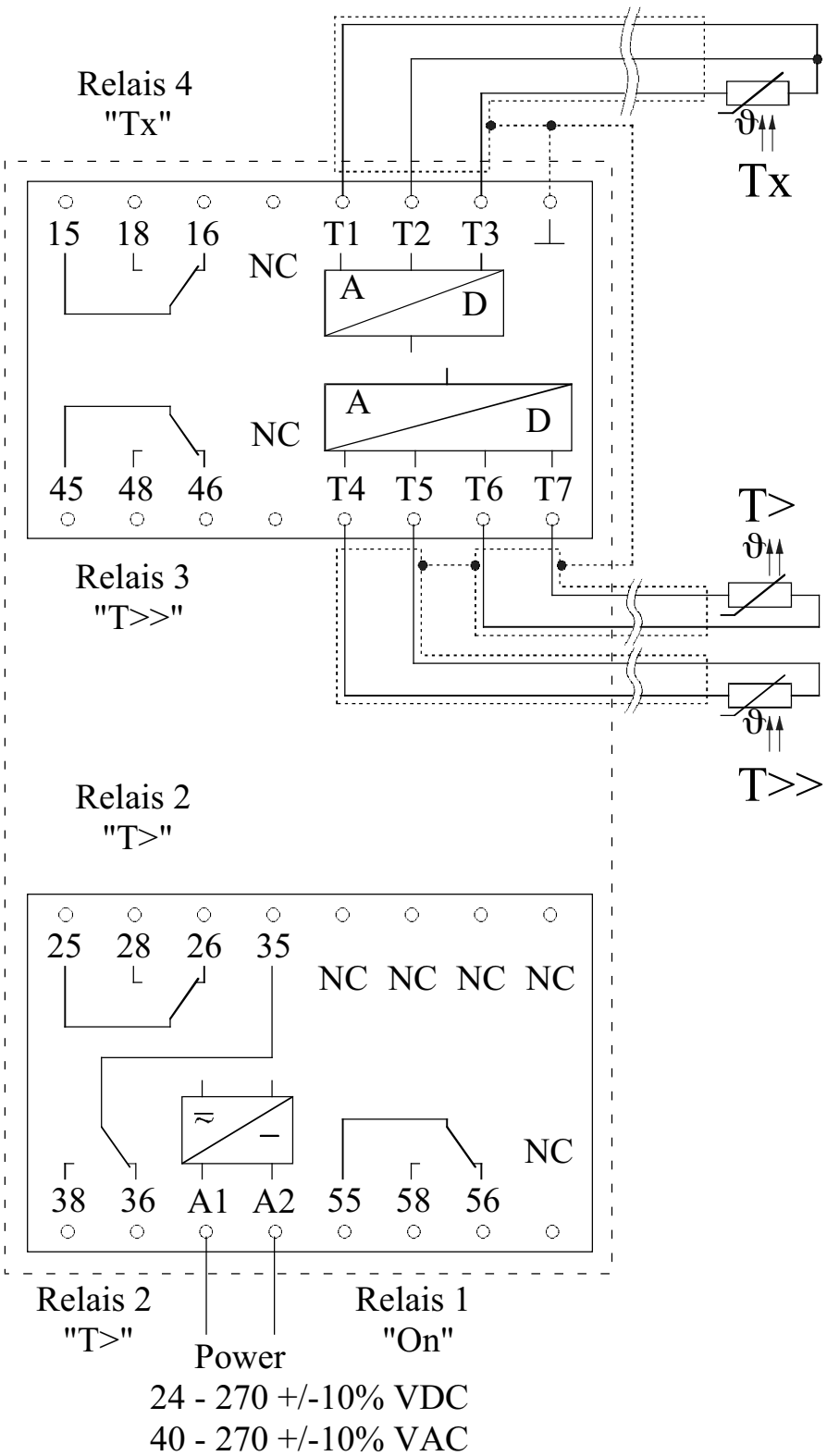
1 Technical Data

Power supply:	24 V – 270V ±10% DC 40V - 270V ±10%, AC 50-60Hz	
Power consumption:	< 6 VA or < 6 W	
PTC thermistor connection:	2-wire connection	
	relay closing	3.0 kΩ < R_{ON} < 3.2 kΩ
	relay opening	1.4 kΩ < R_{OFF} < 1.6 kΩ
PT100 connection:	3-wire connection	
	relay closing	Adjustable
	relay opening	20 °C below closing point
Sensor connecting cable:	Max. 6 Ω resistance	
4 relays:	Max. voltage 230 V	
	Max. current	6 A
	Max. switching capacity	AC 1500 VA DC 120 W
	Re1: Power supply OK (green LED) Re2: PTC thermistor connection, temp. > triggered (yellow LED) Re3: PTC thermistor connection, temp. >> triggered (red LED) Re4: Tx threshold reached [PT100] (orange LED)	
7 segment display (3-digit):	10 mm high digits display for live temperature value or threshold value of the Tx circuit (PT 100)	
Switching accuracy:	1 % of the maximum value (200 °C) = 2 °C	
Display range:	0…200 °C (resolution 1 °C)	
Display accuracy:	2 °C ± 1 digit	
PT100 setting range:	20…200 °C (threshold setting for Re4 adjustable via pushbutton)	
Ambient temperature:	-10…+50 °C	
Terminals size:	Rigid wire	0.2 – 2.5 mm^2
	Flexible wire	0.2 – 2.5 mm^2
Dimensions:	W x H x D	45 mm x 99 mm x 114.5 mm
Mounting:	Snap-on mounting for symmetrical mounting rail (35 mm standard rail)	

2 Block Diagram



3 Technical Description

3.1 General

The TS-02 temperature monitoring unit is used to monitor the temperature of equipment by means of PTC thermistors in accordance with DIN 44081/82 or DIN VDE 0660 Part 303. The temperature is also monitored permanently via PT100 element.
Attached is an example of temperature monitoring of a transformer used for energy distribution in the field of medium-voltage and high-voltage systems.

The user is informed of the temperature via a 3-digit 7-segment display. The user is further on notified of the corresponding temperature and the state of the TS-02 via four LEDs in the front panel. Four relays are related to the different measuring circuits. The significance of the individual measuring circuits and the LEDs can be found in the following sections.

In the “Tx” measuring circuit, the threshold value temperature can be set via the keys (push buttons) in the front panel. A relay is triggered when this temperature is exceeded.

The PTC thermistors are to be designed in such a way that the threshold temperature of the PTC thermistors in the “temp. >” circuit is lower than that of the PTC thermistors in the “temp. >>” circuit.

Example:

“temp. >” threshold temperature:	T1 = 120 °C
“temp. >>” threshold temperature:	T2 = 150 °C

Subject to the hysteresis behaviour of the PTC thermistors, the threshold “on” temperature for the relays is slightly higher than the threshold “off” temperature.

As the operating point of the measuring circuits is in the kΩ range and the resistance of a PTC thermistor is only a few hundred Ohm when operated below the threshold temperature, several PTC thermistors can be connected in series.

A wire breakage as well as a short circuit in the “temp. >”, “temp. >>” and “Tx” measuring circuits leads to an immediate fault display on the 7-segment display. Moreover, if an error occurs in a measuring circuit, relay 4 is triggered.

Every 720 hours, relay 4 picks up for 10 minutes in order to carry out a self-test.

As the TS-02 continuously recalibrates itself, the basis for a measurement result with long-term stability is given.

3.2 “PWR” Measuring Circuit

Relay Re1 is used to monitor the supply voltage. If the necessary operating voltage is applied to the measuring circuit, the relay picks up and the green LED (PWR) lights. A changeover contact is available as an output (terminals 55, 56, 58).
In case of power failure Re1 drops as well as Re2 to Re4, independent of their previous position. The relays are in the position as shown in chapter 4.3 page 9 after power failure. By power return Re1 is energized, the relays Re2-Re4 are energized or dropped, depending of the actual resistance in the different measuring circuits.

3.3 “temp. >” Measuring Circuit

If the threshold temperature of the PTC thermistor (for example, T1 = 120 °C) is exceeded, relay Re2 picks up and the yellow LED (T >) lights. Two changeover contacts are available as outputs for this purpose (terminals: CC1= 25, 26, 28 CC2 = 35, 36, 38). If the temperature decreases below the threshold, the relay drops and the LED extinguishes.

3.4 “temp. >>“ Measuring Circuit

The behaviour of the temp. >> measuring circuit is identical to that of the temp. > measuring circuit. If the threshold temperature of the PTC thermistor (for example, T2 = 150 °C) is exceeded, relay Re3 picks up and the red LED (T >>) lights. A changeover contact is available as an output for this purpose (terminals 45, 46, 48). If the threshold temperature decreases below the threshold after the transformer is switched off, the relay drops out and the LED extinguishes.

3.5 “Tx” Measuring Circuit

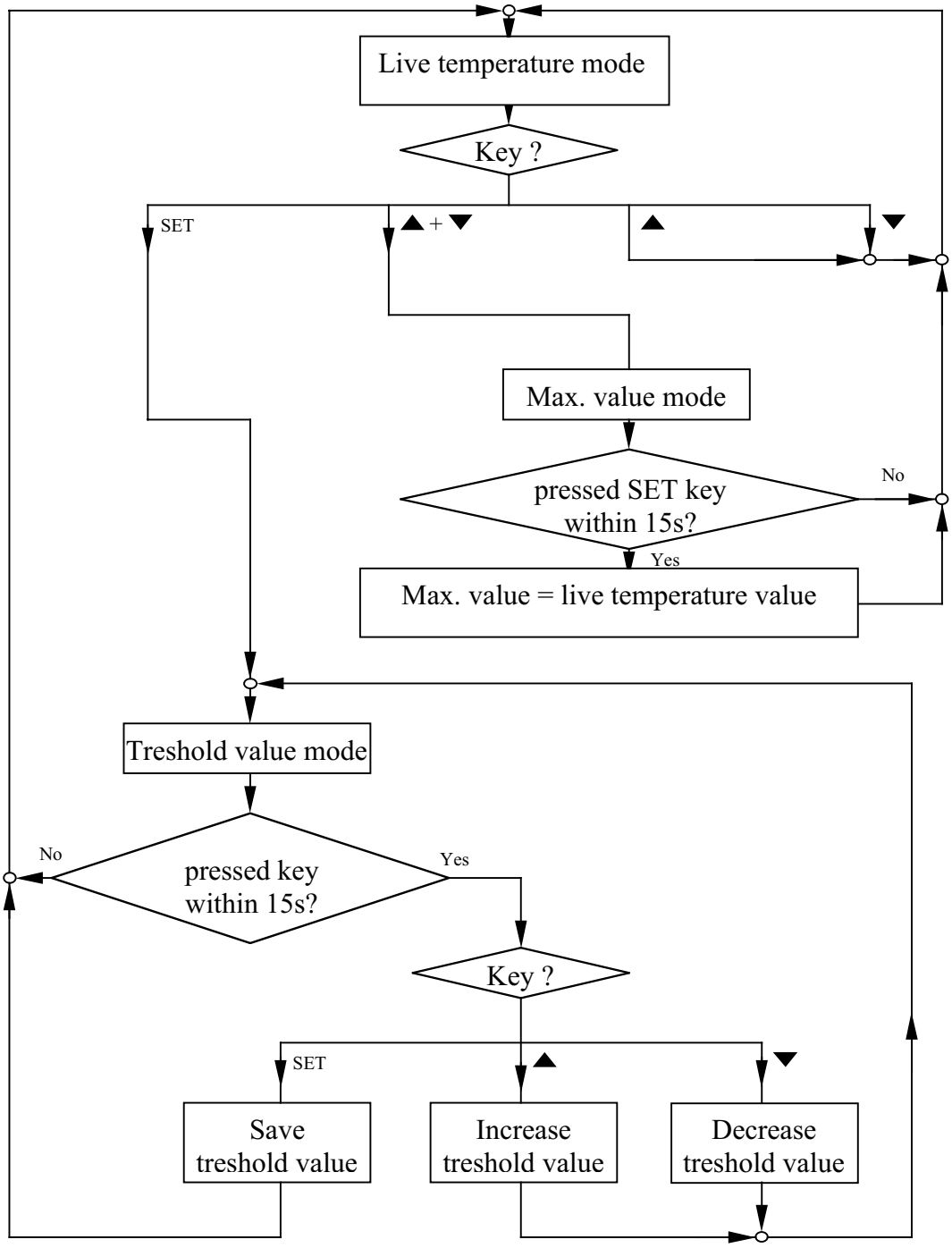
In the Tx measuring circuit, the upper threshold value can be set by the user (see 3.6.4). If it is exceeded, relay Re4 picks up and the orange LED (Tx) lights. A changeover contact is available as an output for this purpose (terminals 15, 16, 18). If the temperature recorded falls below the lower threshold value (upper threshold value – 20 °C), the relay drops out and the LED extinguishes. As a 3-wire connection is used here, the measurement result does not depend on the length of the measuring cable because the cable resistance is also measured and taken into account in the calculation.

3.6 Operation

3.6.1 Seven-segment Display

The live temperature value, the Tx threshold value or the MAX value of the temperature is displayed here. Any error codes are also displayed. The actual value display is refreshed every 1.5 seconds with the current monitoring temperature. If the threshold value, MAX value or an error code is displayed, the display flashes.

3.6.2 Operation Flow Diagram



3.6.3 SET Key

Switches the 7-segment display from the live temperature value to the threshold value and vice versa. If the display is on the live temperature value, pressing the SET key causes the threshold value to be displayed and the display flashes every 1 second. Pressing the SET key again causes threshold value mode to be exited.
The SET key can also be used to reset the max. value to the current actual value if the control is in max. value mode at the time.
The SET key is inactive during the self-test and in the event of an error. Threshold value input is only possible again after the end of the self-test.

3.6.4 ▲ and ▼ Keys

Threshold value mode: (flashing display)

The ∧ and ∨ keys are used to increase or decrease the upper threshold value temperature Tx. Each time the ∧ or ∨ key is pressed, the threshold value changes by 1 degree Celsius. If a key is held down for longer than 1 second, the threshold value changes more rapidly and the display ceases to flash. The process stops as soon as the key is released. The display then flashes again. In this way, any threshold point can be fixed in the temperature range of 20 °C to 200 °C. To leave threshold value mode, the SET key must be pressed. The threshold value is then saved and is retained even if the operating voltage is disconnected.
If no key is pressed for 15 seconds in threshold value mode, the unit automatically switches to the live temperature value display, however without saving the set threshold value.

MAX value mode: (flashing display)

If the ∧ and ∨ keys are pressed at the same time in live temperature value mode, the max. value is displayed. The max. value is the maximum temperature value which has occurred on the PT100 since the last reset with the SET key. If no key is pressed for 15 seconds, the unit automatically switches to the live temperature value display. If the max. value is to be reset (max. value = live temperature value), the SET key must be pressed within 15 seconds.
The max. value is retained even if the operating voltage is disconnected.

3.7 Self-test

Every 720 hours (≙ 30 days), a self-test is performed automatically. It includes, for example, switching on the fan in order to unblock the fan motor shaft. Relay Re4 picks up and the display switches to “3 3 3” (flashing), which indicates that the unit is in self-test mode. After 10 minutes, the relay switches off again, the display switches back to live temperature value and normal operation continues.
During the self-test, it is not possible to adjust the threshold value temperature.

3.8 Error Messages

The TS-02 monitors the measuring circuits permanently for wire breakage and short circuit. If an fault occurs, an error code is displayed in the display. The error code is displayed flashing. The possible error codes are:

“6 0 0”	Wire breakage in temp > measuring circuit → Relay Re4 picked up
“6 6 6”	Short circuit in temp > measuring circuit → Relay Re4 picked up
“7 0 0”	Wire breakage in temp >> measuring circuit → Relay Re4 picked up
“7 7 7”	Short circuit in temp >> measuring circuit → Relay Re4 picked up
“8 0 0”	Wire breakage in Tx measuring circuit (PT100) → Relay Re4 picked up
“8 8 8”	Short circuit in Tx measuring circuit (PT100) → Relay Re4 picked up

In the event of a fault as mentioned above, relays Re2 and Re3 remain in the state they were in before the error occurred.

“3 3 3”	NO ERROR MESSAGE, display during self-test → Relay Re4 picked up

4 Connections

4.1 Inputs

Terminal marking	Connection
T1, T2, T3 #	PT100 sensor
T4, T5 # *	PTC thermistor, temp. >>
T6, T7 # *	PTC thermistor, temp. >
A1, (L/+); A2, (N/-)	24-250 V DC, 40-250 V/50-60 Hz

\# It is recommended that the shield of the measuring cable is attached to terminal ⊥ in order to suppress the influence of interference fields and to ensure interference free operation.

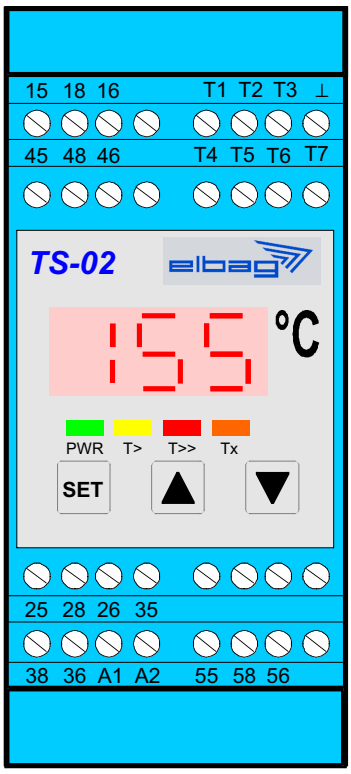
* Standard values for PTC-circuits: R_{serial} < 1,4 kΩ → see chapter 4.5

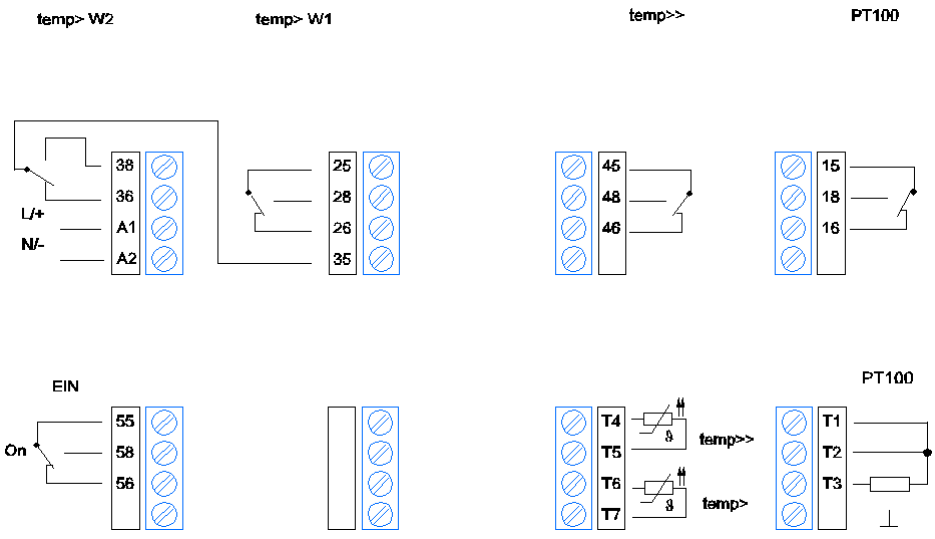
4.2 Outputs

Terminal marking	Connection
16, 15, 18	Tx changeover contact [PT100] (relay Re4)
46, 45, 48	temp. >> changeover contact (relay Re3)
26, 25, 28, 36, 35, 38	2 x temp. > changeover contacts (relay Re2)
56, 55, 58	PWR/ON changeover contact (relay Re1)

x 5 = common
x 6 = NC
x 8 = NO

4.3 Terminal Diagram





4.4 Installation Instructions

PT100 Connection

Connection version	Procedure
2-wire connection	PT100 on terminals T2/T3; jumper on terminals T1/T2
3-wire connection	Short circuit loop on terminals T1/T2; other terminal of PT100 on terminal T3
No PT100 connection	Leave fitted resistor on terminals T2/T3 and jumper on terminals T1/T2

Attention: **If the PT100 is connected with a 2-wire connection, the temperature value in the display is slightly higher than the real value. It deviates increasingly from the actual sensor temperature by the cable length between Monitoring unit and PT100.**

PTC> and PTC >>

Connection version	Procedure
2-wire connection	PTC> on terminals T6/T7 and PTC>> on terminals T4/T5 (protected against polarity reversal in both cases) and remove the fitted resistors
No PTC> connection	Leave fitted resistor on terminals T6/T7
No PTC>> connection	Leave fitted resistor on terminals T4/T5

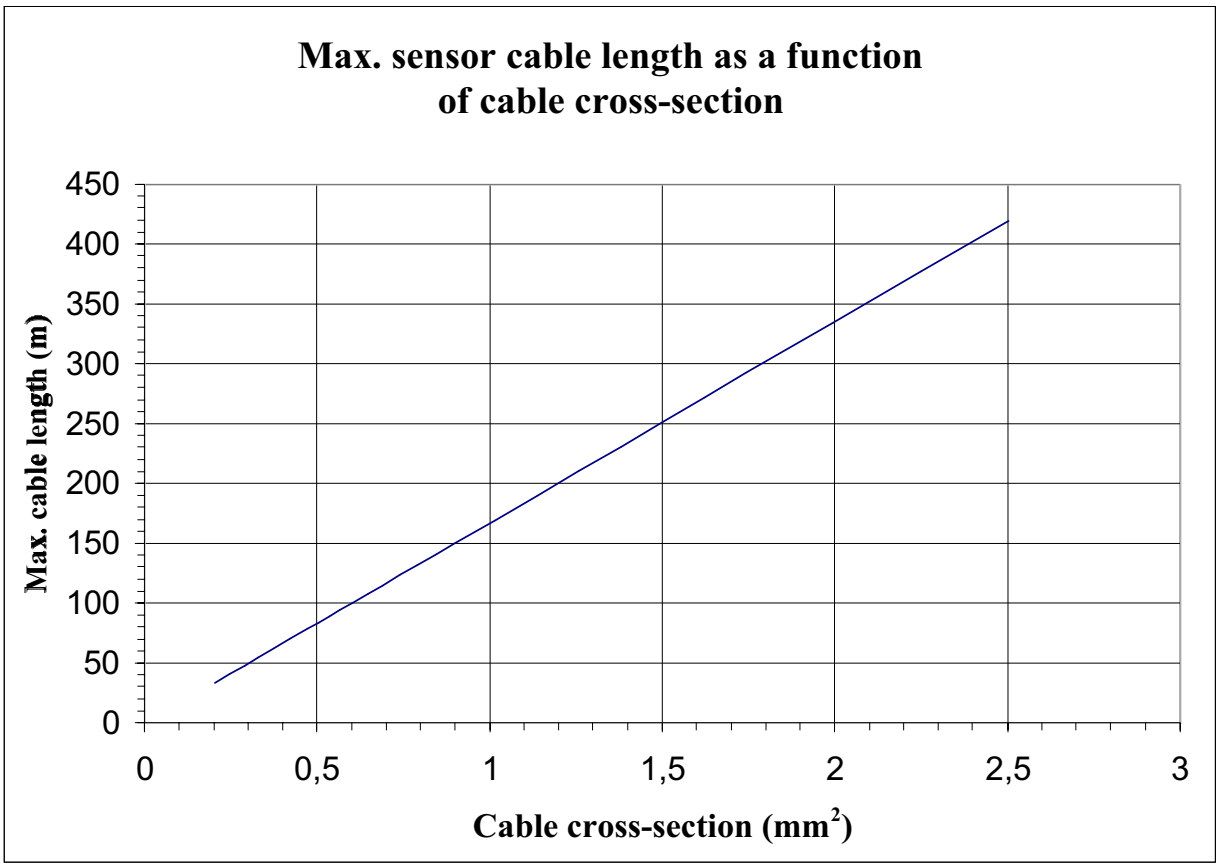
The shield of the sensor cables of PTC>, PTC>> and PT100 should be attached to terminal ⊥ for better interference immunity.

Mains Connection

The mains supply should not be connected until the sensor cables have been attached.
The mains connection is protected against polarity reversal (for AC and DC power supply).
The TS-02 operates without a PE connection. Only terminals for L/+ and N/- are provided.
The PE wire may be NOT connected to terminal ⊥ either.
The power supply is a floating supply, isolating the measuring circuits towards the mains.

Max. Sensor Cable Length

The loop resistance of the connection cable for the temperature sensors should not exceed 6 Ω (lead and return cable). This leads to the following diagram for the maximum (single) length of the sensor cables using copper wire:



4.5 Connection Values of the Temperature Sensors

Permissible Resistance Ranges for the Tx PT100 Circuit

The table below shows the resistance ranges of the PT100 in which the TS-02 temperature monitoring unit works properly.

Function	Resistance range
Short circuit error detection	0 Ω - 15 Ω
Measuring range of the PT100 (temperature range 0-200 °C)	100 Ω - 182 Ω (176 Ω [≅[1] 200 °C] + 6 Ω [= max. cable resistance)
Wire breakage error detection	200 Ω - ∞

Permissible Resistance Ranges for the T> and T>> PTC Circuits

The PTC circuit may consist of both a single PTC or PTC connected in series. The resistance values in the table below should be observed in all cases to guarantee proper operation of the TS-02 temperature monitoring unit.

With series connection, the total resistance of the PTC circuit should not exceed 1.4 kΩ in any case.

Function	Resistance range
Short circuit error detection	0 Ω - 15 Ω
Measuring range of the PTC	50 Ω - 50 kΩ
Wire breakage error detection	100 kΩ - ∞

The standard value of a PTC according DIN 44081/82 or DIN VDE 0660 Part 303 is ≤ 250Ω in the range between –20°C and TNF-20K, and ≥ 4000Ω at TNF+15K. The PTC must be between these limits in range of the operation point TNF.

[1] Translator's note: This is not exactly the symbol used in the original text, but the closest I could find to it.

4.6 Check List for Error Messages

Display	Check	Cause of error
“800”	Unscrew the PT100 cable at terminals T1 and T3; measure the sensor resistance; the value must be between 50 Ω and 176 + 6 = 182 Ω; if the value is higher, the PT100 sensor must be checked.	Wire breakage in the PT100 cable connected to terminal T1 or T3; incorrect sensor was connected (possibly PT1000)
	If the resistance values are in the range stated, the cable must be unscrewed at terminals T1 and T2 and the resistance of the equalising cable must be measured; if the value is higher than 6 Ω, the equalising cable of the PT100 must be checked.	Wire breakage of the equalising cable; connection cable too long; PT100 connected incorrectly (PT100 on T1 and T2); no jumper (for two-wire connection)
“888”	Unscrew the PT100 cable at terminals T1 and T3; measure the sensor resistance; if the value is lower than 15 Ω, the PT100 sensor must be checked.	Short circuit in the sensor cable connected to terminals T1 and T3; equalising cable moved from T1 and T2 to terminals T2 and T3
“700”	Unscrew the PTC resistor in the T>> measuring circuit at terminals T4 and T5; measure the PTC resistance; if the value is higher than 50 kΩ, the PTC must be checked.	Wire breakage in the sensor cable; too many PTCs connected in series; terminals T4 and T7 of measuring circuits T>> and T> possibly switched
“777”	Unscrew the PTC resistor in the T>> measuring circuit at terminals T4 and T5; measure the PTC resistance; if the value is lower than 15 Ω, the PTC must be checked.	Short circuit in the sensor cable
“600”	Unscrew the PTC resistor in the T> measuring circuit at terminals T6 and T7; measure the PTC resistance; if the value is higher than 50 kΩ, the PTC must be checked.	Wire breakage in the sensor cable; too many PTCs connected in series; terminals T4 and T7 of measuring circuits T>> and T> possibly switched
“666”	Unscrew the PTC resistor in the T> measuring circuit at terminals T6 and T7; measure the PTC resistance; if the value is lower than 15 Ω, the PTC must be checked.	Short circuit in the sensor cable