Welcome to Tech Day 2019

RAD-IO2 Product Line

Physical Measurement

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RAD-IO2

Physical Measurement and Control agenda

- INTRO
- Module info
- Connections and software
- What is Isolation?
- Sample Applications
- Questions?

Product Line Overview:

RAD-IO2-TC: 8 Isolated banks, each with 1 isolated channel of K-type thermocouple (8 Total)

RAD-IO2-PWRRLY: 8 Isolated SPDT (single pole double throw) electro-mechanical relays

RAD-IO2-AOUT: 8 Isolated analog output banks, each with three (3) analog outputs per bank (24 Total)

RAD-IO2-AIN: 8 Isolated banks, 1 channel per bank selectable between a high or low voltage input (8 Total)

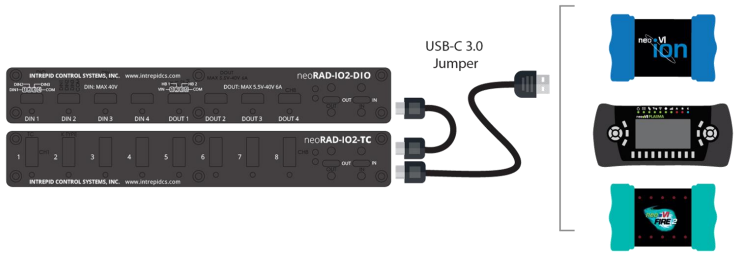
RAD-IO2-DIO: 4 Isolated digital/analog input banks each with 3 input channels and 4 isolated digital outputs banks each with 2 output channels, each configurable independently or as an H-Bridge output

RAD-IO2-CANHUB: CAN FD interface for up to 8 RAD-IO2 devices, 2 Amp limit.

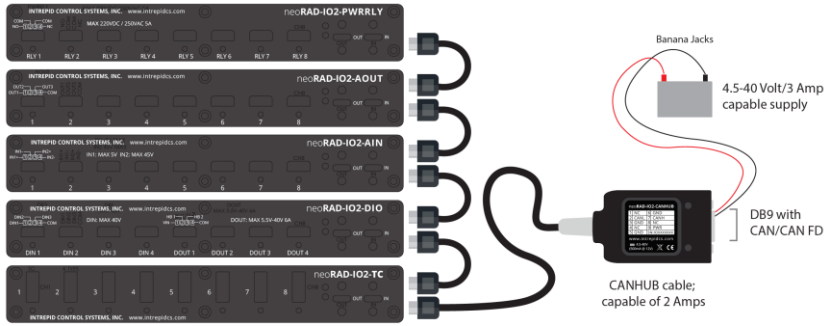
Connection Info Overview

You can connect direct to a PC

- Use free Javascript program to view and log the results
- Write Python or “C”



Connect directly to ION/FIRE2, uses the NeoVI channel



Use the CAN-HUB and convert all the signals to CAN for connection to ANY CAN device

Module Info:

RAD-IO2-TC; 8 Isolated Thermocouples

- 8 Banks; ONE channel per bank
- Each Bank has it's on CJC and A/D chip
- "K" Type only
- K-Type range -270C to 1260C; +/- 2C accuracy
- 60Hz and 50Hz common mode rejection > 105dB
- ISOLATED- No other thermocouple module on the market provides channel to channel isolation at this price without using miniature relays as a multiplexer, which cause a lot of settling time and error.
- Although thermocouples are not as accurate as RTD's, with the high quality of the RAD-IO2-TC, (especially since we calibrate each channel), The RAD-IO2-TC unit is 0.2°C resolution; accuracy better than +/- 1° C is typical.

RAD-IO2-AIN: Analog Input

- 8 “Banks”, each bank with an A/D chip and each one has one Low range and one high range input, you can connect only to the Low or the High not both at the same time.
  - Low range ± 250 mV, ± 1000 mV, ± 5000 mV
  - High range ± 8V, ± 16V, ± 42V
- **You can use the AIN module like a 8 totally independent “floating” voltmeters without fear of one channel influencing the other.**
- Sampling rate: Max 2000 sps (samples per second) aggregate across all daisy chained modules OR max 100 samples per sec channel. For example, 24 channels would yield 2000 / 24 = ~83 samples per second. One channel would yield 100 samples per second.
- RAD-IO2-AIN is great for most static or semi-static measurements but to slow for Electrical Transients, Microphones, Accelerometers

RAD-IO2-AIN: Analog Input

- What is the resolution of the AIN?
  - 16 Bit. It is a Delta-sigma (ΔΣ) analog-to-digital converters (ADCs) so less “jitter” is obtained when slower conversion speeds are used.
  - “Delta-sigma (ΔΣ) analog-to-digital converters (ADCs) are based on the principle of oversampling. The input signal filtered and decimated in the digital domain to yield a conversion result at the respective output data rate.

RAD-IO2-AOUT

- **8 banks of isolated output, each DAC (Bank) has three 0-5V analog outputs and one common ground line per bank, 24 total channels**
- 16bit DAC (76.3uV per bit)
- 5mA output current
- Please note, the same 100 samples per second limitation applies when you try to update the analog signal output. It is be possible (with future firmware) to preload output waveforms and trigger them. Please contact me if you have such an application
- Example of an Analog Output Application:
  - To bench test ECU's, many times multiple analog outputs are required to simulate vehicle sensors or resistive divider networks. This will allow a test set-up to stimulate a ECU that has multiple analog inputs, and vary the outputs based upon the test specification.
  - To generate multiple isolated battery voltages to simulate an E-CAR battery cell potentials

RAD-IO2-DIO

- **8 banks of isolated I/O with one common ground per bank.**
- The first 4 banks are isolated inputs, with three 0-40V 12 bit inputs per bank (a total of 12). These inputs per can be configured as analog inputs or digital inputs with a programmable threshold (in 160mV steps).
  - This is a pretty cool feature compared to most digital inputs that are just TTL logic, and those usually require an opto-isolator for isolation.
- The second 4 banks have two digital outputs that can be configured as separate digital channels or as an H-Bridge output. 8 total.
  - Each output can pass 5.5V to 40V at 6A (user supplied).
  - There are many motors on a car that require half or full bridge outputs to work, and some that require PWM; especially Electronic Throttle body,
  - The DIO has a 12MHz clock onboard, so it should be able control a PWM at up to 47KHz.

RAD-IO2-PWRRLY

- 8 banks of isolated output with one common ground and one normally open contact and one normally closed contact per bank.
- 8x 250VAC 5A relays
- Switching power 60W/62.5VA and switching voltage 220VDC/250VAC
- Dielectric and surge capability up to 2500Vrms between open contacts and 3000Vrms between coil and contacts
- High mechanical shock resistance up to 300g functional

Physical Properties

- **The case is made of rugged Die Cast aluminum.**

Physical Properties

- Which can also act as a cowbell if the front plate is taken off and the circuit board removed.
- There is a Dove Tail on the top to slide the units together for easy stacking
- Metal brackets and fasteners will be included if robust securing is needed

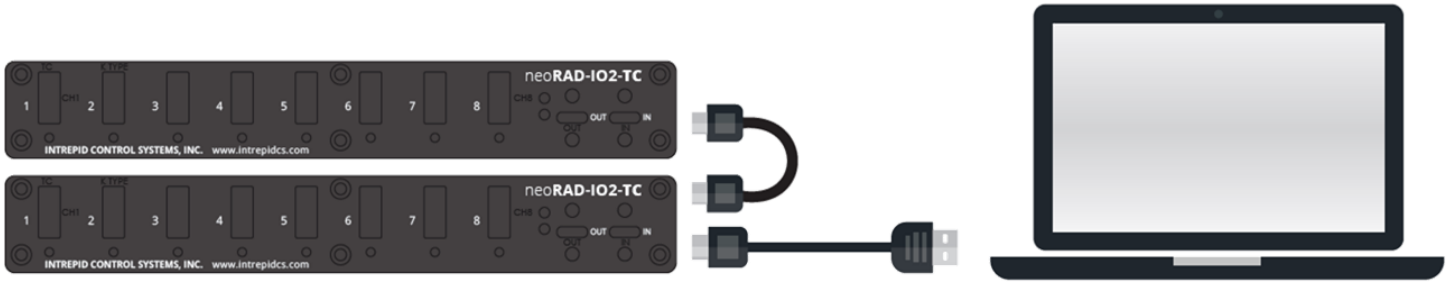
Physical Properties

- All of the modules except for the Thermocouple unit utilize removable spring loaded push in Phoenix connectors
- The modules communicate via USB-C from the “IN” port
- The units are daisy-chained together with a USB-C jumper, one is included with each module
- On average the units draw between 200-300 mA,

Connection Info

1. Connect units to a PC via USB, use free program or write Python.
2. Connect Directly via USB to ION/PLASMA/FIRE2, uses NEOVI channel.
3. Connect to CAN-HUB, which converts the USB-C signal to CAN messages to be read by any CAN device.

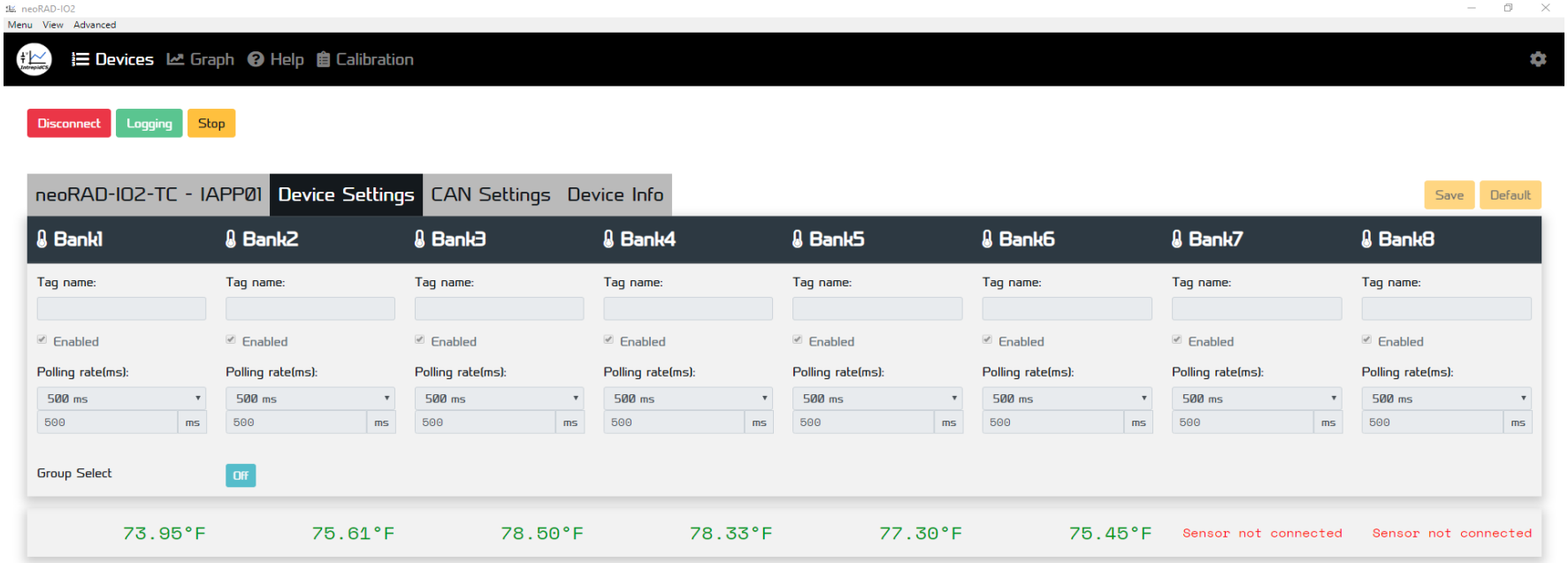
1). Direct to PC via USB



- Single or Multiple units connected to a PC
- Use free Javascript program to:
  - View data and plot
  - Set CAN addresses and sampling speeds
  - Calibrate Analog and Thermocouple channels
- Or write Python or “C” code
- The spec for a standard USB Type A port is 500mA, but some go higher or use a powered Hub

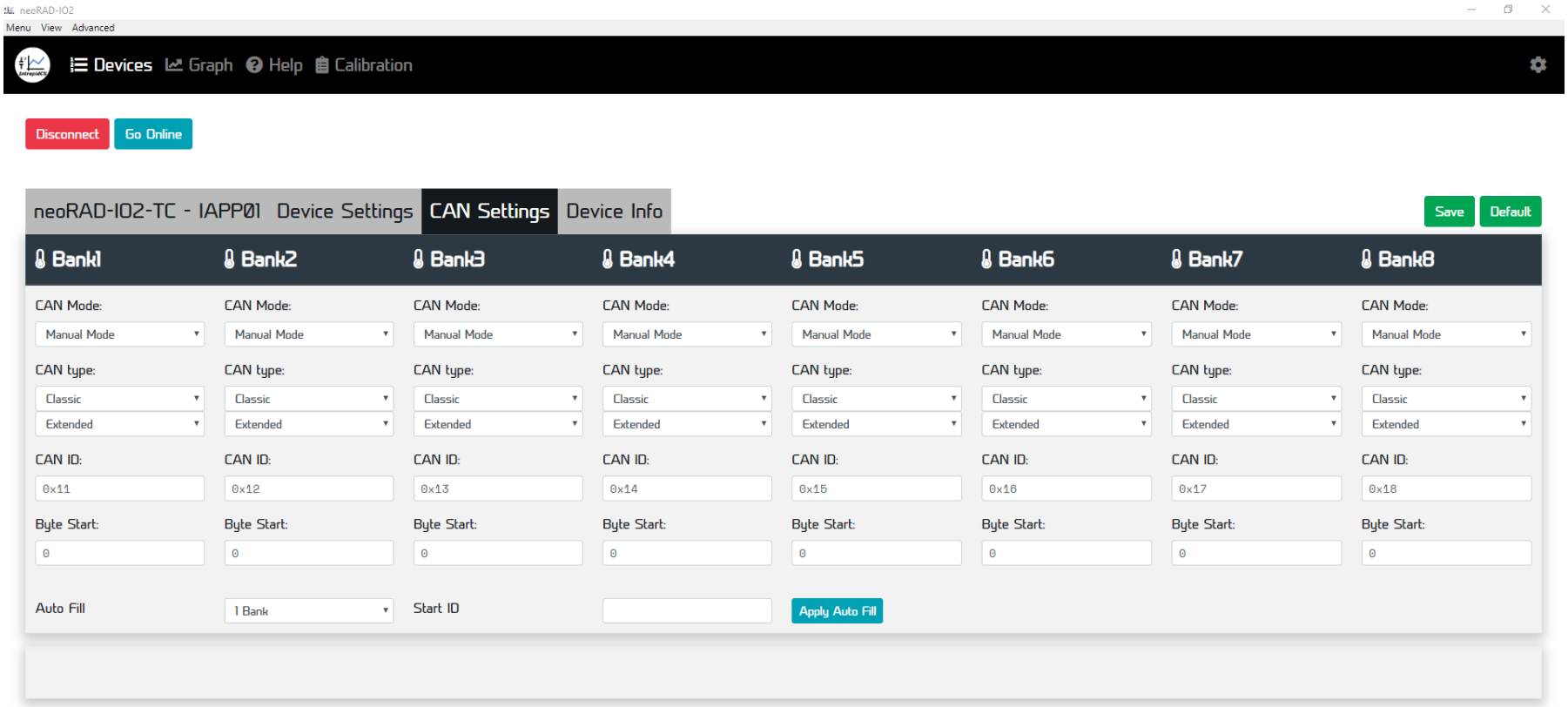
Free Java Script Program

- Use free Javascript program to view the results and plot
- Set TAG names and sampling speeds



Free Java Script Program

- Set CAN Mode, CAN Type, CAN ID, and Byte Start
- Next version will create DBC files



Free Java Script Program

Perform CALIBRATION

Edit Points

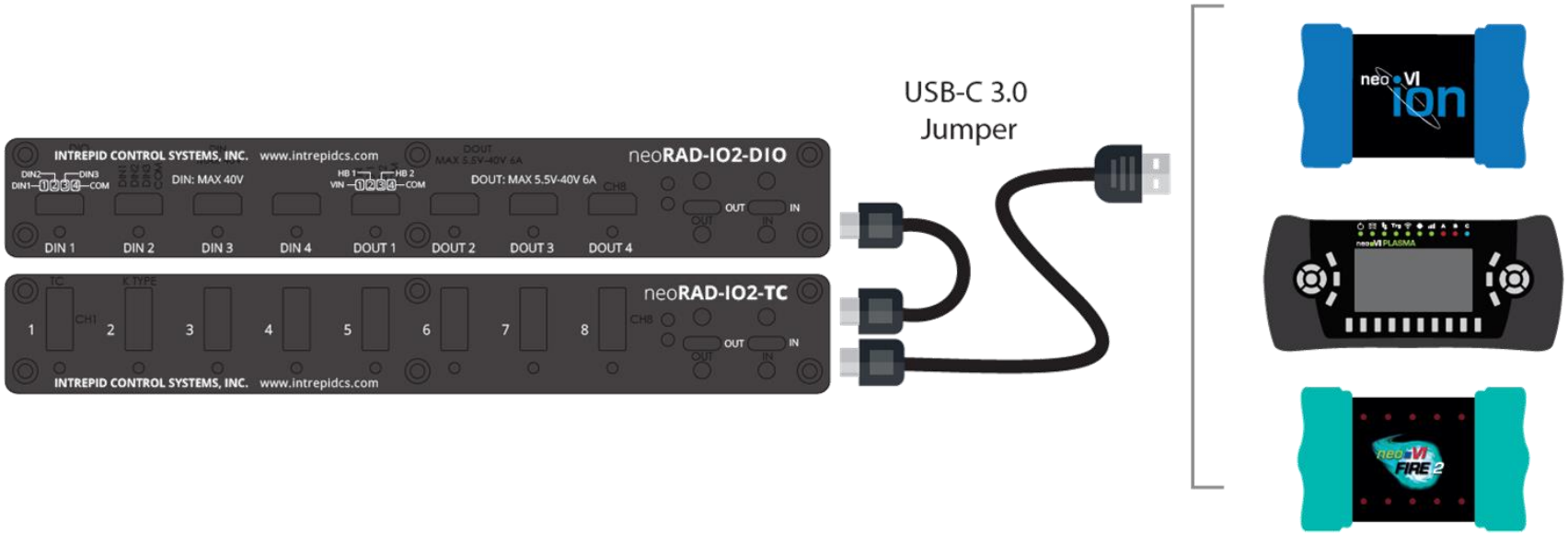
Clear Manual Interactive

Calibration points			Bank1	Bank2	Bank3	Bank4	Bank5	Bank6	Bank7	Bank8
0	V	Stored	0	0	0	0	0	0	0	0
		Measured	0	0	0	0	0	0	0	0
		Error	0	0	0	0	0	0	0	0
16	V	Stored	17.2013	17.2029	17.1996	17.1979	17.2103	17.1877	17.2041	17.1968
		Measured	17.2013	17.2029	17.1996	17.1979	17.2103	17.1877	17.2041	17.1968
		Error	-1.2013	-1.2029	-1.1996	-1.1979	-1.2103	-1.1877	-1.2041	-1.1968

Program it yourself with PYTHON!

- Go to https://github.com/intrepidcs/libneoradio2
- Regarding the Badge- write your own python code
  - 8 Analog inputs
    - 6 Analog 0-5V input channels (not protected)
    - 1 connected to Potentiometer
    - 1 connected to a temperature sensor
  - 4 Digital 5V output channels
  - 4 LEDs for relay module simulation
  - 12-Bit ADC (Analog to Digital Converter)
  - USB Type C connector for power and configuration
  - Through-hole per channel for optional solder connection
  - Push-in mating connector (Phoenix Contact 1778858)

2). Directly to ION/Plasma and FIRE2

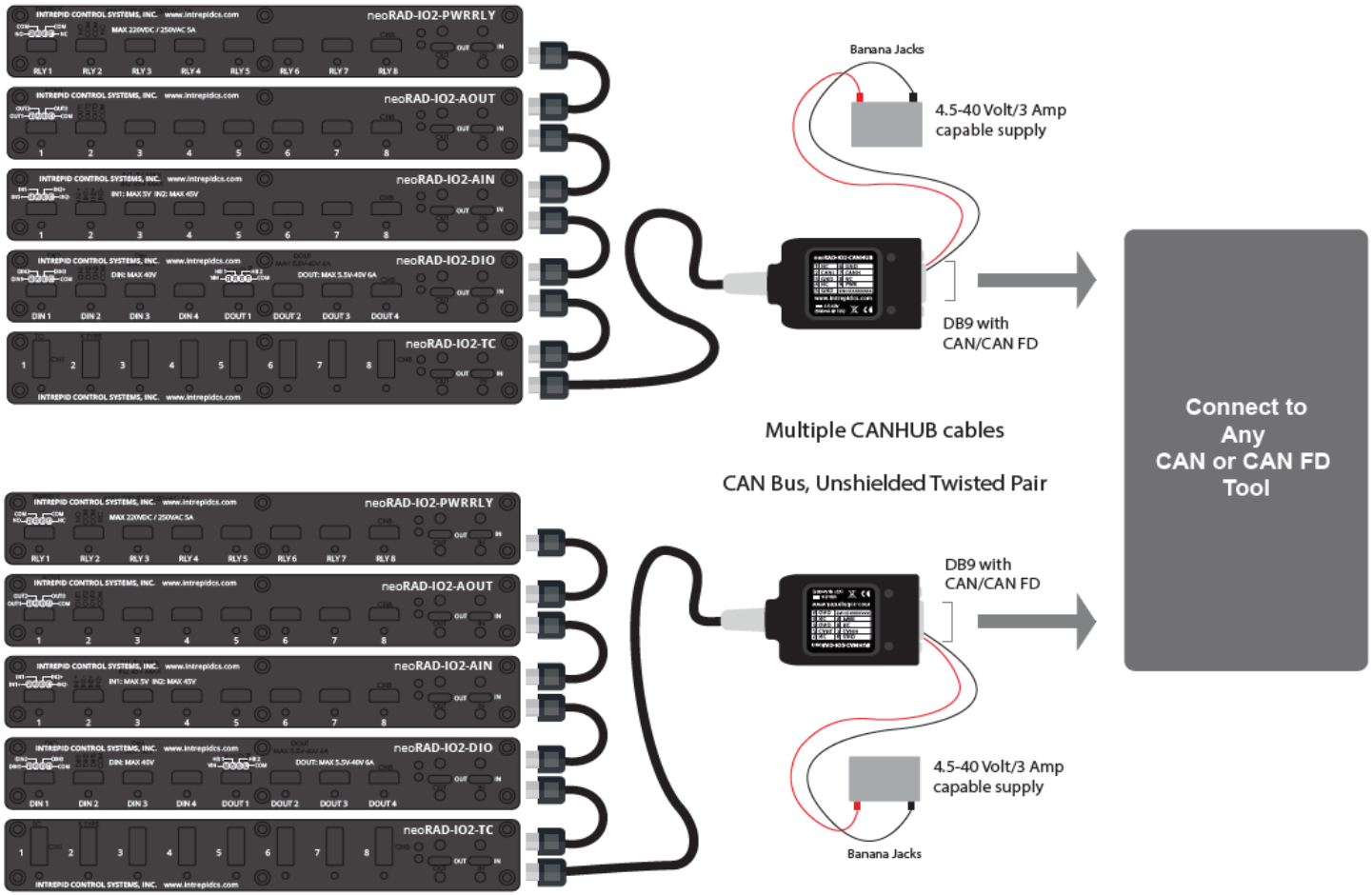


- Data is saved in the NEOVI Channel and viewed via VSPY

RAD-IO2 on ION/Fire2

- Messages sent on the neoVI network are transmitted at the sample rate specified in the neoRAD-IO2 settings
- Their arbIDs specify exactly which USB device, device in the chain, and bank the data came from
- Each message has a three digit arbID
  - First digit specifies the USB device
  - Second digit specifies the device in the device chain
  - Third digit specifies the bank
  - Example: 225- 2nd USB device plugged into the Plasma/ION, 2nd device in the device chain (top being the first), 5th bank on the device
- Messages view in Vehicle Spy defaults to hex format, you can change this by switching to decimal format in the lower left of the view

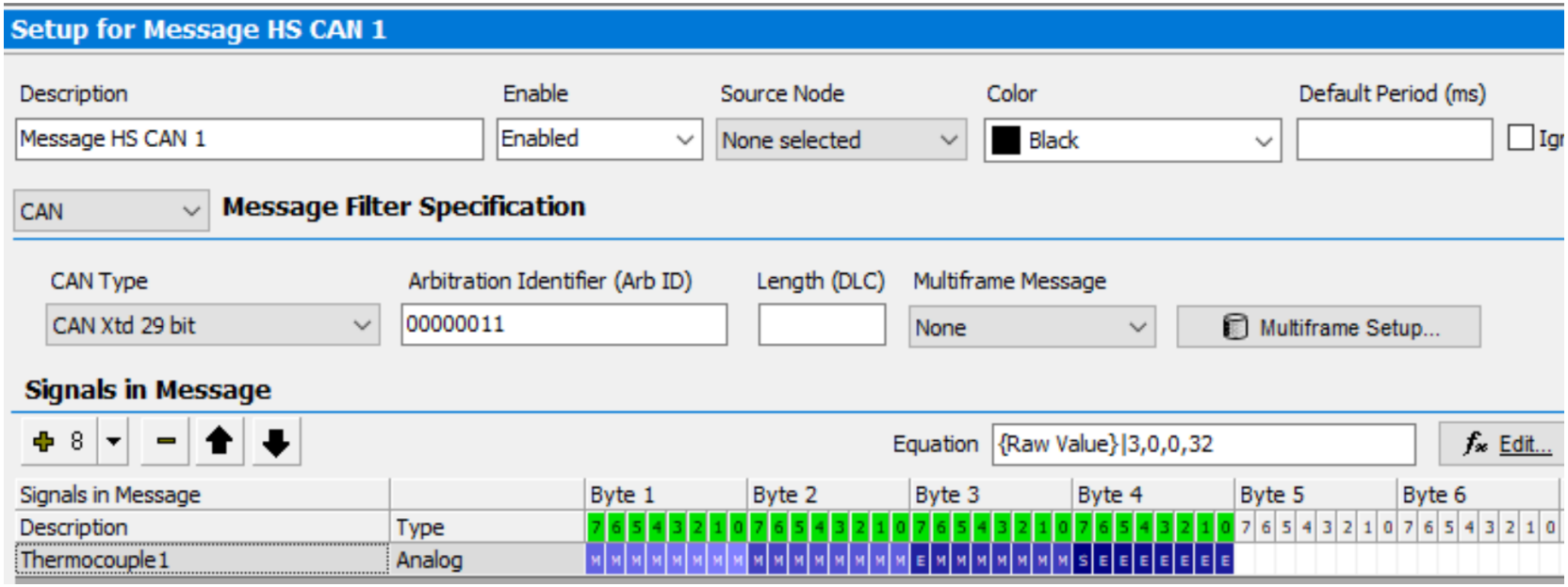
3). Use CAN-HUB to Convert USB to CAN/CAN-FD



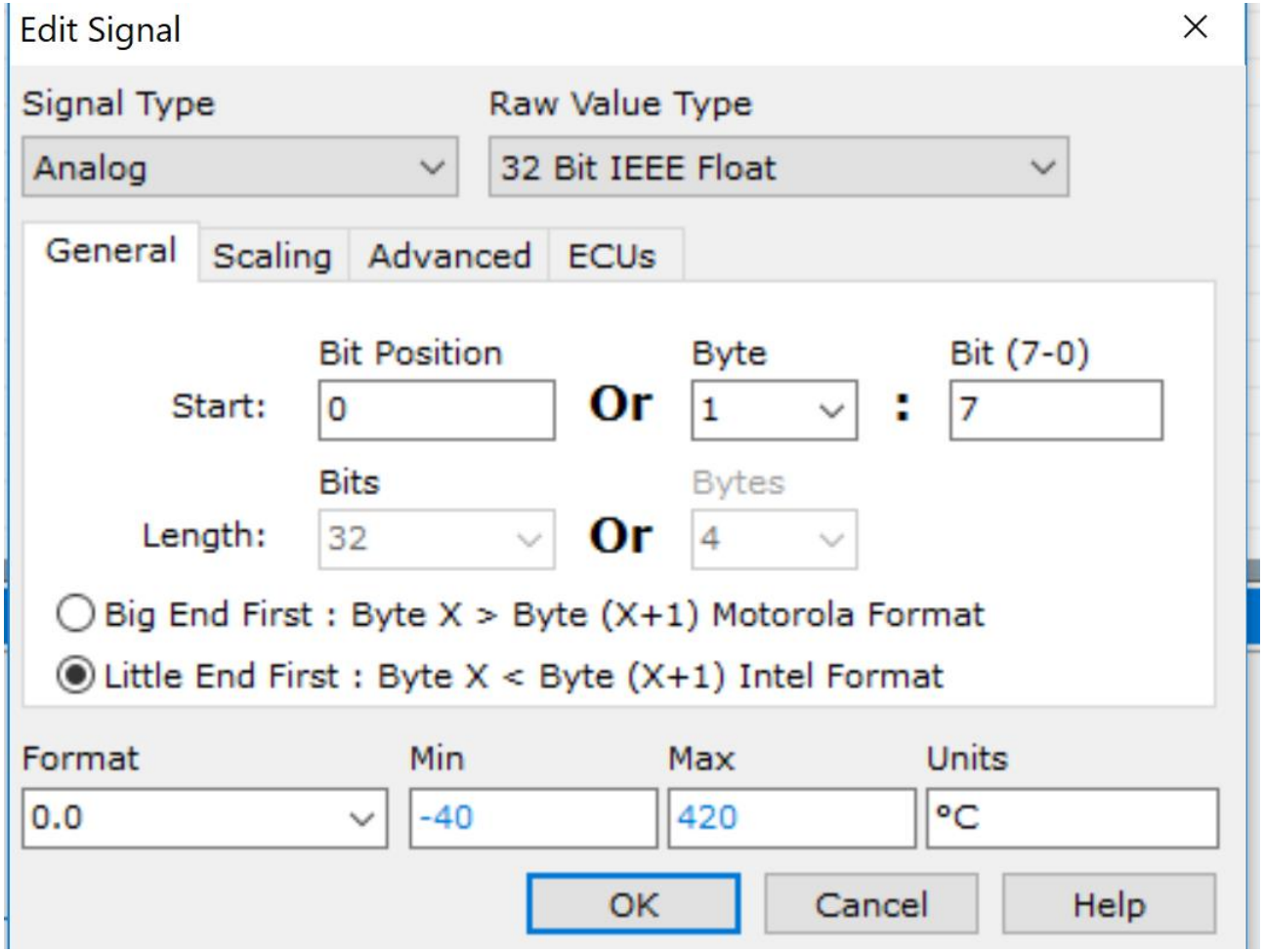
CAN-HUB

- CAN-HUB converts the native UART to CAN/CAN-FD to allow the RAD-IO2 to provide data for ***ANY*** CAN device.
- Use the free Javascript program to set it up.
- Signals are encoded in CAN Messages with 11-Bit or Extended 29-Bit Arbitration ID's of your choosing, and can be packed to start at any byte point.
- The CAN-HUB is limited to 2 Amps of supply current, number of devices supported depends upon the types of units.
- Multiple CAN-HUB's can be utilized to distribute RAD-IO2's in remote locations throughout a vehicle, laboratory, or dyno cell to minimize sensor wiring.

How to Decode RAD-IO2 data in VSPY



How to Set-Up in VSPY



What is ISOLATION?

There are three types of Isolation:

1. Channel to Earth Ground Isolation
2. Bank Isolation (Channel to Bus)
3. Channel to Channel Isolation

Channel to Earth Ground Isolation

- Channel to earth ground Isolation is the most basic type of isolation
- This is typically rated in a specification as the maximum voltage differential that can occur between the channel and the Earth ground.
- For portable devices the USB chipset usually takes care of isolation.
- BEWARE: Many A/D companies will claim “Isolation”, implying channel to channel when it is just Channel to Earth.

Channel to BANK Isolation

- Some A/D devices will use multiplexers and isolate the various multiple analog or digital banks from one another and the earth ground.
- This may be OK depending upon your application, but care must be used in the design of the system.
- The RAD-IO2-AOUT has 8 isolated banks, and each bank has 3 channels for a total of 24 channels. Channel 1 shares a common ground with CH2 and CH3, but not any other channels.

Channel to Channel Isolation

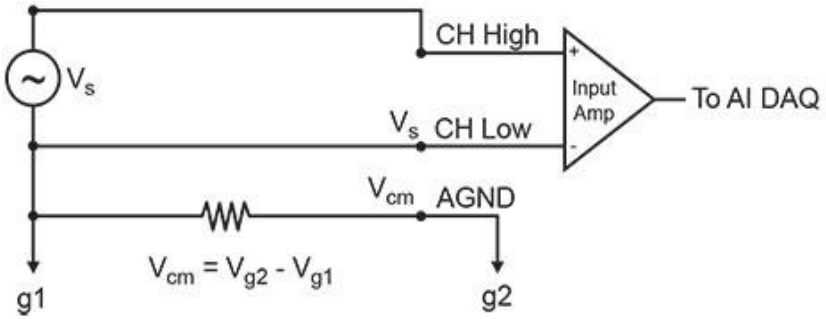
- In a channel to channel isolated system each channel is isolated from one another
  - No ground interference between channels
  - No crosstalk between channels
  - Can measure voltages with no Common Mode issues
- ALL RAD-IO2 products utilize Bank to Bank isolation of 2.5KVA, and in the case of the RAD-IO2-TC and AIN that means channel to channel isolation because there is only one input per bank.

What is Differential Measurement and Common Mode?

What is Differential Measurement and Common Mode?

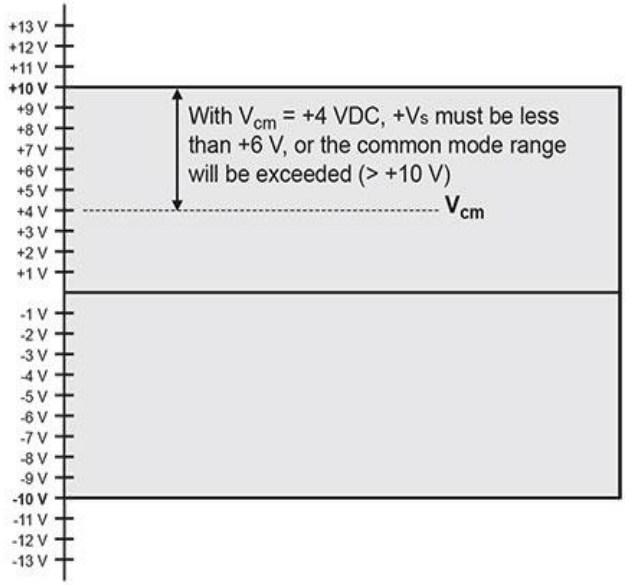
- Differential and isolated analog inputs ***are not*** synonymous, and unless the specifications for the instrument/card state clearly that it is channel to channel isolated- **it most likely is not.**
- Differential inputs still share a common ground, and the ground cannot exceed the common mode specification of the device. Most inexpensive A/D systems or cards have a common mode of 10VDC. This will not even allow you to test a shunt on the high side of an automotive component.

Tech Note:



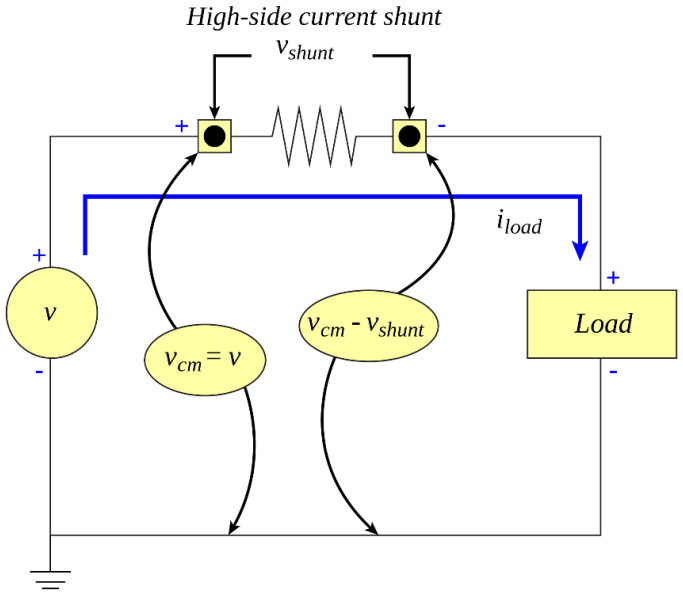
Differential example:
Differential does not mean isolated. There is still a connection to the Analog GND

Common mode example
On a system that allows only 10VDC common mode; if the Vs CH LOW is at 4VDC, you could only measure a signal of 6VDC before you exceed the Common Mode Voltage.
Q). Where can this occur?
A). When measure the cells of a battery pack.



Tech Note:

- Isolated inputs can measure a voltage without regard to common mode

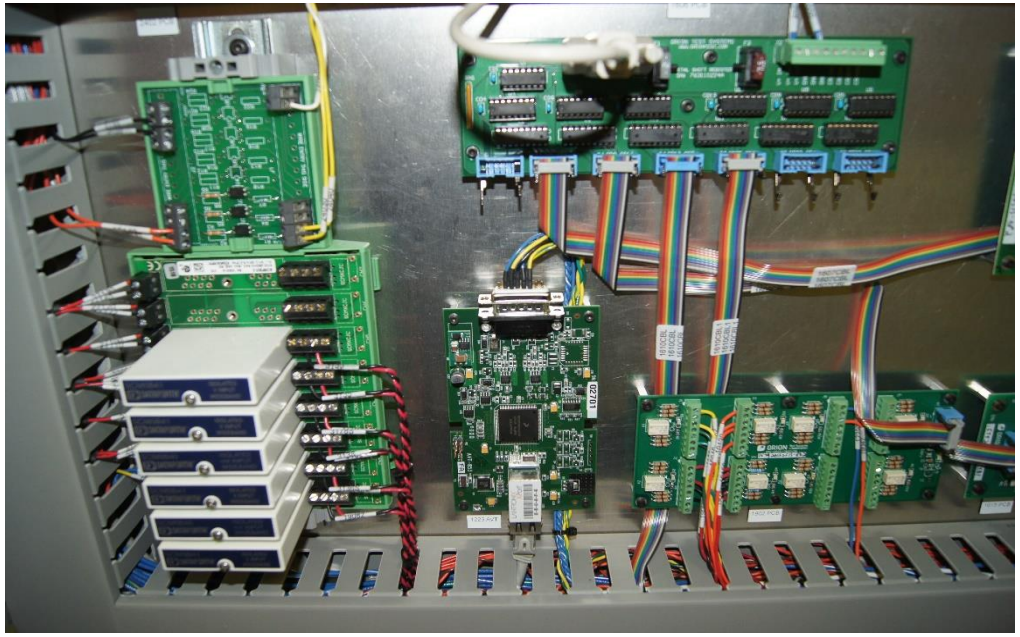


In this example, if you wanted to measure the current going to a load in a 12VDC automotive system, the easiest way *may* be to measure the battery feed, as many times the case of the device is grounded to the chassis. So you would need an isolated differential input (like the RAD-IO2-AIN), or at least an A/D that has a common mode well over the feed voltage (up to 18 VDC to be safe)

When do you need Channel to Channel ISOLATION?

- Anytime you do not want one measurement to influence the other measurement whatsoever (crosstalk), or are worried about Common Mode.
- Test stands that test multiple devices with multiple power supplies- the different grounds ***require*** that isolated measurements are made otherwise the ground of the PC data acquisition system becomes the ground path for all the devices under test, causing ground loops, and erroneous measurements may result.
- Damage to the data acquisition system WILL result if the common mode (signal ground above earth ground) exceeds the data acquisition system specifications, typically just 10VDC.
- 5B or 7B modules insure isolation but are expensive. Typically $175 per channel for Analog and $225 per channel for Thermocouple- plus they need a backplane and they still need the A/D card plus a breakout ($500 and up)

The “other” way to do Analog Isolation



The example on the left would cost about $950 with the backplane
The one above $1,125
Plus you need to wire it to a breakout and an A/D card

Applications

Applications

QUESTION: I need to measure 8 Thermo-Couples on each window regulator motor and measure the feed voltage and current on each of the 4 motors, synchronized to the commanded LIN BUS data at each motor and OBD2 CAN data. How do I do that?

ANSWER: Using an ION, Connect the RAD-IO2-TC unit to USB Port 1 on the ION, and RAD-IO2-AIN to port 2. The data will be output to the NEOVI channels.

If you wanted to use the FIRE2 instead of ION you would need the CAN-HUB and connect to a CAN channel as the current required by both modules exceeds the capability of the USB port.

Applications

QUESTION: I need to measure 48 Thermo-Couples and 20 Analog Inputs throughout the vehicle and measure them along with CAN bus data. How do I do that?

ANSWER: That would be 6 TC units and 4 AIN units and at least 2 CAN-HUBS and connect to any CAN device. You cannot hook up this many channels directly to the FIRE2 or ION for 2 reasons. Current and cabling. Use CAN-HUB and hook up to a dedicated CAN channel on the CAN device, and the data will be available via CAN. Theoretically you could use to the vehicle CAN Bus but not a good idea as you may flood the bus or "stomp" on another modules ARB-ID's.

Anytime you require more than 4 or 5 modules use more than one CAN HUB as there is a 2 Amp limit, AND for easy placement/wiring in the vehicle. They are very cheap at $195 each and by distributing the devices in "pods", you will reduce the thermocouple and analog wiring.

SUMMARY

I. Cost: **INTRODUCTORY** PRICE OF $695/module except for relay module which is $595, CAN-HUB $195

II. Packaging: Rugged die-cast aluminum housing that is easily “user configurable” by sliding the units together and connecting the OUT to the IN.

III. How to get the data
- Use with PC and write your own code
- Connect directly to FIRE2, ION,
- Convert to CAN with CAN-HUB for use with ANY device from ANY manufacturer.

IV. Isolation: Each RAD-IO2 channel is isolated to 2.5 KVA; channel to channel and USB to channel.
- Isolation is a BIG DEAL
- No other input modules on the market provide isolation at this price, especially with rugged external packaging.
- High Common Mode Voltage and Multiple Ground Potentials are the big problems with accurate data collection. Channel to Channel Isolation solves that issue.