Overview

The SEN-30012 is a quad (four) channel, high precision and high accuracy thermocouple shield based on the MAX31856 by Analog Devices and supplied in Arduino Uno R3 as well as “breakout” form factor.

Multiple thermocouple variants are stocked, as well as “universal” configurations. Mini flat-blade thermocouples are supported by the type-specific variants. Universal thermocouple types are supported by screw-terminal and spring-clamp variants using bare wire connections.

Features

- Quad MAX31856 Thermocouple
- Compatible with R3aktor Core
- Wide 3.0V - 5.5V supply and IO range
- Arduino Uno R3 shield form factor
- B-, E-, J-, K-, N-, R-, S-, and T-type thermocouple support
- 19-bit hot-junction temperature resolution (0.008°C/bit) with 0.15% TC voltage accuracy
- 16-bit cold junction resolution (0.016°C/bit) ±0.7°C accuracy
- Thermocouple nonlinearity correction
- Multi-fault detection: Short-to-GND, Short-to-Vcc, Open thermocouple

Kit Includes

- SEN-300012-(x) breakout board, fully assembled

Typical Applications

- Automotive temperature sensing (exhaust, coolant, brakes, etc)
- Industrial instrumentation
- Oven controls
- Home brewing controls
- Hobby applications

Description

Analog Devices (formerly Maxim) has evolved their thermocouple measurement line from the MAX6674 and MAX6675, to the MAX31855, and now, the MAX31856. With the advent of the MAX31856, it is now possible to use a single IC to measure virtually any thermocouple type. However, care must still be taken to ensure consistent junction transitions to avoid unexpected errors. We accomplish this by offering the SEN-30012 in many different configurations.

All SEN-30012 boards include analog filtering on each thermocouple channel. This includes both common- and differential-mode filtering, which compliments the on-chip notch filter for mains frequency noise (50hz or 60hz). This ensures a steady and reliable temperature reading.

Measurements from the MAX31856 are accessed via a 4-wire SPI interface and individual Chip-Select lines. All signals are accessed via the 9-pin header along the back of the board. Multiple boards can be wired together to increase channel count on a single microcontroller. (see our GitHub Page for an example 12-channel MAX31856 datalogger)

While the MAX31856 is a 3.3V (nominal) part, all SPI signals are level shifted to “Vin” using high speed translator ICs. An onboard LDO provides the MAX31856 ICs with clean, 3.3V power. This makes the MAX31856

suitable for any microcontroller or interface device operating between 3.0V and 5.5V.

Electrical Limits and Specifications

Name	Description	Min	Nominal	Max	Unit
V_{Supply}	Supply Voltage	3.3	-	5.5	V
$T_{Ambient}$	Ambient Temperature	-40	-	80	°C
I_{Supply}	Supply Current[1]	-	4.8	8	mA
$V_{CommonMode}$	Common mode voltage which may be applied to thermocouple input pins	0.5	-	1.4	V
	Thermocouple Temperature Resolution		19		Bits
			0.0079		°C
	Cold Junction Temperature Resolution		0.0157		°C
	Thermocouple Linearity Correction Error	-0.24	-	+0.25	°C
t_{sample}	Minimum sample period	47	-	-	ms

Table 1 - Electrical Limits and Specifications

[1] Expected current load with 3.3V supply voltage. Higher supply current as supply voltage increase due to onboard 3.3V LDO

R3aktor Compatible

The SEN-30012 is compatible with the R3aktor Core line of data acquisition products including the Control Center PC software. Simply install the SEN-30012 shield on top of a R3aktor Core and begin measuring data. No programming required when using the factory supplied R3aktor firmware.

Thermocouple measurement

True, type-specific mini thermocouple connectors minimize cold-junction error when accuracy matters most. These connectors feature true J, K, and T-type calibrated contact alloys which introduce less measurement error than copper or beryllium copper contacts.

When flexibility is key, the SEN-30012 is available with generic PUSH-IN connectors and screw terminals which allow a single board measure any combination of K, J, N, R, S, T, E, or B thermocouples.

Application & Guide

SEN-30012 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.

Chip-select Configuration

Individual MAX31856 ICs are accessed via a 4-wire SPI interface with individual Chip-Select lines. Table 2 lists the factory default chip select pin assignments when the SEN-30012 is used as an Arduino shield.

Thermocouple Channel	Chip Select Pin (Arduino digital input)
TC0	6
TC1	7
TC2	8
TC	9

Table 2 - MAX31865 Chip Select pin assignments

The default chip select pin assignments may be modified by removing the zero-Ohm jumper resistors (yellow box in Figure 1) and then soldering jumper wires between the MAX31856 CS vias (orange box) to the Arduino pin vias (red boxes).

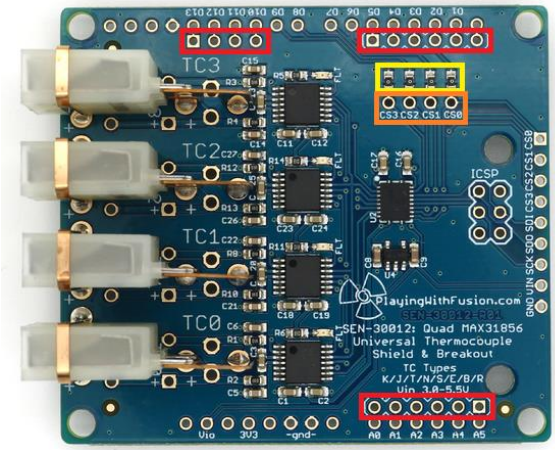


Figure 1 - Chip-select jumper locations

QuickStart

Note: All SEN-30012 boards use the same PCB, but have different connectors to match the application.

1) Start by soldering fly-wires or a straight header (not included) on the SEN-30012. If used as an Arduino shield, solder make headers (not-included) onto the four left/right rows of pins and a 2x6 female header to the ISCP pins.
2) Connect the Vin and GND pins to a voltage supply that matches your microcontroller or interface module.
3) Connect at least the SPI (SDO/SDI/SCK) and CSx lines to your microcontroller.
4) Download the PwFusion example code from GitHub, flash your board, and connect a few thermocouples. Any thermocouple channel that is not plugged will have an illuminated LED showing a fault on that channel (Open, in this case). Other channels will be reading via the serial monitor (be sure to set your baud rate to 115,200).

Advanced User

The PwFusion library can be used to change many of the settings on the MAX31856 based on descriptions in the datasheet. Things like the number of samples to average, notch filter frequency, faults to display, and high- and low-temperature triggers can all be configured via the SPI interface. It is recommended to spend some time with the MAX31856 datasheet once you have gotten the SEN-30012 up and running to ensure optimal performance in your application.

Common Issues

- Not installing all required connections. Vin, GND, SPI (SDO/SDI/SCK), and all 4 CS pins must be connected to function.
- Conflicting Chip Selects
  - Our example code shows using Arduino pins D6-D9 by default, but you can switch this to anything. This is *required* if you have connected something else to pins D6-D9.
  - Remember, many pins on microcontroller carrier boards, like the Arduino and Raspberry Pi, are often used for alternate functions. For example, D0/D1 are used for serial, and D11-D13 for SPI on an Arduino Uno R3. These can NOT be shared with CS pins
- Conflicting SPI modes when used with other boards or modules
  - MAX31856 uses SPI Modes 1 or 3, while many Ethernet controllers and SD cards use Mode 0.
  - Be sure to switch between modes before calling functions for the specific device you are talking to.
  - We show an example of how to handle this in our 12-channel TC logger example on GitHub
- Strange or inconsistent readings with multiple grounded thermocouples
  - Common mode range can result in erroneous readings when the thermocouple is grounded
- MAX31856 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
- Bare wire thermocouple leads not wanting to stay inserted
  - Switch to "W" universal spring clamp connectors or type-specific connectors for industrial and automotive (high vibration) applications

Ordering Options & Related Parts

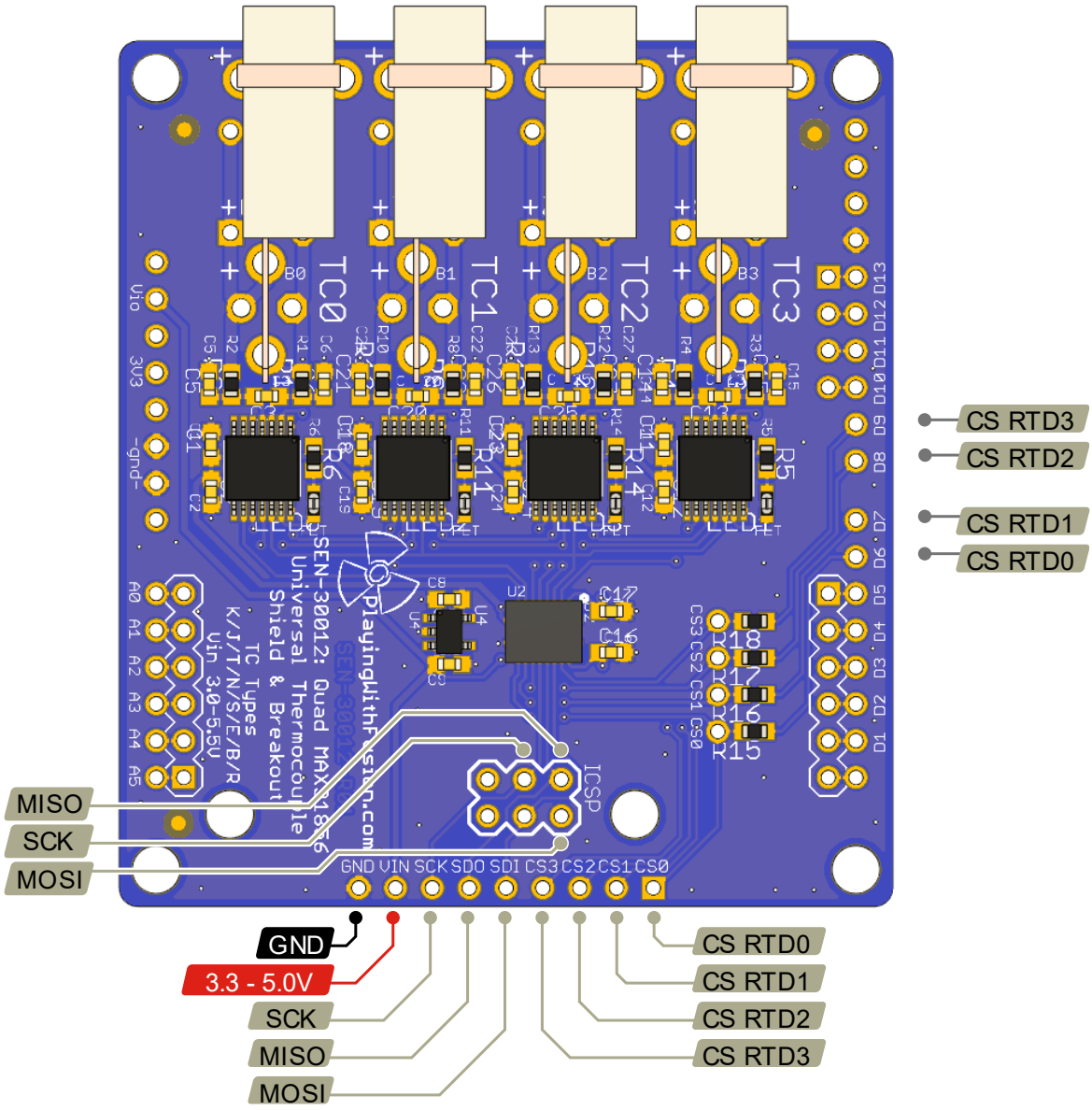
FDQ-30001-J: R3aktor Core - J-type Thermocouple
FDQ-30001-K: R3aktor Core - K-type Thermocouple
FDQ-30001-T: R3aktor Core - T-type Thermocouple
FDQ-30001-W: R3aktor Core - Universal TC

FDQ-30002-PT100: R3aktor Core – PT100 RTD
FDQ-30002-PT1K: R3aktor Core – PT1000 RTD

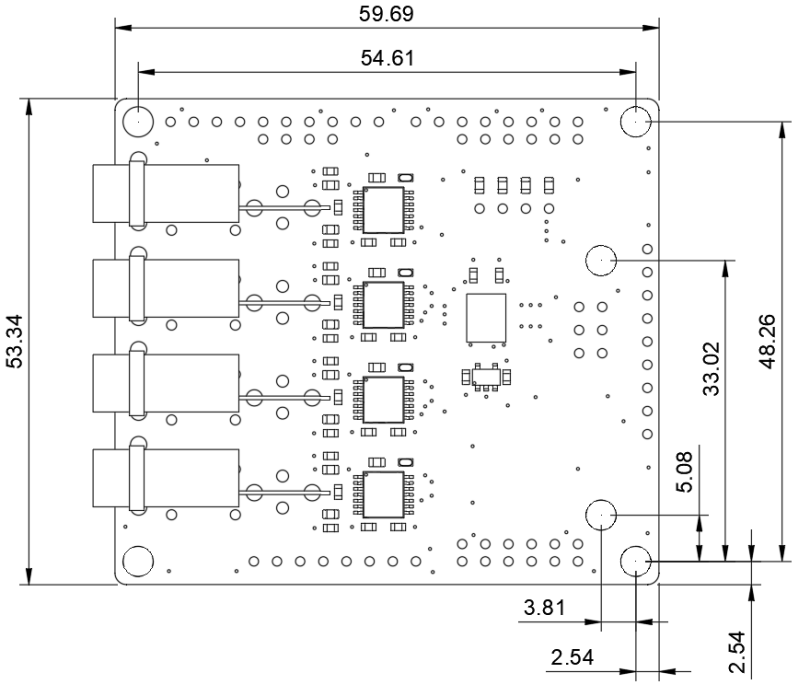
SEN-30012-J: Quad J-type Thermocouple Shield
SEN-30012-K: Quad K-type Thermocouple Shield
SEN-30012-T: Quad T-type Thermocouple Shield
SEN-30012-ST: Quad Screw-terminal TC Shield
SEN-30012-W: Quad Universal Thermocouple Shield

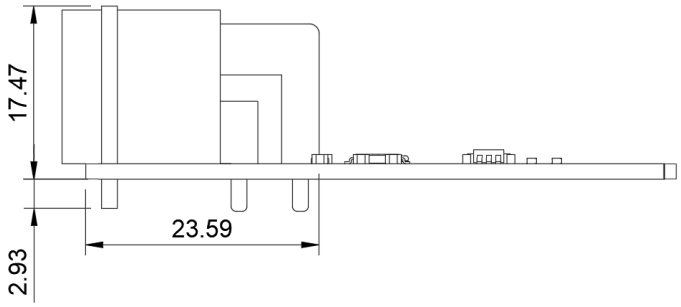
SEN-30203: Quad PT100 RTD Shield
SEN-30203: Quad PT1000 RTD Shield

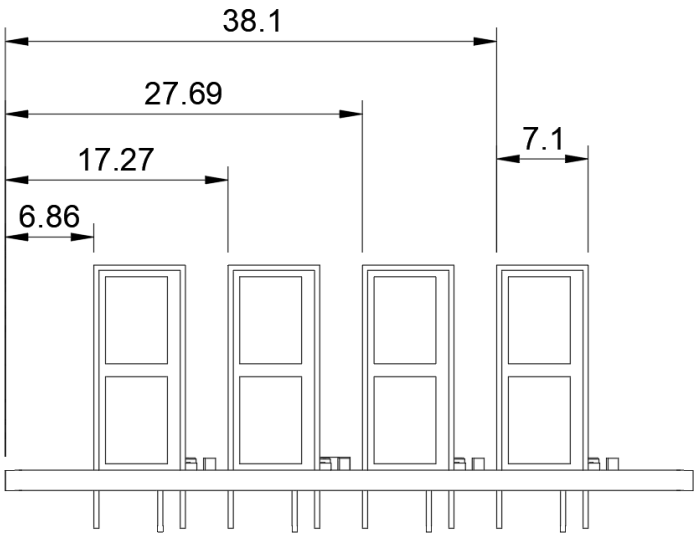
Pinout


CS RTD3
CS RTD2
CS RTD1
CS RTD0
MISO
SCK
MOSI
GND
3.3 - 5.0V
SCK
MISO
MOSI
CS RTD0
CS RTD1
CS RTD2
CS RTD3

Appendix 1: Mech Drawing (Top/Side Views)







Revision History

Date	Author	Notes
08/06/2025	J. Leonard	First revision published