## Overview

SEN-30010 is a single-channel, high precision and high accuracy thermocouple breakout board based on the MCP9601 by Microchip. MCP9601 is a more feature-rich variant of the MCP9600 that includes fault handling of common thermocouple connection issues, including shorts to supply rails and open thermocouple inputs. SEN-30010 is stocked for the K-type thermocouple variant (mini blade-style connector) as well as a universal "spring clamp" variant that is suitable for use with all thermocouple types. Other type-specific variants are available (J, T, N, and more) upon request, so contact us for a quote and lead-time. See our SEN-30011 for a quad-channel version of this board.

Features

- MCP9601 Thermocouple-to-Digital Converter (I2C)
- Qwiic-compatible I2C interface
- B-, E-, J-, K-, N-, R-, S-, and T-type thermocouple support
- "Breakout" form factor with integrated screw holes and 0.1" header interface
- Full thermocouple nonlinearity correction for all thermocouple types
- Multi-fault detection: Short-to-Gnd, Short-to-Vcc, Open thermocouple
- 3.0V - 5.0V supply and digital IO range
- RoHS Compliant
- 18-bit resolution for 0.0625°C/bit output on both hot and cold junction
- Lower-resolution modes can be selected to achieve *up to 200Hz sampling* (in 12-bit mode)

Kit Includes

- SEN-30010-(x) single-channel MCP9601 Breakout
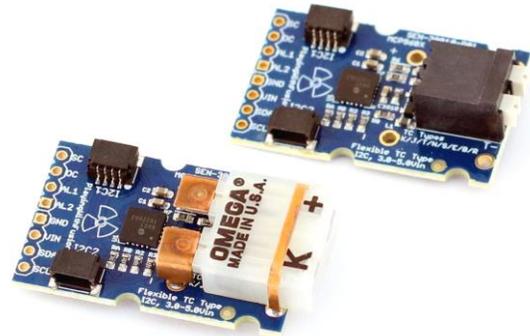
Typical Applications

- Automotive temperature sensing (exhaust, coolant, brakes, etc)
- Industrial instrumentation and thermal management
- Commercial and industrial ovens
- Petrochemical thermal management
- Brewing controls
- Hobby applications

Description

Microchip stepped into the single-chip thermocouple measurement game with the MCP9600 and MCP9601 Thermocouple EMF to Temperature Converter ICs. SEN-30010 integrates the MCP9601 variant as it includes open-circuit and short-circuit detection, whereas MCP9600 does not.

The end result is a ±1.5°C accurate thermocouple interface that handles all common thermocouple types, includes nonlinearity correction, and accounts for cold junction compensation. PwFusion stocks two variants of SEN-30010, one using a mini-blade style thermocouple connector (K-type stocked, other options available upon request) and one with a direct-wire, spring-clamp connector with excellent retention. See Table 1 below for all SEN-30010 purchase options.

Table 1: Orderable Parts

PwF Part No.	Connector	Thermocouple Type
SEN-30010-K	Mini-blade TC	K-type only
SEN-30010-W	push-release spring clamp	universal, bare wire
SEN-30010-*	Mini-blade TC	J, T, other options, special request

While similar in overall performance to the Maxim Integrated MAX31856, MCP9601 is unique in that it uses I2C instead of SPI to communicate to a host controller. Combined with a Qwiic-compatible interface, SEN-30010 is perhaps the easiest-to-use thermocouple interface in its performance class. For users who haven't adopted the Qwiic system yet, we have also included a straight-header interface for breadboarding, including breakouts for short-circuit, open-circuit, and two temperature alert pins. All of this makes it easy to connect up a prototype or install SEN-30010 on a custom carrier board.

MCP9601 uses a pair of resistors to set the device address, which makes it possible to use multiple MCP9601 devices on a single I2C bus. SEN-30010 comes with device address 0x61 as default, but the device address can be modified to support one of two other addresses with a soldering iron and ~30 seconds of desoldering. Need more than three MCP9601 channels? Check out the PwFusion SEN-30011 quad-MCP9601 Qwiic Shield. Using our Qwiic-compatible I2C MUX, it's possible to connect 32 MCP9601 channels to a single microcontroller!

SEN-30010 has been optimized for a wide range of typical applications. To get a clean, consistent reading, SEN-30010 includes differential-mode filtering and the necessary sense circuitry to detect OC and SC conditions. To prevent damage to the device due to ESD and other electrical events, ferrite beads and clamping diodes

have been installed on both thermocouple rails. In short, SEN-30010 integrates all of the functionality the MCP9601 is capable of in a small, easy-to-use package.

MCP9601 supports a wide, 2.7V - 5.5V supply and interface voltage range. As a result, no special translation circuits were required to enable 5V Arduino and 3.3V Raspberry Pi and Qwiic connections on a single board!

Application & Guide

SEN-30010 is designed for rapid setup and integration. We have provided several code examples on our GitHub Page designed to get you up and running quickly.

QuickStart

Start by plugging SEN-30010 into your microcontroller board by a) using a Qwiic-compatible cable or b) soldering headers or fly-wires to power and I2C pins between SEN-30010 and your micro. Next, download the desired PwFusion example code, flash the board, and start measuring! Please note: be sure to set your baud rate to match the Serial.begin() statement in the setup() routine.

Advanced User

The PwFusion library can be used to change many of the settings on the MCP9601 based on descriptions in the datasheet. Things like measurement resolution (directly affects maximum sampling rate) and temperature alerts, with hysteresis, can all be set with our example code. It is highly recommended to spend some time with the MCP9601 datasheet once you have gotten the SEN-30010 up and running to ensure optimal performance in your application.

Common Issues

- Not installing all required connections. Vin, GND, SCL and SDA are *required* for operation
- Conflicting device addresses when using multiple SEN-30010 boards
  - SEN-30010 uses address 0x61 by default
  - See Appendix 2 for details on how to change this address
  - Consider SEN-30011 if you require 4+ thermocouple channels
  - Use an I2C MUX if you want to avoid soldering!
- Strange or inconsistent readings with multiple grounded thermocouples
  - Common mode range can result in erroneous readings when the thermocouple is grounded
  - MCP9601 is typically used for ungrounded thermocouple measurement
  - Try to select ungrounded thermocouples, when possible
  - If you see issues and must use grounded thermocouples, *contact us* to explore what we have available for isolated thermocouple products

Ordering Options & Related Parts

SEN-30010-K: K-type device with Mini flat-blade TC connectors

SEN-30010-W: Universal TC types, supports bare wire connections to board

IFB-10011: Qwiic-compatible I2C MUX based on TCA9548A

WIR-10001: 10cm Qwiic-compatible interconnect cable

SEN-30011-J: Quad J-type MCP9601

SEN-30011-K: Quad K-type MCP9601

SEN-30011-T: Quad T-type MCP9601

SEN-30011-W: Quad universal type MCP9601

SEN-30005: Single MAX31856 thermocouple interface, SPI

SEN-30006: Dual MAX31856 thermocouple interface, SPI

SEN-30007: Quad MAX31856 thermocouple interface, SPI

SEN-30202: Dual MAX31865 RTD interface

Appendix 1a: Mech Drawing (Top View)
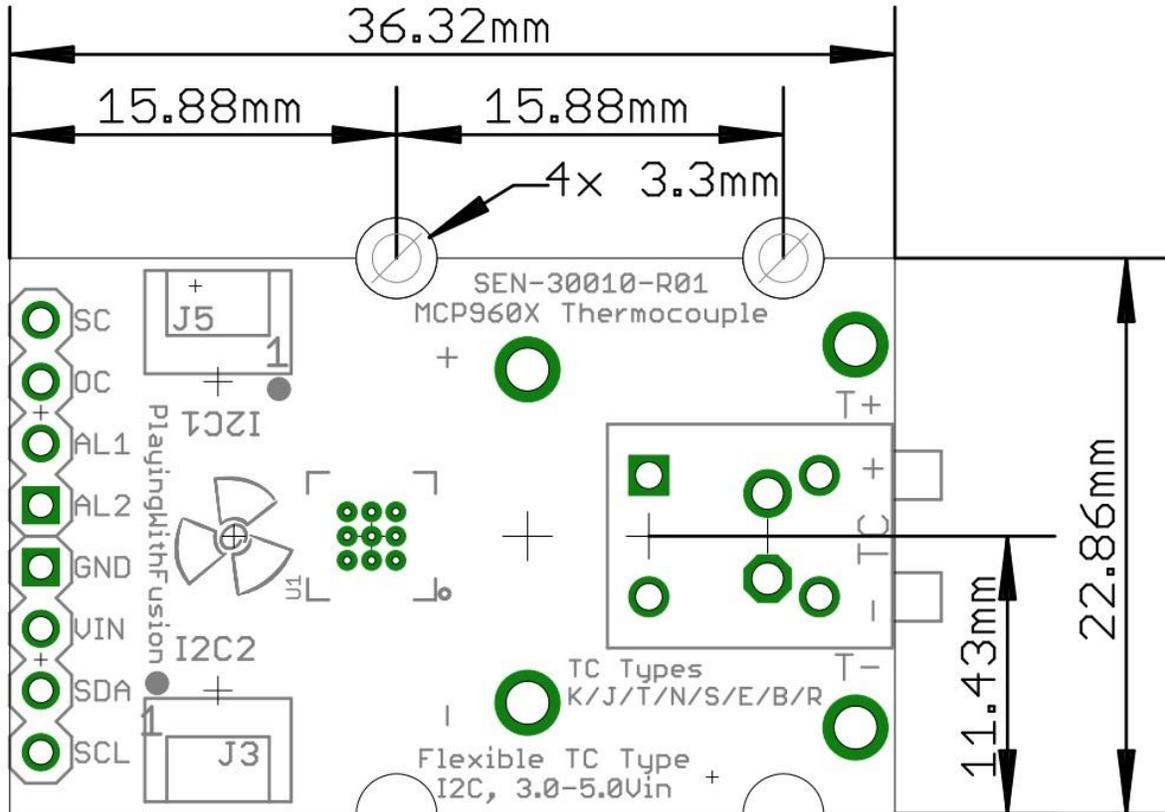
Appendix 2: I2C Address Mod details
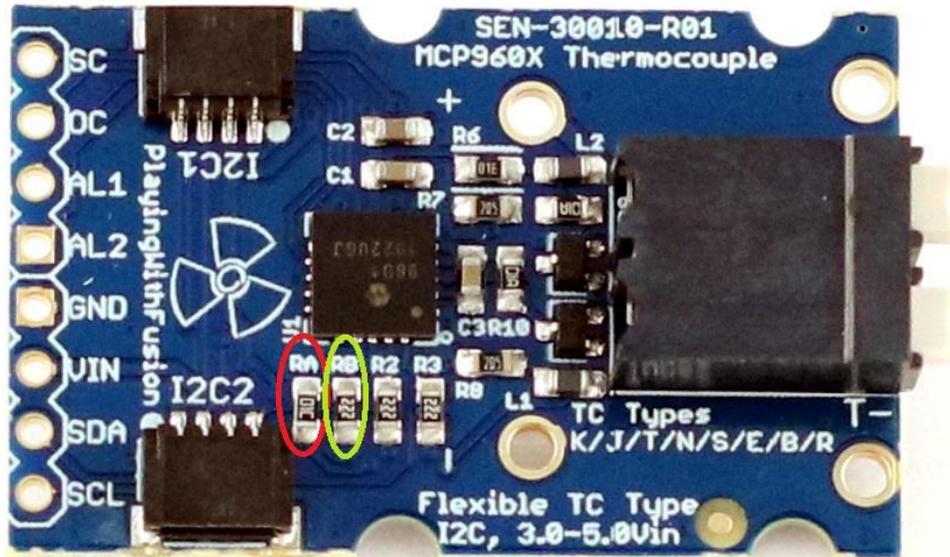
Application: I2C Address for MCP9601 can be anything from 0x60 - x67 (see MCP9601 datasheet for more details). By default, SEN-30010 is configured for 0x61 by using a 10k resistor for RA and a 2.2k resistor for RB. These can be changed (or removed) to swap the address of SEN-30010 and enable multiple to be used on the same bus.
1) To change device address to 0x60, remove RA (circled in red)
2) To change device address to 0x67, remove RB (circled in green)
3) To place 4+ MCP9601 devices on the same I2C bus, consider purchasing SEN-30011, a quad-channel MCP9601 qwiic shield/breakout.

Appendix 3: I2C Pull-up Disable

Application: one pair of pull-up resistors are required for proper I2C operation. If multiple breakouts are used together (think Qwiic daisy-chain), it is possible that an excessive amount of resistance can cause bus issues. If this is the case, resistance must be removed from one or more devices. SEN-30010 has cuttable traces on the back side of the board to make this easy.
1) Identify the I2C pull-up cuttable jumpers on the back of the PCB (circled in green)
2) Using an Exact-O or equivalent device, cut both traces to disable pull-ups on the SEN-30010 board (marked red here)

**Appendix 4a: SEN-30010, Mini TC
connector (K-type shown)**
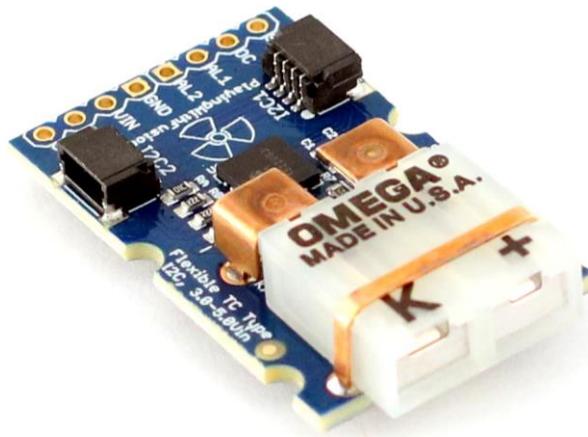
**Appendix 4b: SEN-30010, Spring Clamp
connector, pushbutton release**
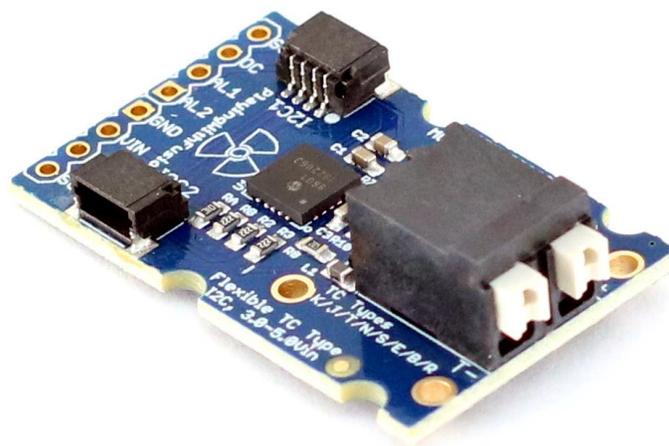
Revision History

Date	Author	Notes
03/18/2021	J. Steinlage	First revision published