TECSYSTEM S.r.l ®

INSTRUCTION MANUAL

NT133-3

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SUMMARY

1) TECHNICAL SPECIFICATIONS

SUPPLY • Rated values: 24-240 V ac-dc • Highest tolerable values 20-270 V ac-dc • Vcc with reversible polarities	**COMMUNICATION** • RS485 output with Modbus RTU protocol
INPUTS • 2 inputs RTD Pt100 (IEC 751) - 3 wires • 3 inputs CT1,CT2,CT3 from 0.8 to 5.2 A • Connections on removable terminals - Input channels protected against electro-magnetic noises • Sensor length cable compensation up to 500 m (section 1mm²)	**OUTPUTS** • 1 relay for ALARM (alert) Oil and Winding • 1 relay for TRIP (trip) Oil and Winding • 1 relay for FAN (ventilation) • 1 relay for PUMP (pumps) • 1 relay for sensor fault or working anomaly (FAULT) • Output relay with 5A-250V ac contacts
TESTS AND PERFORMANCES • Assembling in accordance with CE rules • Protection against electrical noises CEI-EN-61000-4-4 • Insulation: higher than 100Mohm at 500 V dc between GND and terminals, 2 KV RMS at 50 / 60 Hz for 1 minute. • Linearity ± 0,5% full scale value • Resolution 1°C • Accuracy: temperature "Oil" ± 1% full scale value ±1 digit temperature "Winding" ± 1% full scale value ±1 digit • Working temperature from –40°C to +80°C • Humidity 90% no condensing • Housing by self-extinguishing ABS NORYL 94V0 • Front frame in polycarbonate IP65 • Absorption 7VA • Data storage 10 years minimum • Digital linearization of sensor signal • Self-diagnosis circuit • **Option:** protection treatment of the electronic part • (*) Vibration test IEC 68-2-6 Amplitude ± 1 mm from 2Hz a 13.2Hz Acceleration ± 0.7G da 13.2Hz a 100Hz. • (*) Seismic test according to IEEE 344-1.987 *Cross reference T154 for constructive analogy.	**DISPLAY AND DATA MANAGEMENT** - 2 13 mm 3-digit displays to show temperatures and messages • 1 LED ALARM for alert signal for overtemperatures • 1 LED TRIP to indicate trip for overtemperatures • 1 LED FAULT to indicate fault • 1 LED FAN to indicate forced ventilation • 1 LED PUMP to indicate oil recirculation pumps • 1 LED RS to indicate RS485 Modbus RTU communication in progress • Temperature range: from -40°C to 200°C for "Oil" from -40°C to 200°C for "Winding" • 2 thresholds for "Oil" channel • 2 thresholds for "Winding" channel • 4 thresholds to check ON-OFF ventilation • Sensor diagnostics (Flt) • Programming access through front key • Automatic exit from programming after 1 minute of idle time • Wrong programming display • Selection between channel automatic scanning and manual scanning • Storage of the highest temperatures reached by the channels, alarm storage and sensor fault. • Front key to reset the alarms
DIMENSION • L144xH72 mm DIN43700 depth 130 mm (terminal box included) • Panel cut-out L139xH67 mm	

2) INTRODUCTION

NT133-3 is a monitoring unit to check and protect 3 medium/high voltage transformer windings in oil. Easy to use, economic and precise, easy to mount and program.
The monitoring unit is equipped with a RS485 port with Modbus RTU protocol, which allows the remote management of the plant.
TECSYSTEM may also supply this monitoring unit mounted in a wall-type board with IP55 protection with glass door.

3) CONTENTS

The box includes:

NT133-3 monitoring unit
fixing hooks for board front
Instruction manual

4) PRELIMINARY CHECK

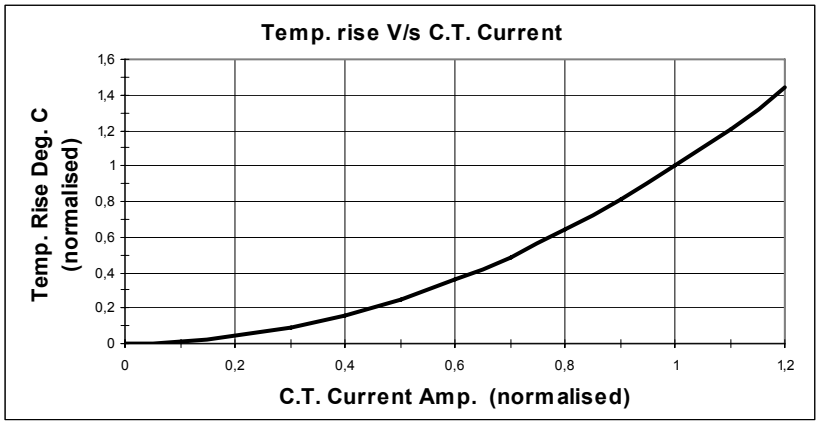
You are kindly requested to carefully read this manual. You can find the default parameters at page 18. Connect the supply between 40 and 42 terminals. Ground conductor (GND) must be connected with terminal 41.
RTD PT100 sensors must be connected with 1-2-3 (RTD1) and/or 4-5-6 (RTD2) terminals.
After having carried out above mentioned operations, you can feed the metering unit.
The display and all the LED's turn on for some seconds; then the display alternatively shows oil temperatures (oil temperature) and winding temperature ("Winding" temperature L1-L2-L3) every 2 seconds. When turning on, in the beginning oil and winding temperatures are the same.
In case one or both of the sensors are open or the temperatures are above the highest values of the temperature range, the display shows "**Foc**" message either for ***"Oil"*** temperature and for "winding temperature L1-L2-L3" temperature, FAULT led is on and FAULT relay switches.
In case one or both of the sensors are in short circuit, wrongly connected or the temperatures are below the lowest values of the temperature range, the display shows "**Fcc**" message either for ***"Oil"*** temperature and for "winding temperature L1-L2-L3" temperature, FAULT led is on and FAULT relay switches.

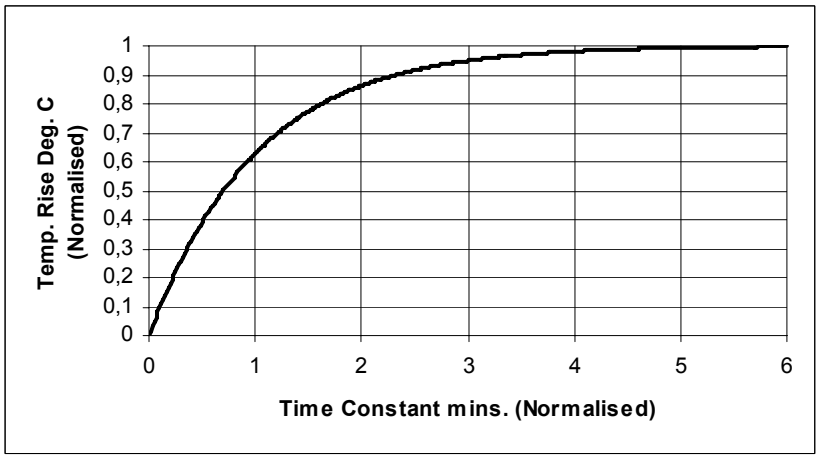
5) PRINCIPLES OF WORKING

Owing to the high voltages on the windings and their insulation conditions, it is not possible to directly reach them to mount the temperature sensor. For this reason, you have to indirectly assess the temperature.
One of the most reliable method to assess the winding temperature lies in measuring the oil temperature in the upper part of the transformer, adding a value given by the "thermal image". Thermal image is digitally composed by **NT133-3** taking into consideration the current which passes through the windings, the time constant and the temperature gradient.
RTD PT100 sensor mounted in the upper part of the transformer measures the oil temperature whilst the measure of the winding current on the low voltage side is taken by a current transformer (C.T.).

Tc time constant and **dt** temperature gradient are programmable data which are supplied by the transformer manufacturer.
Ct current must correspond to the one generated by the current transformer when the transformer in oil is loaded at 100%.

The following graphs show the thermal image features and response time:

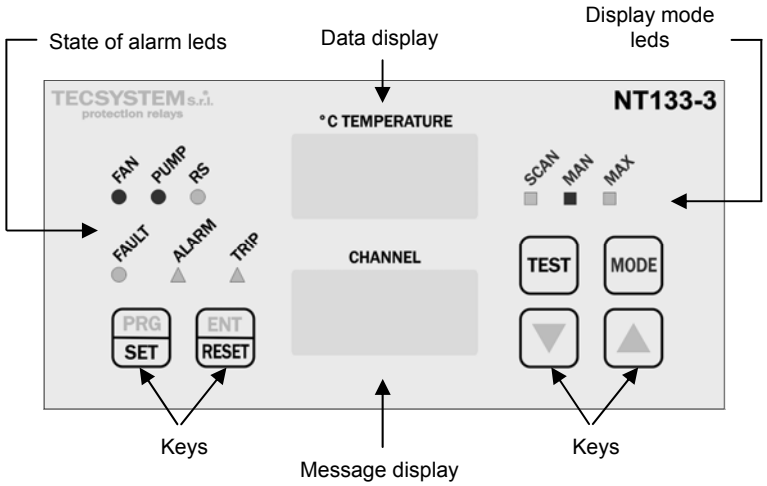




Please note that above graphs are “normalized”.
Multiplying the scale with set values during programming you get the correct values.

NOTE
The thermal image temperature (L1-L2-L3) is processed with a frequency in seconds corresponding to the value in minutes set for TC parameter.
Therefore if TC=5 minutes, the L1-L2-L3 value updating will occur every 5 seconds.

6) FRONT PANEL



7) MOUNTING

7.1) RTD sensor mounting

PT100 temperature sensors are inserted in a stainless-steel pipe with a nipple for well immersion and DIN head. The well fixig is generally 1/2" GAS or 3/4" GAS. If **NT133-3** is connected with a double sensor PT100 the first **nPt** programming step must be set to 2. In case of anomaly, the spare sensor intervenes, always guaranteeing the correct control of the transformer. In case of failure of one of the 2 sensors, **oil** writing starts to blink. The fault contact trips in case of failure for both of the sensors. If NT133-3 is connected with a single sensor, it must be connected with **PT100-1** input and **nPt** function must be set to 1. In case of failure, Fault contact trips.

All the measuring signal transfer cables for Pt100 must absolutely:

- be separated from the power ones
- be made with shielded cable grounded in just one side
- have twisted conductors with at least 0.5 mm^2 section
- be firmly tightened in the terminal boxes
- have tinned or silvered conductors

Tecsystem S.r.l. has designed a cable model (CT-SE) to transfer the measuring signals, according to CEI standards, with all the provided for requirements

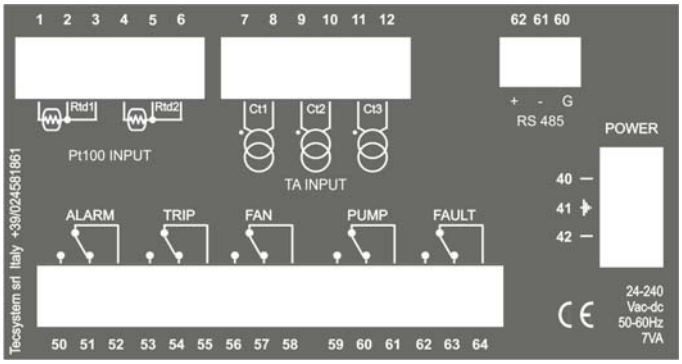
7.2) NT133-3 mounting

NT133-3 is designed for panel mounting inside control boards. Make a 139x67mm slot in the panel of the board; mount **NT133-3** inside the slot and firmly fix the device through the fixing hooks that you will find inside the box. For applications where an IP55 protection is required, you are recommended to mount a suitable gasket between the device and the panel.

In case you have to replace an existing monitoring unit with a new one, in order to guarantee its safe and correct working, you must replace the sensor/relay/supply connection terminals with the new terminals supplied, provided that they are of a brand different from the previously mounted ones.

7.3) Connections

The image shows **NT133-3** back panel. Connection details follow:



7.3.1) Supply connection

NT133-3 feeder is designed to accept every voltage with value between 24 and 240 V ac/dc and must be connected between terminals 40 and 42 not considering the polarities. Ground (GND) must be connected with terminal 41. To protect the transformer, make sure that monitoring unit supply is steady and always present.

IMPORTANT NOTE: When the monitoring unit is fed with 230V ac, to protect it from line overvoltages, we suggest to use the electronic discharger PT-73-220, designed by TECSYSTEM S.r.l. for this specific purpose. As alternative we suggest to use supply voltages from 24 V alternating current or, much better, 24 V direct current..

7.3.2) RTD sensor mounting

RTD sensors mounted on the transformer must be connected with terminals 1-2-3 and/or 4-5-6 (in case you use 2 sensors).
For this connection you have to use a cable with three twisted and shielded wires and a max. section of 1 mm². Make sure to connect the wires respecting the correct sequence. Ground the shielding from just one end of the cable, preferably from the monitoring unit side.
For the correct working it is required the connection of just one PT100 sensor even if **NT133-3** allows to use up to two sensors by redundancy; using two sensors in the same time **NT133-3** chooses RTD1 as default and switches on RTD2 in case of failure.

NOTE: Connection with RTD sensors must be made with turned off monitoring unit, in order to avoid thermal image processing errors which might cause false alarms.

7.3.3) Current transfomer connection

NT133-3 allows the connection of any current transformer between 1 and 5 Ampere (the user may select values from 0.8 to 5.2 A). It is possible to connect from 1 to 3 current transformers depending on the number of windings you want to control, by programming **nCt** function (1-2-3).
It is possible to connect and program current transformers with different values (see the programming table 10.1 at page 15).

7.3.4) Output relay connections

NT133-3 has 5 relay outputs with clean contacts which, properly driven by the programming thresholds may pilot turning on and off of forced ventilation **(Fan)**, of oil recirculation pumps **(Pump)**, signalling alerts **(Alarm)**, transformer tripping **(Trip)** or sensors/monitoring unit failure **(Fault)**. Make all the connections after having taken the terminal box off the monitoring unit.
Fan, **Pump**, **Alarm** and **Trip** relays switch when the temperature exceeds the set threshold whereas **Fault** relay switches when the device is fed and gets de-energised when a fault occurs to PT100 sensors, data memory fault (Ech), exceeding by 30% of the rated current (if during the programming you select **Ovr Yes**) or if the supply voltage is lacking.

7.3.5) Connection with RS485 network.

NT133-3 can be connected with a data acquisition device (PC, PLC, SCADA) for remote control. The used interface is RS485-type, allows to connect 32 devices on the same line and it is based on Modbus RTU protocol.

In order to guarantee the correct working of the network, please follow what is provided for EIA RS485 standard which suggests the use of a 24AWG duplex cable.
Duplex cable that connects all the devices in RS485 could require a 120 ohm ending resistance on the last device of the series
Connect the duplex cable keeping into consideration the polarities and lay the network paying attention not to create sharp curves or ring windings in order not to modify the line impedance.
In the presence of particular noises, it could be necessary to ground the shielding on GND terminal.

7.3.6) Displays

"Oil" and ***"Winding"*** temperatures are alternately displayed on the upper display; lower display shows the selected channel **(Oil, L1, L2, L3)**.
Display may show also the following messages:

Fcc= short-circuited RTD sensor/s or temperature lower than –45°C
Foc= interrupted RTD sensor/s or temperature higher than 205°C
Ovr= transformer secundary current 30% higher than rated current (if during programming you select **Ovr Yes**)
Ech= corrupted data memory. Send the monitoring unit back to Tecsystem Srl for checking and calibration.
Cal= current sensors out of calibration; monitoring unit monitors just oil temperature. Send the monitoring unit back to Tecsystem Srl for checking and calibration.

In case of **Ech** message, fault contact switches.
By pressing **RES** key you cancel the message and the signaling.
Anyway in case of corrupted memory, the monitoring unit cannot calculate the thermal image anymore; therefore just the oil temperature monitoring will be active.

7.3.7) LED indicators

NT133-3 has sixteen LED's for the following indications:

LED	Fixed on LED	Blinking LED
SCAN	SCAN mode: Display alternately shows Oil - L1 - L2 - L3 every 2 seconds	
MAN (Manual)	MANUALE mode: Display shows Oil - L1 - L2 - L3 selecting it with keys ▲ or ▼.	
T. MAX (highest temperatures)	HIGHEST TEMPERATURE MODE: Display shows the highest temperatures for Oil - L1 - L2 - L3, and the alarm historical situation recorded from the last reset.	
FAN	Temperature of selected channel has exceeded the fan-on threshold set during programming. Fan relay switched.	
PUMP	Temperature of selected channel has exceeded the Pump-on threshold set during programming. Pump relay switched.	
ALARM	Temperature of selected channel has exceeded the Alarm threshold set during programming. Alarm relay switched.	Alarm has been reset but temperature is still higher than the loaded threshold. If the temperature goes down, the monitoring unit is ready to report other alarm conditions.
TRIP	Temperature of selected channel has exceeded the trip threshold set during programming. Trip relay switched.	
FAULT		We are in the presence of one of the faults shown in paragraph 7.3.6
RS	RS LED turns on when the monitoring unit has received a Modbus call and turns off after 5 seconds in case of timeout.	

8) KEYS FUNCTIONS

To carry out all the control and programming functions, 6 keys placed on the front frame of the monitoring unit are used.
Some keys have double function and they are hereunder described:

8.1) TEST key:

During standard working, this key allows to verify the correct working of the monitoring unit.
a) If it is pressed once or for less than 5 seconds, all the LED's and the display turn on for approximately 3 seconds, in order to verify their working.
b) If it is pressed for more than 5 seconds, the monitoring unit enters TEST mode.
This function allows to carry out a test on the relay working without using other devices.
The user is empowered to carry out the working test bearing in mind that this could cause the transformer trip.
c) In the TEST function, if pressed once, it allows the monitoring unit to return in the control mode after having carried out a reset (shown by the turning on of all the LED's and display). If no key is pressed for 60 seconds, the monitoring unit automatically resets.

8.2) MODE key:

During standard working, this key allows to select the display mode (Scan, Manual and T.Max); selected display mode is highlighted by the corresponding LED near the display.
In programming or programming parameter display mode, it allows to step back and modify/display the parameter previous the displayed one.

8.3) INCREASE key (▲):

a) In "Manual" or "T.Max" mode, by pressing this key you can choose if display "Oil" or "L1-L2_L3" channel.
b) In programming mode, by pressing this key, you increase the displayed value:
I) if it is pressed and released within 1 second, the value increases by 1
II) if it is pressed for more than 1 second, the value quickly increases until the key is released.

8.4) DECREASE key (▼):

a) In "Manual" or "T.Max" mode, by pressing this key you can choose if display "Oil" or "L1-L2_L3" channel.
b) In programming mode, by pressing this key, you decrease the displayed value:
I) if it is pressed and released within 1 second, the value decreases by 1
II) if it is pressed for more than 3 seconds, the value quickly decreases until the key is released.

8.5) PROGRAM key (**PRG**):

During standard working, this key allows to enter the display mode or programming mode.

a) if it is pressed once or for less than 5 seconds, you enter the programming parameter display mode **(Vis on)**. The User has the possibility to check the parameters without having the possibility to modify them.
b) if it is pressed for more than 5 seconds, you enter the programming mode **(Prg on)**. The user can insert the thresholds and all the parameters suitable for the used transformer. It must be noted that when the monitoring unit is in the programming mode, control and communication functions are suspended.

8.6) ENT/ RESET key:

a) During standard working, this key allows to silence **ALARM** relay if it has switched owing to the reaching of alarm temperature.
b) In T.Max, mode, pressing this key you cancel the stored highest temperatures and possible occurred alarm status.
c) During display or programming mode, pressing this key you return to control mode. If during the programming phase any parameter is modified, by pressing **ENT/RESET** you return to control mode after that all the LED's and display turned on for 2 seconds.
If this key is not pressed within 60 seconds, you leave the programming mode without back-up, restoring data previously set.

9) WORKING

9.1) Standard Mode (Scan mode)

During standard working, **NT133-3** detects oil temperature through PT100 sensors and the secondary current (L1-L2-L3) through the current transformer mounted on the low voltage side. The thermal image estimates the winding temperature basing itself on the oil temperature value as well as on **dt** (temperature gradient), **t.c.** (time constant) and **c.t.** (current trasformer) parameters.
NT133-3 displays temperature in °C, "Oil" and "L1-L2-L3"; it continuously compares these temperatures with the loaded threshold values to activate the forced ventilation, the pumps and the report alarms or tripping.
Before reporting any alarm or tripping, **NT133-3** verifies the real alarm condition for a fixed period of 5 seconds.
The monitoring unit is designed to work in environment with temperatures up to 80 °C.

9.2) FAULT conditions

FAULT relay switches just after turning on of the monitoring unit.
On the contrary, it gets de-energised if one of the following conditions occur:

a) One or both of the Pt100 sensors are
- interrupted, displays Foc
- short-circuited, displays Fcc
- wrongly connected, displays Fcc or Foc
- measure a temperature lower than -45 ^{O}C, displays Fcc
- measure a temperature higher than 205 ^{O}C, displays Foc

b) Estimated winding temperature is higher than 205 ^{O}C, displays Foc
c) Estimated winding temperature is lower than a –45 ^{O}C, displays Fcc
d) Programming data memory corrupted or out of order.
e) One or more current transformers read a current higher by 30% compared to the rated one (if during programming you select **Ovr Yes**). Signalling occurs if the overcurrent stays for a period (expressed in seconds instead of minutes) corresponding to the value loaded for TC (thermal time constant).

You have to note that, in case the displayed message highlights the state of FAULT for both of the PT100 sensors, ALARM and TRIP relays are de-energized and do not switch if the real temperature goes beyond the set thresholds.

9.3) Displayed messages

During standard working, the following messages can be displayed:

Fcc – Sensor in FAULT, as described in point 9.2.
Foc – Sensor in FAULT, as described in point 9.2.
Ovr - Condition of electrical overload, as described in point 9.2.
Ech – Corrupted or defective data memory. Send the monitoring unit back to Tecsystem for checking and recalibration.

9.4) Relay working

9.4.1) FAULT relay

When turnning on, **FAULT** relay switches and gets de-energised if a fault condition is detected.

9.4.2) FAN relay

FAN relay switches:
- When the Oil or L1-L2-L3 temperature exceeds the loaded Fan ON threshold. A 5-second delay allows to verify the real threshold overtaking. When the fan cyclic working is programmed.

FAN gets de-energised:
- When the Oil or L1-L2-L3 temperature goes down the loaded Fan OFF threshold. A
- 5-second delay allows to verify the real threshold overtaking.

9.4.3) PUMP relay

PUMP relay switches:
- When the Oil or L1-L2-L3 temperature exceeds loaded Pump ON threshold. A 5-second delay allows to verify the real threshold overtaking. When the pump cyclic working is programmed.

FAN gets de-energised:
- When the Oil or L1-L2-L3 temperature goes down the loaded Pump OFF threshold. A
- 5-second delay allows to verify the real threshold overtaking.

9.4.4) ALARM relay

Alarm relay switches when the Oil or L1-L2-L3 temperature exceeds loaded alarm threshold and gets de-energised when the temperature goes 1°C below the threshold itself. A 5-second delay allows to verify the real threshold overtaking.

9.4.5) TRIP relay

TRIP relay switches when the Oil or L1-L2-L3 temperature exceeds loaded alarm threshold and gets de-energised when the temperature goes 1°C below the threshold itself. A 5-second delay allows to verify the real threshold overtaking.

9.5) Manual Mode

This mode can be selected by pressing **MODE** key, "**MAN**" LED near the display turns on and the "Oil" or L1-L2-L3 temperatures are continuously displayed. By pressing ▲ or ▼ keys you can select chosen channel.

9.6) Highest temperatures Mode (Max)

This mode can be selected by pressing **MODE** key, "**MAX**" LED near the display turns on. Turning on of ALARM, TRIP and FAULT LED's shows the state of selected channel from tje last reset.

PBy pressing ▲ or ▼ keys you can see the state of the other channels.

In MAX, mode, by pressing **ENT/RESET** key, it is possible to cancel the states of the alarms as well as the stored temperatures

9.7) TEST Mode

NT133-3 is equipped with a mode which allows to verify LED and display working. Pressing **TEST** key once or for less than 5 seconds, all the LED's and the display turn on for approximately 3 seconds, in order to verify their working.
Pressing **TEST** for more than 5 seconds, display shows the relay to be tested:

Alr=	Alarm
Trp=	Trip
Fan=	Ventilation
PuP=	Pumps
Flt=	Fault

Pressing SET and RESET keys it is possible to energize or de-energize the relays. The upper display will show ON and OFF to indicate its state.
To leave TEST mode, press **TEST** key or wait for 60 seconds without pressing any key.
The User must pay much attention in using this mode because it might cause the transformer trip.

9.8) Fan and pump cyclic working.

During cold seasons or under particular conditions, it may happen that forced ventilation is not set off, since the set temperatures are not reached. Anyway it is advisable regularly set off fans and pumps in order to preserve their working conditions. For this reason it is possible to put the fan cyclic working mode into operation. If during the programming you give a value to **hFn** (number of hours between a FAN cycle and the subsequent) and **hPU** (number of hours between a PUMP cycle and the subsequent) parameters you put described mode into operation and FAN and PUMP relays switch for 5 minutes: the time between a cycle and the subsequent corresponds to the values assigned to **hFn** and **hPU** parameters. Described mode can be disabled loading for both of the parameters a value 000.

9.9) Stored data diagnostics

NT133-3 monitors set of stored parameters and if, for whatever reason it detects them corrupted, it loads the default parameters (described at page 14), excludes the thermal image function from the windings and inform the user about the problem displaying the "**Ech**" message.
Monitoring unit must be sent back to Tecsystem for repair and calibration.
Reading of oil temperature is surely correct, whilst CT inputs have to be recalibrated (CAL message displays instead of the temperatures and switches the fault relay).

10) NT133-3 PROGRAMMING

NT133-3 allows the User to modify the set default thresholds and to check the values suggested by the transformer manufacturer for a correct working. In the programming mode, by the ▲ ▼ keys you increase/decrease stored values.
If during this phase **ENT/RESET** key is pressed, the monitoring unit saves the modified parameters and returns control mode using the just modified parameters.

During the programming phase, the temperature survey and the consequent relay control is suspended; therefore the transformer is not controlled.
The programming cycle starts by keeping pressed PRG key for more than 5 seconds;
If it is pressed once or for less than 5 seconds you enter the display mode.
During the programming phase, if no key is pressed for at least 1 minute, the monitoring unit automatically leaves the programming without saving possible modified parameters. You have to note that the ALARM threshold must be lower than the TRIP threshold, as FAN/ PUMP OFF thresholds must be lower than FAN/PUMP ON thresholds.

The monitoring unit leaves the factory with the following default programming:

N.	PARAMETER	DESCRPTION	DEFAULT VALUE
1	NPT	NPT=1 for single PT100 NPT=2 for double PT100	2
2	NCT	Number of CT inputs to be monitored	3
3	DT	Transformer gradient	15°C
4	CT1	Current generated by CT1 at 100% of the oil transformer load	5 Amp.
5	CT2	Current generated by CT2 at 100% of the oil transformer load	5 Amp.
6	CT3	Current generated by CT3 at 100% of the oil transformer load	5 Amp.
7	OVR	Overcurrent indicator In>30%	YES (enabled function)
8	TC	Transformer thermal time constant	5 minutes
9	OIL ALARM	Oil alarm threshold	80°C
10	OIL TRIP	Oil trip threshold	90°C
11	L1-L2-L3 ALARM	Winding alarm threshold	100°C
12	L1-L2-L3 TRIP	Winding trip threshold	110°C
13	FAN	Ventilation control function	YES (enabled function)
14	FAN ON	Fan turning on temperature	70°C
15	FAN OFF	Fan turning off temperature	60°C
16	HFN	Fan test cycle hours	000 (disabled function)
17	PUP	Oil recirculation pumps control function	YES (enabled function)
18	PUMP ON	Pump turning on temperature	80°C
19	PUMP OFF	Pump turning off temperature	70°C
20	HPU	Pump test cycle hours	000 (disabled function)
21	ADR	RS485 modbus network address	001
22	BDR	RS485 modbus network speed	96 (9600 baud)
23	PAR	RS485 network parity bit	No (parity excluded)

10.1) Programming table

N°	KEY	DESCRIPTION	DISPLAY	NOTES
1	PRG SET	Keep pressed PRG key for at least 5 seconds until display shows access message to programming.	PRG ON	
2	▼ ▲	After 2 seconds type of PT100 that you want to use is displayed.	002 NPT	001=single sensor 002=double sensor
3	PRG SET	Press PRG number of enabled CT inputs is displayed	003 NCT	NCT: number of CT in input
4	▼ ▲	Press the arrows to change the value From 1 to 3	1-3 NCT	Loadable from 001 to 003
5	PRG SET	Press PRG transformer gradient value is displayed	015 DT	Dt: temperature difference between oil and windings when the transformer is loaded at 100%
6	▼ ▲	Press the arrows to change the value From 1 to 50	001-050 DT	Loadable from 1°C to 50°C
7	PRG SET	Press PRG CT1 current transformer value is displayed	5.0 CT1	CT: current value generated by CT with the transformer loaded at 100%
8	▼ ▲	Press the arrows to change the value from 0.8 to 5.2 Amp.	0.8-5.2 CT1	Loadable from 0.8 to 5.2 Amp.
9	PRG SET	Press PRG CT2 current transformer value is displayed	5.0 CT2	CT: current value generated by CT with the transformer loaded at 100%
10	▼ ▲	Press the arrows to change the value from 0.8 to 5.2 Amp.	0.8-5.2 CT2	Loadable from 0.8 to 5.2 Amp.
11	PRG SET	Press PRG CT3 current transformer value is displayed	5.0 CT3	CT: current value generated by CT with the transformer loaded at 100%
12	▼ ▲	Press the arrows to change the value from 0.8 to 5.2 Amp.	0.8-5.2 CT3	Loadable from 0.8 to 5.2 Amp.
13	PRG SET	Press PRG "ovr" indication is displayed	No OVR	OVR: fault report for In > In+30%. Useful for having a preliminary report of electrical overload.
14	▼ ▲	Press the arrows to change setting No / Yes	YES / NO OVR	YES: enabled function NO: inhibited function
15	PRG SET	Press PRG transformer thermal constant time expressed in minutes is displayed	005 TC (τ)	TC (τ): transformer thermal constant time, item communicated by the manufacturer.
16	▼ ▲	Press the arrows to load the value from 1 to 60 minutes	1-60 TC (τ)	

N°	KEY	DESCRIPTION	DISPLAY	NOTES
17	PRG SET	Press PRG ALARM alert threshold for oil temperature expressed in °C is displayed	80 OIL	Oil temperature alert threshold. ALARM LED blinks
18	▼ ▲	Press the arrows to change the value from 1 to 199°C	1-199 OIL	Loadable from 1°C to 199°C
19	PRG SET	Press PRG TRIP trip threshold for oil temperature expressed in °C is displayed	90 OIL	Oil temperature trip threshold. TRIP LED blinks
20	▼ ▲	Press the arrows to change the value From 1 to 199°C	1-199 OIL	Loadable from 1°C to 199°C. TRIP threshold must be higher than ALARM threshold to avoid wrong programming indications.
21	PRG SET	Press PRG ALARM alert threshold for (L 1-2-3) winding temperature expressed in °C is displayed	100 L 1-2-3	Winding temperature alert threshold. ALARM LED blinks and display shows the enabled CT inputs.
22	▼ ▲	Press the arrows to change the value from 1 to 199°C	1-199 L 1-2-3	Loadable from 1°C to 199°C.
23	PRG SET	Press PRG TRIP trip threshold for (L 1-2-3) winding temperature expressed in °C is displayed	110 L 1-2-3	TRIP threshold must be higher than ALARM threshold to avoid error indications.
24	▼ ▲	Press the arrows to change the value from 1 to 199°C	1-199 L 1-2-3	Loadable from 1°C to 199°C.
25	PRG SET	Press PRG “FAN” indication is displayed	YES FAN	Option for cooling fan control
26	▼ ▲	Press the arrows to change NO / YES setting	YES / NO FAN	Yes: enabled function No: inhibited function
27	PRG SET	Press PRG FAN-ON fan turning on threshold expressed in °C is displayed	70 ON	Fan turning on threshold. Fan LED blinks.
28	▼ ▲	Press the arrows to change the value from 1 to 199°C	1-199 ON	Loadable from 1°C to 199°C (load FAN ON > FAN OFF to avoid error messages)

N°	KEY	DESCRIPTION	DISPLAY	NOTES
29	PRG SET	Press PRG FAN-OFF fan turning off threshold expressed in °C is displayed	60 OFF	Fan turning off threshold. Fan LED blinks.
30	▼ ▲	Press the arrows to change the value from 1 to 199°C	1-199 OFF	Loadable from 1°C to 199°C (load FAN OFF < Fan ON to avoid error messages)
31	PRG SET	Press PRG fan cyclic test function expressed in hours is displayed	000 HFn	Fan starting up for 5 minutes every “h” hours
32	▼ ▲	Press the arrows to change the value from 1 to 199°C	0-199 HFN	000: inhibited function “H”: number of hours
33	PRG SET	Press PRG “PUP” indication is displayed	YES PUP	Option for cooling oil recirculation pump control
34	▼ ▲	Press the arrows to change No / Yes setting	Yes / No Pup	Yes: enabled function No: inhibited function
35	PRG SET	Press PRG Pump-ON pump turning on threshold expressed in °C is displayed	80 ON	Pump turning on threshold. Pump LED blinks.
36	▼ ▲	Press the arrows to change the value from 1 to 199°C	1-199 ON	Loadable from 1°C a 199°C (load Pump on > Pump off to avoid error messages)
37	PRG SET	Press PRG PUMP-OFF pump turning off threshold expressed in °C is displayed	70 OFF	Pump turning off threshold. Pump LED blinks.
38	▼ ▲	Press the arrows to change the value from 1 to 199°C	1-199 OFF	Loadable from 1°C a 199°C (load Pump off < Pump off to avoid error messages)
39	PRG SET	Press PRG pump cyclic test function expressd in hours is displayed	000 Hpu	Pump starting up for 5 minutes every “h” hours
40	▼ ▲	Press the arrows to change the value from 1 to 199°C	0-199 Hpu	000: inhibited function “h”: number of hours

N°	KEY	DESCRIPTION	DISPLAY	NOTES
41	PRG SET	Press PRG "ADR" indication is displayed	001 ADR	ADR: modbus address assigned to the device
42	▼ ▲	Press the arrows to change the value from 1 to 255°C	001-255 ADR	Loadable from 1 to 255
43	PRG SET	Press PRG "BDR" indication is displayed	96 BDR	BDR: serial line speed in bit per second.
44	▼ ▲	Press the arrows to change the value from 24 to 384	24-384 BDR	24= 2400 baud 48= 4800 baud 96= 9600 baud 192= 19200 baud 384= 38400 baud
45	PRG SET	Press PRG "PAR" indication is displayed	NO PAR	PAR: serial line parity bit
46	▼ ▲	Press the arrows to change setting	EVE-ODD PAR	NO: inhibited parity EVE: even parity ODD: odd parity
47	PRG SET	Press PRG "END" indication is displayed	PRG END	Programming cycle is over.
48	ENT RESET	Press ENTER to confirm programmed data within 60 seconds.	888 888	Carrying out of LAMP-TEST confirms the data programming
NOTE 1 If ENTER is not pressed within 60 seconds, the previous programming is restored.				
NOTE 2 If the thresholds have not been correctly programmed, ERR indication is displayed.				
49	PRG SET	Press PRG to start over the programming.		

NOTE 3
By pressing MODE key you return to the previoius step.

11) RS485 Modbus RTU Output

NT133-3 monitoring unit has a RS485 digital output based on Modbus RTU protocol, for remote control of the device.

11.1) Introduction to Modbus RTU

Modbus RTU is a free use protocol mainly used to control industrial equipments. Besides it has the advantage to be easily converted into other communication protocols thanks to the presence on the market of a wide offer of specific Gateways.

11.2) Working notes

For a correct working of a RS485 Modbus RTU data network is necessary:

- Use a signal transfer cable according to what laid down by EIA RS485 standard which suggests to use a 24AWG duplex cable.
- Connect the duplex cable keeping into consideration the polarities and lay the network paying attention not to create sharp curves or ring windings in order not to modify the line impedance.
- Correctly load the settings relevant to the serial transmission (address, baud rate, parity bit)
- Use the controls provided for NT133-3 monitoring unit (code 3 and code 16)
- Query the registers according to the mapping provided for NT133-3

For a correct working of modbus is necessary to load the RS485 network set-up parameters: address, baud rate, parity bit.
Please see the programming steps from 37 to 42 as shown in the table at page 18
The serial communication of the temperature control monitoring unit is active just when NT133-3 is in temperature control working mode in one of the intended modes (Scan, Auto, Man and T.Max).
When other functions such as programming, programming display and relay test are activated, the ModBus communication is temporarily deactivated.

11.3) Data transmission on RS485

RS485 Modbus RTU interface of NT133-3 allows to read the data shown in the table at page 23-24 and to write the ones shown in the table at page 21.
Monitoring unit is always in slave mode.
NT133-3 monitoring unit is connected with the network just when it is in the temperature reading mode, and not when it is in programming, display / programming or relay test.

11.4) RS485 electrical connections

The signal cable to be used in order to ensure a proper network working, must be the one indicated in the paragraph 11.2
The duplex cable which connects all the units in RS485 could require a 120 ohm termination resistance on the last unit of the series.
If necessary, also the terminal for GND grounding is available

11.5) Data Frame

The frame in asynchronous transmission is composed of: 1 start bit, 8 data bits, 1 parity bit (even or odd, if the parity has been set) and 1 stop bit.
Admitted baud rates are: 2400, 4800, 9600, 19200 and 38400 b/s.
Where no otherwise specified, the word length (DATA) is of 16 bits.

11.6) DATA PACKET

A complete sequence of request/answer is composed as follows:

Master request.

SLAVE ADDRESS	- 1 byte
FUNCTION CODE	- 1 byte
DATA	- variable, it depends by the function code
CRC	- 2 bytes

Slave request.

SLAVE ADDRESS	- 1 byte
FUNCTION CODE	- 1 byte
DATA	- variable, it depends by the function code
CRC	- 2 bytes

11.7) FUNCTION CODE

ModBus module supports the following function codes:

$3_{(10)}$: - holding register reading

$16_{(10)}$: - multiple register writing

If ModBus receives a message and a CRC error is detected, no answer is given.

11.7.1) CODE $3_{(10)}$.

Request:
Slave address, code $3_{(10)}$, Starting address HI, Starting address LO, Number of Point HI, Number of Point LO, Crc LO, Crc HI.

Answer:
Slave address, code $3_{(10)}$, Byte count, Data HI, Data LO……., Crc LO, Crc HI.

11.7.2) CODE $16_{(10)}$.
Request:
Slave address, code $16_{(10)}$, Starting address HI, Starting address LO, Number of Point HI, Number of Point LO, Byte count, Data HI, Data LO……., Crc LO, Crc HI.

Answer:
Slave address, code $16_{(10)}$, Starting address HI, Starting address LO, Number of Register HI, Number of register LO, Crc LO, Crc HI.

The writable registers are the ones containing the following groups

REGISTER DESCRIPTION	NOTES	STARTING ADDRESS	NUMBER OF POINT
TMAX	Just highest temperature memory reset	16	5
STORY	Just alarm historical situation reset	21	5
ALARM	Alert threshold programming. Load alarm PT100-1=PT100-2 and alarm L1=L2=L3	26	5
TRIP	Trip threshold programming. Load trip PT100-1=PT100-2 and trip L1=L2=L3	31	5
FAN ON	Fan turning on threshold programming. Load fan-on PT100-1=PT100-2 and fan-on L1=L2=L3	36	5
FAN OFF	Fan turning off threshold programming. Load fan-off PT100-1=PT100-2 and fan-off L1=L2=L3	41	5
PUMP ON	Pump turning on threshold programming. Load pump-on PT100-1=PT100-2 and pump-on L1=L2=L3	46	5
PUMP OFF	Pump turning off threshold programming. Load pump-off PT100-1=PT100-2 and pump-off L1=L2=L3	51	5
THERMAL IMAGE PARAMETERS	DT: from 1 to 50 CT1: from 0.8 (8) to 5.2 (52) CT2: from 0.8 (8) to 5.2 (52) CT3: from 0.8 (8) to 5.2 (52) TC: from 1 to 60	56	5
NUMBER OF INPUTS	NUM PT100: 1 or 2 NUM CT: from 1 to 3 FREE: not stored FREE: not stored FREE: not stored		

Number of Point parameter can be loaded from 1 to 5 (max).
If a writing request is sent to a starting address different from the above mentioned ones, ModBus will answer with a 02 error code (wrong data address).
If a writing request is sent for more than 5 registers (Number of point LO), ModBus won't be able to grant the request and it won't give any anwer. Therefore the query will go in "timeout".

11.8) NOTES FOR REMOTE PROGRAMMING

In case you want to program a NT133-3 you have to keep into consideration that:

- ALARM PT100-1 and PT100-2 setting must have the same values (registers 26-27)
- ALARM L1, L2 and L3 settings must have the same values (registers 28-29-30)
- TRIP PT100-1 and PT100-2 settings must have the same values (registers 31-32)
- TRIP L1, L2 and L3 settings must have the same values (registers 33-34-35)
- FAN-ON PT100-1,PT100-2 (registers 36-37) and L1, L2 , L3 (registers 38-39-40) settings must have the same values
- FAN-OFF PT100-1,PT100-2 (registers 41-42) and L1, L2 , L3 (registers 43-44-45) settings must have the same values .
- PUMP-ON PT100-1,PT100-2 (registers 46-47) and L1, L2 , L3 (registers 48-49-50) settings must have the same values
- PUMP-OFF PT100-1,PT100-2 (registers 51-52) and L1, L2 e L3 settings must have the same values (registers 53-54-55)

Also in the remote programming via ModBus you have to consider that:

- ALARM thresholds must be lower than TRIP thresholds
- FAN-ON thresholds must be higher than FAN-OFF thresholds
- PUMP-ON thresholds must be higher than PUMP-OFF thresholds

In case you try to load these thresholds in a wrong way, NT133-3 monitoring unit won't proceed with the programming and data storage; therefore in the coming readings you will read the data relevant to the previous programming.

After having sent a writing request, the monitoring unit will require approximately 1'' to store the data in eeprom; during the storage phase, ModBus interface won't be able to process further requests.

If the programming request successfully concludes, the monitoring unit automatically resets and loads the new loaded values.

11.9) ERROR CODES (exception code)

In case of wrong request ModBus will answer with modified codes and codified errors according to the following points:

1: - Non-supported function code
2: - Wrong data address
3: - Wrong data (for instance length)

11.10) POLLING FREQUENCY

The max. time to give an answer to a calling never exceeds 1 second; therefore we suggest not to use polling frequencies with lower duration.

11.11) MODBUS MAPPING

ADR_HI	ADR_LO	DATA_HI	DATA_LO	NOTES
0	1	0	TEMP PT100-1	PT100-1 temperature
0	2	0	TEMP PT100-2	PT100-2 temperature
0	3	0	TEMP L1	L1 thermal image
0	4	0	TEMP L2	L2 thermal image
0	5	0	TEMP L3	L3 thermal image
0	6	0	STATO PT100-1	PT100-1 status register (note 1)
0	7	0	STATO PT100-2	PT100-2 status register (note 1)
0	8	0	STATO L1	L1 status register (note 1)
0	9	0	STATO L2	L2 status register (note 1)
0	10	0	STATO L3	L3 status register (note 1)
0	11	0	SETTING PT100-1	PT100-1 setting register (note 2)
0	12	0	SETTING PT100-2	PT100-2 setting register (note 2)
0	13	0	SETTING L1	L1 setting register (note 2)
0	14	0	SETTING L2	L2 setting register (note 2)
0	15	0	SETTING L3	L3 setting register (note 2)
0	16	0	TMAX PT100-1	PT100-1 max. temperature
0	17	0	TMAX PT100-2	PT100-2 max. temperature
0	18	0	TMAX L1	L1 max. temperature image
0	19	0	TMAX L2	L2 max. temperature image
0	20	0	TMAX L3	L3 max. temperature image
0	21	0	STORY PT100-1	PT100-1 alarm historical situation (note 3)
0	22	0	STORY PT100-2	PT100-2 alarm historical situation (note 3)
0	23	0	STORY L1	L1 alarm historical situation (note 3)
0	24	0	STORY L2	L2 alarm historical situation (note 3)
0	25	0	STORY L3	L3 alarm historical situation (note 3)
0	26	0	ALARM PT100-1	PT100-1 alarm threshold
0	27	0	ALARM PT100-2	PT100-2 alarm threshold
0	28	0	ALARM L1	L1 alarm threshold
0	29	0	ALARM L2	L2 alarm threshold
0	30	0	ALARM L3	L3 alarm threshold
0	31	0	TRIP PT100-1	PT100-1 trip threshold
0	32	0	TRIP PT100-2	PT100-2 trip threshold
0	33	0	TRIP L1	L1 trip threshold
0	34	0	TRIP L2	L2 trip threshold
0	35	0	TRIP L3	L3 trip threshold
0	36	0	FAN ON PT100-1	PT100-1 fan-on threshold
0	37	0	FAN ON PT100-2	PT100-2 fan-on threshold
0	38	0	FAN ON L1	L1 fan-on threshold
0	39	0	FAN ON L2	L2 fan-on threshold
0	40	0	FAN ON L3	L3 fan-on threshold
0	41	0	FAN OFF PT100-1	PT100-1 fan-off threshold
0	42	0	FAN OFF PT100-2	PT100-2 fan-off threshold
0	43	0	FAN OFF L1	L1 fan-off threshold
0	44	0	FAN OFF L2	L2 fan-off threshold
0	45	0	FAN OFF L3	L3 fan-off threshold

ADR_HI	ADR_LO	DATA_HI	DATA_LO	NOTES
0	46	0	PUMP ON PT100-1	PT100-1 pump-on threshold
0	47	0	PUMP ON PT100-2	PT100-2 pump-on threshold
0	48	0	PUMP ON L1	L1 pump-on threshold
0	49	0	PUMP ON L2	L2 pump-on threshold
0	50	0	PUMP ON L3	L3 pump-on threshold
0	51	0	PUMP OFF PT100-1	PT100-1 pump-off threshold
0	52	0	PUMP OFF PT100-2	PT100-2 pump-off threshold
0	53	0	PUMP OFF L1	L1 pump-off threshold
0	54	0	PUMP OFF L2	L2 pump-off threshold
0	55	0	PUMP OFF L3	L3 pump-off threshold
0	56	0	DT	Transformer gradient
0	57	0	CT1	Current generated by CT1 at 100% of the load (note 7)
0	58	0	CT2	Current generated by CT2 at 100% of the load (note 7)
0	59	0	CT3	Current generated by CT3 at 100% of the load (note 7)
0	60	0	TC	Transformer thermal time constant
0	61	0	NUM PT100	number of used PT100
0	62	0	NUM CT	number of used CT 's
0	63	0	*"free"*	Unused registers
0	64	0	*"free"*	"
0	65	0	*"free"*	"
0	66	0	FSPEC	register for special functions (note 4)
0	67	0	HFN	Fan cycle test hours
0	68	0	HPU	Pump cycle test hours
0	69	0	ADR	Modbus address
0	70	0	BDR	modbus speed (note 5)
0	71	0	PAR	modbus parity (note 6)
0	72	0	Measured CT1	Current measured on L1 (note 7)
0	73	0	Measured CT2	Current measured on L2 (note 7)
0	74	0	Measured CT3	Current measured on L3 (note 7)
0	75		*"free"*	Unused registers
0	76		*"free"*	"
0	77		*"free"*	"
0	78		*"free"*	"
0	79		*"free"*	"
0	80		*"free"*	"

NOTE 1: STATUS REGISTER
Status register contains information relevant to the alarm status of the channel that is referred.
Every bit represents a flag that is active when its value is 1.

B7	B6	B5	B4	B3	B2	B1	B0
TRIP	ALARM	PUMP	FAN	OVR In > 30%		FOC	FCC

NOTE 2: SETTING REGISTER
Status register contains information relevant to the setting of the channel that is referred.
Every bit represents a flag that is active when its value is 1.

B7	B6	B5	B4	B3	B2	B1	B0
Non-calibrated CT				Enabled PUMP		Enabled FAN	Enabled channel

NOTE 3: ALARM HISTORICAL SITATION REGISTER
Status register contains information relevant to the alarm intervention storage of the channel that is referred.
Every bit represents a flag that is active when its value is 1.

B7	B6	B5	B4	B3	B2	B1	B0
TRIP	ALARM	PUMP	FAN	OVR In > 30%		FOC	FCC

NOTE 4: SPECIAL FUNCTION REGISTER

B7	B6	B5	B4	B3	B2	B1	B0
							Enabled OVR

Special fuction register contains information relevant to enabling of special functions.

NOTE 5: CODE RELEVANT TO THE TRANSMISSION SPEED
The following table shows the code transmitted via modbus relevant to the set transmission speed.

BDR	2400	4800	9600	19200	38400
CODE	0	1	2	3	4

NOTE 6: CODICE RELATIVO ALLA PARITA' IMPOSTATA
The following table shows the code transmitted via modbus relevant to the parity for the transmission control.

PAR	NONE	EVEN	ODD
CODE	0	1	2

NOTE 7: to obtain ***the real CT value you have to divide by 10 the transmitted value.***

11.12) CRC CALCULATION

This protocol includes 2 CRC-16 bytes in each transmission. The characteristic polynomial (11000000000000101B) is used for the calculation and the result is “hung” at the end of the package. The polynomial is used in the reverse order with the most significant bit suppressed because useless for calculation.

11.13) PARAMETER DESCRIPTION

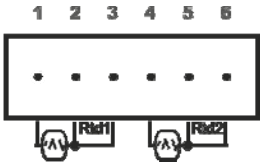
A - 16-bit register
AL - At low side
AH - At huigh side
i,j, - KWH METERS
(+) - EXCLUSIVE OR
Di - Frame data «i»th of the packet
N - number of byte of the packet excluded 2 belonging to CRC
G - Polynomial : 1010-0000-0000-0001
shr - right shift

11.14) ALGORITHM

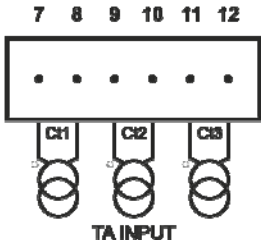
1) 0xFFFF -> A
2) 0 -> i
3) 0 -> j
4) Di (+) AL -> AL
5) j +1 -> j
6) shr A
7) if carry then G (+) A -> A
8) if NOT j=8 then goto 5
9) i +1 -> i
10) if NOT i = N then goto 3
11) A -> in CRC (result is in the order L,H)

12) ELECTRICAL CONNECTIONS

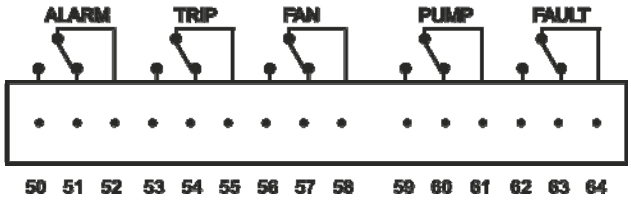
PT100 INPUTS



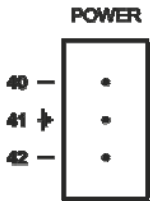
CT INPUTS



RELAY OUTPUTS



SUPPLY INPUT



RS485 OUTPUT

13) RULES FOR WARRANTY

The Product purchased is covered by manufacturer's warranty or the seller's terms and conditions set forth in the "General Conditions of Sale Tecsystem srl", available at www.tecsystem.it and / or purchase agreement.
The warranty is considered valid only when the product will be damaged by causes attributable to TECSYSTEM srl, such as manufacturing or components defects.
The warranty is invalid if the Product proves tampered / modified, incorrectly connected, because voltages outside the limits, non-compliance with the technical data for use and assembly, as described in this instruction manual.
Any action about warranty is always at our factory in Corsico-MI, Italy as stated by the
" General Conditions of Sale Tecsystem srl ".

RAEE: This SYMBOL, shown on the unit, indicates that the waste must be subject to "separate collection". The end-user must send the unit to the "waste collection centers", or return the unit to the dealer against the purchase of a new equivalent device.