

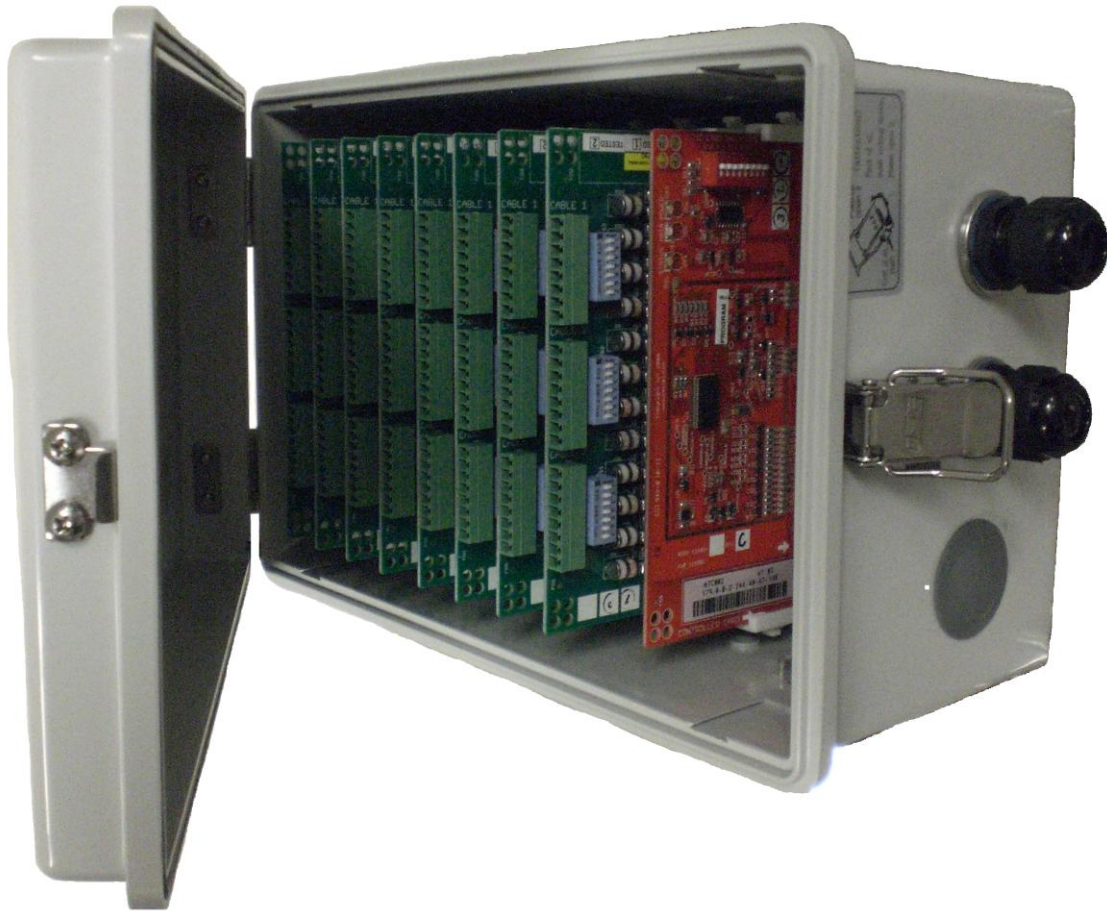


THERMOCOUPLE CONVERTER

1-WIRE[®] INTRINSICALLY SAFE 168
CHANNEL

mTC002

mTC002 Thermocouple Converter



Document No. 11159, Revision D

February 2012

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Revision Notes

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- First release

Revision A, December 13, 2010

- Add T/C cable wire color table

Revision B, February 1, 2011

- Update drawing 11171 to Revision A

Revision C, September 23, 2011

- Add commissioning section

Revision D, February 16, 2012

- Add mounting the enclosures section
- Add pictures of LT enclosure
- Add drawing 11466 Rev A



1. Overview

The mTC002 Thermocouple Converter converts 168 type T thermocouples to scaled temperature values. It is designed to measure the temperature of commodities in bulk storage bins such as grains and wood chips. Ultra low power technology is used to allow operation on CMC Industrial Electronics deployment of the Dallas 1-Wire[®] bus for intrinsically safe locations. When used with the mBC081 Bus Converter the device is Intrinsically Safe.

The unit includes 3 bus cable 110 connectors with branch disconnect switches simplifying service of the installed system. An RJ11 jack is provided for direct connection of the bus converter to the network.

The thermocouple inputs are arranged as 24 sets of 7 inputs. Each group of 7 inputs has a single constantan connection and 7 copper connections on pluggable terminal strips. There are 3 groups of seven inputs on each multiplexer card. Up to 8 multiplexer cards can be installed. A single processor card provides signal processing for the thermocouple inputs. The unit is modular with all cards plugging into a single backplane. The cards are hot swappable for easy service.

The microvolt outputs of the thermocouples are scaled to degrees Celsius. Full temperature compensation is provided. The unit measures temperatures from -40°C to $+214^{\circ}\text{C}$ in 1°C increments with an accuracy of $\pm 2^{\circ}\text{C}$. The unit incorporates 3 levels high voltage ESD protection on the thermocouple input leads.

The mTC002 Thermocouple Converter is supplied pre-installed in a NEMA4X plastic enclosure. This enclosure has been selected to prevent condensation from forming on the internal electronics due to external temperature variations. A "Gore" vent has been installed to remove water vapor from the enclosure. The enclosure should be mounted out of direct sun and provided with a rain shield. Do not alter the provided enclosure or remove the electronics from the enclosure and remount it in any other enclosure. It is permissible to mount the packaged product in its supplied enclosure inside a large enclosure if needed.



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2. Description of Indicators

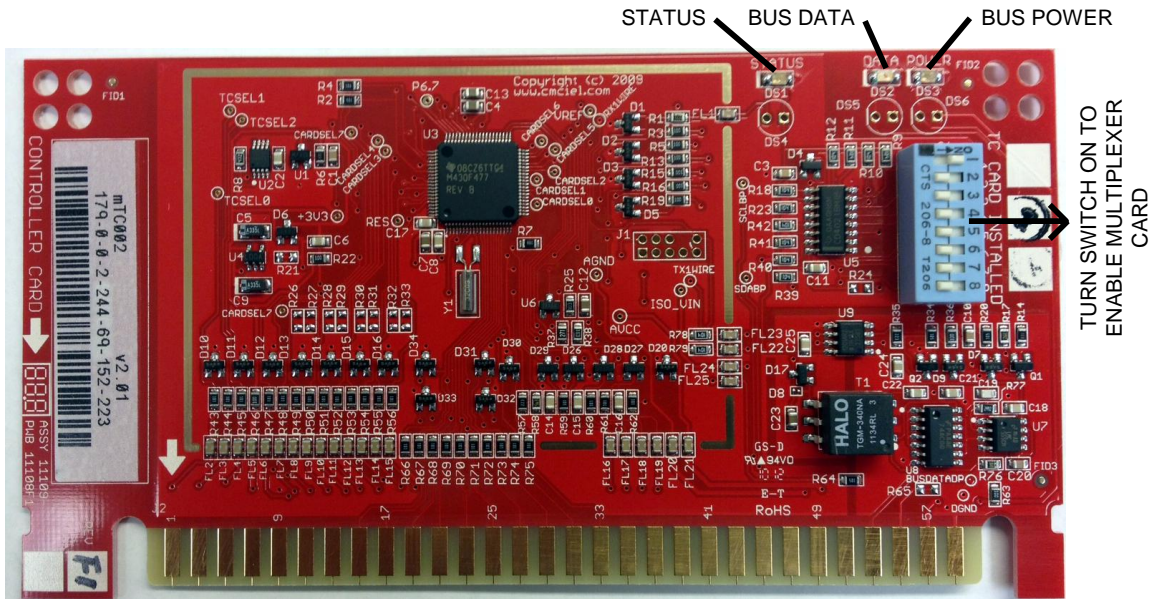


Figure 1 - Illustration of Indicators

There are 3 indicator lamps:

Description	Color	Operation
Bus Power	Red	5 volt DC power on
Bus Data	Green	Flashes if bus data is present
Status		<ul style="list-style-type: none"> 1 flash – Active no communications with bus converter 2 flashes – Active with communications with bus converter 3 flashes – open wire detection in progress 4 flashes – DigiMux bus fault 5 flashes – cold reference sensor fault 6 flashes – power on test failed 7 flashes - calibration table corrupted 8 flashes – firmware test failed

A DIP switch selects which multiplexer cards are installed in the backplane. Move the switch to the right (on position) if the multiplexer card is installed.



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3. Installation

Careful planning of the system installation will ensure reliable operation. Installation of this system should be planned and executed by licensed electricians familiar with installations in hazardous area locations. A local regulatory authority, trained in the inspection of hazardous area electrical systems, should inspect the completed installation.

3.1 Installation Overview

******* IMPORTANT SAFETY NOTICE *******

This system is intrinsically safe. Follow the drawings in the mBC081 Bus Converter Technical Manual exactly to ensure the system remains intrinsically safe. No other cables of any kind may share the network cable conduit system. Placing other cables in the conduit or device enclosures will defeat the intrinsic safety system. Failure to observe the supplied drawings and instructions could result in a fire or explosion and the risk of personal injury or death.

This device must be connected to a good quality electrical system ground through the connections provided on the backplane. The converter incorporates high-energy lightning protection that is shunted to earth ground. Failure to properly ground the provided grounding terminals on the backplane may cause severe internal damage to the device in the event of a high voltage transient on the thermocouple cable inputs.

Electronic systems mounted outdoors require humidity control to prevent condensation from forming inside the enclosure. The system is provided pre-installed in a plastic NEMA4X enclosure that has been selected to maintain a non-condensing atmosphere inside the enclosure. Do not modify the enclosure in any way. The enclosure must be installed as detailed in these instructions. All openings in the enclosure must be sealed to prevent the movement of outside air into the enclosure.

Failure to comply with the installation instructions may cause erratic or incorrect readings.



3.2 Planning the 1-Wire® cabling

The mTC001 thermocouple converter is both a device and junction point for the 1-Wire® network. The system is wired using direct burial CAT5 cable to prevent the entry of air and moisture into the enclosure.

A single RJ-12 jack is provided at each converter for connecting a mBC081 Bus Converter to the network. This connection does not have to be at the start of a network. If a bus converter is connected to the device, do not use the “INCOMING” punch down connector. The network is extended using the “BRANCH A” and “BRANCH B” punch down connectors. For all other devices, the cable from “BRANCH A” or “BRANCH B” on a previous device connects to the “INCOMING” punch down on the next device. Extend the network using the “BRANCH A” punch down first. Figure 2 details a typical 1-Wire® network layout.

Plan your network carefully. It is good layout practice to limit the number of tees in a network.. The maximum CAT5 cable length is 1000 feet.

If the RJ-11 connector on the backplane is not used for a Bus Converter, it may be used to connect any approved CMCIEL sensor to the network. The mTC001 will operate on a mixed network of approved sensors and occupies only one device address.

***** **Note** *****

There are 2 revisions of the mTC002-CC Controller. Hardware revisions starting with Rev F and above have an isolated power supply that requires more current to operate. For controllers bearing Rev E or earlier, the maximum number of mTC002 Thermocouple Converters per bus converter is 32. For hardware Rev F and later devices, the maximum number of mTC002 Thermocouple Converters permitted on a single bus converter is 15.

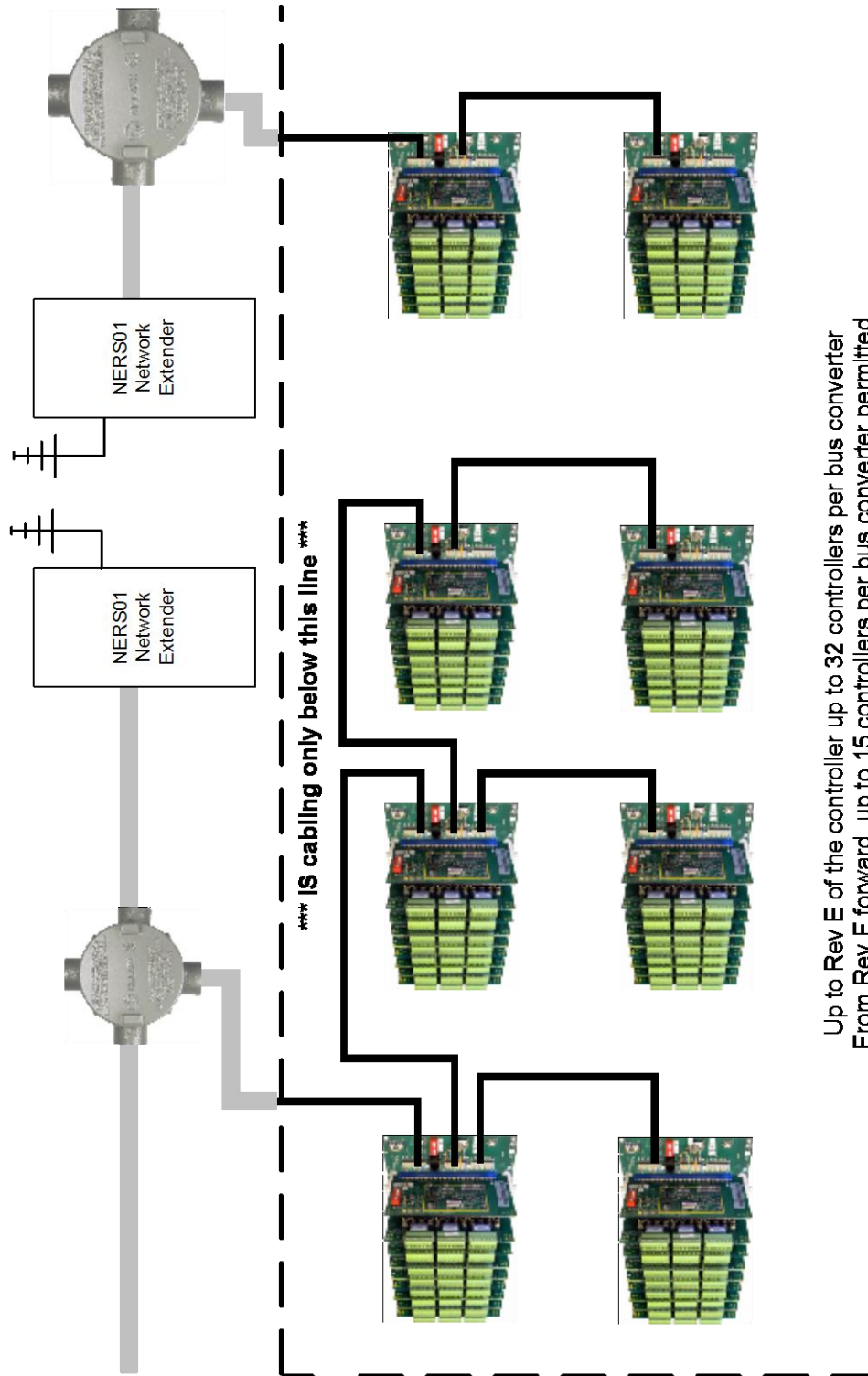


Figure 2 - Typical 1-Wire® Network Layout



3.3 Mounting the enclosures

The environment where these systems are installed can be severe and requires rigorous planning to achieve a reliable, effective system. The following general guidelines should be followed when planning your installation:

1. The mTC002 must be mounted in the supplied specially designed watertight plastic enclosure;
2. The enclosure should be protected from direct sunlight and direct rain and snow;
3. Mount the enclosures where they can be easily serviced;
4. The 1-Wire[®] bus connection should be made using direct burial CAT5 cable and plastic cord grip connectors. This cable is gel filled and will prevent the entry of moisture from the outside air through the cable;
5. The thermocouple lead wires must enter the enclosure using the designated 1" conduit opening. This fitting should be equipped with a plastic or rubber O-ring style seal on the outside of the enclosure. Once the cable has been installed, the fitting should be packed and filled with the supplied silicone sealant. It is imperative that this connection be made as air tight as possible;
6. The backplane of the converters must be connected to earth ground using the provided terminals. This must be a low resistance, high quality earth ground capable of shunting high energy electrical transients to ground. The ground cable should enter the enclosure using the same opening as the thermocouple lead wires.

Observing these basic guidelines will ensure the system remains water and air tight and is easily serviced.

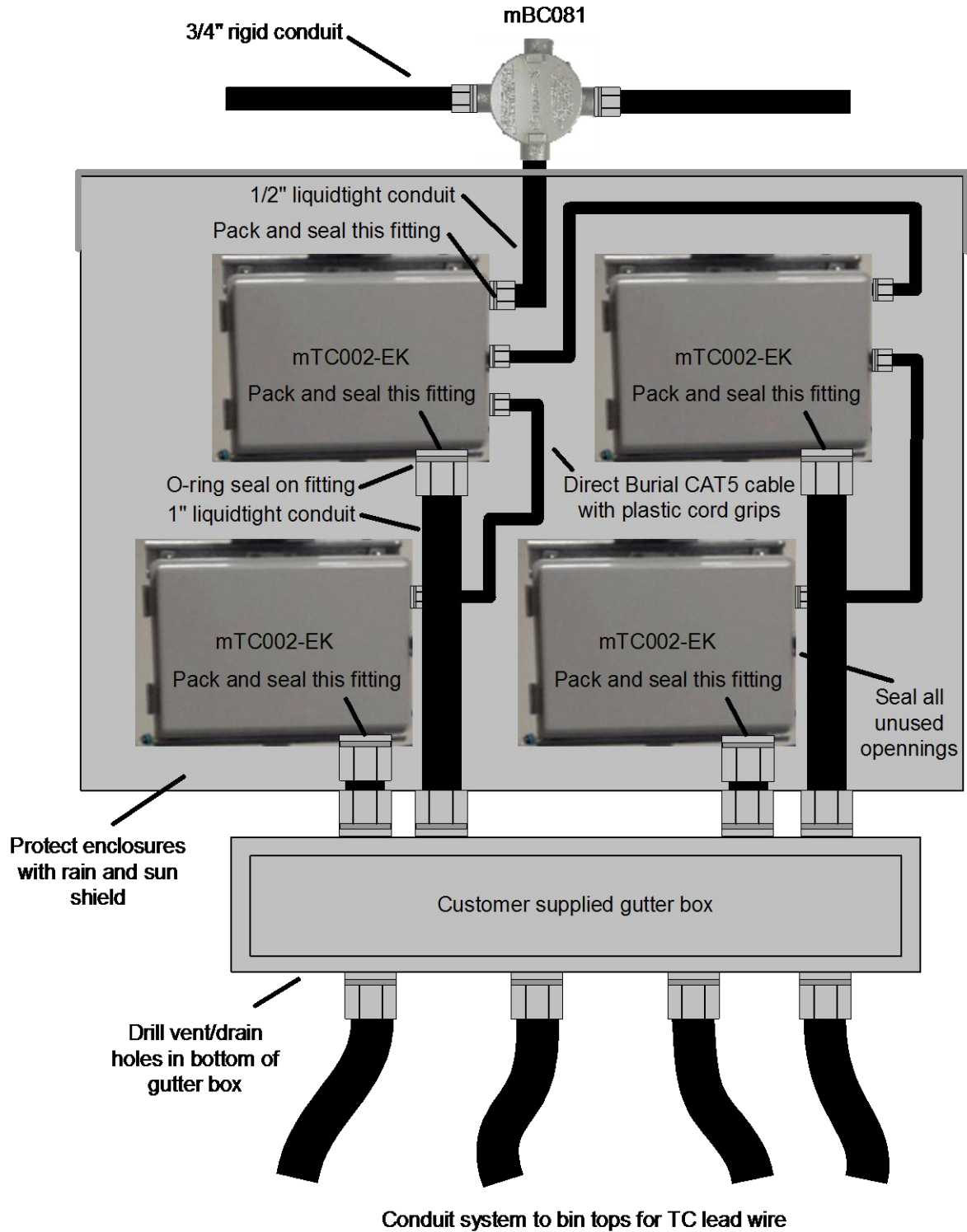


Figure 3 – mTC002-TC enclosure mounting details

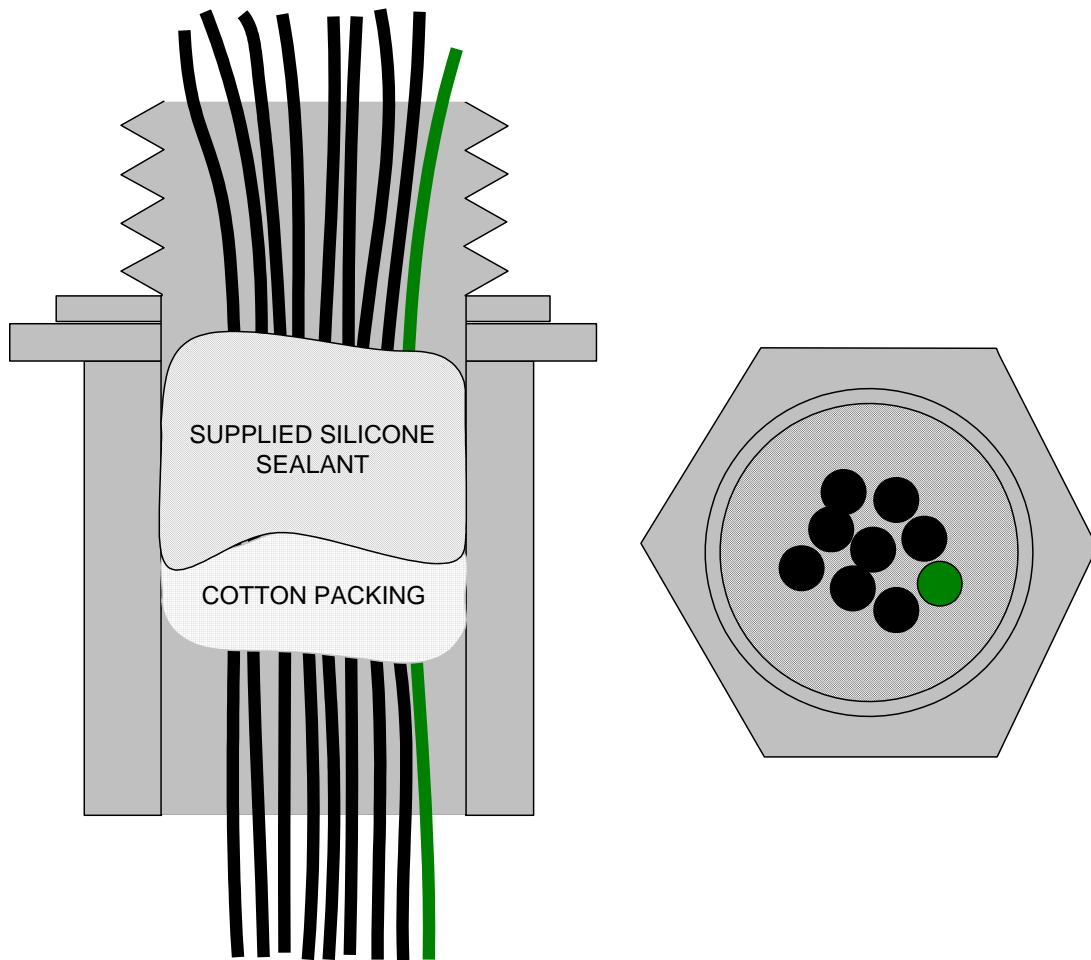


Figure 4 – Thermocouple lead wire and ground wire gland packing and sealing detail



3.4 Wiring the Converter

******* IMPORTANT NOTICE *******

The individual multiplexer cards and processor card are designed to be hot swapped without removing power from the system. Exchanging or removing a card may temporarily cause a disruption in the readings reported by the system.

The electronics used in this product are sensitive to static discharge. Do not handle the electronics cards without observing industry standard static discharge procedures. These include the use of personnel grounding straps in high static areas. Do not remove the electronics cards from their static protected packaging until all wiring is completed and verified. Handle the cards by their edges and do not handle unnecessarily. If a card is removed for service, return it immediately to the supplied antistatic packaging for transportation. Failure to properly handle the card may result in permanent damage.

Before wiring the system, mount the provided enclosure as shown above.

Connect the ground lug on the backplane to earth ground with a minimum #12 gauge conductor. Use crimp lugs on the wiring to make the connections. A minimum of #12 gauge wiring should be used for all grounding conductors. Failure to properly ground the system may result in permanent damage to the electronics in the event of a severe transient such as lightning.

The 1-Wire[®] network is wired using 110 punch down terminals. Use only a certified 110 punch down tool to make the connections. Using screwdriver or knife to make the connections will permanently damage the connectors and void the warranty.

Connect the direct burial copper shields using the provided clamps and screw terminals. Only the first device on the network should have the cable shields connected to earth ground. A jumper is provided on the backplane to connect the shielding system to earth ground. Install this jumper only on at the first device directly connected to the mBC081 Bus converter.

A Bus Converter or other CMCIEL sensor can be connected directly to the RJ11 connector on the backplane. See the section "Planning the I1-Wire[®] Cabling" for details on wiring the 1-Wire[®] network.

The thermocouple cables are connected to screw terminals on pluggable terminal strips. Attach the cables to the terminal strips before plugging the strips into the multiplexer cards. Figure 3 details the thermocouple cable connections

The thermocouple inputs are arranged as 3 groups of 7 thermocouples on each multiplexer card. Each group has a single constantan and up to 7 copper wires. We have provided a wire color table for current thermocouple cables that should be correct for most cables. Many different cable configurations exist. Follow the color code provided for the cables you are using.



If the cables have 7 or less thermocouples, each cable will use one channel of the multiplexer. If the cable has 8 to 14 thermocouples it will use 2 channels. If the cable has from 15 to 21 thermocouples it will use 3 channels. Cables that have less than 7 wires in a bundle will still connect to a single connector for each bundle. For instance a 12 wire cable (2 bundles of 6 wires) will use TC1 – TC6 on Channel 1 and then TC8 – TC13 on Channel 2. The next cable would use TC15 – TC-20 on Channel 3 and TC1 – TC6 on Channel 1 of the next card.

Typically, the first thermocouple closest to the bottom of the bin of the first cable connects to T/C 1 input on Channel 1 on TC CARD1 (card farthest from the controller).

It is not necessary to jumper unused inputs to the constantan terminal. Many cables have the constantan conductors joined together internally and this is permitted. Cables with joined constantan conductors can span two multiplexer cards.

Unused inputs must be disabled using the DIP switches directly below the terminal blocks. The input is disabled when the switch is turned on. The input will read ambient temperature if the DIP switch is set to “TC Input Not Used”. The DIP switch does not disconnect the thermocouple input; it internally connects the input to the constantan common terminal.

DIP switches on the processor card are used to disable multiplexer card slots not in use. See Figure 1 for a description of the DIP switch operation. Turn on the DIP switch associated with each multiplexer card installed in the backplane. Unused multiplexer cards do not have to be installed. If a card select switch is on and the multiplexer card not present, the system will display an open cable fault for the inputs associated with the missing multiplexer card.

Once the wiring is complete and verified, install the multiplexer cards and the processor card. Follow the “Important Notice” instructions above whenever handling the multiplexer cards and processor card. Follow the steps outlined in “Section 4 – Commissioning” to ready the system for operation.

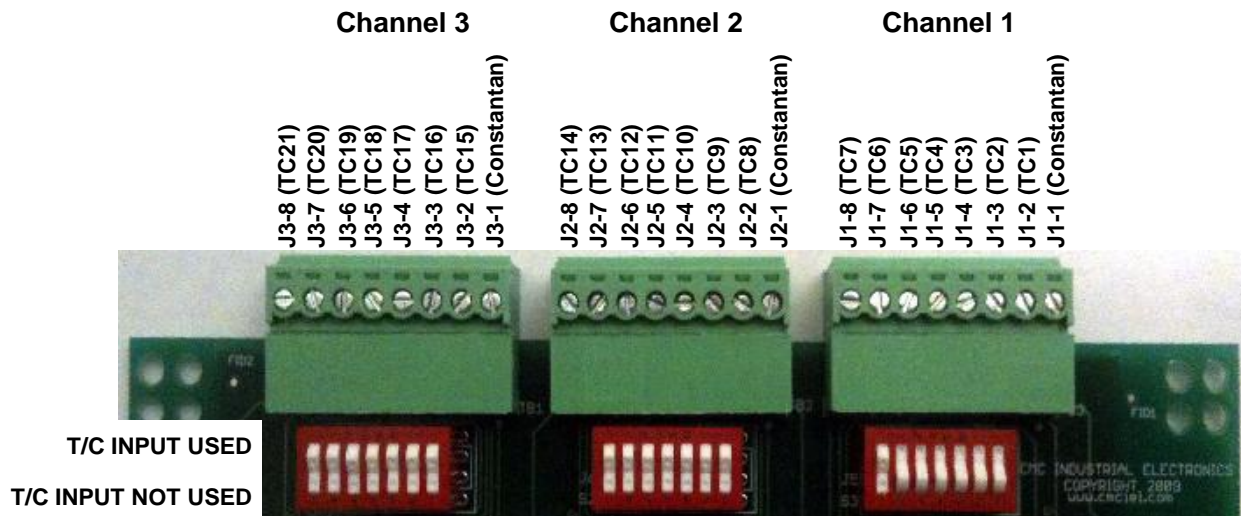


Figure 5 – mTC002-TC card wiring details



The drawing below details the typical construction of a 21 wire grain cable. Also below are wire color tables for various cable sizes from 6 to 21 thermocouples provided by a variety of manufacturers.

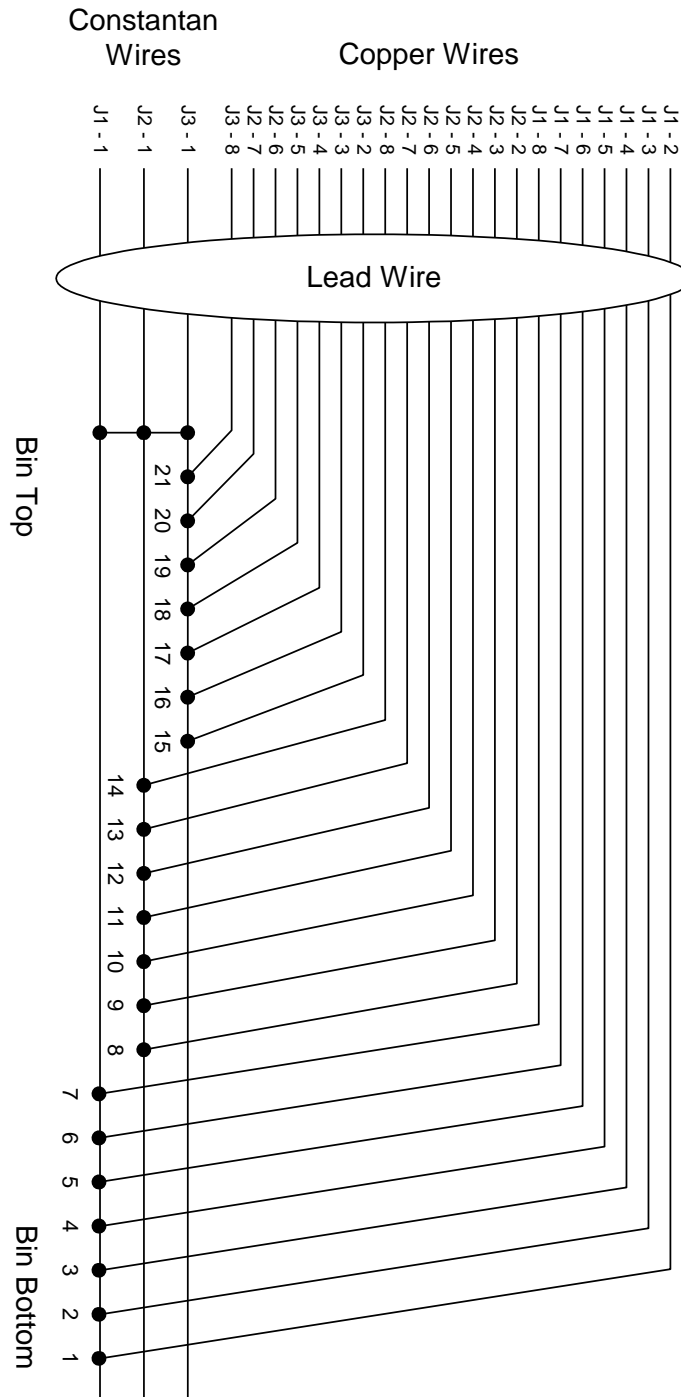


Figure 6 – Typical Grain Bin Thermocouple Cable



T/C #	ROLFES, BOONE & TSGC	HOT SPOT	HOT SPOT	OLD ROLFES	BURDICK	DECATUR, BRICE	ZELNY
Top of cable (18)	CLEAR	CLEAR	YELLOW	BLUE	BLUE	BLUE	RED/SLATE
17	YELLOW	YELLOW	RED	PINK	GREEN	GREEN	RED/BLACK
16	RED	RED	GREEN	YELLOW	YELLOW	YELLOW	RED/GREEN
15	GREEN	GREEN	BLUE	GREEN	ORANGE	CLEAR	RED/YELLOW
14	BLUE	BLUE	BLACK	BLACK	RED	RED	RED/RED
13	BLACK	BLACK	VIOLET	RED	BROWN	BROWN	RED/BLUE
Constantan 3	ORANGE *	BROWN *	BLACK STRING	CLEAR *	BLACK *	WHITE *	HEAVY WHITE *
12	CLEAR	CLEAR	YELLOW	BLUE	BLUE	BLUE	WHITE/SLATE
11	YELLOW	YELLOW	RED	PINK	GREEN	GREEN	WHITE/BLACK
10	RED	RED	GREEN	YELLOW	YELLOW	YELLOW	WHITE/GREEN
9	GREEN	GREEN	BLUE	GREEN	ORANGE	CLEAR	WHITE/YELLOW
8	BLUE	BLUE	BLACK	BLACK	RED	RED	WHITE/RED
7	BLACK	BLACK	VIOLET	RED	BROWN	BROWN	WHITE/BLUE
Constantan 2	BROWN *	ORANGE *	YELLOW STRING	BROWN *	WHITE *	GRAY(SILVER) *	HEAVY WHITE *
6	CLEAR	CLEAR	YELLOW	BLUE	BLUE	BLUE	SLATE
5	YELLOW	YELLOW	RED	PINK	GREEN	GREEN	BLACK
4	RED	RED	GREEN	YELLOW	YELLOW	YELLOW	GREEN
3	GREEN	GREEN	BLUE	GREEN	ORANGE	CLEAR	YELLOW
2	BLUE	BLUE	BLACK	BLACK	RED	RED	RED
Bottom of cable (1)	BLACK	BLACK	VIOLET	RED	BROWN	BROWN	BLUE
Constantan 1	WHITE *	WHITE *	WHITE STRING	WHITE *	GRAY(SILVER) *	BLACK *	HEAVY WHITE *

18 T/C LEAD WIRE COLOR CODE



T/C #	ROLFES, BOONE & TS6C	HOT SPOT	HOT SPOT	HOT SPOT	OLD ROLFES	BURDICK	DECATUR, BRICE	ZELENY
Top of cable (12)	CLEAR	CLEAR	YELLOW	YELLOW	BLUE	BLUE	BLUE	WHITE/SLATE
11	YELLOW	YELLOW	RED	RED	PINK	GREEN	GREEN	WHITE/BLACK
10	RED	RED	GREEN	GREEN	YELLOW	YELLOW	YELLOW	WHITE/GREEN
9	GREEN	GREEN	BLUE	BLUE	GREEN	ORANGE	CLEAR	WHITE/YELLOW
8	BLUE	BLUE	BLACK	BLACK	BLACK	RED	RED	WHITE/RED
7	BLACK	BLACK	VIOLET	VIOLET	RED	BROWN	BROWN	WHITE/BLUE
Constantan 2	BROWN *	ORANGE *	YELLOW STRING	YELLOW STRING	BROWN *	WHITE *	GRAY(SILVER) *	HEAVY WHITE *
6	CLEAR	CLEAR	YELLOW	YELLOW	BLUE	BLUE	BLUE	SLATE
5	YELLOW	YELLOW	RED	RED	PINK	GREEN	GREEN	BLACK
4	RED	RED	GREEN	GREEN	YELLOW	YELLOW	YELLOW	GREEN
3	GREEN	GREEN	BLUE	BLUE	GREEN	ORANGE	CLEAR	YELLOW
2	BLUE	BLUE	BLACK	BLACK	BLACK	RED	RED	RED
Bottom of cable (1)	BLACK	BLACK	VIOLET	VIOLET	RED	BROWN	BROWN	BLUE
Constantan 1	WHITE *	WHITE *	WHITE STRING	WHITE STRING	WHITE *	GRAY(SILVER) *	BLACK *	HEAVY WHITE *

12 T/C LEAD WIRE COLOR CODE

T/C #	ROLFES, BOONE & TS6C	HOT SPOT	HOT SPOT	HOT SPOT	OLD ROLFES	BURDICK	DECATUR, BRICE	ZELENY
Top of cable (6)	CLEAR	CLEAR	YELLOW	YELLOW	BLUE	BLUE	BLUE	SLATE
5	YELLOW	YELLOW	RED	RED	PINK	GREEN	GREEN	BLACK
4	RED	RED	GREEN	GREEN	YELLOW	YELLOW	YELLOW	GREEN
3	GREEN	GREEN	BLUE	BLUE	GREEN	ORANGE	CLEAR	YELLOW
2	BLUE	BLUE	BLACK	BLACK	BLACK	RED	RED	RED
Bottom of cable (1)	BLACK	BLACK	VIOLET	VIOLET	RED	BROWN	BROWN	BLUE
Constantan 1	WHITE *	WHITE *	WHITE STRING	WHITE STRING	WHITE *	GRAY(SILVER) *	BLACK *	HEAVY WHITE *

6 T/C LEAD WIRE COLOR CODE



4. Commissioning

The mTC002 Thermocouple Converter can read up to 168 thermocouples on grain bin cable systems. The multiplexer is divided into bundles of seven thermocouples. The thermocouples are type T using copper and constantan wires. Each bundle has seven copper and one constantan conductor. If a grain cable has more than one bundle of wires, the constantan conductors are usually joined together at the splice at the top of the cable.

Commissioning grain cable systems is a time consuming project. The primary commissioning task is the verification of the thermocouple cables. The project needs to be handled in a systematic manner to achieve success. Worksheets should be prepared for each multiplexer unit detailing which cables are connected to each input connector. The worksheets should be used during the verification process described below to ensure that each step of the process is completed. A sample worksheet is attached.

The multiplexer has 8 channel cards each connecting to 3 groups of seven thermocouples. The multiplexer allows constantan conductors to be connected together and connected constantans' can span channel cards.

Before connecting any cables to the multiplexer the operation of the system should be verified. This document assumes that the PLC/HMI system displaying the thermocouple temperatures has been commissioned and verified.

The following steps will confirm the operation of the multiplexer:

1. Mount and install the multiplexer in its final location in the facility;
2. Connect the CMC 1-Wire® network to the multiplexer using the punch down terminals. Be sure to use the correct 110 punch down tool to make the connections;
3. Install the controller and required channel cards in each backplane;
4. Set the channel enable switches on the controller card to select the multiplexer cards installed in the backplane;
5. Turn all channel card thermocouple disable switches to the "ON" or "DISABLE" position;
6. Power up the system and acquire the controller cards;
7. Verify that all controller cards have been acquired and are active on the 1-Wire® network;
8. Verify that all channels read ambient temperature, plus or minus 2° C (4° F). Use the each controller's ambient temperature reading as the reference for the multiplexers on that controller.

Once these steps have been completed and all multiplexer channels are indicating ambient temperature, the system is ready for grain cable verification and commissioning.

There are several color code systems in use for grain cables. See Figure 3 for the most common color code scheme. The thermocouple with the lowest resistance will be at the top of the grain bin. Thermocouples are normally wired from the bottom of the bin up on the multiplexer terminal blocks. This means the bottom thermocouple (highest resistance) is connected to the first pin of the first connector. Make sure the order of the wiring scheme matches the display order used for the PLC/HMI application.



Take the following steps for each cable before connecting the cable to the multiplexer. Record the results of the tests on the worksheets as each cable is tested:

1. Use a high quality multi-meter, capable of measuring megohms, to check for any resistance between any of the thermocouple wires and earth ground. A common cable fault is a short between the thermocouple wires and the steel messenger cable that supports the cable due to mechanical damage or water ingress. Cables with ground resistance of 1 megohm or less cannot be used;
2. Measure the resistance between the constantan and each copper conductor, one copper conductor at a time, starting from the top of the cable. Connect the meter to only one constantan and one copper wire for each resistance check. Do not parallel the constantan wires. The resistance should increase as you move from the top of the cable to the bottom by between 5 and 10 ohms per thermocouple depending on the thermocouple spacing. Constantan wire is made of 45% nickel and 55% copper. The resistance of constantan wire varies from 0.7526 ohms/foot for 24 gauge to 1.204 ohms/foot for 26 gauge wire. The copper wire resistance is negligible. The resistance of each thermocouple should equal the "length of cable x the ohms/foot", including the lead wire;
3. The resistance between the constantan and the longest copper conductor must be less than 2000 ohms. Thermocouples with higher resistance than 2000 ohms will indicate as faulted when read by the multiplexer.

Once the cables have been verified, connect the cables to the multiplexer one at a time and verify the readings from each cable.



mTC002 Thermocouple Converter Commissioning Worksheet

mTC002 1-Wire address: 179-0-0-2-244-54-9-122

	Bin	30	30	30	30	30	30	30	30
	Cable	1	2	3	4	5	6	7	8
	Card	1	2	3	4	5	6	7	8
	Ground	10M	10M	10M	10M	10M	10M	10M	10M
Top	J3-8	105	105	105	105	105	105	105	105
	J3-7	110	110	110	110	110	110	110	110
	J3-6	115	115	115	115	115	115	115	115
	J3-5	120	120	120	120	120	120	120	120
	J3-4	125	125	125	125	125	125	125	125
	J3-3	130	130	130	130	130	130	130	130
	J3-2	135	135	135	135	135	135	135	135
	J2-8	140	140	140	140	140	140	140	140
	J2-7	145	145	145	145	145	145	145	145
	J2-6	150	150	150	150	150	150	150	150
	J2-5	155	155	155	155	155	155	155	155
	J2-4	160	160	160	160	160	160	160	160
	J2-3	165	165	165	165	165	165	165	165
	J2-2	170	170	170	170	170	170	170	170
	J1-8	175	175	175	175	175	175	175	175
	J1-7	180	180	180	180	180	180	180	180
	J1-6	185	185	185	185	185	185	185	185
	J1-5	190	190	190	190	190	190	190	190
	J1-4	195	195	195	195	195	195	195	195
	J1-3	200	200	200	200	200	200	200	200
Bottom	J1-2	205	205	205	205	205	205	205	205

Figure 7 – Typical Commissioning Worksheet



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5. Communications

The mTC002 Thermocouple Converter is a fully compliant Dallas 1-Wire[®] device. The mTC002 connects to the CMCIEL wiring system using CAT5 cable. A single RJ-11 jack is provided for connecting an mBC081 Bus Converter or other approved CMCIEL 1-Wire[®] device to the wiring system.

The mTC002 requires a bus converter to convert the Dallas 1-Wire[®] signaling system to a system recognized by commercial programmable controllers. The Bus Converters provide a Modbus485 RTU interface. CMCIEL manufactures Bus Converters for both commercial and hazardous areas. The Bus Converters will automatically acquire the serial number of the mTC002 on request.

As a Dallas 1-Wire[®] device, the mTC002 value is returned using the read scratch function as 3 bytes, the first 2 bytes a signed word containing the multiplexed temperature values and the 3rd byte the Dallas 1-Wire[®] - 8 bit CRC. The family code for the converter is 179 decimal or B3 Hex. The mTC002 responds to the following Dallas function codes:

Code Decimal	Code Hex	Function
240	F0	Search ROM
85	55	Match ROM
15	0F	Read ROM
51	33	Read ROM
204	CC	Skip ROM
190	BE	Read Scratch, 3 bytes, low byte + high byte + Dallas 8 bit CRC

Refer to Dallas Semiconductor documentation for complete details on the operation of the Dallas 1-Wire[®] signaling system. Decoding the Converter Data Word

The output of the converter is a single 16 bit word. The word consists of an 8 bit address, and an 8 bit unsigned thermocouple temperature offset by 40 °C (i.e. a value of 40 corresponds to 0°C). The address occupies the upper 8 bits of the word. The converter provides 170 values over the multiplexed bus. The address and associated value are automatically incremented every 3 seconds. During startup and, periodically for open sensor detection, the incrementing will stop for up to 1 minute. During this time the address will remain on 0 and the status register will indicate the function in progress. The returned value associated with each address is:

Address	Value
0	Converter status bits: 1 – open wire detection in progress 2 – startup in progress



	3 – cold reference sensor fault 4 - power on tests failed 5 -calibration tables corrupted 6 – controller firmware corrupted
1	Ambient temperature in degrees Celsius
2 - 22	Thermocouple temperatures in degrees Celsius 2 – 8 correspond to slot 1 terminals T/C1 – T/C 7 9 – 15 correspond to slot 1 terminals T/C8 – T/C 14 16 – 22 correspond to slot 1 terminals T/C15 – T/C 21
23 - 43	Thermocouple temperatures in degrees Celsius 23 – 29 correspond to slot 2 terminals T/C1 – T/C 7 30 – 36 correspond to slot 2 terminals T/C8 – T/C 14 37 – 42 correspond to slot 2 terminals T/C15 – T/C 21
44 - 64	Thermocouple temperatures in degrees Celsius 44 – 50 correspond to slot 3 terminals T/C1 – T/C 7 51 – 57 correspond to slot 3 terminals T/C8 – T/C 14 58 – 64 correspond to slot 3 terminals T/C15 – T/C 21
65 - 85	Thermocouple temperatures in degrees Celsius 65 – 71 correspond to slot 4 terminals T/C1 – T/C 7 72 – 78 correspond to slot 4 terminals T/C8 – T/C 14 79 – 85 correspond to slot 4 terminals T/C15 – T/C 21
86 - 106	Thermocouple temperatures in degrees Celsius 86 – 92 correspond to slot 5 terminals T/C1 – T/C 7 93 – 99 correspond to slot 5 terminals T/C8 – T/C 14 100 – 106 correspond to slot 5 terminals T/C15 – T/C 21
107 - 127	Thermocouple temperatures in degrees Celsius 107 – 113 correspond to slot 6 terminals T/C1 – T/C 7 114 – 120 correspond to slot 6 terminals T/C8 – T/C 14 121 – 127 correspond to slot 6 terminals T/C15 – T/C 21
128 - 148	Thermocouple temperatures in degrees Celsius 128 – 134 correspond to slot 7 terminals T/C1 – T/C 7 135 – 141 correspond to slot 7 terminals T/C8 – T/C 14 142 – 148 correspond to slot 7 terminals T/C15 – T/C 21
149 - 169	Thermocouple temperatures in degrees Celsius 149 – 155 correspond to slot 8 terminals T/C1 – T/C 7 156 – 162 correspond to slot 8 terminals T/C8 – T/C 14 163 – 169 correspond to slot 8 terminals T/C15 – T/C 21

All temperatures are presented as unsigned 8 bit values in the lower 8 bits of the word. An offset of 40 is added to the value (i.e. a value of 40 corresponds to 0°C). The range of temperatures that can be reported is -40°C to +214°C.

The converter automatically checks for open cables at startup and every 60 complete cycles. The time between cable checks will vary depending on the number of enable cards. Thermocouples with high resistance are marked as open wire and set to the temperature 215°C



(reported value of 255). During the cable check, the address will remain at 0 and the status register will have bit 2 set. A card that is not disabled and not installed will report as open wire.

To decode the values received from the converter you will need a table to store the received values. Create a sensor values table for the number of cards installed ((21 entries x number of cards) + 2). The values table will include entries for the status and ambient temperature values. Create 3 temporary storage locations, the last received register, the index pointer register and the sensor value register.

To decode the address and temperature value perform the following steps:

1. Compare the current received value to the last received register and if they are equal skip the remaining steps;
2. Copy the current received value to the last received register;
3. Copy the current received value to the index pointer register;
4. Perform a logical AND with the constant FF00 HEX and the index pointer register;
5. Divide the index pointer register by 256 (or shift it 8 bits right), this creates the index pointer into the sensor values table (offsets will be from 0 – 169);
6. Copy the received data word to a temporary register named the temporary sensor value register;
7. Perform a logical AND with the constant 00FF HEX and the temporary sensor value register;
8. Subtract 40 from the temporary sensor value register;
9. If the temperature is to be display as Fahrenheit, multiply the temporary sensor value register by 9, divide it by 5, then add 32;
10. Using an indexed move operation, copy the temporary sensor register into the sensor values table using the index pointer register as the offset.

The above algorithm will automatically populate a table of converter values from the received data word. Unused card slots can be disabled using the DIP switch on the processor card. Turn off the DIP switch associated with an unused to card to remove that card from the polling routine. For example if switches 1,2 3, and 4 are on, the polling routine will return index addresses from 0 to 85. It is good programming practice to ensure that the decoding program will handle all possible 170 address locations. These addresses may inadvertently occur during service if a technician modifies the DIP switch setting or if a bad value is returned due to noise or a 1-Wire[®] bus disturbance. Indexed writes into non-existent PLC memory table locations can cause PLC faults that may halt the PLC program execution.

If the card disable DIP switch settings are changed and left in the new position for 10 seconds or longer, the card will perform a cable check during the next polling cycle. The new DIP settings are not effective until the beginning of a new polling cycle, starting with address 0.

When designing a hazards monitoring application it is important to reduce false alarms. False data readings can be caused by a number of conditions including static charge from material moving within bins or a 1-Wire[®] bus disturbance. These disturbances are rare but possible. To prevent false alarms, the alarming application should employ timers or multiple data point



verification before declaring an alarm. The time constants being monitored are typically long and most false alarms can be eliminated using a simple timer or reading count scheme.



6. Service

6.1 Card replacement

The system is designed to allow hot swap replacement of all cards in the system. Individual cards can be removed and replaced without removing power from the system. To remove a card press firmly on the retaining clips on both card guides and pull the card straight up. See Figure 4 for the location of the retaining clip.

Multiplexer cards require no calibration and are interchangeable. Replacing multiplexer cards may cause a temporary false reading from the sensors currently being reported. This may cause false alarms. Cards removed from the system that are not disabled using the disable DIP switch will indicate open cables on the next cable check sequence. The readings obtained for the removed card prior to the cable check sequence will be indeterminate.

The processor card has a unique serial number on the 1-Wire[®] network. Changing the processor card will require that the new card's address be acquired by the network.

USE SCREWDRIVER TO RELEASE LOCKING TABS
STARTING WITH THE TOP CARD GUIDE

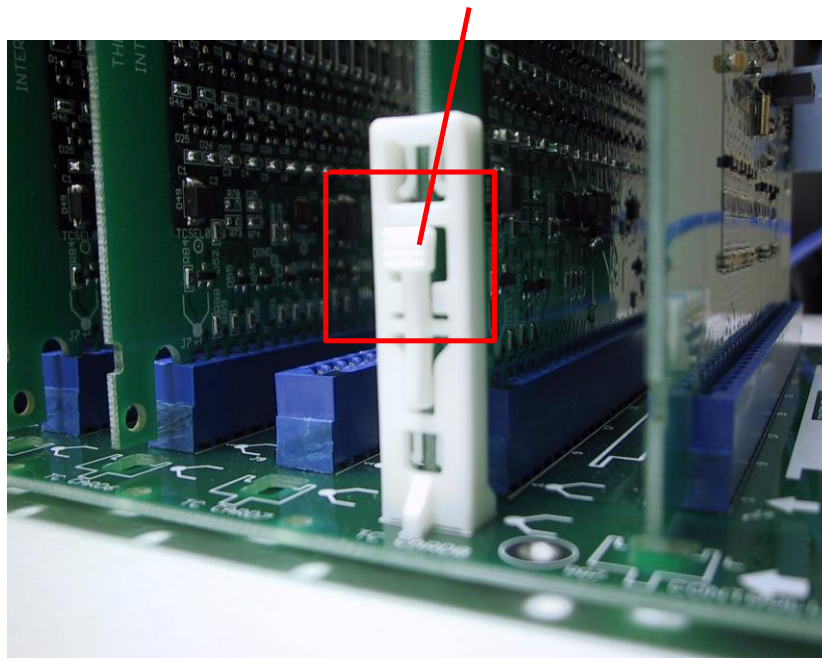


Figure 8 – Card guide retaining clip



6.2 Troubleshooting a completely inoperative network

These instructions assume that the mBC081 is communicating over the RS-485 network to its host and that the network problem is with the 1-Wire[®] network. It is also assumed that the mBC081 has been correctly configured and that the network addresses for the devices have been acquired. If this is the first time the network is being started, the addresses are not required to get the lamps flashing properly. The addresses are required to retrieve data over the network. The mTC002 employs branch disconnect switches to aid in the diagnosis of a completely inoperative network. Follow this procedure for troubleshooting:

1. Remove the cover from the mBC081 serving the network;
2. Observe the 2 status indicators on the mBC081. The red status indicator should be flashing at a once per second rate. The green communication indicator should be flashing verifying communications with the host. If the red lamp is flashing one of the following error codes, the problem is likely with the network cabling or devices:

Flashes	Description
1	5VDC supply wire shorted to common wire
2	No sensors detected on the bus
3	Data wire shorted to common wire
4	Data wire shorted to 5VDC wire

3. Observe field interconnect or mTC002 where the mBC081 is connected;
4. Observe the network status lamps. The red power indicator should be on and the green data indicator should be flashing;
5. If the network status lamps are flashing properly, observe the status lamp on the first connected mTC002. It should be flashing 2 short flashes. If the lamp is flashing 1 short flash the device is not being addressed by the mBC081. Verify that all of the device serial numbers have been acquired before proceeding. If error codes 5 –9 are flashing (see Section 2 for an explanation of codes), the card is defective and should be returned for service;
6. If the field interconnect or mTC002 network status lamps are not illuminating properly, turn off both branch disconnect switches. The branch disconnect switches are marked BRANCH A and BRANCH B;
7. If the network status lamps resume normal operation the problem is with a device or cabling on one of the disconnected branches. Turn on one switch at a time to determine the defective branch. Continue along the network, using the disconnect switches until the defective cable or device is located.
8. If the network status lamps do not resume normal operation, the fault is with a sensor connected to this field interconnect or with the processor card if the device is an



mTC002. Disconnect the sensors in this field interconnect or remove the mTC002 processor card. If the lamps do not resume normal operation, the mBC081 is defective or the wiring between the mBC081 and this device is damaged or incorrectly connected. If the network status lamps resume normal operation, and the device is an mTC002 the processor card is defective. If the device is a field interconnect plug the sensors in one at a time until the network status lamps go out. This is the defective sensor.

6.3 Troubleshooting incorrect temperature readings

If all temperature readings for this device are incorrect, observe the status indicator on the processor card. It should be flashing 2, 3 or 4 short flashes. If the lamp is flashing 1 short flash the device is not being addressed by the mBC081 and no data is being read from the device. Verify that all mTC002 serial numbers have been acquired before proceeding. If any error codes 5 –8 are flashing (see Section 2 for an explanation of codes), the processor card is defective and should be returned for service.

If some of the readings are incorrect, verify the connections at the thermocouple terminal blocks. A process meter capable of reading thermocouples can also be used to verify the integrity of the thermocouple cables. If you do not have a process meter, swap the thermocouple cables between multiplexer cards. If the problem remains on the same thermocouple numbers, the multiplexer card is defective. If the problem moves, the cable is defective.

Cable ground faults can disrupt readings by placing stray signals on the cable. Thermocouple signals are very low voltage and are easily influenced by high impedance external signal sources such as wet cables in contact with earth ground. The multiplexer cards are isolated from each other during operation and a ground fault on a single card should not affect the other cards. If a constantan connection is shared between 2 cards, both cards will be affected if a ground fault occurs.



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7. Specifications

Description	Characteristic
Sensor bus	
Voltage	5 VDC
Current	3.5 mA max
Communications	1-Wire [®] Bus
Type T Inputs	
T/C Inputs	168 arranged as 24 groups of 7 inputs
Resolution	1°C
Range	-40°C to +214°C
Accuracy	
Span accuracy	±2°C (-40°C to +50 °C case temperature)
Offset accuracy	±1°C for each 10°C change maximum
Calibration temperature	20°C
Environment	
Temperature	-40 to 70°C (-40 to 158 °F)
Relative Humidity	0 to 95% non-condensing
Dimensions	
Length	257 mm (10.10 in)
Height	168 mm (6.60 in)
Depth	121 mm (4.75 in)



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Appendix 1 - Installation Drawings

The following is a list of the installation drawings in this appendix:

11466 MTC002 Thermocouple Converter Installation and Mounting Details

