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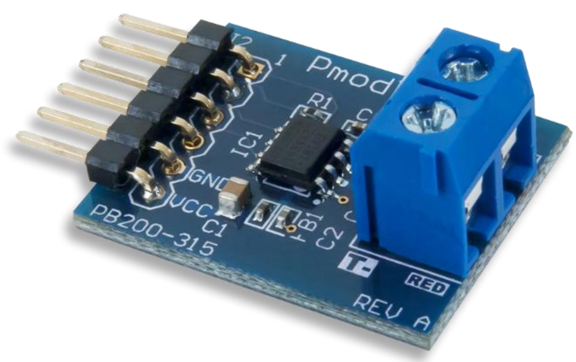
PmodTC1™ Board Reference Manual

Revised March 25, 2015
This manual applies to the PmodTC1 rev. A

Overview

The Digilent PmodTC1™ is a cold-junction compensated thermocouple-to-digital converter module designed for a classic K-Type thermocouple wire. The peripheral module is built around the MAX31855 and reports the measured temperature in 14-bits with 0.25°C resolution.



The PmodTC1.

Features include:

- 14-bit signed, 0.25^0 C resolution
- SPI compatible interface (read only)
- Cold-junction temperature compensation
- Typical accuracy ± 2^0 C for temperatures ranging -200^0 C to $+700^0$ C

1 Functional Description

The PmodTC1 utilizes a K-Type thermocouple wire to measure a wide range of temperatures. The wire provided with the PmodTC1 is capable of measuring temperatures ranging from -73^0 C to 482^0 C, although the module itself is capable of measuring temperatures ranging from -270^0 C up to 1800^0 C.

A thermocouple wire needs to be attached onto the screw terminal. The polarity of the thermocouple matters, therefore it is required to have the wires screwed down into the right orientation for accurate temperature readings. The device measures the difference in temperature between the two ends of the thermocouple, of which one is the internal temperature and serves as the reference junction. Once a temperature reading is established, the data passes onto a 14-bit ADC and then passed out through SPI.

2 Interfacing with the Pmod

The PmodTC1 communicates with the host board via the SPI protocol. The module sends a variety of information to the host board in 32 clock cycles, including the temperature measured by the thermocouple, the temperature of the “cold junction, as well as signals indicating if there is a fault with the thermocouple. The PmodTC1 uses a 6-pin connector to connect to the host board.

To read data, the host board drives the slave select (SS) pin low and drives a clock to the slave device, the PmodTC1. The first bit (and the sign bit) of the 14-bits of data is loaded onto the master-in-slave-out (MISO) line on the falling edge of the chip select (CS) and can be read by the host board on the rising edge of the serial clock (SCLK) line. Similarly, each consecutive bit of data, starting with the most significant bit (MSB), are placed onto the data line on each falling edge of SCLK and is read on the subsequent rising edge of SCLK. Users can then choose to stop reading information from the PmodTC1 by driving the CS line high.

Temperature data is updated only when the chip select (CS) pin is held high, therefore it is recommended to drive CS high after reading. A complete temperature reading of the thermocouple requires 14 clock cycles. 32 clock cycles are required to read both the thermocouple and reference junction temperatures. Table 1 below shows the bit memory map of the thermocouple temperature data.

	14-Bit Thermocouple Temperature Data			
Bit	D31	D30	…	D18
Value	Sign	MSB 2^{10} (1024^{0}C)	…	LSB 2^{-2} (0.25^{0}C)

Table 1. Bit memory map of thermocouple temperature data.

	12-Bit Internal Temperature Data						Res	SCV Bit	SCG Bit	OC Bit
Bit	D15	D14	D13	…	D5	D4	D3	D2	D1	D0
Value	Sign Bit	MSB 2^{6}(64°C)	2^{5}(32°C)	…	2^{-3}(0.125°C)	2^{-4}(0.0625°C)	Reserved	1 = Short to Vcc	1 = Short to GND	1 = Open Circuit

Table 2. Incoming data example.

Note 1* Table information modified from Table 2 in the MAX31855 datasheet.

Note 2* Bits D2, D1, and D0 refer to the thermocouple is shorted to VCC, shorted to GND, and the thermocouple has an open connection, respectively.

Table 3 below is the pin mapping of the output pins on the PmodTC1 that connect to a host board.

Pin	Signal	Description
1	CS	Active Low Chip Select
2	N/A	N/A
3	MISO	Serial Data Out
4	SCLK	Serial Clock
5	GND	Power Supply Ground
6	VCC	Power Supply (3.3V)

Table 3. Pin mapping of the output pins.

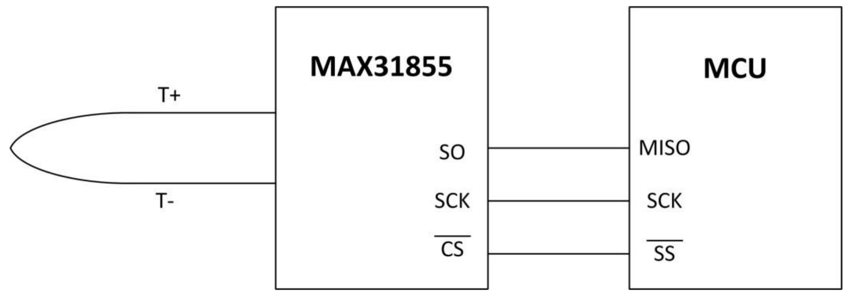


Figure 1. Block diagram of MAX31855 interfacing with a microcontroller over SPI.

2.1 Digital Temperature Data Format

Two tables (Tables 4 & 5 from the MAX31855 datasheet) are provided below to show the temperature that corresponds to the two's compliment bit values received by the host board.

Temperature (°C)	Digital Output (D31-D18)
+1600.00°C	0110 0100 0000 00
+1000.00°C	0011 1110 1000 00
+100.75°C	0000 0110 0100 11
+25.00°C	0000 0001 1001 00
0.00°C	0000 0000 0000 00
-0.25°C	1111 1111 1111 11
-1.00°C	1111 1111 1111 00
-250.00°C	1111 0000 0110 00

Table 4. 14-bit thermocouple temperature data.

Temperature (°C)	Digital Output (D15-D4)
+127.0000°C	0111 1111 0000
+100.5625°C	0110 0100 1001
+25.0000°C	0001 1001 0000
0.0000°C	0000 0000 0000
-0.0625°C	1111 1111 1111
-1.0000°C	1111 1111 0000
-20.0000°C	1110 1100 0000
-55.0000°C	1100 1001 0000

Table 5. 12-bit cold-junction temperature data.

The on-board chip on the PmodTC1 requires at least 200 ms to power up before being able to conduct accurate temperature readings. Each temperature conversion takes up 100 ms to complete and outputs a voltage (to then be converted into a digital value) by the following linear equation (assuming a virtual reference point of 0°C):

$$V_{OUT} = (41.276\ \mu V/°C) \times (T_R - T_{AMB})$$

Where V_{OUT} is the thermocouple output voltage in µV, T_R is the temperature of the remote thermocouple junction (the cold-junction) in °C, and T_{AMB} is the temperature of the thermocouple itself in °C.

Any external power applied to the PmodTC1 must be within 3.0V and 3.6V; It is recommended that Pmod is operated at 3.3V.

3 Physical Dimensions

The pins on the pin header are spaced 100 mil apart. The PCB is 1 inch long on the sides parallel to the pins on the pin header and 0.8 inches long on the sides perpendicular to the pin header.