

Michigan Scientific Corporation

12-Channel Analog to CAN Module



Models: MUX-BC350-12
for Slip Ring & Non-spinning set-ups

Technical Support

For technical support, contact Michigan Scientific Corporation.

Details and specifications provided in this document are purely for informational purposes and are subject to alterations. No liability is accepted for errors or omissions.

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Introduction

Overview of the MUX System

Michigan Scientific's 12-Channel Analog to CAN Modules are designed for high-channel-count measurement applications. These MUX modules combine multiple sensor inputs into a single high-speed digital output, streamlining data acquisition for complex test environments. Each of the six radial connectors can mate with two sensor inputs. MUX modules are software configurable allowing for independent channel configuration. MUX devices can be connected for applications requiring higher channel counts. Up to 4 devices can be connected to provide 48 channels of synchronously sampled data. Additionally, the configuration software allows for real-time data viewing and recording to a PC.

Each module provides sensor excitation, amplification, and digitization of the signals. The digitized data is output to a controller area network (CAN) bus. The MUX uses four input/output connections: two for input power, and two for output data. The output data is software configured by the user for either CAN 2.0 or CAN FD format. The CAN data bus is also used for configuring the device. Once configured, the software can be used to generate the corresponding database file (DBC) for use with data recorders.

The MUX device has twelve independent amplifiers that measure sensors. The MUX is designed to have low cross talk between channels and to be insensitive to temperature change. Each MUX has internal shunt resistors. A shunt calibration can be initiated at power-up or initiated by user with the MUX configuration software. Each MUX device contains non-volatile memory for storing user configuration settings. The memory contains all the calibration information, last Zero off-set values, and test set-up selections.

The MUX is designed for use in spinning and non-spinning applications. For spinning applications, the MUX is designed to be used with Michigan Scientific slip rings. Its compact size and rugged design allow it to be installed on rotating transducers in harsh environments.

Included Items

- MUX module for 350 ohm Quarter Arm Strain Gauge Sensors
- Mating cable assembly for input power and CAN data connections
- USB-to-CAN FD hardware adapter
- MUX Tool software version 1.0.7 for Windows
- Manual in PDF format

Model Variant

MUX-BC350-12 (Quarter-Arm Strain Measurement Module)

- Designed for quarter-arm strain-gauge–based transducers.
- Provides 4.5 V excitation per channel.
- Includes internal shunt resistors for calibration (100 k Ω with emulated values up to 10 M Ω).
- Performs strain-gauge–specific offset and shunt verification.
- Input range: ± 36 mV.

Properties and Requirements

Properties at a Glance

In General

- 12-channel analog inputs to single digital output
- Modular design allows stacking 4 units for 48-channels
- Stacked units synchronize with each other to sample 48-channels
- Integrated shunt calibration resistors
- Software-configure each channel independently
- Output data up to 8ksps (CAN-FD) / 2ksps (CAN 2.0)
- Pair with Michigan Scientific slip ring for spinning applications
- Use with absolute quadrature encoders to output position and speed
- Compact design for non-spinning and spinning applications
- Rugged design for use in harsh environments
- Galvanic isolation (analog inputs-to-power input...analog inputs-to-data out)

Quarter-Arm Strain Measurement Module, MUX-BC350-12

- Used with 350 ohm strain gauge based transducers
- Integrated shunt resistors for sensor verification
- Sensor excitation (4.5V) provided for each sensor

Specifications

Quarter-Arm Strain Model Specifications

Model: MUX-BC350-12
12-Channel Analog to CAN Module

Measurement Inputs	
Type of Bridge and Connection	Quarter-arm, 3-wire
Input voltage range	+/-36mV
Dynamic range	32:1 (62x-1984x)
Bridge Balancing	Software, up to input voltage range
Input impedance	> 10 Meg ohm
Time synchronization (max chan.-to-chan. skew)	5.5us
Data out rate (max per channel)	8000 sps
Data out resolution	16-bit
Hardware input filter	Low-pass, single-pole, approx. 5kHz
Software input filter	Low-pass, FIR type, 40 to 1600Hz, selectable
Frequency Response	
Bandwidth to -0.1dB	500 Hz (@ 4ksps or 8ksps output rate)
Bandwidth to -3dB	1.6kHz (@ 4ksps or 8ksps output rate)
Measurement Deviation	
Offset (@ 25degC), referred to input, max	50uV
Offset drift, referred to input, max	0.5uV per degC
Gain error (@ 25degC), max	0.2%
Gain drift error, max	0.004% per degC
Noise	
0.1-10 Hz, referred to input	typ 50nV rms
Density, referred to input	~ 12nV rms per sqrt(Hz)
Excitation	
Bridge Excitation Volts	4.5Vdc (ratiometric)
Amps (max per channel)	13mA
Integrated Bridge Completion	
Completion resistance	350 ohm

Completion resistor accuracy	0.01%, 2ppm/degC
Integrated Shunt Verification	Positive and Negative shunt verification
Shunt resistance	100k ohm (up to 10Meg ohm, emulated)
Shunt resistor accuracy	0.075% 15ppm
CAN Interface	CAN 2.0 or CAN FD
Max Output Rate (with CAN FD, 4Mbps)	8ksps (12 channels)
Max Output rate (with CAN 2.0)	2ksps (12 channels)
CAN bitrate, fixed	1Mbps
CAN FD bitrate, selectable	2 or 4Mbps
Termination, fixed internal	2k ohm
Galvanic Isolation	(No safety isolation for high voltage applications)
Channel to CAN, Channel to Power	200V
Power Requirements	
Minimum volts	10 Vdc
Maximum volts	20 Vdc
Power Consumption (@12Vdc, with 12 bridges)	approx. 2W typ.
LED indicators	
Single green	power / status / synchronization
Housing	
Diameter	D=86mm (3.375 inch)
Height	H=25.4mm (1 inch)
Mass	approx. 300 grams
Protection class (w/ stacking connectors)	IP67
Connectors	
Metric circular M8	6-pin, receptacle with sockets, code A
Interface Power/Data Cable Requirements	
Length, max	15m (approx. 50 ft)
Impedance	100 or 120 ohm
Conductor	26 AWG min
Operating Temperature range	-40 to 85 degC (-40deg to 185degF)

Slip Ring Encoder Specifications

Model: SR10AW/WFT

10-slip ring with integrated absolute quadrature encoder

Encoder	
Accuracy (max cumulative error)	0.25 deg
Angular resolution	1024 ppr (4096 cpr)
Output type	0 to 5V TTL
Maximum Speed	2000 rpm
Power Requirements	
Minimum input volts	5 Vdc
Maximum input volts	20 Vdc
Current amps	60m Adc
Housing	
Diameter, base	D=54.6mm (2.15 inch)
Height	H=89.4mm (3.52 inch)
Mass	approx. 410 grams
Protection class (w/ stacking connectors)	IP67
Connectors	
Circular, 10-pin, male	Amphenol 38999-20TC98PN
Operating Temperature range	-40 to 100 degC (-40deg to 212degF)

System Components

Product Designation and Model Part Number

Product Designation	Model Part No.
MUX for Quarter-Arm Strain based Sensors	MUX-BC350-12
MUX Interface Power/Data Cable Assembly, 3m	MUX-IPDC-3
USB-to-CAN FD adapter	IPEH-004022
CAN Termination Plug	GC-CAN-TERM-GC
Slip ring adapter	MUX-ENC-ADA
Slip ring with integrated encoder	SR10AW/WFT
Transducer (direct) interface cable, 1.5m	Phoenix 1522299
MUX Configuration Software	1.0.7

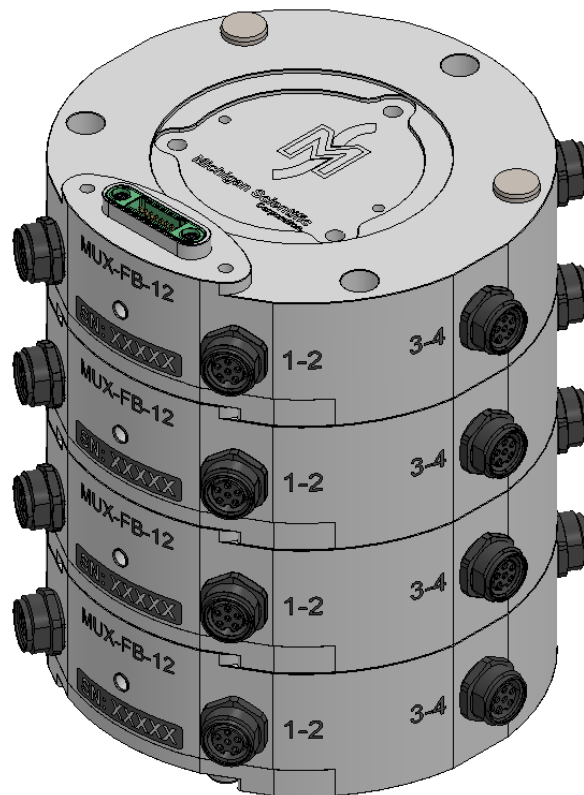
MUX Module



Figure 1: MUX device (ISO view).

Each MUX has 12 independently configured channels. The 12 channels are divided into six 6-pin connectors: two channels per connector. Additionally, each device has a single connector to interface with power, data and MUX-to-MUX synchronization.

MUX Module Stack



MUX modules are designed to be stacked together for higher channel count applications. Up to 4 MUX modules can be stacked together for 48 channels. Use a 2mm wrench to remove the bottom cover to expose the connector which mates to another module below it.

Figure 2: MUX bottom view showing connector cover removal.



Input Channel Cable Assemblies



Figure 3: Input Channel Cables. Example cable assembly, Phoenix Contact 1522299.

Input channel cable connects from the transducer to the MUX. The standard cable length is 1.5m (4.92ft). Cable lengths up to 10m (32.81ft) are available.

The MUX has six input connectors for 12 transducer channels: 2 channels per connector. Input channel splitter cable assemblies are an optional accessory used to breakout the 2 channels to individual connectors.

Channel Splitter Cable Assembly



Figure 4: Channel splitter (1-to-2) cable assembly for MUX.

The channel splitter cable assembly is an optional accessory used to breakout the MUX 2 channel connections to 2 individual connectors. Splitter lengths are typically 1m (3.28ft). The channel splitter cable assembly includes circular metric M8 connectors on each end. The M8 connector pinouts vary per MUX module model.

Interface Cable



Figure 5: MUX Interface cable for power and data.

Interface Cable connects the MUX to the Slip ring. The power connections are flyleads. The data connections are provided using two 9-pin DSUB female connectors: one DSUB connector per CAN bus. When multiple MUX modules are stacked together, the CAN data from each module can either be transmitted on its own individual bus or combined together. When used with a slip ring encoder, up to 4 stacked modules can transmit data across either one or two data busses. Standard interface cable length is 5m. Cable lengths up to 10m are available.

USB to CAN converter tool



USB to CAN converter tool. The MUX device is software configurable using its multiplexed CAN data bus. Detailed configuration instructions start on page - 23 -. Software to configure each MUX device, view data in real-time and record to PC is included with each MUX device.

Inline CAN bus terminator



Figure 6: CAN bus termination inline plug.

Inline CAN bus terminator used to terminate the end of a CAN bus. Users should verify whether their data recorder or logger has termination integrated already.

~ Do NOT use this item if the data acquisition already includes termination. ~

Slip ring with Integrated Encoder (SR10AW/WFT)



Figure 7: Slip ring with integrated encoder (Model SR10AW/WFT).

For spinning applications, a slip ring is often used to transfer power and data signals to the data recorder. Optionally, some slip rings include an integrated encoder to output position and velocity information. Michigan Scientific offers slip rings with integrated encoders for use with the MUX modules. The slip ring model SR10AW/WFT is suggested for use with the MUX modules in spinning applications.

MUX to Slip ring Adapter (MUX-ENC-ADA)



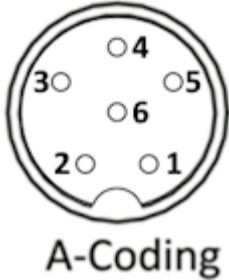
Figure 8: MUX to SR10AW/WFT Slip ring Adapter

An adapter layer is required to connect the MUX to slip ring (model SR10AW/WFT).

Connectors

The MUX has 6 input connectors for sensors, and a single connector for input power and CAN data.

Sensor: Quarter-Arm Strain Type

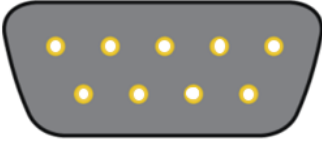
Pin	MUX Connector (M8 size, 6-pin, sockets)	Function	Mating Cable Wire Color (Phoenix 1404137)
1	 A-Coding	CH1, Signal -	Brown
2		CH1, Excitation +	White
6		CH1, Sense -	Pink
3		CH2, Signal -	Blue
4		CH2, Excitation +	Black
5		CH2, Sense -	Gray

Interface Power/Data Cable Assembly

Power

Function	Wire Color	Optional Connector (Anderson SB-50)
Power -	Black	-
Power +	Red	+

Data

Pin	Function	Data Connector (DSUB, 9-pin, sockets)
		5 4 3 2 1
2	CAN Low	
3	CAN Ground	
7	CAN High	
		9 8 7 6

Basic Hardware Connections

Applying Power

To begin using the MUX, apply 10 to 20 VDC (min 0.25A DC per MUX) to the MUX power lead wires. The configuration of the MUX device is done using the USB-to-CAN converter with MUX Software tool.

Connecting CAN Data

Connect the MUX Interface Power/Data Cable Assembly data connector to USB-to-CAN converter and inline CAN termination plug. Configure the MUX device using instructions found in the section named [Software Configuration Instructions](#) starting on page - 23 -.

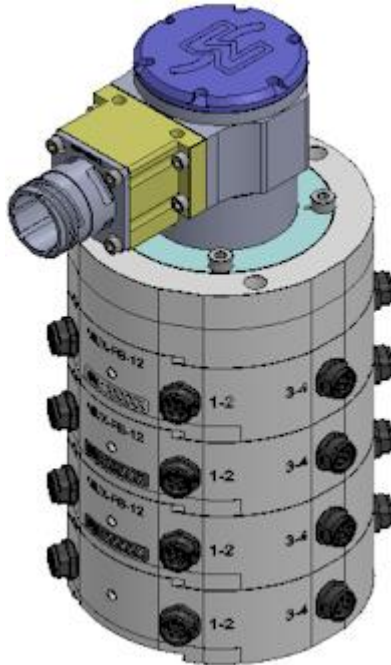
Inline Termination

Connect the USB to CAN converter tool to the Interface cables 9-pin DSUB connector. The converter tool does not typically include integrated bus termination. An inline CAN bus terminator can be used to terminate the end of a CAN bus. Users should verify whether their data recorder or logger has this integrated already.

Ensure the USB to CAN converter hardware drivers¹ are installed and verify the device is functioning properly.

¹ USB-to-CAN hardware drivers are available from the manufacturer, PEAK System, <https://www.peak-system.com/>

Multiple MUX devices stacked



Each MUX is used with up to 12 full bridge strain sensors. When using multiple MUX devices, the MUX is designed to be stacked. The housing has a magnetic feature designed to guide the devices into alignment. Once stacked, secure with hardware. Electrical connections between the MUX devices are made with connectors.

When multiple MUX modules are stacked, they will communicate with each other through the stacking connectors. When modules share a single data bus, the operator can software select and configure each module individually.

Power Requirements

The MUX requires 10 to 20 VDC power. The approximate power required is near 2 watts for each device when sensors are attached.

One power cable will power a stack of MUX devices (up to 4).

Operation & Device Modes

MUX devices operates in 5 different modes:

1. Listening
2. Streaming_ack_required
3. Streaming_listen_only
4. Config_mode
5. Bootloader

Listening Mode (Initial Power-On Behavior)

At power ON, the MUX device is in Listening mode. By default, the device will remain in listening mode for 20 seconds without any user interaction. In listening mode, the MUX device sends a health status once per second using CAN 2.0 messages. After 20 seconds, the device automatically changes state to streaming mode. During Listening mode, the user may enter configuration mode by pressing the Read Config button.

Streaming Mode

In streaming mode, the device is outputting sensor data at the rate configured. With Single MUX Listen Only Streaming Disabled (acknowledgement enabled), the device is in Streaming_ack required mode. With Single MUX Listen Only Streaming Enabled, the device enters Streaming_listen_only mode.

Config Mode

Configuration mode is used to setup the sensors and the device. With acknowledge enabled, at any time, the user may enter configuration mode by pressing the Read Config button. When listen only mode is enabled, configuration mode can only be entered within the first 20 seconds of power ON. If the device is in Streaming_listen_only mode, power cycle the MUX device to be able to enter configuration mode within 20 seconds of Power ON.

Bootloader Mode

Bootloader mode is entered briefly at start-up of normal operation, as well as used for device recovery and firmware update operations.

Software Configuration Instructions

MUX devices are configured through their CAN interface, using a USB-to-CAN converter and the Michigan Scientific MUX Software Tool.

Software required

For configuration and firmware update (both via CAN):

- Windows 11
- Michigan Scientific MUX Software Tool (version 1.0.7, or later)
 - Contact Michigan Scientific for the latest version.
- USB-to-CAN converter drivers (Ensure the drivers² are installed and verify the device is functioning properly.)

NOTE: MUX devices are configured with CAN 2.0. Therefore, all PC-CAN interfaces from PEAK-System will work for configuration purposes. A PC-CAN FD device is only required to **view and record** data of devices that are configured for streaming data using CAN FD. ‘

MUX Software Setup

After ensuring the MUX has power, open the MSC MUX Tool software to configure a MUX device. If another software tool was used to verify communication, close the other software to free the connection.

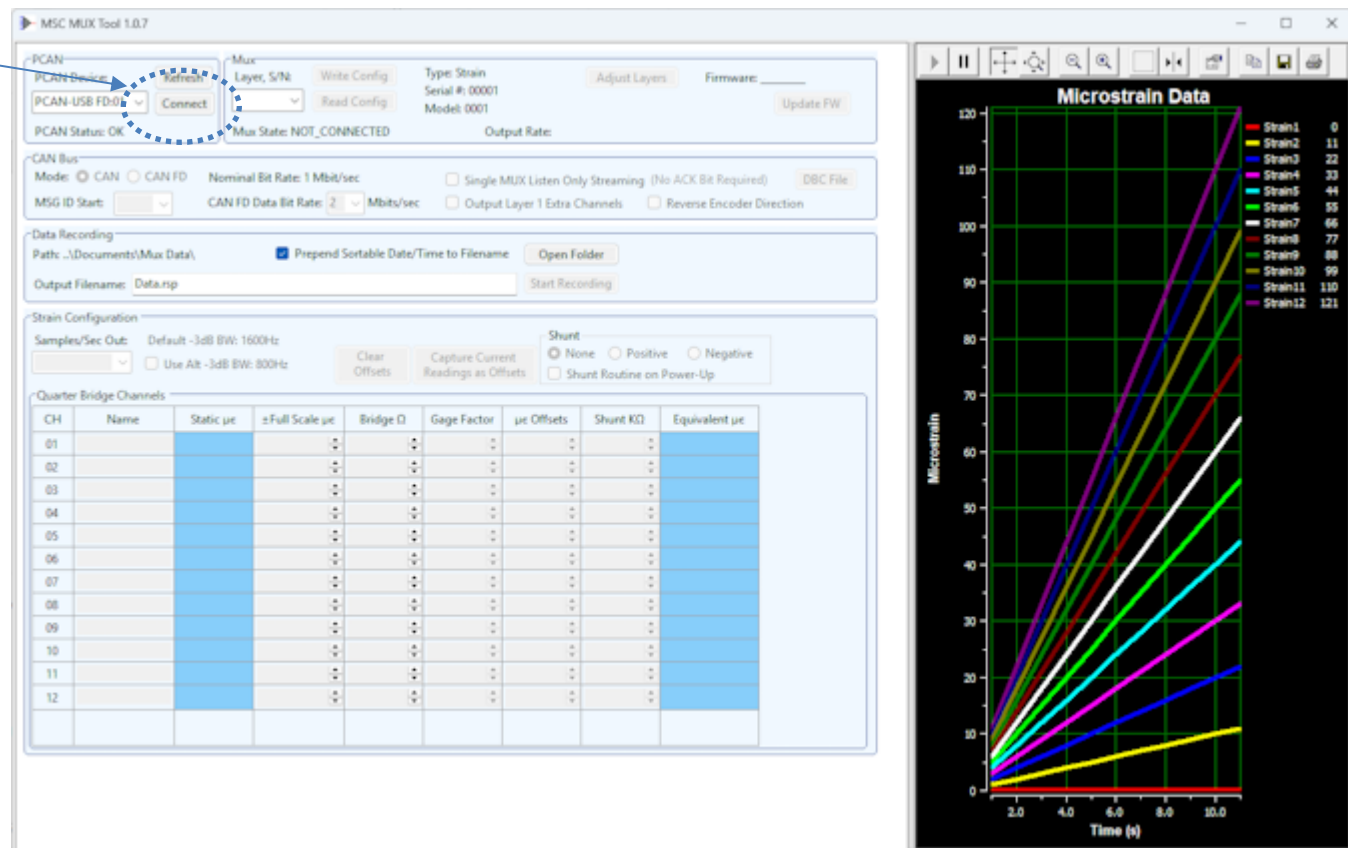
² USB-to-CAN hardware drivers are available from the manufacturer, PEAK System, <https://www.peak-system.com/>

Quarter-Arm Strain Model Setup (e.g. 350 ohm resistive strain gauge sensors)

This section will describe how to configure a MUX quarter-arm strain measurement model. This model is often used for interfacing with 350 ohm resistive strain based sensors. A MUX quarter-arm strain measurement model outputs a precision regulated 4.5VDC for sensor excitation.

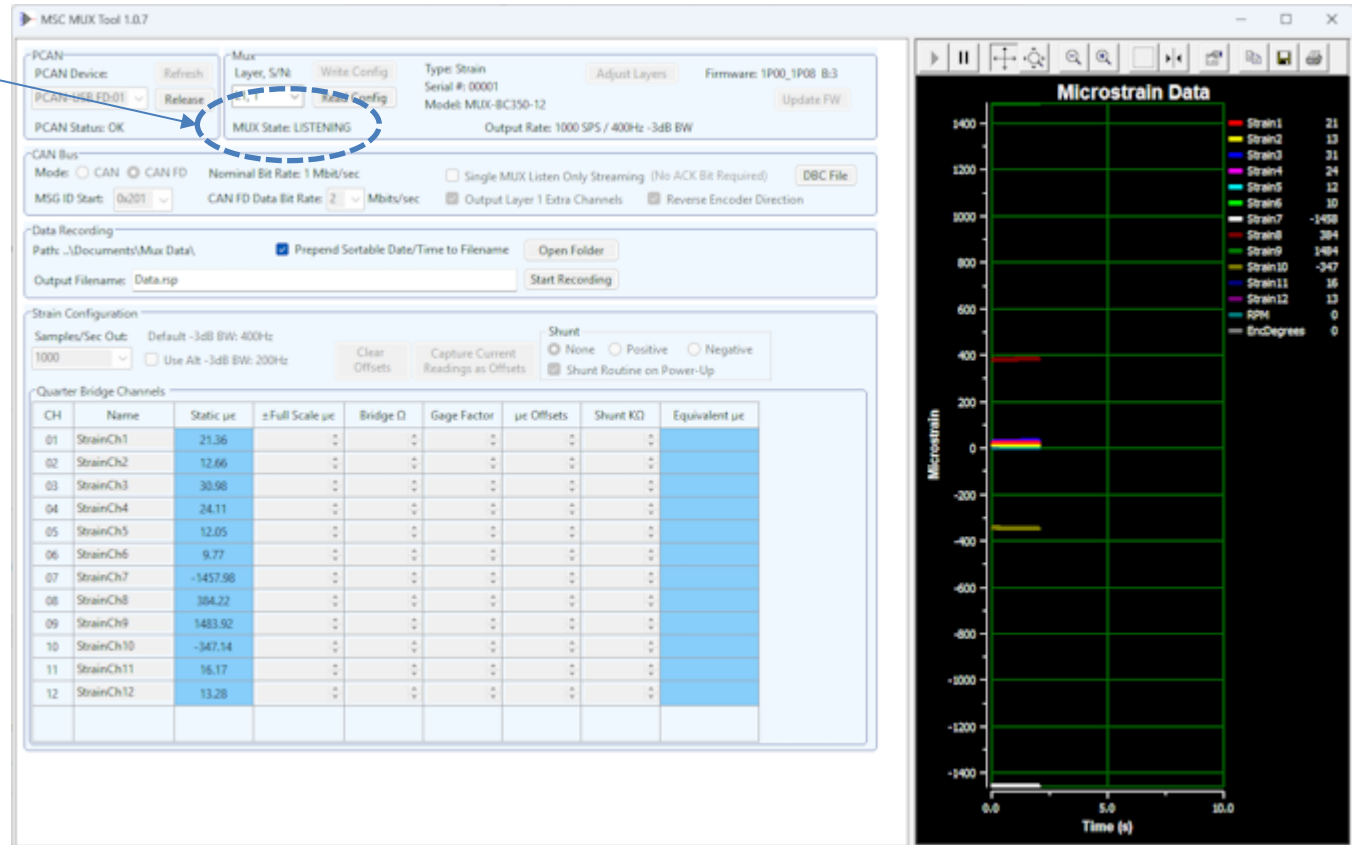
USB-to-CAN and MUX Information, Quarter-Arm Strain

Once software opens, press
“Connect” button.



Observe

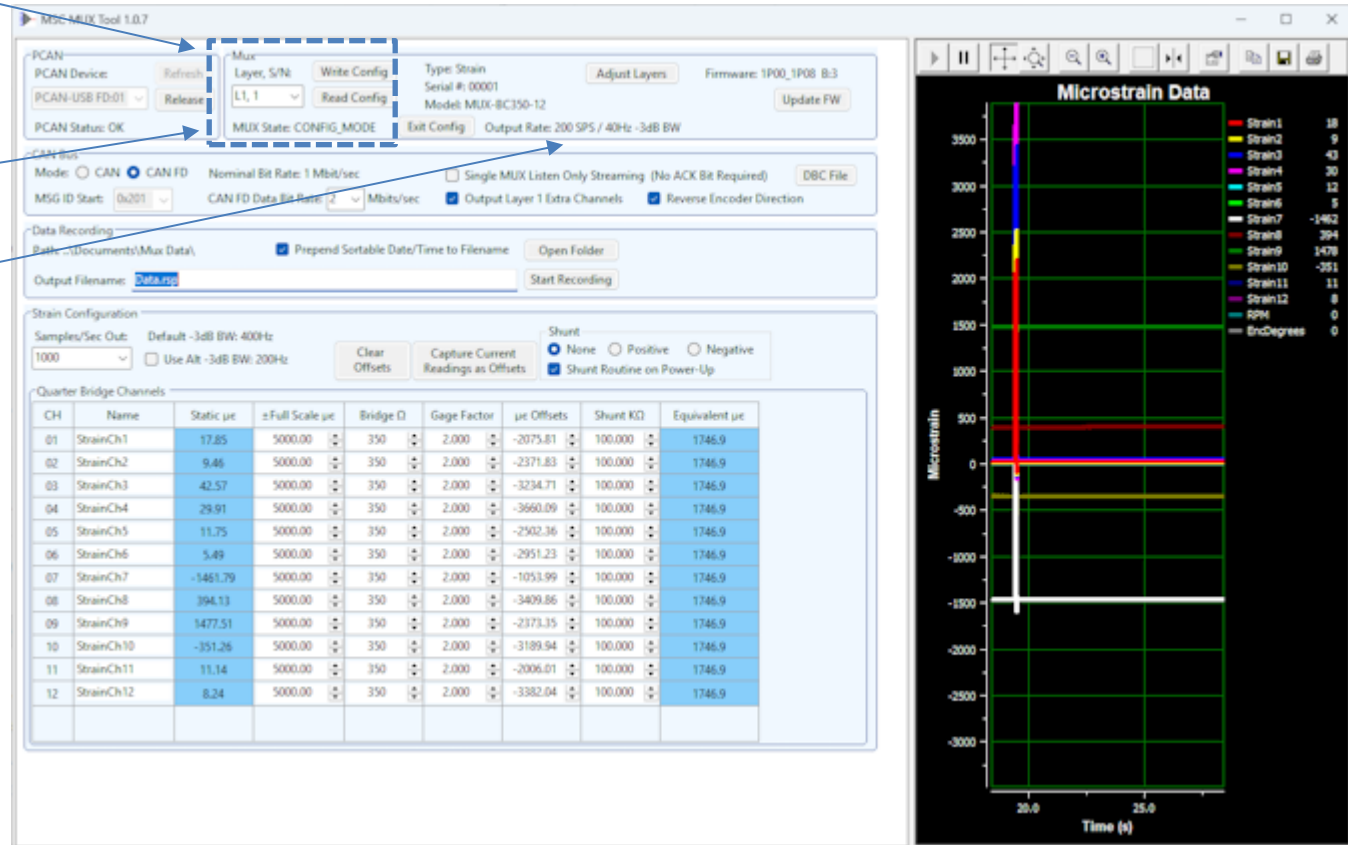
[1] MUX state changes to Listening, for 30 seconds from power ON, and then changes to a streaming mode



[1] Press “Read Config” button to view and edit device settings.

[2] Observe MUX state changes from LISTENING or STREAMING to CONFIG_MODE. Note, the data output sample rate is fixed at 200SPS while in config mode.

[3] Wait for data to refresh the screen.

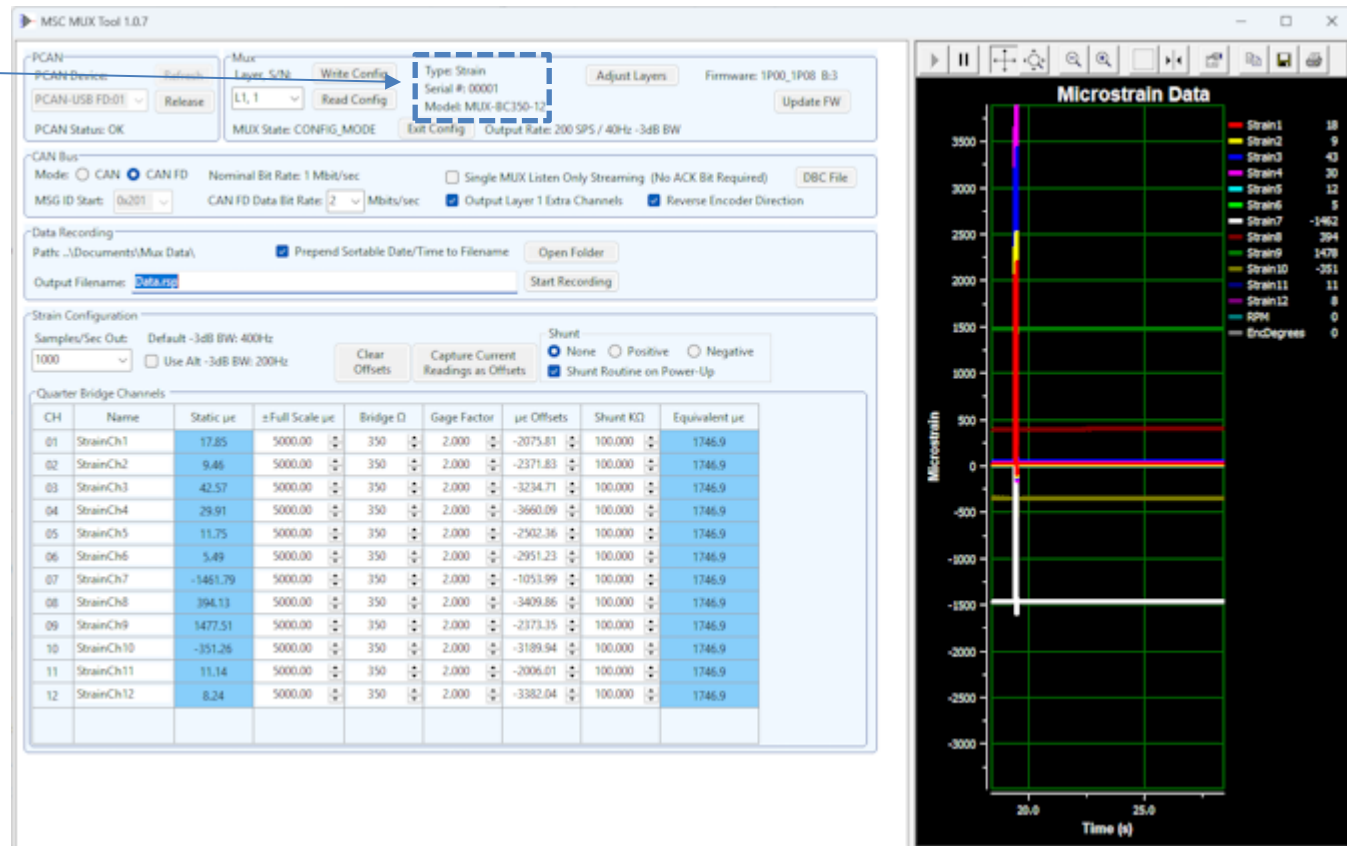


The MUX device model and serial numbers are displayed in top-middle of screen:

Select the particular MUX device to edit.

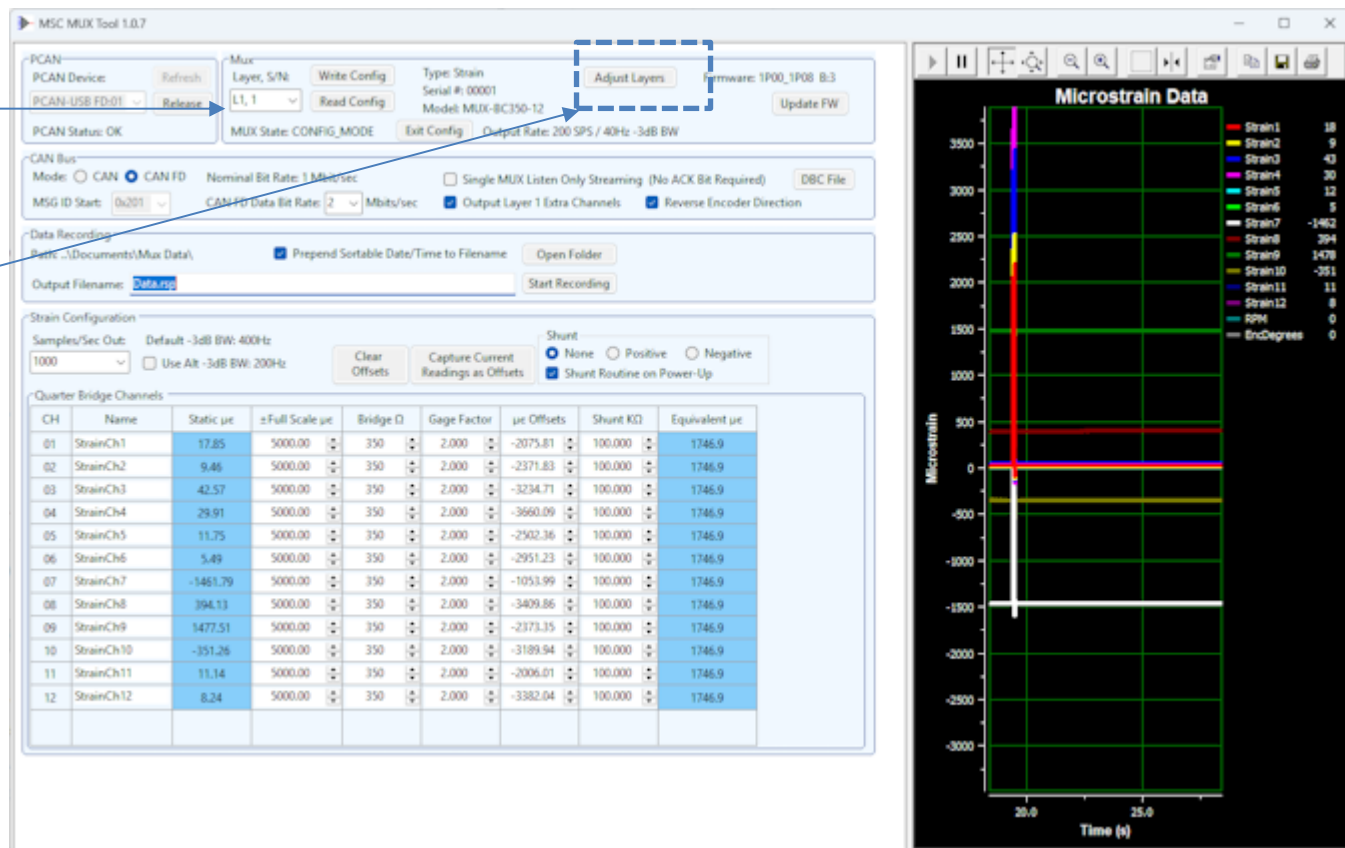
Once the MUX serial number (S/N) is selected, wait for data to refresh.

Note, each MUX device within a stack must be assigned a unique layer number. If not, CAN data message errors will result.



When multiple MUX devices are stacked together, they must be assigned a unique layer number.

To assign unique layer numbers for each device in a stack, select the 'Adjust Layers' button.



Pressing the 'Assign Layers' button opens a new window for the user to select numbers.

Assign a unique layer number, 1 to 4, and then press the 'Update' button.

Alternately, press the 'Auto Select' button to have the layer numbers assigned automatically.

MUX SN	MUX Layer
4	☐ Layer1 ☒ Layer2 ☐ Layer3 ☐ Layer4

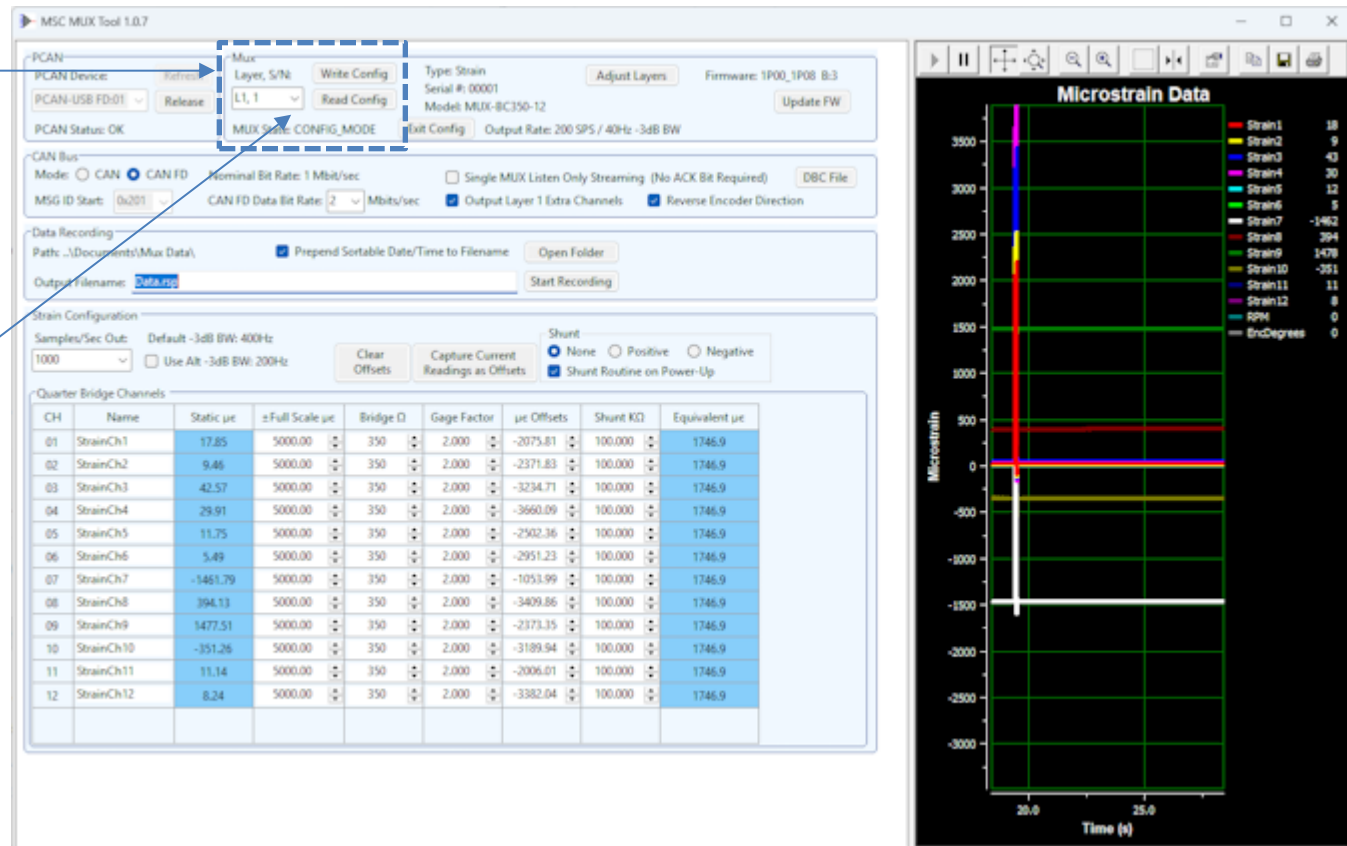
One MUX must always be set as a Layer 1 Sync Leader
Layers 2-4 are Sync Followers

Cancel Auto Select Update

After Updating the Layer numbers, press the 'Write Config' button to store the settings into the MUX device memory.

Next, select the MUX device to configure from the drop-down menu. This menu shows the layer number, and serial number.

Press the 'Write Config' button to store the new settings in the MUX device memory.



CAN Bus Configuration, Quarter-Arm Strain

Configure the CAN Bus baud rate for the selected device.

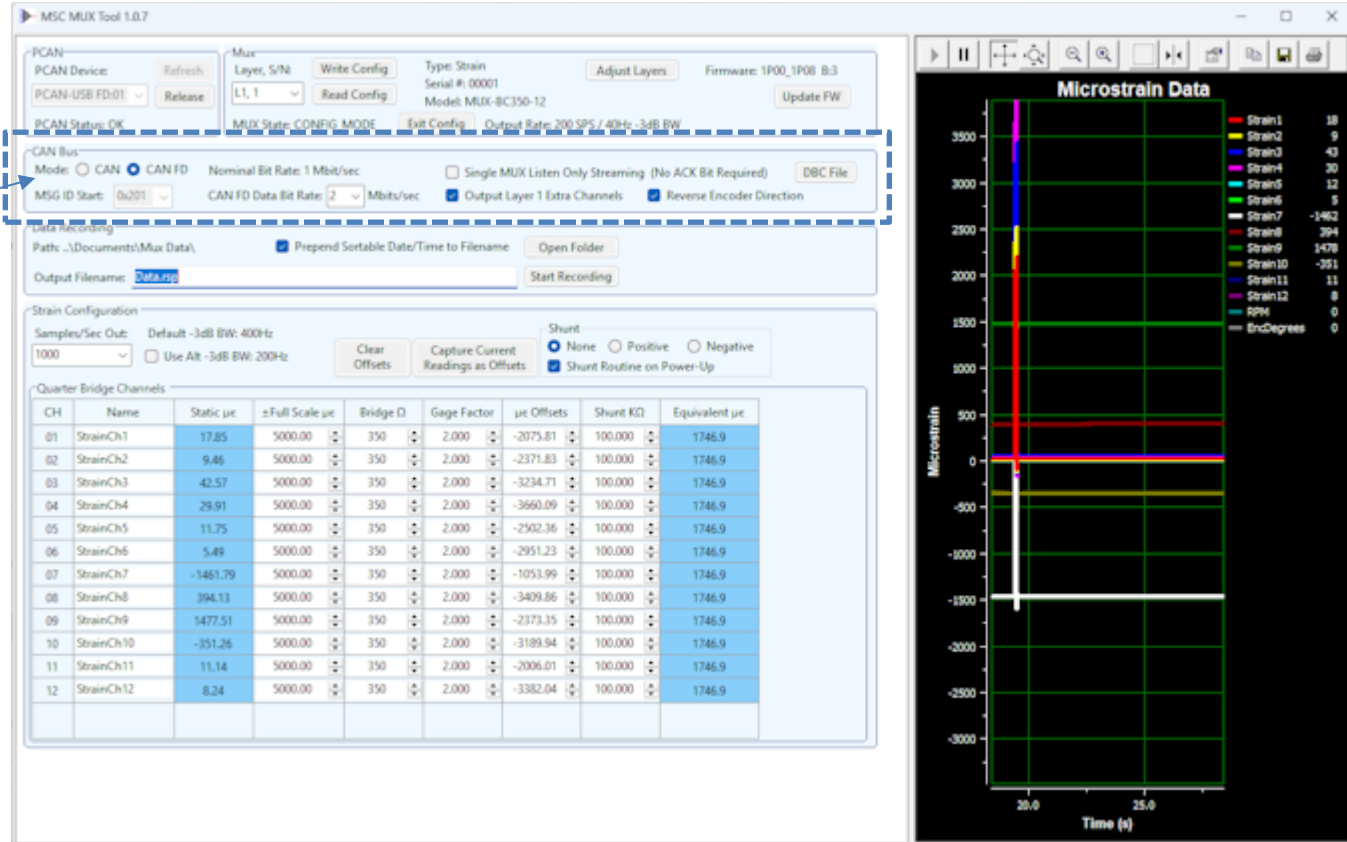
[1] Choose radio button for either CAN 2.0 or CAN FD mode:

CAN 2.0 defaults to 1Mbps.

CAN FD provides options for either 2 or 4Mbps.

Note: all MUX modules on a shared bus must be configured to operate in the same mode. When in the same mode, modules on a shared bus can output data at different sample rates.

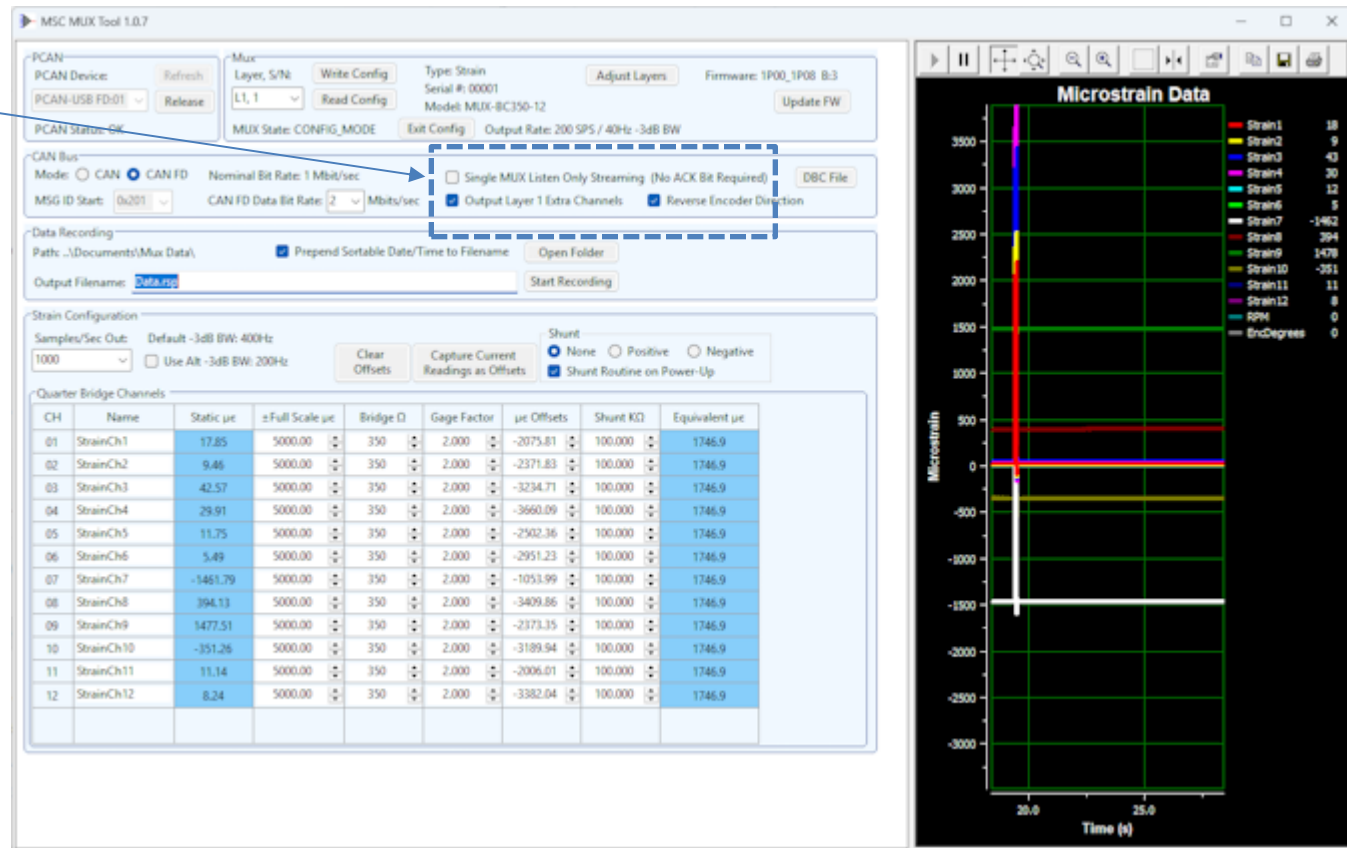
Press the 'Write Config' button to store the new settings in the MUX device memory.



[1] With multiple devices stacked on a shared bus, ensure 'Single MUX Listen Only Streaming' is NOT checked. This is required for arbitration of devices on the bus.

With a single device operating at a higher sample rate, the data may arrive at the DAQ more consistently in time when using listen only mode. In this case, checking the box named 'Single MUX Listen Only Streaming' will ignore any bus errors and limit retry transmission attempts.

Press the 'Write Config' button to store the new settings in the MUX device memory.



Extra Channels: Encoder and Temperatures, Quarter-Arm Strain

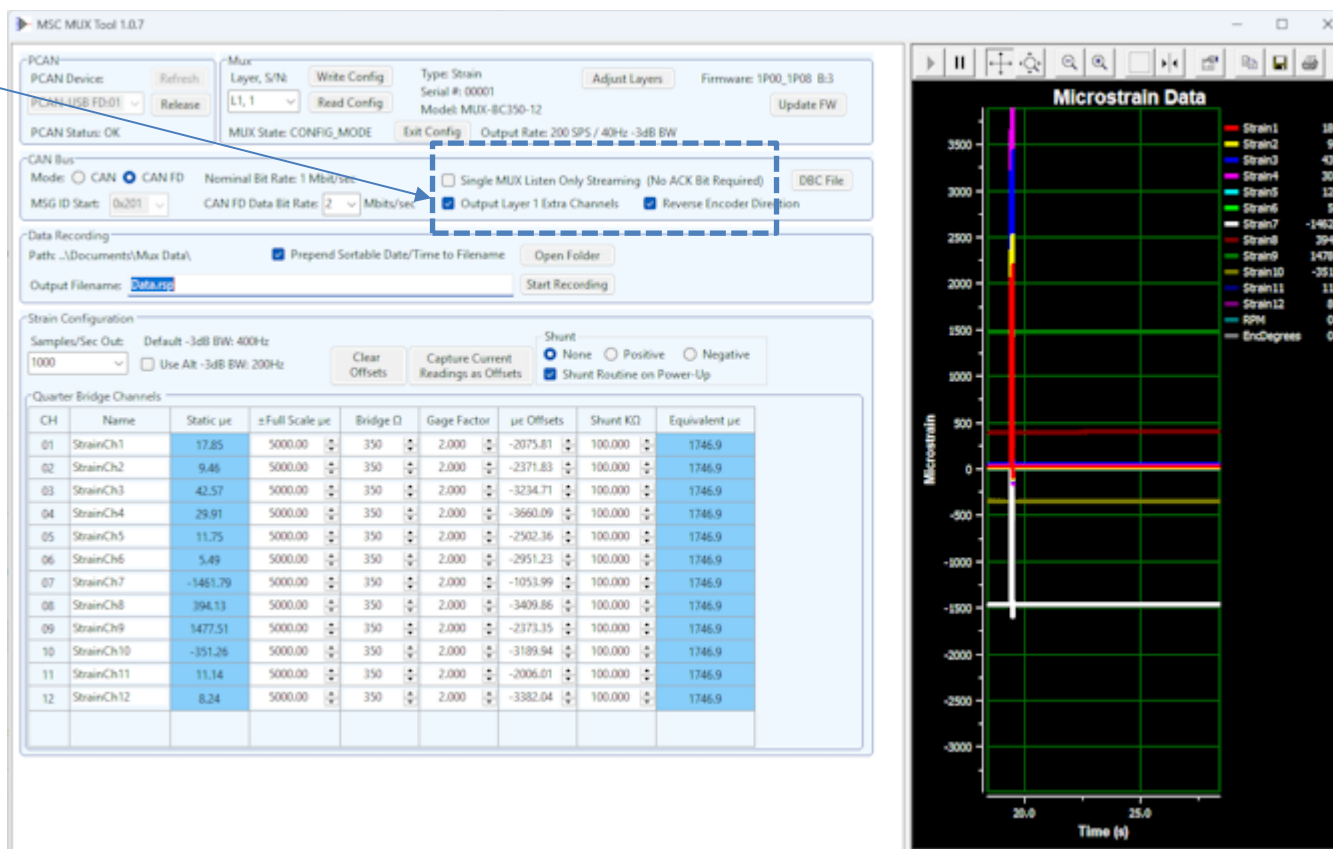
Check the box for 'Output Layer 1 Extra Channels' for devices which include a slip ring with encoder.

Enabling this option will output the encoders velocity and position data.

Check the box named 'Reverse Encoder Direction' as necessary. See Appendix for direction polarity information.

Additionally, enabling this option will output the devices two internal temperature sensors data in degC.

Press the 'Write Config' button to store the new settings in the MUX device memory.



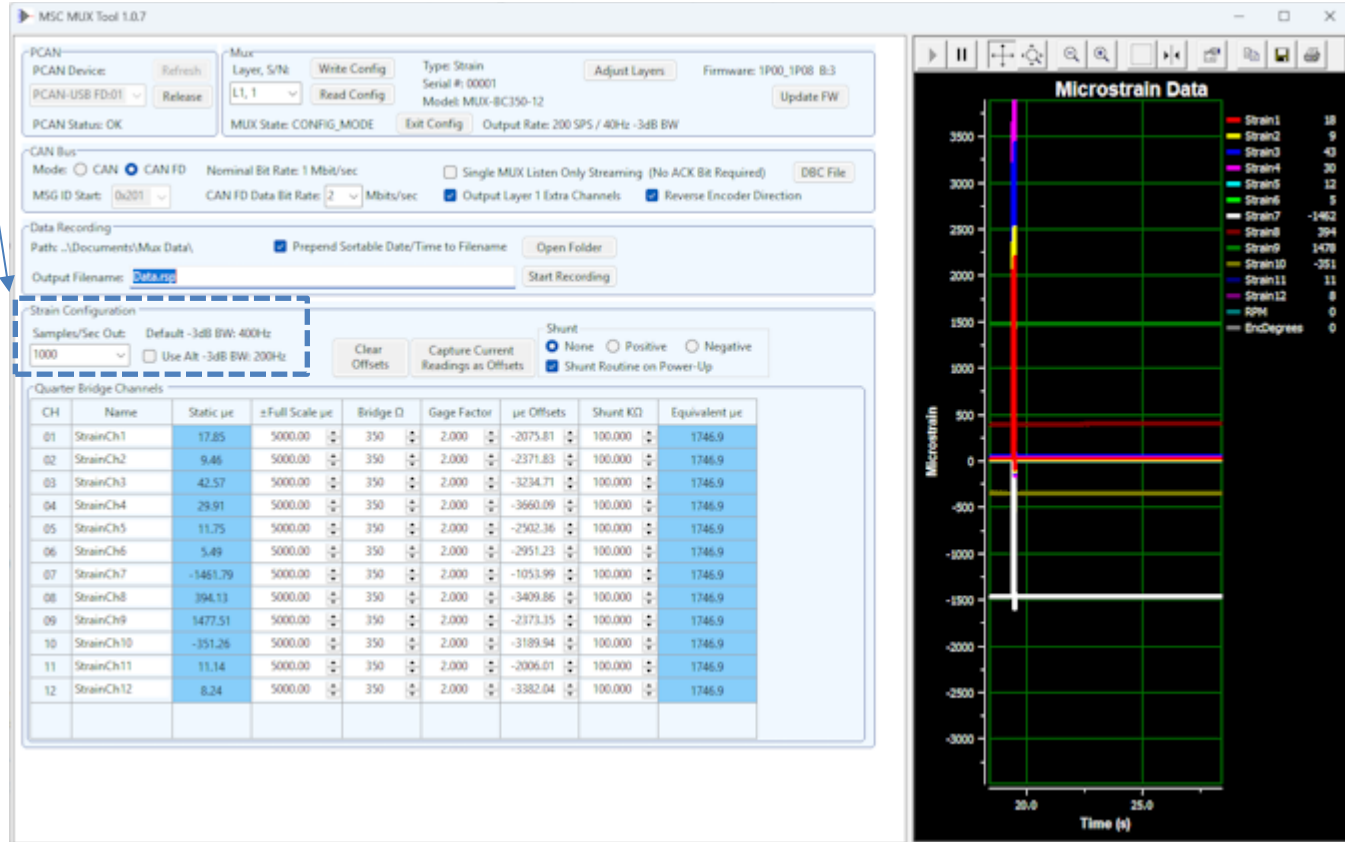
Sample Rate, Quarter-Arm Strain

Configure the Sample rate using the drop-down menu.

See data sample rate limitations shown in table Figure 10.

Check the box 'Use Alt -3dB BW' to enable a more aggressive low pass filter. The bandwidth is shown for the selected sample rate.

Press the 'Write Config' button to store the new settings in the MUX device memory.



Channel Info and Setup, Quarter-Arm Strain

Configure the Channel input info:

- [1] Name
- [2] Full Scale (magnitude)
- [3] Bridge resistance (ohms)
- [4] Gage Factor

Click the Name field and type a new value. The new value will be highlighted yellow to notify the user that the value has changed but not stored into the MUX memory.

Repeat this for the Full Scale, bridge resistance, and gage factor fields.

To write the new value(s) into the MUX memory, press the “Write Config” button.

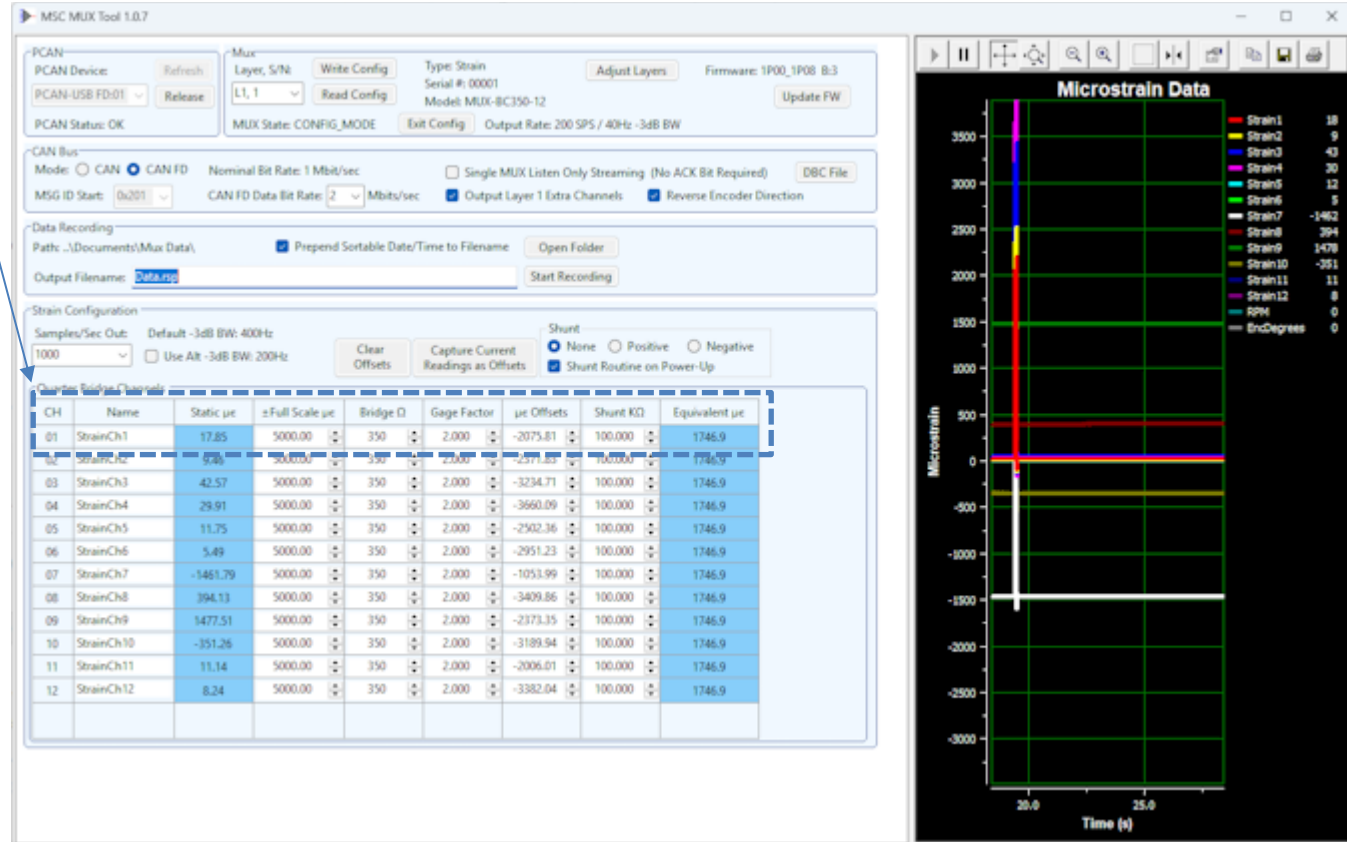
Example shown, channel 1 updated:

Name = StrainCh1

Full scale = 5000

Bridge ohms = 350

Gage factor =2.000



Channel Zero balance, Quarter-Arm Strain

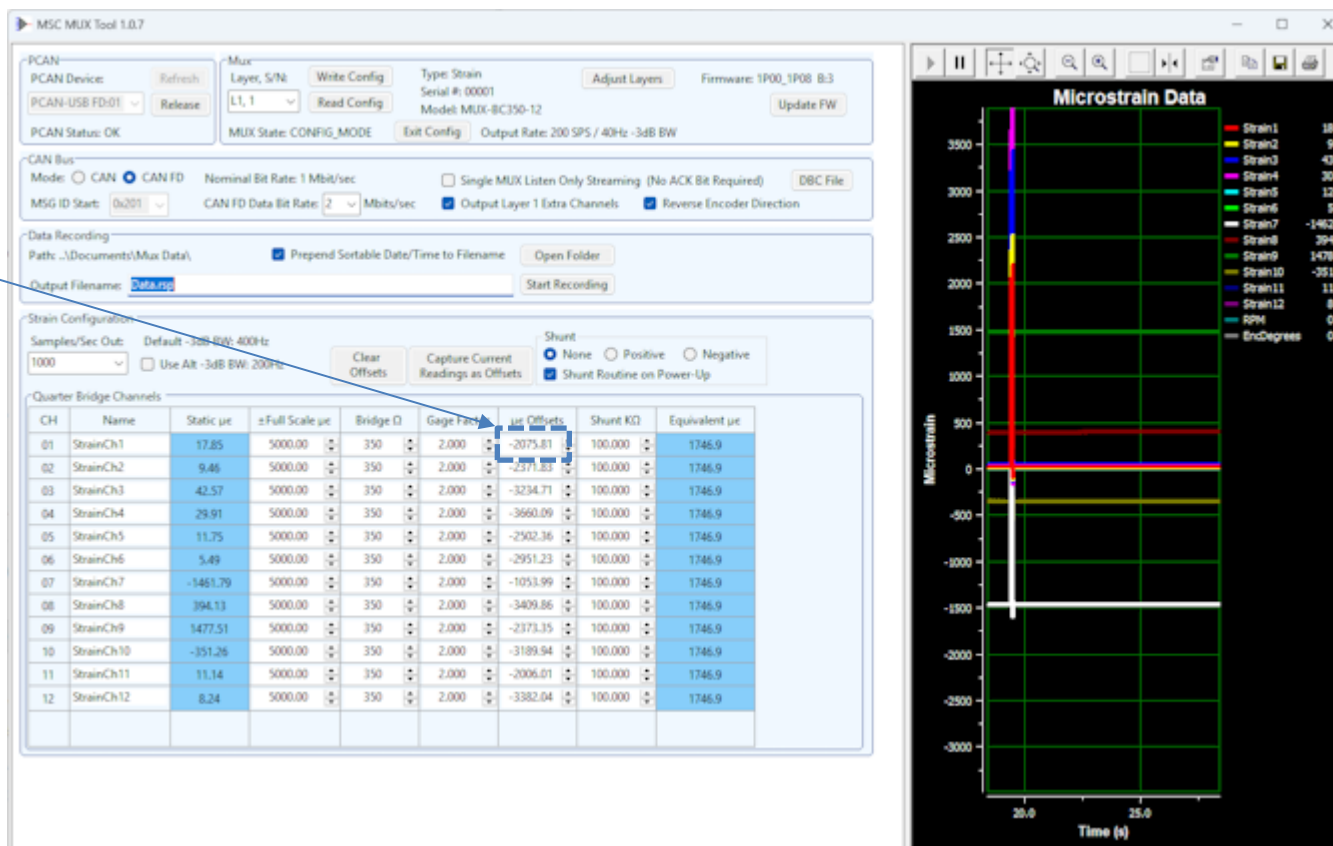
Place the sensor in balanced condition to null out any offset.

Once positioned, right-click on the specific channel field in the column named “ue offset”.

A pop-up dialogue appears.

Left-click on pop-up window to capture the current reading and use as offset. Offsets may also be entered manually.

Press “Write Config” to store the captured offset value into MUX memory.

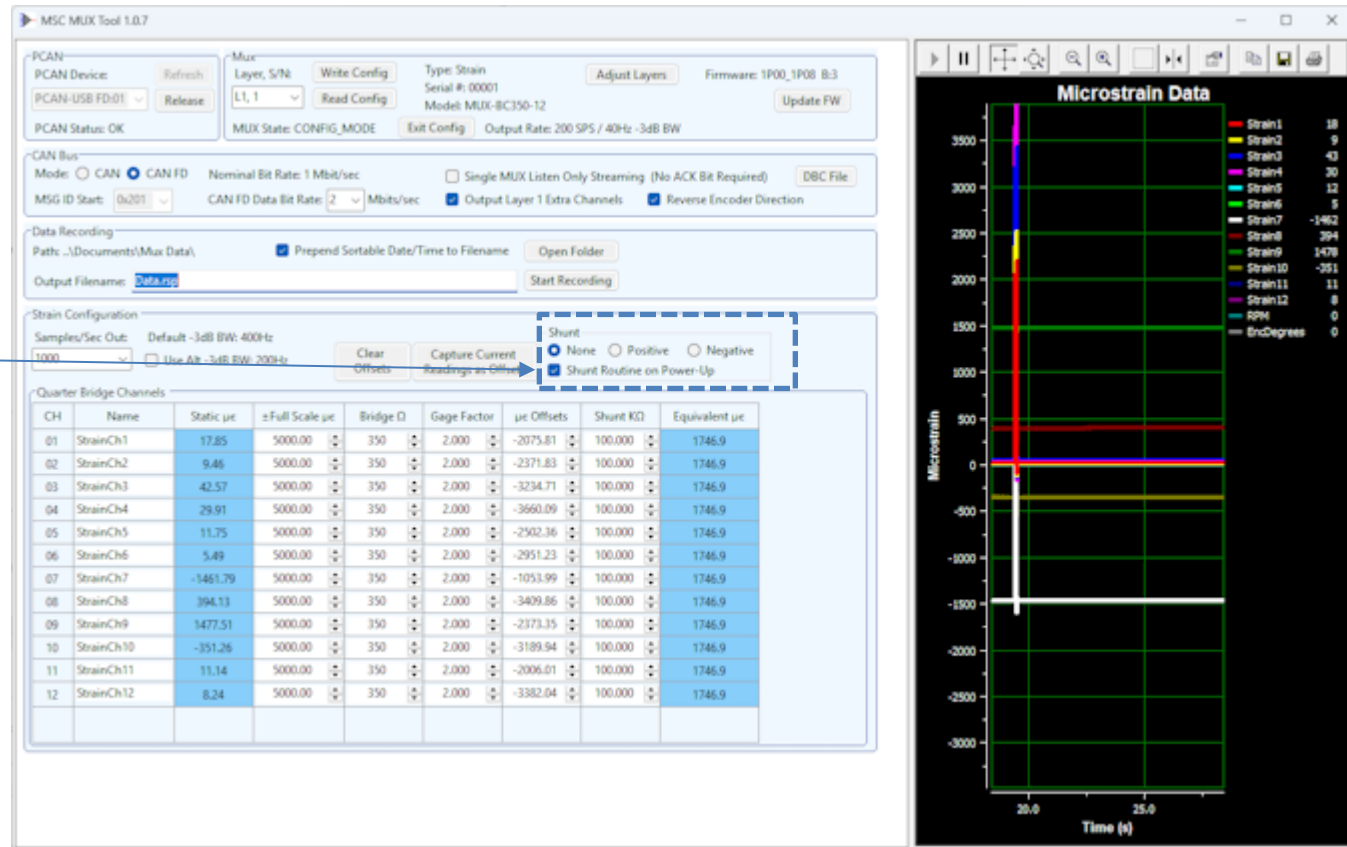


Channel Shunt Verification, Quarter-Arm Strain

The MUX has internal shunt resistors for sensor verification.

In CONFIG_MODE, a shunt routine can be performed manually by pressing the corresponding radio button for either a positive or negative shunt respectively.

Additionally, a shunt routine can be performed every time the module powers ON. To enable this feature, check the corresponding box and then press button WriteConfig to retain this setting change.



Data Streaming and Recording, Quarter-Arm Strain

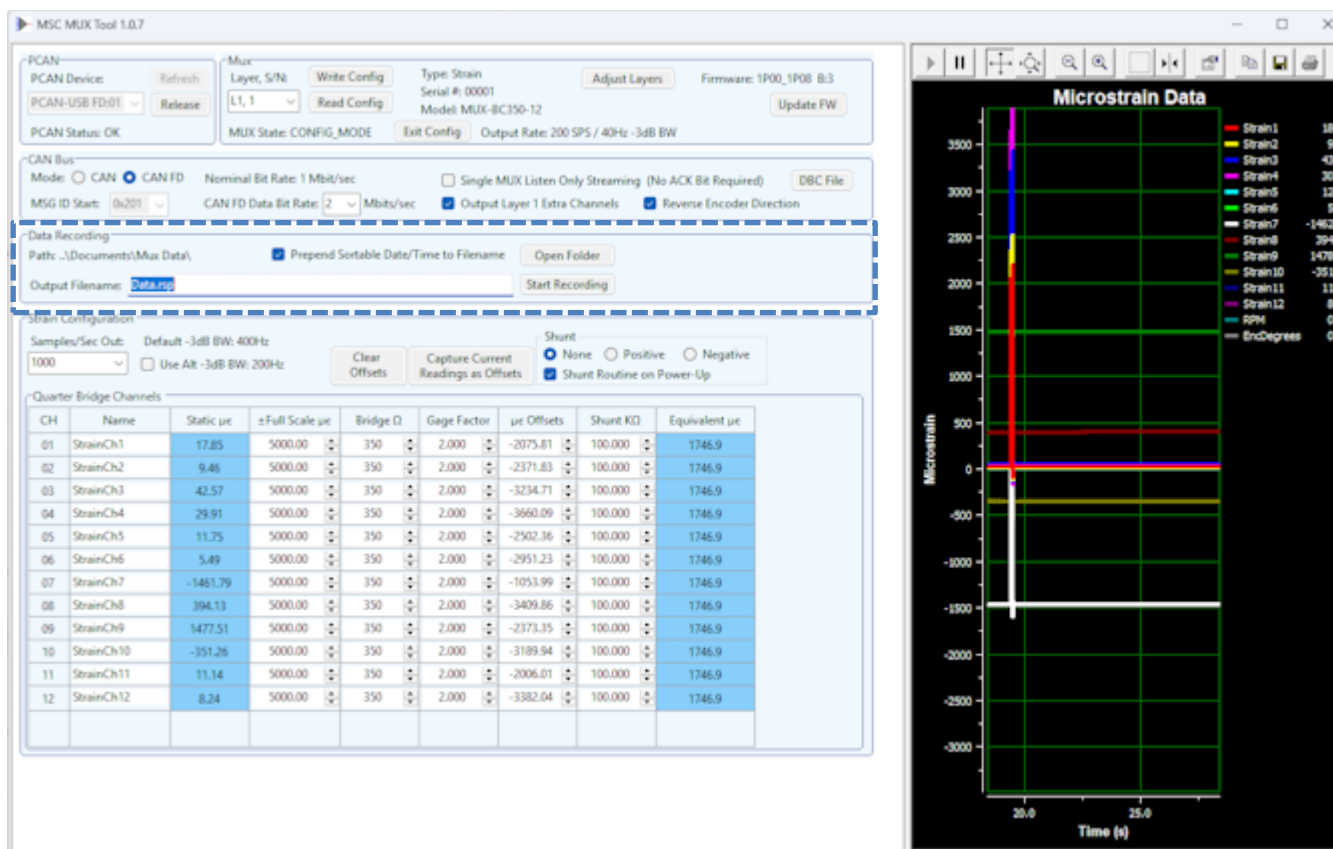
The MUX software can be used to view and record live data to a PC.

The MUX data is viewed in the plot window, and the plot has many features that can be adjusted to optimize the range and scaling.

To record data, specify the output filename, and press the button to Start Recording.

To stop recording, press the button named Stop Recording.

The default location for data storage is in the Documents folder named "MUX Data." The data format is MTS RPC-III.



Advanced Operation & Configuration Features

Signal Outputs

Each MUX outputs its data on the CAN bus. Any MUX device can be selected in software with corresponding serial number and assigned layer number. The data can be viewed in real time for the selected MUX. Data can also be recorded to the PC at the user configured sample rate.

A .dbc file can be created and downloaded using the MUX software. Once the .dbc file is loaded into the data acquisition, and the systems are connected, all the channels will be properly labeled and scaled (in engineering units). One consideration for using CAN signal outputs is the signal delay which is dependent on output rate. See page - 41 - for details on signal delays.

Shunt Calibration Operation

This section describes how to perform a shunt routine during operation.

The MUX has integrated fixed 100k ohm shunt resistors per channel. Different shunt values, up to 10Meg ohm, can be emulated per channel. In CONFIG_MODE, A shunt routine can be invoked at any time with a radio button. Additionally, the MUX can be programmed to perform the shunt operation at power ON every time. To enable this feature, select the box to shunt at power ON.

MUX Serial Number/Layer Number

Synchronization Settings

Multiple MUX devices can be stacked together for higher channel counts. The devices can be connected, and configured, to ensure synchronous input sampling. To configure the stack of MUX devices, use the software to configure one to be the leader, and others as followers.

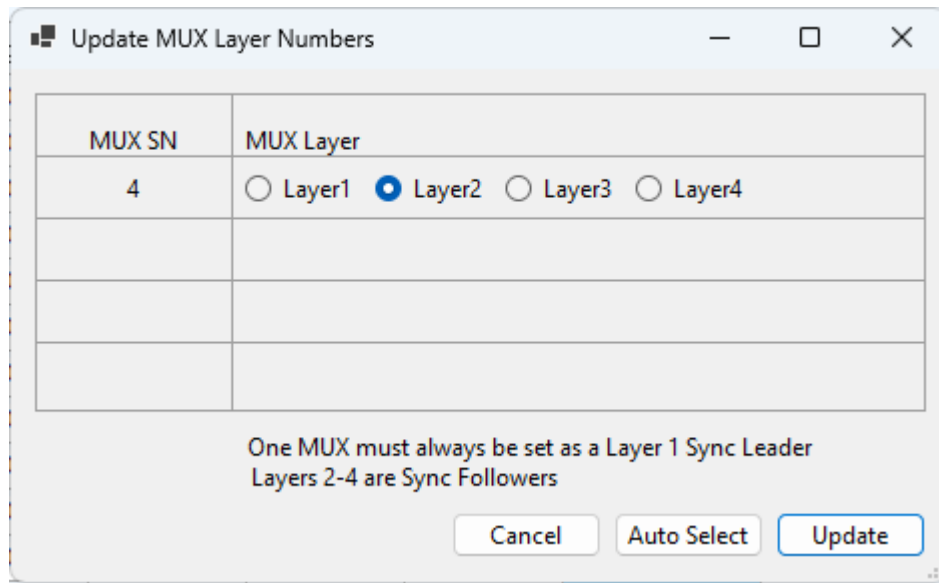


Figure 9: MUX stack synchronization layer select window.

Note: The MUX can either be configured to receive a CAN acknowledge bit (default) from the connected data acquisition system, or configured for passive (listen-only) mode.

Realtime plots

Realtime data can be plotted and recorded.

The data will be stored in your Documents folder, in an .RSP file (MTS RPC-III format).

The Baud Rate of the Data logger must be set to 1 Mbps for CAN 2.0. The CAN FD data bit rate can either be 2Mbps or 4Mbps. This is the amount of data that can be transferred on a standard CAN Bus.

Maximum Output Sample Rates with CAN 2.0 and CAN FD

The following output sampling rate limitations apply:

	CAN 2.0 1Mbps nominal (no encoder)	CAN 2.0 1Mbps nominal (with encoder)	CAN-FD 1Mbps nominal 2Mbps Data	CAN-FD 1Mbps nominal 4Mbps Data
1 Mux / 12 ch	2000	1000	4000	8000
2 Mux / 24 ch	1000	500	2000	4000
3 Mux / 36 ch	500	500	1000	2000
4 MUX / 48 ch	500	500	1000	2000

Figure 10: MUX Max Output Rates on a Single Dedicated Bus. CAN-FD rates are shown with or without an encoder.

Delay

There is signal delay caused by filtering performed by the MUX to decimate the data down to the selected output rate. The filter delays are listed in the chart below for the corresponding selected bandwidth.

Selected -3dB BW (Hz)						
	1600	800	400	200	80	40
Delay (ms)	1.15	2.90	4.90	8.90	16.90	51.90
-- From analog input to CAN output (typical) --						

Figure 11: MUX filter delays.

Filter Magnitude Response

The MUX input data is digitally filtered using a Finite Impulse Response (FIR) filter which can be configured for different sampling rates. The filter characteristics are provided for the magnitude response below.

MUX System Typical Magnitude Response per Bandwidth Setting

(Frequency in 0 to 1200Hz)

Fin (Hz)	Selected -3dB BW (Hz)					
	1600	800	400	200	80	40
Attenuation (dB)						
0	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	-0.04
30	0.00	0.00	0.00	0.00	0.00	-0.53
40	0.00	0.00	0.00	0.00	-0.10	-2.64
50	0.00	0.00	0.00	0.00	-0.31	-7.97
60	0.00	0.00	0.00	0.00	-0.77	-18.47
70	0.00	0.00	0.00	0.00	-1.59	-37.68
80	0.00	0.00	0.00	-0.01	-2.88	-83.53
90	0.00	0.00	0.00	-0.03	-4.77	
100	0.00	0.00	0.00	-0.06	-7.37	
150	-0.01	-0.01	-0.01	-0.68	-37.26	
200	-0.01	-0.01	-0.07	-2.99	-112.05	
250	-0.02	-0.02	-0.25	-8.36		
300	-0.03	-0.03	-0.69	-18.30		
350	-0.04	-0.05	-1.55	-35.61		
400	-0.06	-0.09	-3.00	-72.71		
450	-0.07	-0.15	-5.20			
500	-0.09	-0.25	-8.32			
550	-0.11	-0.41	-12.54			
600	-0.14	-0.65	-18.14			
650	-0.16	-0.98	-25.47			
700	-0.20	-1.44	-35.21			
750	-0.24	-2.04	-48.81			
800	-0.28	-2.82	-71.94			
850	-0.34	-3.80				
900	-0.40	-5.01				
950	-0.48	-6.47				
1000	-0.56	-8.22				
1050	-0.66	-10.28				
1100	-0.78	-12.69				
1150	-0.91	-15.50				
1200	-1.06	-18.76				

Figure 12: MUX Filter Magnitude Response chart for input signal frequency to 1200Hz.

MUX System Typical Magnitude Response per Bandwidth Setting
(Frequency in 1250 to 3800Hz)

Fin (Hz)	Selected -3dB BW (Hz)					
	1600	800	400	200	80	40
	Attenuation (dB)					
1250	-1.23	-22.53				
1300	-1.42	-26.90				
1350	-1.64	-31.99				
1400	-1.88	-37.98				
1450	-2.15	-45.13				
1500	-2.44	-53.95				
1550	-2.77	-65.51				
1600	-3.13	-83.77				
1700	-3.94					
1800	-4.90					
1900	-6.02					
2000	-7.30					
2100	-8.77					
2200	-10.42					
2300	-12.29					
2400	-14.37					
2500	-16.70					
2600	-19.30					
2700	-22.18					
2800	-25.39					
2900	-28.96					
3000	-32.94					
3100	-37.42					
3200	-42.50					
3300	-48.33					
3400	-55.18					
3500	-63.55					
3600	-74.68					
3700	-94.92					
3800	-98.69					

Figure 13: MUX Filter Magnitude Response chart for input signal frequency 1250 to 3800Hz.

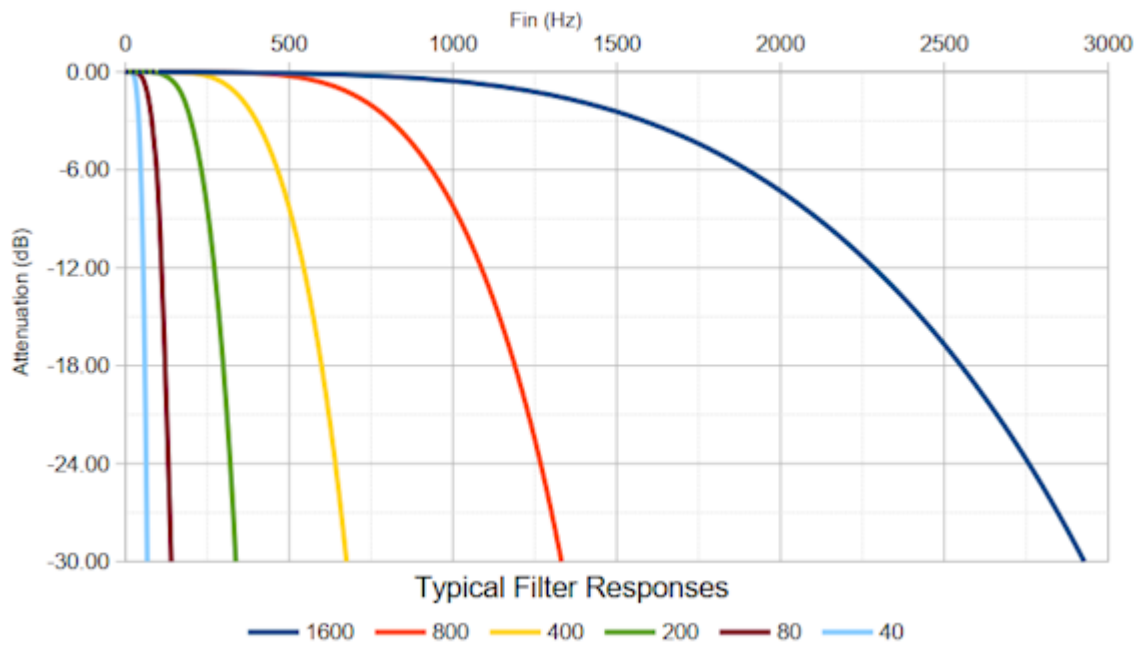


Figure 14: MUX Filter Magnitude Response plot.

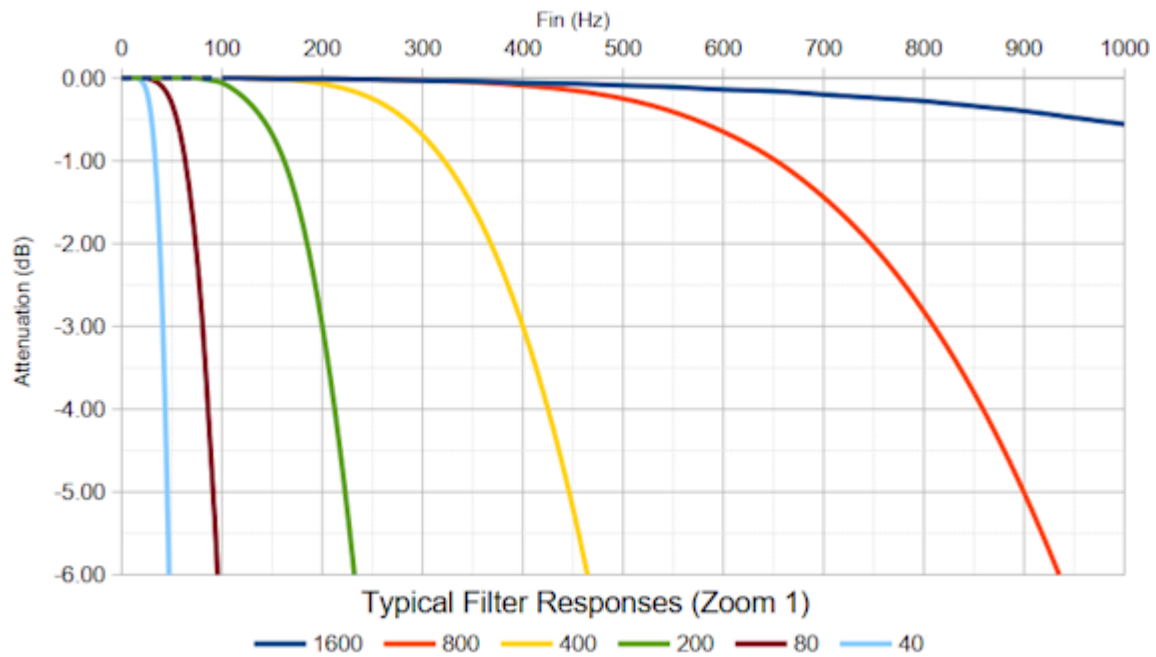


Figure 15: MUX Filter Magnitude Response plot (zoom1).

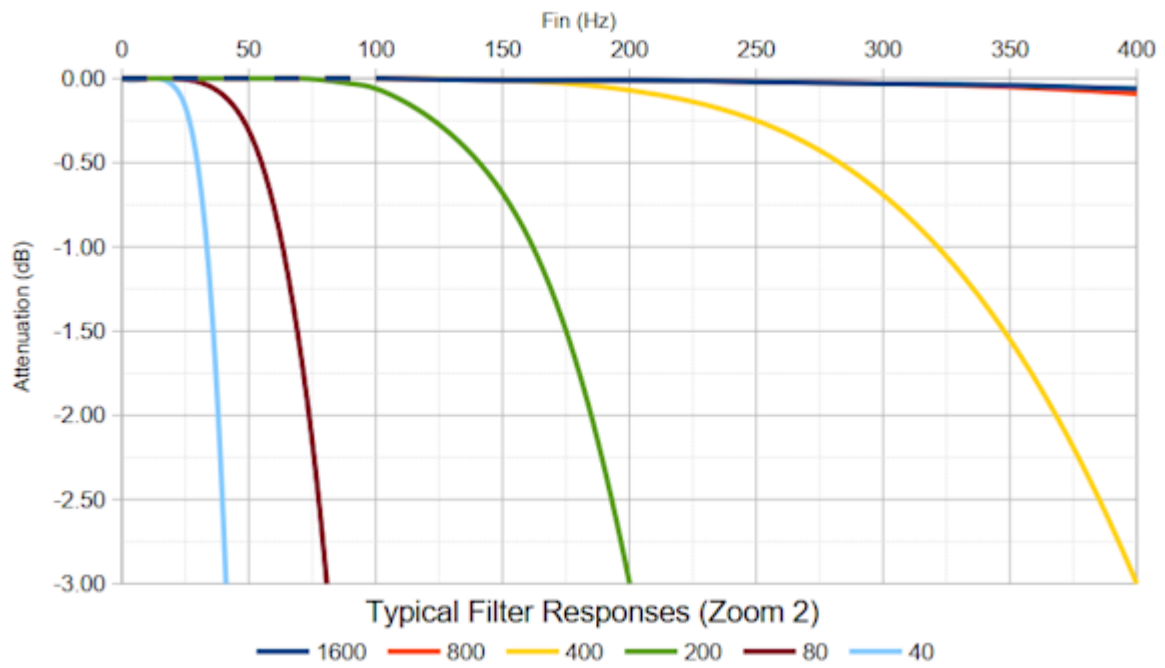


Figure 16: MUX Filter Magnitude Response plot (zoom2).

CAN Bus Termination

A 120 Ohm CAN termination resistor should be installed at each end of the CAN bus. The resistor is external to the MUX device and is either integrated into the supplied interface cabling or encoder adapter layer. The CAN Bus should also be properly terminated at the data acquisition side.

DBC file creation

A CAN database (.dbc) file is needed by the data acquisition to de-code the digital data sent by the MUX. A .dbc file is created by the MUX, by clicking the 'DBC File' button. A window should pop-up enabling you to save the file to your computer. If browser is not up to date or pop-ups have been disabled, this button may not work properly. Once created, the .dbc can be imported to the data acquisition.

MUX Firmware

The MUX software tool allows the user to easily update firmware without having to send the device back to the factory. Current MUX firmware is either available upon request, or downloaded from MSC's website. This allows updates or repairs to be done in the field. With a MUX connected, the firmware version is displayed in the top right corner:

Firmware version

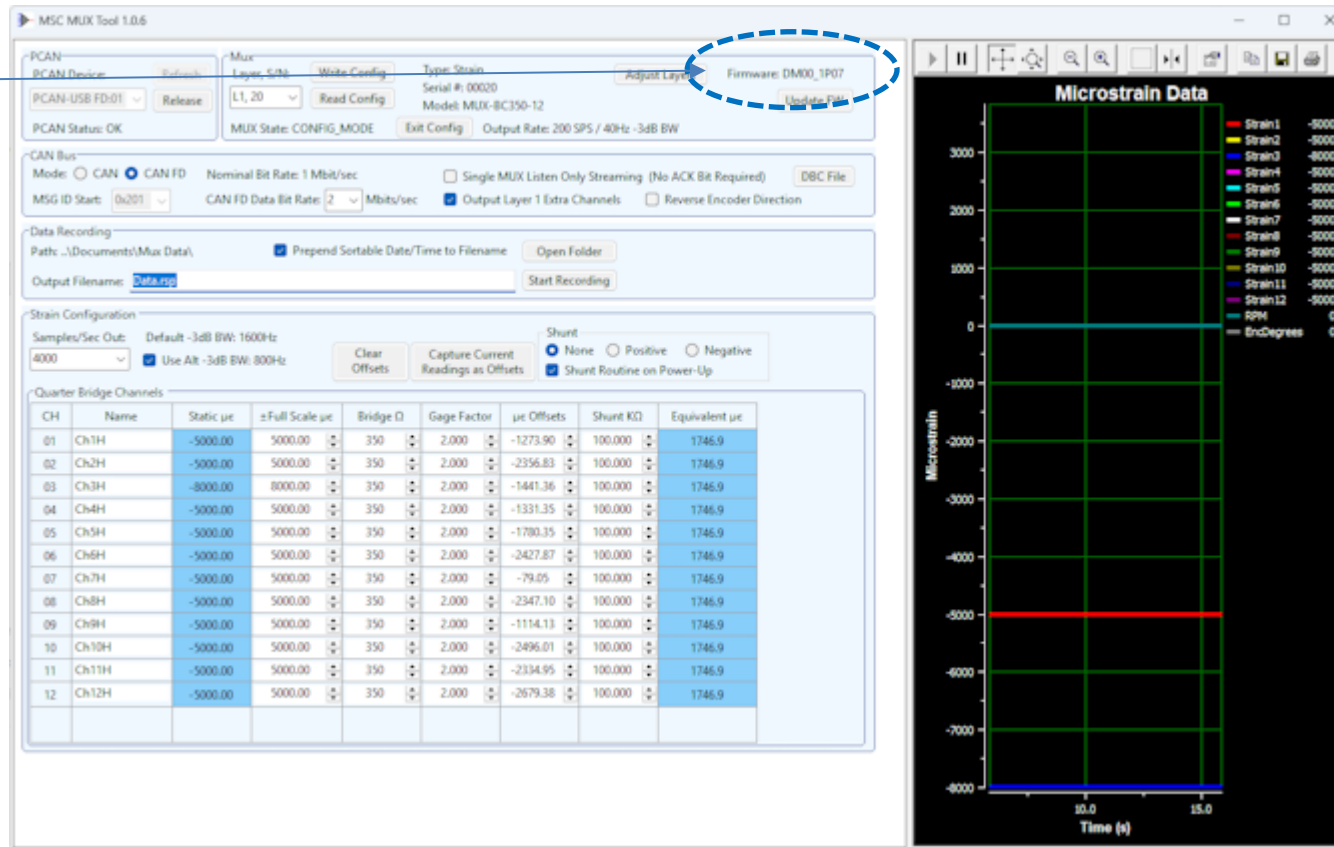


Figure 17: MUX Software Main Screen showing Firmware version.

If a firmware update is available, Michigan Scientific will provide an installation file. Save this file onto your laptop. To update the MUX:

- Connect the MUX to computer using the USB-to-CAN tool
- Click 'Connect'
- Select the layer to update, one layer at a time
- Click 'Update FW', and a new pop-up window is displayed to browse for the file
- Press the Browse button and select the installation file.
- Press the Open button
- The file will be uploaded. Follow the prompts on the screen.
- Once complete, you will be prompted to cycle power on the MUX.
- Once power has been cycled, the new firmware is ready to be used.

Caution: Do not disconnect the MUX or power down the computer or MUX during the update.

Note: Only the MUX connected, and layer selected in a stack, will be updated. Each MUX device must be updated separately.

Note: Update all MUX electronics with the same version of firmware before using them in a stacked configuration.

Weatherproofing

The MUX sensor inputs and electronics are IP67 rated when all connectors are mated.

Troubleshooting

Symptom	Possible Causes	Solution
MUX does not power ON when power is applied	Power supply voltage is too low.	Check that supplied voltage is in range, and the supply is not current limited.
	Power supply polarity is incorrect.	Check polarity. If incorrect, reverse leads and try again.
	Internal overload circuit is tripped.	Inspect for shorted wires on input.
MUX does not communicate with computer	USB-to-CAN device is not working.	Verify the USB-to-CAN device is working. Use other software to verify.
	Another device is connected.	Verify no other software is open which may be trying to communicate with the USB to CAN tool.
	Hardware connection problem	Verify all connections are secure. Verify total resistance across CAN bus is near 120 ohms. Verify no short from CAN signal to shield or ground.

Appendix

Appendix A: Wiring and Shielding

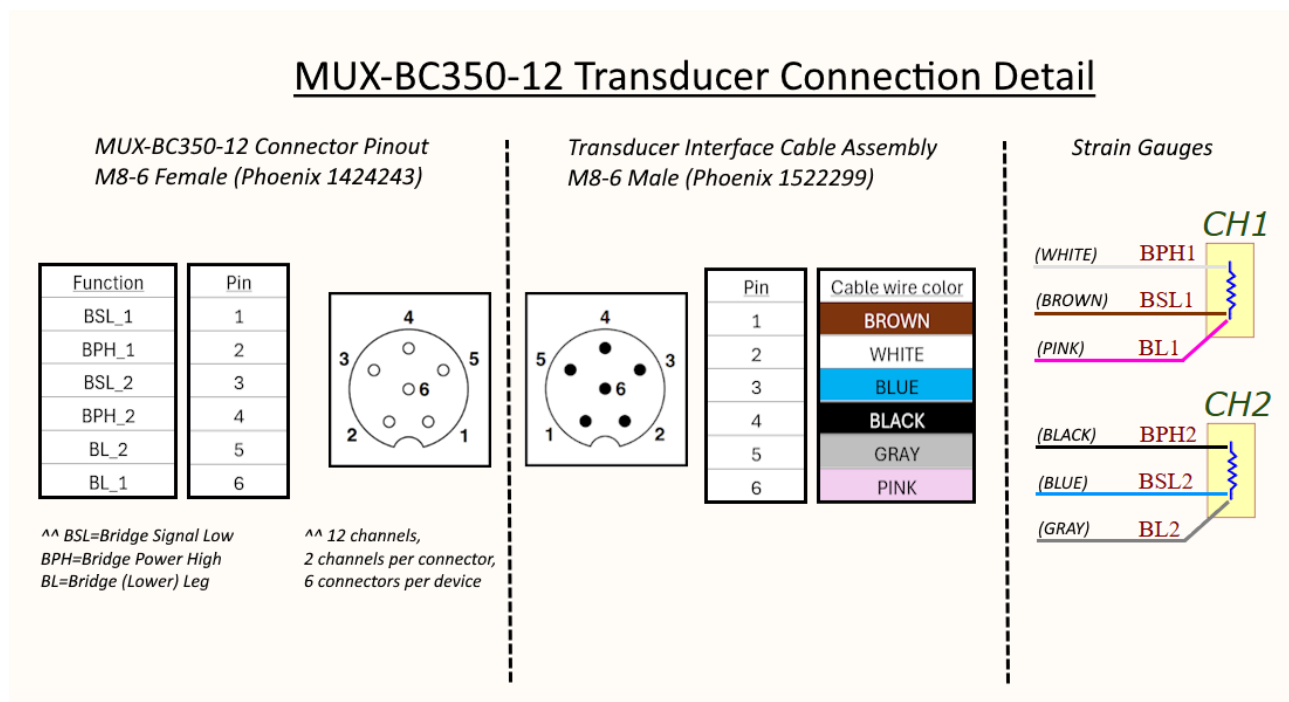
Galvanic Isolation

- The MUX sensor inputs are galvanically isolated from the input power and CAN data.
- The MUX sensor inputs are NOT galvanically isolated from each other.
- The MUX enclosure is galvanically isolated from sensor inputs, input power, and CAN data.

Shielding

For the sensor input wiring, it's preferred to use a shielded cable. The sensor input connectors are electrically connected to the MUX enclosure. Do not electrically connect the sensor input cable shield to the transducer at the sensor end of cable.

Transducer Connections



Appendix B: Dimensional Drawing, Slip ring SR10AW/WFT

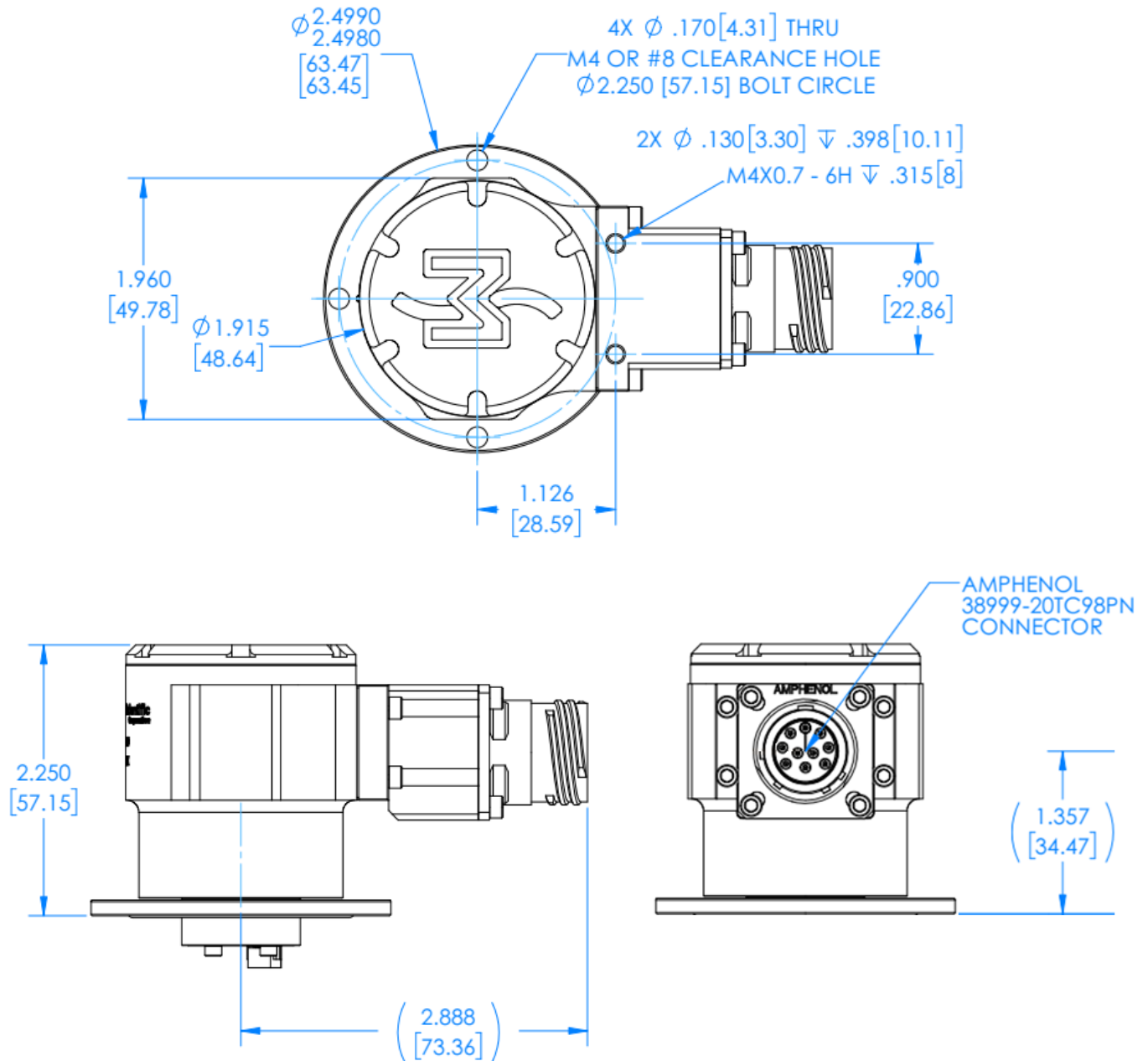


Figure 18: Dimensioned Drawing for Slip Ring Model SR10AW/WFT with units shown as inches [mm].

Appendix C: Dimensional Drawing, MUX with Slip ring and adapter

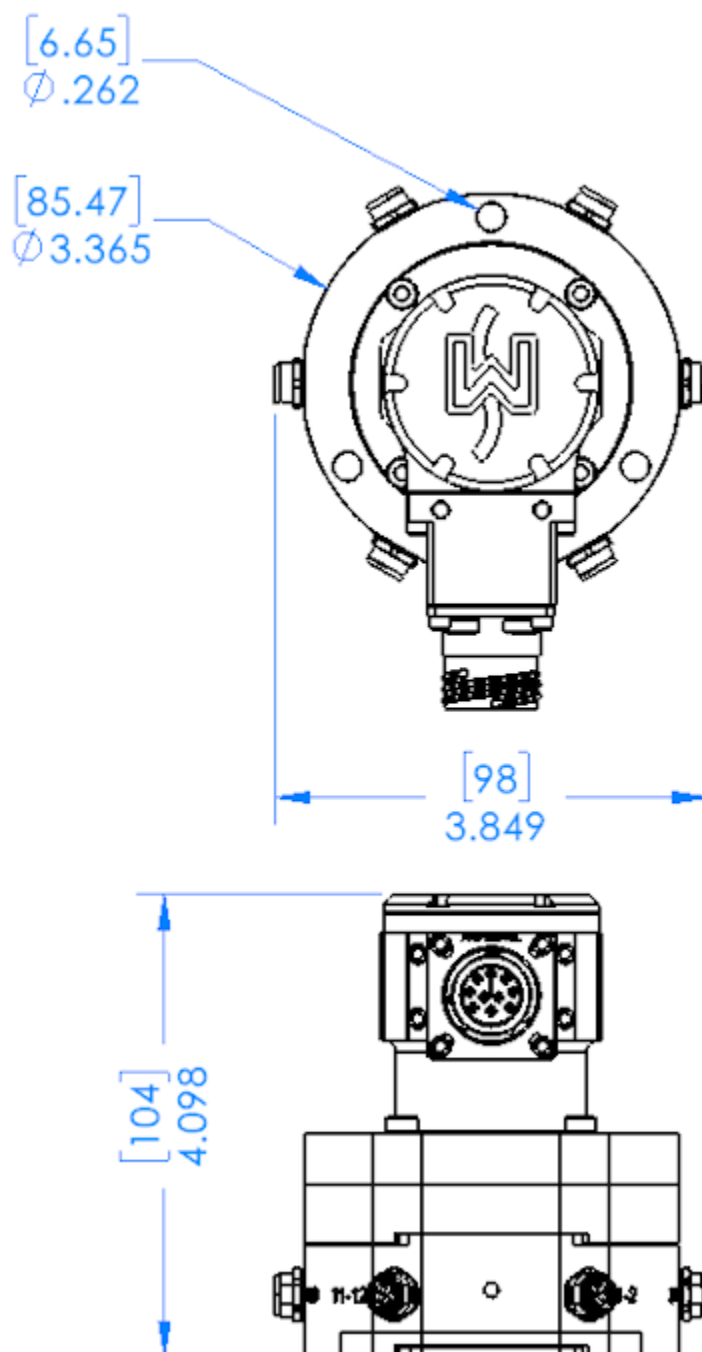
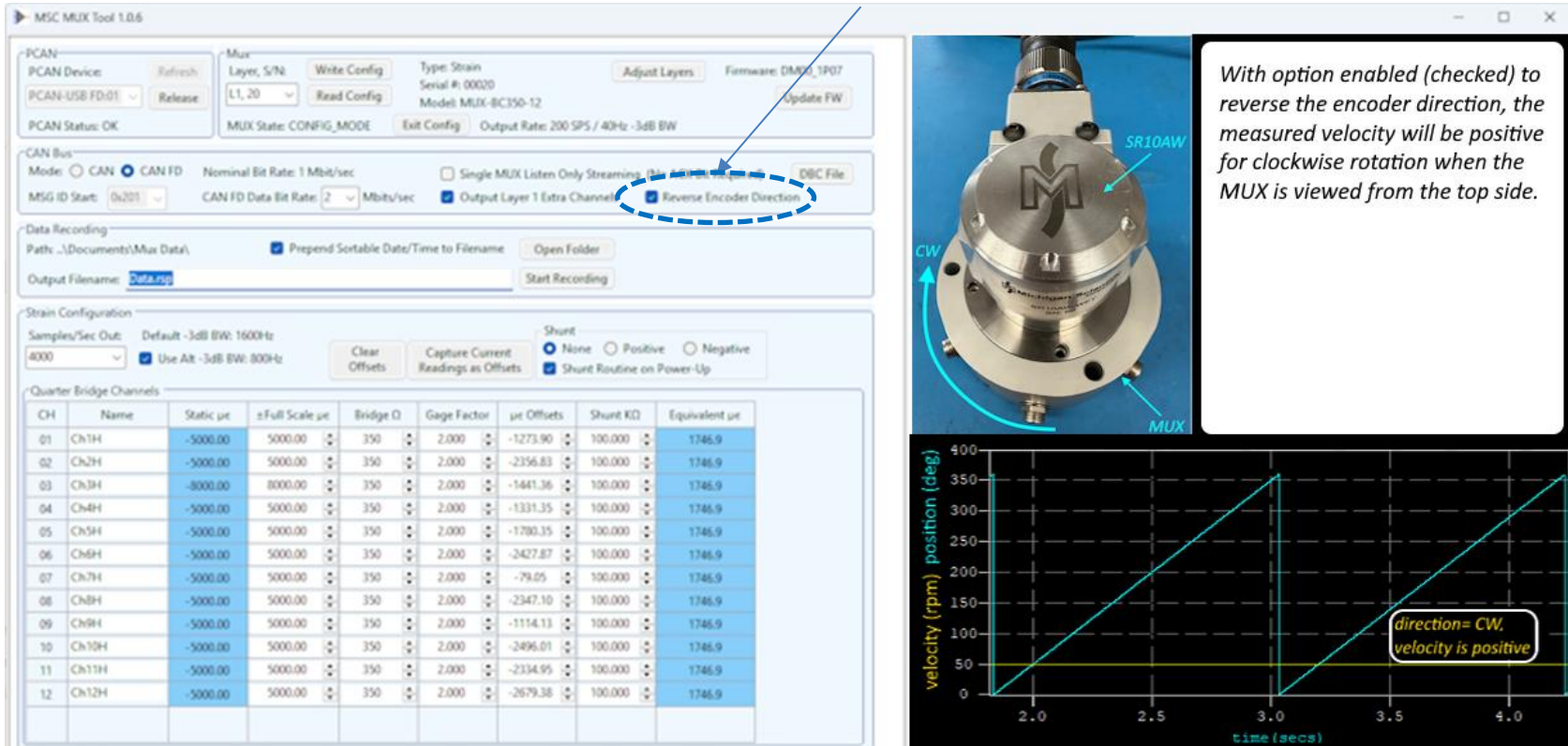


Figure 19: Dimensioned Drawing with units shown as inches [mm].

Appendix D: Encoder Direction

The MUX software can interface with data from absolute quadrature encoders. The user can choose whether the encoder outputs a positive or negative velocity with corresponding clockwise or counterclockwise spinning direction.

Encoder Direction, Enable Reverse option



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