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TRANSFORMER TEMPERATURE MONITOR AND COOLING CONTROL SYSTEM

BCI Bulletin BCI-TTM-AC/DC-T

Revision #5.3AT 1/9/2008

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I. Description of Operation

The model TTM-AC/DC-T is a solid state transformer temperature monitor that is SCADA ready and monitors both oil and winding temperatures. The **TTM-AC/DC-T** is designed for easy installation on single or three phase single tank transformers.

In addition to temperature monitoring and cooling control functions there are several Barrington innovations added for utility convenience and to extend the useful life of the transformer. (1.) The "LOOKBACK" feature is provided for ambient compensation. This feature allows the utility to compensate for hot spells with ambient temperature set back capability. This feature can be used to start the cooling system at a lower temperature for hot spells and can effectively provide a cooling "head start." (2) The cooling monitor feature can be set to alarm for any reduced cooling current. (i.e. One or two fans not running.) (3) A selectable feature is provided to exercise the cooling system for a ten minute period each 24 hours. (4) A selectable feature is provided that will alternate the stage 1 and stage 2 cooling banks once each week. **The "alternate cooling stage" feature allows a user to select the mode that switches between the two cooling stages every 168 hours. This feature, if enabled, allows the unit to swap the cooling stage that is selected to operate as the first stage to exercise and use the stages equally. This can be both a labor saving and a desired maintenance feature.**

Local indication includes calculated winding temperature, calculated peak winding temperature, top oil temperature and peak top oil temperature with manual reset. Winding temperature is obtained using a single pt100 RTD probe and one or three snap on current transformers with calculations to closely approximate actual conditions. Displays are .39" backlit LCD's that continuously display all four temperatures simultaneously. Communications include SCADA ready outputs, dry contacts for local annunciation and a RS232/485 port. The TTM-AC/DC-T measures the actual Top Oil temperature in the transformer and measures the actual current in each phase of a transformer using three supplied snap-on current transducers. The current is displayed as a percentage of full scale for each phase, using only highest phase for calculation. The winding temperature over top oil temperature is calibrated at maximum based upon the transformer manufacturer's "heat run." This insures that at higher temperatures, where winding temperature is important, the readings are very accurate. In testing per national standards, placing the probe in a calibration oil bath, the TTM-AC/DC-T measurement accuracy is within plus/minus 0.2 degrees C compared with the calibration temperature of the oil bath. Readings are displayed as a directly linear curve over top oil temperature. For example:

Top oil temperature	Load	Winding temperature
40 deg C	0 amps	40 deg C
80 deg C	Full Load	80 deg C + heat run

The **TTM-AC/DC-T** is housed in an 8" X 10" X 6" NEMA 4 windowed enclosure. The enclosure is designed to be mounted on an existing transformer control cabinet. Ambient operating temperature range is -40 degrees C to 70 degrees C. Winding and oil temperatures are both obtained using a single RTD probe in the top oil well of the main transformer tank and one or three snap on current transformers. Installation requires connecting supplied snap on CT's (current transducers) to existing secondary current and cooling supply circuits. Installation is quite easy. Operation is very reliable. Power requirements are autosensing, 120 or 240 VAC 50/60hz -or- 110 to 270VDC. The analog outputs can be connected to an existing SCADA system. The analog outputs supplied are 0 - 5 VDC, 4-20 ma, or 0-1ma "switchable" for oil and winding temperatures. The **TTM-AC/DC-T** is designed to meet IEEE/ANSI C37.90 surge specifications for protective relaying applications.

TTM-AC/DC-T FRONT PANEL CONTROL AND DISPLAY

The new **TTM-AC/DC-T** design includes a 2 line by 16 character alpha-numeric display and a five key keypad. This document outlines the basic operation and concepts of the various displays. The TTM-AC/DC-T has a standard display of temperature data. This standard display will be shown at all times except when a user has entered one of the two menus to setup the control of the TTM-AC/DC-T**. If the user leaves the TTM-AC/DC-T in one of these menus it will timeout and return to the standard display.**

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TTM DISPLAY SCREENS

MENU
(PRESS MENU)

NEXT

- MANUAL FANS OFF
- OIL TEMP ALARM 80 °C
- WIND TEMP ALARM 120 °C
- STAGE 1 OIL 70 °C
- STAGE 1 WIND 70 °C
- STAGE 1 CURRENT 80 %
- STAGE 2 OIL 80 °C
- STAGE 2 WIND 80 °C
- STAGE 2 CURRENT 80 %
- HYSTERESIS 0.1 °C
- ALARM DELAY 10.0 SEC
- OIL TEMP TRIP 180 °C
- WINDING TEMP TRIP 180 °C
- TRIP DELAY 120.0 SEC

CONFIG
(PRESS MENU FOR 3 SECONDS)

NEXT

- COMM MODE RS232
- COMM RATE 1200
- COMM FORMAT 8-N-1
- COMM ADDRESS 0
- COMM PERIOD 0.0 MIN
- FULL SCALE RISE 55.0 °C
- ANALOG 1 OUT 0-1 ma
- ANALOG 2 OUT 0-1 ma
- RTD 1 OFFSET 0.0 °C
- RTD 2 OFFSET 0.0 °C
- 24 HOUR FAN CYCLE 0 1=ON
- FAN ALTERNATE OFF
- LOOKBACK PERIOD 48 HOURS
- LOOKBACK TEMP 150 °C
- LOOKBACK HOURS 12 HOURS
- LOOKBACK SETBACK 20.0 °C

NEXT
(PRESS NEXT)

NEXT

- AMBIENT TEMP 25 °C
- STAGE 1 0.0 % STAGE 2 ° 0.0%
- PHASE A - B - C 0% 0% 0%

CALIBRATE
(PRESS NEXT & PREV)

NEXT

- ANALOG#1 = 1ma 3200
- ANALOG#2 = 1ma 3200
- STAGE #1 0%
- STAGE #2 0 %
- PHASE A 0%
- PHASE B 0%
- PHASE C 0%

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The five key pad keys:

MENU When pressed and released the TTM-AC/DC-T will start the main menu sequence of displays to allow the user to setup the normal operating parameters. When held for three seconds the TTM-AC/DC-T will enter the configuration menu. This secondary menu allows the user to setup the configuration and calibration of the TTM-AC/DC-T.

NEXT When the TTM-AC/DC-T is displaying the standard display no action is taken. When in the main or secondary menu pressing this key will advance to the next item in the menu's sequence.

PREV When the TTM-AC/DC-T is displaying the standard display no action is taken. When in the main or secondary menu, pressing this key will return to the previous item in the menu's sequence.

∇ When the TTM-AC/DC-T is displaying the standard display no action is taken. When in the main or secondary menu, pressing this key will reduce the current parameter to the next possible value.

Δ When the TTM-AC/DC-T is displaying the standard display no action is taken. When in the main or secondary menu, pressing this key will increase the current parameter to the next possible value.

∇ Δ Simultaneously pressing both the ∇ Δ and will reset both peak temperatures to the current values.

[MENU] **Default display shows current top oil temperature, current calculated winding temperature, peak top oil temperature and peak calculated winding temperature.** The following menus & lists detail the sequence for the TTM-AC/DC-T. The COMM column indicates which values may be read and /or written through the communication link.

MAIN MENU DISPLAY	DESCRIPTION	COMM
MANUAL CONTROL ON OFF	Digital control to turn on the cooling system Range: Off (normal) On	
OIL TEMP ALARM	Top oil temperature alarm value Range: -40.0 to +180.0ºC	yes
WIND TEMP ALARM	Calculated winding temperature alarm value Range-. -40.0 to +180.0ºC	yes
STAGE 1 OIL	Stage 1 cooling control oil temperature Range: -40.0 to +180.0ºC	yes
STAGE 1 WIND	Stage 1 cooling control winding temp Range: -40.0 to +180.0ºC	yes
STAGE 1 CURRENT	Stage 1 cooling current minimum value Range: 0 to 100% of full scale cooling current	yes
STAGE 2 OIL	Stage 2 cooling control oil temperature Range: -40.0 to + 180.0ºC	yes
STAGE 2 WIND	Stage 2 cooling control winding temp Range: 4.0.0 to +180.0ºC	yes
STAGE 2 CURRENT	Stage 2 cooling current minimum value Range: 0 to 100% of full scale cooling current	yes
HYSTERESIS	Control Hysteresis value Range: 0.1 to 100.0ºC	yes
ALARM DELAY	Alarm delay time Range: 0.1 to 999.9 seconds	yes
OIL TEMP TRIP	Top Oil Trip Temperature Range: 0.0 to 180ºC (Must also have standing oil temp alarm to trip)	yes
WINDING TEMP TRIP	Winding Trip Temperature Range: 0.0 to 180ºC (Must also have standing winding temp alarm to trip)	yes
TRIP DELAY	Trip Delay Time Range: 10 to 1000 Seconds	yes

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Configuration Menus

The TTM-AC/DC-T has secondary menus for controlling the communications, analog output signals and temperature calibration. It also provides for calibration of the five current sensing inputs.

COMM. DISPLAY	ACTION	DESCRIPTION	COMM
COMM MODE <mode>	Down/Up to select	Communications mode Modes: RS232, RS485, RS485 Multi-point	no
COMM RATE <rate>	Down/Up to select	Communication baud rate Possible rates: 1200, 2400, 4800, 9600	no
COMM FORMAT < format >	Down/Up to select *# bits- parity check- stop bit*	Communication data format Possible formats: 8-N-1, 7-N-1, 7-E-1	no
COMM ADDRESS < address >	Value entry for RS485 *Allows 1 modem to address multiple unit addresses*	Communication address (RS485 Multi only) Possible values: 0-255	no
COMM PERIOD	Value entry *0.0 selects no automatic output*	Communication output period Range: 0.0 to 3000.0 minutes	yes
FULL SCALE RISE	Value entry *Transformer manufacturer's heat run data*	Manufacturer's specified degrees (C) winding temperature increase over Top Oil temperature from heat run data. See pages 2 & 14	yes
ANALOG 1 OUT <mode>	Down/Up to select	Analog output 1 mode (Top Oil Temp) Possible modes- 0 -1ma, 4-20ma, 0-5v	no
ANALOG 2 OUT <mode>	Down/Up to select	Analog output 2 mode (Calculated Winding Temp) Possible modes- 0 -1ma, 4-20ma, 0-5v	no
RTD 1 OFFSET	Value entry *Determined by calibration to known temperature*	RTD 1 offset value in tenths of a degree Range: -20.0 to +20.0ºC	read
RTD 2 OFFSET	Value entry *Determined by calibration to known tempera*	RTD 2 offset value in tenths of a degree Range: -20.0 to +20.0ºC	read
24 HR FAN CYCLE <value>	Down sets to "1" [on] Up sets to "0" [off]	Automatically run cooling stages for 10 minutes each 24 hours	yes
FAN ALTERNATE ON OFF	Down sets to [on] Up sets to [off]	Automatically alternates cooling stages every 168 hours. (Weekly)	no
LOOKBACK PERIOD <value>	Value entry *Previous hour period for setback window*	Number of previous hours used to make setback decision Range: 0 to 120 hours	no
LOOKBACK TEMP <value>	Value entry *Temp threshold to trigger count toward setback*	Ambient temp above which is counted toward setback decision Range: –40 to 180 ºC	no
LOOKBACK HOURS <value>	Value entry *Cumulative hour count above trigger threshold within setback window period*	Number of hours that the ambient temperature must be above the lookback temperature to trigger the setback Range: 1 to 120 hours	no
LOOKBACK SETBACK <value>	Value entry *Degrees C bias reduction from cooling mode start set point*	Number of degrees C that both stages of cooling start will be reduced Range: 0 to 180 ºC	no

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NEXT DISPLAY	DESCRIPTION	COMM
AMBIENT TEMP	Display ambient temperature (RTD #2)	no
STAGE #1 % STAGE #2 %	Display cooling current percentage value	no
PHASE A % - B % - C %	Display primary current (percentage of full scale)	no

CALIBRATION DISPLAY *(Select Next and previous together)*	DESCRIPTION	COMM
ANALOG #1 =	Used to set analog output to match jumper settings and Calibrate analog output #1	no
ANALOG #2 =	Used to set analog output to match jumper settings and Calibrate analog output #2	no
STAGE #1 AMPS <value>	Used to set full scale cooling current value for Stage #1	no
STAGE #2 AMPS <value>	Used to set full scale cooling current value for Stage #2	no
PHASE A AMPS <value>	Used to calibrate primary current value for A phase	no
PHASE B AMPS <value>	Used to calibrate primary current value for B phase	no
PHASE C AMPS <value>	Used to calibrate primary current value for C phase	no

TTM-AC/DC-T – IBM (PC) INTERFACE CABLE REQUIREMENTS

SIGNAL	TTM-AC/DC-T	9 PIN SERIAL CABLE
RS232		
DATA FROM PC	PIN 3	PIN 3
DATA TO PC	PIN 4	PIN 2
GROUND	PIN 2	PIN 5
RS-485		
DATA +	PIN 5	
DATA -	PIN 6	
5VDC (Modem supply power)	Pin 1	

RS232 TERMINAL SETTINGS: Emulation – ANSI, Data Bits – 8, Parity – None, Stop Bits – 1, Flow Control – None, Keyboard Caps – On. (Remove JMP1)

HyperTerminal can be used. (supplied with Windows)

ANALOG SCALING VALUES

	0 to 1 mA	4 to 20 mA	0 to 5 VDC
Temperature 0°C	0.200 mA	10.00 mA	1.00 VDC
Slope per °C	0.004 mA	0.050 mA	0.020 VDC
Minimum Scale	0 mA = -50°C	4 mA = -120°C	0 VDC = -50°C
Maximum Scale	1 mA = +200°C	20 mA = +200°C	5 VDC = +200°C

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TTM FUNCTIONAL EXAMPLE

For Transformer Monitor and Cooling Control

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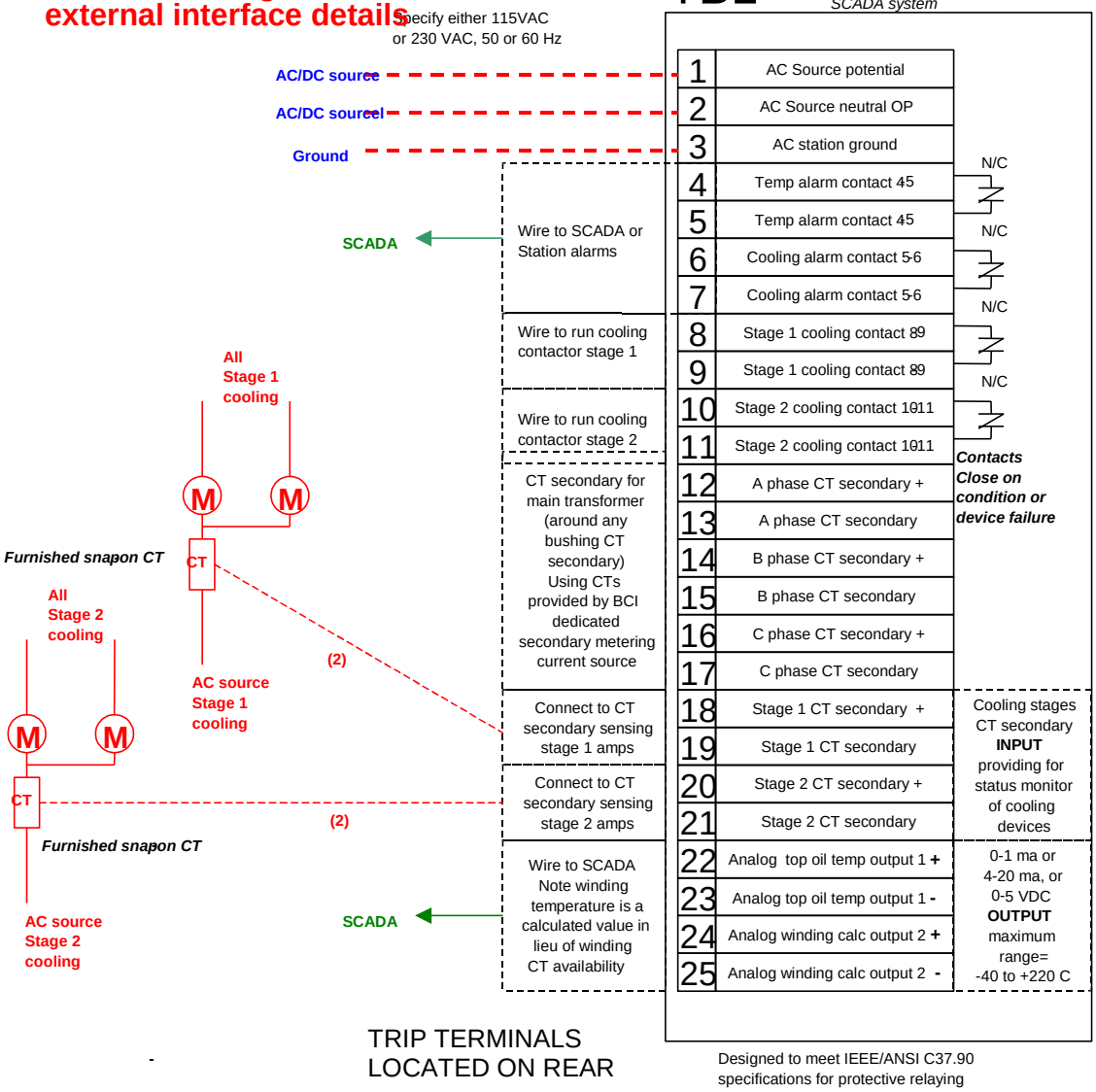
CAUTION

External wiring connections are shown only as functional examples, consult your installation engineer for external interface details

The solid state TTM unit monitors oil temperature, calculates winding temperature for a single phase or three phase transformer contained in one oil filled unit, and is ready to provide input for existing SCADA system



See next page forlocation of TTM-AC/DC-T trip relay terminal

TTM-AC/DC-T Functional Diagram

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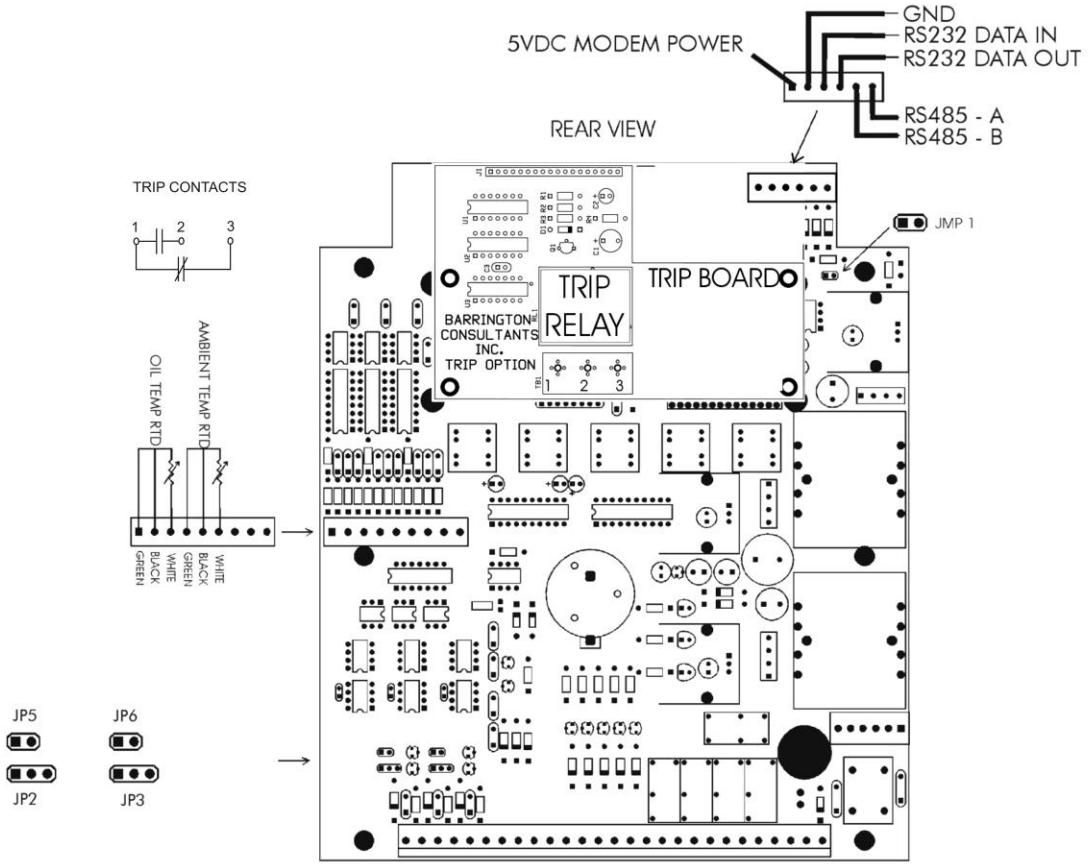

CONFIGURATION JUMPERS: (* = DEFAULT)

Terminals 1-2 of Trip Relay green terminal board = 30 A AC/DC Tripping

JP3	Top Oil Analog Output	Jumper on 1&2 – Enables Voltage **Jumper on 2 & 3 - Enables Current ***
JP2	Winding Analog Output:	Jumper on 1 & 2 - Enables Voltage **Jumper on 2 & 3 - Enables Current ***
JP6	Top Oil Analog Output	Jumper on - 4 to 20 ma **Jumper off - 0 to 1 ma** *
JP5	Winding Analog Output	Jumper on - 4 to 20 ma **Jumper off - 0 to 1 ma** *
JMP1	RS485 Termination.	Jumper on – RS485/Enables 120 Ohm termination * **(Remove for RS232)**

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COMMUNICATIONS STRING FORMAT Syntax:

[..]	Optional items
<..>	Value field
?	Value query
*	Preceding item may be repeated
<cr>	Carriage return
<If>	Line feed
<chksum>	Checksum, sent only if received with command. Sum of all ASCII characters up to and including =

COMMANDS

[<adr>:] <nem> (?|<value>) [,<nem> (?|<value>)]* [=<chksum>] (<cr>|<lf>)

```
_______  ______  ___________  ________________________  _____________  ___________
   |        |         |              |                       |            |
   |        |         |              |                       |            |_Ending
   |        |         |              |                       |_Optional       checksum
   |        |         |              |_Mnemonics may be repeated
   |        |         |_Query (?) or value
   |        |_Mnemonic command – see table below
   |_Communications address – Multipoint protocol only
```

RESPONSES

[<adr>:] <nem> <value> [,<nem> <value>]* [=<chksum>] <cr><If>

```
_______  ______  ________  ____________________  _____________  _________
   |        |         |             |                    |             |
   |        |         |             |                    |             |_Ending
   |        |         |             |                    |_Checksum, if received
   |        |         |             |_Mnemonics may be repeated
   |        |         |_Value
   |        |_Mnemonic command – see table below
   |_Communication Address – multipoint only
```

TERMINAL COMMUNICATION COMMANDS

TTM-AC/DC-T ?|<value> 0.0 to +3000.0 minutes per transmission
Output: [<adr>:] TOT, CWT, POT, PWT [=<checksum>]<cr><lf>
TOT is Top Oil Temp CWT is Calculated Winding Temp
POT is Peak Oil Temp PWT is Peak Winding Temp

OTA	?|<value>	-40.0 to +180.0 ºC	(Top Oil Temp Alarm)
WTA	?|<value>	-40.0 to +180.0 ºC	(Winding Temp Alarm)
S1O	?|<value>	-40.0 to +180.0 ºC	(Stage 1 [Oil Cooling Control])
S1W	?|<value>	-40.0 to +180.0 ºC	(Stage 1[Winding Cooling Control])
S1C	?|<value>	0.0 to 100.0 % Full Scale	(Stage 1 cooling current minimum value in %)
S2O	?|<value>	-40.0 to +180.0 ºC	(Stage 2 [Oil Cooling Control])
S2W	?|<value>	-40.0 to +180.0 ºC	(Stage 2[Winding Cooling Control])
S2C	?|<value>	0.0 to 100.0 % Full Scale	(Stage 2 cooling current minimum value in %)
FST	?|<value>	0.0 to 999.9 Seconds	(Alarm Delay Time)
FST	?|<value>	0.0 to +180.0 ºC	(Full Scale Temperature)
FCC	?|<value>	0 OR 1	(Fan Cycle – off / on)
LBP	?|<value>	0.0 to 120 Hours	(Lookback Period)
LBH	?|<value>	1 to 120 Hours	(Lookback Hours)
LBT	?|<value>	-40 to +180.0 ºC	(Lookback Temperature)
LBS	?|<value>	0 to +180.0 ºC	(Lookback Setback Temperature)
OTT	?|<value>	0 to +180.0 ºC	(Top Oil Trip Temperature)
WTT	?|<value>	0 to +180.0 ºC	(Winding Trip Temperature)
TDT	?|<value>	10 to 999.9 Seconds	(Trip Delay Time)

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FRONT PANEL LED INDICATORS AND ALARMS

EACH LED INDICATOR WILL LIGHT CONTINUOULSY WHILE AN ALARM CONDITION IS PRESENT. EACH LED WILL BLINK IF THE ALARM CONDITION HAS OCCURRED BUT IS NO LONGER VALID. BLINKING WILL CONTINUE UNTIL THE TTM-T HAS BEEN RESET BY PUSHBUTTONS. This feature is useful to identify the cause of short term alarm conditions.

30 AMP TRIP CONTACTS ARE LOCATED ON THE REAR OF THE CIRCUIT BOARD. (TERMINALS 1 & 2 ON REAR TB#1)

TRIPPED INDICATORS ARE LOCATED ON THE MAIN DISPLAY. THE DISPLAY WILL INDICATE "TRIPPED" UNDER THE PRESENT TOP OIL OR WINDING TEMPERATURE. (WHICHEVER CAUSED THE TRIP)

TRIPPED INDICATORS MUST BE MANUALLY RESET BY PRESSING BOTH RESET BUTTONS.

Note: We have designed several safety features into the trip function.

1. A trip condition must remain on continuously for the trip delay time period. Any temperature scan below the trip temperature forces the timing period (TRIP DELAY) to restart.
2. RTD failure inhibits the trip function. (The display will read "RTD FAILURE")
3. High temperature alarm condition must be currently present before the trip is allowed.

EXPLANATION OF HYSTERESIS

The HYSTERESIS setting is a deadband adjustment for toggling an event or alarm. It is there to increase stability and prevent fast on-off operations of alarms and events.

Example 1: (HYSTERESIS = 2.0 deg C and Alarm is set for 60 Deg C.)
Alarm is activated at 60 Deg. C (After ALARM TIME DELAY)
Alarm will not reset until temperature is reduced to 58 Deg. C.

Example 2: (HYSTERESIS = 2.0 deg C and cooling stage #1 is set to start at 50 Deg C.)
Cooling starts at 50 Deg. Cooling stage #1 runs until temperature is reduced to 48 Deg. C.
(This will prevent repeated application of starting current to the cooling motors)

Lookback setback example: *Given lookback period setting= 96 hours; Lookback temperature setting=+33 C ("+" sign not entered on TTM-AC/DC-T); Lookback hours setting= 8 hours; and Lookback setback= 10 C. In a rolling window of 96 hours from any present hour, when there have been 8 cumulative hours during which the ambient temperature exceeded 33 C (91.4 F), the cooling devices start point will be biased to initiate 10 degrees C less than the TTM-AC/DC-T display cooling mode entered set point.*

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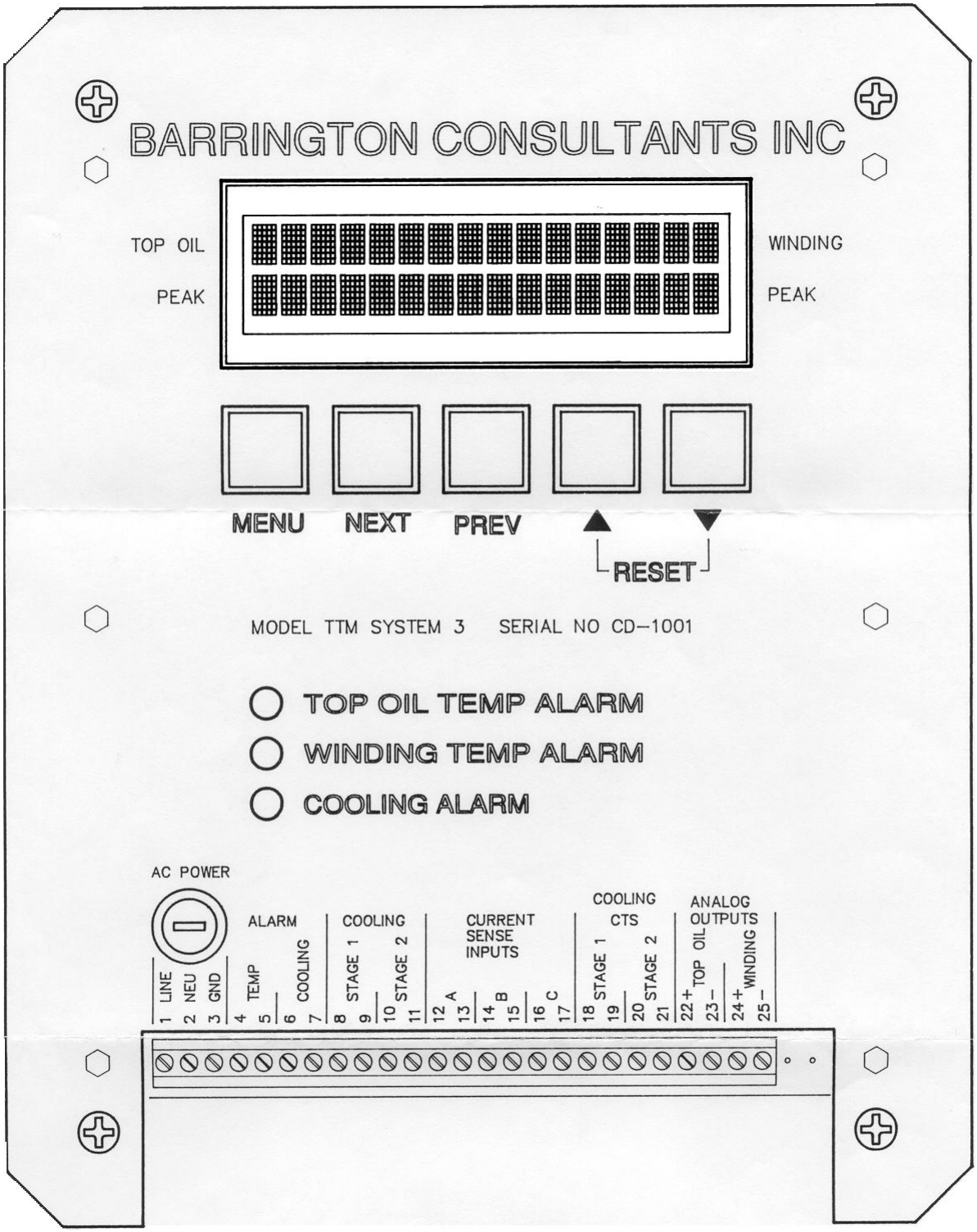
II. TTM-AC/DC-T-AC/DC INSTALLATION GUIDE



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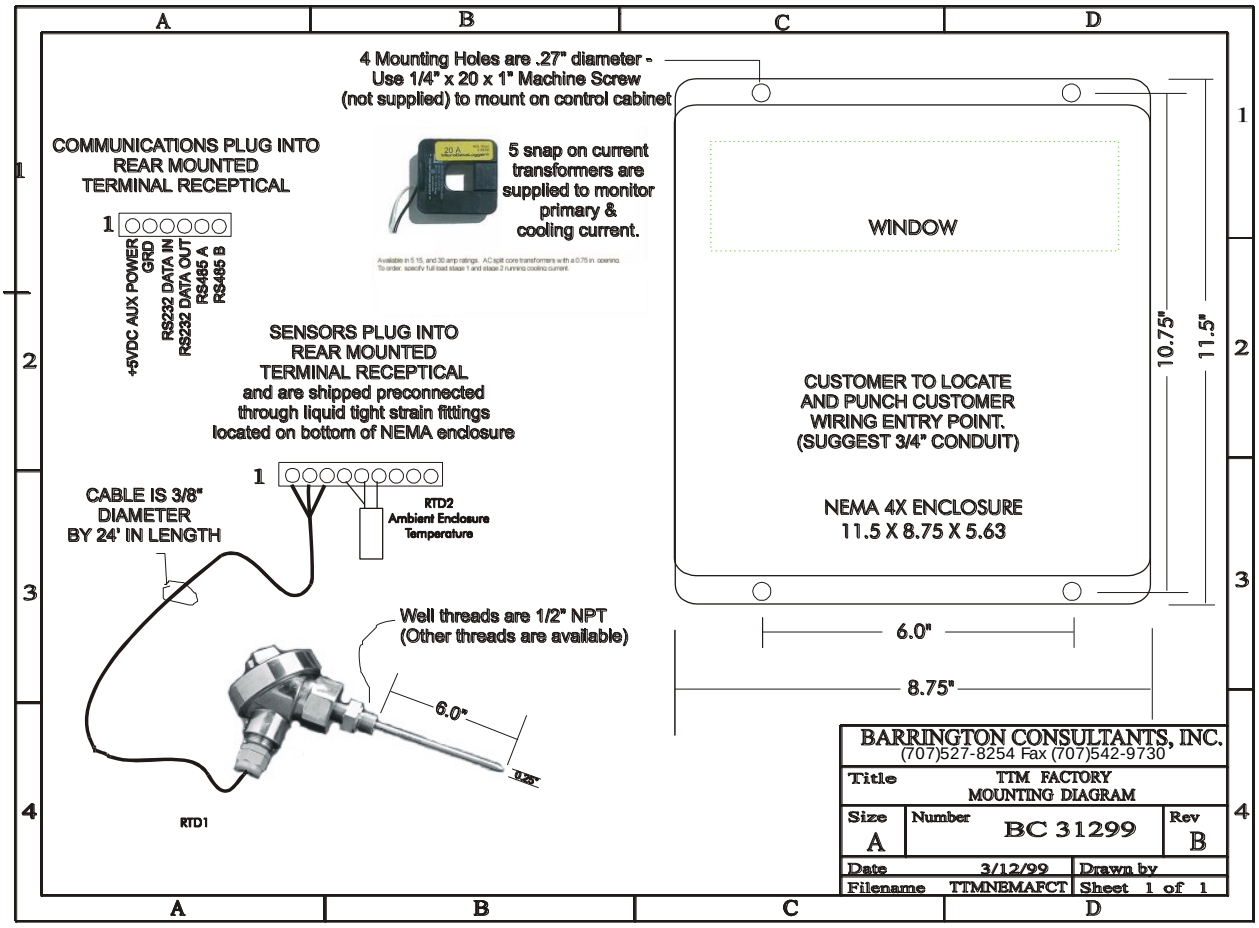

All relay contacts (except trip) are normally closed until power is applied to the TTM-AC/DC-T. This will provide a "fail safe" mode of operation. Before installation, always safety check your work area, review your plans, and apply caution to preclude accidents, errors, or undesired outcomes.

FIELD MOUNTING & INSTALLATION

1. Mount the TTM using four machine screws.
2. Punch and mount a 3/4" conduit elbow from the underside of the TTM to the interior of the control cabinet. Provide rated power to the TTM.
3. Install the temperature probe. The temperature probe supplied is ¼" X 6" (spring loaded). For field orders an adapter sleeve for ¼" to ½" is also supplied. Additionally an adapter is supplied for ½" NPT to 7/8" X 14 thread thermowells. Coil up the extra probe cable and tie wrap, or shorten to desired length.
4. Factory orders include a ½"NPT Brass Thermowell and no adapters are included.
5. Set the analog out put jumpers on the back of the circuit board for the desired analog output modes. (see page #5) 0-1 ma is the factory default
6. Configure the TTM (Using the Configuration Menu) for the same analog scaling values selected above.
7. Connect the top oil / winding alarm contact point to an existing annunciation system. The contacts are "dry" and are compatible with existing annunciators.
8. Snap the A, B, & C phase snap on current transducers around the high or low side bushing CT secondarys. (Shorting blocks should be available in the control cabinet for easy accessibility) Wire them to the CURRENT SENSE input terminals. (12-17)

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9. Snap the stage one and stage two snap on current transducers around the power source to each stage of cooling. (Usually available and located at the cooling stage contactor.) Wire them to the cooling CT input terminals. (18-21)

CALIBRATING MAIN TANK AND AMBIENT TEMP ANALOG OUTPUT VALUES

Pressing "NEXT" AND "PREVIOUS" at the same time enters the calibration mode.

1. Determine which analog output is desired and configure the jumpers on the rear of the circuit board. The following is a description of the 0 – 1 mA calibration procedure.
2. Enter the configuration mode by pressing menu and holding for 3 seconds.
3. Configure the analog outputs to match the output jumpers selected in step 1.
4. Press "MENU" (or wait for 30 seconds) to return to the default four temperature display.
5. Enter calibration procedure by pressing "NEXT" AND "PREV" AT THE SAME TIME.
6. Display will read ANALOG #1.
7. With a very accurate DC ammeter, read current across analog output #1.
8. Current should read 1.000 DC ma.
9. Using the up and down arrows, adjust the output voltage to read 1.000 DC mA.
10. Pressing "NEXT" will display ANALOG OUTPUT #2.
11. Repeat steps 7 and 8 for analog #2.
12. Press the "MENU" key (or wait for 30 seconds) to return to normal operation.

CALIBRATING STAGE 1 AND STAGE 2 100% CURRENT VALUES
Pressing "NEXT" AND "PREVIOUS" at the same time enters the calibration mode.

1. After entering the calibration mode, press next until the Stage#1 display appears.
2. While stage #1 cooling is running, adjust the percentage to 100%. Use up or down arrow to nudge the percentage values. Note: Pressing both the up and down arrows simultaneously will automatically set the 100% value. The current transformer normally supplied is rated for 15 amps AC cooling current. (Other ranges are available)
3. Press next until the Stage#2 display appears.
4. While stage #2 cooling is running, adjust the percentage to 100%. Use up or down arrow to nudge the percentage values. Note: Pressing both the up and down arrows simultaneously will automatically set the 100% value. The current transformer normally supplied is rated for 15 amps AC cooling current. (Other ranges are available)

CALIBRATING A B & C PHASE 100% CURRENT VALUES
THE TTM-AC/DC-T IS SET AT THE FACTORY FOR 5 AMPS SECONDARY EQUALS 100% PRIMARY CURRENT.
Pressing "NEXT" AND "PREVIOUS" at the same time enters the calibration mode.
(METHOD #1)

1. After entering the calibration mode, press next until the PHASE A display appears.
2. While applying 5 amps (or full scale secondary CT rated current) through the A PHASE snap on current transformer, adjust the percentage to 100%. Use up or down arrow to nudge the percentage values. Note: Pressing both the up and down arrows simultaneously will automatically set ("LEARN") the 100% value.
3. Press next until the PHASE B display appears.
4. While applying 5 amps (or full scale secondary CT current) through the B PHASE snap on current transformer, adjust the percentage to 100%. Use up or down arrow to nudge the percentage values. Note: Pressing both the up and down arrows simultaneously will automatically set the 100% value.
5. Press next until the PHASE C display appears.
1. While applying 5 amps (or full scale secondary CT current) through the C PHASE snap on current transformer, adjust the percentage to 100%. Use up or down arrow to nudge the percentage values. Note: Pressing both the up and down arrows simultaneously will automatically set the 100% value.

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(METHOD #2) This calibration method is useful for installation on in service transformers

1. Determine the current percentage of full load current.
2. After entering the calibration mode, (NEXT AND PREVIOUS) press next until the PHASE A display appears.
3. Adjust the calibration percentage (USING THE UP AND DOWN ARROWS) to match the actual percentage.
4. Press NEXT to display PHASE B.
5. Repeat step 3.
6. Press NEXT to display PHASE C.
7. Repeat step 3.

The display "Full Scale Rise" refers to the winding temperature increase above Top Oil temperature furnished by the manufacturer. The TTM-AC/DC-T calculates the winding temperature as a direct degree (C) increase over top oil temperature based upon this data. Using the configuration menu enter the full scale winding temperature increase over the oil temperature provided by the transformer manufacturer's heat run data. (Usually 15 degrees C for a 65 degree rise transformer) This data refers to the C temperature difference between the transformer main tank oil temperature and the winding temperature at full rated load. *The referenced value is not nameplate ambient temperature rise*. The winding temperature is calculated based upon the highest of the three current values. If the manufacturer's value has been de-rated or modified by your authorized in-house actions, use the value specified by your authorized alternative sources.

For installation on single phase transformers connect only one of the snap on CTs.

Barrington consultants would appreciate any feedback about the TTM-AC/DC-T. We want to provide top quality products to satisfied customers. We will be happy to answer any questions you might have about installation or operation of our products.

It is the user's responsibility to determine proper set points, adequately engineer, test, install, and ensure desired operating status.

Barrington Consultants Inc. assumes no responsibility for installation or user operation of the TTM-AC/DC-T.

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TTM-AC/DC-T SPECIFICATIONS

RTD	-100°C to 600°C (DIN 43760 Class B) .00385 ohms/ohm/ °C
STABILITY	Maximum change in ice point resistance of less than 0.2°C/Year
REPEATABILITY	0.05% of actual span

INPUT	Dual Pt 100 RTD (One Top Oil Temp & One Ambient Temp)
TOP OIL INPUT PROBE TYPE	(1ea) 6" X ¼" probe W ½" NPT Thread (7/8" X 14 thread adapter supplied) or (1ea) 75LB Pull Surface Magnetic
INPUT PROBE CABLE	24' type UV/SJT
INPUT SPAN	-40□C Min 200°C Max
ANALOG OUTPUT	0 - 5V, 0-1mA or 4-20mA (Independently selectable)
LINEARITY	Better than 0.2% of span
LEAD WIRE COMP.	Automatic – 3 wire
TEMPERATURE STABILITY	Better than .03% /°C of span
Surge Withstand	Designed to meet ANSII/IEEE C37.90
C.M.R.R.	120db DC to 60 Hz
POWER SUPPLY RANGE	120 or 240 VAC 50/60hz -or- 110 to 270VDC (auto-sensing)
OPERATING TEMP.	-20°C (-40 optional heater) to +70°C
ENCLOSURE	NEMA 4 10" X 8" X 6"
DIGITAL RESOLUTION:	>12 bits.
OVERALL ACCURACY	Less than 0.3°C input temperature / display
ALARM:	Dry contact spst relay output rated @ 5A 250 VAC.
ALARM RESPONSE TIME:	Programmable - .1 sec to 999.9 sec.
ALARM HYSTERESIS	0.1 TO 100 DEG C (DEAD BAND)
DISPLAY:	16 × 2 Character .39" LCD indicator for programming and display of input and output parameters and status.
SUPPLY:	100 to 260 VAC/DC 50/60 Hz
OPERATING CONDITIONS:	-20°C to +70°C. 0-95% RH, non condensing.
STORAGE TEMP.:	-55°C to 105°C.
HUMIDITY:	0-95% RH, non condensing.
TURN-ON TIME:	Within 60 seconds to rated response.
RESPONSE TIME:	5 seconds to 99% of reading. (1 update/second).
DAMPING FACTOR:	10.0 Seconds.
TTM-AC/DC-T LONG TERM STABILITY:	Less than ±0.1% of span for six months.
(D/A) LINEARITY:	±O.O5% of span.
LINEARIZATION:	better than ±0.03°C for Pt-100 RTD,
CALIBRATION:	adjustable on-site, factory preadjusted

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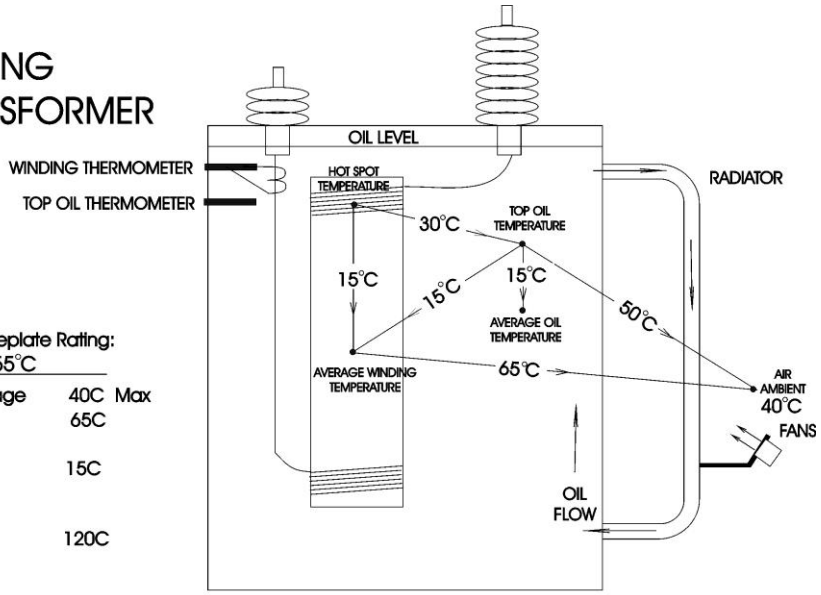
TRANSFORMER HEATING
65 DEG C RISE TRANSFORMER

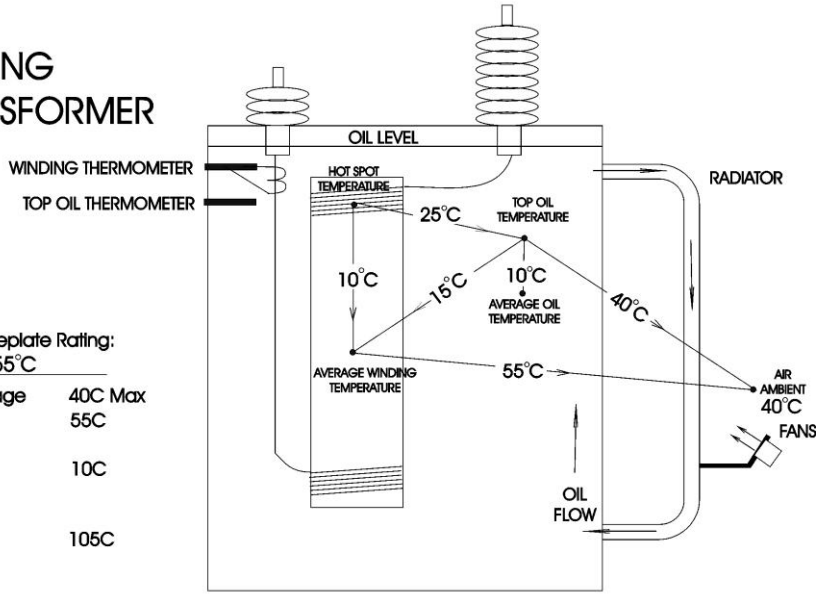


Typical Temperature Difference At Nameplate Rating:
Rated Average Winding Rise: 55°C

Ambient:	30C Average	40C Max
Average Winding Rise	65C	65C
Hot Spot Rise Over Average Winding:	15C	15C
Max Hot Spot Temp For Normal Life:	110C	120C
Top Oil Alarm Setting:	90C	
Winding Alarm Setting:	120C	

TRANSFORMER HEATING AND TEMPERATURE RELATIONSHIPS

TRANSFORMER HEATING
55 DEG C RISE TRANSFORMER



Typical Temperature Difference At Nameplate Rating:
Rated Average Winding Rise: 55°C

Ambient:	30C Average	40C Max
Average Winding Rise	55C	55C
Hot Spot Rise Over Average Winding:	10C	10C
Max Hot Spot Temp For Normal Life:	95C	105C
Top Oil Alarm Setting:	80C	
Winding Alarm Setting:	105C	

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TTM-AC/DC-T, Transformer Temperature Monitor, Complete with Standard 6" ½"NPT thread replacement RTD well probe, 24ft SJT UV treated connector cables, 5 Snap-On current transformers, SCADA ready outputs for Top Oil, Calculated Winding Temperatures, Two adjustable dry contacts for temperature and cooling alarms, Ambient compensation, 2 stage cooling control, Four display readout with Top oil, Calculated Winding, Peak Top oil, and Peak Winding temperatures, Trip option, RS232/485/485 multipoint communications. NEMA type 4x windowed enclosure. **Delivery - Stock to 6 weeks ARO**

The TTM-AC/DC-T may be special ordered with the following options:

1 Special sensor probe lengths and threads.
2. Top Oil and/or Winding Temperature TRIP capability
3. Various Cooling CT ratioes. 15, 30, 60, 100 Amp
4. Substitute Magnetic surface mount RTD temperature probe instead of thermowell RTD probe.
5. ¼" x 6" ½"NPT Brass Thermowell
6. 7/8 x 14 thread adapter for 7/8 x 14 thermowell

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