In' selects the nominal secondary current of the CT.

## 7.10.2 RS232

The REG-DMA is equipped with two RS232 interfaces (COM1 and COM2). The COM1 interface is mainly used as provisioning interface. The COM2 is normally connected to the SCADA interface and therefore not available for external use. Whether the COM2 is occupied by a SCADA interface or not can be seen in the according wiring diagram. The PIN assignment of the COM-Interfaces can be found in the technical data in chapter 17.

To communicate to a PC the COM1 mode has to be ECL. The baud rate, the parity and the handshake can be selected. The standard setting is 115200/NONE/RTS/CTS. The COM1 interface is available with a Mini-USB connector (Feature I1). The USB interface is an integrated Serial-to-USB converter; therefore the parameters for the communication stay the same.

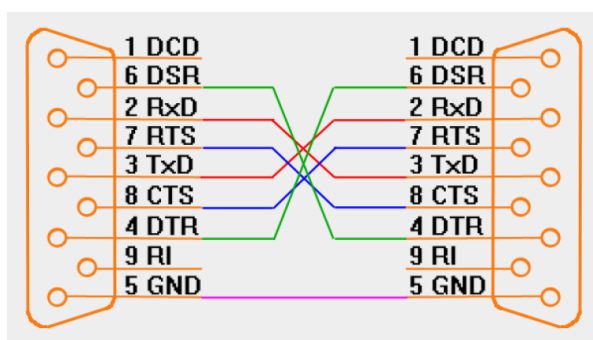
The COM interfaces support the following modes:

Mode	Description
0: OFF	COM interface is switched off
1: ECL	Communication with Eberle specific protocol (e.g. PC software)
2: ECLADR	Communication with Eberle specific protocol with addressing for RS485 use (not supported by A. Eberle Toolbox software)
8: PROFIBUS	ProfibusDP mode, external ProfibusDP module necessary
10: ELAN-L	Redirection of the ELAN-L to the COM interface
11: ELAN-R	Redirection of the ELAN-R to the COM interface
15: DCF77	COM interface is used as DCF77 input, specific DCF77 receiver necessary

### Connection-diagram "zero-modem"-cable

9pole Sub-D plug

9pole Sub-D plug

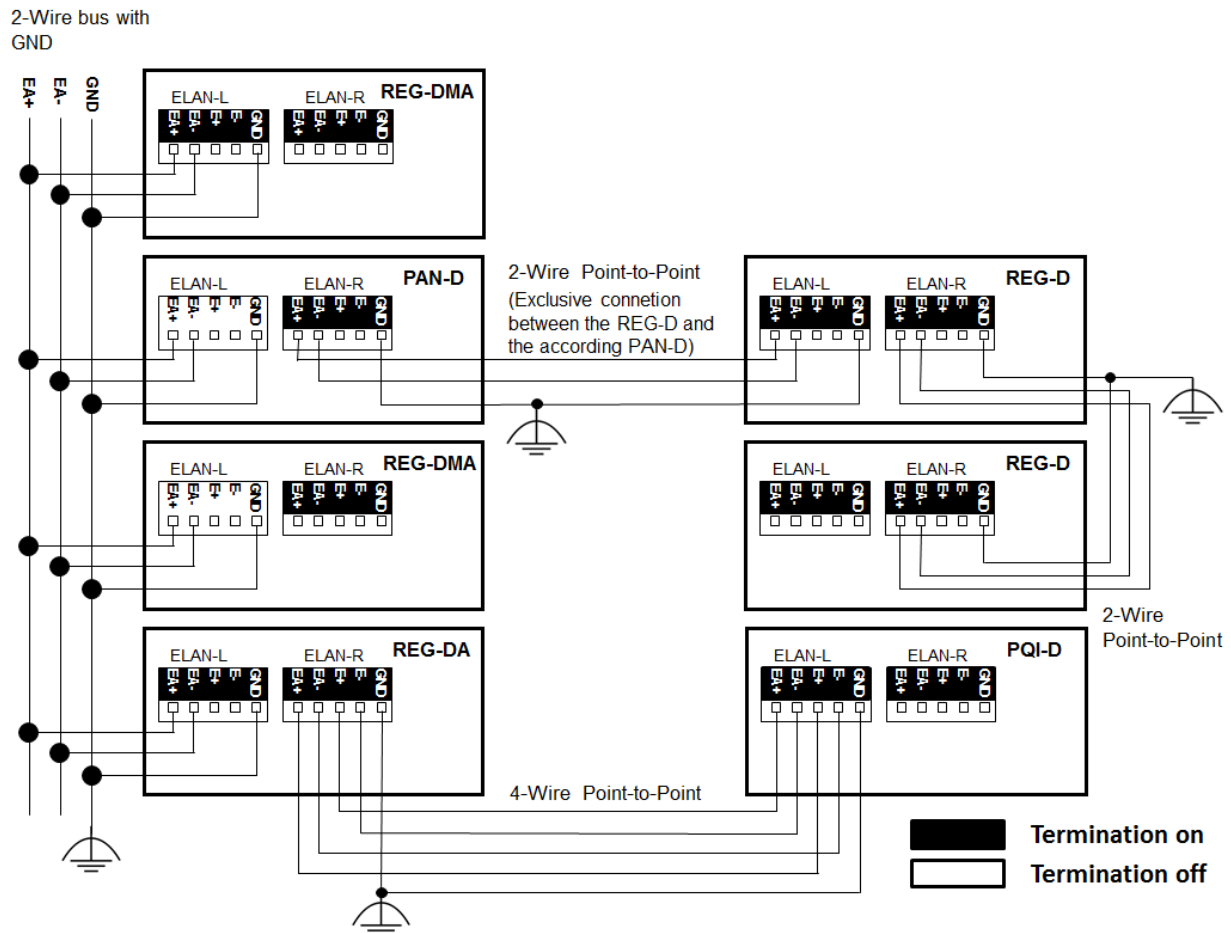


### 7.10.3 E-LAN (Energy - Local Area Network)

Each REG-DMA has two E-LAN interfaces: an E-LAN LEFT and an E-LAN RIGHT. Each E-LAN interface works with a 2-wire line or 4-wire transmission technology (both RS485).

The communication parameters (MODE, BAUDRATE) for the devices connected to a bus must match in order for the communication to be successful.


The setting for the terminating resistors (only in 2-wire mode) is shown in the below Figure. The terminating resistor should be set to open <sup>F1</sup> when a bus consists of more than two devices and the relevant E-LAN interface is not physically at the beginning or the end of the bus. In all other cases, the terminating resistors should be set to guarantee the best possible communication.

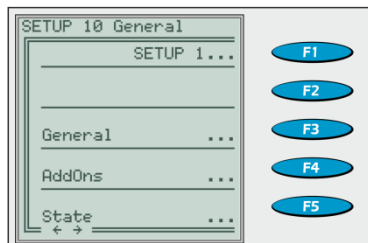


If communication with the E-LAN is successful, the square brackets for the two connected E-LAN interfaces will display as [X]. The X signifies that the neighbouring station is recognized.

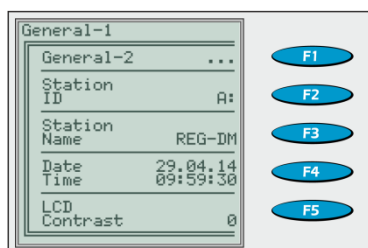
If the communication for an E-LAN interface is faulty, the X will flash [X].

## 7.11 SETUP 13

 SETUP 13 is accessed by pressing the '→' arrow or <F1> in SETUP 12.



### 7.11.1 General



The controller's identifier, participant name, date, time, and the contrast of the LCD are set in the 'General 1' menu.

The identifier is the controller's ID and consists of a letter and, optionally, a number. If several controllers are connected to the E-LAN, they must have unique identifiers in order to guarantee a fault-free operation. The station name is a user defined name that consists of up to eight characters (no blank possible). This is also where the recorder's repository (Characteristic S1) and the Logbook is deleted.

#### 7.11.1.1 Password protection

To restrict access to the REG-DMA, passwords are set and changed in the 'General 2' menu. The password protection only blocks the change of parameters. All parameters and measured values can be checked on the REG-DMA screen if the password protection is active.

In total there are five different users available. Every user is able to define its own password. The password consists of six numbers out of the range from one to five [1, 2, 3, 4, 5].

The login of a user is recorded in the logbook.

#### Activation of the password protection

The password protection becomes active as soon as the password for user 1 (Master user) gets defined. The users are also activated by defining passwords for them. For security reasons the password has to be entered twice (two dialogs).

### **Changing the password of an existing user**

To change the password of an existing user the user of the user 1 has to log on. After that the according user must be selected in the password menu by the F1 to F5 key. The new password is entered in the upcoming password dialog and verified in a second password dialog.



#### **Changing of passwords**

The User 1 is able to change all passwords (passwords are not visible on this process). All other users are only able to change their own password.

### **Switch off password protection and erase user 2 to 5**

The password protection is switched off if the password of the user 1 is set to "111111".

If the password of user 2 to 5 is set to "111111" the according user gets erased.

Both operations are only available for user 1.

### **Login**

The login screen comes automatically up if you are about to change a password protected parameter or the password protection itself. In the first dialog you select the user 1 to 5. In the following dialog you put in the according password. After a successful login the parameter change is carried out. After that the system is open for five minutes. Every interaction on the REG-DMA panel (pressing a key) extends this time by five minutes. That means if you change some parameters it's not necessary to log on again for every single parameter. The system is closed (password protection active) five minutes after the last interaction on the panel.

### **Imitate activation of the password protection**

The password protection normally becomes active after a time period of 5 minutes after the last interaction with the device (press a button). By pressing the "<"-key (left arrow key) in the menu SETUP-13\General-2\Password it's possible to initially switch on the password protection.



#### **Delete the password of user 1**

If the password of user 1 is set to "111111" (deleted) the complete password protection of the device is switched off. The passwords of user 2 to 5, if they exist, are still there and will be recovered if the password for user 1 is set again to activate the password protection.



#### **Forgot your password**

In case you forgot your password it's possible to release the password protection by entering a device specific code via terminal program. Therefore please contact the REGSys Support ([regsys-support@a-eberle.de](mailto:regsys-support@a-eberle.de), +49(9)11/628108-101).

### **7.11.2 Functions:**

This is where the language, screen saver (activation after 60 min) and the behaviour after a power supply interruption are set.

If the parameter 'MAN after reset' is set to 'Yes', the controller will be in manual mode after a reset (sysreset or power supply interruption).

If the parameter is set to 'No', the controller will be in the same mode as it was before.

### **7.11.3 State**

This is where information about the firmware version of the REG-DMA, the size of the RAM and the condition of the battery is read out. It is also where the software characteristics, the COM and ELAN status, H-Programs and the error status can be viewed.



## 8. Download of a background program (h-code)

In the following the download of a background-program with the software "REGUpdate" is described in detail. As an alternative also the parameterization software AE Toolbox can be used.

### Accessories:

- Zero-modem-cable (see connection diagram at chapter 7.10.2)
- PC-Software "REGUpdate"(Update32.exe)

### The Following steps are necessary:

- 1.) With the zero-modem-cable connect the REG-DMA via COM1 with a free COM-interface at the PC.

- 2.) Setup COM at the regulator

Choose the menu: "Setup12" - "RS232" - "COM1"

The following steps are necessary:

Parameter	Value
<b>Mode</b>	ECL
<b>Baudrate</b>	9600 (choose able)
<b>Parity</b>	--
<b>Handshake</b>	RTS/CTS

- 3.) Start of the PC-Software

Use the program "REGUpdate"(Update32.exe) under the operating systems Windows 95 / 98 / NT / XP / 7 und 8:

- 3.1 Choose the language
- 3.2 Choose the corresponding COM
- 3.3 Choose the connected device

- 4.) The baudrate at the REG-DMA must be the same as the PC. Compare the baudrate at the REG-DMA with the baudrate in the update program under menu-point: "Configure" – "baud rate"



Information:

- The standard value of 9600 Baud is in praxis approved for download of background-programs ("REG-L download") and should be changed only in exceptional cases.
- The standard value of 115200 Baud is in praxis approved for firmware updates.

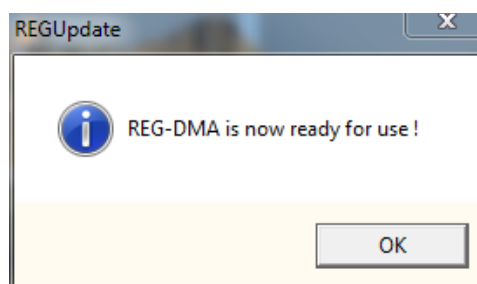
5.) Download of the background-program ("REG-L download")

Choose in program "REGUpdate" the menu "Update" - "REG-L Download.." and choose the corresponding background-file.

If you have chosen the type of the file, the fitting files will be suggested.

Device type	Background program extension
<b>REG-D(A)</b>	*.rgl
<b>PAN-D</b>	*.pnl
<b>REG-DP(A)</b>	*.dpl
<b>PQI-D</b>	*.pql
<b>REG-DM(A)</b>	*.dml
<b>MMU-D</b>	*.mml

6.) The message "REG-DMA is now ready for use" (transmission ok) indicates a successful download.



7.) For transferring a background program from the regulator to the PC please choose "REG-L upload..." instead of "REG-L download...".

## 9. Download of firmware and Bootloader

The steps for downloading the firmware are basically the same as for downloading a background program.

**The Following steps are necessary:**

- 1.) With the zero-modem-cable connect the REG-DMA via COM1 with a free COM-interface at the PC.

- 2.) Start the bootloader of the REG-DMA

Enter the status menu and hold the F1-key pressed until the bootloader starts:  
"Setup13" - "State" - F1 pressed

The following COM settings are necessary for firmware and bootloader updates:

Parameter	Value
<b>Baudrate</b>	115200
<b>Handshake</b>	RTS/CTS

- 3.) Start of the PC-Software

Use the program "REGUpdate"(Update32.exe) under the operating systems Windows 95 / 98 / NT / XP / 7 und 8:

- 3.1 Choose the language
- 3.2 Choose the corresponding COM
- 3.3 Choose the connected device

- 4.) The baudrate at the REG-DMA must be the same as the PC. Compare the baudrate at the REG-DMA with the baudrate in the update program under menu-point: "Configure" – "baud rate"

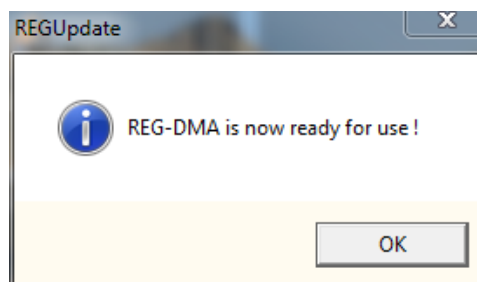
- 5.) Download of the firmware ("new Firmware") or bootloader ("new Booter")

Choose in program "REGUpdate" the menu "Update" - "new Firmware.." and choose the corresponding firmware file.

If you have chosen the type of the file, the fitting files will be suggested.

Device type	Firmware extension
<b>REG-D(A)</b>	hr*.moc/mot
<b>PAN-D</b>	pan*.moc/mot
<b>REG-DP(A)</b>	dp*.moc/mot
<b>PQI-D</b>	pqi*.moc/mot
<b>REG-DM(A)</b>	dm*.moc/mot
<b>Bootloader</b>	boot*.moc/mot

- 6.) The message "REG-DMA is now ready for use" (transmission ok) indicates a successful download.



## 10. Increasing the system's hardware resources

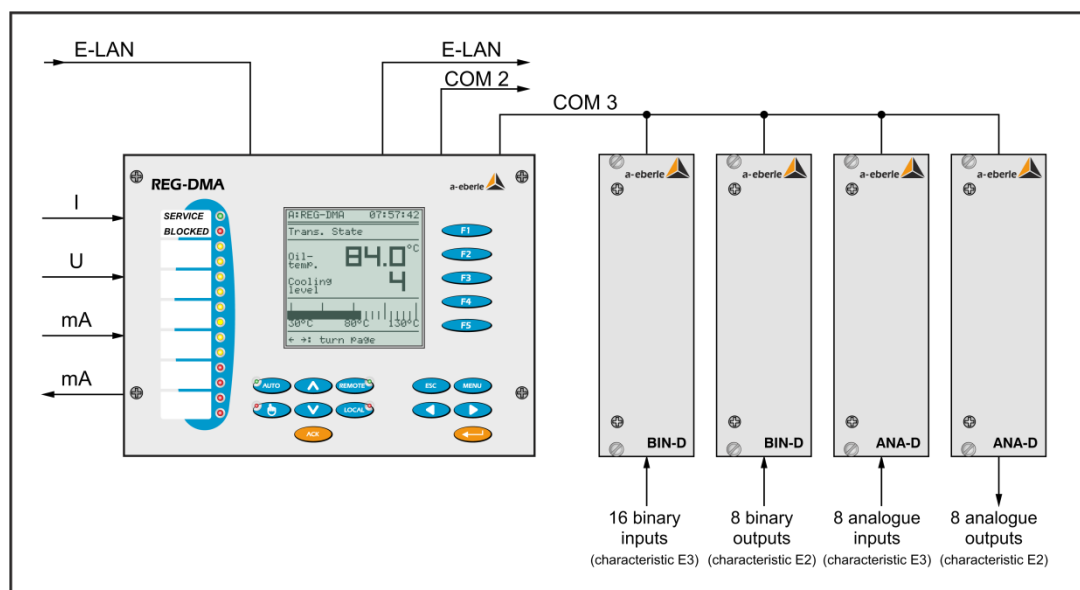
To increase the number of channels, multiple interface cards can be connected on the COM 3 (RS485) peripheral interface. Interface cards are available for analogue inputs and outputs (ANA-D) as well as for binary inputs and outputs (BIN-D). It is also possible to communicate directly with other devices through the COM3/Modbus converter.

### 10.1 Additional inputs and outputs

The ANA-D interface card can be supplied with either eight analogue inputs or eight analogue outputs. It is not possible to combine inputs and outputs on one card.

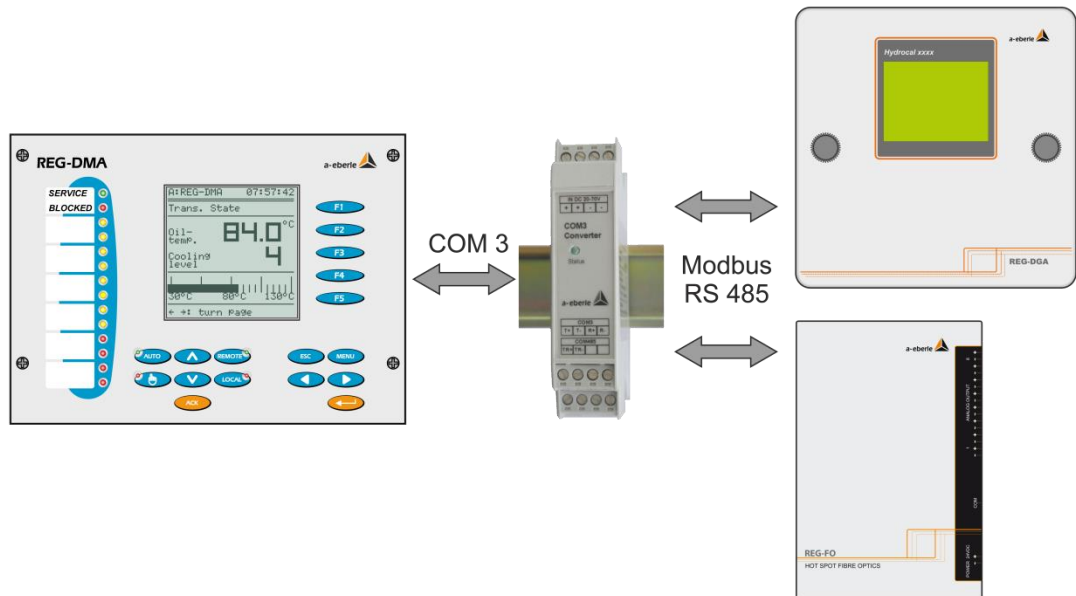
The BIN-D interface card can be supplied with either eight relay outputs or sixteen optically decoupled binary inputs.

ANA-D and BIN-D interface cards can be combined on COM3 as desired.



## 10.2 COM3/Modbus (RTU Master) Converter

The COM3/Modbus converter enables serial communication with any sensor or device that supports the Modbus RTU protocol (slave). This enables temperature, gas in oil and ambient measurements to be directly recorded and processed. Conversion to an mA-Signal is no longer necessary. The recorded data can be used and recorded for monitoring, and of course transferred to the control system.



## 11. Temperature measurement

As described earlier, there are two ways of measuring the oil temperature:

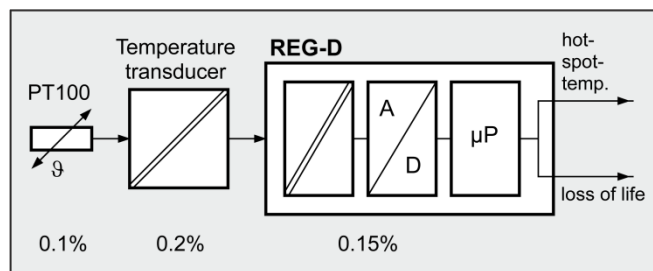
- The temperature signal is supplied by a temperature transducer as a 4 .. 20 mA signal.
- The temperature signal is supplied by a PT-100 sensor in a three-wire circuit.

### 11.1 Accuracy considerations

From a measurement standpoint, the accuracy of the hot-spot temperature recording is essentially influenced by the oil temperature measurement.

Calculating the hot-spot temperature from the measured oil temperature does not introduce any additional errors.

**The measuring chain:**



**Error determination:**

Assuming that the error in the resistance thermometer PT100 in temperature range 20 to 140°C does not exceed 0.1%, the average total error is achieved when using the proposed temperature transducer:

The average error is:

$$F_m = \sqrt{0,10 \%^2 + 0,20 \%^2 + 0,15 \%^2}$$

$$F_m = 0,26 \%$$

The maximum error is, however:

$$F_{max} = 0,10 \% + 0,20 \% + 0,15 \%$$

$$F_{max} = 0,45 \%$$

In the case of the built-in PT100 module, the average error is:

- the average error is: 0.13 %
- and the maximum error is: 0.35 %



**Note:**

All errors are relative to the measurement range max. value.



## 12. Maintenance and power consumption

### 12.1 Fuse replacement

**⚠ DANGER!**

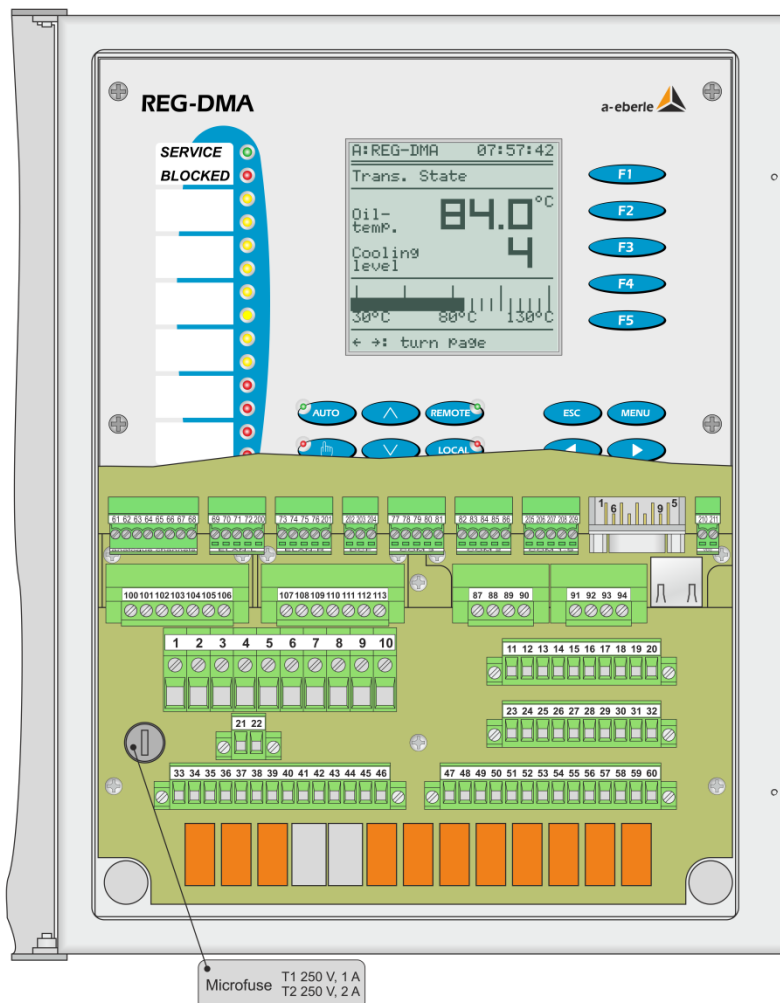
**Electric shock!**  
Injury or Death

➡ Disconnect the device from all life circuits like aux. supply, measurement circuits and so on before changing the fuse.


#### Required fuses:

- Characteristic H0: Microfuse T1 (inert) 250 V, 1 A (order no. 582.1002)
- Characteristic H2: Microfuse T2 (inert) 250 V, 2 A (order no. 582.1019)

The fuse holder is in the REG-DMA's terminal compartment.



## 12.2 Battery replacement

 <b>DANGER!</b>	<b>Electric shock!</b>
	Injury or Death
	➡ Disconnect the device from all life circuits like aux. supply, measurement circuits and so on before changing the battery.

The REG-DMA's battery is behind the front panel. This means that the four set screws must be removed from the front panel so it can be opened and the battery replaced.

<b>NOTICE:</b>	The connection cable is on the far left side of the front panel. This cable must not be damaged when opening the front panel. If the cable was unplugged, make sure it is plugged in properly after the front panel is put back in place.
----------------	---

### Devices delivered before September 2013:

All of the parameters are lost as soon as the battery is removed!

For devices with a dual connector, insert the new battery and then remove the old battery.

#### Required battery:

- Lithium 3 V Type CR14250 with cable and connector (order no. 570.0003.00)

#### Service life:

- When the REG-DMA is in storage (no auxiliary voltage) > 6 years
- When the REG-DMA is in use with a switch-on time > 50% > 10 years

We recommend letting the factory change the batteries.

### Devices delivered after September 2013:

The sole purpose of the battery is to support the real-time clock. This means that no data are lost when the battery is removed. The time may have to be adjusted when the new battery is installed.

#### Required battery:

- Lithium button cell 3 V Type CR1632 (order no. 570.0005)

#### Service life:

- When the REG-DMA is in storage (no auxiliary voltage) > 6 years
- When the REG-DMA is in use with a switch-on time > 50% > 6 years

We recommend letting the factory change the batteries.

## 12.3 Power consumption REG-DMA

### Measurement results

Switch-on spike at 100 V DC:

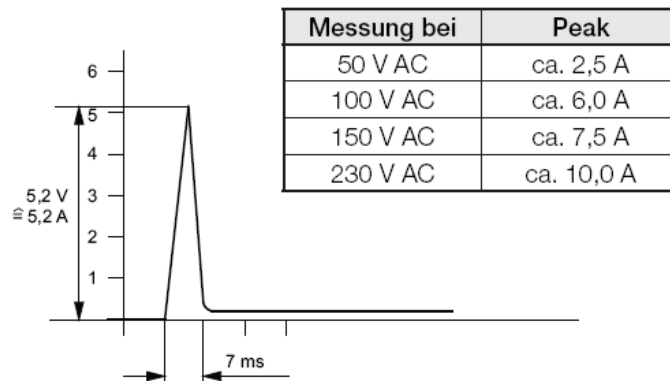


Figure 9: The measured values are intended to provide information on the choice of fuse.

## 13. Notes on storage

The devices and related spare components must be stored in rooms that are dry and clean at a temperature in the range of -25°C to +65°C.

The relative humidity may not result in the creation of condensation or ice.

It is recommended to limit the storage temperature to a range of +0°C and +55°C to prevent the electrolytic capacitors from ageing prematurely.

It is also recommended to connect the devices to the auxiliary voltage every two years to train the replaced electrolytic capacitors. This should also be done before the device is put in service. In extreme climate conditions (in the tropics), this also 'preheats' the device and prevents condensation.

Before the device is put under voltage for the first time, it should lie in the technical room for at least two hours to equalize the temperature and prevent humidity and condensation.

## 14. Notes on cleaning

Use a short, slightly damp, lint-free cloth. Make sure no liquid gets in the housing. Do not use window cleaner, household cleaners, sprays, dissolvent, cleaners that contain alcohol, ammonia solutions or abrasive cleaning agents.

**NOTICE:**

**Do not clean the device with unsuitable products!**

This can damage the surface of the device and remove markings  
Please follow the cleaning instructions above.

## 15. Disposal

### Disposal note for EU member states



To preserve and protect the environment, prevent pollution, and improve the recycling of raw materials, the European Commission issued a directive that requires manufacturers to take back electrical and electronic devices so they can be properly disposed of or recycled.

The devices with this symbol are not allowed to be disposed with normal solid household waste:

### Special note for customers in Germany

The electronic devices manufactured by A. Eberle are intended for commercial use. These devices may not be disposed of at municipal recycling centres for electrical devices, but are taken back by A. Eberle.

If you have question, please contact us by phone or email:

+49-(0)911-628 108-0

[info@a-eberle.de](mailto:info@a-eberle.de)

If the device is not operated within the European Union, the national waste-disposal regulations in the respective country must be respected.

## 16. Product Warranty

The guarantee period is three years starting on the delivery date.

The guarantee lapses if the controller is retrofitted by an unauthorized agent. The guarantee remains unaffected if the device is returned to A. Eberle for modification.

## 17. Technical Data

### 17.1 Technical Specifications

#### Regulations and standards

IEC 61010-1 / EN 61010-1

CAN/CSA C22.2 No. 1010.1-92

IEC 60255-22-1 / EN 60255-22-1

IEC 61326-1 / EN 61326-1

IEC 60529 / EN 60529

IEC 60068-1 / EN 60068-1

IEC 60688 / EN 60688

IEC 61000-6-2 / EN 61000-6-2

IEC 61000-6-4 / EN 61000-6-4

IEC 61000-6-5 / EN 61000-6-5 (in preparation)



#### UL Certificate Number 050505 - E242284



AC voltage inputs (U <sub>E</sub> )	
Measuring voltage U <sub>E</sub>	0 ... 160 V The nominal value can be selected in the software
Shape of the curve	Sine
Frequency range	16... <u>50</u> ...60...65 Hz
Internal consumption	≤ U <sup>2</sup> / 100 kΩ
Overload capacity	230 V AC continuous

AC input I <sub>E</sub> )	
Measuring current I <sub>n</sub>	1 A / 5 A (can be selected in the software)
Shape of the curve	Sine
Frequency range	16... <u>50</u> ...60...65 Hz
Control range	0 ... I <sub>n</sub> ... 2.1 I <sub>n</sub>
Internal consumption	≤ 0.5 VA
Overload capacity	10 A continuous 30 I <sub>n</sub> for 10 s 100 I <sub>n</sub> for 1 s (max. 300 A) 500 A 5 ms

Analogue inputs (AI)	
Quantity	See order specifications
Input range Y1...Y2	-20 mA...0...20 mA Y1 and Y2 programmable
Control limit	± 1.2 Y2
Voltage drop	≤ 1.5 V
Potential isolation	Optocoupler
Common-mode rejection	> 80 dB
Series-mode rejection	> 60 dB / Decade from 10 Hz
Overload capacity	≤ 50 mA continuous
Error limit	0.5%

The regulator comes with an analogue input (e.g. for the tap position indicator).

The inputs can be continuously short-circuited or operated open. All inputs are galvanically isolated from all of the other circuits.

Temperature input PT100	
Quantity	one PT100 input at Level III possible two PT100 inputs at Level II possible
Type of circuit	Three-wire circuit
Current through sensor	< 8 mA
Potential isolation	Optocoupler
Line compensation	No compensation required
Transmission behaviour	linear

Resistance input (tap change potentiometer, WidMod)	
Quantity	See order specifications
Connection	Three-wire, convertible to four-wire
Total resistance in the resistor chain	R1: 2 kΩ R3: 20 kΩ
Tap resistance	adjustable R1: 5...100 Ω/tap R3: 50...2000 Ω/tap
Number of stages	≤ 38
Potential isolation	Optocoupler
Current through resistor chain	max. 25 mA

The measuring device has a broken-wire detection.

Analogue outputs (AO)	
Quantity	See order specifications
Output range Y1...Y2	-20 mA...0...20 mA Y1 and Y2 programmable
Control limit	± 1.2 Y2
Potential isolation	Optocoupler
Burden range	$0 \leq R \leq 8 \text{ V} / Y2$
Alternating component	<0.5% of Y2

The outputs can be continuously short-circuited or operated open. All output connections are galvanically isolated from all of the other circuits.

Binary inputs (BI)	
Inputs E1 ... E16 (... E22, ... E28)	
Control signals $U_{st}$	in the AC/DC range 48 V ... 250 V, 10 V ... 50 V, 80 V ... 250 V, 190 V ... 250 V in accordance with Characteristic Dx
Shape of the curve, permissible	Rectangular, sinusoidal
48 V...250 V H - Level L - Level	≥ 48 V < 10 V

Binary inputs (BI)	
10 V...50 V H - Level L - Level Input resistance	≥ 10 V < 5 V 6.8 kΩ
80 V ... 250 V H - Level L - Level	≥ 80 V < 40 V
190 V ... 250 V H - Level L - Level	≥ 176 V < 88 V
Signal frequency	DC, 40 ... 70 Hz
Input resistance	108 kΩ, except 10...50 V
Potential isolation	Optocoupler; Groups of four, each galvanically isolated from each other.
Debouncing	Software filter with integrated 50 Hz filter

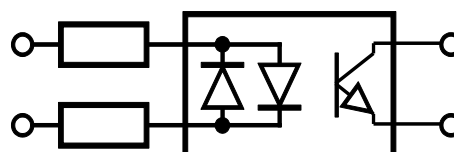


Figure 10: Simplified diagram of a binary input

Binary outputs (BO)	
R 1 ... R13 (... R19, . R25) max. switching frequency	≤ 1 Hz
Potential isolation	Isolated from all device-internal potentials
Contact load	AC: 250 V, 5 A ( $\cos\varphi = 1.0$ ) AC: 250 V, 3 A ( $\cos\varphi = 0.4$ ) Switching capacity max. 1250 VA DC: 30 V, 5 A resistive DC: 30 V, 3.5 A L/R=7 ms DC: 110 V, 0.5 A resistive DC: 220 V, 0.3 A resistive Switching capacity max. 150 W

Binary outputs (BO)	
Inrush current	250 V AC, 30 V DC 10 A for max. 4 s
Switching operations	$\geq 5 \cdot 10^5$ electrical

Display	
LC - Display	128 x 128 displays graphics
Lighting	LED, switches off after 15 min

Indicator elements		
The regulator has 14 light-emitting diodes (LED)		
LED Service	Normal operation	Green
LED Blocked	Faulty operation	Red
LED 1 ... LED 8	freely programmable	Yellow
LED 9 ... LED 12	freely programmable	Red

Each LED can be labelled on site.

If the labelling wishes are known at the time of order placement, labelling can be done at the factory.

A to D converter	
Type	Successive approximation
Resolution	+/- 11 bit
Sampling rate	24 samples per period, e.g. 1.2 kHz for a 50 Hz signal *

\*The measurement inputs have an anti-aliasing filter.

Real-time clock (RTC)	
Accuracy	+/- 20 ppm
Buffering	Lithium button cell

Limit-value monitoring	
Limit values	programmable
Response times	programmable
Alarm indicators	LEDs are programmable or are programmable on an LCD

Measured quantities (optionally as mA value)	
TRMS voltages	$U_{12}, U_{23}, U_{31} (\leq 0.25\%)$
Current TRMS	$I_1, I_2, I_3 (\leq 0.25\%)$
Active power	$P (\leq 0.5\%)$
Reactive power	$Q (\leq 0.5\%)$
Apparent power	$S (\leq 0.5\%)$
Power factor	$\cos \varphi (\leq 0.5\%)$
Phase angle	$\varphi (\leq 0.5\%)$
Reactive current	$I \cdot \sin \varphi (\leq 1\%)$
Frequency	$f (\leq 0.05\%)$

Reference conditions	
Reference temperature	$23^\circ\text{C} \pm 1\text{ K}$
Input quantities	$U_E = 0 \dots 160\text{ V}$ $I_E = 0 \dots 1\text{ A} / 0 \dots 5\text{ A}$
Auxiliary voltage	$H = H_n \pm 1\%$
Frequency	45 Hz...65 Hz
Shape of the curve	Sinusoidal, form factor 1.1107
Burden (only for Characteristics E91...E99)	$R_n = 5\text{ V} / Y_2 \pm 1\%$
Other	IEC 60688 - Part 1

Electrical safety	
Safety class	I
Degree of pollution	2
Measurement category	IV/150 V
Measurement category	III/300 V

Operating voltages		
50 V	150 V	230 V
E-LAN, COM1 ... COM3 Analogue inputs, analogue outputs inputs 10...50 V	Voltage inputs, current inputs	Auxiliary voltage, binary inputs (E1...E16), relay outputs R1...R13), Status

Transmission behaviour of the analogue outputs	
Error limit	0.05% / 0.25% / 0.5% / 1% related to Y2 (see 'Measured quantities')
Measurement cycle time	≤ 10 ms

Electromagnetic compatibility	
EMC requirements	EN 61326-1 Equipment class A Continuous, unmonitored operation, industrial area and EN 61000-6-2 and 61000-6-4
Interference emissions	
Conducted and radiated emission	EN 61326 Table 3 EN 61000-6-4
Harmonic currents	EN 61000-3-2
Voltage fluctuations and flicker	EN 61000-3-3
Disturbance immunity	EN 61326 Table A1 and EN 61000-6-2
ESD	IEC 61000-6-5 6 kV/8 kV contact/air

Electromagnetic compatibility	
Electromagnetic fields	IEC 61000-4-3\80 – 2000 MHz: 10 V/m
Fast transient	IEC 61000-4-4 4 kV/2 kV
Surge voltages	IEC 61000-4-5 4 kV/2 kV
Conducted HF signals	IEC 61000-4-6 150 kHz – 80 MHz: 10 V
Power-frequency magnetic fields	IEC 61000-4-8 100 A/m (50 Hz), continuous 1000 A/m (50 Hz), 1 s
Voltage dips	IEC 61000-4-11 30% / 20 ms, 60% / 1 s
Voltage interruptions	IEC 61000-4-11 100% / 5s
Damped oscillations	IEC 61000-4-12, Class 3, 2.5 kV

Test voltages*	Description	Test voltage / kV	Feedback control loops
Auxiliary voltage	U <sub>h</sub>	2.3	COMs, AO, AI
Auxiliary voltage	U <sub>h</sub>	2.3	BI, BO
Measuring voltage	U <sub>e</sub>	2.3	COMs, AO, AI
Measuring voltage	U <sub>e</sub>	3.3	U <sub>h</sub> , BE, BA
Measuring voltage	U <sub>e</sub>	2.2	I <sub>e</sub>
Measuring current	I <sub>e</sub>	2.3	COMs, AO, AI
Measuring current	I <sub>e</sub>	3.3	U <sub>h</sub> , BE, BA
Interfaces, COMs	COMs	2.3	BI, BO
Analogue outputs	AO	2.3	BI, BO
Analogue outputs	AO	0.5	COMs, AI
Analogue inputs	AI	2.3	BI, BO
Analogue inputs	AI	0.5	COMs, AO
Binary inputs	BI	2.3	BI
Binary inputs	BI	2.3	BO
Binary outputs	BO	2.3	BO

\* All test voltages are AC voltages in kV that can be applied for 1 minute. The COMs are tested against each other with 0.5 kV.



Power supply		
Characteristic	H0	H2
AC	85 ... 264 V	–
DC	88 ... 280 V	18 ... 72 V
Power consumption AC	≤ 35 VA	–
Power consumption DC	≤ 25 W	≤ 25 W
Frequency	45 ... 400Hz	–
Microfuse	T1 250 V	T2 250 V

The following applies to all characteristics:

Voltage dips of ≤ 25 ms result neither in data loss nor malfunctions.

Ambient conditions	
Temperature range	
Function	-15°C ... +60°C
Transport and storage	-25°C ... +65°C
Dry cold	IEC 60068-2-1, - 15°C / 16 h
Dry heat	IEC 60068-2-2, + 65°C / 16 h
Humid heat constant	IEC 60068-2-78 + 40°C / 93% / 2 days
Humid heat cyclical	IEC 60068-2-30 12+12 h, 6 cycles +55°C / 93%
Drop and topple over	IEC 60068-2-31 100 mm drop height, un-packaged
Vibration	IEC 60255-21-1, Class 1
Shock	IEC 60255-21-2, Class 1
Earthquake resistance	IEC 60255-21-3, Class 1

Storage	
Firmware and additional recorder data	Flash storage
Device characteristics and calibration data	serial EEPROM with ≥ 1000 k write/read cycles
Other data and basic recorder data	MRAM, No buffer battery needed

## 17.2 Mechanical configuration

Housing:	Sheet steel, RAL 7035 light-grey
High:	325 mm incl. PG connectors
Width:	250 mm
Total depth:	114 mm
Mounting dept:	87 mm
Weight:	≤ 6.0 kg
Housing doors:	with silicate glass
Front panel:	Plastic, RAL 7035 grey on aluminium brackets
Control panel cut-out	
High:	282 mm
Width:	210 mm
Protection type:	IP 54
Protection type with brush sealing:	IP 12

Conductor cross section and terminal torque				
Level	Function/ Terminal no.	Conductor/mm <sup>2</sup>		Torque Nm
		flexible	solid	
I	Measurement inputs 1..10	4	6	0.6
I	BIs, relays, aux progs. 11...60	2.5	2.5	0.6
II	Control system, all except XW90..93+97+98 87...98	0.5	0.5	---
II	Control system, only XW90..93+97+98 87...94	2.5	2.5	0.6
II	Extensions C90..99 100...113	2.5	2.5	0.6
III	COMs, AIs 61...86/200...211	1.5	1.5	0.25

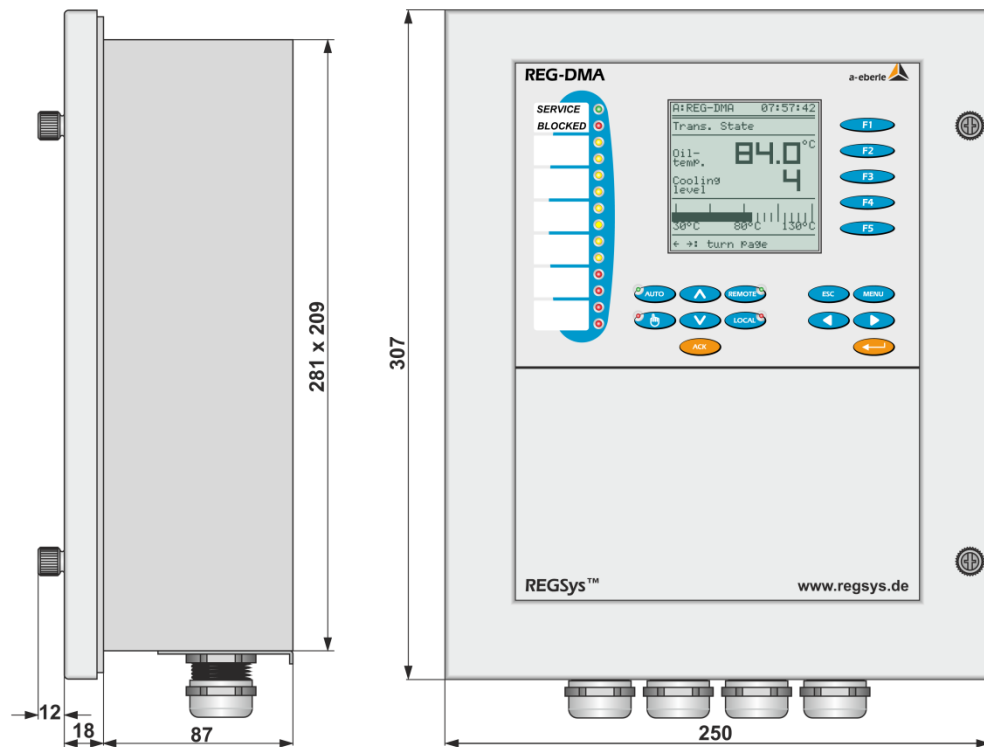


Figure 11: Mechanical dimensions in mm

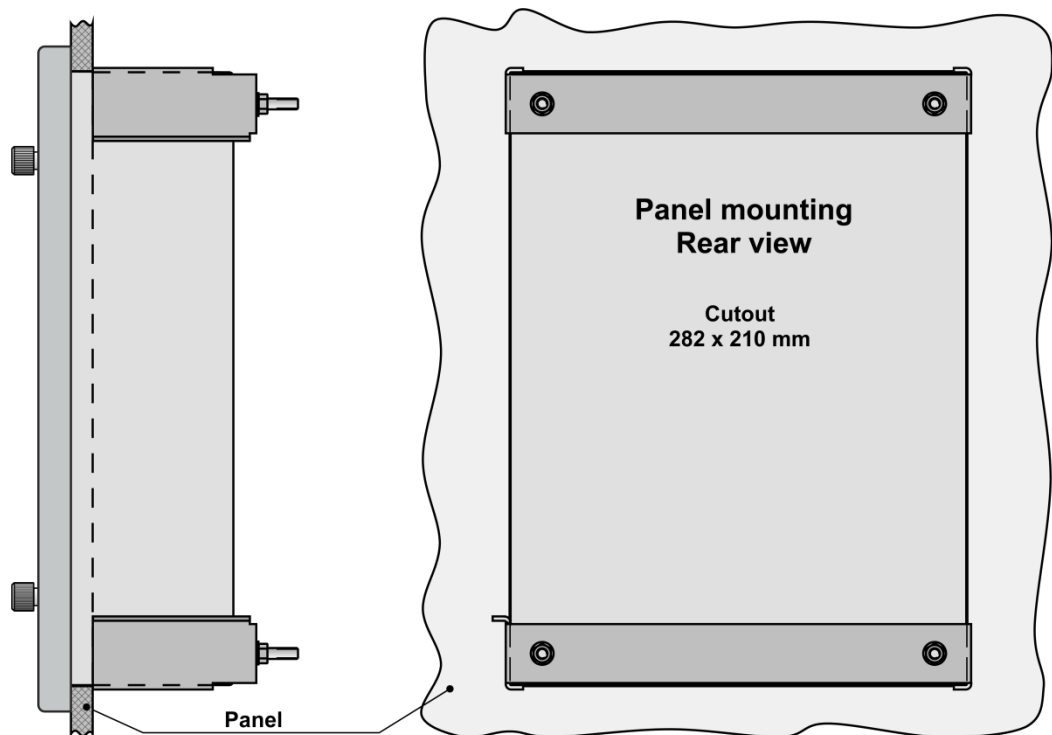


Figure 12: Mechanical dimensions, in-panel mounting

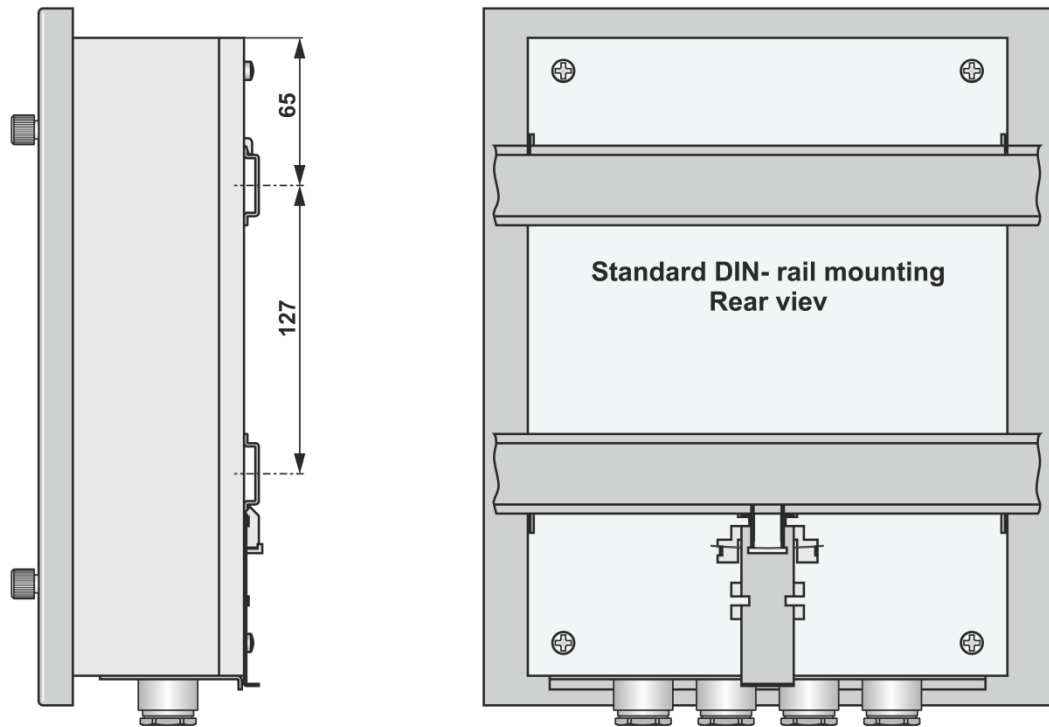


Figure 13: Mechanical dimensions, DIN-rail mounting, in mm

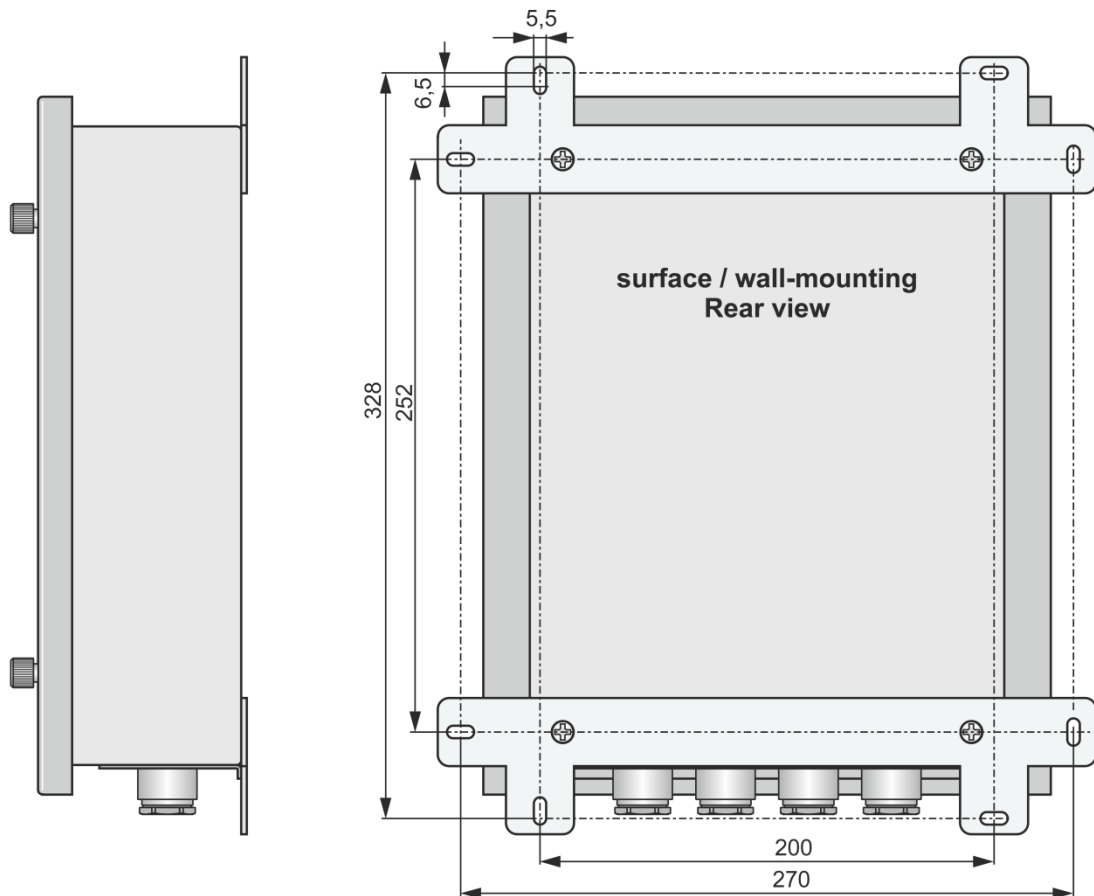
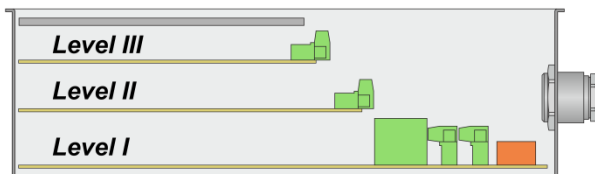


Figure 14: Mechanical dimensions, wall-mounting, in mm

### General information about the connection technology

The regulator has three printed circuit boards or connection levels.



The auxiliary voltage, the input voltage, the currents, the relay outputs, binary inputs etc., are connected on **Level I**.

The hardware for all control system connections is on **Level II**.

The corresponding connection elements on Level II must be used for RS232 and RS485 connection technology.

When working with an Ethernet connection (coupling required for IEC 61850, IEC 60870-5-104 or DNP 3.0 over Ethernet!), the corresponding plug connection is also accessible on Level II (RJ45 and/or fibreglass ST or LC).

For fibre optical connections up to a baud rate of 19200 (e.g. IEC 60870-5-101 or 103), the connection elements (send and receive diode as ST or FSMA connection) are directly mounted on the flangeplate where they can be connected without opening the device.

Additional binary inputs and outputs, and mA inputs and outputs can be installed on Level II.

There are two slots that can be equipped with the following modules:

- Module 1: 6 binary inputs AC/ 48 V...250 V
- Module 2: 6 relay outputs
- Module 3: 2 mA inputs
- Module 4: 2 mA outputs
- Module 5: PT100 – input

The connections for each of the COMs, the E-LAN, the analogue inputs and outputs and for PT100 direct input (E91 + E94) are on **Level III**.

### Optical interfaces

The REG-DMA regulator can also be directly connected through a fibre optic interface.

Transmission and receiver equipment is available for fibreglass and synthetic fibre optic cables.

It is also possible to choose between different mechanical connection options (ST, FSMA and LC connection technology)

Please refer to the list of characteristics for an overview of the available options.



*Figure 15: Fibre optical connection (ST connection technology, V17, V19)*



*Figure 16: Fibre optical connection (FSMA connection technology V13, V15)*



Figure 17: Fibre optical connection (1 x Ethernet ST, XW93)

### Optical transmitter

Serial communication up to 19200 baud  
(Characteristic V13 ... V19)

Prod- uct	Wave length	Fibre	Pmin [dBm] 1)	Pmax [dBm] 1)
Fibreglass ST Fibreglass FSMA	$\lambda = 820$ nm	50/125 $\mu\text{m}$ NA=0.2	-19.8	-12.8
		62.5/125 $\mu\text{m}$ NA=0.275	-16.0	-9.0
		100/140 $\mu\text{m}$ NA=0.3	-10.5	-3.5
		200 $\mu\text{m}$ HCS NA=0.37	-6.2	+1.8
Synthetic ST	$\lambda = 650$ nm	1 mm POF	-7.5	-3.5
		200 $\mu\text{m}$ HCS	-18.0	-8.5
Plastic FSMA	$\lambda = 650$ nm	1 mm POF	-6.2	0.0
		200 $\mu\text{m}$	-16.9	-8.5

Communication over Ethernet 100 Mbit (100 Base Fx)  
(Characteristics XW92, XW93.x, XW95.x, XW96.1 and XW98)

Prod- uct	Wave length	Fibre	Pmin [dBm] 1)	Pmax [dBm] 1)
Fibreglass ST Fibreglass LC	1310 nm	62.5/125 $\mu\text{m}$ NA=0.275	-20	-14

1) TA = 0..70°C, IF = 60 mA, measured after 1 m fibre optic cable

### Optical receiver

Serial communication up to 19200 baud  
(Characteristic V13 ... V19)

Prod- uct	Wave length	Fibre	Pmin [dBm] 2)	Pmax [dBm] 2)
Fibreglass ST Fibreglass FSMA	$\lambda = 820$ nm	100/140 $\mu\text{m}$ NA=0.3	-24.0	-10.8
Synthetic ST	$\lambda = 650$ nm	1 mm POF	-20.0	0.0
		200 $\mu\text{m}$ HCS	-22.0	-2.0
Plastic FSMA	$\lambda = 650$ nm	1 mm POF	-21.6	-2.0
		200 $\mu\text{m}$	-23.0	-3.4

Communication over Ethernet 100 Mbit (100 Base Fx)

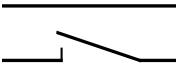
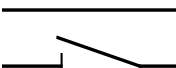
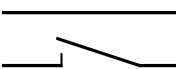
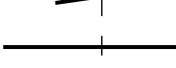
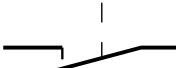


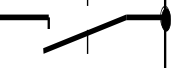
(Characteristics XW92, XW93.x, XW95.x, XW96.1 and XW98)


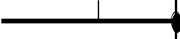
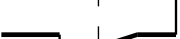

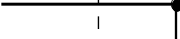
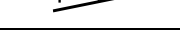
Prod- uct	Wave length	Fibre	Pmin [dBm] 2)	Pmax [dBm] 2)
Fibreglass ST Fibreglass LC	1310 nm	62.5/125 $\mu\text{m}$ NA=0.275	-14	-32

2) TA = 0...70°C, VCC = 5 V $\pm$ 5%, output level LOW (active)

## 17.3 Terminal configuration

No.					
Level I		Option	M1*	M2*	M9*
	2 5	Measuring	U1a U1b	U <sub>L1</sub> U <sub>L2</sub>	U1a U1b
	8 10	Measuring	-	U <sub>L3</sub> -	U2a U2b
	1 3	S1 S2	Current input I <sub>1</sub>		
	4 6	S1 S2	Current input I <sub>2</sub>		
	7 9	S1 S2	Current input I <sub>3</sub>		
	21 22	L/(+) L/(-)	U <sub>H</sub> = Auxiliary voltage		
Level III	63	mA input		+ A1	
	64	mA input		- A1	
	61	mA input or output		+ A2	
	62	mA input or output		- A2	
	65	mA input or output		+ A3	
	66	mA input or output		- A3	
	67	mA input or output		+ A4	
	68	mA input or output		- A4	
Level I	11	Binary input 1		freely programmable	
	12	Binary input 2		freely programmable	
	13	Binary input 3		freely programmable	
	14	Binary input 4		freely programmable	
	15	Binary input 1..4		GND	
	16	Binary input 5		freely programmable	
	17	Binary input 6		freely programmable	
	18	Binary input 7		freely programmable	
	19	Binary input 8		freely programmable	
	20	Binary input 5..8		GND	
	23	Binary input 9		freely programmable	

Level I	24	Binary input 10	freely programmable
	25	Binary input 11	freely programmable
	26	Binary input 12	freely programmable
	27	Binary input 9...12	GND
	28	Binary input 13	freely programmable
	29	Binary input 14	freely programmable
	30	Binary input 15	freely programmable
	31	Binary input 16	freely programmable
	32	Binary input 13...16	GND
	33		freely programmable R <sub>5</sub>
	34		
	35		freely programmable R <sub>4</sub>
	36		
	37		freely programmable R <sub>3</sub>
	38		
	39		freely programmable R <sub>2</sub>
	40		
	41		
	42		freely programmable R <sub>1</sub>
	43		
	44		
	45		
	46		
Level I	47		freely programmable R <sub>11</sub>
	48		freely programmable R <sub>10</sub>
	49		freely programmable R <sub>9</sub>
	50		freely programmable R <sub>8</sub>
	51		freely programmable R <sub>7</sub>
	52		freely programmable R <sub>6</sub>

	53		GND	$R_6 \dots R_1$ 1
	54		closes in the event of a fault	
	55		Life contact (status)	
	56		opens in the event of a fault	
	57		MAN	
	58		MAN/AUTO	
	59		AUTO	
Level III	69	E-	ELAN (L)	
	70	E+		
	71	EA-		
	72	EA+		
	2000	GND		
	73	E-	ELAN (R)	
	74	E+		
	75	EA-		
	76	EA+		
	2010	GND		
	77	Tx+	COM3 (RS485)	
	78	Tx-		
	79	Rx+		
	80	Rx-		
	81	GND		
	82	TxD	COM2 (RS232)	
	83	RxD		
	84	RTS		
	85	CTS		
	86	GND		
	202	DCF-	DCF 77 **	
	203	DCF EA+		
	204	GND		
	205	TxD	COM1 - S	
	206	RxD		
	207	RTS		
	208	CTS		

Level II	209	GND	Voltage output 5 VDC (max. 2 W)
	210	GND	
	211	VCC+	
			Terminal configuration for the control system see page 107
			Please refer to Terminal Configuration Level II (page 105) for additional configuration options at Level II.

**\*Option M1** Used for standard applications.

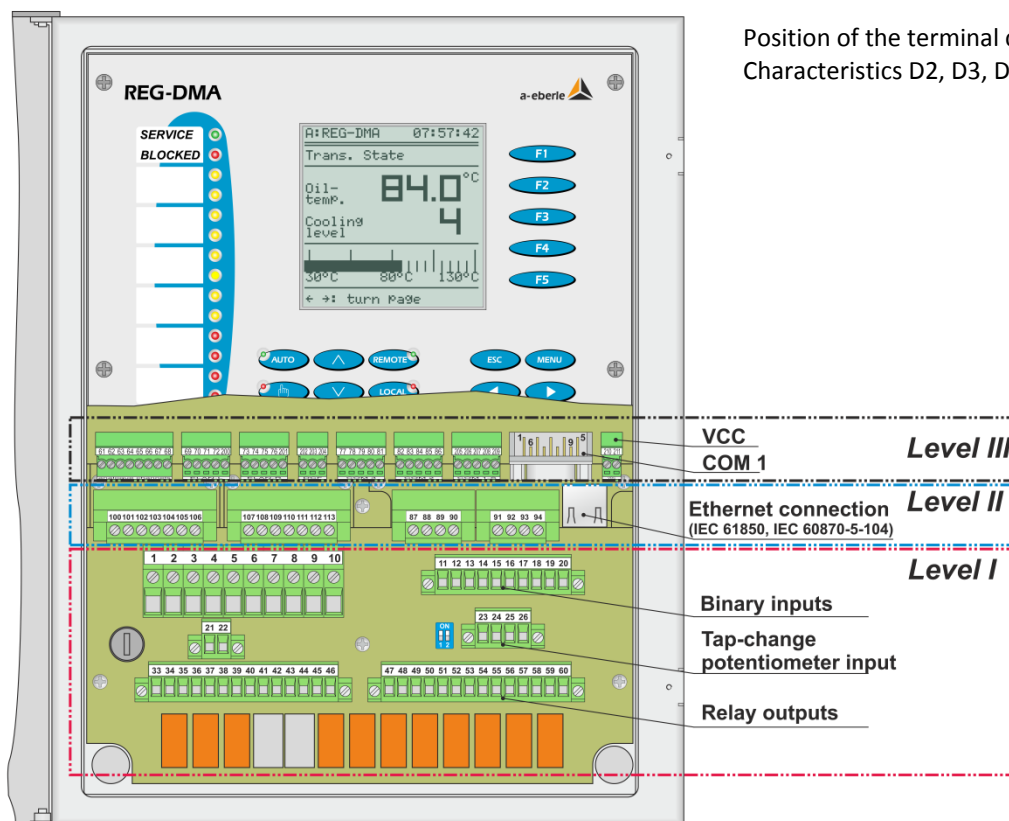
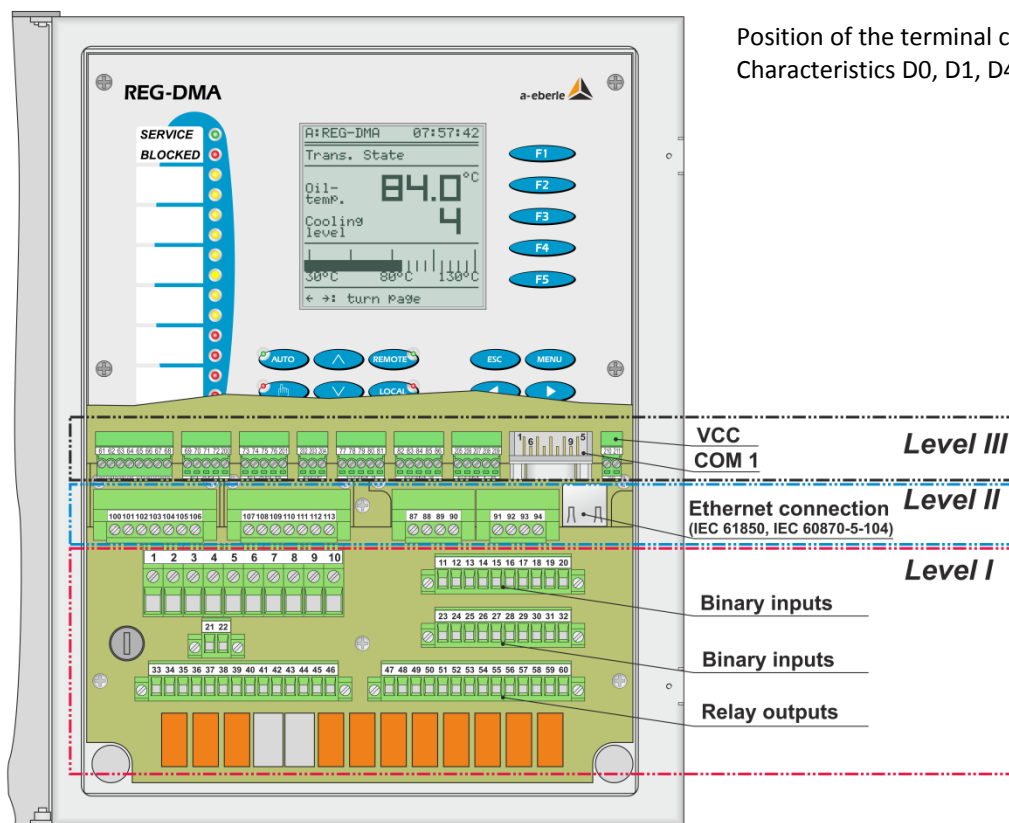
Three-wire grids are generally considered as symmetrical ( $I_1 = I_2 = I_3$ ).

**Option M2** Only used in randomly loaded three-phase grids ( $I_1 \neq I_2 \neq I_3$ ).

**Option M9** For triple-wound applications, two galvanically isolated voltage inputs are needed for U1 and U2.

\*\* The DCF77 input will be implemented in a later version of the firmware

The configuration of terminals 23 to 32 will change according to Characteristic D. The configuration for D0 / D1 / D3 / D7 / D9 is displayed.





## 17.4 Terminal configuration Level II

Characteristics: C90...C99

**Characteristic C90** – (e.g. 2 x PT100, other combinations are possible)

	No.			
Module 5	100	PT100	Ik+	A10
	101		Ue+	
	102		Ue-	
	103		Ik-	
Module 5	104	PT100	Ik+	A12
	105		Ue+	
	106		Ue-	
	107		Ik-	

**Characteristic C91** – 6 additional binary inputs  
AC/DC 48 V ... 250 V

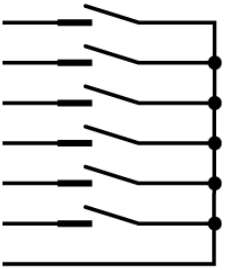
	No.		
Module 1	100	Binary input	E17
	101	Binary input	E18
	102	Binary input	E19
	103	Binary input	E20
	104	Binary input	E21
	105	Binary input	E22
	106	GND	E17 ... E22

**Characteristic C92** – 12 additional binary inputs  
AC/DC 48 V ... 250 V

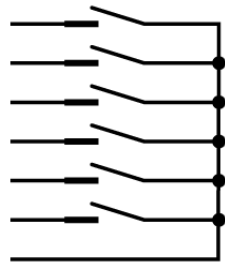
	No.		
Module 1	100	Binary input	E17
	101	Binary input	E18
	102	Binary input	E19
	103	Binary input	E20
	104	Binary input	E21
	105	Binary input	E22
	106	GND	E17 ... E22

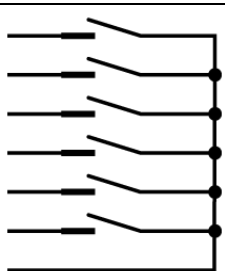
Module 1	107	Binary input	E23
	108	Binary input	E24
	109	Binary input	E25
	110	Binary input	E26
	111	Binary input	E27
	112	Binary input	E28
	113	GND	E23 ... E28

**Characteristic C93** – 6 additional relay outputs  
(NOC)

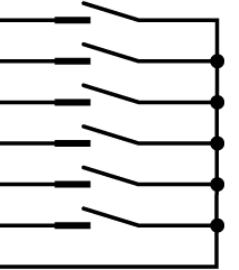
	No.		
Module 2	100		R12
	101		R13
	102		R14
	103		R15
	104		R16
	105		R17
	106		GND R12 ... R17

**Characteristic C94** – 12 additional relay outputs  
(NOC)

	No.		
Module 2	100		R12
	101		R13
	102		R14
	103		R15
	104		R16
	105		R17
	106		GND R12 ... R17

Module 2	107		R18
	108		R19
	109		R20
	110		R21
	111		R22
	112		R23
	113		GND R18 ... R23

**Characteristic C95** – 6 additional binary inputs  
AC/DC 48 V ... 250 V and 6 additional relay out-  
puts (NOC)

	No.		
Module 1	100	Binary input	E17
	101	Binary input	E18
	102	Binary input	E19
	103	Binary input	E20
	104	Binary input	E21
	105	Binary input	E22
	106	GND	E17 ... E22
Module 2	107		R12
	108		R13
	109		R14
	110		R15
	111		R16
	112		R17
	113		GND R12 ... R17

**Characteristic C96** – 2 additional analogue inputs

	No.			
Module 3	100	analogue input	+	A10
	101		-	
	102	analogue input	+	A11
	103		-	

**Characteristic C97** – 4 additional analogue inputs

	No.			
Module 3	100	analogue input	+	A10
	101		-	
	102	analogue input	+	A11
	103		-	
Module 3	104	analogue input	+	A12
	105		-	
	106	analogue input	+	A13
	107		-	

**Characteristic C98** – 2 additional analogue out-  
puts

	No.			
Module 4	100	analogue output	+	A10
	101		-	
	102	analogue output	+	A11
	103		-	

**Characteristic C99** – 4 additional analogue out-  
puts

	No.			
Module 4	100	analogue output	+	A10
	101		-	
	102	analogue output	+	A11
	103		-	
Module 4	104	analogue output	+	A12
	105		-	
		analogue output	+	A13
	107		-	

## 17.5 Terminal configuration

### Control system Level II

Characteristics: Z10..15, 17..23, 90, 91, 99, XW90...98

**Characteristics Z10..15, 17..20, 90, 91** – REG-P communication interface

	No.	
COM1 RS485	87	RS485-N (B)
	88	RS485-P (A)
COM1 RS232	89	RS232-TxD
	90	RS232-RxD
	91	RS232-RTS
	92	RS232-CTS
	93	RS232-GND
PE	94	PE
COM1 fibre optic cable	95	Fibre optic cable In
	96	Fibre optic cable Out
	97	Fibre optic cable GND
	98	Fibre optic cable VCC

**Characteristics Z22..23** – REG-PM communication interface

	No.	
COM1 RS485	92	RS485-P (A)
	93	RS485-N (B)
	94	RS485-GND
COM1 RS232	87	RS232-TxD
	89	RS232-RxD
	88	RS232-RTS
	90	RS232-CTS
	91	RS232-GND
COM1 fibre optic cable	96	Fibre optic cable In
	97	Fibre optic cable Out
	95	Fibre optic cable GND
	98	Fibre optic cable VCC
PARAM (SUB-D)		Parameter Interface

**Characteristic Z21** – REG-LON communication interface

	No.	
Fibre optic cable		Fibre optic cable In
		Fibre optic cable Out
		Fibre optic cable GND
		Fibre optic cable VCC

**Characteristic Z99** – Profibus-DP communication interface

	No.	
PARAM (RJ11)	1	RS232-GND
	2	RS232-GND
	3	RS232-RxD
	4	RS232-TxD
Profibus-DP (SUB-D)	3	B-Line (Rx/Tx +)
	4	RTS
	5	GND BUS
	6	+5 V BUS
	8	A-Line (Rx/Tx -)



**Characteristic XW90..93+97+98** – REG-PE communication interface

	No.	
PARAM 1	87	RS232-RxD
	88	RS232-TxD
	89	RS232-GND
	90	RS232-GND-SCR
PARAM 2	91	RS232-RxD
	92	RS232-TxD
	93	RS232-GND
	94	RS232-GND-SCR
Ethernet	RJ45 Connector	or Fibre optic cable (ST or LC)

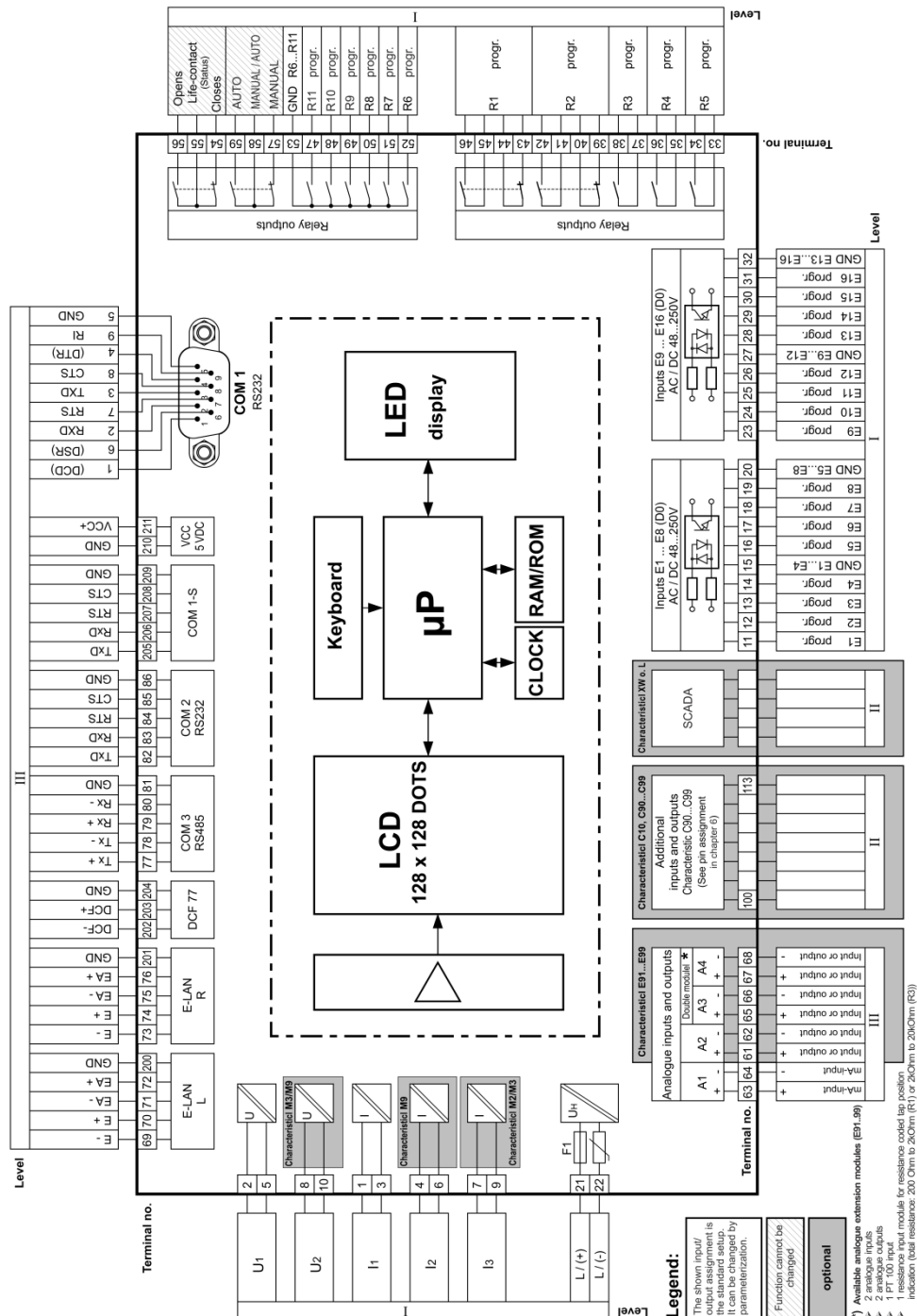
We take care of it.

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**Characteristic XW94..96 – REG-PED communication interface**

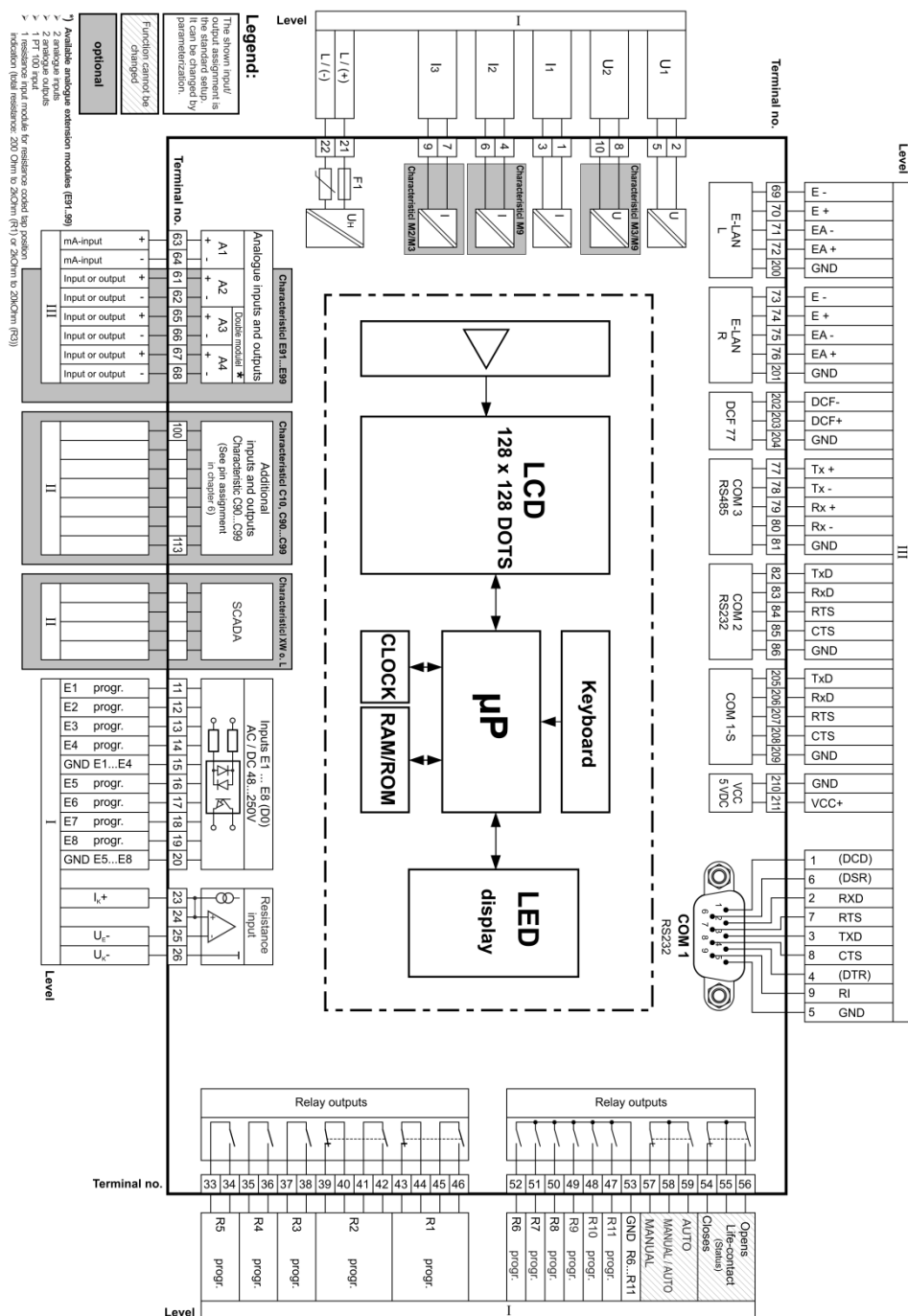
	No.		
COM1	87	RS485-P (A)	
	88	RS485-N (B)	
	89	RS232-TxD	
	90	RS232-RxD	
	91	RS232-RTS	
	92	RS232-CTS	
	93	RS232-GND	
PE	94	PE/Shield	
PARAM	95	PARAM-RxD	
	96	PARAM-TxD	
	97	PARAM-GND	
Ethernet 1	RJ45 Connector	or	 Fibre optic cable (ST or LC)
Ethernet 2	RJ45 Connector	or	 Fibre optic cable (ST or LC)

## 17.6 Block diagram - Characteristics D0, D1, D4, D7, D9

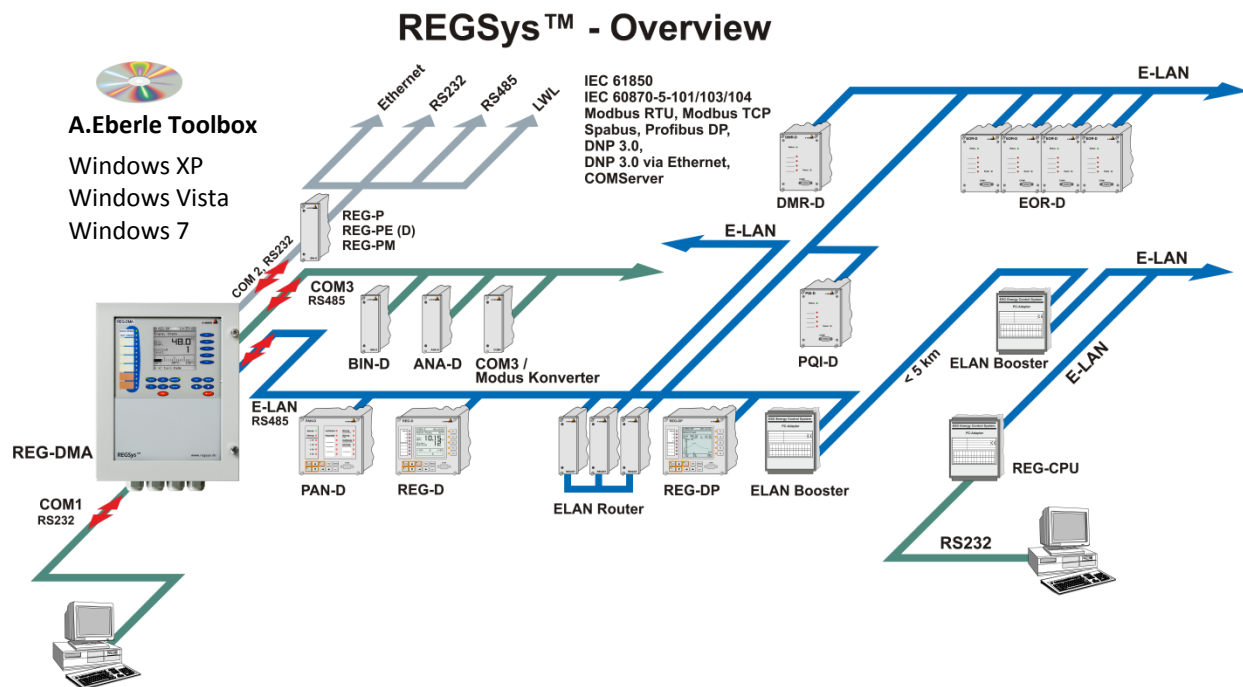


\*) The dual module comes as a dual mA input module or a dual mA output module. The position is configured with a PT100 module if the temperature is to be recorded directly.

### 17.7 Block diagram - Characteristics D2, D3, D5, D6, D8



\*) The dual module comes either as a dual mA input module or a dual mA output module.  
The position is configured with a PT100 module if the temperature is to be recorded directly.



## 17.8 Network

Several REG-DMAs can be combined into a network of monitoring systems. Each of the devices in the grid can access the data on the other devices. For example, two REG-DMAs can be connected to the control system through a control system connection. A grid also enables other A. Eberle devices such as the REG-D(A) voltage regulator to be accessed and all of the connected devices to be configured from one connection point.

If a network is needed over longer distances, the E-LAN can be redirected through the fibre optic cable or the Ethernet.

## 17.9 Serial interfaces

The REG-DMA has two RS232 serial interfaces with three connections (COM1, COM1-S, COM2). COM1 is the parameterization interface, while COM2 is mainly used to connect the REG-DMA to the higher control units. COM1-S is an alternative connection option for COM1. COM1 has priority, meaning that when COM1 has a connection,

COM1-S is switched off. Devices connected to COM1-S do not have to be disconnected. This enables COM1-S to function as an alternative remote parameterization interface that is only active when parameters are not set locally. COM1 can also be configured as a USB connection (optional).

If a control system module is not installed, COM2 in the terminal compartment can be used to connect a modem, a COM server or a PC.

### Connection elements

COM1	Sub-D 9-pin male (optionally as mini-USB) in the connection compartment
COM1-S	Terminal connection in the connection compartment
COM2	Terminal connection in the connection compartment
Connection options	PC, terminal, modem, PLC
Number of data bits/protocol	8 / even, none
Transmission rate bit/s	9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600
HANDSHAKE	RTS / CTS, XON / XOFF, delay, none

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

Every REG-DMA has two E-LAN interfaces that are used to communicate with other REG-DM(A)s or other A. Eberle devices (e.g. voltage regulator REG-D(A)).

Time can also be synchronized through the control system.

The time synchronization input is not supported until firmware version 2.02.

### **Characteristics**

- 255 addressable participants
- Multi-master structure
- Integrated repeater function
- Open ring, bus or point-to-point connection possible
- Transmission rate 15.6 ... 375 kbit/s

### **COM3 (peripheral interface)**

To connect up to 16 interface modules (BIN-D, ANA-D) to a REG-DMA in any combination. COM3 is an RS485 interface.

Optionally, a fibre optic cable can be used to connect COM3 devices that are not in the vicinity of the REG-DMA.

The COM3/Modbus converter can also be connected in order to establish direct serial communication with other Modbus devices. This enables the REG-DMA to get values such as the winding temperature or the gas-in-oil ratio from other devices and transmit them to the control system or record them in the recorder.

### **Time synchronization input (DCF input)**

The time synchronization input enables the time on the REG-DMA to be synchronized using a DCF77 signal. The input is designed for an RS485 (5 V) and can be wired to several devices as time synchronization bus. The termination (terminating resistor) can be switched on and off by using jumpers on the CPU board. If a DCF signal cannot be received, a GPS clock or control system card that emulates a DCF signal can be used.



## 17.10 A.Eberle Toolbox Parameterization and configuration software

The A.Eberle Toolbox is used to parameterize and programme the system, and to archive and view recorded data.

The A.Eberle Toolbox runs on the following operating systems:

Windows XP, Vista, Windows 7

### REG-DMA - Parameter (selection)

Parameter	Setting range
Rated current for each cooling stage	0...3000 A
Thermal time constant for each cooling stage	0..50000 s
Hot-spot temperature increase H <sub>gr</sub>	0...90K
Winding exponent $\gamma$	0...3
Basis of the control (Cooling stage control)	Oil Winding SmrtCtrl
Temperature limit for each cooling stage	-30...200°C
IEC Formula	IEC 60354 IEC 60076
Type of air cooling	AN AF
Type of oil cooling	ON OF OD ON/OF ON/OD
Fan assignment	fixed cyclical
Number of fans	1...6
Transformer oil temperature alarm	0...150°C
Tap changer oil temperature alarm	0...150°C
Winding temperature alarm	0...200°C

Parameter	Setting range
Winding temperature trigger	0...200°C
Transformer oil level alarm	0 ... 150%
Tap changer oil level alarm	0 ... 150%
Gas-in-oil alarm	0...1000000 ppm
Water-in-oil alarm	0...1000000 ppm
H <sub>2</sub> -in-oil alarm	0...1000000 ppm
CO-in-oil alarm	0...1000000 ppm
Operating hours transformer	0...999999 h
Service life consumption transformer	0...999999 h
Operating hours fans	0...999999 h
Operating hours oil pumps	0...999999 h
Operating hours tap changer	0...999999 h
Switching load tap changer	0...900000000000 A <sup>2</sup> s
max. winding temperature	-30...200°C
Time to max. temperature	1..7200 s
Time delay limit values (adjustable for every limit value)	0...900 s

## 17.11 Order specifications

Only one unit in a group of codes with the same capital letter can be ordered.

When a code's capital letter is followed by the number 9, additional information may be required.

When a code's capital letter is followed only by zeros the code may be omitted.

X characteristics such as XE91 cannot be combined with all of the other characteristics. Please read the notes and explanations.

CHARACTERISTIC	CODE
<b>Transformer Monitoring System – REG-DMA</b> with dual E-LAN interface COM2, COM3 and an mA input channel, e.g. to measure the oil temperature Comes with 16 binary inputs and 12 relay outputs plus a status output, and includes the parameterization software to set parameters, program and view all data. Includes connection cable Binary 3-channel line recorder additional recorder function with 4 x 64 channels and 108 MB repository <b>Note:</b> COM2 is only freely accessible when operated without SCADA communication.	REG-DMA
<b>Model</b> In-panel mounting or wall mounting (H x W x D) 307 x 250 x 102 mm including flange plate with brush element with DIN-rail adapter	B0 B1
<b>Serial interface COM1</b> RS232 with SUB-D connector (9-pin male), default if Characteristic I is not specified USB (Mini USB connector)	I0 I1
<b>Power supply</b> external AC 85 V ... 110 V ... 264 V / DC 88 V ... 220 V ... 280 V external DC 18 V ... 60 V ... 72 V	H0 H2
<b>Input current (can be changed at a later stage)</b> $I_{EN}$ 1A $I_{EN}$ 5A	F1 F2
<b>Voltage and current measurement</b> Three-wire three-phase system with equal load Three-wire three-phase system with random load (Aron circuit) other transducer application (2 x I, 2 x U, e.g. three winding)	M1 M2 M9
<b>additional analogue inputs and outputs</b> without with one PT100 input with two mA inputs with two mA outputs with one PT100 input and one mA output with two mA inputs and one mA output	E00 E91 E92 E93 E94 E95

CHARACTERISTIC	CODE
with three mA outputs	E96
Tap change potentiometer input total resistance 180 $\Omega$ ... 2 k $\Omega$ , min. 5 $\Omega$ /tap	E97
Tap potentiometer input total resistance 2 k $\Omega$ ... 20 k $\Omega$ , min. 50 $\Omega$ /tap	E98
other combinations of inputs and outputs	E99
<b>Binary inputs and tap change potentiometer input</b>	
16 units binary Inputs AC/DC 48...250 V (E1...E16)	D0
8 units binary inputs AC/DC 10...50 V (E1...E8) and 8 units AC/DC 48...250 V (E9...E16)	D1
16 units binary inputs AC/DC 10...50 V (E1...E16)	D4
16 units binary Inputs AC/DC 190...250 V (E1...E16)	D7
16 units binary Inputs AC/DC 80...250 V (E1...E16)	D9
1 tap change potentiometer input (total resistance 180 ... 2k $\Omega$ ) and 8 binary inputs AC/DC 48...250 V	D2
1 tap change potentiometer input (total resistance >2 ... 20 k $\Omega$ ) and 8 binary inputs AC/DC 10...50 V	D3
1 tap change potentiometer input (total resistance 180 ... 2 k $\Omega$ ) and 8 binary inputs AC/DC 10...50 V	D5
1 tap change potentiometer input (total resistance >2 ... 20 k $\Omega$ ) and 8 binary inputs AC/DC 48...250 V	D6
1 tap change potentiometer input (total resistance >2 ... 20k $\Omega$ ) and 8 binary inputs AC/DC 80...250 V	D8
<b>Level II: Additional inputs and outputs as well as the standalone monitoring function PAN-A2</b>	
without	C00
with 6 binary inputs AC/DC 48 V...250 V	C91
with 12 binary inputs AC/DC 48 V...250 V	C92
with 6 relay outputs	C93
with 12 relay outputs	C94
with 6 binary inputs and 6 relay outputs	C95
with 2 analogue inputs	C66
with 4 analogue inputs	C97
with 2 analogue outputs	C98
with 4 analogue outputs	C99
other combinations 6 inputs, 6 outputs, 2 analogue inputs, 2 analogue outputs or PT100 input	C90
<b>Note on C90:</b> Two slots are usually available on Level II. Each slot can be equipped with 6 binary inputs, 6 binary outputs or with an analogue module.	
<b>COM3 interface</b>	
RS485 (default, characteristic specifications can be omitted )	R1
RS485 and for remote components fibre optic cable (fibreglass) with ST connector	R2
<b>Note:</b> COM3 is needed for ANA-D, BIN-D and COM3/Modbus converters!	

CHARACTERISTIC	CODE
<b>Integrated control system connection in conformity with: IEC 61850, IEC 60870-5-104, DNP 3.0 over Ethernet or MODBUS TCP/IP (RTU)</b>	
without (continue with Characteristic group 'L')	XW00
IEC 60870-5-104/RJ 45 (continue with Characteristic group 'G')	XW90
IEC 60870-5-104 with fibre optic cable connection (continue with Characteristic group 'G')	XW92
<b>Note:</b> Please specify the target system for connections in conformity with IEC 60850-5-104	
IEC 61850/RJ 45 (continue with Characteristic group 'G')	XW91
IEC 61850 with fibre optic cable with ST connection (continue with Characteristic group 'G')	XW93
IEC 61850 with fibre optic cable with LC connection (continue with Characteristic group 'G')	XW93.1
IEC 61850 with 2 x RJ45 connection (continue with Characteristic group 'G')	XW94
IEC 61850 with 2 x fibre optic cable with ST connection (continue with Characteristic group 'G')	XW95
IEC 61850 with 2 x fibre optic cable with LC connection (continue with Characteristic group 'G')	XW95.1
IEC 61850 with 1 x RJ45 and 1 x fibre optic cable with ST connection (Continue with Characteristic group 'G')	XW96
IEC 61850 with 1 x RJ45 and 1 x fibre optic cable with LC connection (continue with Characteristic group 'G')	XW96.1
<b>Note:</b> Please specify the target system for connections in conformity with IEC 61850	
DNP 3.0 over Ethernet with 1 x RJ45 connection (continue with Characteristic group 'G')	XW97
DNP 3.0 over Ethernet with 2 x RJ45 connection (continue with Characteristic group 'G')	XW94.1
DNP 3.0 over Ethernet with 1 x fibre optic ST connection (continue with Characteristic group 'G')	XW98
DNP 3.0 over Ethernet with 1 x fibre optic LC connection (continue with Characteristic group 'G')	XW98.1
DNP 3.0 over Ethernet with 2 x fibre optic ST connection (continue with Characteristic group 'G')	XW95.2
DNP 3.0 over Ethernet with 2 x fibre optic LC connection (continue with Characteristic group 'G')	XW95.3
DNP 3.0 over Ethernet with 1 x RJ45 and 1 x fibre optic ST connection (Continue with Characteristic group 'G')	XW96.4
DNP 3.0 over Ethernet with 1 x RJ45 and 1 x fibre optic LC connection (continue with Characteristic group 'G')	XW96.5
<b>Note:</b> Please specify the target system for connections in conformity with DNP 3.0	
MODBUS TCP/IP with 2 x RJ45 connection (continue with Characteristic group 'G')	XW94.2
MODBUS RTU with RS485 (and with 1x RJ45/1x FO) connection (continue with Characteristic group 'G')	XW96.2
<b>Note:</b> Please specify the target system for connections in conformity with MODBUS	
<b>Integrated control system connection in conformity with: IEC 60870- 5-101/ ...-103,...DNP...</b>	
without (continue with Characteristic group 'G')	L0
to connect the REG-DA to a SCADA system	L1
to connect several systems to a SCADA system (REG-D/DA/DP etc.)	L9
<b>Note:</b> L9 can only be combined with Characteristics Z15 to Z19 and Z91	

CHARACTERISTIC	CODE
<b>Connection type</b> Copper <ul style="list-style-type: none"> <li>● RS 232</li> <li>● RS 485 2-wire operation only</li> </ul> Fibre optic cable with FSMA connection technology <ul style="list-style-type: none"> <li>● Fibreglass (Wave length 800...900 nm, range 2000 m)</li> <li>● Plastic (wave length 620...680 nm, range 50 m)</li> </ul> Fibre optic cable with ST connection technology <ul style="list-style-type: none"> <li>● Fibreglass (Wave length 800...900 nm, range 2000 m)</li> <li>● Plastic (wave length 620...680 nm, range 50 m)</li> </ul>	V10 V11 V13 V15 V17 V19
<b>Protocol</b> IEC60870-5-103 for ABB IEC60870-5-103 for Areva IEC60870-5-103 for SAT IEC60870-5-103 for Siemens (LSA/SAS) IEC60870-5-103 for Sprecher Automation IEC60870-5-103 for others IEC60870-5-101 for ABB IEC60870-5-101 for IDS IEC60870-5-101 for SAT IEC60870-5-101 for Siemens (LSA/SAS) IEC60870-5-101 for others DNP 3.00 LONMark (on request) SPABUS MODBUS RTU Profibus-DP (always with V11!) (on request)	Z10 Z11 Z12 Z13 Z14 Z90 Z15 Z17 Z18 Z19 Z91 Z20 Z21 Z22 Z23 Z99
<b>User Manual</b> German English other	G1 G2 G9
<b>Display language</b> German English Spanish other	A1 A2 A4 A11
<b>Use of IEC 61850 GOOSE applications</b>	GOOSE
<b>IEC 61850 with bonding in active backup mode</b>	Bonding
<b>DCF simulation over NTP and E-LAN extension over Ethernet (CSE)</b> <b>Note:</b> Only in combination with XW94.x, XW95.x, XW96.x	DCF/E-LAN

REG-DMA accessories	ID No.
<b>Fuses, batteries:</b>	
1 pack microfuses T1 L 250 V, 1 A, for auxiliary voltage range H0	582.1002
1 pack microfuses T2 L 250 V, 2 A, for auxiliary voltage range H2	582.1019
1 lithium battery (pluggable)	570.0003.00
1 lithium battery (solderable)	on request
1 button cell CR1632	570.0005
<b>Connection technology:</b>	
PC connection cable (null-modem cable)	582.020B
Modem connection cable	582.2040
RS232 10 m extension cable	582.2040.10
USB/RS232 adapter with integrated null-modem cable (FTDI), 1,5m	111.9046.01
E-LAN interface -> fibreglass, (RS485 conversion to fibre optic cable), ST fibre optic cable connection, 2 units needed for each line	111.9030.10
E-LAN interface -> fibreglass, (RS485 conversion to fibre optic cable), LC fibre optic cable connection, 2 units needed for each line	111.9030.11
E-LAN booster, Uh: DC 20..75 V, DIN-rail housing 22.5 mm width, if necessary with mains adapter H1 111.9030.36	111.9027.02
E-LAN router, one outgoing circuit with booster, Uh: DC 20..75 V, DIN-rail housing 22.5 mm width, if necessary with mains adapter H1 111.9030.36	111.9027.03
<b>Time synchronization:</b>	
Radio clock (DFC 77)	111.9024.01
GPS radio clock NIS time, RS485, Uh: AC 85 V ... 110 V ... 264 V / DC 88 V ... 220 V ... 280 V	111.9024.45
GPS radio clock NIS time, RS485, Uh: DC 18 V ... 60 V ... 72 V	111.9024.46
GPS radio clock NIS time, RS232, Uh: AC 85 V ... 110 V ... 264 V / DC 88 V ... 220 V ... 280 V	111.9024.47
GPS radio clock NIS time, RS232, Uh: DC 18 V ... 60 V ... 72 V	111.9024.48
<b>Modems:</b>	
Develo MicroLink 56Ki analogue modem, tabletop device incl. 230 V AC mains adapter	111.9030.02
Develo MicroLink 56Ki analogue modem, DIN-rail device incl. 230 V AC power supply	111.9030.03
Industrial analogue modem that can be used as dial-up modem or dedicated line; (Uh: AC 20..260 V/DC 14 V..280 V) with DIN-rail adapter; can be used with the PC and the device.	111.9030.17
Insys industrial analogue modem that can be used as a dedicated line; supply voltage DC: 10...60 V, can be used with PC and device!	111.9030.20
ISDN modem for DIN-rail mount; Uh: DC 10 ... 60 V	111.9030.27
ISDN modem as tabletop device; incl. 230 V AC mains adapter	111.9030.37
GPRS modem (Insys) for DIN-rail mount; incl. magnet foot antenna and parameterization software; Uh: DC 10 ..60 V	111.9030.29
<b>Power supply:</b>	
Phoenix mains adapter for DIN-rail mounting:In:AC 120 V..230 V, DC 90..250 V, Out: DC 24 V	111.9005.02

REG-DMA accessories	ID No.
Mains adapter for DIN-rail mounting: In: AC 80 V...250 V; Out: DC 24 V	111.9030.31
Mains adapter for DIN-rail mounting: In: DC 18 V...60 V...72 V; Out: DC 24 V	111.9030.32
Mains adapter for E-LAN router or booster: In: AC 100 to 240 V, Out: 24 V/1.3 A	111.9030.36
UPS HighCAP2403-1AC, In: 230 V AC Out: 24 V DC, max. 3 A, 1000 Joule (1 kW), DIN-rail	111.9030.38
Additional input and output module:	
Analogue input module (2 inputs)	320.0004.00
Analogue output module (2 outputs)	320.0003
Input module for tap-potentiometer total resistance 180 ...2 k $\Omega$ , min. 5 $\Omega$ /tap	320.0002.01
Input module for tap-potentiometer total resistance 2 ...20 k $\Omega$ , min. 50 $\Omega$ /tap	320.0002.03
Input module for PT100 in conformity with DIN 43760 in three-wire circuit	320.0005.01
Operating instructions:	
Additional operating instructions for REG-DA (please specify the language)	GX

General add-ons	CODE
<b>Profibus-DP module</b> Includes RS485 interface with connection cable; for external power supply with 24 V DC <b>Model</b> Can be mounted on DIN-rail (120 x 75 x 27 mm) ext. 24 V power supply adapter	<b>Profi-DP</b>  B0
<b>TCP/IP adapter</b> <ul style="list-style-type: none"> <li>10 Mbit mountable on DIN-rail with mains adapter for Uh AC 230 V</li> <li>100 Mbit</li> </ul>	<b>REG-COM</b> A01 A90
<b>COM3 converter</b> COM3 to Modbus converter to connect external devices with Modbus interface to the transformer monitoring module. For example, to analyse the gas-in-oil ratio online, directly measure the winding temperature, etc. <ul style="list-style-type: none"> <li>Auxiliary voltage <ul style="list-style-type: none"> <li>AC 85...264 V, DC 88 ... 280 V, DC 18 ... 72 V</li> <li>DC 18 ... 72 V</li> </ul> </li> </ul>	<b>COM3-MOD</b>  H1 H2
<b>IRIG-DCF77 converter</b> AC 85 V ... 110 V ...264 V / DC 88 V ... 220 V ... 280 V DC 18 V ... 60 V ... 72 V as wall-mounting housing 20 TE	<b>IRIG-DCF</b> H1 H2 B2

## 18. Index

### A

Additional inputs and outputs.....	54
Analogue inputs and outputs .....	40
Aron measurement .....	22

### B

Basis of the control.....	29
Battery replacement .....	59
Binary inputs and outputs .....	45
Block diagram .....	78, 79

### C

Calculation .....	30
IEC Formula .....	31
Limited oil flow.....	30
Type of air cooling.....	30
Characteristic M2 .....	32
Cleaning.....	61
CO content.....	40
COM3/Modbus (RTU Master) Converter .....	55
Connection technology .....	69
Current measurement.....	32
Conversion of the transformer.....	32
Tap changer switching time .....	32
Transducer connection.....	32

### D

Description for the Transformer Monitoring System .....	7
Determining the oil temperature.....	11
Disposal .....	61

### E

E-LAN .....	51, 80
-------------	--------

### F

Fan assignment.....	31
Functions: .....	53
Fuse replacement.....	58

### G

Gas content .....	39
General Setup.....	53
Guarantee .....	61

### H

H2 content.....	39
<b>Hot-spot calculation</b> .....	11
Hot-spot temperature.....	7, 9, 10

### I

Increasing the system's hardware resources..	54
In-panel mounting.....	6

### M

Max. Winding temperature.....	50
Mechanical configuration .....	66
Monitor .....	14

### N

Number of fans .....	31
----------------------	----

### O

Oil level (TC) .....	35
Oil level (TC/Transformer).....	16
Oil level (transformer).....	35
Oil pumps .....	49
Oil temperature (Alarm).....	36
Oil temperature (TC) .....	34
Oil temperatures (TC/Transformer).....	16
Operating hours .....	17
Operating hours fans.....	50
Optical interfaces .....	69
Order specifications .....	83
Overload.....	16

### P

Parameter selection .....	82
Power consumption .....	60



Product Warranty .....	61	Technical Data .....	62
Protocol .....	8	Technical Specifications .....	62
<b>R</b>		Temperature limits.....	29
Recorder .....	23	Temperature measurement.....	56
Absolute deviation .....	26	Terminal configuration.....	71, 74, 76
Allocation.....	25	ThreeWindingCharateristic .....	32
Deleting recorded data .....	26	Time to max. temperature .....	50
Number of channels .....	25	Transducer installation.....	51
Step distance .....	26	Transducer mode .....	22
RS232 .....	51	Transformer Parameter	
<b>S</b>		Hot-Spot Temperature Increase Hgr.....	28
Safety instructions .....	6	Transformer Parameters .....	27
Scope of Delivery .....	7	Rated current .....	27
Serial interfaces .....	80	Thermal time constant for the winding .....	28
Service life .....	17	Transformer service life .....	48
Service life consumption .....	19	<b>W</b>	
Status .....	53	Water content .....	38
Storage.....	60	Winding currents and winding temperature ..	16
<b>T</b>		Winding temperature (Alarm).....	37
Tap changer service life .....	49	Winding temperature (Trigger) .....	37

We take care of it.

## Notes

[illegible]

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