Overview

The SEN-30101 is a four-channel analog thermocouple amplifier (thermocouple signal conditioner). These boards convert very low voltages from thermocouples to a highly-linear, 0.005V/°C output with cold-junction compensation.

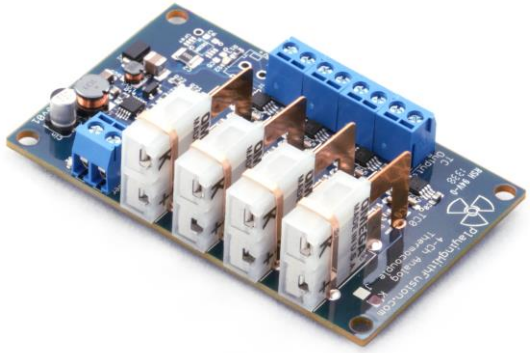
The output signal can be read by a multitude of standard measurement devices, including digital multimeters, data acquisition systems or an analog input on an Arduino.

Features

- Available for J and K type thermocouples (K std, J upon request / 1 week lead)
- Cold-junction compensated
- Wide supply voltage range (5-32V)
- 0-5V or 0-10V output (max range)
- +/- 3°C initial accuracy
- Measures full range of thermocouples (K: -260-1380°C; J: -180-1200°C)
- Ttc = ((Vout – 2.05) / 0.005)°C (see below for nonlinearity information)
- Mini thermocouple connectors
- Screw blocks for power and output signals
- LED indicators for power supply status
- 4 mounting holes sized for 4-40 screws
- Small 1.7” x 2.77” footprint
- RoHS compliant

Typical Applications

- Automotive data acquisition (exhaust, coolant, brakes, etc)
- Industrial instrumentation
- Oven temperature measurements
- Home brew setups
- Celsius thermometer
- Full range of hobby projects
- 5V supply range allows use with Arduino power source



Description

The SEN-30101K1/J1 series boards are analog thermocouple amplifier devices based on the AD849x series from Analog Devices, successor of the AD597. These quad-channel thermocouple boards convert very low voltage signals from K and J-type thermocouples to a highly-linear, 0.005V/°C output with 0V or 2.05V offset (0°C = 0V or 2.05V output) that is cold-junction compensated. The output signal can be read by a multitude of standard measurement devices, including digital multimeters, data acquisition systems or an analog input on an Arduino (with input range limiting). See Appendix for application info.

The standard output signal range is within 0-10V that covers the entire standard operating range of the different thermocouples (K: -260–1380°C; J: -180–1200°C), with correction tables available to accommodate non-linearity at very low and very high temperatures. The wide supply voltage range is designed to support a wide variety of applications, from hobbyist projects (Arduino, homebrew) to automotive and industrial temperature measurement. See Table 1 for the

optimized operating range for the different sensor options.

Table 1: Sensor Temperature Ranges

PWF Part No.	Thermo-couple Type	Optimized Temperature Range	
		Ambient Temperature (board temperature)	Measurement Junction
SEN-30101/J1	J	0°C to 50°C	Full J type range
SEN-30101/K1	K	0°C to 50°C	Full K type range

*sensors optimized for ambient environments from 25-100°C available upon request

In addition, analog filtering is included to remove unwanted EMI on the input stage of the conditioner. Common mode filtering with a cutoff frequency of 1 kHz is included, as well as 50 Hz differential signal filtering. Included in the input stage is a 1 MΩ resistor that is connected to the negative input line. This is to minimize any common-mode voltage without injecting any additional measurement errors.

Performance Characteristics

The SEN-30101/XX devices are designed to output a linear signal based on an input from J-Type or K-Type thermocouples. This is accomplished by the integration of an operational amplifier and cold-junction compensation within the AD849x series ICs. As a result, the output of the SEN-30101/XX can be approximated as linear over a specified window, with degradation of the estimate outside of this window. See Table 2 for details.

Table 2: Sensor Temperature Linearization

PWF Part No.	Thermo-couple Type	Ranges	
		+/- 2°C linearity, no correction applied	Correction tables applied
SEN-30101/J1	J	-35°C to 95°C	Full J type range
SEN-30101/K1	K	-25°C to 400°C	Full K type range

As such, one of two methods should be used to handle the output voltage from the sensors. The method chosen will depend on linearity accuracy requirements as well as the required operational range of the input signal. Absolute accuracy is separate from the linearity accuracy, and can be found in Table 4.

In one application example, if a +/- 2°C linearity accuracy is acceptable and the sensing application will stay within the windows shown in Table 2, temperature conversion is straight forward and calculated based on output voltage with the formula:

$$Ttc(10V) = \frac{Vout - 2.05}{0.005}\,^{\circ}\mathrm{C}$$

Equation 1 - Voltage to Temperature Conversion (10V Variants)

$$Ttc(5V) = \frac{Vout}{0.005}\,^{\circ}\mathrm{C}$$

Equation 2 - Voltage to Temperature Conversion (5V Variants)

This formula applies for both J-Type and K-type sensors. This formula is also fitting for applications with less stringent linearity accuracy requirements and wider operating ranges. See Figure 1 for accuracy and Figure 2 for sensor response across the input temperature operating range.

If linearity accuracy provided by the formula in the previous example is not acceptable, there is an alternative method that corrects for linearity error. Specifically, correction

tables can be used to correct the high-order non-linearity across the sensor's operating range. See Table 5 for this information (calculated based on Analog Devices AN-1087). This correction is directly related to the high-order

response characteristics of the respective thermocouples.

Figure 1: Temperature Error vs Probe Temperature

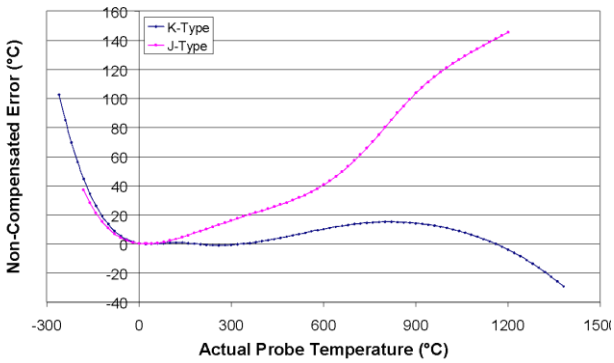


Figure 2: Temperature vs Output Voltage

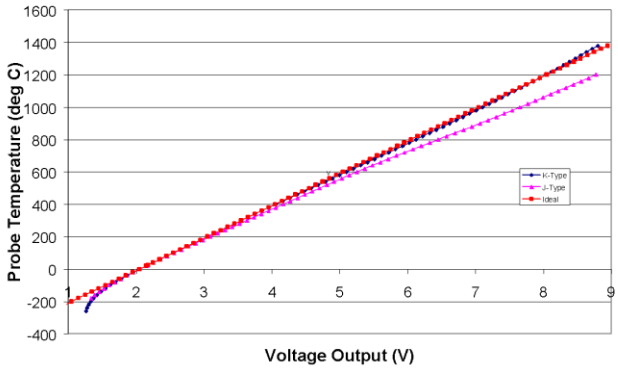


Table 3: Absolute Maximum Ratings

Parameter	Rating
Supply Voltage (operational)	4.75V to 32V
Reverse Supply Protection	-32V across supply pins
Output Short Circuit Duration	Indefinite
Operating Temperature	-25°C to 85°C
Storage Temperature	-40°C to 125°C

Table 4: Optimized Operating Characteristics

Parameter	Rating
Supply Voltage	5.0V to 32V
Operating Temperature (Tamb)	0°C to 50°C
Absolute Accuracy (initial)	3°C
Storage Temperature	-40°C to 125°C

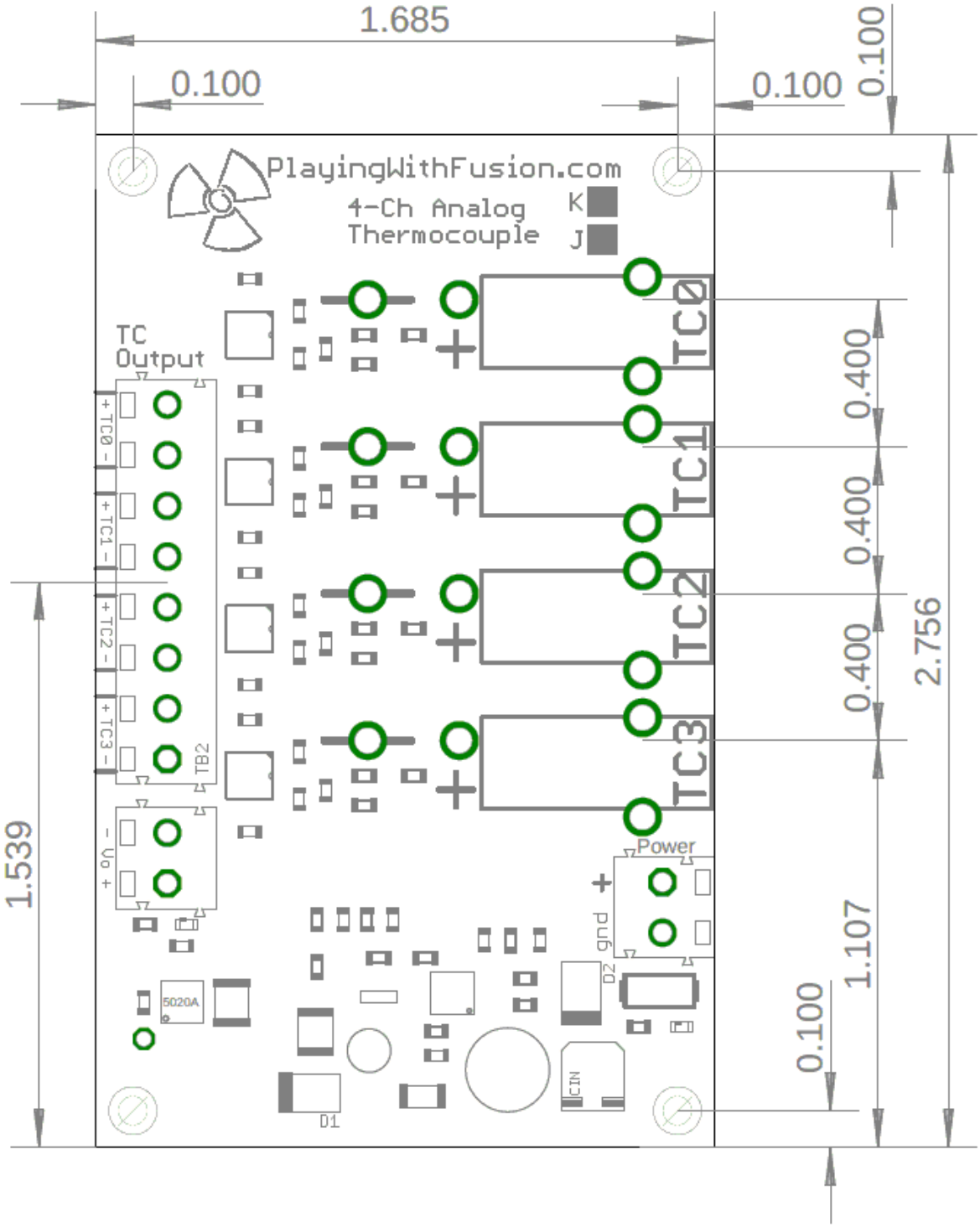
Voltage to Temperature Correction Tables

Measurement Junction Temperature (°C)	Ideal Output (V)	Actual Output (V)			
	SEN30101/K SEN30101/J	SEN30101-K K-Type	SEN30101-K5V0 K-Type	SEN30101-J J-Type	SEN30101-J5V0 J-Type
-260	0.75	1.284	0		
-240	0.85	1.276	0		
-220	0.95	1.299	0		
-200	1.05	1.331	0		
-180	1.15	1.373	0	1.336	0
-160	1.25	1.423	0	1.392	0
-140	1.35	1.481	0	1.456	0
-120	1.45	1.546	0	1.527	0
-100	1.55	1.618	0	1.604	0
-80	1.65	1.695	0	1.685	0
-60	1.75	1.778	0	1.772	0
-40	1.85	1.866	0	1.862	0
-20	1.95	1.957	0	1.955	0
20	2.05	2.053	0.003	2.052	0.002
25	2.15	2.15	0.1	2.15	0.1
40	2.25	2.25	0.125	2.175	0.125
60	2.35	2.351	0.2	2.251	0.201
80	2.45	2.452	0.301	2.353	0.303
100	2.55	2.554	0.402	2.456	0.406
120	2.65	2.655	0.504	2.561	0.511
140	2.75	2.755	0.605	2.667	0.617
160	2.85	2.853	0.705	2.773	0.723
180	2.95	2.951	0.803	2.879	0.829
200	3.05	3.049	0.901	2.987	0.937
220	3.15	3.147	0.999	3.094	1.044
240	3.25	3.246	1.097	3.201	1.151
260	3.35	3.345	1.196	3.309	1.259
280	3.45	3.446	1.295	3.416	1.366
300	3.55	3.547	1.396	3.523	1.473
320	3.65	3.649	1.497	3.63	1.58
340	3.75	3.751	1.701	3.737	1.687
360	3.85	3.853	1.803	3.844	1.794
380	3.95	3.956	1.906	3.951	1.901
400	4.05	4.06	2.01	4.058	2.008
420	4.15	4.163	2.113	4.164	2.114
440	4.25	4.267	2.217	4.271	2.218
460	4.35	4.371	2.321	4.378	2.324
480	4.45	4.475	2.425	4.485	2.435
500	4.55	4.579	2.529	4.592	2.542
520	4.65	4.684	2.634	4.609	2.65

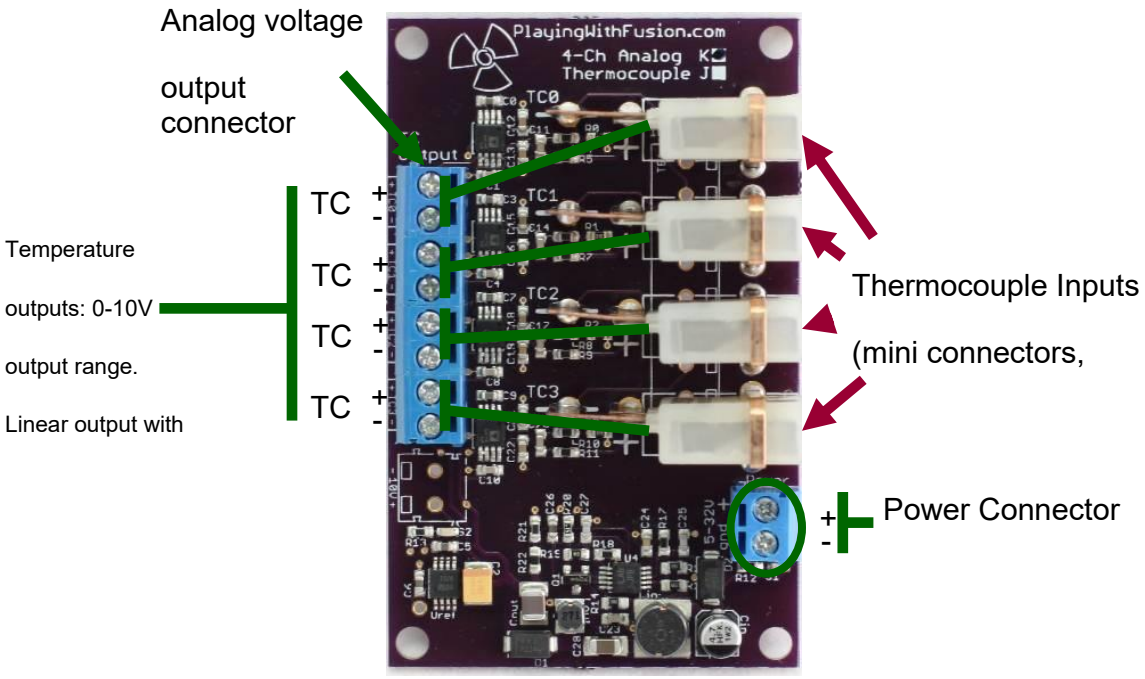
540	4.75	4.788	2.738	4.818	2.759
560	4.85	4.893	2.843	5.029	2.899
580	4.95	4.997	2.947	5.14	3.09
600	5.05	5.101	3.051	5.253	3.203
620	5.15	5.205	3.155	5.366	3.316
640	5.25	5.309	3.259	5.481	3.431
660	5.35	5.412	3.362	5.598	3.548
680	5.45	5.515	3.465	5.716	3.666
700	5.55	5.618	3.568	5.836	3.786
720	5.65	5.72	3.67	5.956	3.906
740	5.75	5.822	3.772	6.079	4.029
760	5.85	5.924	3.874	6.202	4.152
780	5.95	6.025	3.975	6.326	4.276
800	6.05	6.126	4.076	6.451	4.401
820	6.15	6.226	4.176	6.576	4.526
840	6.25	6.325	4.275	6.7	4.65
860	6.35	6.424	4.374	6.824	4.774
880	6.45	6.523	4.473	6.947	4.897
900	6.55	6.621	4.571	7.068	5
920	6.65	6.719	4.669	7.188	5
940	6.75	6.816	4.766	7.307	5
960	6.85	6.913	4.863	7.424	5
980	6.95	7.009	4.959	7.54	5
1000	7.05	7.105	5	7.656	5
1020	7.15	7.2	5	7.77	5
1040	7.25	7.295	5	7.883	5
1060	7.35	7.389	5	7.996	5
1080	7.45	7.482	5	8.108	5
1100	7.55	7.575	5	8.22	5
1120	7.65	7.667	5	8.332	5
1140	7.75	7.759	5	8.444	5
1160	7.85	7.85	5	8.555	5
1180	7.95	7.941	5	8.666	5
1200	8.05	8.03	5	8.777	5
1220	8.15	8.119	5		
1240	8.25	8.208	5		
1260	8.35	8.295	5		
1280	8.45	8.382	5		
1300	8.55	8.468	5		
1320	8.65	8.553	5		
1340	8.75	8.637	5		
1360	8.85	8.721	5		
1380	8.95	8.804	5		

Table 1- Temperature to Voltage Correction Values

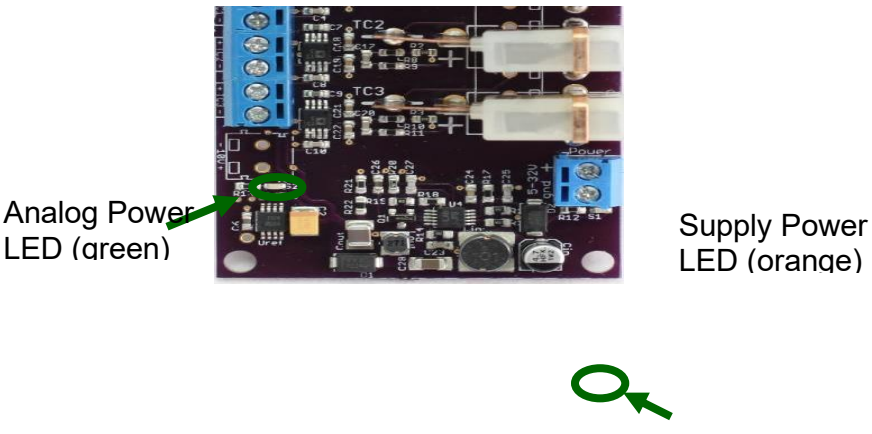
Appendix 1: Mechanical Drawing



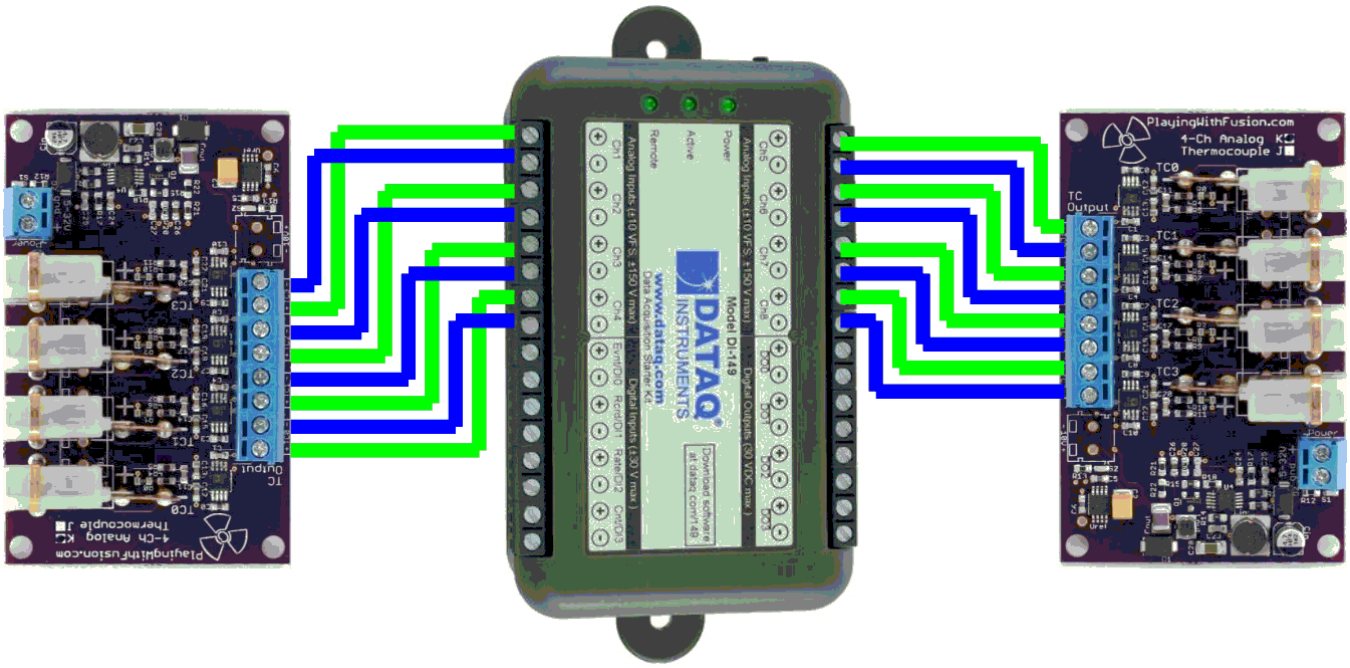
Appendix 2: Application Information



Appendix 3: Power Indicators



Appendix 3: Connection to DataQ-149



Revision History

Date	Author	Notes
03/21/2021	J. Steinlage	Initial revision
05/09/2025	J. Steinlage	Added 5V voltage to temperature conversion tables
08/06/2025	J. Leonard	Updated styling/format