

Relay for OLTC Control & Transformer Monitoring

Model REG-DA

- ▶ Wall mounting housing
- ▶ Panel mounting housing
- ▶ Din-rail mounting



1. Application

The REG-DA relay for OLTC control & Transformer Monitoring is used to perform both complex and simple measurement, control and regulation tasks on tap-changing transformers. To achieve these tasks, the REG-DA voltage regulator can be used with an array of add-on components, such as the BIN-D and ANA-D remote I/O modules, and an assortment of communication cards.

Each REG-DA has transducer and statistical modes, as well as optional multi-channel recorder, transformer monitoring module (TMM) and ParaGramer.

Transducer Mode displays all of the relevant measured variables of the voltage network, while Statistical Mode provides a clear overview of the various switching operations of the tap changer.

Voltage regulators operating in parallel are connected via a fibre optic or copper ELAN bus, which enables the automatic sharing of relevant data. ParaGramer then detects which transformers have been switched into a parallel control scheme and displays this information via a single-line diagram.

The powerful TMM functions enable the continuous monitoring of various conditions within the transformer and tap changer. Information such as hot-spot temperature (IEC 60354 or IEC 60076) and transformer loss-of-life are calculated, and if necessary up to six cooling levels can be activated.

As an alternative to direct measurement, the U, I, tap position and $\cos(\phi)$ value can also be transmitted to the REG-DA via SCADA client function (IEC 61850, IEC 60870-5-104), IEC61850-9-2 Sampled Values, IEC61850 GOOSE or by mA inputs, thereby eliminating the need for CT and VT cabling to the regulator.

The REG-DA regulator can communicate with a SCADA system (see list of characteristics) through all of the common protocols.

Freely programmable inputs and outputs enable the implementation of application specific tasks.

A number of different communication cards are available for the REG-DA, with connections that range from copper RS232 to fibre optic Ethernet.

A variety of protocols are available to communicate with a SCADA system or RTU:

- IEC 61850 including GOOSE and Sampled Values
- IEC 60870 - 5 - 101 / 103 / 104
- DNP 3.0 via Ethernet
- DNP 3.0
- MODBUS TCP
- MODBUS RTU
- Profibus DP (external module)
- SPABUS

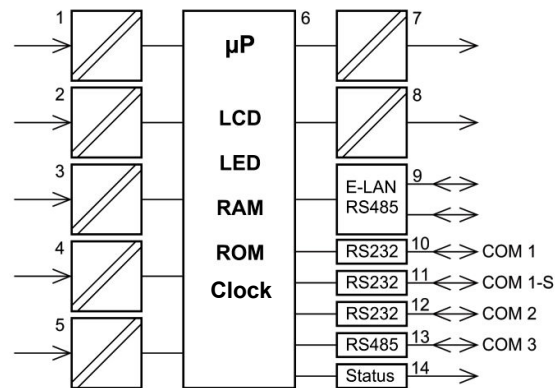
The integrated SCADA communication cards are capable of most of these protocols and may be switched between them and configured using the free WinConfig software. WinConfig is specifically designed to provide a similar configuration interface for all of the protocols, thereby reducing engineering time.

The communication interfaces of the REG-DA are equipped with cyber security features including role based access control (RBAC) with remote user authentication via e.g. the Radius protocol.

2. Characteristics of the REG-DA

- Cyber security with role based access control (RBAC) and remote authentication via e.g. Radius
- Large backlit LCD (128 x 128) with all important information (tap, voltage etc.)
- Measurement functions (U, I, P, Q, S, $\cos \phi$, ϕ , I sin ϕ , f)
- Recorder function (3-channel line recorder)
- Statistics function (total number of switching operations, switching operations per tap)
- Event recorder (logbook)
- Transformer monitoring functions to calculate the hot-spot temperature and lifetime consumption and to control the fans and oil pumps. In addition the moisture content in cellulose and the risk of bubble formation is evaluated
- 14 (26) freely programmable binary inputs
- 9 (21) freely programmable binary outputs
- Freely programmable analogue inputs or outputs (mA)
- PT100 direct input
- Input for tap-potentiometer (resistor input) (200 Ω ...20 k Ω total resistance)
- Regulation of three winding transformers
- Regulation of phase-shifting transformers
- Regulation of transformer banks
- Control of capacitor banks
- Limit-value monitoring for all measured quantities
- 4 freely programmable setpoint values
- Dynamic adjustment of the setpoint values based on the load (Z-compensation, LDC)
- Programmable rated U and I values
- Open programmability enables implementation of PLC functions (background program)
- Peripheral bus (COM3) for additional interface modules (ANA-D, BIN-D, Modbus converter)
- Ability to enter externally measured quantities (gas-in-oil ratio, winding temperature, etc.) by communicating directly with the measuring devices through Modbus
- All of the measurements (including external measurements) and events can be transferred to SCADA
- ParaGramer function to view and automate the parallel connection of up to fifteen transformers
- Provisioning software to set parameters, program devices, and view and archive data
- REGSim™ simulation software to simulate parallel operations, network and load situations
- UL certification (depends on the hardware configuration)

3. Description

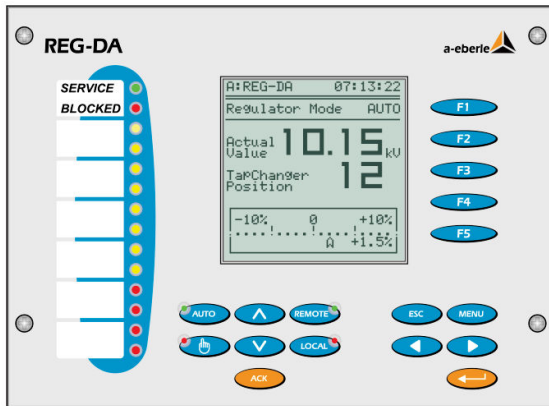


Functions of the REG-DA regulator (all options)

- 1 three current and two voltage measuring inputs
- 2 Analogue inputs, PT100 (optional)
- 3 Binary inputs
- 4 Input for resistance-coded tap-position indicator (optional)
- 5 Auxiliary voltage / Power Supply
- 6 Display and processing unit
- 7 Analogue outputs
- 8 Binary outputs
- 9 ELAN connection (2 x RS485 with repeater function)
- 10 COM1, RS232
- 11 COM1-S, RS232 (can be used alternatively to COM1, on devices with characteristic S2 the COM1-S can be switched into COM4)
- 12 COM2, RS232 (on devices with characteristic S2 the COM2 can be split into COM2 and COM5)
- 13 COM3, RS485
- 14 Status contact (life contact)

3.1 Regulator mode

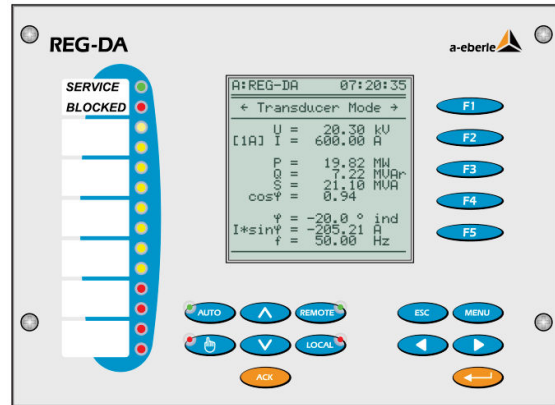
The actual value and a fixed or load-dependent setpoint value are continually compared in the regulator, which then determines the correct commands for the transformer's tap changer. The regulator's parameters can be fine-tuned to the dynamic time behaviour of the grid voltage to obtain high control performance for a low number of switching operations.



3.2 Transducer mode

The values of all relevant variables of a three-wire, three-phase system with balanced or unbalanced load are calculated from the measured CT & VT inputs.

All of the measured and calculated values can then be viewed on the LCD display or transferred by analogue signal and SCADA connection.



Connecting transformers in parallel

Each regulator is capable of operating in parallel with up to 9 other regulators, without the need for additional components.

A number of different parallel control schemes are available, catering for transformers that operate in parallel on a single busbar, as well as those that are feeding the same grid from different substations.

Parallel control schemes are listed in Table 1 below:

Case	REG-DA – Programme	Conditions
Parallel operation on one or more busbars	$\Delta I \sin \phi$	Identical transformers, identical or different tap size
	$\Delta I \sin \phi (S)$	Transformers with different performances, different or equal tap size
	Master/slave	Identical transformers, same tap size
Free feed in	$\Delta \cos \phi$	Any transformer, any tap size
Emergency program in the event of a ELAN failure	$\Delta \cos \phi$	Any transformer, any tap size, for the programs $\Delta I \sin \phi$ and $\Delta I \sin \phi (S)$

Table 1 Parallel operated transformers

Measured quantities on the displays

Voltage U_{eff}

Current I_{eff}

Active power P

Reactive power Q

Apparent power S

$\cos \phi$

Phase angle ϕ

Reactive current $I \sin \phi$

Frequency f

Circulating reactive current (see page 2 of the transducer display)

All of the measured and calculated values can be transferred to an analogue output or to SCADA.

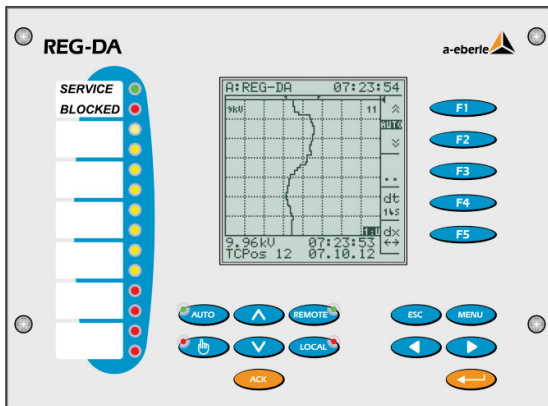
We take care of it.

3.3 Recorder mode

Up to two selectable analogue values can be continuously recorded and displayed as a line chart with an adjustable time grid. The tap position*, setpoint value*, tolerance band and Manual/Auto state, as well as the time and date are recorded in addition to these measured quantities. This enables the voltage and the time-correlated tap position to be viewed at any time, for example. The average storage time for voltage and tap position (1 channel) is approximately six weeks.

The stored values can also be retrieved and displayed by the Control software.

(*requires the voltage to be recorded on channel 1)



Time grid dt 14 s, 1, 5, 10, 30, min / Division

Regardless of the selected time grid (feed rate) of the display, all of the measurements are stored at a standard rate of 1 data point per second. Each data point then represents the arithmetic mean of 10 measurements that were generated at 100 ms intervals.

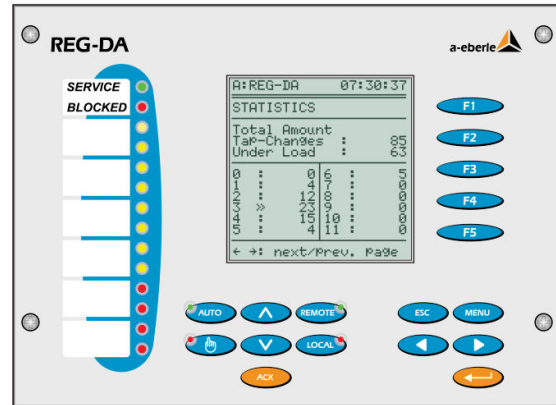
Storage behaviour in the case of an overflow	Overwrite with FIFO (First in First out)
Storage time (voltage plus tap)	< 18.7 days worst case on average > 1 month

3.4 Statistics mode

The Statistics mode records all of the tap changer's switching operations. Separate logs are stored for switching operations under load and without load.

This information can be used to analyse how many taps were made in a certain timeframe, as well as how often a particular tap was selected. This information is then used to fine-tune the regulator's settings.

The stored values can also be retrieved and displayed by the Control software, using the Online/Service module.



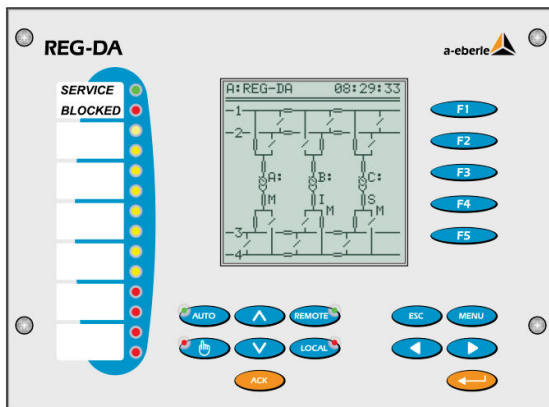
3.5 ParaGramer mode

ParaGramer is an efficient tool that automatically detects which transformers have been switched into a parallel control scheme and displays this information via a single-line diagram.

The artificial word ParaGramer is a combination of the terms parallel and single-line diagram.

Paragramer can monitor the positions of circuit breakers, isolators, bus ties and bus couplings. Based on the status of these inputs and of the regulators in the parallel scheme, the system automatically determines optimum tap positions for all of the transformers.

Multiple busbars are configurable on both the HV and LV sides of the transformers.



As shown in the graphic, both transformers A and C are working on busbar '3', while transformer B is feeding into busbar '4'.

3.5 Transformer monitoring module TMM

The Transformer Monitoring module collects and calculates information about the condition of the transformer and tap changer.

The hot-spot temperature is calculated in accordance with IEC 60354 and IEC 60076, and is used to determine the transformers loss of life.

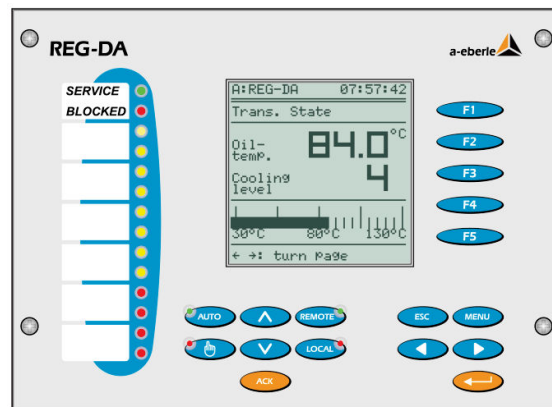
The optional TM+ function evaluates the moisture content of the cellulose and the risk of bubble formation.

Up to 6 groups of fans and 2 oil pumps can be controlled to regulate the temperature of the transformer. The operating times of the fans and pumps are stored for maintenance purposes.

Oil temperature is measured either directly as a PT100 input, or via a mA transducer, and also be recorded using the Recorder mode.

A total of three analogue input slots are available in the REG-D, allowing the monitoring of several temperatures, oil levels, gas levels and so on.

Please refer to characteristic group 'E' in the Order specifications for a list of the combination options.



4. Technical specifications

Regulations and standards

- IEC 61010-1 / EN 61010-1
- CAN/CSA C22.2 No. 1010.1-92
- CISPR 22 Ed.6 (2009-09)
- IEC 60255-11 / EN 60255-11
- IEC 60255-21 / EN 60255-21
- IEC 60255-22-1 / EN 60255-22-1
- IEC 60255-25 / EN 60255-25
- IEC 60255-26 / EN 60255-26
- IEC 60255-27 / EN 60255-27
- 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

UL Certificate Number 050505 - E242284



AC voltage inputs (U _E)	
Nominal input voltage U _n	100 VAC
Input voltage range	0 ... 160 VAC
Rated voltage	230 VAC
Frequency range	16... <u>50</u> ... <u>60</u> ...65 Hz
Crest factor @ U _r	≤ 2
Input resistance	100...102 kΩ
Internal consumption	≤ 0.01mW/V ²
Bandwidth	420 Hz
ADC	12 Bit, 24 samples/cycle
Over voltage category	300V CAT II / 150V CAT III
Isolation	reinforced*
Isolation test voltage	2.3kVAC, 5s

* The voltage measurement inputs can be interconnected with a 100kΩ resistor.

AC input (I _E)	
Nominal input current I _n	1 A / 5 A, software selectable
Measurement range	0 ... 2.1·I _n
Rated current	10 A
Over load capacity	100 A for 1s
Frequency range	16... <u>50</u> ... <u>60</u> ...65 Hz
Crest factor @ I _n	≤ 3
Internal consump. @ 5A	≤ 0,5 VA
Bandwidth	420Hz
ADC	12 Bit, 24 samples/cycle
Over voltage category	300V CAT II / 150V CAT III
Isolation	reinforced, per channel
Isolation test voltage	2.3kVAC, 5s

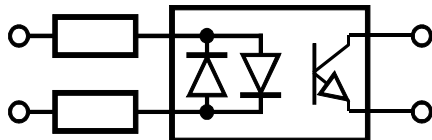
Measured values	
True RMS voltages	U ₁₂ , U ₂₃ , U ₃₁ (≤ 0.25%)
True RMS current	I ₁ , I ₂ , I ₃ (≤ 0.25%)
Active power	P (≤ 0.5%)
Reactive power	Q (≤ 0.5%)
Apparent power	S (≤ 0.5%)
Power factor	cos φ (≤ 0.5%)
Phase angle	φ (≤ 0.5%)
Reactive current	I · sin φ (≤ 1%)
Frequency	f (≤ 0.05%)

Reference conditions	
Reference temperature	23°C ± 1 K
Input quantities	U _E = 0 ... 160 V I _E = 0 ... 1A / 0 ... 5A
Frequency	45 Hz...65 Hz
Shape of the curve	Sinusoidal, form factor 1.1107
Load (only for characteristics E91...E99)	R _n = 5 V / Y2 ± 1%
Other	IEC 60688 - Part 1

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	IEC 60068-2-31 100 mm drop height, unpacked
Vibration	IEC 60255-21-1, Class 1
Shock	IEC 60255-21-2, Class 1
Earthquake resistance	IEC 60255-21-3, Class 1

Binary inputs (BI)	
General	
Signal frequency	0 ... 70Hz
AC debouncing	40 ... 70Hz
Form factor	≤ 1.16
Binary input type HV (High voltage)	
Input voltage	≤ 250V (r.m.s.)
Input resistance	107...116kΩ
Over voltage category	300V CAT II
Isolation between input groups	basic isolation ^{a)}
Isolation against touchable parts	reinforced
Isolation test voltage	2.3kVAC, 5s
Binary input type LV (Low voltage)	
Input voltage	≤ 50V (r.m.s.)
Input resistance	6.5...8.1kΩ
Characteristic D0 – Binary input groups 1...4, 5...8, 9...12, 13...16 Characteristic D1 – Binary input groups 9...12, 13...16 Characteristic D2 – Binary input groups 1...4, 5...8 Characteristic D6 – Binary input groups 1...4, 5...8	
Input type	HV
H – Level	≥ 48 V
L - Level	< 10 V
Characteristic D1 – Binary input groups 1...4, 5...8 Characteristic D3 – Binary input groups 1...4, 5...8 Characteristic D4 – Binary input groups 1...4, 5...8, 9...12, 13...16 Characteristic D5 – Binary input groups 1...4, 5...8	
Input type	LV
H - Level	≥ 10 V
L - Level	< 5 V
Characteristic D8 – Binary input groups 1...4, 5...8 Characteristic D9 – Binary input groups 1...4, 5...8, 9...12, 13...16	
Input type	HV
H – Level	≥ 80 V
L - Level	< 40 V
Characteristic D7 – Binary input groups 1...4, 5...8, 9...12, 13...16	
Input type	HV
H - Level	≥ 176 V
L - Level	< 88 V

^{a)} In the case of DC voltage, the sum of the operating voltages of adjacent binary input groups must not exceed 300V!



Simplified diagram of a binary input

Binary outputs (BO)	
max. switching frequency	≤ 1 Hz
Potential isolation	Isolated from all internal device potentials
Contact load	AC: 250 V, 5 A (cosφ = 1.0) AC: 250 V, 3 A (cosφ = 0.4) Switching capacity max. 1250 V A 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
Inrush current	250 V AC, 30 V DC 10 A for max. 4 s
Switching operations	≥ 5·10 ⁵ electrical
Over voltage category	300V CAT II
Isolation between outputs or output groups	Basic isolation ^{b) c)}
Isolation against touchable parts	reinforced
Isolation test voltage	2.3kVAC, 5s

^{b)} In case of DC voltage, the sum of the working voltages of adjacent outputs or output groups must not exceed 300V!

^{c)} If an output or an output group is connected to a dangerous active circuit, the neighboring outputs or output groups must not be connected with SELV circuits or other touchable parts!

Auxiliary Voltage			
Characteristic	H0	H0 with PB 1..4	H2
AC Nominal voltage range	100 ... 240V	100 ... 240V	–
Total voltage range	90 ... 264V	90 ... 264V	–
DC Nominal voltage range	100 ... 300V	100 ... 250V	20 ... 70 V
Total voltage range		100 ... 370V	
AC Power consumption	≤ 35 VA	≤ 65 VA	–
DC Power consumption	≤ 25 W	≤ 25 W	≤ 25 W
Frequency	50/60 Hz	50/60 Hz	DC
Microfuse	T1 250 V	T1 250 V	T2 250 V
Over voltage category	300V CAT II	300V CAT II	150V CAT II
Isolation	reinforced	reinforced	reinforced
Isolation test voltage	2.3kVAC, 5s	2.3kVAC, 5s	1.4kVAC, 5s

The following applies to all characteristics:

Voltage dips of ≤ 25 ms do not cause a power on reset of the device. Fuses are time lag (slow blow) type.

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Electrical safety	
Safety class	I
Degree of pollution	2
Standards	IEC 61010-1

Electromagnetic compatibility	
EMC requirements	EN 61326-1 Equipment class A Continuous, unmonitored operation, industrial location and EN 61000-6-2 and EN 61000-6-4 and EN 60255-X
Interference emissions	
Conducted and radiated emission	EN 61326 Table 3 EN 61000-6-4 EN 60255-25/-26 CISPR 22 Ed. 6
Harmonic currents	EN 61000-3-2
Voltage fluctuations and flicker	EN 61000-3-3
Disturbance immunity	EN 61326 Table A1 EN 61000-6-2 EN 60255-11/-22/-26
ESD	IEC 61000-6-5 6 kV/8 kV contact/air
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, EN 60255-11 30% / 500ms, 60% / 200ms
Voltage interruptions	IEC 61000-4-11 100% / 5s
Damped oscillations	IEC 61000-4-12, Class 3, 2.5 kV
Ripple on d.c. input power port immunity test	IEC 60255-11 AC ripple 15% of U_r , 100 Hz, 5 min

Analogue inputs (AI)	
Quantity	See order specifications
Input range Y1...Y2	-20 mA...0...20 mA points Y1 and Y2 are programmable
Control limit	$\pm 1.2 Y2$
Voltage drop	$\leq 1.5 V$
Isolation	functional, per channel
Common-mode rejection	$> 80 \text{ dB}$

Series-mode rejection	$> 60 \text{ dB}$ / Decade from 10 Hz
Overload capacity	$\leq 50 \text{ mA}$ continuous
Error limit	0.5%

The REG-DA is supplied with 1 x mA Analogue Input (e.g. for the tap position indicator) as standard.

Analogue outputs (AO)	
Quantity	See order specifications
Output range Y1...Y2	-20 mA...0...20 mA Y1 and Y2 programmable
Control limit	$\pm 1.2 Y2$
Isolation	Functional, per channel
Load range	$0 \leq R \leq 8 V / Y2$
Alternating component	$< 0.5\%$ of Y2

Temperature input PT100	
Quantity	one PT100 input at Level III possible two PT100 inputs at Level II possible
Type of connection	Three-wire circuit
Current through sensor	$< 8 \text{ mA}$
Isolation	functional
Line compensation	no compensation required
Transmission behaviour	linear

Resistance input (tap change potentiometer)		
Characteristic	R1	R3
Quantity	See order specifications	
Connection	Three-wire / Four-wire with open wire detection	
Total resistance in the resistor chain	180Ω ... 2 kΩ	2kΩ ... 20kΩ
Tap resistance	5Ω ... 100Ω	50Ω ... 2kΩ
Number of taps	≤ 38	
Isolation	functional	
Current through resistor chain	$\leq 25 \text{ mA}$	$\leq 2.5 \text{ mA}$

Communication interfaces			
Name	Standard	Wires	Isolation
COM1	RS232	4, GND	-
COM1-S	RS232	4, GND	functional
COM2	RS232	4, GND	functional
COM3	RS422	4, GND	functional
E-LAN-L	RS485/422	2/4, GND	functional
E-LAN-R	RS485/422	2/4, GND	functional
DCF77	RS485	2, GND	functional

Device real time clock	
Accuracy	+/- 20 ppm 0 ... 10 ppm with charact. S2
Buffer battery	Lithium button cell 3V Type CR1632

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

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

Display	
LC - Display	128 x 128 graphic display
Back-lighting	LED, automatic switch off after 15 minutes

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.

Storage	
Firmware and recorder data Characteristic S2	Flash memory
Device characteristics and calibration data	serial EEPROM with ≥ 1000 k write/read cycles
Other data and recorder data Characteristic S1	MRAM

5. Mechanical design

Housing	Sheet steel, RAL 7035 light-grey
- Height - Width - Total depth - Mounting depth - Weight	325 mm incl. cable glands 250 mm 114 mm 87 mm ≤ 6.0 kg
Housing door	with silicate glass
Front panel	Plastic, RAL 7035 grey on aluminium brackets
Control panel cut-out	
- Height - Width	282 mm 210 mm
Protection type with flange plate and cable gland	IP 54 IP 30 with characteristic PB1 to PB4
Protection type with brush sealing	IP 12 IP 10 with characteristic PB1 to PB4

Conductor Cross Section and tightening torque of Terminals				
Level	Function/ terminal no.	cross section / mm ²		torque Nm
		stranded	solid	
I	measurement input 1..10	4	6	0,6
I	BIs, relays, power supply 11...60	2,5	2,5	0,6
II	SCADA interface (without REG-PE TK860), 87...98, 130...151	0,5	0,5	---
II	SCADA interface (only REG-PE TK860) 87...94	2,5	2,5	0,6
II	Extensions C10, C90..99 100...113	2,5	2,5	0,6
III	COMs, analogue IO 61...86/200...211	1,5	1,5	0,25