# TMM-100

# Temperature Measurement Module

# Operating Manual


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Revision 4

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TEA acknowledges the contributions to the TMM-100 design and software made by:

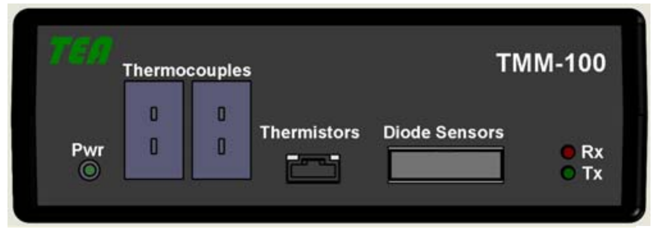
- John Keenan, MicroReady Inc.
- James Christofferson, Electro-Thermo-Optic

This manual is intended solely for TEA customers in the application of the Temperature Measurement Module product described herein. The product is designed for the specific tasks detailed herein and any use of this product in other application tasks is at the user's risk and responsibility.



Thermal Test Chips mentioned in this manual are offered for use in characterizing assembly processes, packages, materials and any other applications requiring precise control of heat flux generation and temperature measurement. Applying the data from the test die to a functional system is the responsibility of the user. TEA makes no warranty, expressed or implied including the implied warranties of merchantability and fitness for a particular purpose, that the user's system designed using that data will perform as intended by the user.

## DESCRIPTION




The TMM-100 is designed to simplify the gathering of temperature data from eight Thermal Test Chip diode temperature sensors. The system contains precision current sources for supplying diode measurement current ($I_M$), voltmeter capability for diode measurement ($V_M$), and Type-T thermocouple and 10KΩ NTC thermistor measurement capability for monitoring the environment temperature. Front-panel mounted connectors provides for up to eight temperature sensing diodes, two thermocouples and two thermistors. All temperature sensor channels can individually be enabled or disabled using simple commands.

For any of the selected eight diode temperature sensing channels, the internal precision $I_M$ current source provides 1.00mA with a voltage compliance of 2V. The internal voltage measurement circuit measures to 1.999V with 1mV resolution. The temperature measurement resolution of 0.1°C for all sensors provides for accurate temperature differential measurements.

The TMM is powered through its USB connection to a computer, so no external power supply is required.

## FEATURES

- Self-contained for easy setup and operation
- 8 diode voltage measurement channel circuitry
- Diode channels use 1.0mA current source.
- 2 Integrated Type-T thermocouple measurement circuitry
- 2 10KOhm NTC thermistors measurement circuitry
- Thermistor channels use 100µA current source
- 1mV resolution on differential voltage measurements
- Rear Panel connector for controlling temperature environment fan
- USB connection for power, programming, and data logging.
- LabVIEW Virtual Instrument Option (model TMM-100-01)

## SPECIFICATIONS

| | |
|---|---|
| **Diode Current Source** | |
| Number of Channels | 8 |
| Measurement Current | 1.00mA |
| Accuracy | 0.1% |
| Voltage compliance | 1.999V |
| Polarity | - or + to GND |
| Connection | Front Panel, IDC Ribbon Cable Connector |
| **Diode Voltage Measure** | |
| Number of Channels | 8 (integrated with Current Source) |
| Range | 1.999V |
| Resolution | 1mV |
| Accuracy | 0.01% of fs ±1 mV |
| **Temperature Measure (Thermocouple)** | |
| Number of Channels | 2 |
| Type | T |
| Range | 0 to +199°C |
| Resolution | 0.1°C |
| Accuracy | 0.1% of fs ±1.4°C |
| Connector | Front Panel, Miniature Jack (Omega NMP-T or equivalent) |
| **Temperature Measure (Thermistor)** | |
| Number of Channels | 2 |
| Type | 10KΩ (nominal @ 25ºC) |
| Operating Current | 100μA |
| Range | 0 to +199°C |
| Resolution | 0.01°C |
| Accuracy | 0.1% of fs ±1.4°C |
| Connector | Front Panel, (type TBD) |
| **Power Indicator** | |
| Type | LED |
| Color | Green |
| **Data Indicator** | |
| Type | LED |
| Tx Color | Green |
| Rx Color | Red |
| **Computer Connection** | |
| Type | USB 2.0 or higher |
| Connector | Rear Panel, USB Type B |
| **Relay Connection** | |
| Configuration Type | Single Pole, Double Throw (SPDT) |
| Connector | Rear Panel |

## SPECIFICATIONS (continued)

| Physical | |
|---|---|
| Height | 51.0mm (2.00in) |
| Length | 179.50mm (7.067in) |
| Width | 154.00mm (6.063in) |
| Weight | 0.42Kg (14.7oz) |

## GETTING STARTED

Unpack Your Module

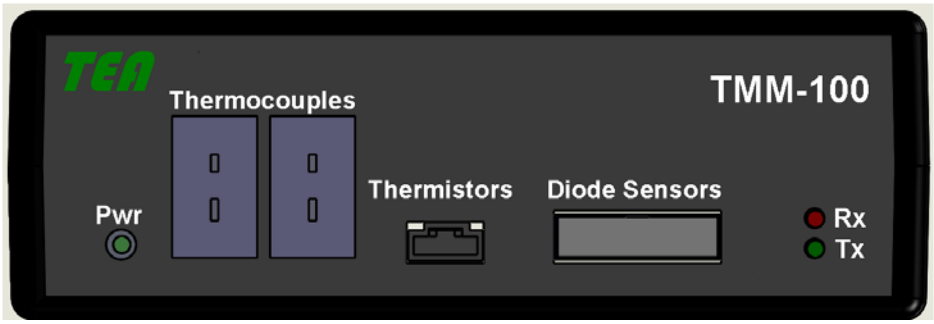
Your box should contain the following items:

- TMM-100 Temperature Measurement Module
- USB 2.x Cable (Type A on one end, Type B on other end)
- Combination Diode/Thermistor Sensors connection cable
- Type-T #36 Gauge Thermocouples with mating connectors
- USB Flash Drive containing operating software and module operating manual

## Hardware Description

Before you cable your router, take a moment to become familiar with the label and the front and back panels. Pay particular attention to the LEDs on the front panel.

Module Front Panel




The TMM-100 front panel has:

- Green Power LED
- Red LED for USB Tx Data
- Yellow LED for USB Rx Data
- 2 x 8 connector for Diode connections
- 2 x Thermistor connector
- 2 x Thermocouple sockets


The TMM-100 rear panel has:

- Standard USB B-type connector
- Fan Control connector

## SOFTWARE INSTALLATION

See Section 4.

Once the TMM-100.exe file has been started, the Opening Screen shown in Figure 1 will appear.

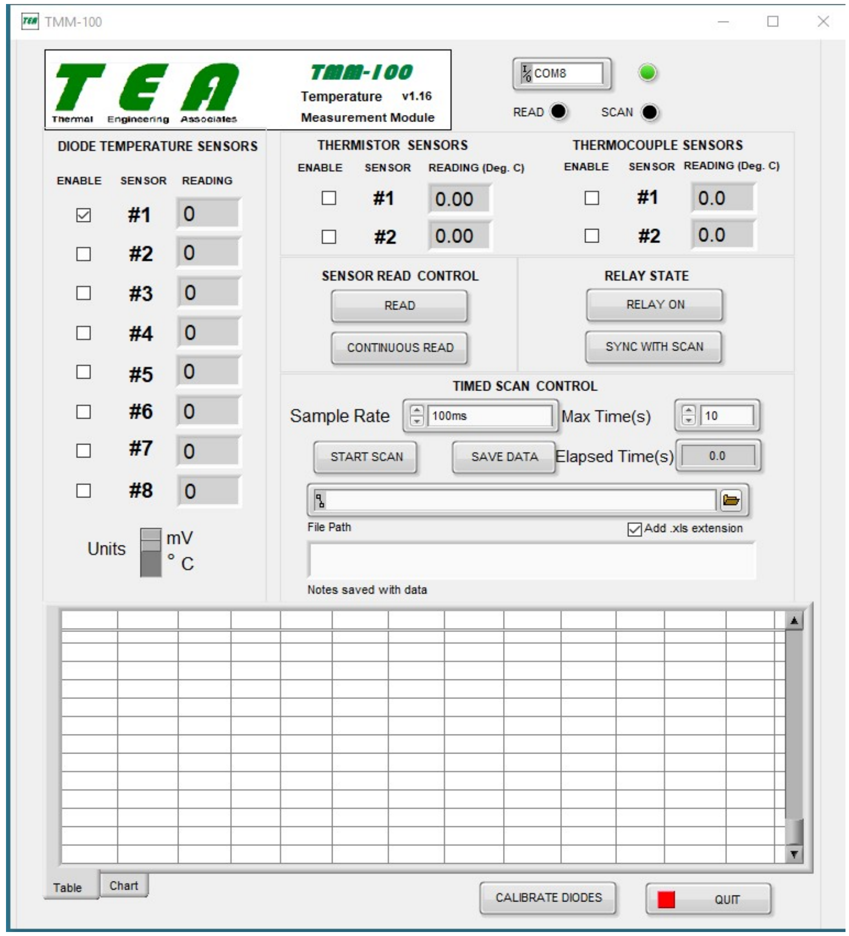



**Figure 2-1 Opening Screen**

If the TMM-100 unit is already connected to the computer, the green indicator to the right of the COM port box (near top right of the screen) will turn green and the connected COM port number will appear in the port box.

If the TMM-100 unit is not plugged into the computer, the indicator next to the COM port box will be red and a message box (see Figure 2-2) will appear. Plug the unit's USB into the correct computer port, wait about 10 seconds, and then click on the Retry button. After a few more seconds, the connection indicator will turn green and the COM port actually used will appear in the COM port box.

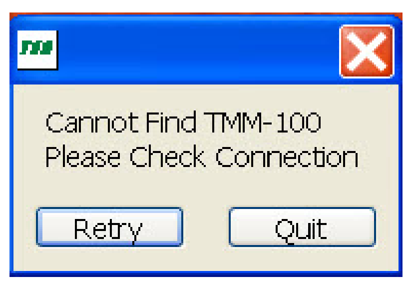



**Figure 2-2 Missing Module Message**

The TMM-100 is now ready for use.

The TMM-100 Operating Screen is divided into several sections:

<u>Communications Status</u>

Located in the top right (see Figure 2-1). This section contains the COM port box and COM port status indicator. Immediately below are the status indicators for data READ and SCAN.

<u>Sensor Selection</u>

Down the left center are the selection check boxes for Diode Temperature Sensors numbered 1 through 8. At the bottom of the diode selection is a slide to select between diode readings in millivolts and degrees centigrade.

Immediately below the unit model number and name are the Thermistor Sensor selection check boxes.

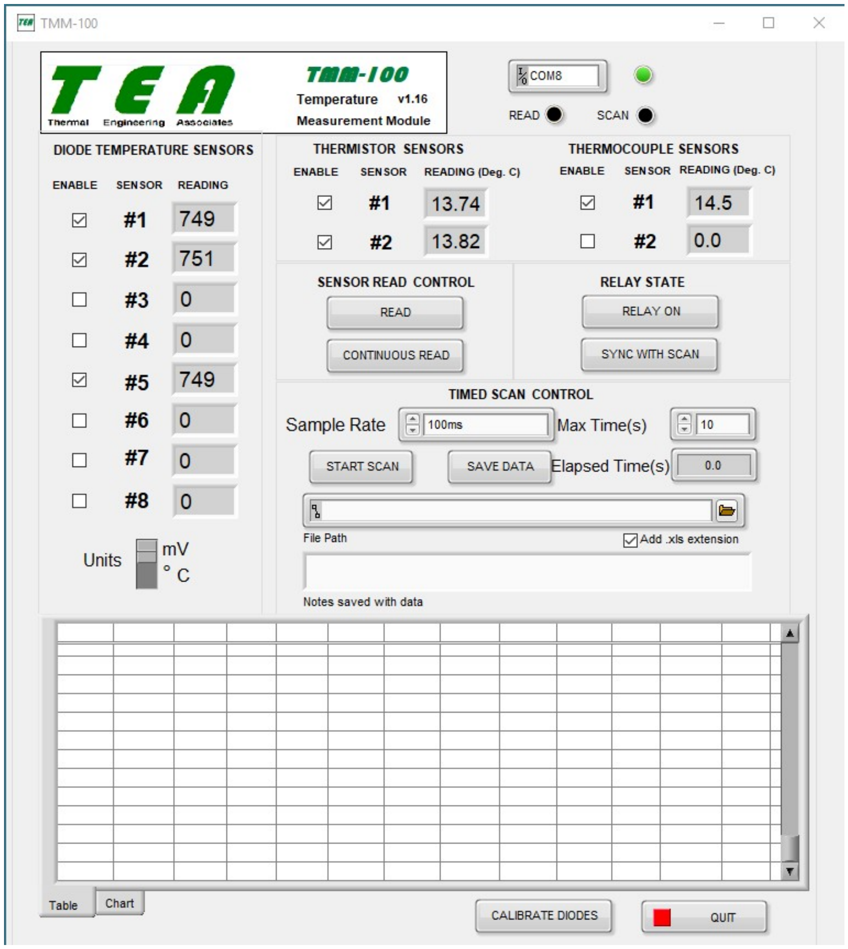



**Figure 2-3 Sensor Selection**

Under the Communications Status section is the Thermocouple Sensor selection check boxes.

The data will only be read for those sensors that have check marks in their boxes, as shown in Figure 2-3.

<u>Sensor Read Control</u>

Located in the center right portion of the screen, this second deals with the actual collection sensor reading collection.

Clicking on the READ button, will cause a single data reading for each selected sensor. The collected readings will appear in the data box to the right of the individual sensors.

If a sensor is not selected, its data box will contain a "0", as shown in Figure 2-4.

The Diode Temperature Sensor data is in terms of millivolts (mV) or degrees centigrade (ºC), as determined by the slide control below the diode selection column. In order for the diode results to be in centigrade, the diode voltage must be correlated to temperature by clicking on the CALIBRATE DIODES button near the QUIT button at the bottom right of the screen. The calibration procedure is described below.

The data for both the Thermistor and the Thermocouple Sensor is in terms of ºC.

The CONTINOUS READ button is a toggle type which is either OFF, as shown in Figure 2-4 as a grey button, or ON, as shown in Figure 2-5 as a green button. Clicking on the button will change the operational state.

Clicking on the CONTINOUS READ button will cause the data for all the selected sensors to be updated every 100ms.

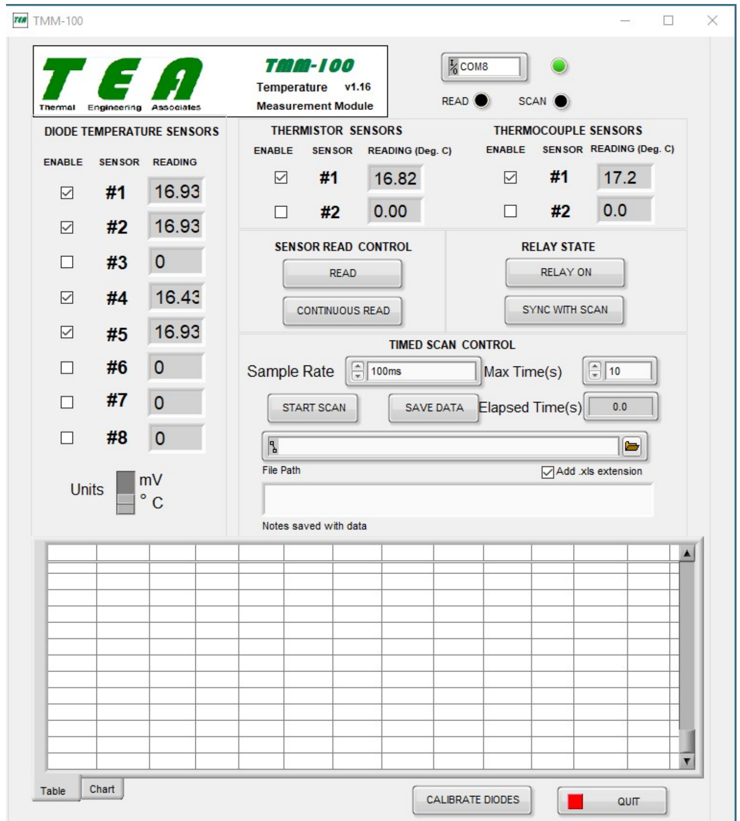



**Figure 2-4 Sensor Read**


**Figure 2-5 CONTINUOUS READ button**

## Fan State

Immediately to the right of the SENSOR READ CONTROL section is the FAN STATE section. As shown in Figure 2-6, the button in this section toggles between FAN OFF and FAN ON states. A relay connection on the module's rear panel allows either for direct control of a power supply for powering (≤50V, ≤0.75A) a measurement system fan or for providing a digital signal for fan control circuitry or other measurement environmental system.


**Figure 2-6 FAN STATE button**

Timed Scan Control

This section is dedicated to the controls required for collecting data at a fixed sample rate over some period of time. Clicking on the START SCAN button begins the collection of data from all the selected sensors. When clicked, the grey START SCAN turns into the yellow ABORT SCAN button causing the scan operation to cease.

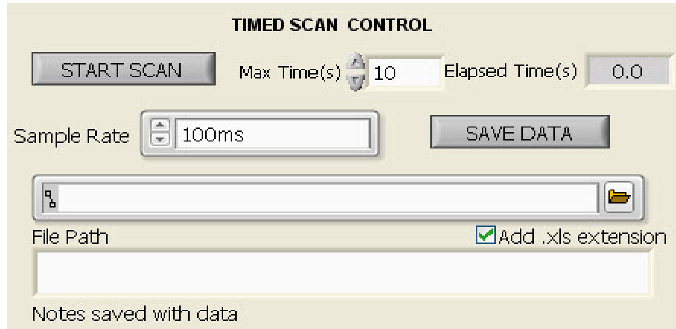



**Figure 2-7 Time Scan Controls**

In the top middle of the section is the control for setting the maximum time period from 1 second to 10,000 seconds in steps of 1 second. The Max Time in seconds can be set by either using the up/down arrows on the left of the time set box or by actually entering the max time in the box. To the right of the setting box is an Elapsed Time indicator box to show where within the max time the current data scan is.

The Sample Rate selection control has three fixed rates – 10ms, 100ms, and 1s – that can be selected by clicking the up/down arrow on the left of the data box. The 10ms selection only works when a single sensor (i.e.,either Diode, Thermistor, or Thermocouple) is selected. The 100ms and 1s selections will work for any combination of selected sensors.

Immediately below the Sample Rate control is the entry box for the datafile path and filename.

- If the TMM-100 is running on a Windows XP Pro computer, then the full path and filename must be entered here in order to save the data file.
- If the TMM-100 is running on a Windows 7.X, 8.1 or 10 computer, then clicking on the folder button to the right of the filename area brings up the Windows Save As dialog box that allows for setting the path but the filename still have to be entered.
- If the box is checked for *Add .xls extension*, then the datafile will be saved with the .xls suffix. Otherwise, the filename is saved as a text file.

The Notes area is designed to accept up to 4 lines of entered alphanumeric information that can be use to describe the measurement run operating conditions, information about measurement samples, or other information.

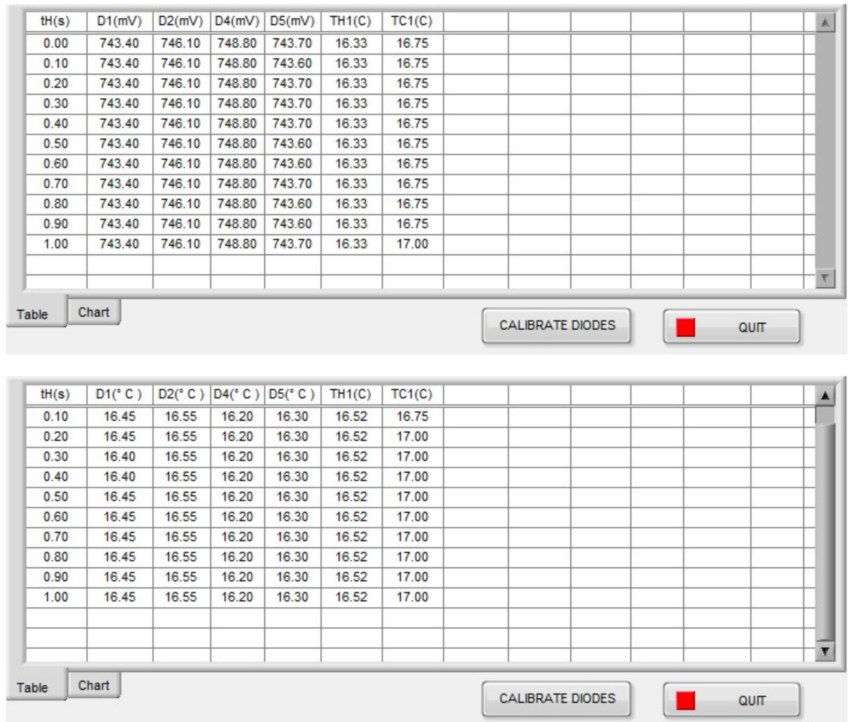
The data, with Notes can be saved after collection by clicking the SAVE DATA button.

## Data Display

In the TIMED SCAN mode, the collected data is shown near the bottom of the screen in either tabular form, as shown in Figure 2-8, or in chart form, as shown in Figure 2-9. The tabs at the lower left of the data area are for selection of either Table or Chart mode.

In the Table mode, the heating time shown is in the left-most column ($t_{H(s)}$), with a column header name for each temperature sensor selected. A few seconds after starting the scan, data will appear in the table on a row-by-row basis. The last data collected is shown on the last line. The top table in Figure 2-8 shows mV for each diode and ºC for the thermistor and thermo-couple sensors. Bottom table shows ºC for all sensors if the Units slide is in the ºC setting.

In the Chart mode, the heating time remains in seconds but the diode sensor data is in mV or ºC depending on the Units slide position. The vertical scale minimum and maximum values can be changed by using the computer cursor to highlight the existing number(s) and then typing in the desired number. The chart will automatically adjust to the new min/max values.



| tH(s) | D1(mV) | D2(mV) | D4(mV) | D5(mV) | TH1(C) | TC1(C) |
|---|---|---|---|---|---|---|
| 0.00 | 743.40 | 746.10 | 748.80 | 743.70 | 16.33 | 16.75 |
| 0.10 | 743.40 | 746.10 | 748.80 | 743.60 | 16.33 | 16.75 |
| 0.20 | 743.40 | 746.10 | 748.80 | 743.70 | 16.33 | 16.75 |
| 0.30 | 743.40 | 746.10 | 748.80 | 743.70 | 16.33 | 16.75 |
| 0.40 | 743.40 | 746.10 | 748.80 | 743.70 | 16.33 | 16.75 |
| 0.50 | 743.40 | 746.10 | 748.80 | 743.60 | 16.33 | 16.75 |
| 0.60 | 743.40 | 746.10 | 748.80 | 743.60 | 16.33 | 16.75 |
| 0.70 | 743.40 | 746.10 | 748.80 | 743.70 | 16.33 | 16.75 |
| 0.80 | 743.40 | 746.10 | 748.80 | 743.60 | 16.33 | 16.75 |
| 0.90 | 743.40 | 746.10 | 748.80 | 743.60 | 16.33 | 16.75 |
| 1.00 | 743.40 | 746.10 | 748.80 | 743.70 | 16.33 | 17.00 |

| tH(s) | D1(° C ) | D2(° C ) | D4(° C ) | D5(° C ) | TH1(C) | TC1(C) |
|---|---|---|---|---|---|---|
| 0.10 | 16.45 | 16.55 | 16.20 | 16.30 | 16.52 | 16.75 |
| 0.20 | 16.45 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |
| 0.30 | 16.40 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |
| 0.40 | 16.40 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |
| 0.50 | 16.45 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |
| 0.60 | 16.45 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |
| 0.70 | 16.45 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |
| 0.80 | 16.45 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |
| 0.90 | 16.45 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |
| 1.00 | 16.45 | 16.55 | 16.20 | 16.30 | 16.52 | 17.00 |



**Figure 2-8 Table Data Display**


**Figure 2-9 Chart Data Display**

<u>Diode Calibration</u>

In order for the diode temperature sensors to produce readings in units of ºC, the diode voltage must be correlated to temperature. The DIODE SENSOR CALIBRATION routine performs this function. The steps to using this routine are as follows:

1) Determine which of the other sensors (either Thermistor or Thermocouple) best represents diode junction temperature when the diode and other sensor are in the same temperature ambient. For example, consider the case of a Thermal Test Chip (TTC) diode sensor and a thermistor that is integrated into heat sink mounted on top of the chip.

2) To insure that both the diode sensor(s) and reference sensor (Thermistor or Thermocouple) are at the same temperature, allow all sensor readings to stabilize (i.e., not change) over some significant period of time period of time (for example, 5 to 10 minutes). This can be done by selecting the appropriate sensors and then clicking on the CONTINOUS READ button described above.

3) Click on the CALIBRATE DIODES button below the data area bottom right. This will bring up one of the calibration screens shown in Figure 2-10, the top screen for a single diode sensor and the bottom screen for multiple diode sensors.

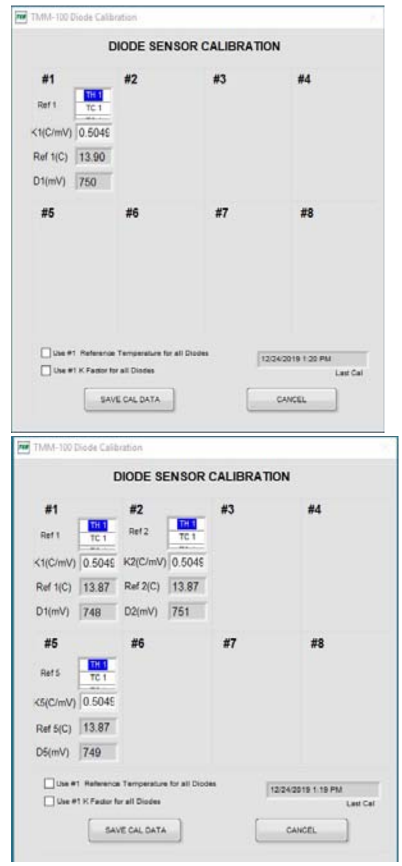



**Figure 2-10 Diode Calibration**

4) If a single diode sensor is being used, enter in the K Factor (K) value for the diode in units of ºC/mV. (See Diode Temperature Sensing section in Chapter 3.) For multiple diode sensors, individual K values can be entered or sensor #1 value can be used for all the sensors by checking the box in the lower left of the screen.

5) The reference temperature sensor used in step 1) above can be selected in the Ref 1 scrolling list. Typically, it is best use a thermistor as a reference because of greater accuracy compared to a thermocouple. The same reference sensor can be used for all the selected diode sensors by checking the box in the lower left of the screen.

6) Once all the values have been entered and the appropriate boxes checked, clicking the SAVE CAL DATA will write the information to a file that will be used whenever the TMM-100 program is run.

To cease operation of the TMM-100 software, click on the QUIT button at the lower right of the screen. The unit can be left connected (the front panel green indicator will remain on) to the computer but will be inactive until the TMM-100 program is again loaded and run.

Exit Program

To cease operation of the TMM-100 software, click on the QUIT button at the lower right of the screen. The unit can be left connected (the front panel green indicator will remain on) to the computer but will be inactive until the TMM-100 program is again loaded and run.

## Electrical Connections

The TMM-100 unit is supplied with cables and thermocouples to facilitate user connection to the various temperature sensors measured by the unit. The user is responsible for making the electrical connection between the unit and sensors according to the schematic shown in Figure 3-1.

*Note: The supplied temperature sensor cable is rated for use in a temperature environment below 105ºC.*

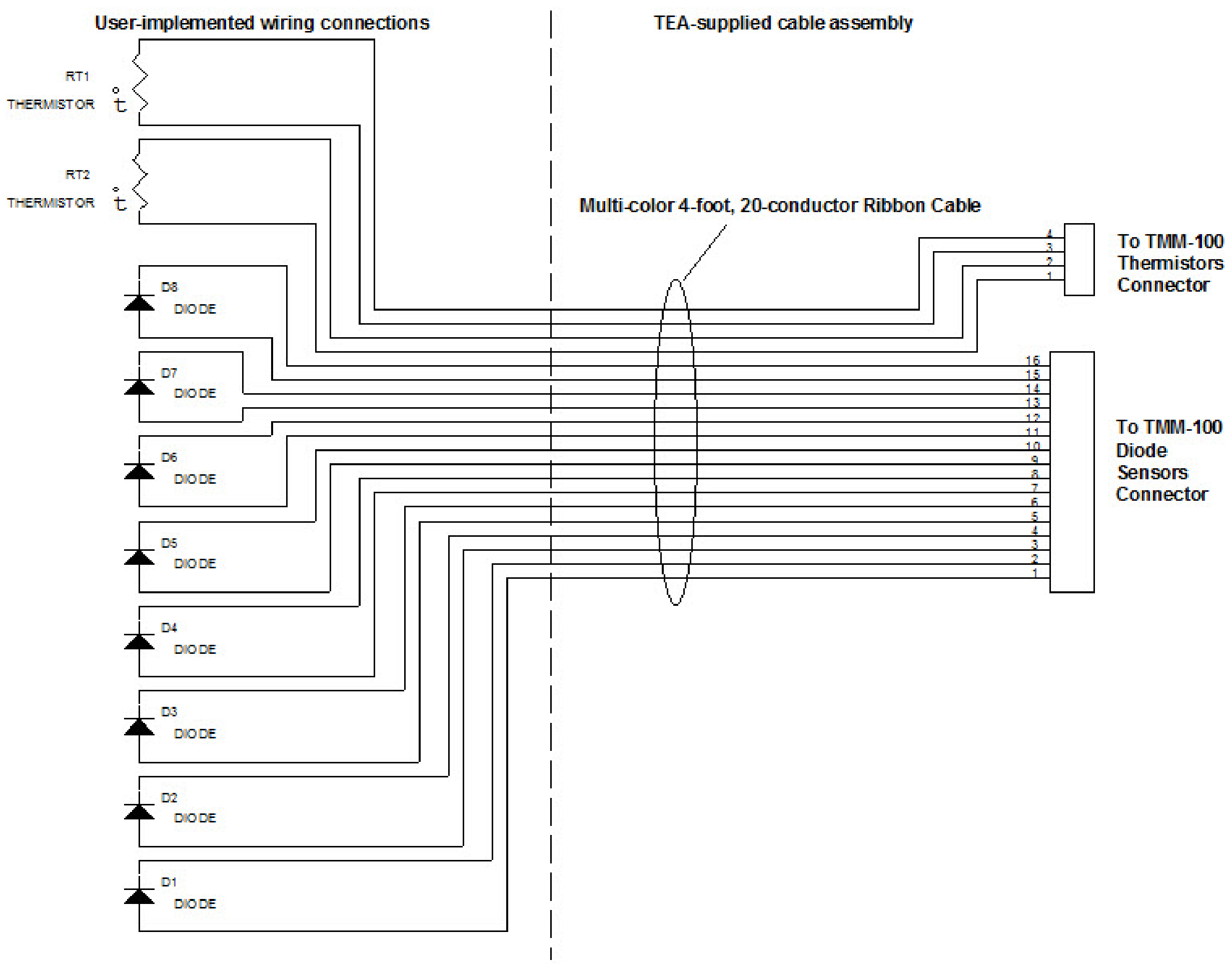



Figure 3-1

The ribbon cable conductor color coding follows the standard numerical coding used for re-sistors –

| | |
|---|---|
| Brown ➔ 1 | Red ➔ 2 |
| Orange ➔ 3 | Yellow ➔ 4 |
| Green ➔ 5 | Blue ➔ 6 |
| Violet ➔ 7 | Grey ➔ 8 |
| White ➔ 9 | Black ➔ 0 |

For example –

- For diode D1, anode connects to the first Brown conductor and cathode connects to first Red conductor.
- For diode D5, anode connects to the first White conductor and cathode connects to first Black conductor.
- For diode D6, anode connects to the second Brown conductor and cathode connects to second Red conductor.

The TMM-100 is designed to used 10KΩ NTC (Negative Temperature Coefficient) thermistors. A surface mount device, such as Murata NCP18XV103J03RB [Digi-Key part # 490-6944-1-ND] or equivalent, is a small chip that can be mounted to a printed circuit board near a heat source without impacting air flow.

A Fan Control cable is also supplied with the TMM-100. Two alternative wiring configurations are shown in Figure 3-2. The relay load capability should be limited to <50V and <0.5A.

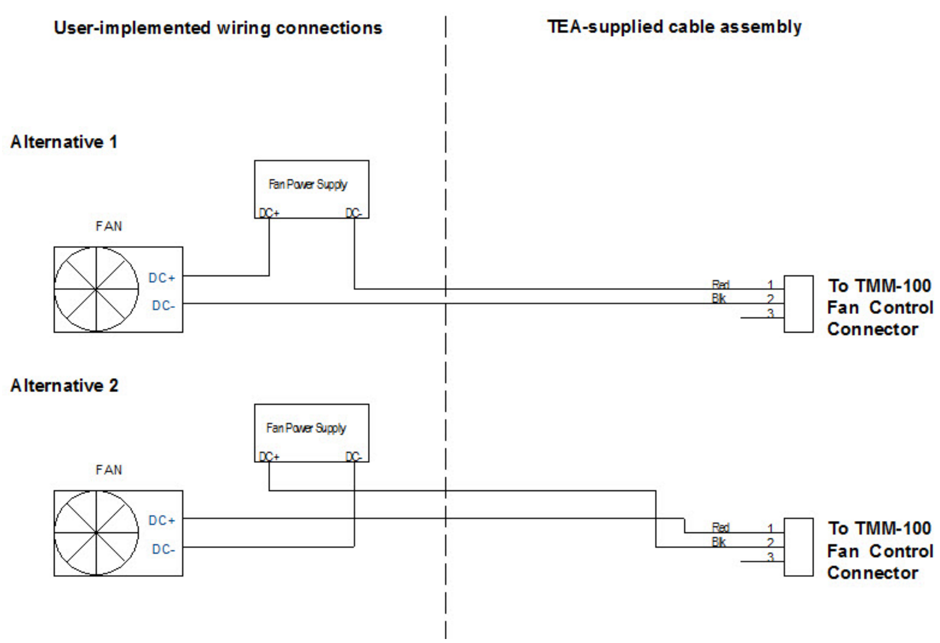



Figure 3-2

### Diode Temperature Sensing

Temperature sensing can be done in either of two ways –
- Absolute measurement which requires calibration of a specific diode voltage at a specific measurement current against a known temperature, or a
- Differential measurement which requires the difference between two diode voltage measurements at a specific measurement current multiplied by the K Factor (see Tech Brief TB-02) to calculate a temperature differential.

Because thermal measurements are typically based on temperature differentials, the latter approach is typically used. K Factor values at a measurement current of 1mA for TEA's Thermal Test Chips are:

| | |
|---|---|
| TTC-1001 | 0.5598ºC/mV |
| TTC-1002 | 0.5046ºC/mV |

The TMM-100 supplies 1mA to each of the diodes connected and measures the voltage for each of the diodes selected (see Figure 2-8). The diode voltage will decrease as the sensor heats up. The diode voltage value at equilibrium before heating occurs minus the diode voltage at a specified time during the heating produces a voltage difference that is multiplied by the K Factor to produce a temperature difference. For example using the TTC-1002 –

At equilibrium, $V_{Flo}$ = 0.724V
At some time after heat is applied, $V_{Fhi}$ = 0.678V
Voltage difference = 46mV
Temperature change = 46mV x 0.5046ºC/mV = 23.21ºC

### Example Measurement Procedure (TIM Application-Oriented Thermal Resistance)

1) Mount the heat sink solution, including the TIM, on the TTV-410X unit, as shown in Figure 3-3.

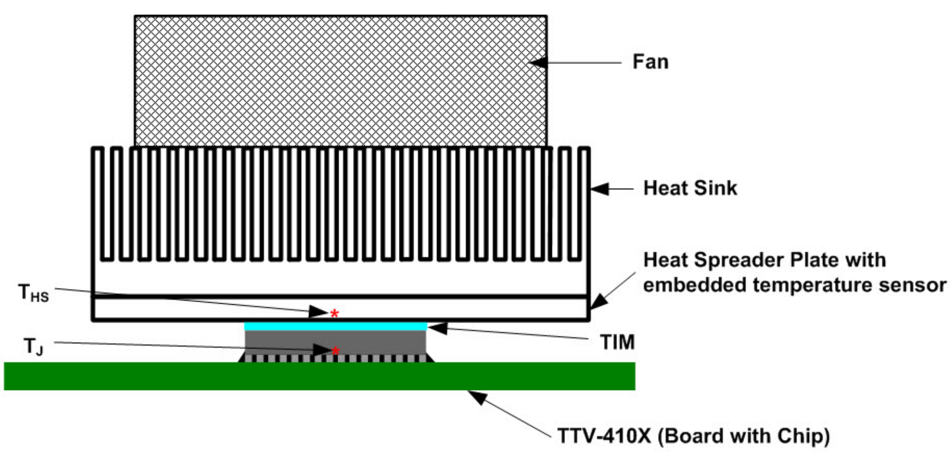



Figure 3-3

2) Connect up the power supply and measurement equipment shown in the Apparatus Setup.

3) Apply the 1.0mA Measurement Current to the diodes used for temperature measurement.

4) Wait for thermal equilibrium to occur - i.e., when the diode voltages stop changing - to record the diode voltage. Also record the Heat Sink temperature and the ambient temperature.

5) Apply power to the TTV Heating Resistors by setting the power supply to reach the desired power level.

6) Monitor the diode voltage with the 1.0mA current applied until a steady-state condition has occurred - i.e., when the diode voltages stop changing - to record the diode voltage and the Heat Sink temperature.

7) Monitor the heat sink temperature until a steady-state condition has occurred - i.e., when the diode voltages stopped changing - to record the heat sink temperature

8) Remove the power to the TTV Heating Resistors.

9) Calculate the Thermal resistance from Junction to Heat Sink as follows:

$$\Theta_{\mathrm{J-HS}} = \left| \frac{\left[ (\boldsymbol{V}_{Di} - \boldsymbol{V}_{Df}) \times \boldsymbol{K} \right] - (\boldsymbol{T}_{HSf} - \boldsymbol{T}_{HSi})}{\boldsymbol{P}} \right| \ {}^{\circ}\mathrm{C/W}$$

where:

$V_{Di}$ and $T_{HSi}$ are from step 4

$V_{Df}$ and $T_{HSf}$ are from steps 6 and 7

P is from step 5 recorded just before step 6 readings

K is the K Factor value - either the nominal value shown in the TTC Application Manual (http://www.thermengr.net/TTC/TTC_Manual_R7.pdf) or calibrated as described in the manual (see Chapter 3).

The software for installing and running the TMM-100 is supplied on a USB Flash Drive. The steps for installing the software on Windows 7.x or Windows 8.x operating system computer is described below.

Step 1. Connect the supplied USB Cable into the TMM-100 rear panel; DO NOT plug the other cable end into the computer's USB port.

Step 2. After starting the computer, insert the USB Flash Drive into the system.

Step 3. Use Windows Explorer to open the flash drive directory, as shown in Figure 4-1.

Step 4. Select "Installer" and double-click to run the program. The window shown in Figure 4-2 will appear. Click *Next* button to proceed.

Step 5. The next window, shown in Figure 4-3, shows the destination directories for both the TMM-100 software and the National Instruments support files. The operating system will automatically determine the location and name of these directories. The user can either accept the directories presented or change them to suit specific requirements. Click *Next* button to proceed.

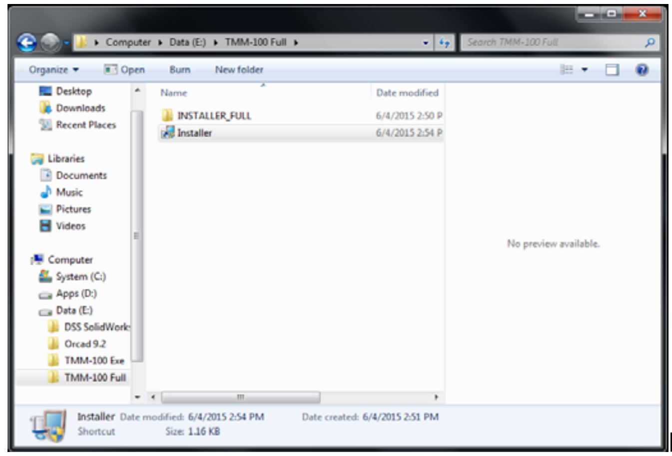



Figure 4.1


Figure 4-2

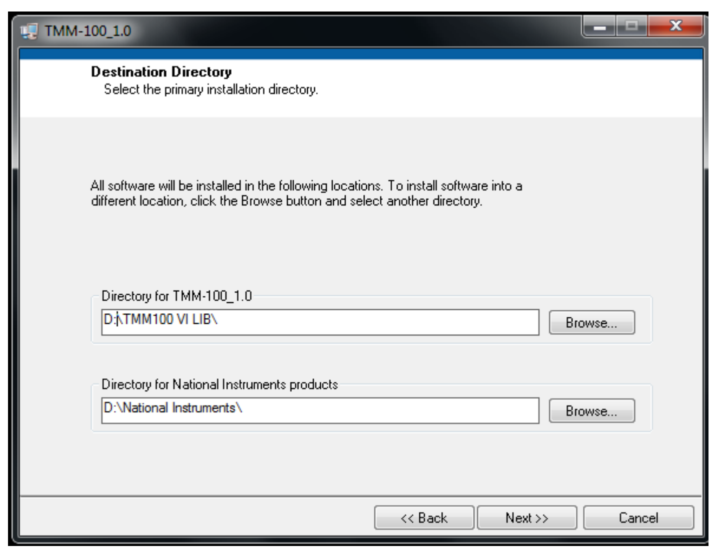



Figure 4-3

Step 6. The next window that appears, see Figure 4-4, provides a list of files to be loaded and/or changed. Unless changes are required, click *Next* button to proceed.

The software will then be installed. One or more information boxes may appear showing installation progress.

Step 7. When the software installation is complete, the final window, see Figure 4-5, will appear. Click *Next* button to proceed.

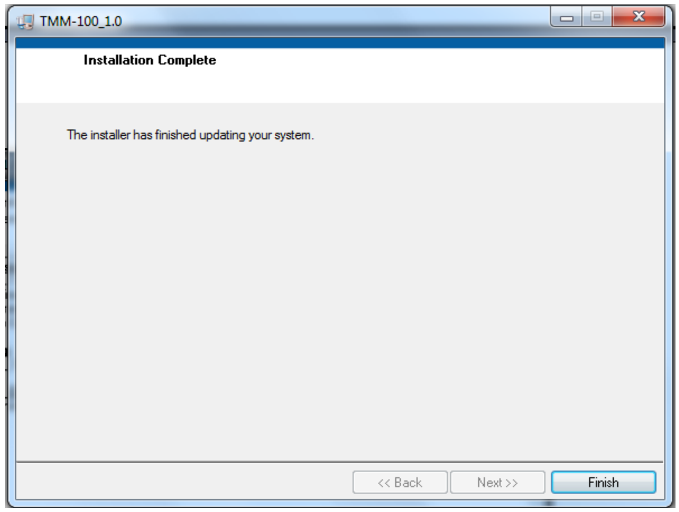
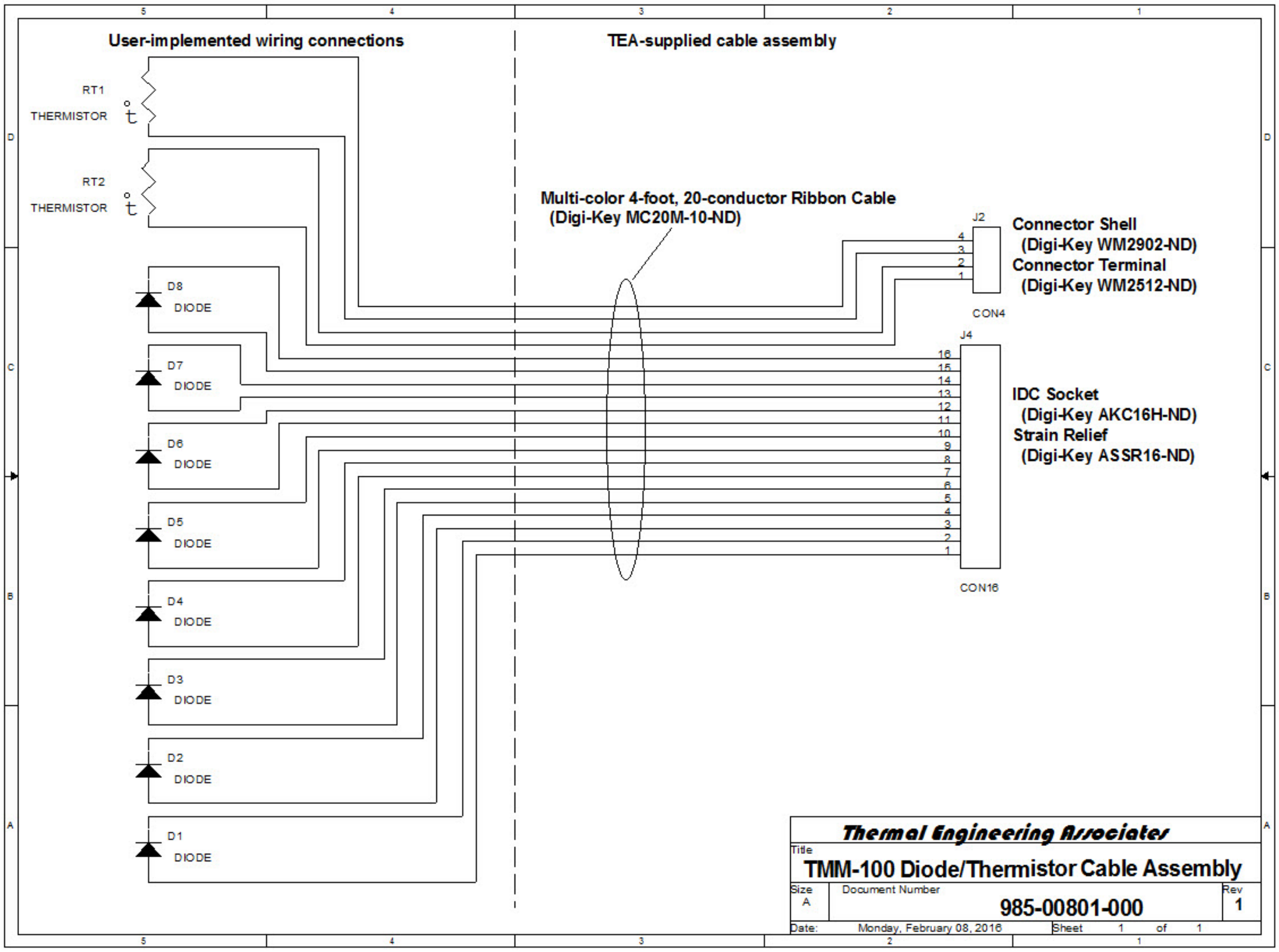



Figure 4-4

Step 8. With the installation complete, the last step is to create a desktop icon for easy access to the TMM-100 software. Follow the procedure normally used to create a desktop icon.

The TMM-100 can now be connected to the computer. Plug the cable into a computer USB port and open the TMM-100 software.

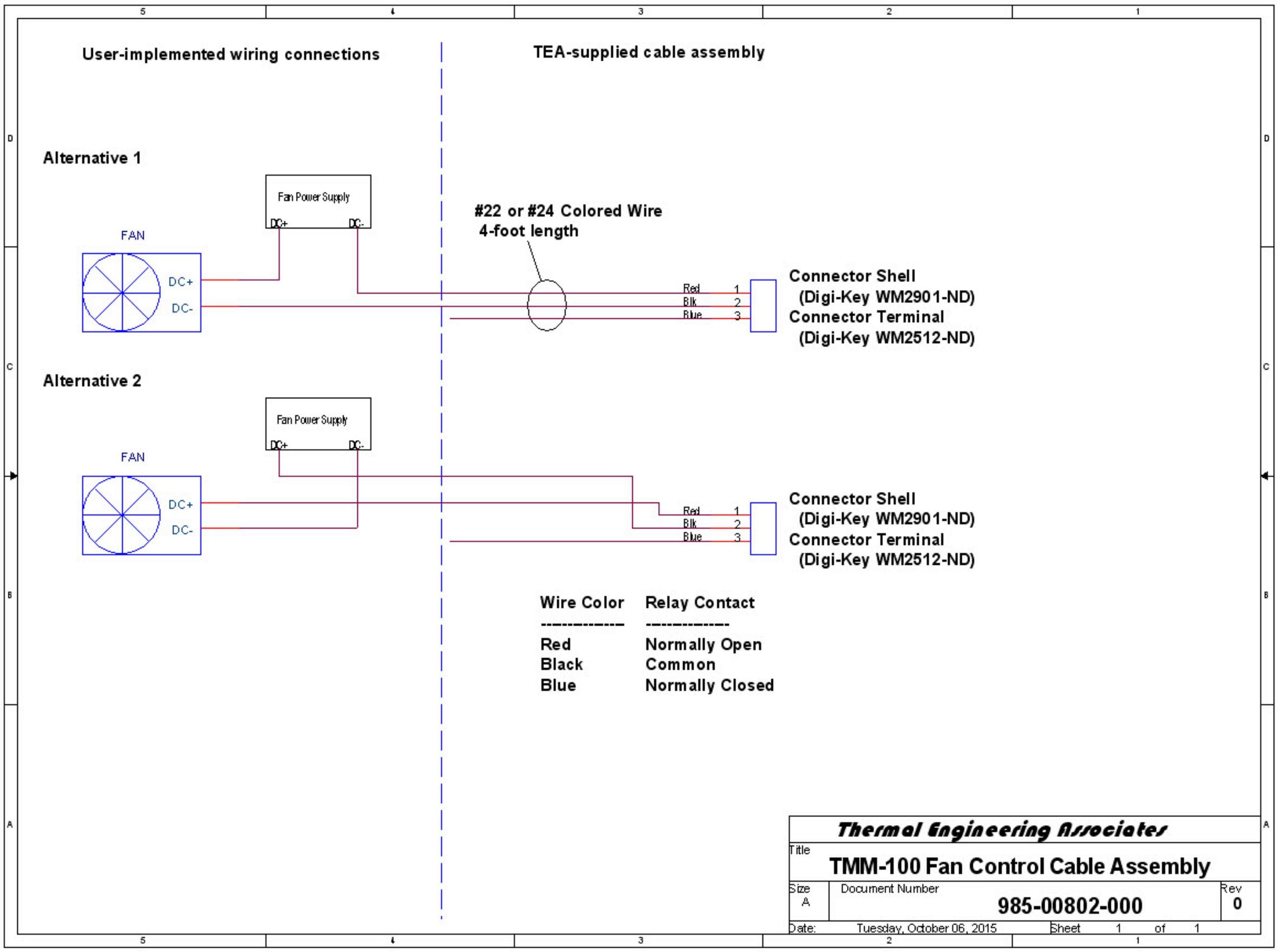
## Diode/Thermistor Cable Assembly (TEA PN: 985-00801-000)




## Thermocouples (TEA PN: 680-00002-001)

Type-T #36 gauge 3-feet long (Omega Engineering (SC-TT-T-36-36)

## Fan Control Cable Assembly (TEA PN: 985-00802-000)



## Warranty

All Thermal Engineering Associates, Inc. (TEA) thermal test equipment products are fully warranted for six (6) months against defects in material, components and subsystems, and on workmanship, from the date of shipment.

*This warranty specifically does not apply to consumable items such as printer paper, printer ribbons or ink cartridges, test chips or devices, etc. or to peripheral items such as printers, video monitors, keyboards, etc. that are supplied with TEA products. Modifications to TEA product(s) made by the customer without the express written permission of TEA will cause the WARRANTY to become null and void. Product failure(s) caused by neglect, misuse, weather, shipping damages, acts of war, act of God, or other acts not under control of TEA render the WARRANTY inapplicable.*

Defective products will be repaired or replaced at the option of TEA during the warranty period provided that they are returned to TEA; round-trip shipping expenses are the customer's responsibility. Additionally, repair work not covered by the warranty will be charged to the customer according to TEA's normal rate and billing procedures. All returns must be authorized in writing by TEA prior to being returned.

No other warranty, expressed or implied, accompanies this product. TEA is not liable for any consequential damages.

Defective products under warranty should be returned to TEA via the same procedure described in the following Repair section.

## Repair

TEA maintains a staff of competent personnel to assist customers in the repair and maintenance of its products. If you must return a product to the factory for repair and/or calibration, please follow the guidelines listed below to insure rapid, accurate turnaround;

1. Contact TEA Customer Service for a Return Material Authorization (RMA) number. A customer service person will discuss the problem with you to make sure product return to the factory is necessary. In many instances, the customer service person may be able to correct defective product problems by phone, fax or e-mail. If factory service is required, the customer service person will issue a RMA number. Always refer to the RMA number when returning anything for service.

   TEA Customer can be reached via:

   | | | |
   |---|---|---|
   | Phone: | 1-650-961-5900 | During the hours of 9 AM to 5 PM Pacific Time, during any business day |
   | FAX: | 1-650-323-9237 | |
   | E-mail: | cs@thermengr.com | |

2. **<u>If the product is covered under the six-month TEA Warranty</u>** (see Warranty section above), there is no charge for parts or labor involved in the repair. The customer will pre-pay shipment of the product back to TEA and agrees to accept return of the repaired or replaced product via shipping costs collect.

3. **<u>If the product is NOT covered under the six-month TEA Warranty</u>** (see Warranty section above), there is a minimum charge for Repair and Calibration that will be quoted at the time the RMA number is issued. The minimum charge provides for complete product calibration and up to four (4) hours of repair effort; minimal parts replacement is included. A customer purchase order must be issued for the minimum charge before TEA will start any Repair and Calibration work. Should the repair activity exceed four hours and/or parts replacement value exceed the minimal value, the customer will be contacted for authorization to proceed against a quoted not-to-exceed addition to the original customer purchase order. The customer will prepay shipment of the product back to TEA and agrees to accept return of the repaired or replaced product via shipping costs collect or be billed by TEA for the return shipping costs. (See shipping instructions below.)

4. A description of the problem with the TEA product must be provided with the returned product(s). Please be brief but very explicit in preparing the written description; this will save the customer both time and money and will help insure a more complete repair. Also include with the returned product(s) any appropriate related accessory items (Calibration Verification Fixture, test fixture, sample devices, cables, etc.) that might relate to the problem and/or will assist in the repair and calibration of the product.

5. Be sure to properly package items to be returned to avoid potential damage in shipment. Use quality packaging material in a suitable container to insure sage return delivery. TEA will use the same container and packaging material to return the repaired/calibrated items to the customer. Smaller items can be shipped via UPS, FedEx, DHL, etc., subject to weight and size limitations. Heavier items, especially those packaged in wooden containers, should be shipped via air or motor freight.

6. All shipping container labels should contain the following information:

Ship To: Thermal Engineering Associates, Inc.
Customer Service - RMA# XXXXXXXX
3287 Kifer Road
Santa Clara, CA 6051-0826 USA

From: Customer Company
Customer Address
Customer City, State, ZIP#
Customer Country

RMA# XXXXXXXX

7. Normal factory turnaround for Repair and Calibration is fifteen (15) working days from the date the customer's property reaches TEA until it is shipped from TEA. Transportation time in both directions is additional. The fifteen working day period is subject to manufacturing schedules at TEA and the availability of replacement parts if required and not in stock at TEA at the time of the repair. Expedited turnaround is available at extra cost.

# ADDENDUM:
# LabView DRIVERS & VIs

## INTRODUCTION

The LabVIEW VI library is intended for users that want to incorporate the TMM-100 into their own system using LabVIEW as the controlling software for custom applications. This library of sub-Vis is an extra cost option (part number TMM-100-01) and is available on a USB Flash Drive.

## INSTALLATION

The procedure for installing this software is the same as described in Section 4.

After running the installer, the VI library should be installed at C:\Program Files (x86)\TMM100_1.0\TMM100 VI LIB. As noted in Section 4, the destination directories fro the software can be changed during the installation process.

## VI LIBRARY REFERENCE CHART

| VI Name | Brief Description |
|---|---|
| TMM_100_Control.vi | Example code to control TMM module |
| Enab_diode.vi | Adds Selected diode to Scan List |
| Enab_Therm.vi | Adds Selected Temperature Sensor to Scan List |
| Find_Serial_Port.vi | Returns the Serial Port of Connected Device |
| Firmware_version.vi | Returns The Current Firmware revision of TMM module |
| Read_diode.vi | Performs immediate read of selected diode |
| Read_Therm.vi | Performs immediate read of selected Temperature sensor |
| Scan_cycle.vi | Sets the timebase of a scan operation |
| Scan_limit.vi | Sets the time limit for a scan operation |
| Scan_read.vi | Periodically reads back data from a Scan operation |
| Scan_start.vi | Starts a scan of the selected channels |
| Scan_stop.vi | Immediate Abort of the running Scan |
| Set_Get_echo.vi | Sets echo communication for TMM module |

**VI LIBRARY DESCRIPTION:**

**TMM_100_Control.vi**

This is the main user example to show the usage of the VI library. This example demonstrates how to read/write and control the TMM-100 module. Please refer to the more detailed usage of the program in the previous section.

**Enab_Diode.vi**

This will add the selected diode to the scan list, thus allowing for timed data acquistion.

Input Numeric: Diode number (0-7),

Input boolean: True= Enable, False =Disable

**Enab_Therm.vi**

This adds the Thermistors (channels (1-2)) and/or the thermocouples (channels 3-4) to the scan list. Use this function to remove the sensors from the list also.

Input Numeric: Thermal sensor number (0-3)

Input Boolean: True=add to scan, False= remove from scan list

**Find_Serial_Port.vi**

Use this VI to find and initialize the serial port connected to the TMM-100 module,

This VI will reinitialize other COM ports so should be called first if using other COM ports in LabVIEW

**Firmware_Version.vi**

This VI returns the current version of the Firmware for TMM-100

Return: String containing firmware version

**Read_Diode.vi**

Returns the immediate read for the selected diode number:

Input Numeric: Diode number (0-7)

Output Numeric: Read value of diode

**Read_Therm.vi**

This Function performs and immediate read of the temperature sensors on the TMM module. Sensors 1 and 2 are Thermistors, Sensors 3 and 4 are Thermocouples. For precise timing one should use the scanning commands.

Input Numeric: Thermal sensor number (0-3)

Output Numeric: Value of sensor in degrees Celsius

**Relay.vi**

Use this VI for Fan Relay Control

Input Boolean: True=Relay ON, False= Relay OFF

**Scan_Cycle.vi**

Scan Cycle can be set from 0-2

Scan_Cycle sets the sampling rate. Set this variable before calling Scan_Start.vi. The 10ms setting is only valid for a single sensor. For multiple sensors the highest sample rate is 100ms.

0=10ms (only valid for single sensor)

1=100ms

2=1 second

Input Numeric: Scan cycle value (0-2)

**Scan_limit.vi**

This vi sets the scan limit, and should be setup prior to calling the Scan_start.vi. The scan limit(N) is the number of overall samples. For example if N=100 at 100ms there is 10 seconds of data. The sample rate is set with Scan Cycle.vi

Input Numeric: Scan limit value

**Scan_Read.vi**

Scan read checks if there are bytes at the serial ports and returns whatever characters are ready to be read. This VI must be used in a loop and the buffer should be used with a shift register as shown in the example. As the buffer string is built the lines are picked off and organized into a table. The first line contains the header of the selected sensor, and the last line contains the end char #>. In the example both first and last lines are removed, and the data put in a table.

Input String: Buffer to be used for parsing the rows during a scan

Output String: Chars read at the serial port

**Scan Start.vi**

Initiates a Scan that has previously been set up with the Scan Cycle and Scan Limit commands, and the channels of interest have been added to the list. After the scan has started the TMM module will periodically send the data to the computer and the data must be read out using the Scan Read.vi

To abort a running scan use the Scan Stop vi

**Stop Scan.vi**

Aborts a scan started by the Start Scan command.

**Set_Get_Echo.vi**

This VI can set or get ECHO. Echo will return the typed commands if using in the terminal mode.

ECHO on will repeat back the command send to the TMM-100 module.

Input Boolean: True=Echo ON, False= Echo Off