INSTRUCTION INVOLVED

SD383, MYCRO Multi-Point Display Station, Installation and Service Instruction, issue 1.

SUBJECT

Thermocouple Expander Board

INTRODUCTION

A Thermocouple Expander Board (T/C Board) can either be added in the field to a MYCRO 383B Multi-Point Display Station (MDS) with a 40 terminal case or installed at the factory in a Model 383T MDS. The physical layout of the T/C Board is shown in Figure 1.

The Thermocouple Expander Board is an assembly consisting of a Thermocouple Input Board and an Isolated Power Supply Board. The Isolated Power Supply Board (Figure 2) furnishes isolated supply voltages to the T/C Board. The T/C Board accepts ten thermocouple inputs. Each input can be configured for a thermocouple type and range. Temperature values can be shown on the station's Display Assembly as either a percentage of the full-scale temperature value, or directly in degrees Fahrenheit or Celsius (DEGF or DEGC appears in the alphanumeric display).

SPECIFICATIONS

T/C Board:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T/C Types</td>
<td>J, K, E, T, R, S, B, and N</td>
</tr>
<tr>
<td>(configurable for each input)</td>
<td></td>
</tr>
<tr>
<td>Number of T/C Inputs</td>
<td>10</td>
</tr>
<tr>
<td>Reference Junction Compensation</td>
<td>Automatic</td>
</tr>
<tr>
<td>Normal Mode Rejection</td>
<td>6dB @ 2 Hz</td>
</tr>
<tr>
<td></td>
<td>60dB @ 60Hz</td>
</tr>
<tr>
<td>Common Mode Rejection</td>
<td>120dB @ 60Hz</td>
</tr>
<tr>
<td>Ambient Temperature Effect</td>
<td>+/-0.75% of span</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>Greater than 200,000 ohms</td>
</tr>
<tr>
<td>Isolation Voltage</td>
<td>100 Vdc</td>
</tr>
<tr>
<td>Maximum Continuous Input</td>
<td>+/-30 Vdc</td>
</tr>
<tr>
<td>Linearization</td>
<td>Automatic</td>
</tr>
<tr>
<td>Burnout Protection</td>
<td>Up or down scale (configurable for each input)</td>
</tr>
</tbody>
</table>
FIGURE 1 Thermocouple Input Board
Digital Filter Range .................. 0.001 to 10 Hz (configurable breakpoint frequency)
Resolution ......................... 16 bit
Update Rate for all T/C Inputs ....... 500 ms

Type "J" T/C
Range Limits ....................... -300°F to 2000°F (-185°C to 1095°C)
Zero (configurable) .................. -300°F to 1000°F (-185°C to 540°C)
Span (configurable) .................. 125°F to 2000°F (70°C to 1110°C)
Accuracy ........................... +/-0.7°F for span less than 700°F
 +/-0.1% of span for span greater than 700°F
Burnout Drive Rate ................. 30°F/sec

Type "K" T/C
Range Limits ....................... -300°F to 2500°F (-185°C to 1370°C)
Zero (configurable) .................. -300°F to 1300°F (-185°C to 700°C)
Span (configurable) .................. 175°F to 2500°F (95°C to 1390°C)
Accuracy ........................... +/-0.9°F for span less than 900°F
 +/-0.1% of span for span greater than 900°F
Burnout Drive Rate ................. 30°F/sec

Type "E" T/C
Range Limits ....................... -300°F to 1800°F (-185°C to 980°C)
Zero (configurable) .................. -300°F to 800°F (-185°C to 430°C)
Span (configurable) .................. 100°F to 1500°F (55°C to 835°C)
Accuracy ........................... +/-0.6°F for span less than 600°F
 +/-0.1% of span for span greater than 600°F
Burnout Drive Rate ................. 30°F/sec

Type "T" T/C
Range Limits ....................... -319°F to 750°F (-195°C to 400°C)
Zero (configurable) .................. -319°F to 600°F (-195°C to 315°C)
Span (configurable) .................. 150°F to 900°F (85°C to 500°C)
Accuracy ........................... +/-0.8°F for span less than 800°F
 +/-0.1% of span for span greater than 800°F
Burnout Drive Rate ................. 30°F/sec

Type "R" T/C
Range Limits ....................... 0°F to 3200°F (-18°C to 1760°C)
Zero (configurable) .................. 0°F to 2600°F (-18°C to 1430°C)
Span (configurable) .................. 600°F to 3200°F (330°C to 1780°C)
Accuracy ........................... +/-3°F for span less than 3000°F
 +/-0.1% of span for span greater than 3000°F
Burnout Drive Rate ................. 120°F/sec
Type "S" T/C
Range Limits .......................... 0°F to 3000°F (-18°C to 1650°C)
Zero (configurable) ...................... 0°F to 2400°F (-18°C to 1320°C)
Span (configurable) ..................... 600°F to 3000°F (330°C to 1670°C)
Accuracy ................................. +/-3°F
Burnout Drive Rate ..................... 120°F/sec

Type "B" T/C
Range Limits .......................... 0°F to 3300°F (-18°C to 1815°C)
Zero (configurable) ...................... 0°F to 1800°F (-18°C to 980°C)
Span (configurable) ..................... 1500°F to 3300°F (830°C to 1830°C)
Accuracy .................................. +/-2.5°F for span less than 2500°F
.................. +/-0.1% of span for span greater than 2500°F
Burnout Drive Rate ..................... 100°F/sec

Type "N" T/C (14 gauge)
Range Limits .......................... -300°F to 2350°F (-185°C to 1300°C)
Zero (configurable) ...................... -300°F to 1300°F (-185°C to 700°C)
Span (configurable) ..................... 125°F to 2350°F (95°C to 1300°C)
Accuracy .................................. +/-0.9°F for span less than 900°F
.................. +/-0.1% of span for span greater than 900°F
Burnout Drive Rate ..................... 120°F/sec

INSTALLATION
Install the Thermocouple Expander Board according to the directions in SD383, section 2.6.3, Expander Board. No jumper-plugs or switches need be set. Install the Sensor Board and make all thermocouple connections at the rear terminals. Table 1 shows the rear terminal assignments.

CALIBRATION
The Model 383T contains a factory calibration for each T/C type over the maximum temperature range of each T/C type. The calibration includes 16 gauge T/C extension wire; different gauge wire may cause slight inaccuracies in temperature measurements and each input can be field calibrated as described in this section to resolve any inaccuracies. Recalibration will be necessary if the Base Board, Thermocouple Expander Board, or Temperature Sensor Board is replaced. Use the following procedure to calibrate a Thermocouple Expander Board.

Calibration must be performed with the Board installed in the MDS in which it will be used and the Sensor Board must remain with the MDS. Tables 1 and 2 lists the values for hard configuration parameter HTCT and for calibration parameters 'CZxx' and 'CFxx' of each thermocouple input (where 'xx' is the number of the function block being calibrated). The T/C Board is configured under function blocks 16 to 25.
### TABLE 1 Rear Terminal Wiring and Calibration Parameters

<table>
<thead>
<tr>
<th>T/C INPUT NUMBER</th>
<th>DISPLAY NUMBER</th>
<th>FUNCTION BLOCK</th>
<th>REAR TERMINALS (+) (-)</th>
<th>TERMINAL ASSIGNMENTS</th>
<th>CALIBRATION PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>FB16</td>
<td>C1 C2</td>
<td>A116+, A116-</td>
<td>C116, CF16, CV16</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>FB17</td>
<td>C3 C4</td>
<td>A117+, A117-</td>
<td>C117, CF17, CV17</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>FB18</td>
<td>C5 C6</td>
<td>A118+, A118-</td>
<td>C118, CF18, CV18</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>FB19</td>
<td>C7 C8</td>
<td>A119+, A119-</td>
<td>C119, CF19, CV19</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>FB20</td>
<td>C9 C10</td>
<td>A110+, A110-</td>
<td>C120, CF20, CV20</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>FB21</td>
<td>D1 D2</td>
<td>A111+, A111-</td>
<td>C121, CF21, CV21</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>FB22</td>
<td>D3 D4</td>
<td>A112+, A112-</td>
<td>C122, CF22, CV22</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>FB23</td>
<td>D5 D6</td>
<td>A113+, A113-</td>
<td>C123, CF23, CV23</td>
</tr>
<tr>
<td>9</td>
<td>14</td>
<td>FB24</td>
<td>D7 D8</td>
<td>A114+, A114-</td>
<td>C124, CF24, CV24</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>FB25</td>
<td>D9 D10</td>
<td>A115+, A115-</td>
<td>C125, CF25, CV25</td>
</tr>
<tr>
<td>---</td>
<td>Sensor Board</td>
<td>A9 A8</td>
<td>AI+A1C-</td>
<td></td>
<td></td>
</tr>
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</table>

### TABLE 2 Calibration Parameters

<table>
<thead>
<tr>
<th>T/C TYPE</th>
<th>T/C TYPE HTCT</th>
<th>ZERO INPUT CZxx</th>
<th>MV</th>
<th>°F</th>
<th>FULL SCALE INPUT CFxx</th>
<th>MV</th>
<th>°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>1</td>
<td>-0.885</td>
<td>53.525</td>
<td>1700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>2</td>
<td>-0.692</td>
<td>52.939</td>
<td>2400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>-1.026</td>
<td>70.821</td>
<td>1700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>4</td>
<td>-5.341</td>
<td>19.095</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>5</td>
<td>2.017</td>
<td>19.518</td>
<td>3000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>6</td>
<td>1.962</td>
<td>17.347</td>
<td>3000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>7</td>
<td>3.274</td>
<td>11.829</td>
<td>3000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>-4.277</td>
<td>46.048</td>
<td>2300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
REQUIRED EQUIPMENT

Calibration of a T/C Board requires the use of some or all of the following equipment:

1. Model 383 with T/C Board installed. The Sensor Board must be installed on station rear terminals.

2. Precision millivolt or thermocouple calibration source for required thermocouple type and calibration range. The signal source must be adjustable to an accuracy of +/-0.01% or better and provide a source resistance of 100 ohms or less.

3. Two containers of crushed ice and water and a laboratory bulb thermometer or a commercially produced ice bath reference.

4. Two foot length of appropriate T/C extension wire.

IMPORTANT

Use the same gauge of wire that will be used when the Station is on line.

5. Two 2-foot lengths of #16 gauge, insulated copper wire.


PROCEDURE

Each thermocouple input is calibrated as described below. The process must be repeated for each thermocouple input.

IMPORTANT

The ambient temperature must remain constant during the entire calibration procedure.

The calibration procedure prepares the MDS for the type thermocouple and the zero and full scale calibration input values in millivolts or degrees F for a specific thermocouple temperature range (calibration parameters). Refer to Table 2 for the required calibration input values while calibrating a thermocouple input. Actual operating engineering units (F) and temperature range are entered as hard (H) configuration parameters after calibration is completed.
Three "off-line" methods for calibrating thermocouple inputs are illustrated in Figure 3. Methods 1 and 2 are the most accurate and are therefore recommended. Method 3 is provided as an alternative should circumstances prevent the use of Method 1 or 2.

Select a method from Figure 3 and proceed as follows:

1. With power off at Station, verify that ‘C’ (calibration), ‘T’ (table), ‘H’ (hard), ‘F’ (factory configured option) lockout switches on the Base Board are enabled.

2. Place T/C extension wires (using the actual gauge wire used in the final installation) under the rear terminals of the thermocouple input being calibrated and tighten screws. See Table 1. Do not use alligator or similar clips for connections.

3. Connect as follows:

   Method 1 - Connect each end of the extension wires to separate 2-foot lengths of insulated copper wire (solder or twist ends), and insert junction points into separate ice baths. Connect opposite ends of copper wires to calibration source. (Power off at calibration source.)

   Methods 2 and 3 - Connect T/C extension wires to calibration source. Observe polarity as indicated. (Power off at calibration source.)

4. Refer to Table 1 and connect Sensor Board between rear terminals.

5. Verify Station’s model number and input power requirement. Apply power to Station.

   IMPORTANT

   Allow at least 1 hour for warm up before proceeding. Calibration area’s ambient temperature should be as close as possible to the operating area’s ambient temperature.

6. Press ENTER CONF button to enter configuration mode at MENU level.

7. Set ESN of T/C inputs to be calibrated.

8. To set-in T/C type or check Station’s configured T/C type:

   A. Press ENTER CONF and rotate Pulser Knob to select "H" Menu level on alphanumeric display.

   B. Press STEP DOWN button to enter the FUNCTION BLOCK level.
NOTES:
1. CALIBRATION OF FUNCTION BLOCK 16 IS SHOWN IN FIGURE.
2. WHERE THERMOCOUPLE EXTENSION WIRES ARE SHOWN, IT IS ADVISABLE TO CALIBRATE WITH THE SAME GAUGE OF WIRE USED IN THE ACTUAL OPERATING INSTALLATION.

FIGURE 3 Typical Calibration Hook-Up Diagrams
C. Rotate Pulser Knob to select the appropriate function block.

D. Press STEP DOWN button to enter PARAMETER level. (HTCT appears in alphanumeric display.)

E. Press STEP DOWN and rotate the Pulser Knob to select the desired thermocouple type (e.g., a 2 must be displayed for a type K T/C).

F. Press STORE button to lock-in value.

**IMPORTANT**

Before storing the thermocouple type, be sure that the thermocouple or T/C calibration source has been connected for at least 2 minutes to the station rear terminals for the T/C input being calibrated.

G. Press EXIT button.

9. To set-in Zero Input value:

A. Press ENTER CONF and rotate the Pulser Knob to select the "C" Menu.

B. Press STEP DOWN button and rotate Pulser Knob to desired FUNCTION BLOCK to be calibrated.

C. Press STEP DOWN button to enter PARAMETER level. (CZxx appears in alphanumeric display.)

D. Press STEP DOWN button to enter VALUE level. (CAL appears in 4-1/2 digit display.)

E. Refer to Table 2 and obtain value in millivolts under Zero Input (CZxx) column for type T/C selected.

F. For Method 1, verify that ice baths are at 32°F (0°C). Periodically, stir slurry gently with thermometer and monitor temperature. Add crushed ice as required.
G. Set calibration source as follows:

**IMPORTANT**

For all methods below, allow at least 2 minutes after changing applied input voltage before proceeding to step H. This is to allow the hardware filter voltage time to stabilize.

Method 1 - Apply power to calibration source and adjust output to millivolt value from Table 2 and step E.

Method 2 - A T/C calibrator with direct temperature readout and cold junction compensation is used. Refer to calibrator instruction manual for detailed calibrator operation. Apply power and set temperature in °F to Zero Input value listed in Table 2.

Method 3 - The value obtained for (CZxx) from Table 2 must be compensated to 32°F (0°C) as follows:

a) Touch bulb end of thermometer to one of the input terminals. Allow reading to stabilize before recording temperature.

b) In an appropriate T/C Table, look up the equivalent millivolts.

c) Subtract the millivolts of step b) above from the millivolts obtained in Table 2 for step E.

d) Apply power to calibration source and adjust output to value obtained in step c) above.

H. Press STORE button to store desired value. (CAL blinks and PAUSE will appear for about 5 seconds.)

I. Press STEP UP button once to return to the parameter level.

10. Rotate Pulser Knob to select CFxx on alphanumeric display.

11. To set-in Full Scale Input value:

A. Press STEP DOWN button to enter VALUE level. (CAL appears in 5 digit display.)

B. Refer to Table 2 and obtain value in millivolts from Full Scale Input (CFxx) column for type T/C selected.

C. For Method 1, verify that ice baths are at 32°F (0°C). Periodically, stir slurry gently with thermometer and monitor temperature. Add crushed ice as required.
D. Set calibration source as follows:

**IMPORTANT**

For all methods below, allow at least 2 minutes after changing applied input voltage before proceeding to step E. This is to allow the hardware filter voltage time to stabilize.

Method 1 - Adjust calibration source to millivolts value (CFxx) from Table and step B above.

Method 2 - Refer to calibrator instruction manual for detailed calibrator adjustment. Set calibrator temperature in °F to Full Scale Input value listed in Table 2.

Method 3 - The value obtained for (CFxx) from Table 2 must be compensated to 32°F (0°C) as follows:

a) Touch bulb end of thermometer to one of the input terminals.

b) In an appropriate T/C Table, look up the equivalent millivolts.

c) Subtract the millivolts of step b) above from the millivolts obtained in Table 2 for step B.

d) Adjust output to value obtained in step c) above.

E. Press STORE button to store desired value. (CAL blinks and PAUSE will appear for about 5 seconds.)

12. To verify calibration:

A. Press STEP UP button.

B. Rotate Pulser Knob to select CVxx on alphanumeric display.

C. Press STEP DOWN button. (100.00% should appear in 4-1/2 digit display since calibration source is set to Full Scale Input value.)

D. Adjust calibration source to Zero Input value. (0.00% should appear in 4-1/2 digit display.)

13. Repeat steps 8 through 12 if Station fails calibration verification.

If calibrating other thermocouple inputs, repeat the process beginning with step 8.

If all inputs are calibrated, proceed to step 14.
14. Press EXIT button. (The calibration parameters are transferred to the nonvolatile EEPROM and will remain indefinitely even if power is disconnected from the Station.)

15. Remove power from Station.

16. Disconnect wires from terminals.

NOTE

The Sensor Board between terminals A8 and A9 must remain in place for on-line operation. DO NOT disconnect.

This completes the calibration procedure. Lockout the C (calibration) mode on Base Board.

CIRCUIT DESCRIPTION

THERMOCOUPLE BOARD

The hardware block diagram of the T/C Board is shown in Figure 4. There are 10 identical thermocouple circuits. For clarity, only the first and the last circuits are shown. As Figure 4 indicates, the T/C Board plugs into the Base Board. Thermocouple signals and the Sensor Board Reference currents are routed from the station's rear terminals through the Base Board to the T/C Input Board.

A Reference Junction Temperature Sensor Board must be mounted on case rear terminals A8 and A9. This sensor inputs a current that is proportional to ambient temperature. The Current To Voltage Converter (located on the Isolated Power Supply Board) accepts this current and outputs a voltage (on line IN3) to the Base Board for automatic temperature compensation.

Each of the 10 T/C input channels contains an Open T/C Detection stage, a Gain Block & Filter stage, and an A/D Converter & Shift Register stage. Each channel is powered by an isolated 5V DC to DC Converter on the Isolated Power Supply Board.

The thermocouple input signal is applied to the Open T/C Detection stage. This stage detects and responds to a T/C break. If a break occurs, the station's Display Assembly will show either a -3.3% or 103.3% reading for that channels display, depending on the station configuration.

Station configuration determines the gain of the Gain Block & Filter stage. When configured for a T/C type J, N, K, or E, the gain of the stage is set to "Wide". When configured for a T/C type T, R, S, or B, the gain of the stage is set to "Narrow". The low pass filter circuits remove high frequency noise.
FIGURE 4 Hardware Block Diagram, Thermocouple Input Board
The thermocouple signal is then applied to the input of the A/D Converter. The Converter produces a digital signal on the MISO line, consisting of a hexadecimal number whose value represents the amplitude of the signal (lines SCK and MOSI are used for the serial clock and control functions). The Control Interface sequentially strobes each thermocouple input channel. The values on the MISO lines are then routed through the daisy-chained Isolating Transformers to the Control Interface and to the Base Board. The digitized thermocouple signal then can be manipulated by the MPU.

The output line to the Control Interface circuit can be accessed by the Base Board's MPU and exit via the data bus. The MPU can also initiate a read operation and access the configuration information stored in the UVEPROM Memory. The UVEPROM also contains routines for the MPU to perform the following functions to process digitized thermocouple signals:

1. Linearization
2. Calibration
3. Filtering
4. Output Scaling

The address and data buses deliver information to and from J3.

ISOLATED POWER SUPPLY BOARD

The Hardware Block Diagram of the Isolated Power Supply Board is shown in Figure 5. It contains an Oscillator (U21) that converts the +12 VDC from P1 to a square wave. The Duty Cycle Adjust potentiometer (R9) is factory set and should not be altered by the user. A RESET line enters the Duty Cycle Adjust to provide control over the output. The Buffer/Amplifier (U22) and the Switching Circuit (Q1, Q2) condition the square wave for the ten Isolation & Pulse Transformers (T1-T10). Bridge Rectifiers (BR1-BR10), Filters (C1-C20), and Voltage Regulators (U1-U20) produce ten isolated +5 DC and -5 DC voltages for use on the T/C Board.

A Current to Voltage Converter accepts the current from the Reference Junction Temperature Sensor mounted on rear terminals A8 and A9. The Resistor Ladder (R2, R5) and Converter circuitry (U23) allow the T/C Board to compensate for the ambient temperature. The voltage is sent to P1 by line IN3.

MAINTENANCE

Refer to section 6.0 in SD383 for detailed instructions.
FIGURE 5 Hardware Block Diagram, Isolated Power Supply Board

- Oscillator U21
- Buffer/Amplifier U22
- Switching Circuit 01 02
- Duty Cycle Adjust R5*
- Isolation and Pulse Transformer T1
- Bridge Rectifier BR1
- Filter C1, C2
- Voltage Regulator U1
- -5 VDC
- Isolated Ground (Isolated DC Sources to T/C Board)
- Isolated Ground

- Isolation and Pulse Transformer T10
- Bridge Rectifier BR10
- Filter C19, C20
- Voltage Regulator U10

- Reference Junction Temperature Sensor from Rear Terminals A8 & A9

- Factory Set — Do Not Adjust