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MODEL TDM System 3

ON-LINE LTC TEMPERATURE DIFFERENTIAL MONITOR
Monitoring & LTC Failure Avoidance Alarm

BCI Bulletin BCI-TDM-5.1 Revision August 1, 2002

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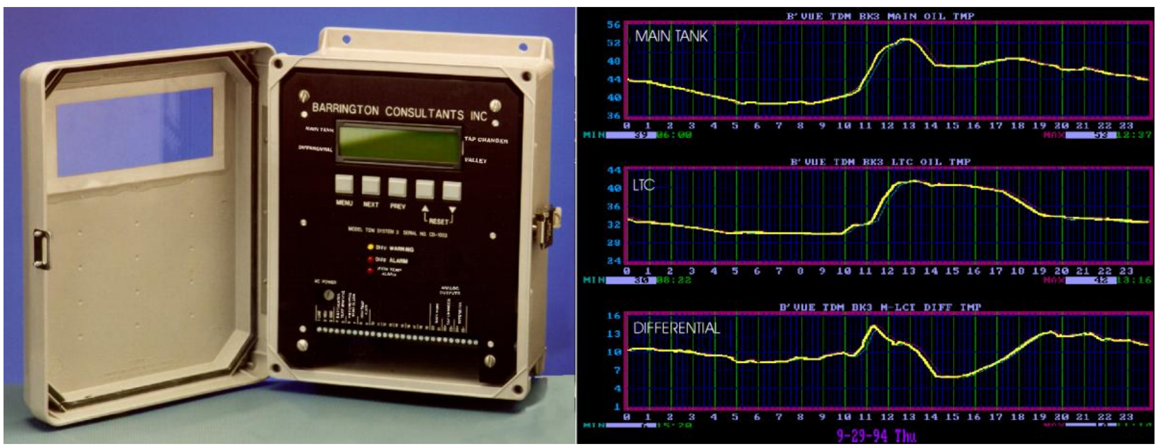
I. Description of Operation

The model TDM SYSTEM 3 is a solid state device that monitors differential temperature (ΔT) between the transformer main tank and the load tap changer (LTC) compartment. The unit is SCADA ready and provides alarming for differential temperatures. The TDM SYSTEM 3 is designed for easy installation on transformers and requires no internal tank connections.

Heating in the LTC compartment is a key indicator of potential failure. By monitoring the temperatures in both the main transformer tank and the LTC compartment, early detection and alarming can provide a real edge in failure avoidance. While no system can prevent every failure, the TDM System 3 is a cost effective tool in monitoring and alarming to provide both, a maintenance alert for slowly increasing ΔT or immanent failure warning for high ΔT. Failures originating in LTC mechanisms are common in the industry. TDM System 3 provides the edge for failure risk management, while providing a maintenance indicator measurable at the same time.



TDM SYSTEM 3 With Typical SCADA Trending Data

The temperatures are monitored by using one Dual 75LB pull magnetic surface mount platinum 100 Ohm RTD each, on the exteriors of the LTC compartment and main transformer tank at an upper location in oil space. The unit includes 30 year UV treated SJT jacketed connecting cables for the two RTD magnetic sensor units.

The TDM System 3 has three SCADA analog output channels and three independently adjustable dry contact relays for local alarming functions. Factory settings are -1 deg C for ordinary and -5 deg C for urgent alarms. Alarm setpoints are easily changed on or off site.

The display is shown at all times, except during user entry and menu action. The default display is main tank temperature, LTC temperature, differential temperature (ΔT) and valley temperature.

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LTC Failure and LTC Temperature

Main Dial Switch

1. Arcing tip fracture	Temperature Increase
2. Oxidation	Temperature Increase
3. Overload	Temperature Increase
4. Misalignment	Temperature Increase
5. Poor maintenance	Temperature Increase

Reversing Switch Failure

1. Inactivity in operating	Temperature Increase
2. High contact resistance	Temperature Increase
3. Overheating	Temperature Increase
4. Coking - Carbonizing	Temperature Increase

Load Transfer Switch Failure

1. Contact erosion from normal load	Temperature Increase
2. Mechanical failure from poor timing	Temperature Increase
3. Improper contact alignment	Temperature Increase
4. Improper contact pressure	Temperature Increase
5. Weak drive spring assembly	Temperature Increase

Main Diverter Tank

1. Carbon build up	Temperature Increase
2. Dielectric strength deterioration	Temperature Increase

Drive mechanism

1. Faulty mechanism	Temperature Increase
2. Inter tap interlock failure	Temperature Increase

Loading

1. Overloading	Temperature Increase

The above list was compiled from actual historical records of various LTC failures and causes. Temperature is the most universal indicator for this list. This includes situations where fault gas is not generated but heating takes place due to overloading, or lack of adequate contact pressure. Contact wear occurs as the load tap changer operates to maintain a constant voltage with varying load. This erosion is a normal operating characteristic, but the rate can be accelerated by improper design, faulty installation, misalignment, and high loads. The TDM System 3 can detect and alarm, even when the heating condition only occurs during peak loading. In this way the ΔT (differential temperature) alarms can be set to flag the need for routine LTC maintenance or alarm for immediate action (failure avoidance). The TDM System 3 is the answer to both needs.

Coking usually occurs at the end of the normal contact life cycle. Contact wear is proportional to the square of the current through the contacts, therefore heavily loaded LTCs may create a thermal runaway condition in which contact resistance increases rapidly, causing more coking and more heating. Arcing is normal for reactance and resistive type LTCs. This produces carbon which can be deposited on the tap changer contacts. This layer of carbon can increase the resistance of the contacts and cause heating and coking. Thus the cycle is again a thermal indicator and self destructive. (*Normal tap changer contact resistance is commonly maintained at less than 80 microohms.)*

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Common Causes of Thermal Runaway Conditions

Cause	Symptom	TDM Alarms
Arcing time increase	Temperature increase	YES
Oil carbonizes quicker	Temperature Increase	YES
Increased contact wear	Temperature Increase	YES
Increased arcing time	Temperature Increase	YES
Increased contact oxidizing	Temperature Increase	YES
oil sludge's (Dirty Oil)	Temperature Increase	YES
Loading (excessive)	Temperature Increase	YES
Faulty installation, etc.	Temperature Increase	YES
Misalignment	Temperature Increase	YES

SAFETY!

The TDM System 3 is a product that can alert utility companies to all of the above abnormal conditions in Load Tap Changers. Extra precautions should then be taken when manually operating LTCs
which show symptoms of internal abnormalities.

Employee Caution & TDM System 3 working together to reduce risk,
Increase safety margin, & keep employees SAFE!

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Front Panel & Display

The TDM SYSTEM 3 features a new, user friendly interface. At the heart of this interface is a 2 line by 16 character alpha-numeric display and a five key keypad.

The TDM SYSTEM 3 unit features a standard display of temperature data. This standard display is shown at all times except when a user has entered one of the two menus to setup the control of the unit. If the user leaves the unit in one of these menus, it will timeout and return to the standard display.

Standard Temperature Display

Main tank temp →	**65.2ºC**	**61.6ºC**	← LTC tank temp
Differential temp ΔT→	**3.6ºC**	**-1.2ºC**	← Valley temp

The display shows the current temperature of each sensor, the difference between the two sensors and the "valley" difference temperature seen since the last reset. Pressing both the " UP " &" DOWN " resets this value to the current difference temperature.

KEYPAD KEYS

MENU When pressed and released, the unit starts the main menu sequence of displays to allow the user to setup the normal operating parameters. When held for three seconds, the unit enters the configuration menu. This secondary menu allows the user to setup the units configuration and calibration of the unit.

NEXT When the unit 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.

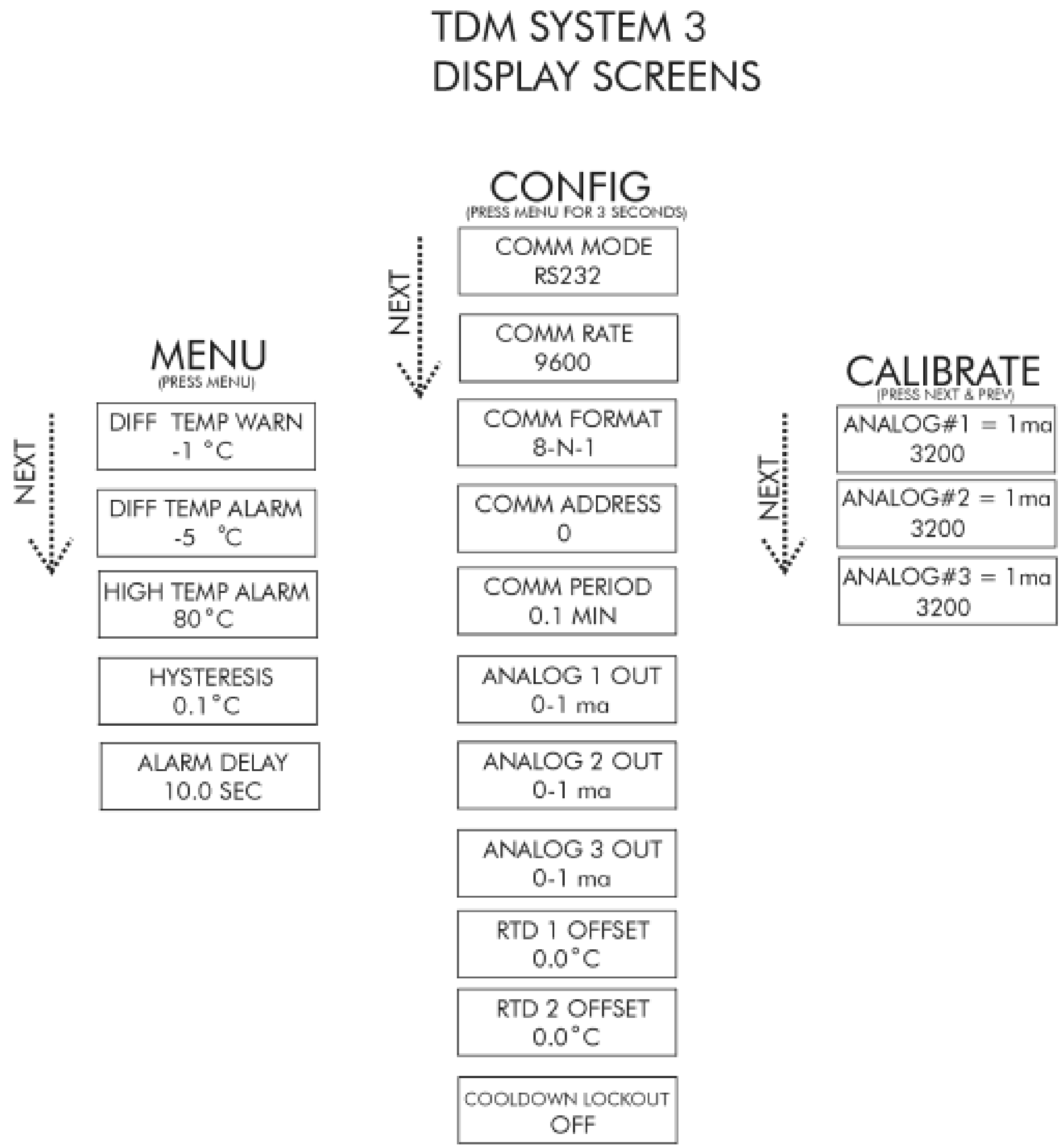
PREV When the unit is displaying the standard display, no action is taken. When in the main or secondary menu, pressing this key will return to the previous item in the menu's sequence.

∇ When the unit is displaying the standard display, no action is taken. When in the main or secondary menu, pressing this key will advance the current parameter to the next possible value.

Δ When the unit is displaying the standard display, no action is taken. When in the main or secondary menu, pressing this key will change the current parameter to the previous possible value.

∇ Δ Simultaneously pressing both the **∇ Δ** and will reset the valley temperature to current value.

MENUS:
The TDM SYSTEM 3 has a set of menus to setup control values and unit configuration.



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The lists below detail the sequence for each menu item. The COMM column indicates which values may be read and /or written through the communication link.

MAIN MENU ITEMS

COMM. DISPLAY	ACTION	DESCRIPTION	COMM
DIFF TEMP WARN <value>	Numerical entry Note ΔT will be negative value when LTC temperature is greater than that of main tank (ΔT= main tank oil temp- LTC compartment oil temp)	Differential temperature warning value Default –2.3C degrees C, range –40C to +180C	no
DIFF TEMP ALARM <value>	Numerical entry Note ΔT will be negative value when LTC temperature is greater than that of main tank (ΔT= main tank oil temp- LTC compartment oil temp)	Differential temperature urgent value Default –3.5 C degrees C, range –40C to +180C	no
HIGH TEMP ALARM <value>	Numerical entry	High temperature alarm value Either LTC or main tank temperature that exceeds this high temp alarm trigger (setpoint) will initiate alarm. Degrees C, range –40C to +180C	yes
HYSTERESIS <value>	Numerical entry	Control hysteresis value establishes a “deadband” before reset Default set at 0.1 C Range 0.1 to 100.0 C	yes
ALARM DELAY <value.	Numerical entry	This value establishes a time delay before alarm initiation Default = 1 second Range 1.0 to 1000 seconds	yes

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CONFIGURATION & CALIBRATION MENU ITEMS

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 output*	Communication output period Range: 0.0 to 3000.0 minutes	yes
COOLDOWN LOCKOUT	Down/Up to select "OFF" or ON"	If selected to "ON" mode, alarming & valley update is disabled while LTC temperature is deceasing	yes
ANALOG 1 OUT <mode>	Down/Up to select	Analog output 1 mode (main tank) Possible modes- 0 -1ma, 4-20ma, 0-5v	no
ANALOG 2 OUT <mode>	Down/Up to select	Analog output 2 mode (LTC compartment) Possible modes- 0 -1ma, 4-20ma, 0-5v	no
ANALOG 3 OUT <mode>	Down/Up to select	Analog output 3 mode (ΔT main tank minus LTC) 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 temperature*	RTD 2 offset value in tenths of a degree Range: -20.0 to +20.0ºC	read

COMMUNICATIONS STRING FORMAT:

Syntax:

[..]	Optional items
<..>	Value field
?	Value query
*	Preceding item may be repeated
<cr>	Carriage return
<lf>	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 tables below
   |_ Communication Address - multipoint protocol only
```

RESPONSES:

```
[<adr>:] <nem> <value>) [,<nem> <value>]* [=<chksum>] <cr><lf>
________ _____ ________ _________________ ___________ ________
   |      |     |           |            |        |
   |      |     |           |            |        |_ Ending
   |      |     |           |            |_ Checksum, if received
   |      |     |           |_ Mnemonics may be repeated
   |      |     |_ Value
   |      |_ Mnemonic command - see tables below
   |_ Communication Address - multipoint protocol only
```

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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
Differential Temp 0°C	0.500 mA	12.00 mA	2.50 VDC
Slope per °C	0.004 mA	0.050 mA	0.020 VDC
Minimum Scale	0 mA = -125 °C	4 mA = -160°C	0 VDC = -125 °C
Maximum Scale	1 mA = +125 °C	20 mA = +160 °C	5 VDC = +125 °C

TDM SYSTEM 3 – IBM INTERFACE CABLE (PC SERIAL CABLE)

SIGNAL	TDM SYSTEM 3	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 4	
DATA -	PIN 5	

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 98)

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 = 1.0 deg C and High Temp Alarm is set for 80 Deg C.)
Alarm is activated at 80 Deg. C (After ALARM TIME DELAY)
Alarm will not reset until temperature is 79 Deg. C.

Example 2: HYSTERESIS = 0.1 deg C (default) and differential alarm is set for -5 Deg C.)
Alarm is activated at -5 Deg. C (After ALARM TIME DELAY)
Alarm will not reset until temperature is –4.9 Deg. C.

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COMMAND DEFINITIONS:

Set TDM SYSTEM 3 Alarm, Data output rate or Get TDM SYSTEM 3 data set

TDM ?|<value> 0.0 to +3000.0 minutes per transmission

OUTPUT: [<adr>:] MTT, TCT, DIF, VAL [=<checksum>]<cr><lf>

MTT is Main Tank Temp TCT is Tap Changer Temp
DIF is Differential Temp VAL is Valley temp

Set / Get Differential Temperature Warning value.
DTW ?|<value> -130.0 to +130.0 degrees C

Set / Get Differential Temperature Alarm value.
DTA ?|<value> -130.0 to +130.0 degrees C

Set / Get High Temperature Alarm value.
HTA ?|<value> -40.0 to +180.0 degrees C

Set / Get Alarm Delay Time.
ADT ?|<value> 1.0 to +1000.0 seconds

Set / Get Hysteresis value.
HYS ?|<value> 0.1 to +100.0 degrees C

Get RTD #1 calibration offset value.
R1O ? -20.0 to +20.0 degrees C

Get RTD #2 calibration offset value.
R2O ? -20.0 to +20.0 degrees C

NOTES:
1. All numbers are passed as ASCII strings. (CAPS LOCK ON)
2. Maximum input and output string length is 80 characters including ending.
3. All spaces and tabs outside tokens are ignored.
4. All control characters except <cr> and <lf> are ignored.

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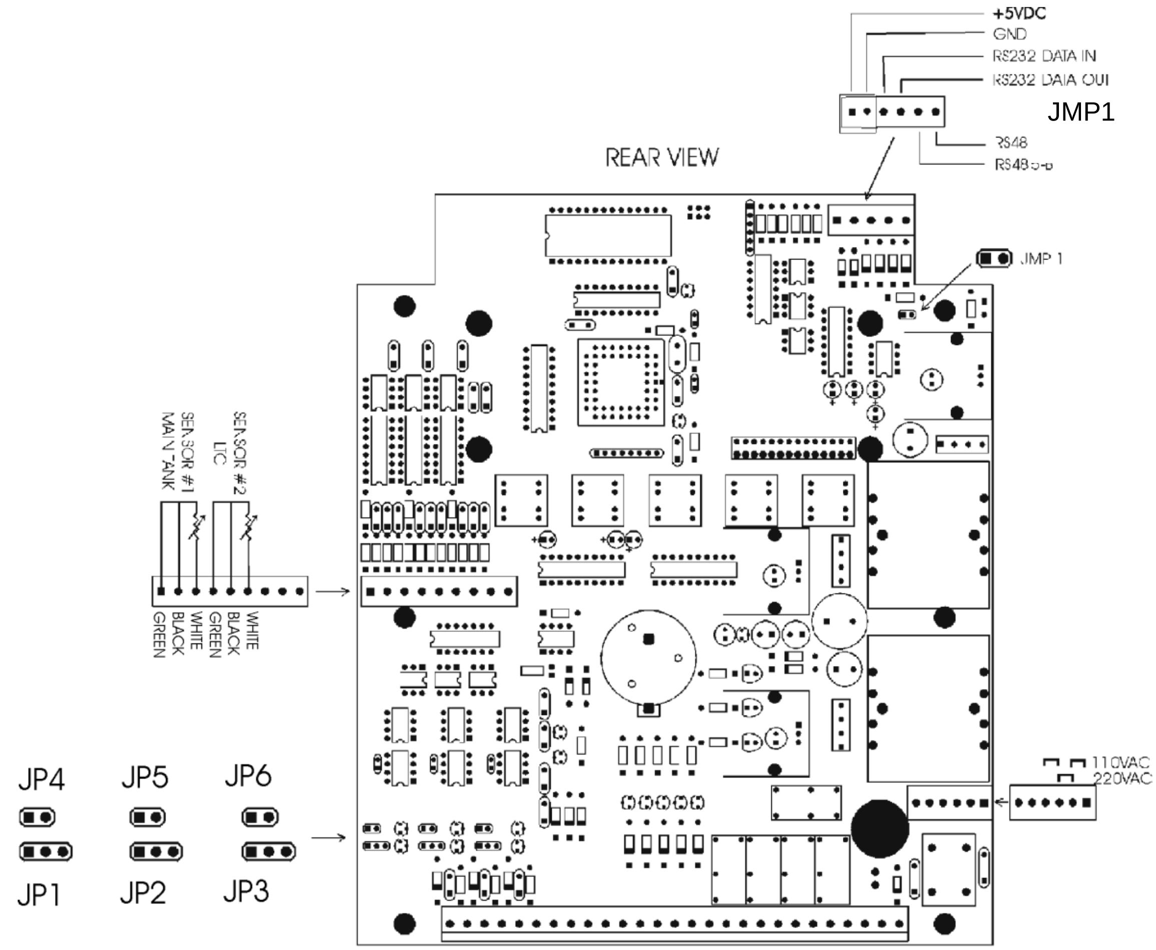


CONFIGURATION JUMPERS: (* = DEFAULT)

JP1	Difference Analog Output	Jumper on 1&2 – Enables Voltage
		Jumper on 2 & 3 - Enables Current *
JP2	LTC Analog Output:	Jumper on 1 & 2 - Enables Voltage
		Jumper on 2 & 3 - Enables Current *
JP3	Main Tank Analog Output:	Jumper on 1 & 2 - Enables Voltage
		Jumper on 2 & 3 - Enables Current *
JP4	Difference Analog Output:	Jumper on - 4 to 20 ma
		Jumper off - 0 to 1 ma *
JP5	LTC Analog Output:	Jumper on - 4 to 20 ma
		Jumper off - 0 to 1 ma *
JP6	Main Tank Analog Output:	Jumper on - 4 to 20 ma.
		Jumper off - 0 to 1 ma *
JMP1	RS485 Termination.	Jumper on - Enables 120 Ohm termination *

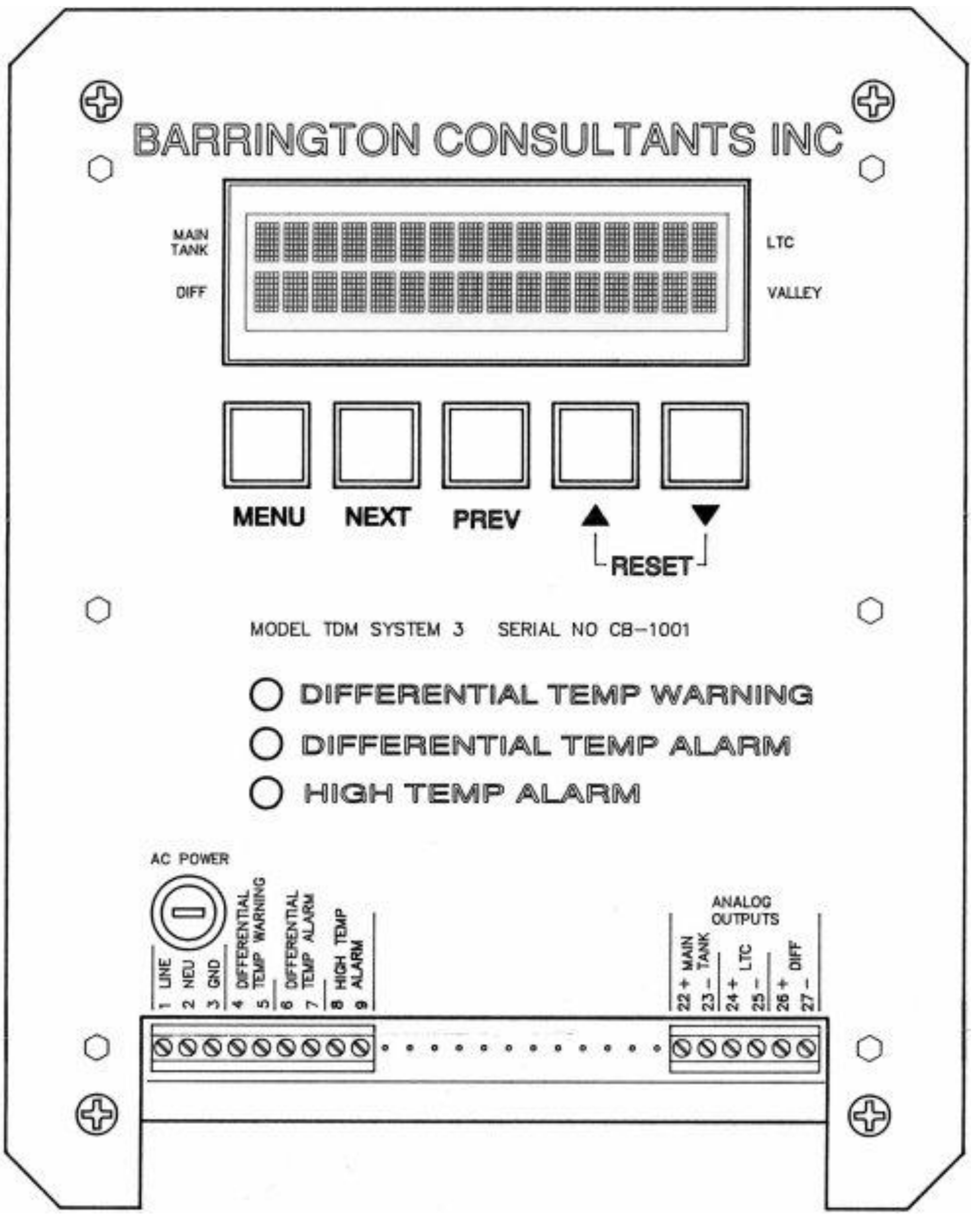
Note: remove the 120 ohm termination jumper (JMP1) for RS232 applications. **II.**

TDM SYSTEM 3 INSTALLATION

This optional procedure will prevent initial false alarms while the TDM SYSTEM 3 determines the proper alarm setpoints.

1. Follow mounting Instructions, but do not hook up the alarms or SCADA input.
2. Let the TDM SYSTEM 3 monitor the two temperatures from a few days to a month or so to establish the alarm setpoint benchmarks. (30 days is recommended)
3. Note the valley temperature. (This is the maximum temperature differential since installation.)
4. Set the first alarm point a little beyond the maximum valley temperature.
5. Set the second alarm point 5 -10 degrees beyond the first alarm point.
6. Complete the wiring and installation to annunciation and SCADA.

Installation requires no service interruption or further calibration.



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1. Mount the TDM SYSTEM 3 on the LTC control cabinet using four machine screws.
2. Punch and mount a 3/4" conduit elbow from the underside of the TDM SYSTEM 3 to the interior of the control cabinet. Provide AC power to the TDM SYSTEM 3.
3. Apply a thin film of heat sink compound or silicon based grease (NO-OX works fine) to the RTD probe surfaces (located under the sensors) and attach the sensors to the tap changer and the main tank. Be sure that both sensors are located below the tank oil level near the top of the tanks and that both sensor cords are located at the bottom of the sensors. Apply RTV or Silicon around the sensors to seal out moisture.
4. Coil up the extra cable and tie wrap. If it is necessary to shorten the cable length, remove them from the NEMA box and shorten them at the terminal plug. Do not remove the cables at the magnetic end of the sensors.
5. Connect the analog points to an existing SCADA system. Program the SCADA master station for the output values selected.
6. Connect the alarm warning contact point to an existing annunciation system. The contacts are "dry" and are compatible with existing annunciators. This alarm has been factory set at -1 degree C. (The alarm will operate when the LTC is 1 degree hotter than the main tank.)
7. The second alarm contact is provided to provide an urgent response alarm. The contacts are "dry" and are compatible with existing annunciators. This alarm has been factory set at -5 degree C. (The alarm will operate when the LTC is 5 degree hotter than the main tank.) This alarm is to intended to indicate if an immediate response is required to prevent a failure.
8. Monitor and establish a "benchmark temperature differential". (VALLEY TEMPERATURE)
9. Set the SCADA temperature DIFFERENTIAL alarm point slightly more negative than the lowest reading. You are looking for a condition where the LTC compartment is hotter than the main tank. This will be indicated by a negative temperature differential. Conditions where the main tank is warmer than the LTC are normal conditions.

"Valley" temperature (**this is the one to watch as it is the maximum differential temperature since the system was last reset.**

Ideally, the warning alarm point for the temperature differential should be set beyond the valley differential temperature. **If the alarm point is set too close, there will be nuisance alarms**. If the alarm point is set too wide, it will not alarm at all. The second alarm relay is intended to indicate a major temperature differential problem. This could be off-step, broken springs, severe arcing, etc. Emergency response is recommended for second alarm conditions.

If the SCADA system has "trending" you can get a normal temperature footprint after installation for later comparison.

Barrington consultants would appreciate any feedback about the TDM SYSTEM 3. 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.

Barrington Consultants bears no responsibility for installation or user operation of the TDM SYSTEM 3. It is up to the user to establish the proper alarm points.

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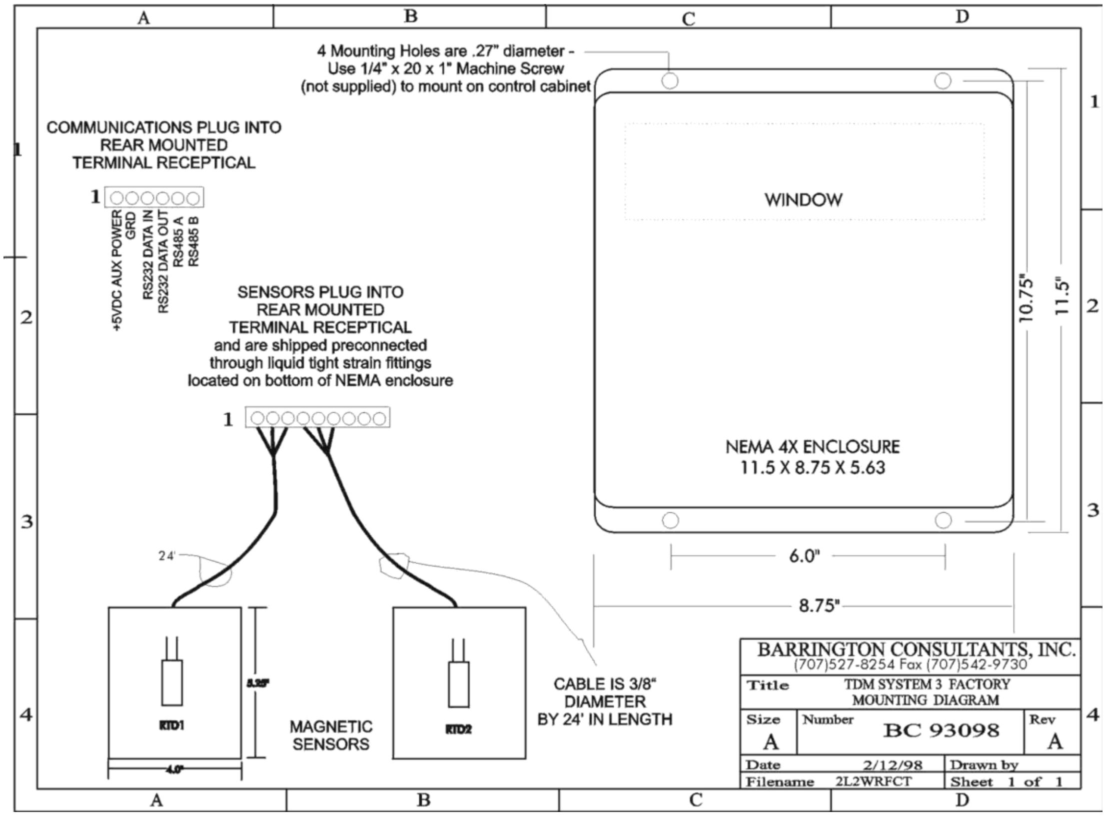

RECALIBRATING MAIN TANK AND LCT TANK ANALOG OUTPUT VALUES

Pressing “NEXT” AND “PREV” at the same time enters the analog output calibration procedure. Calibration is done at the factory but can be readjusted in the field using the following procedure.

1. Determine which analog output is desired and configure the jumpers on the rear of the circuit board.
2. The following is a description of the 0 –1 mA calibration procedure.
3. Enter the configuration mode by pressing menu and holding for 3 seconds.
4. Configure the analog outputs to match the output jumpers selected in step 1.
5. Enter calibration procedure by pressing “NEXT” AND “PREV” AT THE SAME TIME.
6. Display will read ANALOG OUTPUT #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.
12. Pressing “NEXT” will display ANALOG OUTPUT #3.
13. Repeat steps 7 and 8.
14. Press the “MENU” key to return to normal operation.

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TDM SYSTEM 3 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

OIL TEMP INPUT TYPE	75LB Pull Surface Magnetic mount platinum 100 Ohm RTDs (1 each for LTC compartment and main tank)
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)
CALIBRATION	Automatic -40°C to 200°C
LINEARITY	Better than 0.2% of span
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	115/230VAC - 50/60Hz
OPERATING TEMP.	-20°C (-40 optional heater) to +75°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 1000 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:	AC: 115 or 230 VAC 50/60 Hz ± 10%,
OPERATING CONDITIONS:	-40°C to +75°C. 0-95% RH, non condensing.
STORAGE TEMP.:	-55°C to 105°C.
HUMIDITY:	0-95% RH, non condensing.
TURN-ON TIME:	Within 10 seconds to rated response.
RESPONSE TIME:	5 seconds to 99% of reading. (1 update/second).
DAMPING FACTOR:	3.0 Seconds.
TDM SYSTEM 3 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