

Titan *Thermocouple*

User Manual



29 C Street • Laurel, Maryland • 20707

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Warning

Only a qualified technician or representative of Mars Labs should attempt to service the components of this system. There are no user-serviceable parts inside.

For the safety and protection of the equipment, power must be turned off prior to connecting or disconnecting cables and sensors.

**Titan Thermocouple User Manual v4.3
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Table of Contents

Introduction

Furnished Accessories	4
Support	4
General Guidelines and Warnings	5
Guidelines for Wiring Sensors	6

Operation

Front Panel	7
Rear Panel	8
Theory and Operation of Thermocouples	10

Configuration Options

Issuing commands in TCS	12
Issuing commands in a Terminal Emulator	12
SET_BAUD_RATE	13
SET_DEFAULT_BAUD_RATE	13
SET_THERMOCOUPLE	14
SET_SYNC	15
ENABLE_THERMOCOUPLE	15
SET_OUTPUT_TYPE	16
SET_OUTPUT_UNIT	17

Transforms

Type K	18
Type T	19
Type J	20

Additional Configuration Information

22

Features & Specifications

Key Features	23
Specifications	23

Titan Thermocouple Nomenclature

24

Troubleshooting

25

Warranty & Repair

26

Introduction

The Titan Thermocouple is a fully integrated data acquisition system that features a 16-channel interface with on-board signal conditioning, programmable gain and filtering, and A/D conversion. The Titan Thermocouple can be powered by the supplied USB ‘Y’ cable when connected to a PC, or by applying power to the auxiliary power connector.

This manual is intended to provide an overview of the Titan Thermocouple, with complete feature descriptions, specifications, setup procedures and operational information. It contains important safety information as well.

Furnished Accessories

The Titan Thermocouple is shipped with the following items:

1. Titan Thermocouple
2. USB ‘Y’ Cable
3. CD-ROM Installation Disc

Depending on the model, the Thermocouple may also be shipped with an external power adapter (when the power adapter is provided, the USB ‘Y’ cable may not be included).

The CD-ROM Installation Disc contains the Titan Control Software (TCS) installation files, related support files, and PDF images of the Thermocouple User Manual and TCS User Manual.

Documentation supplied with the shipment includes:

1. Calibration Certificate
2. Calibration Data Sheet
3. Titan Thermocouple User Manual (hardcopy)
4. Titan Control Software (TCS) User Manual (hardcopy)

Support

Support for this product is available by contacting the factory during regular business hours (9am – 6pm EST) at 301-470-3278. Additional information can be found on our web site: <http://www.marslabs.com>

General Guidelines and Warnings

Electro-Static Discharge

Electro-Static Discharge (ESD) occurs when a static charge builds up on either yourself or the Titan hardware, and then you touch the Titan hardware. The static spark can be so small that you don't feel it, however, it can flaw a semiconductor. These flaws may generate an immediate failure, or, in most cases, cause a slight reduction in performance which will continue to degrade, eventually leading to failure of the hardware. When you feel a static shock, you are experiencing a minimum of 3,000 volts of electricity.

It is good practice to always ground yourself and the Titan hardware while connecting and removing sensors.

Always use approved ESD handling procedures to prevent ESD damage.



Grounding Titans

In general, grounding the Titan hardware to the test vehicle or test structure will usually reduce noise pickup. Also, while setting up and configuring the Titan hardware and sensors, you should take precautions to avoid establishing ground loops.



Specific Warnings

When using a power adapter with a Titan device, always connect the adapter to the device *before* applying power. Never hot plug a device under any circumstances - hot plugging may damage the device!

Guidelines for Wiring Sensors

Observe the following guidelines when wiring and connecting sensors to the Titan hardware:

1. Observe polarity of sensor wires
2. Strain relieve all connections
3. Secure cables with wire ties and bundle cables where possible.
4. Apply heat shrink to exposed wires
5. Double check all connections prior to connecting the cables to the Titan.
6. Use only heavy gauge CAT-6 cables with locking tabs when connecting to the Titan CPU.
7. When routing cables, be aware of sharp edges and pinch points where cables can bind, or be cut, introducing shorts in the wiring.

Operation

Front Panel

The Titan Thermocouple front panel incorporates a USB interface and a power connector:



Power Connector

Depending on the model, a 3-pin XLR connector (shown) or a 4-pin connector is used to provide power to the Thermocouple.

For the XLR connector, pin 1 is negative, pins 2 and 3 are positive.

For the 4-pin connector, pin 1 is negative, pin 2 is positive, pin 3 is case ground and pin 4 is NC.

For either type of connector, a power pinout label can be found on the side of the case closest to the connector.

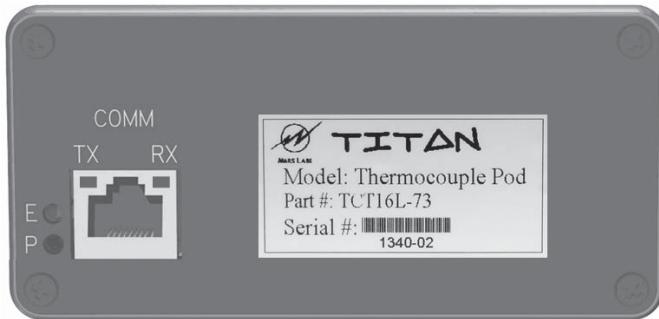
WARNING: When using a power adapter with a Titan device, always connect the adapter to the device before applying power. Never hot plug a device under any circumstances - hot plugging may damage the device!

USB Port

A USB Type B connector provides the communications interface between the Titan Thermocouple and a PC running the Titan Control Software (TCS) application.

Rear Panel

The Titan Thermocouple rear panel incorporates two LED status indicators and a communications port:



Status Indicators

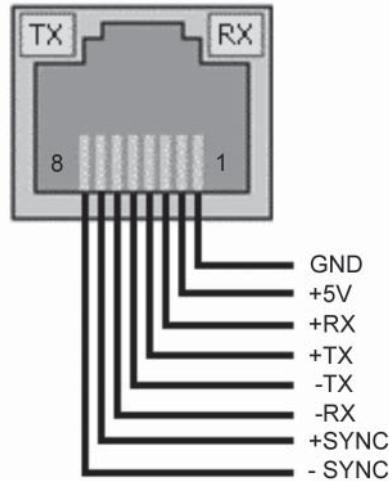
P (Power) – A green LED indicating that the Titan Thermocouple is ON.

E (Error) – A red LED indicating that a sensor output has met or exceeded the range for the configured sensor channel as displayed on the TCS ‘Tags & Channels’ screen. If the input signal exceeds the maximum amount, either negative or positive, the Error LED will be lit for as long as the input exceeds the maximum. When the input signal falls back into the acceptable range, the Error LED will go out. Note that the Error LED will be lit for any channel that exceeds the maximum range. If you are viewing signals in the TCS Runtime screen, the signals will be clipped when they exceed the maximum allowable input.

COMM

An RJ-45 connector is used to interface the Thermocouple with the Titan CPU Channel Multiplexer and provide other communication options. Integrated LED's in the connector (TX and RX) indicate when the Thermocouple is transmitting or receiving data through this port.

Pinout:



NOTE: For information on configuring the COMM port for communication with TCS instead of the USB port, refer to 'Running with RS-422' in the TCS User Manual

Theory and Operation of Thermocouples

This section will address the theory and operation of thermocouples in real-world applications.

A thermocouple consists of a junction between two different metals that produces a voltage related to temperature. All dissimilar metal junctions exhibit this phenomenon, called the “Seebeck effect”. One common thermocouple is the T-Type, which is shown below:



Figure 1. Thermocouple Junction

The voltage on the Copper and Constantin (Cu and C, respectively) leads is related to the temperature of the junction J1 by a polynomial in general, and linearly when the temperature range is small. Connection of those Cu and C leads directly to a copper volt-meter results in one additional junction between the Constantin of the Thermocouple and Copper lead of the Meter, as seen below at junction J2 (J3 is Cu-Cu, which results in zero voltage):

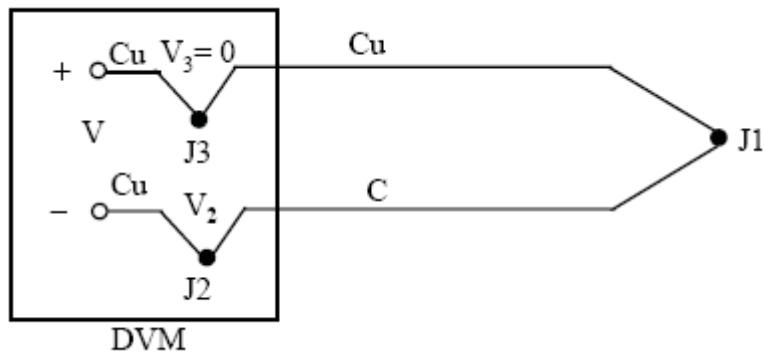


Figure 2. Thermocouple attached to a Digital Volt Meter

Compensation for this additional junction is accounted for within the Titan devices, the details of which are outside the context of this discussion.

The purpose of this discussion is to emphasize the sensitivity of the measurement to external effects. By extending the thermocouple with regular hookup wire, for instance, an additional junction is created between the thermocouple and the hookup wire. This will lead to an error in the

measurement unless some compensation for the junction is made. Additionally, by placing the junction J1 in an environment that may affect its output voltage such as in an electrolytic solution, the thermocouple may report misleading values. Finally, connection of the thermocouple to some conductive surface may or may not be of concern. Should that surface have any electrical path back to the Titan Thermocouple device such as a common ground, voltage readings from the thermocouple may be unreliable. **These concerns suggest that any and all electrical isolation (galvanic isolation) precautions should be taken when installing a thermocouple.** The material used to isolate the thermocouple should depend on the application. In most applications where temperatures are within –55 to 260 degrees C, nonconductive epoxy such as J-B Weld may be used. In more extreme temperatures, applications may call for specialty epoxy or cement. For example, if the temperature event under study is very fast the method of isolation must be very quick to change temperature. Omega Engineering sells thermally conductive cement called OmegaBond that is electrically isolating and suitable for such uses. Thin coats of this cement may be applied to thermocouples to isolate them electrically while allowing high thermal conductivity. This cement is suitable for high temperature applications. For more information on OmegaBond, go to:

http://www.omega.com/ppt/pptsc.asp?ref=OB_BOND_CHEM_SET&Nav=termf08

Thermocouples are available in several variants. *Titan Thermocouple* devices support the **J**, **K**, or **T** type, depending on the model purchased. The table below displays the temperature ranges and related connection information for the three supported thermocouple types.

Type	Temp Range (C)	Positive (+) Lead	Recommended TCS Gain
K	-180 to +1300	Yellow	32
J	-180 to +800	White	32
T	-250 to +400	Blue	32

In summary, when using thermocouples:

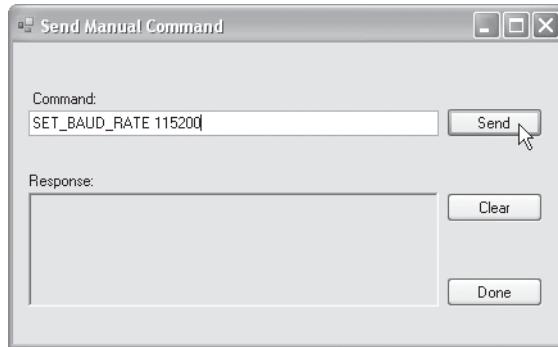
- 1) Electrically isolate thermocouples from the environment in which they are used
- 2) Minimize isolation mass around thermocouple when concerned with high-speed temperature events
- 3) Use the appropriate thermocouple for the application
- 4) Use appropriate thermocouple hookup or extension cabling for the type of thermocouple in use
- 5) Always observe the polarity of connections

Configuration Options

Titan Thermocouples offer a number of configuration options. This section will address the most basic configuration options used in typical thermocouple applications and explain how each option can be configured by issuing simple commands in TCS or via a terminal emulation program. For a complete list of configuration commands, refer to the ICD Specification for Titan Thermocouple Devices, SPC-2034.

Issuing Commands in TCS

TCS has a ‘Send Manual Command’ feature that allows you to issue configuration commands to the connected device. To access this feature, connect to the Titan device and then go to Device/Advanced/Send Manual Command, or select F10. Either method will present you with a command window:



Type the desired configuration command in the COMMAND field (observing the proper syntax) and click the ‘SEND’ button. Only one command may be issued at a time.

Issuing Commands in a Terminal Emulator

A terminal emulator (e.g. RealTerm, Hyperterminal, etc.) can be used to issue configuration commands to the device. If you are using a terminal emulator, you will need to specify the port of the device as well as the baud rate that the device is configured for (if connecting via USB, baud rate is not necessary). Refer to the terminal emulator documentation for additional instructions on connecting and issuing commands.

NOTE: *The port for the target device can not be in use by any other program. In TCS the port can be released by selecting ‘Disconnect’ or F1 while connected.*

Configuration Commands

SET_BAUD_RATE

The SET_BAUD_RATE command is used to set the baud rate of the COMM port. Valid baud rates are:

115,200
230,400
921,600
1,843,200
3,000,000

The command syntax is:

SET_BAUD_RATE <VALUE> <CR>

Example:

SET_BAUD_RATE 3000000 <CR>

The example shown will set the baud rate to 3Mbits/second. Note that baud rate values do not include commas. If an invalid baud rate value is issued, the Titan Thermocouple will respond with an ERROR.

SET_DEFAULT_BAUD_RATE

The SET_DEFAULT_BAUD_RATE command is used to set the baud rate of the COMM port when the Titan device powers up. If no default is set the board will power up at 115,200 baud. Valid baud rates are:

115,200
230,400
921,600
1,843,200
3,000,000

The command syntax is:

SET_DEFAULT_BAUD_RATE <VALUE> <CR>

Example:

SET_DEFAULT_BAUD_RATE 921600 <CR>

The example shown will set the baud rate to 921600 baud. Note that baud rate values do not include commas. For any command issued, the Titan Thermocouple will respond with an ACK (acknowledgement) for valid baud rate values, and an ERROR for invalid ones. To reset the baud rate back to the default status (no default selected), send the command:

SET_DEFAULT_BAUD_RATE 0 <CR>

SET_THERMOCOUPLE

The SET_THERMOCOUPLE command is used to set the Thermocouple type and range for the system. Valid types are 0 (Type J), 1 (Type K) and 2 (Type T); valid ranges depend on the thermocouple type.

For Type J, the ranges are:

- 0 : -210 to 0 degrees C
- 1 : 0 to 760 degrees C
- 2 : 760 to 1200 degrees C
- 4 : Full Range

For Type K, the ranges are:

- 0 : -270 to 0 degrees C
- 1 : 0 to 500 degrees C
- 2 : 500 to 1372 degrees C
- 4 : Full Range

For Type T, the ranges are:

- 0 : -200 to 0 degrees C
- 1 : 0 to 400 degrees C
- 4 : Full Range

The command syntax is:

```
SET_THERMOCOUPLE <TYPE> <RANGE> <CR>
```

Example:

```
SET_THERMOCOUPLE 1,1 <CR>
```

The example shown will set the Thermocouple for Type K transforms with a range of 0 to 500 degrees C. For any command issued, the Titan Thermocouple will respond with an ACK for valid settings, and an ERROR for invalid ones.

SET_SYNC

The SET_SYNC command enables or disables the sync word. The sync word precedes every scan and has a value of 0x5A 0x5A. Valid inputs are:

- 0 : Sync word OFF
- 1 : Sync word ON
- 2 : Extended sync (scans will be preceded by alternating sync bytes of ‘5A’ and ‘A5’).

The command syntax is:

SET_SYNC <VALUE> <CR>

Example:

SET_SYNC 1 <CR>

The example shown will turn the sync word ON. For any command issued, the Titan Thermocouple will respond with an ACK for valid settings, and an ERROR for invalid ones.

ENABLE_THERMOCOUPLE

The ENABLE_THERMOCOUPLE command is used to enable cold junction compensation on the specified channel. Command input values specify the channel <CH> and enable/disable status <VALUE>.

Channel: Integer values are used to specify individual channels (1-16). A CH value of 0 will set all channels to the selected enable or disable value.

Value 0 : Disable
 1 : Enable

The command syntax is:

ENABLE_THERMOCOUPLE <CH> <VALUE> <CR>

Example:

ENABLE_THERMOCOUPLE 1,1 <CR>

The example shown will enable the cold junction compensation on channel 1. If the Thermocouple output is configured for Raw Float or ASCII Encoded Float output mode, transforms on channel 1 will also be enabled. For any command issued, the Titan Thermocouple will respond with an ACK for valid settings, and an ERROR for invalid ones.

SET_OUTPUT_TYPE

The SET_OUTPUT_TYPE command sets the output format for the Thermocouples. Valid output modes are:

- 0 : Normal output, no transform applied
- 1 : Raw Float, transform applied
- 2 : ASCII Encoded Float, transform applied

NOTE: When transforms are applied (OUTPUT TYPE = 1 or 2), the thermocouple must be operated in Low Speed mode.

The command syntax is:

SET_OUTPUT_TYPE <VALUE> <CR>

Example:

SET_OUTPUT_TYPE 1 <CR>

The example shown above enables the output for Raw Float mode. Note that for any command issued, the Titan Thermocouple will respond with an ACK for valid settings, and an ERROR for invalid ones.

In normal output mode, the Titan Thermocouple will output temperature values directly. These can be viewed in either degrees C or degrees F in the TCS.

In raw floating point output mode, hexadecimal floating point values are used to represent temperature. Raw floating point values are 4 bytes in length with the least significant byte (LSB) first. For example, the Titan Thermocouple might output a floating point value like:

00 29 C8 41

Reversing the byte order, the true hex floating point representation becomes:

41 C8 29 00

Converting this to a decimal value gives a temperature of 25.02 degrees C.

In ASCII Encoded Float output mode, temperature is represented by a series of ASCII values. As an example, for a measured temperature of 25.02 degrees C, the Titan Thermocouple output would be:

32 35 2E 30 32

NOTE: The Titan Thermocouple must be set to normal output mode for proper operation with TCS or with the Titan CPU by issuing ‘SET_OUTPUT_TYPE 0 <CR>’

SET_OUTPUT_UNIT

The SET_OUTPUT_UNIT command is used to specify the temperature output unit (Celsius or Fahrenheit).

Value	0 : Celsius
	1 : Fahrenheit

The command syntax is:

```
SET_OUTPUT_UNIT <VALUE> <CR>
```

Example:

```
SET_OUTPUT_UNIT 1 <CR>
```

The example shown will set the Output units to degrees Fahrenheit. The Titan Thermocouple will respond with an ACK for valid settings, and an ERROR for invalid ones.

NOTES:

1. *The SET_OUTPUT_UNIT command is only valid when transforms are applied (see SET_OUTPUT_TYPE on the preceding page); this command will be ignored when OUTPUT TYPE is set to ‘Normal Output’ (Mode 0) .*
2. *‘Celsius’ is the default output when transforms are applied.*

Transforms

Titan Thermocouple devices apply transforms for Raw Float and ASCII Encoded Float output modes. The transforms are shown below.

(Transform information obtained from the NIST Thermocouple database at <http://srdata.nist.gov>).

Type K Transforms

```
*****
* This section contains coefficients of approximate inverse
* functions for type K thermocouples for the subranges of
* temperature and voltage listed below. The range of errors of
* the approximate inverse function for each subrange is also given.
* The coefficients are in units of °C and mV and are listed in
* the order of constant term up to the highest order.
* The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ...
*      + d_n*E^n,
* where E is in mV and t_90 is in °C.
*
*      Temperature          Voltage          Error
*      range              range          range
*      (°C)                (mV)            (° C)
*      -200. to 0.        -5.891 to 0.000    -0.02 to 0.04
*      0. to 500.         0.000 to 20.644   -0.05 to 0.04
*      500. to 1372.     20.644 to 54.886   -0.05 to 0.06
*****
Inverse coefficients for type K:

Temperature  -200.          0.          500.
Range:       0.             500.        1372.

Voltage    -5.891          0.000        20.644
Range:      0.000          20.644      54.886

          0.0000000E+00  0.000000E+00  -1.318058E+02
          2.5173462E+01  2.508355E+01   4.830222E+01
          -1.1662878E+00  7.860106E-02  -1.646031E+00
          -1.0833638E+00  -2.503131E-01  5.464731E-02
          -8.9773540E-01  8.315270E-02  -9.650715E-04
          -3.7342377E-01  -1.228034E-02  8.802193E-06
          -8.6632643E-02  9.804036E-04  -3.110810E-08
          -1.0450598E-02  -4.413030E-05  0.000000E+00
          -5.1920577E-04  1.057734E-06  0.000000E+00
          0.0000000E+00  -1.052755E-08  0.000000E+00

Error      -0.02          -0.05        -0.05
Range:     0.04          0.04        0.06
```

Type T Transforms

```
*****
* This section contains coefficients of approximate inverse
* functions for type T thermocouples for the subranges of
* temperature and voltage listed below. The range of errors of
* the approximate inverse function for each subrange is also given.
* The coefficients are in units of °C and mV and are listed in
* the order of constant term up to the highest order.
* The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ...
*      + d_n*E^n,
* where E is in mV and t_90 is in °C.
*
*      Temperature          Voltage          Error
*      range                range          range
*      (°C)                 (mV)           (° C)
*      -200. to 0.          -5.603 to 0.000   -0.02 to 0.04
*      .0 to 400.          0.000 to 20.872   -0.03 to 0.03
*****
```

Inverse coefficients for type T:

Temperature	-200.	0.
Range:	0.	400.

Voltage	-5.603	0.000
Range:	0.000	20.872

0.0000000E+00	0.000000E+00
2.5949192E+01	2.592800E+01
-2.1316967E-01	-7.602961E-01
7.9018692E-01	4.637791E-02
4.2527777E-01	-2.165394E-03
1.3304473E-01	6.048144E-05
2.0241446E-02	-7.293422E-07
1.2668171E-03	0.000000E+00

Error	-0.02	-0.03
Range:	0.04	0.03

Type J Transforms

```
*****
* This section contains coefficients for type J thermocouples for
* the two subranges of temperature listed below. The coefficients
* are in units of °C and mV and are listed in the order of constant
* term up to the highest order. The equation is of the form
* E = sum(i=0 to n) c_i t^i.
*
* Temperature Range (°C)
*      -210.000 to 760.000
*      760.000 to 1200.000
*****
Name: reference function on ITS-90
Type: J
Temperature units: °C
EMF units: mV

Temperature
Range:      -210.0 to 760.0

          0.000000000000E+00
          0.503811878150E-01
          0.304758369300E-04
          -0.856810657200E-07
          0.132281952950E-09
          -0.170529583370E-12
          0.209480906970E-15
          -0.125383953360E-18
          0.156317256970E-22

Temperature
Range:      760 to 1200.0

          0.296456256810E+03
          -0.149761277860E+01
          0.317871039240E-02
          -0.318476867010E-05
          0.157208190040E-08
          -0.306913690560E-12
```

Type J Transforms

```
*****
* This section contains coefficients of approximate inverse
* functions for type J thermocouples for the subranges of
* temperature and voltage listed below. The range of errors of
* the approximate inverse function for each subrange is also given.
* The coefficients are in units of °C and mV and are listed in
* the order of constant term up to the highest order.
* The equation is of the form t_90 = d_0 + d_1*E + d_2*E^2 + ...
*      + d_n*E^n,
* where E is in mV and t_90 is in °C.
*
*      Temperature          Voltage          Error
*      range                range            range
*      (°C)                 (mV)           (° C)
*      -210. to 0.          -8.095 to 0.000   -0.05 to 0.03
*      0. to 760.           0.000 to 42.919   -0.04 to 0.04
*      760. to 1200         42.919 to 69.553   -0.04 to 0.03
*****
```

Inverse coefficients for type J:

Temperature	-210.	0.	760.
Range:	0.	760.	1200.
Voltage	-8.095	0.000	42.919
Range:	0.000	42.919	69.553
0.0000000E+00	0.000000E+00	-3.11358187E+03	
1.9528268E+01	1.978425E+01	3.00543684E+02	
-1.2286185E+00	-2.001204E-01	-9.94773230E+00	
-1.0752178E+00	1.036969E-02	1.70276630E-01	
-5.9086933E-01	-2.549687E-04	-1.43033468E-03	
-1.7256713E-01	3.585153E-06	4.73886084E-06	
-2.8131513E-02	-5.344285E-08	0.00000000E+00	
-2.3963370E-03	5.099890E-10	0.00000000E+00	
-8.3823321E-05	0.000000E+00	0.00000000E+00	
Error	-0.05	-0.04	-0.04
Range:	0.03	0.04	0.03

Additional Configuration Information

In the Titan Control Software (TCS), observe the following configuration guidelines:

1. Thermocouple channels should always be set to ‘VCAL’ (voltage calibration).
2. Configuring the Titan Thermocouple for a gain of 32 will provide the full temperature range for all supported thermocouple types.
3. Configuring the Titan Thermocouple for a gain of 64 will cause the device to max out at 750 degrees C for Type K thermocouples and 550 degrees C for Type J thermocouples.

Features and Specifications

Key Features

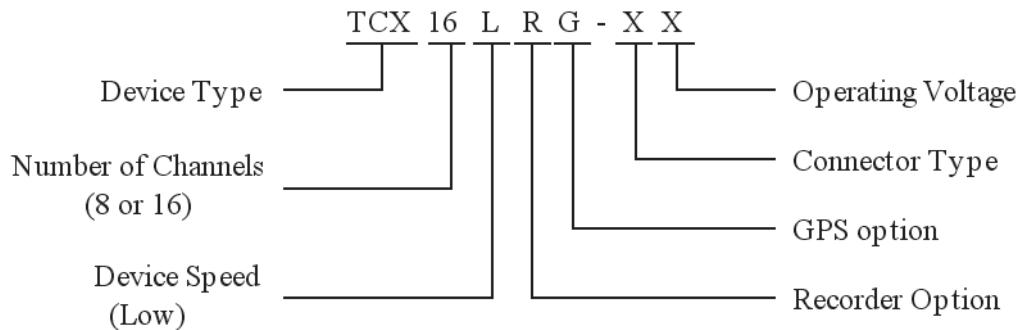
- Supports multiple modes of operation:
 - Connected to a PC recording up to 16 channels
 - Connected to an 8-port Titan CPU for up to 128 channels
- Lightweight and portable
- Sensor input connections via mini-TC jacks
- Simplified user interface provides easy operation under difficult operating conditions.
- Sample rates up to 1200 Hz/channel (up to 512Hz/channel in floating point output mode)

Specifications

Number of Channels and Filters	16
Input Connector	Mini Thermocouple
Power Requirements	9-32 VDC (Auxiliary Power) 5V @ 100mA (USB typical)
Sensors Supported	Thermocouple Types J, K & T
PC Operation	Via USB Connector
Titan CPU Channel Multiplexer Operation	Via RJ45 COMM connector

Titan Thermocouple Nomenclature

Titan Thermocouples are offered in a wide range of configuration options. Device configurations are specified by the part number in the following format:



Titan Device Type:

TCJ = Type J thermocouple

TCK = Type K thermocouple

TCT = Type T thermocouple

Connector Type:

Two connector types are available:

0 = DB37 (no top board)

7 = Thermocouple mini-plugs

Operating Voltage:

1 = 12V (isolated)

2 = 24V (isolated)

3 = Wide input range (9 - 32V - non-isolated)

Troubleshooting

This section under development

Warranty

Mars Labs warrants all their manufactured equipment to be free from defects in material and workmanship. **Mars Labs** liability under this warranty is limited to servicing or adjusting any equipment returned to the factory for that purpose, and to replace any defective parts thereof. The warranty remains effective for 365 days following delivery to the original purchaser. During this time, equipment will only receive repair when the original purchaser prepays all return transportation charges, and **Mars Labs** finds to its satisfaction that the equipment is indeed defective.

If the fault has been caused by misuse or abnormal conditions of operation, normal service charges will prevail. In this case, an estimate will be submitted before work is started. **Mars Labs** must authorize any warranty returns.

Mars Labs reserves the right to make changes in the design of its instruments without incurring any obligation to make the same changes on equipment previously purchased.

This warranty will be void if unauthorized alterations or modifications are found which impede the repair or testing of the equipment.

Receipt of Equipment

The equipment should be tested as soon as it is received. If the equipment is damaged in any way, a claim should be obtained by the claim agent, and this report should be forwarded to **Mars Labs**.

Mars Labs will then advise the customer of the disposition to be made of the equipment and arrange for repair or replacement. When referring to this equipment for any reason, the model number, serial number and purchase order number should be included.

Malfunction

If the unit fails to operate, or any fault develops, **Mars Labs** should be notified, giving full details of the difficulty, including model number and serial number. Upon receipt of this information, **Mars Labs** will provide service data and shipping instructions.

This warranty is expressly in lieu of all other obligations or liabilities on the part of **Mars Labs**, which neither assumes nor authorizes any person to assume for it any other liability in connection with the sale of its equipment. Contact:

Mars Labs
29 C Street
Laurel, MD
20707
(301) 470-3278
email: Support@MarsLabs.com

Notes



29 C Street • Laurel, Maryland • 20707