MULTILIN

TB3 TEMPERATURE MONITOR INSTRUCTION MANUAL

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LR58954

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1. INTRODUCTION

1.1 TB3 FEATURES

The Multilin TB3 bearing temperature monitor is designed to monitor and protect industrial motors with 3 bearings. Other equipment with up to 3 temperature sensors can also be monitored. 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 pre-alarm control, alarm and trip. Each setpoint is independantly adjustable over a range of 0-250 degrees 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 TB3 Features

- 3 RTD inputs, 3 wire lead compensated
- Pre-alarm output, adjustable setpoint 0-250 °C or off.
- Alarm output & audible alarm, adjustable setpoint, 0-250 °C or off.
- Trip output, adjustable setpoint 0-250 °C or off.
- 0.6" display of actual temperatures/setpoints
- Maximum temperature recall of each RTD
- Broken sensor alarm
- Test feature for all outputs
- Provision for tamperproof setpoint settings
- 0-1mA output of hottest temperature for remote monitoring
- Plug-in base, rugged compact case

1.2 TYPICAL APPLICATIONS

To protect 3 phase motor bearings a separate RTD is embedded in each bearing housing. Normally the pre-alarm setpoint will be the lowest value, the alarm an intermediate value below the maximum allowable bearing temperature and the trip setpoint the maximum bearing temperature at which permanent damage occurs. As the bearing temperature rises, the pre-alarm will come on at the preset 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 shut down the motor before damage to its bearings can occur.

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

1.3 TECHNICAL SPECIFICATIONS

TABLE 1.2 TB3 TECHNICAL SPECIFICATIONS

INPUTS

- 3 wire RTD
- 100 ohm platinum (DIN 43760) or 100/120 ohm nickel or 10 ohm copper
- 3 wire lead compensation

OUTPUTS

Pre-Alarm Output:	NO/NC Form C, 10A/250 VAC, Set: at pre-alarm setpoint Reset: 3 °C below pre-alarm setpoint (for pre-alarm setpoints 3-250 °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 shutdown setpoint when reset key pressed

TEMPERATURE RANGE

- RTD sensor 0-250 °C +/− 1 °C
- Pre-alarm setpoint OFF/0-250 °C, 3 °C deadband
- Alarm setpoint OFF/0-250 °C, 3 °C deadband
- Trip setpoint OFF/0-250 °C latched

POWER SUPPLY

- 120/240 VAC +/− 20% @ 10VA, 50/60 HZ

ENVIRONMENT

- −10 TO +60 °C operating temperature

1.4 ORDER CODE

All features described are standard. The type of RTD sensor to be used must be specified with the order. Unless otherwise specified the TB3 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:

TB3 — 100P — 240

RTD SENSOR 100P: 100 ohm platinum
10C: 10 ohm copper
100N: 100 ohm nickel
120N: 120 ohm nickel

Control Voltage 120 or 240

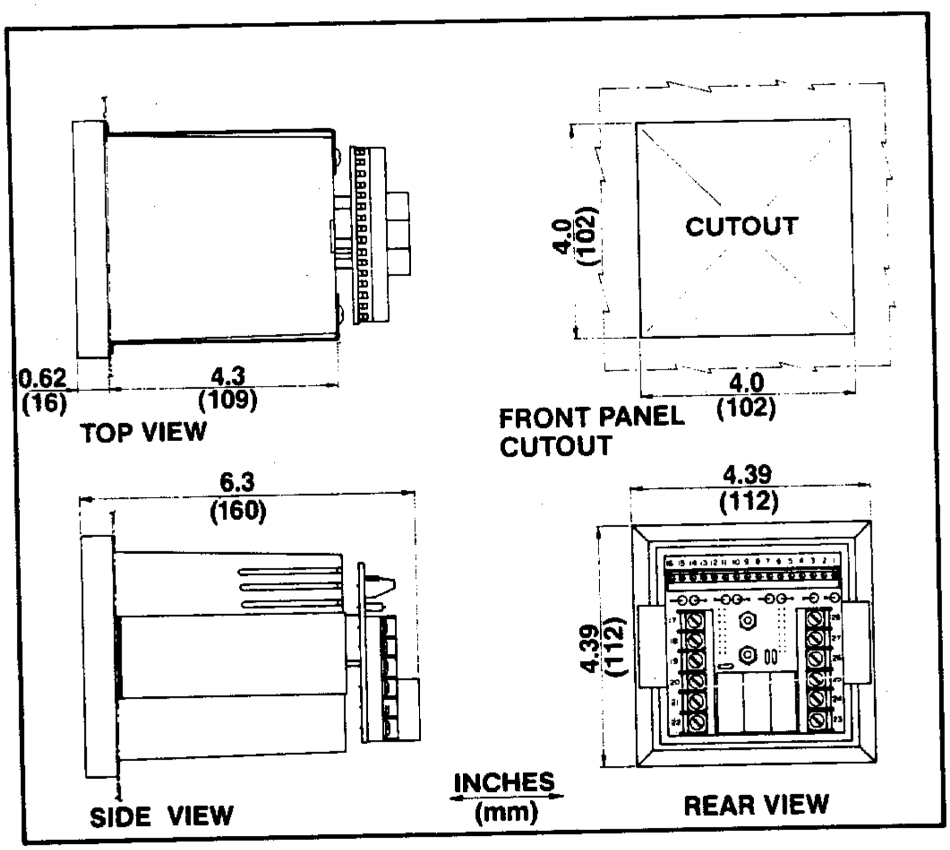
EXAMPLE: TB3 for use with 100 ohm platinum RTD sensors and 240VAC 50/60 HZ voltage.

2. INSTALLATION

2.1 PHYSICAL DIMENSIONS

Dimensions of the TB3 monitor 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



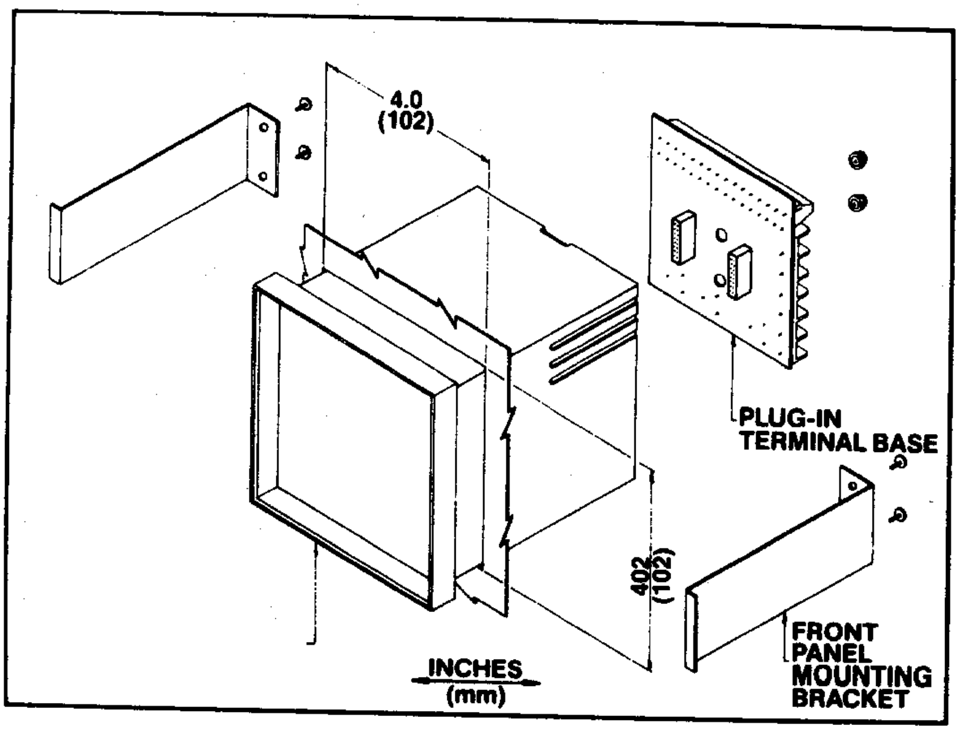
2.2 MOUNTING

The TB3 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 TB3 is then placed in the cutout and secured using two Z-shaped mounting brackets supplied.

To minimize noise pickup or interference the TB3 should be placed as far away as possible from high current conductors or sources of strong magnetic fields.

It is possible to remove the TB3 once wired 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

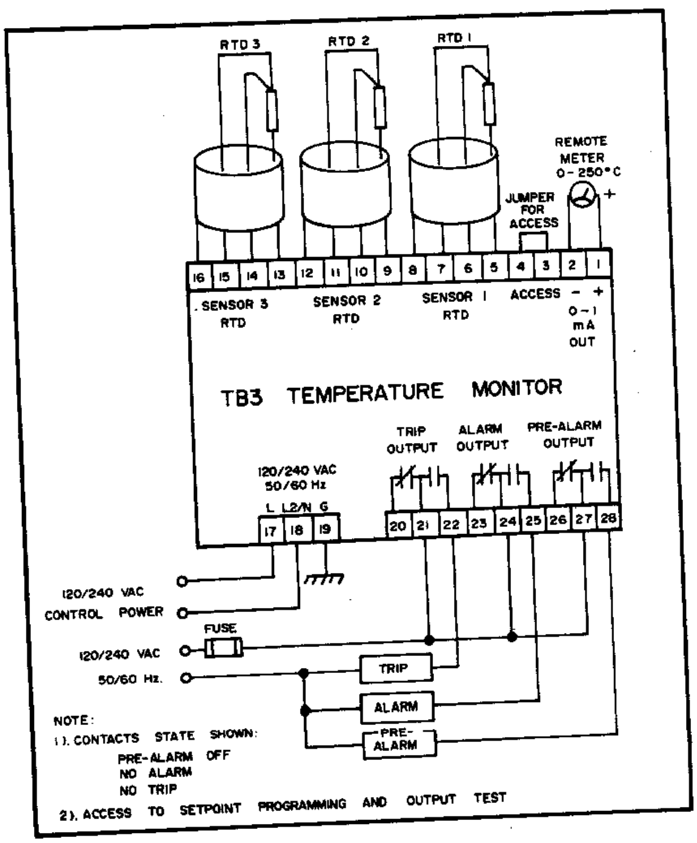
A typical wiring diagram for the TB3 is shown in fig. 2.3. TB3 units are interchangeable providing they accept the same type of RTD and can be quickly replaced using the plug-in base.

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) Pre-alarm 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

The TB3 can be ordered for four types of RTD sensors: 100 ohm platinum (DIN 43760, R100/R0 = 1.3850), 100 ohm nickel, 120 ohm nickel or 10 ohm copper. Each of the 3 RTDs must be of the same type and be specified with the order. When it is possible to specify the RTD sensor to be used, 100 ohm platinum is recommended as the best choice for output sensitivity and linearity. 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. 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% of the 0 °C value. This can be accomplished using identical lengths of the same type of wire.

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 #18 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 since all shields are internally grounded at the TB3 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 PRE-ALARM CONTACTS

An isolated set of normally open/normally closed output contacts capable of switching 250 VAC 10A is provided for switching at pre-alarm. If higher currents or voltage switching is required, an auxiliary relay with higher ratings should be used.

The position of the pre-alarm contacts shown in fig. 2.3 is for a temperature below the pre-alarm setpoint. If supply power to the TB3 is lost, these contacts will revert to the pre-alarm off condition as shown in fig. 2.3. A deadband of 3 °C is provided for the pre-alarm contacts; that is, the pre-alarm will not switch off until each RTD temperature falls 3 °C below its pre-alarm setpoint.

2.6 ALARM CONTACTS

An isolated set of normally open/normally closed 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 TB3 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 each RTD falls 3 °C below its alarm setpoint once the alarm has been activated.

2.7 TRIP CONTACTS

An isolated set of normally open/normally closed output contacts capable of switching 250 VAC 10A is provided to switch a remote breaker coil for removing the motor whose bearings are being monitored from the line.

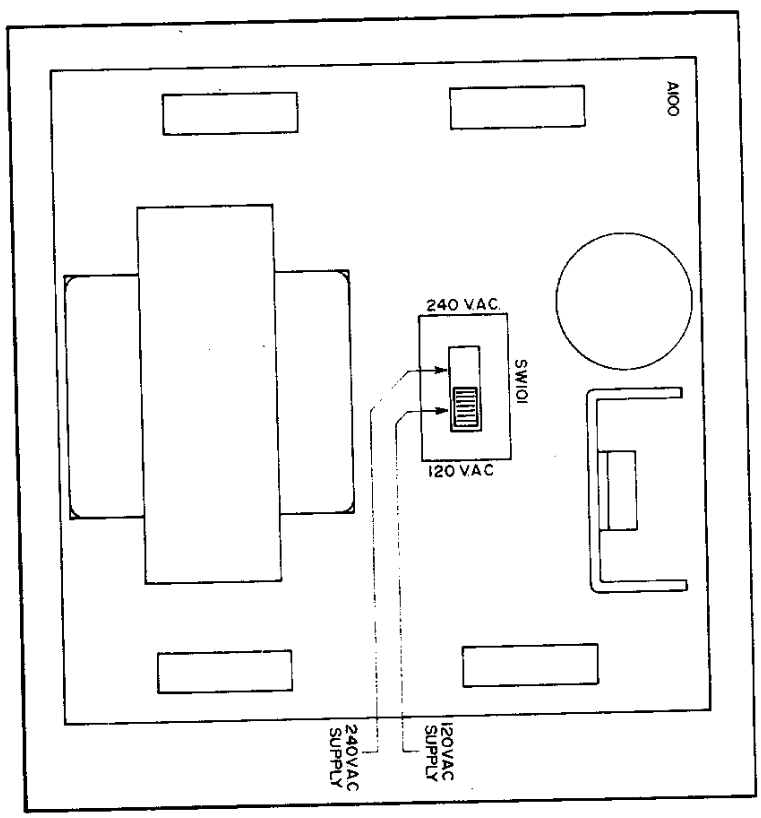
The position of the trip contacts shown in fig. 2.3 is for a temperature below the trip setpoint. Once the trip setpoint is reached the trip contacts remain latched until reset from the front panel. If control power to the TB3 is lost the trip contacts revert to the untripped state to prevent nuisance tripping.

2.8 SUPPLY POWER

A power supply of 120V or 240V +/– 20% @ 10VA, 50/60 Hz is required by the TB3 for correct operation. Selection of 120 or 240 volt control voltage is via 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: pre-alarm off, no alarm, no trip which is the state of the contacts shown in fig. 2.3. When power is lost, setpoints and maximum temperatures are retained in memory. When control power is first applied, the trip contacts are reset.

Fig. 2.4 120/240 Volt Selection



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 displayed on 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 pre-alarm, alarm or trip setpoint, the front panel no access light comes on and the old setpoint remains. If the no access jumper is installed, the front panel output test key is also disabled.

2.10 0-1 mA ANALOG OUTPUT

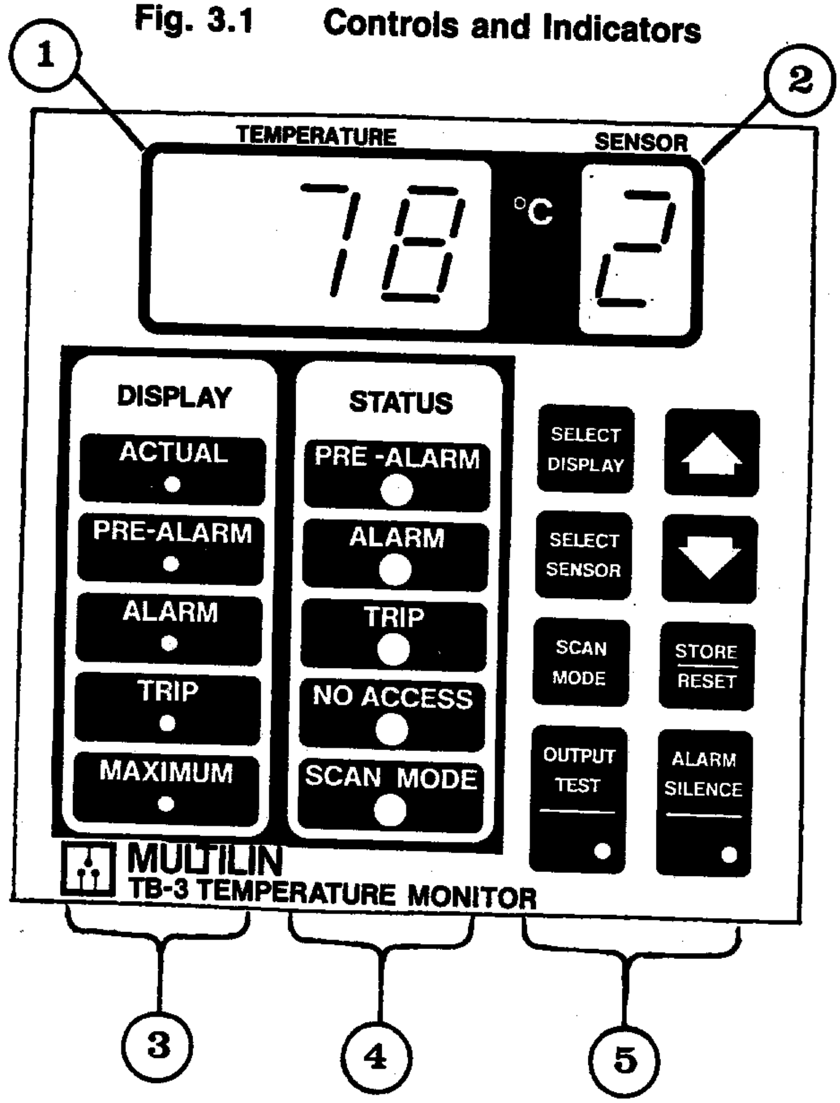
Using the analog output feature, a current of 0-1 mA corresponding to a linear range of 0-250 °C can be obtained by connecting a load to terminals 1 and 2. This output is a current source for connection to a remote meter or computer. Total lead and load resistance must not exceed 2000 ohms or saturation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

Multilin recommends the use of twisted pair wire from the analog out terminals to the meter, in order to increase noise immunity.

3. SET-UP AND USE

Fig. 3.1 Controls and Indicators



3.1 CONTROLS AND INDICATORS (Continued)

No.	NAME	FUNCTION
1	Temperature °C	Measured temperature or setpoint in °C. Display temperature indicators show which parameter is being displayed.
2	RTD 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. "OFF"—No sensor connected. **PRE-ALARM:** Display value is the setpoint for the indicated RTD sensor at which the pre-alarm output will be activated. "OFF"—Pre-alarm output for indicated RTD sensor is disabled. **ALARM:** Display value is the set-point in °C for the indicated RTD sensor at which the internal and external alarm will turn on. "OFF": Alarm output for indicated RTD sensor is disabled. **TRIP:** Display value is the set-point in °C for the indicated RTD sensor at which the trip output will activate. "OFF": Trip output for indicated RTD sensor is disabled. **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	**PRE-ALARM:** The pre-alarm output is on. This output is activated when any RTD exceeds its pre-alarm setpoint or the output test key is pressed (access enabled). **ALARM:** The external alarm output and internal alarm (if enabled) are on. This output is activated when any RTD exceeds the alarm setpoint or the output test key is pressed (access enabled). **TRIP:** The trip output is on. This output is activated when any RTD exceeds its trip setpoint or the output test key is pressed (access enabled). Reset is required to clear the trip output. **NO ACCESS:** An attempt has been made to store a setpoint or activate output test when no access is allowed. Resets automatically after 5 seconds. **SCAN MODE:** Automatic scan mode active. RTD temperatures or highest priority fault displayed.
5	Control Keys/ Key Status Lights	**SELECT DISPLAY:** Each time this key is pressed the display temperature moves to the next parameter. **SELECT SENSOR:** Each time this key is pressed the next RTD sensor is selected for display. **SCAN MODE:** Display automatically displays each RTD sensor actual temperature. If any RTD exceeds its pre-alarm/alarm/trip temperature the display locks onto this temperature. Autoscan status LED indicates when this mode is active. **OUTPUT TEST:** Activates outputs separately each time key pressed: pre-alarm/alarm/alarm + internal alarm/trip/normal. Disabled if no access mode. **UP:** Active only during setpoint programming. Each time the key is pressed the display increments. Hold button down for continuous 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 temperature status: ACTUAL-reset trip output relay if all RTDs are below the trip setpoint. PRE-ALARM/ALARM/TRIP-stores setpoint indicated by display. MAXIMUM-resets maximum temperature of RTD sensor currently displayed. **ALARM SILENCE:** Alternately enables/disables internal audible

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 pre-alarm/alarm/trip setpoints, or inadvertently activating the outputs using the output test key, a no access feature is provided. When no jumper is connected across terminals 3 and 4, setpoints cannot be stored and the output test key is disabled. However, all measured values and set-points can be displayed, the maximum temperature for any sensor can be cleared and the latched trip relay can be reset. To store setpoints or use the output test feature 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 or activate the output test key 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 PRE-ALARM SETPOINT

The pre-alarm setpoint can be individually set for each of the 3 RTD sensors. To program this value, press the SELECT DISPLAY key until the pre-alarm display temperature status indicator comes on. Press the SELECT SENSOR key until the desired sensor is displayed. Press the UP or DOWN key holding the key down until the desired setpoint is reached. Once the display reaches the appropriate value press the STORE key to permanently save the setpoint in non-volatile memory. To defeat the pre-alarm output press the UP key to increment the display until the word "OFF" appears. Then press the STORE key to defeat the pre-alarm for the selected sensor.

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 old 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 pre-alarm output will be activated. This output will automatically revert to the off state when the temperature of all 3 RTDs falls 3°C below their pre-alarm setpoints.

3.5 ALARM SETPOINT

The alarm setpoint can be individually set for each of the 3 RTD sensors. To program this value, press the SELECT DISPLAY key until the alarm display temperature status indicator comes on. Press the SELECT SENSOR key until the desired sensor is displayed. Press the UP or DOWN key holding the key down until the desired setpoint is reached. Once the display reaches the appropriate value press the STORE key to permanently save the setpoint in non-volatile memory. To defeat the alarm output press the UP key to increment the display until the word "OFF" appears. Then press the STORE key to defeat the alarm for the selected sensor.

If less than 3 RTDs are connected the alarm will always be on to indicate a broken sensor condition. To eliminate a nuisance alarm, program the alarm "OFF" for any sensor channels where an RTD is not connected.

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 old 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 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 their alarm setpoints.

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. However, this key has no effect on the external alarm. If any RTD sensor becomes disconnected, the alarm will be activiated to indicate a broken sensor.

3.6 TRIP SETPOINT

The trip setpoint can be individually set for each of the 3 RTD sensors. To program this value, press the SELECT DISPLAY key until the trip display temperature status indicator comes on. Press the SELECT SENSOR key until the desired sensor is displayed. Press the UP or DOWN key holding the key down until the desired setpoint is reached. Once the display reaches the appropriate value press the STORE key to permanently save the setpoint in non-volatile memory. To defeat the trip output press the UP key to increment the display until the word "OFF" appears. Then press the STORE key to defeat the trip for the selected sensor.

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 old 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 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 1° below the trip setpoint. Press the DISPLAY SCAN 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 continuous update of the maximum temperature measured by each RTD is made by the TB3. This value can be monitored at any time by pressing the SELECT DISPLAY key to select the RTD of interest. Once the display is in "maximum" status, pressing the RESET key will clear the maximum value for the indicated RTD and the TB3 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 bearings. The maximum value of all 3 RTDs is retained whenever control power is lost.

3.8 SCAN MODE

The autoscan 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 pre-alarm, 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 1 setpoint
	RTD2 actual temp	RTD2 exceeds trip 2 setpoint
	RTD3 actual temp	RTD3 exceeds trip 3 setpoint
	RTD1 actual temp	RTD1 exceeds alarm 1 setpoint
	RTD2 actual temp	RTD2 exceeds alarm 2 setpoint
	RTD3 actual temp	RTD3 exceeds alarm 3 setpoint
	RTD1 actual temp	RTD1 exceeds pre-alarm 1 setpoint
	RTD2 actual temp	RTD2 exceeds pre-alarm 2 setpoint
	RTD3 actual temp	RTD3 exceeds pre-alarm 3 setpoint
Lowest	RTD1/RTD2/RTD3 actual temp	normal conditions - no pre-alarm/alarm/trip setpoints are exceeded.

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

3.9 REMOTE TEMPERATURE OUTPUT

The TB3 is equipped with a remote temperature output, so that a meter, programmable controller or computer can be connected to it. A current proportional to the actual temperature of the hottest RTD is output. Note that this is the current hottest RTD not the value that is saved in the maximum temperature memory for recall. This feature is particularly useful for remote monitoring of bearings

The output current is represented as:

0 mA = 0 °C,

0.004 mA/°C,

1.024 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.

3.10 OUTPUT TEST

A test feature is provided to verify correct system operation during commissioning and routine maintenance checks. Each time this key is pressed a different output is separately activated as follows for a sequence of 5 key strokes: pre-alarm, alarm, alarm and audible alarm, trip and return to normal operation. When the OUTPUT TEST key is active the key indicator is on. This key is disabled in the no access mode.

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 TB3 for all tests but not necessarily to the equipment 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 TB3. Suitable values of RTD resistance can be determined from the resistance/temperature relationship for RTDs using table 4.1. Use the table for the RTD type which the TB3 under test has been calibrated for. Ensure that there is a jumper across terminals 3 and 4 to allow setpoint programming.

Enter the desired pre-alarm/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 pre-alarm/alarm/trip goes on when the simulated RTD reaches the preset temperature and that this activates the appropriate external devices eg. pre-alarm, 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 TB3, reconnect the wiring to the RTD sensors located on the bearing housing and remove the no access jumper if desired to prevent changing the stored setpoints.

Table 4.1 RTD Resistance vs Temperature

TEMP. °C	OHMS 100 Ohm Pt. (DIN 43760)	OHMS 120 Ohm Ni.	OHMS 100 Ohm Ni.	OHMS 10 Ohm Cu.
0	100.00	120.00	100.00	9.04
10	103.90	127.17	105.97	9.42
20	107.79	134.52	112.10	9.81
30	111.67	142.06	118.38	10.19
40	115.54	149.79	124.82	10.58
50	119.39	157.74	131.45	10.97
60	123.24	165.90	138.25	11.35
70	127.07	174.25	145.20	11.74
80	130.89	182.84	152.37	12.12
90	134.70	191.64	159.70	12.51
100	138.50	200.64	167.20	12.90
110	142.29	209.85	174.87	13.28
120	146.06	219.29	182.75	13.67
130	149.82	228.96	190.80	14.06
140	153.58	238.85	199.04	14.44
150	157.32	248.95	207.45	14.83
160	161.04	259.30	216.08	15.22
170	164.76	269.91	224.92	15.61
180	168.47	280.77	233.97	16.00
190	172.16	291.96	243.30	16.39
200	175.84	303.46	252.88	16.78
210	179.51	315.31	262.76	17.166
220	183.17	327.53	272.94	17.555
230	186.82	340.14	283.45	17.945
240	190.46	353.14	294.28	18.335
250	194.08	366.53	305.44	18.726

4.3 EQUIPMENT MONITORING

Apply power to the complete system including the equipment 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.

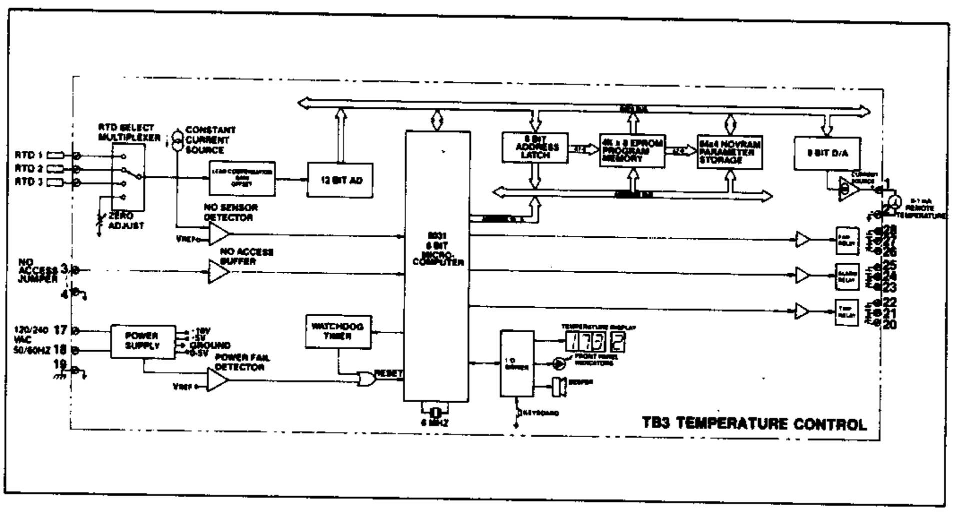
Disconnect RTD1 at the bearing and connect a known resistance to the terminals leading to the TB3. If the symptoms continue to appear, the fault most likely lies in the wiring either from incorrect connections or noise pickup. Rapid fluctuations due to noise can usually be overcome using the precautions 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 to the bearing.

5. THEORY OF OPERATION

5.1 HARDWARE

All control, computation and logic for TB3 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 TB3.

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 the RTD. 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 independent relays for pre-alarm/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.

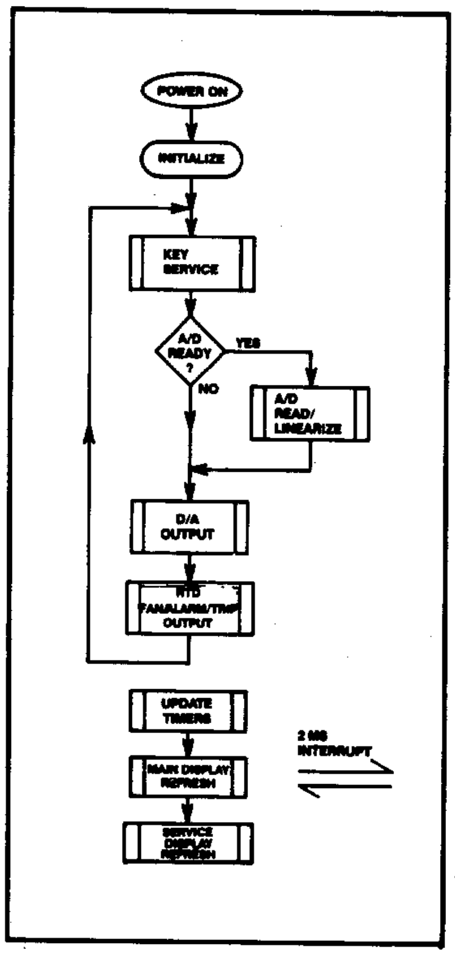
Multiplexing of the display digits and front panel LEDs is used to minimize component count. Each digit or group of LEDs is individually driven in rapid sequence using segment lookup tables in memory to convert numeric values to the appropriate segment drivers. The keyboard is also periodically scanned 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 TB3 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 PRE-ALARM/ALARM/TRIP routine. If no sensor is connected, setpoints are not checked but the alarm output is activated. This routine also drives the pre-alarm/alarm/trip output relays as required.

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