

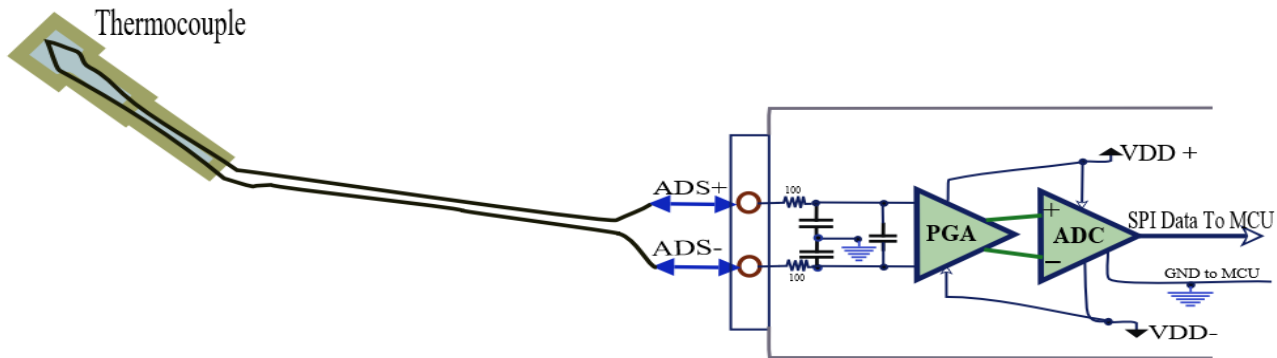
## Thermocouple Measuring in Remote Zones

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### Overview

Thermocouple Sensors are common temperature sensors used in a many commercial and industrial applications and well suited for monitoring environmental applications. The measured output voltage of the thermocouples is converted back to a temperature by the RAZN. This describes *How to Use a Thermocouple* sensor with a RTC, PLC, or RAZN.

Thermocouples cover a wide temperature range, are self-powered, and have a fast response time. Their simple construction make them inexpensive and durable. A thermocouple consists of two wires of dissimilar metals joined together at the end. The junction between the thermocouple metals and the copper wires is called: *Cold Junction*.



Raveon's Remote Autonomous Zone Node (RAZN) has delta-sigma analog-to-digital converters (ADCs) are ideal data converters for measuring, monitoring, and reporting thermocouples.

A programmable Gain Amplifier (PGA) is also within the RAZN, so gain can be from 0.125 to 128. Large gain for small signals, or low gain for large signals, is configurable. Most Thermocouples types have low output so high gain PGA are correct for this type of sensor.

### Thermocouples Temperature Measurement Sensors

Thermocouples are temperature measurement sensors that output a voltage that changes over temperature. The thermocouple industry has created many versions thermocouple optimized for measuring different ways, and different thermocouples have different output voltages. Use the thermocouple's specific wiring when connecting it over any distance. A thermocouple was created with two dissimilar metals touching at one end and are measured at the other end.

RAZN's ADS terminal inputs are modern ultra-high resolution that can use any thermocouple version. These are high resolutions are more linear, almost perfect linearity, and more accurate. All common thermocouple types can be used with RAZN. Here is the common thermocouple list and their characteristics, and the **THC X T** command can setup the thermocouple type code and the RAZN will compute temperature the way these parameters show.

#### List of Common Thermocouple Types

Type Code	Lead Metal A (+)	Lead Metal B (-)	Temperature Range (°C)	mV over Temperature Range	Volt variations $\mu\text{V}/^\circ\text{C}$ at 0°C

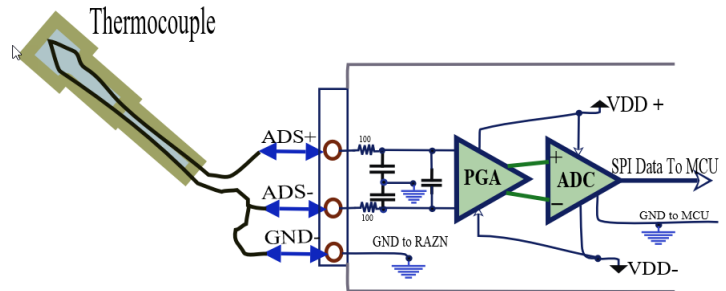
E	Chromel	Constantan	-270 to 1000	-9.385 to 76.373	58.70	
K	Chromel	Alumel	-270 to 1370	-6.458 to 54.136	39.48	
J	Iron	Constantan	-210 to 1200	-8.095 to 69.553	50.37	
T	Copper	Constantan	-200 to 400	-6.258 to 20.872	38.74	
S	Platinum and 10% Rhodium	Platinum	-50 to 1768	-0.236 to 18.693	10.19	

Here is an example of output voltages for a type K Thermocouples at various temperatures.

°F	32	50	77	122	392	200	572	752	932	1112	1292	1472	1832	2012
°C	0	10	25	50	100	200	300	400	500	600	700	800	1000	1100
mV	0.000	0.397	1.001	2.023	4.096	8.138	12.209	16.397	20.644	24.905	29.129	33.275	41.276	45.119

**Grounded Thermocouple**

Most thermocouples do not need to be grounded. For thermocouple that are in very remote areas with potential large noise, voltage spikes, or ESD, the thermocouple may be connected to the system ground also. Even though the ADS input is differential having the ground connected to the thermocouple may make the system safer. When grounded is at a different electrical potential than the contact from the thermocouple and the ADS may be disrupted. For example, a grounded or exposed thermocouple may contact the earth ground, which may not be the same as the RAZN ground. This can cause a variety of problems so don't ground if this won't work for your system, and when not grounded ensure that lightning or large voltage spikes won't hit the thermocouple. When using an exposed or grounded thermocouple, ensure that the thermocouple contact does not disrupt signals.



**Calculating the Temperature sensed by the Thermocouple Version you use.**

The thermocouple generates a voltage related to the temperature difference between the thermocouple junction and the leads attached to the cold junction at the isothermal block. The voltage output from the thermocouple is non-linear depending on the temperature of the cold junction. The RAZN's smart CPU factors in the cold junction temperature.

With the RAZN, you can monitor the voltage or high-resolution digital ADC value to monitor the thermocouple. Setup input port in the RAZN to the actual common thermocouple type connected to it, and the RAZN will compute the temperature. Temperatures calculated are stored in registers that can be read. These temperature registers can be handled in many ways with this innovative RAZN.

- A. Read the temperature with SCADA commands over long-range wireless, Ethernet, or serial ports.
- B. Automatically send out the temperature the way you want.
  - Periodically send at the configured report rate.
  - Send at specific times of minutes, hours, or days.
  - Send text messages with the temperature in them along with text phrases.
- C. With the TOAA feature, you can autonomously control other output terminals based on the input temperatures, time, and other actions. At certain times you want, you can do this:
  - Check temperature, and based on pre-set thresholds, report alerts.
  - Check temperature and control output terminals over time you want to change them.
    - Turn something ON for certain amount of time.
    - Turn some output OFF based on temperature threshold level you have.
    - Pulse something based on temperature.

- Measure some other thing and if it also is in some state that matters, trigger and Action (Text, Output control, MODBUS PLC out,...)
- Turn something ON until the temperature rises to where you want.
  - Turn on an Output terminal (Switched voltage, relays, TTL,...)
  - Turn on a remote Output terminal via the wireless link up to many miles.
- Turn something OFF till the temperature falls down to where you want.
  - Turn off an Output terminal (Switched voltage, relays, TTL,...)
  - Turn off a remote Output terminal via the wireless link up to many miles.
- Actions and Events with TOAA technology can be sent wirelessly, Ethernet, or RS-485 to many other RAZNs connected to the main RAZN that spotted the Action to perform.

This may make the system much safer, so you can monitor thermocouples as you want, and also setup a safety TOAA event to make sure something properly takes place related to temperatures. You can setup the safety *Timer Operations Actions Alerts* (TOAA) event to only take place if something had failed such as communications or dangerous over-temperature.

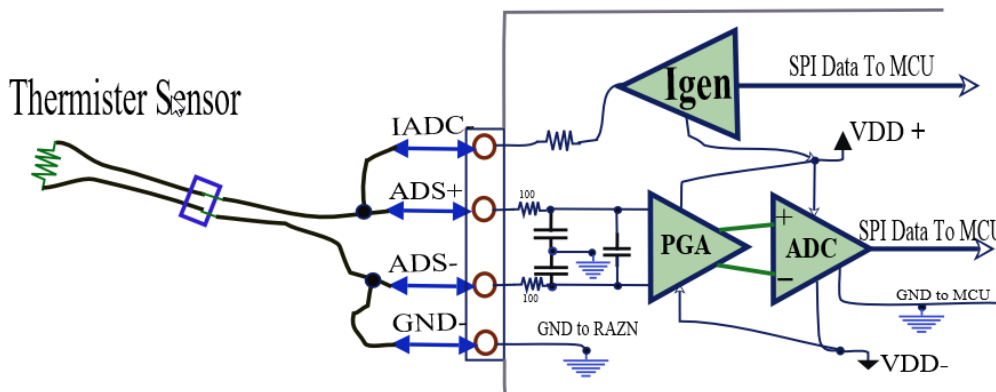
Thermocouple voltage output is small and requires a low-noise precision ADC for measurement. The RAZN uses an ultra-high resolution 24 bit ADC chip from TI that is the best in the world for measuring small voltages. **Small Thermocouple voltages are easy to read with high resolution ADCs.** The great features this ADC chip used for the [ADS](#) terminal inputs on the RAZN are listed here:

- A. 24-bit delta-sigma ADC. This is one of the best in the world.
- B. High-voltage, high-impedance.  $\pm 20$  V
- C. Configurable gain 0.125 - 128.
- D. Input impedance: 1 G $\Omega$
- E. Low noise ADCs. 45 nV RMS
- F. Internal 2.5-V reference voltage, 0.1-0.2% accuracy, <21ppm/  $^{\circ}\text{C}$  ,
- G. Dual positive and negative power supplies to have input up to  $\pm 18$  V
- H. Each [ADS](#) IO has two input pins, a positive (+) and negative (-) terminal pin.
- I. The RV-N55-7 RAZN has two [ADS](#) IO ports (4 pins for 2 ports...)

## Resistor Sensor or Thermocouples Using Power

Some types of sensors do need output current, and some RAZN outputs have current output capability. The RV-N55-7 version has Current Output two [IADC](#) terminals to put out electrical current power via the IADC output terminals.

You can set the output current as need from 0 nA to 3.0 mA. The available settings are:  
 50  $\mu\text{A}$  100  $\mu\text{A}$ , 250  $\mu\text{A}$ , 500  $\mu\text{A}$ , 750  $\mu\text{A}$ , 1.00 nA, 1.50 nA, 2.00 nA, 2.50 nA, 3.0 nA.



Resistor temperature sensors definitely need current put into them, and some Thermocouple sensors have used current powering them.

## Remote Autonomous Zone Node (RAZN) Sensor Monitoring

Use Raveon’s RAZN to remotely monitor temperature. Over a large areas, do whatever you want based on temperature monitored via this long range communication technology the RAZN has.

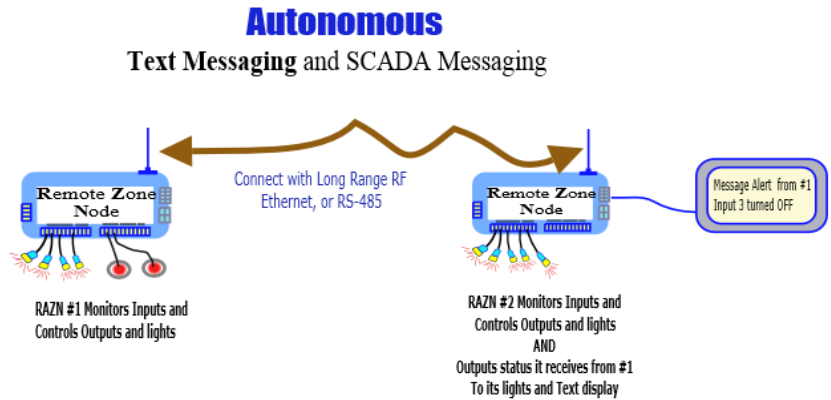
In remote areas, the RV-N55-7 RAZN can accurately monitor sensors with the ultra-high precision Analog to Digital Converter is has within it. The [ADS](#) input terminals are analog differential inputs to measure the different voltage or current between two input pints.

Using Raveon’s Daisy Radios for daisy chaining your network or your system, the RAZN can work across many miles

Daisy chaining RAZN together can also monitor things remotely and then send messages to other remote areas to control what you need.

RAZN can autonomously use the [ADS](#) information to remotely control things, and report temperatures into remote computers, Master controllers, IoT servers, or simple to a graphical display. Many different versions of the RAZN have analog inputs, and the RV-N55-7 version has the ultra-high resolution ADC in it that is the ideal device to monitor a Thermocouple Sensor.

Here is an overview of the RV-N55-7 RAZN Input and Output Terminals with many IO features. The [ADS](#) terminals IO# 3 and IO# 4 are perfect for Thermocouple Sensor monitoring.



### RV-N55-7 8 FIO and 2 high-res Differential ADCs

The RV-V55-7 interface terminal connector pin-outs are as follows:

**Terminal A** Analog Inputs, Relay Driver, and voltages.

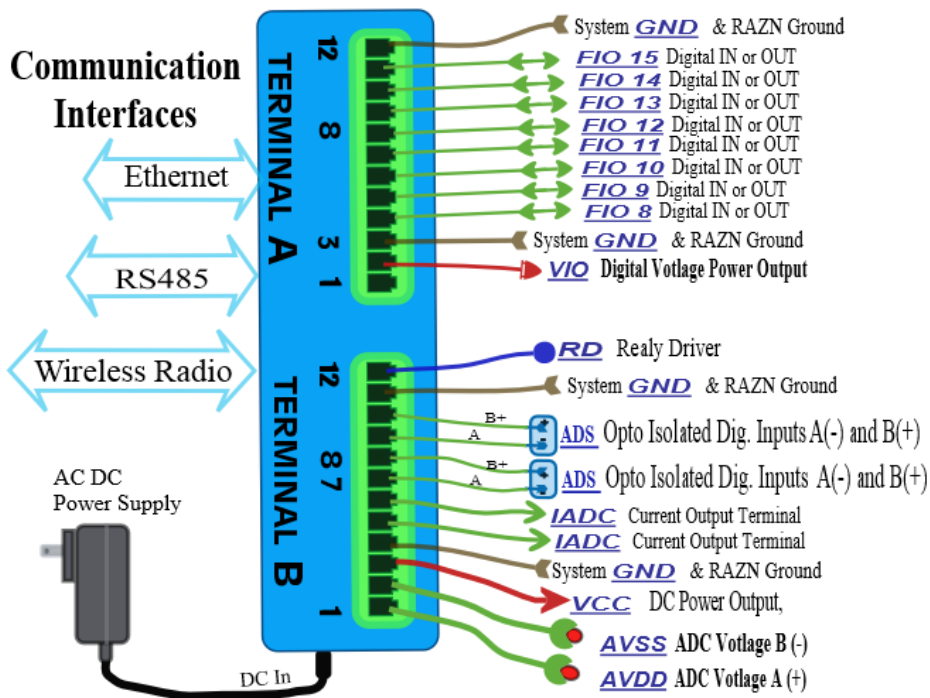
Pin #	1	2	3	4	5	6	7	8	9	10	11	12
Function	AVDD	AVSS	VCC	GND	IADC	IADC	ADS+	ADS-	ADS+	ADS-	GND	RD
IO#					1	2	3	3	4	4		7

**Terminal B** Configurable FIO pins: 8

Pin #	1	2	3	4	5	6	7	8	9	10	11	12
Function	NC	VIO	GND	FIO	FIO	FIO	FIO	FIO	FIO	FIO	FIO	GND
IO#				8	9	10	11	12	13	14	15	

Pin # is the Terminal Port Pin Number. IO# is the software reference and register code for this port.

## RAZN RV-N55-7 Terminal Interfaces



**ADCG x gg** command sets the Programmable Gain Amplitude (PGA). Index for input terminal number IO# is **x** to set **gg** as the gain value.

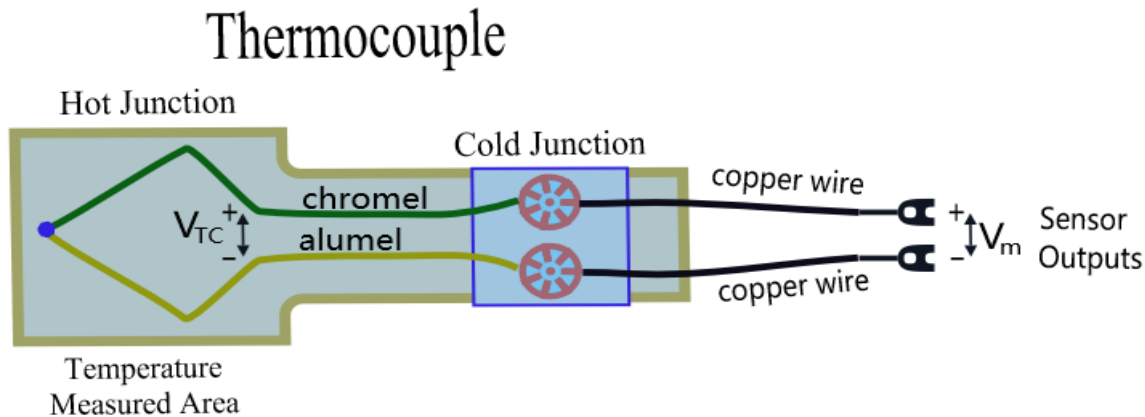
The **ADS** inputs are a signed 24 bit register for high resolution ADC.  $2^{23} = 8,288,608$  so with 8 million bit resolution this has the highest resolution ADC in the world. The ADC data is stored in SCADA registers 6040-6055 for IO terminals IO#0 – IO# 15.

Commands **GVOLT x** can read the voltage in IO terminal **x**.

Command **TEMC X** can read the calculated Celsius Temperature of the thermocouple connected to RAZN terminal IO# **X**. Command **TEMF X** can read the calculated Fahrenheit Temperature of the thermocouple connected to RAZN terminal IO# **X**.

## RAZN Enclosure Reference Temperature

The thermocouple is used to measure a temperature at its *hot* junction. The temperature influence at the *cold* junction wire interface affects the measurement. Here is a diagram of a common K type Thermocouple example how it is wired.



The two Cold Junction connections should be made at the same temperature. The Cold Junctions are mounted on an isothermal block of high thermally conductive material. If the Cold Junction was at 0°C then Sensor Output would be zero volts and we would be able to measure the hot junction voltage directly.

The RAZN assumes the Cold Junction is at the same area with the same temperature of the RAZN, so the temperature calculation factors in the RAZN's enclosure temperature.

You can read the RAZN's enclosure temperature with the **ATTE** command. Or re-calibrate it to factor in some other Cold Junction temperature you want factored in.

The **TEMC** command reads the temperature in Celsius degrees. The **TEMF** command reads the temperature in Fahrenheit degrees. Register 5002 is the RAZN device temperature, and registers 6060-6075 are the input terminal voltages calculated for the type of thermocouple or sensor connected to the RAZN's ADS input terminals.

## ***Ways to Monitor Sensors with a RAZN***

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### ***Traditional SCADA Method Monitoring***

1. Query the input voltage with a MODBUS message from a Master controller.
2. Query the input voltage with a MODBUS message from a PLC.
3. Program the Logic in the RAZN to control outputs based on temperature sensors.
4. Communicate via: RS-485, Ethernet, or long-range Wireless data radio built in the RAZN.

### ***Innovative RAZN Technologies for Monitoring Sensors***

1. Wide variety of communication interface options and Long Range wireless features.
2. Autonomous actions to make your system safe and reliable with no communications.
3. Locally trigger outputs based on temperature measured.
4. Locally trigger outputs based on temperature measure and combination of:
  - a. sensor levels (As you want),
  - b. The time and date(as you want),
  - c. Local inputs from buttons, other sensors, temperature, and input status.
  - d. RAZN monitored input events (# on, # off, pulse rate, Time ON, time OFF,...)
5. Remotely trigger outputs by a RAZN
  - a. From a RAZN monitor locally and communicates wirelessly to remote RAZNs.
  - b. Use the RS-485
  - c. The outputs triggered from temperature can be many different kinds of outputs.
  - d. Many different RAZN models have many IO features. See the list of RAZNs.

### ***Communication Methods to and from RAZNs***

**Ethernet** Connect an Ethernet Cable or Wi-Fi adaptor to the RAZN's 10/100mbps Ethernet connector. This is a *Terminal Server* with 1-3 TCP/IP ports for 1-3 simultaneous client connections.

**RS-485 Serial** Connect an RS-485 serial cable to a RAZN or dozens of RAZNs that share this differential serial communications port connection.

**Narrow Band RF** The RAZN can have Raveon's RV-M6, or RV-M8 data radio modem installed inside for ultra long range RF data 1-50 miles in VHF or UHF RF bands.

**LoRa RF** The RAZN can have Raveon's RV-M50 LoRa data radio modem installed inside for long range license-free RF data 1-10 miles.

**RS-232 Serial** Connect an RS232 serial cable to a RAZN. This is an optional feature on all versions of the RV-N55 RAZN.

**Wi-Fi** The Ethernet connection can connect to a Wi-Fi modem to use Wi-Fi.

Raveon is always interested in adding features and options our customers need, and we are willing to adding any "linearizing software" for the thermocouple. And if you would like some additional Thermistor sensor to factor temperatures to your thermocouple, please contact Raveon customer support.

Or if you'd like the RAZN to wirelessly mimic the voltage from the thermocouple over a long distance, please contact Raveon customer support because this high accuracy 24bit ADC can wirelessly send voltage information to wherever you want it.

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