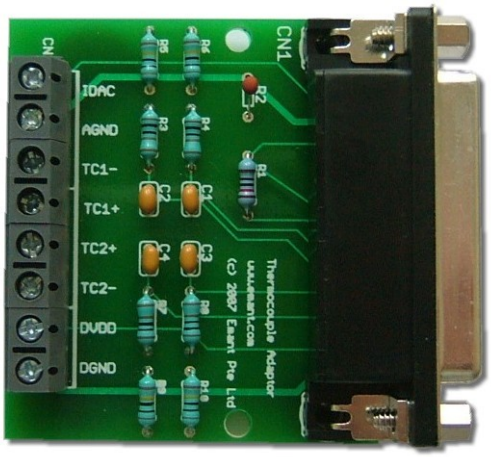
THERMOCOUPLE APPLICATION ADAPTOR FOR EMANT300



The Thermocouple Application Adaptor allows users to connect thermocouples to the **EMANT300** Low Cost USB Data Acquisition Module without soldering or breadboarding. It is ideal for use in hands-on teaching laboratories and projects that require temperature measurements.

Comes with example programs in LabVIEW and .NET C# and Visual Basic.

FEATURES

- Accepts up to 2 thermocouples
- Types J,K,T,E, R,S,B Thermocouples
- Onboard Cold Junction Compensation
- Accepts Thermistors, RTDs

Thermocouples produce an output voltage which depends on the temperature difference between the junctions of two dissimilar metal wires. It is important to appreciate that thermocouples measure the temperature difference between two points, not absolute temperature.

In our example, we measure one of the junctions the **cold junction** temperature using a thermistor, whilst the other end is attached to a probe. We will use the **Type K Thermocouple**. The positive conductor is made of Chromel, and the negative conductor is made of Alumel.

The NIST ITS-90 Thermocouple Database gives temperature -- electromotive force (emf) reference functions and tables for the letter-designated thermocouple types B, E, J, K, N, R, S and T. These reference functions have been adopted as standards by the American Society for Testing and Materials (ASTM) and the International Electrotechnical Commission (IEC).

Thermocouple type	Metal	Temperature range
J	Iron Constantan	–210 to 1200
K	Chromel Alumel	–270 to 1370
T	Copper Constantan	–200 to 400
E	Chromel Constantan	–270 to 1000

Table 1 : Common Thermocouples and their characteristics

The relationship between the temperature difference and the output voltage of a thermocouple is nonlinear and is given by a complex polynomial equation (which is fifth to ninth order depending on thermocouple type).

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**********************************
* 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
```

Since we are interested in measuring in the room temperature range, we will use the coefficients from the second column.

$$T_C = 2.508355E+01*V + 7.860106E-02*V^2 - 2.503131E-01 * V^3 ....$$

where T_C is the temperature in C and V is in mV.

The LabVIEW VI that measures the temperature using the thermocouple is called EMANT300 Thermocouple w Thermistor CJC.VI

The **Cold Junction Temperature** is measured using the thermistor (see application note on measuring temperature using Thermistor). The programmable gain amplifier (PGA) is set to 64 using the EMANT300 Configure Analog Simple.VI by setting the low limit and high limit. This is necessary as the maximum voltage from the K thermocouple even at 500°C is just 20.644mV.

Using the equations above, the measured thermocouple voltage is then converted to temperature using the Volts to Temperature Thermocouple.VI.

This temperature is then added to the CJC temperature to obtain the actual temperature measured by the thermocouple.

Optional Accessories

K Type Thermocouple

Together with the thermocouple application adaptor and EMANT300, it forms a thermocouple training kit. This K type thermocouple is only suitable for temperatures up to 150^{o} C as the tip is soldered and not welded.

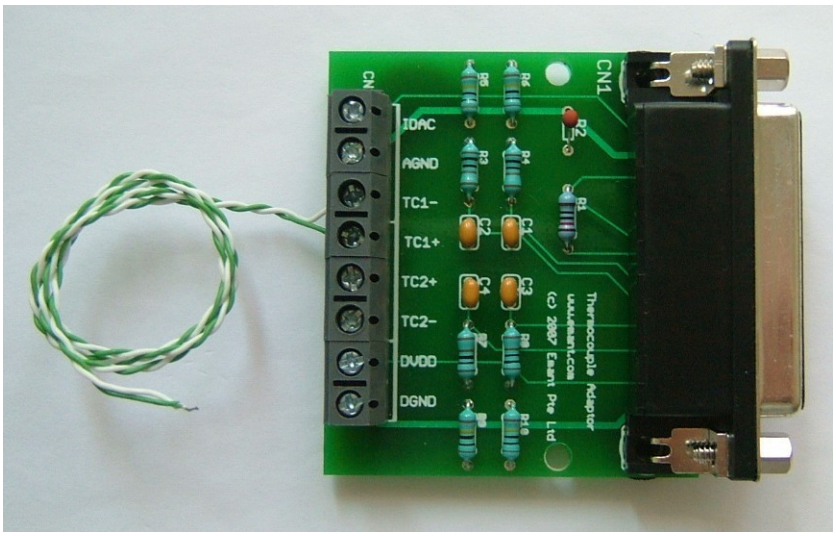
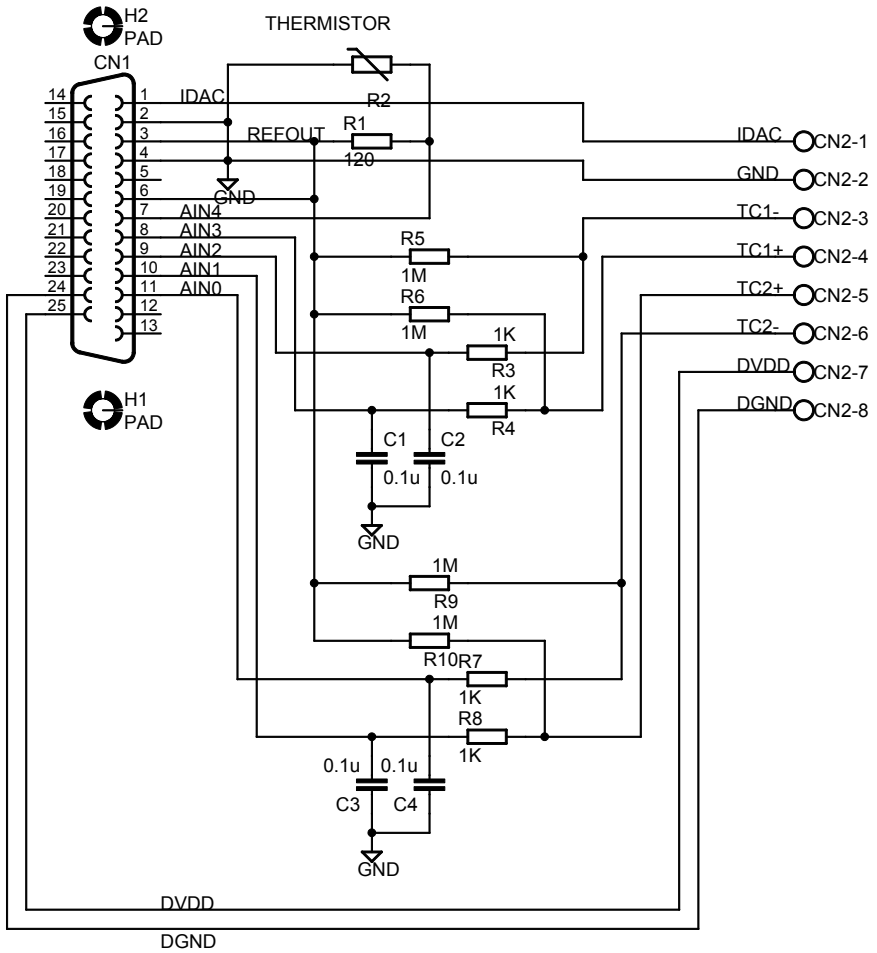


Fig 1: Optional K type thermocouple with thermocouple application adaptor

NOTE: Use 1% or better tolerance resistors



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