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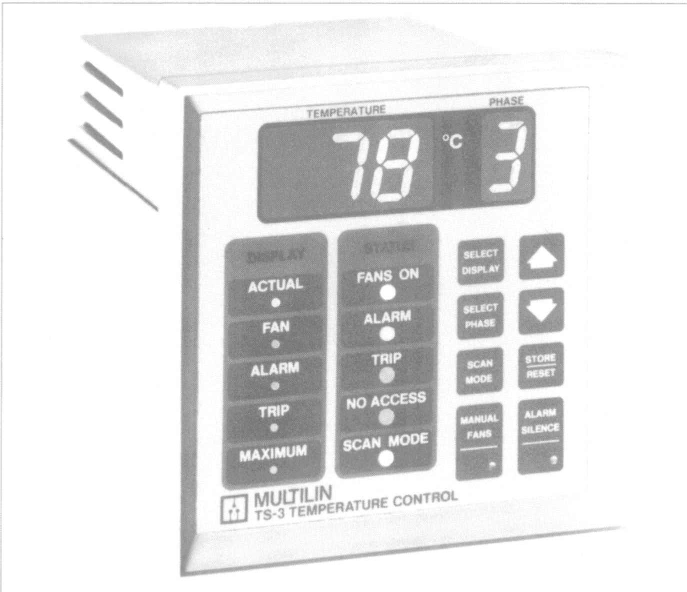

TS3 TEMPERATURE CONTROL

INSTRUCTION MANUAL

MULTILIN

TS3 TEMPERATURE MONITOR INSTRUCTION MANUAL

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1. INTRODUCTION

1.1 TS3 FEATURES

The Multilin TS3 fan controller temperature monitor is designed to monitor and protect 3 phase transformers. It accepts temperature inputs from three RTDs (resistance temperature detectors) and activates separate output relays at preset temperatures. These outputs will normally be used for fan control, alarm and trip. Each setpoint is independantly adjustable over a range of 0-250 °C or may be set off.

A digital display of all measured values, setpoints and the associated RTD number is provided. Wiring and servicing are simplified through the use of a plug-in base.

TABLE 1.1 TS3 Features

- 3 RTD inputs, 3 wire lead compensated
- fan output, adjustable setpoint 0-250 °C
- alarm output & audible alarm, adjustable setpoint, 0-250 °C
- trip output, adjustable setpoint 0-250 °C
- 0.60" display of actual temperatures/setpoints
- maximum temperature recall of each RTD
- broken sensor alarm
- manual fan control
- provision for tamperproof setpoint settings
- 0-1 mA output of hottest temperature for remote monitoring
- plug-in base, rugged compact case

1.2 TYPICAL APPLICATIONS

To protect 3 phase transformers a separate RTD is embedded in the air duct of each phase. Normally the fan setpoint will be the lowest value, the alarm an intermediate value below the maximum allowable winding temperature and the trip setpoint the maximum winding temperature. As the transformer temperature rises the fans (if installed) will come on at the preset fan temperature. Should the temperature continue to rise an audible and remote alarm will be activated. If corrective action fails to stop the temperature rise, the trip output can be used to remove the transformer load before damage can occur.

A maximum temperature memory for each phase allows core heat rise to be monitored periodically. For transformers mounted in remote locations, an analog output of the hottest sensor temperature is provided for connection to a meter or computer in a central control room.

1.3 TECHNICAL SPECIFICATIONS

TABLE 1.2 TS3 TECHNICAL SPECIFICATIONS

INPUTS	
• 3 wire RTD • 100 ohm platinum DIN 43760 • 3 wire lead compensation	
OUTPUTS	
Fan Output:	NO/NC Form C, 10A @ 250 VAC, set: at fan setpoint or manual fans key reset: 10°C below fan setpoint (for fan setpoints 10-250 °C)
Alarm Output:	NO/NC Form C, 10A @ 250 VAC, set: at alarm setpoint or broken RTD sensor reset: 3°C below alarm setpoint (for alarm setpoints 3-250 °C)
Trip Output:	NO/NC Form C, 10A @ 250 VAC, set: at trip setpoint reset: 1°C below trip setpoint when reset key pressed
Remote Output:	0-1 mA = 0-250 °C (2000 ohm load maximum)
TEMPERATURE RANGE	
• RTD sensor 0-250 °C +/− 1 °C • Fan setpoint OFF/0-250 °C, 10 °C deadband • Alarm setpoint OFF/0-250 °C, 3 °C deadband • Trip setpoint OFF/0-250 °C latched, manual reset	
POWER SUPPLY	
• 120/240 VAC +/− 20% @ 10VA	
ENVIRONMENT	
• −10 TO +60 °C operating temperature	

1.4 ORDER CODE

All features are standard when the TS3 is ordered. Unless otherwise specified the TS3 will be set to operate from 120 VAC 50/60 Hz control power. This can be changed to 240 volts by means of a switch or at the time of order.

Use the following order code:

TS3 — 120

specify 120 or 240 volt control power ______________________ (→ 120)

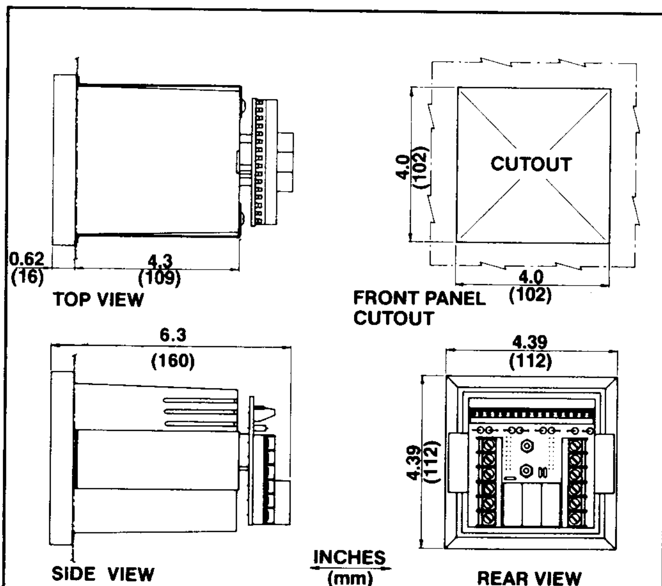
*DC SUPPLY POWER — Consult Factory

2. INSTALLATION

2.1 PHYSICAL DIMENSIONS

Dimensions of the TS3 controller, and panel cutout are shown in figure 2.1. The terminal base board is secured by 2 screws to the unit and is detachable for rapid replacement. The case is made of rugged flame retardant plastic with a splash-proof front panel.

Fig. 2.1 Physical Dimensions



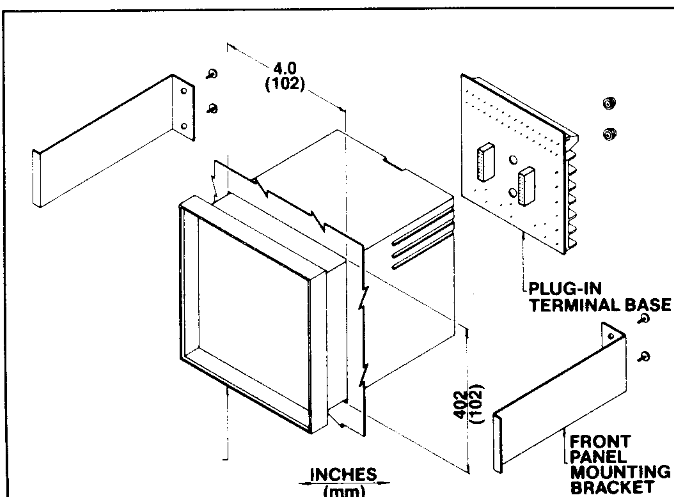
2.2 MOUNTING

The TS3 should be positioned so that the display is visible and the front panel keyboard is accessible. A square cutout is made in the panel as shown in fig. 2.1. The TS3 is then placed in the cutout and secured using two Z-shaped mounting brackets supplied.

To minimize noise pickup or interference the TS3 should be placed as far away as possible from high current conductors or sources of strong magnetic fields.

It is possible to remove the TS3 after wiring by unplugging the terminal base after removing the two retaining nuts. Mounting of the unit is illustrated in fig. 2.2.

Fig. 2.2 Mounting



2.3 EXTERNAL CONNECTIONS

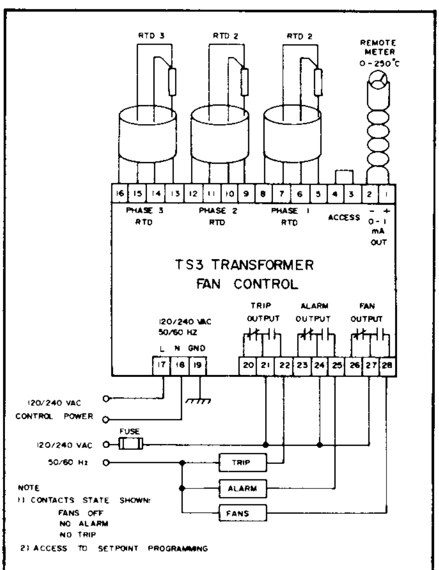
A typical wiring diagram for the TS3 is shown in fig. 2.3. TS3 units are interchangeable and can be quickly replaced using the plug-in base.

Possible connections are:

Inputs:
1) 120/240 VAC 50/60 Hz control power
2) RTD 1: 3 wires plus shield
3) RTD 2: 3 wires plus shield
4) RTD 3: 3 wires plus shield
5) no access jumper

Outputs:
1) fan contacts: 1 set form C
2) alarm contacts: 1 set form C
3) trip contacts: 1 set form C
4) analog output 0-1mA = 0-250 °C

Fig. 2.3 TYPICAL WIRING



2.4 RTD SENSORS

Only 100 ohm platinum (DIN 43760, R100/RO = 1.3850) RTDs can be connected to the TS3. Since the RTD indicates temperature by the value of its resistance, it is necessary to compensate for the resistance of the connecting wires which varies with length and ambient temperature. Identical lengths of the same type of wire should be used. The actual resistance of the connecting leads will be cancelled providing all three leads are the same length and the lead resistance is not greater than 25 ohms.

Shielded, 3 wire cable must be used in industrial environments to prevent noise pickup. Where possible, the RTD wires should be kept close to grounded metal cabinets and avoid areas of high electromagnetic or radio frequency fields. RTD wires should not run adjacent to or in the same conduit as high current carrying wires. Typically a 3 wire shielded cable of #16 copper conductors will be suitable. Colour coding such as red-white-white from the RTD sensor indicates that the 2 similar colours are connected to the same point at the sensor as shown in fig. 2.3. The shield should not be grounded at the RTD sensor end since all shields are internally grounded at the TS3 when terminal 19 is connected to ground. This prevents noise pickup that might otherwise occur due to circulating currents from differences in ground potential on a doubly grounded shield.

If no RTD sensor is to be connected to an input for some reason, the RTD terminals should be shorted together with the shield terminal left open to produce a low temperature value. Otherwise the no sensor alarm will always be activated.

2.5 FAN CONTACTS

An isolated set of normally open/normally closed output contacts capable of switching 250 VAC @ 10A is provided for controlling cooling fans. If higher current or voltage switching is required, an auxiliary relay with higher ratings should be used.

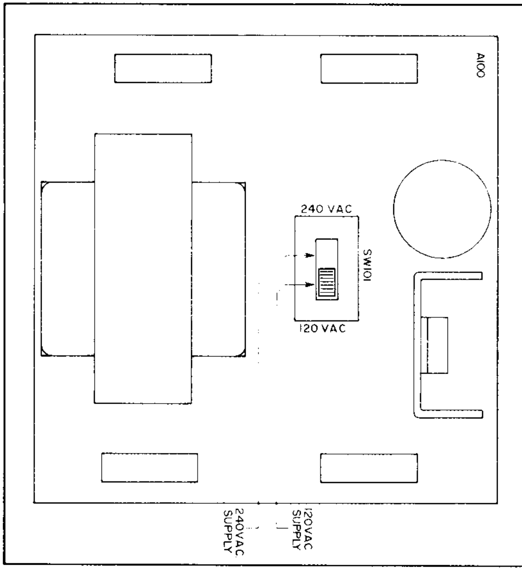
The position of the fan contacts shown in fig. 2.3 is for a temperature below the fan setpoint and manual fans switch in the off position. If supply power to the TS3 is lost, these contacts will revert to the fans off condition as shown in fig. 2.3. A deadband of 10 °C is provided for the fan contacts; that is, the fans will not switch off until all RTD temperatures fall 10 °C below the fan setpoint.

2.6 ALARM CONTACTS

An isolated set of NO/NC form C output contacts capable of switching 250 VAC @ 10A is provided for switching a remote alarm. The internal alarm will also sound, if enabled, whenever the remote alarm contacts are in the alarm state.

The position of the alarm contacts shown in fig. 2-3 is for a temperature below the alarm setpoint. If supply power to the TS3 is lost, these contacts will revert to the alarm off condition as shown in fig. 2-3. A deadband of 3 °C is provided for the alarm contacts to prevent contact chatter; that is, the alarm will not switch off until the temperature of all 3 RTDs falls 3 °C below the alarm setpoint once the alarm has been activated.

Fig. 2.4 120/240 Volt Selection



2.7 TRIP CONTACTS

An isolated set of NO/NC output contacts capable of switching 250 VAC @ 10A is provided to switch a remote breaker coil foı removing the transformer from the line.

The position of the trip contacts shown in fig. 2-3 is for a temperature below the trip setpoint. Once the trip set-point is reached the trip contacts remain latched until reset from the front panel. If control power to the TS3 is lost the trip contacts revert to the untripped state.

2.8 SUPPLY POWER

A power supply of 120 V or 240 V 50/60 Hz +/- 20% @ 10VA is required by the TS3 for correct operation. Selection of 120 or 240 volt control voltage is via soldered jumpers which will normally be set for 120 VAC unless otherwise specified. Voltages can be changed in the field by repositioning the switch as shown in fig. 2-4.

Loss of control power will cause the outputs to be: fans off, no alarm, no trip which is the state of the contacts shown in fig. 2-3. When power is lost, all setpoint values and maximum temperatures are retained. When control power is first applied, the trip contacts are reset.

2.9 ACCESS INPUT

When a jumper is connected between terminals 3 and 4, all setpoints can be programmed from the front panel. Once programming is complete, no jumper will normally be connected to these terminals. This still allows all measured values to be accessed from the front panel as well as the maximum temperature and trip contacts to be reset. However, if an attempt is made to enter a new fan, alarm or trip setpoint, the front panel no access light comes on and the previous setpoint remains.

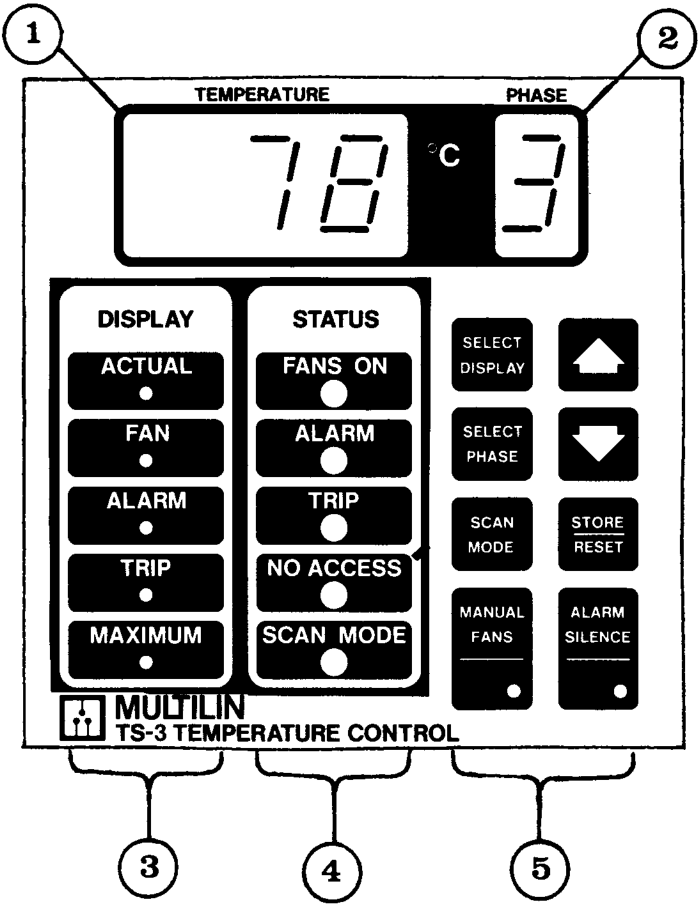
2.10 0-1 mA ANALOG OUTPUT

Using the analog output feature, a current of 0-1 mA corresponding to a linear range of 0-250 °C can be obtained by connecting a load to terminals 1 and 2. This output is a current source for connection to a remote meter or computer. Total lead and load resistance must not exceed 2000 ohms or saturation of the output will produce an incorrect value. Below this value the output current will not be affected by total resistance.

If a meter is used, it should have a 0-1 mA movement and be calibrated in linear divisions from 0-250 °C. A computer or programmable controller input will require a resistive load such as 1000 ohms to convert 0-1 mA to 0-1 volt DC for analog conversion. This analog output is not isolated. Terminal 2 is internally connected to system ground terminal 19. Consequently the negative terminal of the associated load must not be at a potential other than ground. For RTD inputs above 250 °C, the output will be 1.020 mA to prevent meter damage from overloads.

Note: It is recommended that a twisted pair be used for Analog Output connection for better noise immunity.

Fig. 3.1 Controls and Indicators



3. SET-UP AND USE

3.1 CONTROLS AND INDICATORS

No.	NAME	FUNCTION
1	Temperature (°C)	Measured temperature or setpoint in °C. Display temperature indicators show which parameter is being displayed.
2	RTD Phase Sensor	Indicates which sensor is being displayed. Flashing value indicates that RTD temperature exceeds alarm setpoint.
3	Display Temperature Indicators	ACTUAL: Display value is the actual temperature of the corresponding RTD sensor in °C. "LO"—Temperature is below 0 °C. "HI"—Temperature is above 250 °C. FAN: Display value is the common setpoint for all RTD sensors at which the fan output will be activated. "OFF"—Output is disabled. ALARM: Display value is the common setpoint in °C for all 3 RTD sensors at which the internal and external alarm will turn on. TRIP: Display value is the common setpoint in °C for all 3 RTD sensors at which the trip output will activate. MAXIMUM: Display value is the highest temperature in °C measured for the corresponding RTD sensor since last reset. "OFF"—Sensor momentarily disconnected since last reset or broken lead.
4.	Status Indicators	FANS ON: The fan output is on. This output is activated when any RTD exceeds the fan setpoint or the manual fans switch is pressed. ALARM: The external alarm output and internal alarm (if enabled) are on. This output is activated when any RTD exceeds the alarm setpoint. TRIP: The trip output is on. This output is activated when any RTD exceeds the trip setpoint. Reset is required to clear the trip output. NO ACCESS: An attempt has been made to store a setpoint when no access is allowed. Resets automatically after 5 seconds.
5.	Control Keys/ Key Status Lights	SELECT DISPLAY: Each time this key is pressed the display temperature moves to the next parameter. SELECT PHASE: Each time this key is pressed the next RTD sensor is selected for display. Since setpoints are common to all RTDs, this key has no effect in fan/alarm/trip setpoint display mode. SCAN MODE: Display automatically displays each RTD sensor actual temperature. If any RTD exceeds the alarm temperature the display locks onto this temperature. Scan mode LED indicates scan mode when lit. MANUAL FANS: Alternately turns fans on or off. Key LED is on when manual fans mode is on. UP: Active only during setpoint programming. Each time the key is pressed the display increments. Hold button down for continous increment. DOWN: Active only during setpoint programming. Each time the key is pressed the display decrements. Hold button down for continuous decrement. STORE/RESET: Function depends on display mode. Actual-resets trip output relay if all RTDs are below the trip setpoint. Fan/Alarm/Trip-stores setpoint indicated by display Maximum-resets maximum temperature of RTD sensor currently displayed. ALARM SILENCE: Alternately enables/disables internal audible alarm. Does not affect external alarm output. LED on indicates internal alarm silenced. Alarm silence mode disabled if no alarm condition present.

3.2 RTD SCANNING

Each RTD is scanned about twice each second. The new value is compared against setpoints and saved in the maximum temperature memory if appropriate. No matter what value is being displayed, scanning and setpoint monitoring will be continuous and not affected.

3.3 NO ACCESS

In order to prevent operators from tampering with fan/alarm/trip setpoints, a no access feature is provided. When no jumper is connected across terminals 3 and 4, setpoints cannot be entered. However, all measured values and setpoints can be displayed, the maximum temperature for any sensor can be cleared and the latched trip relay can be reset. To store setpoints a jumper must temporarily be installed across terminals 3 and 4. This jumper should be removed once setpoints are stored to prevent settings from being altered.

If an attempt is made to program a setpoint in the no access mode, the no access indicator will be activated. It will remain on for approximately 5 seconds then automatically go off. This is used to warn the operator that the new setpoint was not stored.

3.4 FAN SETPOINT

The fan setpoint is the same for all 3 RTD sensors. To program this value, press the SELECT DISPLAY key until the fan display temperature status indicator comes on. Press the UP or DOWN key holding the key down until the desired setpoint is reached. Incrementing the display value until the word "OFF" appears defeats the fan output. Once the display reaches the appropriate value press the STORE key to permanently save the setpoint in non-volatile memory.

If the no access indicator comes on when the STORE key is pressed, the new value is not stored (see section 3.3). A timeout feature causes the previously stored setpoint to be displayed if the new setpoint value is not stored 30 seconds after pressing the UP/DOWN keys.

Once the setpoint is reached by any RTD the fan output will be activated. This output will automatically revert to the off state when the temperature of all 3 RTDs falls 10 °C below the fan setpoint. This ensures that the fans remain on long enough to provide adequate cooling. Pressing the MANUAL FANS key alternately enables or disables the manual fans output. When the manual fans key indicator is on, the fan output is activated whether or not the fan setpoint has been exceeded.

3.4 (a) FAN EXERCISE FEATURE

Transformer fans may sit idle for long periods of time during cold winter months or low load utilization. Consequently, the first time that the cooling fans are required, they may seize due to lack of bearing lubrication, rust, insulation breakdown or other problems.

To ensure that the fans remain lubricated and operate when required, this TS3 relay is equipped with a fan exercise feature. Every 7 days if the fans have not been turned on, they will automatically be activated by going into manual fans mode for 5 minutes. During this 5 minute period the manual fans light and fan output relay will be energized. If it is undesirable to turn on the fans for this automatic cycling, set the fan setpoint to "OFF" which defeats this feature.

Should a fan failure occur, the fan exercise mode will give plenty of advance warning for corrective maintenance.

3.5 ALARM SETPOINT

The alarm setpoint is the same for all 3 RTD sensors. To program this value, press the SELECT DISPLAY key until the alarm display temperature status indicator comes on. Press the UP or DOWN key holding the key down until the desired setpoint is reached. Incrementing the display value until the word "OFF" appears defeats the alarm output. Once the display reaches the appropriate value, press the STORE key to permanently save the setpoint in non-volatile memory.

If the no access indicator comes on when the STORE key is pressed the new value is not stored (see section 3.3). A timeout feature causes the previously stored setpoint to be displayed if the new setpoint value is not stored 30 seconds after pressing the UP/DOWN keys.

Once the alarm setpoint temperature is reached by any RTD, the alarm output and internal alarm (if enabled) will be activated. The alarm will automatically revert to the off state when the temperature of all 3 RTDs falls 3 °C below the alarm setpoint.

Each time the ALARM SILENCE key is pressed the internal alarm is enabled or disabled. When no alarm condition is present, the alarm silence mode is disabled and this key has no effect. If the alarm silence indicator is on, the internal audible alarm is disabled. If any RTD sensor becomes disconnected and the alarm setpoint is enabled, the alarm will be activated to indicate a broken sensor.

3.6 TRIP SETPOINT

The trip setpoint is the same for all 3 RTD sensors. To program this value, press the SELECT DISPLAY key until the trip display temperature status indicator comes on. Press the UP or DOWN key holding the key down until the desired setpoint is reached. Incrementing the display value until the word "OFF" appears defeats the trip output. Once the display reaches the appropriate value, press the STORE key to permanently save the setpoint in non-volatile memory.

If the no access indicator comes on when the STORE key is pressed, the new value is not stored (see section 3.3). A timeout feature causes the previously stored setpoint to be displayed if the new setpoint value is not stored 30 seconds after pressing the UP/DOWN keys.

Once the trip setpoint temperature is reached by any RTD the trip output will be activated. This output remains latched after the RTD temperature falls below the setpoint. To reset the trip output, all 3 RTDs must be below the trip setpoint. Press the SELECT DISPLAY key until the "actual" display status indicator comes on. Now press the RESET key and the trip output should reset.

3.7 MAXIMUM TEMPERATURE MEMORY

A continous update of the maximum temperature measured by each RTD is made by the TS3. This value can be monitored at any time by pressing the DISPLAY SCAN key until the "maximum" display status indicator comes on. Use the SELECT PHASE key to select the RTD of interest. Once the display is in this status, pressing the RESET key will clear the maximum value for the indicated RTD and the TS3 will begin storing a new maximum value. If the RTD sensor is momentarily disconnected due to an intermittent fault, the maximum value will display "OFF". This indicates a potential defect in the system wiring or the RTD sensor itself.

The maximum temperature recall feature is particularly useful for noting trends and periodic overloading of an unattended transformer. The maximum value of all 3 RTDs is retained whenever control power is lost.

3.8 SCAN MODE

The scan mode will normally be selected for unattended operation. In this mode, the actual temperature of each RTD sensor will alternately be displayed under normal conditions. When alarm or trip setpoints are exceeded, the display will automatically indicate the most serious fault condition present according to the following hierarchy:

PRIORITY	DISPLAY VALUE	CONDITION
Highest	RTD1 actual temp	RTD1 exceeds trip setpoint or trip/no reset
	RTD2 actual temp	RTD2 exceeds trip setpoint or trip/no reset
	RTD3 actual temp	RTD3 exceeds trip setpoint or trip/no reset
	RTD1 actual temp	RTD1 exceeds alarm setpoint or alarm/in deadband
	RTD2 actual temp	RTD2 exceeds alarm setpoint or alarm/in deadband
	RTD3 actual temp	RTD3 exceeds alarm setpoint or alarm/in deadband
Lowest	RTD1/RTD2/RTD3	normal conditions-no alarm or trip

If the RTD currently displayed exceeds the alarm setpoint the RTD phase number digit will flash. Faults can be rapidly identified using the scan mode feature to determine which RTD sensor is measuring the highest temperature.

3.9 REMOTE TEMPERATURE OUTPUT

The TS3 is equipped with a remote temperature output so that a meter, programmable controller or computer can be connected to the TS3. A current proportional to the actual temperature of the hottest RTD is output. Note that this is not the value that is saved in the maximum temperature memory for recall. This feature is particularly useful for remote monitoring of transformers.

The output current is represented as:

0 mA = 0 °C,
0.004 mA/°C,
1.020 mA = over 250 °C.

For example, if the RTDs had actual temperatures of 62 °C, 85 °C and 100 °C, then the analog output would be: 0.004 (mA/°C) x 100 (°C) = 0.4 mA.

4. TESTING

4.1 COMMISSIONING TESTS

Prior to applying power to a new installation, system operation can be checked by simulating different temperature inputs. Control power should be applied to the TS3 for all tests but not necessarily to the transformer that it is protecting.

4.2 TEMPERATURE SIMULATION

Connect a variable resistor or decade resistance box to RTD1 and fixed resistors below the desired setpoints to RTD2 and RTD3 terminals of the TS3. Suitable values of RTD resistance can be determined from the resistance/temperature relationship for 100 ohm platinum RTDs using table 4.1. Ensure that there is a jumper across terminals 3 and 4 to allow setpoint programming.

Table 4.1 RTD Resistance vs Temperature (100 OHM Platinum Din 43760)

TEMPERATURE ('C)	RESISTANCE (OHMS)
0	100.00
10	103.90
20	107.79
30	111.67
40	115.54
50	119.39
60	123.24
70	127.07
80	130.89
90	134.70
100	138.50
110	142.29
120	146.06

TEMPERATURE ('C)	RESISTANCE (OHMS)
130	149.82
140	153.58
150	157.32
160	161.04
170	164.76
180	168.47
190	172.16
200	175.84
210	179.51
220	183.17
230	186.82
240	190.46
250	194.08

Enter the desired fan/alarm/trip setpoints according to section 3. Vary the resistance of the simulated RTD1 while displaying the actual temperature of this sensor and ensure that the temperature displayed and resistance agree according to table 4.1. Check that each output for fan/alarm/trip goes on when the simulated RTD reaches the preset temperature and that this activates the appropriate external devices eg. fans, remote alarm and breaker trip.

Reset the maximum temperature of RTD1 according to section 3.7. While displaying the actual temperature of RTD1, simulate a high value noting the reading and then reduce the reading by reducing the resistance of RTD1. Now read the maximum value of RTD1 which should be the previously noted high reading.

Once these tests have been performed to verify correct operation of the TS3, reconnect the wiring to the RTD sensors located inside the transformer. Remove the no access jumper if no further setpoint programming is required.

4.3 TRANSFORMER MONITORING

Apply power to the complete system including the transformer being monitored. Read the actual temperature of each RTD sensor and ensure that the values are sensible. For example, each RTD should give a temperature equal to the ambient temperature when power is first applied. If the readings do not make sense or if they fluctuate rapidly perform the following tests.

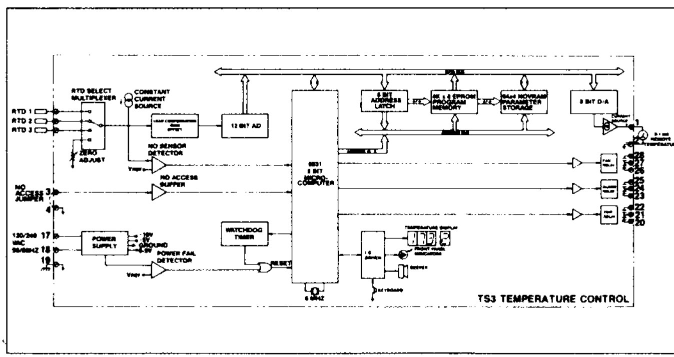
Disconnect RTD1 at the transformer and connect a known resistance to the terminals leading to the TS3. If the symptoms continue to appear, the fault most likely lies in the wiring either from incorrect connections or noise pickup. Rapid fluctuations due to noise can usually be overcome using the precautions outlined in section 2.4. If the symptoms disappear when the simulated sensor is used there is likely to be a fault with the RTD or sensor wiring inside the transformer.

5. THEORY OF OPERATION

5.1 HARDWARE

All control, computation and logic for TS3 operation is performed by a powerful single chip microcomputer. Although the 8031 8 bit microcomputer IC contains its own RAM and timers, program firmware is stored in an external 4k x 8 EPROM and setpoints are saved in a non-volatile NOVRAM. Fig. 5.1 is a block diagram of the hardware for the TS3.

Fig. 5.1 Hardware Block Diagram



A constant current source is alternately connected to each RTD and a zero reference resistance. The voltage drop produced by passing the known current through the external RTD is measured by a 12 bit A/D convertor after passing through a circuit to provide lead resistance compensation, gain and offset. This voltage is converted to digital form using a dual slope, auto zero integration method. The integration period is chosen to provide good common mode rejection of 50/60 Hz noise. Drift due to aging and temperature is cancelled out since the microcomputer subtracts the zero reference resistor value which passes through the same circuitry used to measure the actual RTD resistance. A firmware linearization algorithm is used to compensate for the non-linear temperature vs resistance characteristic of platinum RTDs. A no sensor detector circuit signals if no current is flowing to distinguish this state from a high temperature condition.

Firmware is used to process the RTD values, compare them to setpoints and activate the 3 independant relays for fan/alarm/trip as required. The no access jumper is detected by the microcomputer as a direct input. Like all inputs, transient protection and filtering are provided.

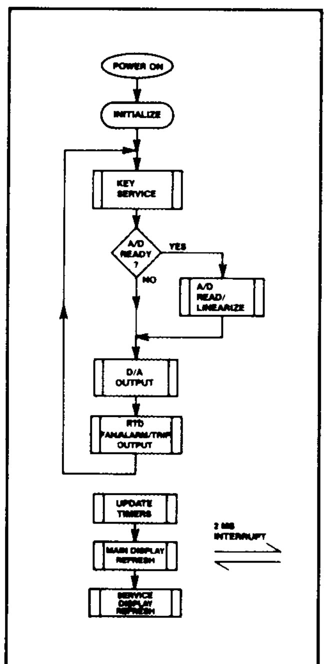
Multiplexing of the display digits and front panel LEDs is used to minimize component count. Each digit or group of LEDs is individually driven in rapid sequence using segment lookup tables in memory to convert numeric values to the appropriate segment drivers. The keyboard is also periodically scanned for new key entries. Key debounce and hold down for scanning is performed under firmware control.

To provide the analog output, the DAC receives a digital value corresponding to the temperature of the hottest RTD. This is converted to an analog voltage and used to drive a voltage to current convertor. The output current is independent of the load connected.

A conventional power supply using a dual primary transformer for connection to 120/240 VAC is used. Regulated supply voltages of +/− 5 VDC are used for logic and analog signals while an unregulated + 10 VDC supplies the relay and display drivers. A power fail detector is used to reset the relay whenever the supply voltages are out of range for correct circuit operation. A separate hardware watchdog timer must be periodically reset by firmware or it will time out and reset the microcomputer. If correct program execution does not occur due to transients or a system malfunction the watchdog timer will reset the microcomputer.

5.2 FIRMWARE

Fig. 5.2 Firmware Block Diagram



A block diagram of the firmware execution is shown in fig. 5.2. Firmware is stored in a 4K x 8 bit EPROM memory. At power on RAM memory is cleared, the real-time clock is started and parameters are initialized. Every 2 mS the clock generates an interrupt to update the timers, refresh the front panel display and read the keyboard. A service display which can be connected for calibration and diagnostic use is also refreshed at this time.

Program flow continuously loops through several routines that control the TS3 operation. KEYSERVICE examines any new key values, determines system status and takes appropriate action based on the key value.

During A/D READ the new A/D value is read and processed. A previously saved zero offset is subtracted from each new RTD reading before the RTD value is linearized and converted to the equivalant °C reading. The updated value is saved in memory and the maximum temperature updated if required. Before exiting this routine the RTD multiplexer selects the next RTD and a new A/D conversion is started.

In the D/A OUTPUT routine the hottest RTD value is output to the D/A convertor. If the value is over-range then a value of 256 °C is output.

All setpoints are checked against each RTD in the RTD FAN/ALARM/TRIP routine. If no sensor is connected, setpoints are not checked but the alarm output is activated. This routine also drives the fan/alarm/trip output relays as required.

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TS3
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