

Michigan Scientific Corporation

12-Channel High Level Measurement System



Models: MUX-HL-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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Table of Contents

TECHNICAL SUPPORT	- 2 -
REVISIONS.....	- 5 -
LIST OF FIGURES.....	- 6 -
INTRODUCTION.....	- 7 -
OVERVIEW OF THE MUX SYSTEM	ERROR! BOOKMARK NOT DEFINED.
INCLUDED ITEMS	- 7 -
MODEL VARIANT	- 8 -
MUX-HL-12 (Full-Bridge Strain Measurement Module)	- 8 -
PROPERTIES AND REQUIREMENTS	- 9 -
PROPERTIES AT A GLANCE.....	- 9 -
<i>In General</i>	- 9 -
<i>High Level Version</i>	- 9 -
SPECIFICATIONS	- 10 -
FULL-BRIDGE MODEL SPECIFICATIONS	ERROR! BOOKMARK NOT DEFINED.
SLIP RING ENCODER SPECIFICATIONS	- 12 -
SYSTEM COMPONENTS	- 13 -
PRODUCT DESIGNATION AND MODEL PART NUMBER.....	- 13 -
MUX MODULE (MUX-HL-12).....	- 14 -
MUX MODULE STACK	- 15 -
INPUT CHANNEL CABLE ASSEMBLIES (1522299)	- 16 -
CHANNEL SPLITTER CABLE ASSEMBLY (MUX-SSC-BC)	- 16 -
INTERFACE CABLE (MUX-IPDC-3).....	- 17 -
USB TO CAN CONVERTER TOOL (IPEH-004022).....	- 18 -
INLINE CAN BUS TERMINATOR (GC-CAN-TERM-GC).....	- 18 -
SLIP RING WITH INTEGRATED ENCODER (SR10AW/WFT)	- 19 -
MUX TO SLIP RING ADAPTER (MUX-ENC-ADA)	- 19 -
CONNECTORS.....	- 20 -
SENSOR: HIGH LEVEL TYPE.....	- 20 -
INTERFACE POWER/DATA CABLE ASSEMBLY	- 20 -
<i>Power</i>	- 20 -
<i>Data</i>	- 20 -
ELECTRICAL SETUP	- 21 -
OVERVIEW	ERROR! BOOKMARK NOT DEFINED.
SENSOR CONNECTIONS.....	- 21 -
POWER CONNECTIONS	- 21 -
CAN DATA CONNECTIONS.....	- 21 -

INLINE TERMINATION	- 22 -
MULTIPLE MUX DEVICES STACKED	- 23 -
POWER REQUIREMENTS.....	- 23 -
OPERATION & DEVICE MODES	- 24 -
LISTENING MODE (INITIAL POWER-ON BEHAVIOR).....	- 24 -
STREAMING MODE	- 24 -
CONFIG MODE.....	- 24 -
BOOTLOADER MODE.....	- 24 -
SOFTWARE CONFIGURATION INSTRUCTIONS	- 25 -
SOFTWARE REQUIRED	- 25 -
MUX SOFTWARE SETUP	- 25 -
<i>High Level Model Setup (e.g. Resistive Strain Gage Based High Level Transducers).....</i>	<i>- 26 -</i>
ADVANCED OPERATION & CONFIGURATION FEATURES.....	- 46 -
SIGNAL OUTPUTS.....	- 46 -
DBC FILE CREATION	- 46 -
SHUNT VERIFICATION OPERATION	- 46 -
<i>MUX Serial Number/Layer Number.....</i>	<i>- 46 -</i>
SYNCHRONIZATION SETTINGS	- 46 -
REALTIME PLOTS.....	- 47 -
OUTPUT SAMPLE RATES	- 49 -
<i>Maximum Data Rates.....</i>	<i>- 49 -</i>
<i>Delay</i>	<i>- 49 -</i>
<i>Filter Magnitude Response.....</i>	<i>- 50 -</i>
MUX FIRMWARE.....	- 53 -
WEATHERPROOFING.....	- 55 -
TROUBLESHOOTING.....	- 56 -
APPENDIX	- 57 -
APPENDIX A: WIRING AND SHIELDING.....	- 57 -
<i>Galvanic Isolation.....</i>	<i>- 57 -</i>
<i>Shielding.....</i>	<i>- 57 -</i>
<i>Transducer Connections</i>	<i>- 57 -</i>
APPENDIX B: DIMENSIONAL DRAWING, SLIP RING SR10AW/WFT	- 58 -
APPENDIX C: DIMENSIONAL DRAWING, MUX WITH SLIP RING AND ADAPTER.....	- 59 -
APPENDIX D: ENCODER DIRECTION	- 60 -

Revisions

Number	Date	Description
1.0	December 2025	Initial
1.1	April 2026	Updated to match formatting of BC350 manual
2.0	July 2026	Updated transducer connection diagram, and formatting changes.

List of Figures

Figure 1: MUX device (ISO view).....	- 14 -
Figure 2: MUX stack.	- 15 -
Figure 3: MUX bottom view showing connector cover removal.	- 15 -
Figure 4: Input Channel Cables. Example, Phoenix Contact 1522299.	- 16 -
Figure 5: Channel splitter (1-to-2) cable assembly for MUX.	- 16 -
Figure 6: MUX Interface cable for power and data.	- 17 -
Figure 7: PEAK USB-to-CAN converter.	- 18 -
Figure 8: CAN bus termination inline plug.....	- 18 -
Figure 9: Slip ring with integrated encoder (Model SR10AW/WFT).....	- 19 -
Figure 10: MUX to SR10AW/WFT Slip ring Adapter	- 19 -
Figure 11: MUX stacked module CAN bus connections.....	- 22 -
Figure 12: MUX stack of 4 with slip ring adapter layer and slip ring assembly.	- 23 -
Figure 13: MUX stack synchronization layer select window.	- 47 -
Figure 14: MUX stack synchronization layer select window.	- 48 -
Figure 15: MUX Max Output Data Rates.	- 49 -
Figure 16: MUX filter delays.	- 49 -
Figure 17: MUX Filter Magnitude Response chart for input signal frequency to 1200Hz.....	- 50 -
Figure 18: MUX Filter Magnitude Response chart for input signal frequency 1250 to 3800Hz.....	- 51 -
Figure 19: MUX Filter Magnitude Response plot.....	- 52 -
Figure 20: MUX Filter Magnitude Response plot (zoom1).	- 52 -
Figure 21: MUX Filter Magnitude Response plot (zoom2).	- 52 -
Figure 22: MUX Software Main Screen showing Firmware version.	- 53 -
Figure 23: Transducer Connection Diagram.	- 57 -
Figure 24: Dimensioned Drawing, Slip Ring Model SR10AW/WFT.....	- 58 -
Figure 25: Dimensioned Drawing of MUX, slip ring and encoder adapter.....	- 59 -
Figure 26: MUX software main screen showing encoder direction reverse option.....	- 60 -

Introduction

Overview of the MUX System

Michigan Scientific's 12-Channel Analog to CAN Modules are designed for high-channel-count measurement applications. These Multiplexing (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. Multiple MUX modules can be connected for applications requiring higher channel counts. Up to 4 modules can be connected to provide 48 channels of synchronously sampled data. The configuration software allows for real-time data viewing and recording to a PC¹.

Each module provides sensor power, 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 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.

¹ Data viewing and recording is for a single MUX module at a time: software select each module layer to view its data.

Included Items

- MUX module (MUX-HL-12) for High Level Ratiometric 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-HL-12 (High Level Measurement Module)

- Designed for ratiometric sensors such as string pots and accelerometers.
- Provides 4.8 V sensor power per channel.
- Null sensor offset and store to non-volatile memory.
- Input range: $\pm 2.2\text{V}$.

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 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)

High Level Version

- Used with ratiometric sensors such as string pots and accelerometers
- Sensor excitation (4.8V) provided for each sensor

Specifications

High-Level Model Specifications

Model: MUX-HL-12

12-channel signal conditioning amplifier and multiplexing device

Measurement Inputs	
Connection	3-wire
Input signal voltage range	+/- 2.2Vdc
Input signal-to-ground (absolute max)	+/-32Vdc
Dynamic range	32:1 (62x-1984x)
Zero 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
Accuracy (@ 25degC), max	0.1% ²
Noise	
for bandwidth 1.6kHz	approx 12uVrms
Sensor Power	
Volts	4.8Vdc (ratiometric)
Amps (max per channel)	13mA
Amps (max, aggregate for ch1-6 or 7-12)	80mA
Integrated Shunt Calibration	
Shunt resistance	100k ohm (up to 10Meg ohm, emulated)
Shunt resistor accuracy	0.075% 15ppm

² Accuracy is specified as referenced to excitation mid-point after completing a tare operation.

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	36 Vdc
Power Consumption (@12Vdc, no sensors)	approx. 1W 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
Protection class (w/ solder terminals)	not specified
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 High Level Sensors	MUX-HL-12
MUX Interface Power/Data Cable Assembly, 3m	MUX-IPDC-3
Sensor Splitter Cable, for High Level Sensors	MUX-SSC-HL
Sensor Splitter Cable, for String Pots	MUX-SSC-SP
Sensor Splitter Cable, for 3D Accelerometers	MUX-SCC-ACC
Sensor to Splitter Cable, for String pot, 5m length	MUX-SPC-5
USB-to-CAN FD adapter	IPEH-004022
CAN Termination Plug	GC-CAN-TERM-GC
MUX Configuration Software	1.0.7

MUX Module (MUX-HL-12)

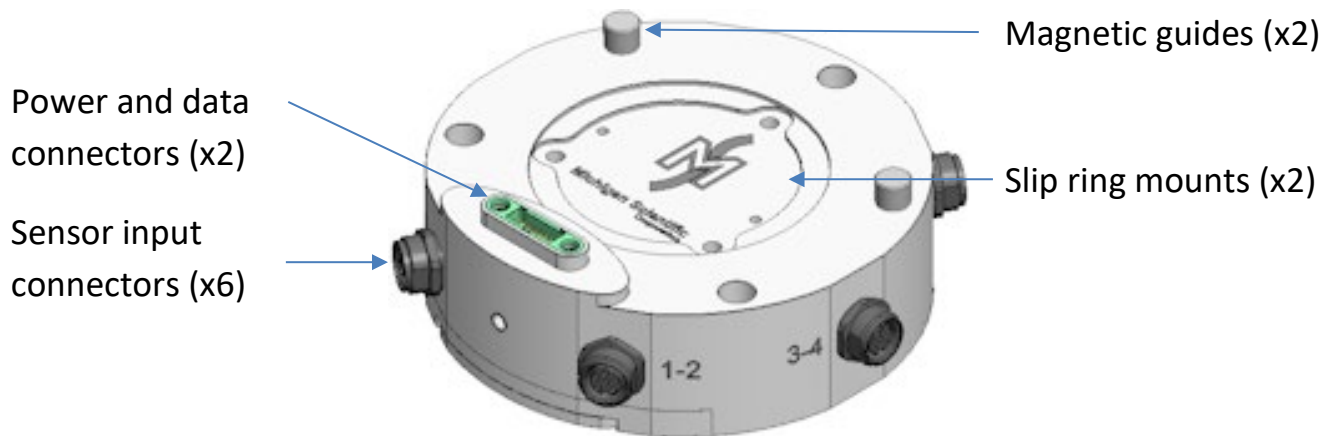


Figure 1: MUX device (ISO view).

The MUX module has 12 independently configured channels. The 12 channels are divided into six connectors: two channels per connector.

Each module has two connectors to interface with power, CAN data and MUX-to-MUX synchronization. The modules are designed with connectors on top and bottom to allow multiple modules to stack in plug and play fashion.

The MUX modules have magnetic guides used for aligning multiple modules in a stack. Additional hardware is required to completely secure the modules together.

The top of the MUX modules have mounting features which are used with a variety of Michigan Scientific slip rings.

MUX Module Stack

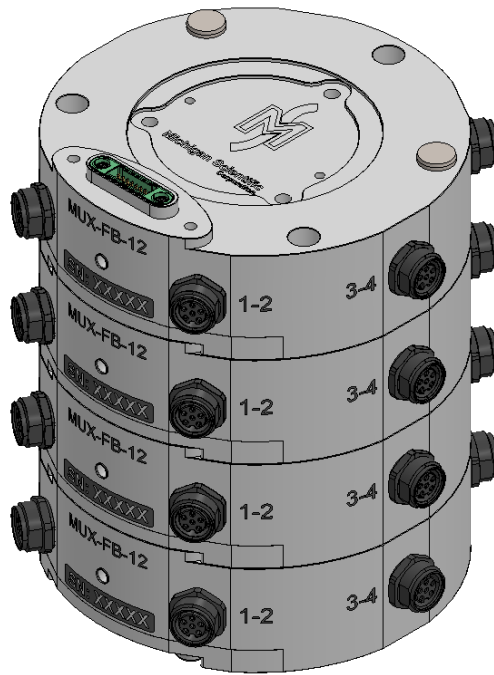


Figure 2: MUX stack.

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 a bottom cover to expose the connector which mates to another module below it.



Figure 3: MUX bottom view showing connector cover removal.

Input Channel Cable Assemblies (1522299)



Figure 4: Input Channel Cables. Example, 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 (MUX-SSC-HL)



Figure 5: 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 (MUX-IPDC-3)



Figure 6: 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 connector per CAN bus. When multiple MUX modules are stacked, the CAN data from each module can either be streamed on its own bus or combined together. When used with a slip ring encoder, up to 4 stacked modules can stream 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 (IPEH-004022)



Figure 7: PEAK USB-to-CAN converter.

USB to CAN converter tool. The MUX module is software configurable using its multiplexed CAN data bus. Detailed configuration instructions start on page - 25 -. Software to configure each MUX module, view data in real-time and record to PC is included with each MUX module. Ensure the USB to CAN converter hardware drivers³ are installed and verify the device is functioning properly before connecting to the MUX module.

Inline CAN bus terminator (GC-CAN-TERM-GC)



Figure 8: 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.

³ USB-to-CAN hardware drivers are available from the manufacturer, PEAK System, <https://www.peak-system.com/>

Slip ring with Integrated Encoder (SR10AW/WFT)



Figure 9: 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 10: MUX to SR10AW/WFT Slip ring Adapter

A slip ring adapter layer is required to connect the MUX to slip ring (model SR10AW/WFT). Slip ring adapter dimensions are provided on page - 59 -.

Connectors

The MUX has 6 input connectors for high level sensors (M8-6 Plug with female sockets, Phoenix 1424243). Each connector interfaces 2 channels, as shown below.

Sensor: High Level Type

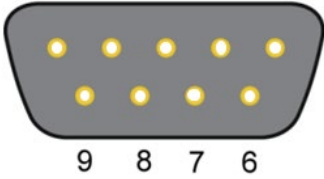
Pin	MUX Connector (M8 size, 6-pin, sockets)	Function	Mating Cable Wire Color (Phoenix 1404137)
1		CH1, Signal	Brown
2		CH1, Power	White
6		CH1, Ground	Pink
3		CH2, Signal	Blue
4		CH2, Power	Black
5		CH2, Ground	Gray

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)
2	CAN Low	
3	CAN Ground	
7	CAN High	

Electrical Setup

Overview

All connections to the MUX module and slip ring, are designed to be plug and play:

1. Attach each sensor to the MUX module using the input cable channel assemblies
2. Attach DC power source (10-20Vdc, 0.25Amin) to the interface cable fly leads
3. Attach the 12-pin circular connector of the interface cable to the slip ring stator
4. Attach the 9-pin DSUB connector of the interface cable to USB-to-CAN converter⁴

Sensor Connections

Attach each sensor to the MUX module using the input cable channel assemblies shown on page - 16 -. The cable assemblies are provided with fly leads. The wire color details are provided on page - 20 -. See appendix, on page - 57 -, for additional wiring details.

Power Connections

Attach a stable DC power source (10-20Vdc, 0.25Amin) to the interface cable fly leads. The wire color details are provided on page - 20 -.

CAN Data Connections

Attach the 12-pin circular connector of the interface cable to the slip ring stator, and the appropriate 9-pin DSUB connector to the USB-to-CAN converter⁴. The interface cable (MUX-IPDC-3) has connectors for 2 separate CAN bus connections. When a single MUX module is being used, the CAN data will be output on connector labeled CAN1. When multiple modules are stacked together, the appropriate 9-pin DSUB connector depends on the order the modules are stacked. See Figure 11 on page - 22 - for reference.

⁴ Inline termination may be required.

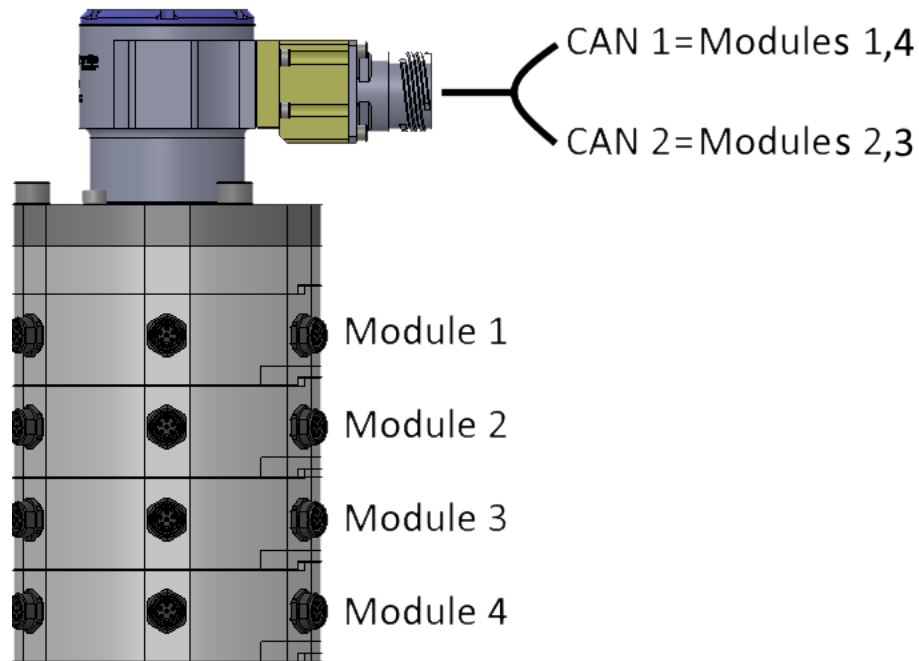


Figure 11: MUX stacked module CAN bus connections.

Inline Termination

A 120 Ohm CAN termination resistor should be installed at each end of the CAN bus. The resistor is external to the MUX module 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.

The interface cables two CAN busses are terminated at the slip ring end: the slip ring adapter layer has integrated fixed resistors for CAN bus termination. The other end of the interface cable with 9pin DSUB connectors do NOT have integrated termination. When termination is lacking in either the data recorder or USB-to-CAN device, an external inline CAN bus terminator can be used to terminate the end of a CAN bus. The inline termination plug is shown on page - 18 - and attaches to the interface cable 9-pin DSUB connector.

NOTE: users should verify whether their data recorder has integrated CAN termination.

Multiple MUX devices stacked

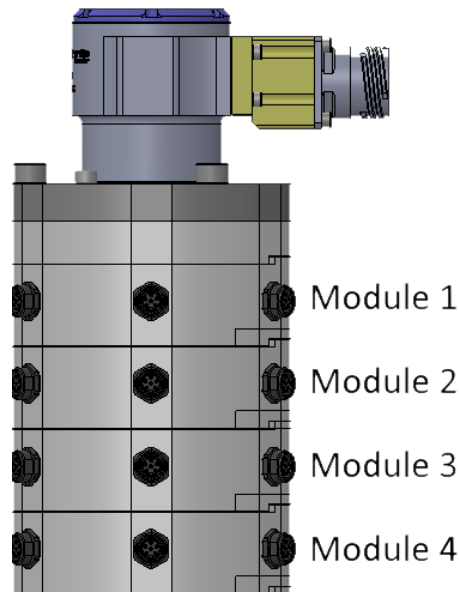


Figure 12: MUX stack of 4 with slip ring adapter layer and slip ring assembly.

Each MUX module can be used with up to 12 strain sensors. Multiple MUX modules can be stacked together for 48 channels total. Each module has a magnetic feature designed to guide the devices into alignment when stacking. Once stacked, the modules must be secured with additional hardware.

Stacked MUX modules are designed to communicate with each other to ensure sensor data is synchronously sampled (up to 48 channels). With the proper interface cabling and slip ring adapter layer, a stack of 4 modules can output data to a single CAN bus. In a single CAN bus configuration, the MUX software must be used to configure the stacked layers to have unique CAN IDs.

Power Requirements

The MUX requires 10 to 20 VDC power. The approximate power required is 2 watts for each device when sensors are attached. One power cable will power a stack of MUX devices (up to 4). To begin, apply 10 to 20 VDC (min 0.25A DC per MUX) to the MUX power lead wires.

Operation & Device Modes

MUX devices operate in different modes:

1. Listening
2. Streaming_ack_required, or Streaming_listen_only
3. Config_mode
4. Bootloader

Listening Mode (Initial Power-On Behavior)

At power ON, the MUX module is in Listening mode. By default, the module will remain in listening mode for 20 seconds without any user interaction. In listening mode, the MUX module 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.

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 modules 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 drivers⁵ are installed and verify the device is functioning properly.)

NOTE: MUX modules 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 module. If another software tool was used to verify communication, close the other software to free the connection.

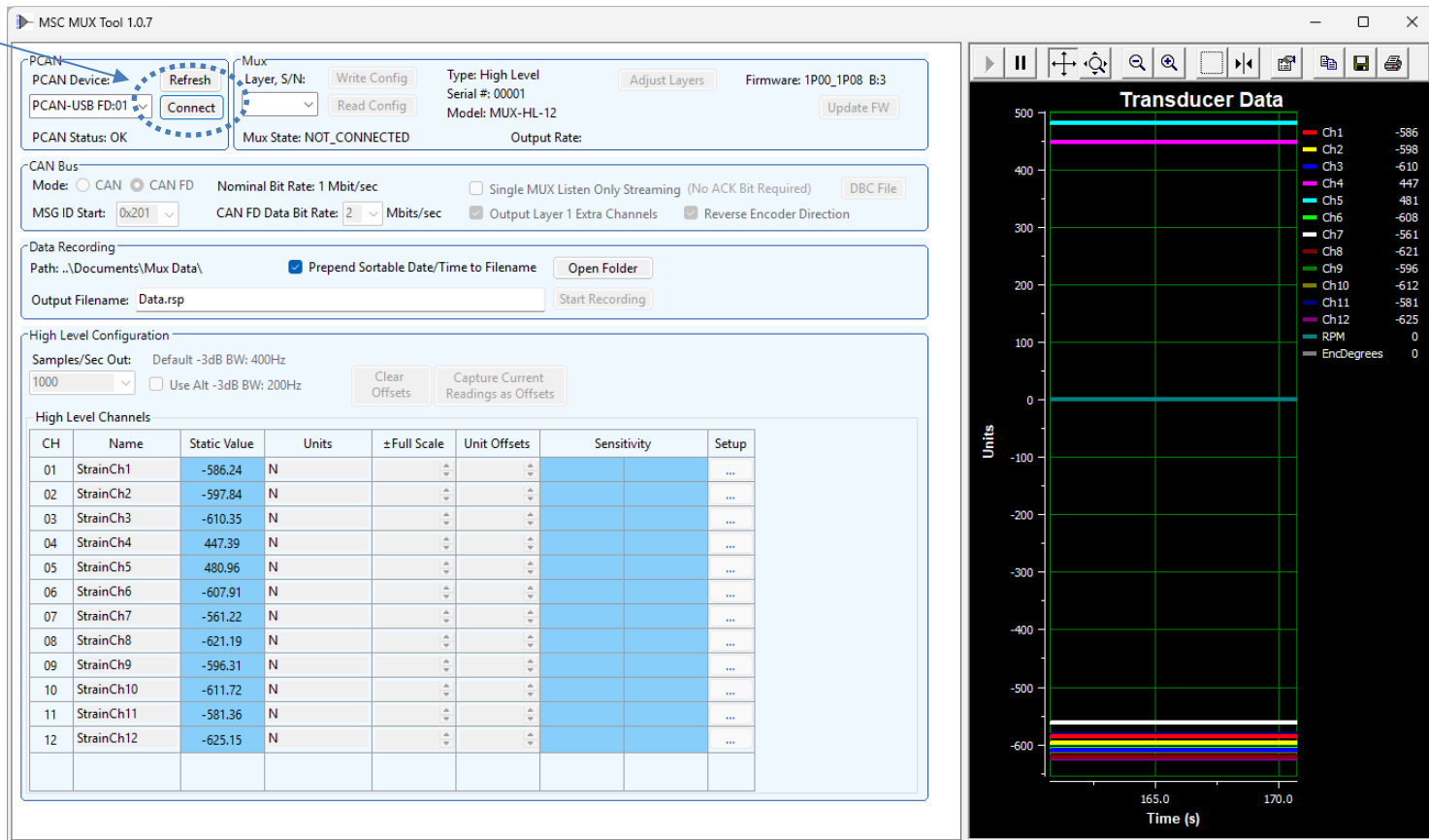
⁵ USB-to-CAN hardware drivers are available from the manufacturer, PEAK System, <https://www.peak-system.com/>

High Level Model Setup (e.g. Resistive Strain Gage Based High Level Transducers)

This section will describe how to configure a MUX High Level measurement model. This model is often used with ratiometric sensors such as string pots and accelerometers. A MUX High Level measurement model outputs a precision regulated 4.5VDC for sensor excitation.

USB-to-CAN and MUX Information, High Level

Once software opens, press
“Connect” button.



MSC MUX Tool 1.0.7

PCAN: PCAN Device: PCAN-USB FD-01 Refresh Connect PCAN Status: OK Mux: Layer, S/N: Write Config Read Config Mux State: NOT_CONNECTED Type: High Level Serial #: 00001 Model: MUX-HL-12 Adjust Layers Firmware: 1P00_1P08 B:3 Update FW Output Rate:

CAN Bus: Mode: ☐ CAN ☒ CAN FD Nominal Bit Rate: 1 Mbit/sec Single MUX Listen Only Streaming (No ACK Bit Required) DBC File MSG ID Start: 0x201 CAN FD Data Bit Rate: 2 Mbits/sec Output Layer 1 Extra Channels Reverse Encoder Direction

Data Recording: Path: ..\Documents\Mux Data\ Prepend Sortable Date/Time to Filename Open Folder Output Filename: Data.rsp Start Recording

High Level Configuration: Samples/Sec Out: 1000 Default -3dB BW: 400Hz Use Alt -3dB BW: 200Hz Clear Offsets Capture Current Readings as Offsets

High Level Channels:

CH	Name	Static Value	Units	±Full Scale	Unit Offsets	Sensitivity	Setup
01	StrainCh1	-586.24	N				...
02	StrainCh2	-597.84	N				...
03	StrainCh3	-610.35	N				...
04	StrainCh4	447.39	N				...
05	StrainCh5	480.96	N				...
06	StrainCh6	-607.91	N				...
07	StrainCh7	-561.22	N				...
08	StrainCh8	-621.19	N				...
09	StrainCh9	-596.31	N				...
10	StrainCh10	-611.72	N				...
11	StrainCh11	-581.36	N				...
12	StrainCh12	-625.15	N				...

Transducer Data

Units

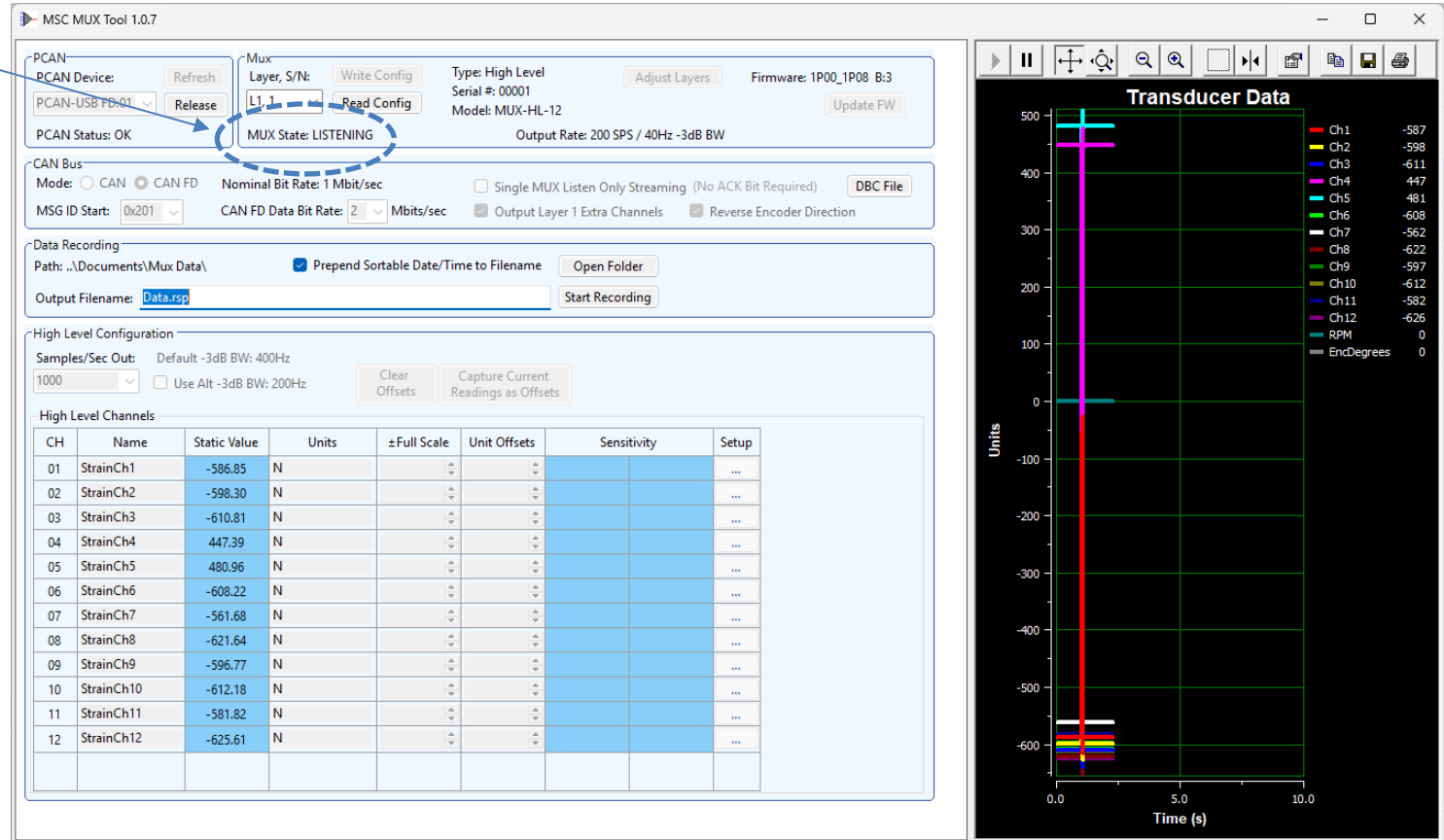
Time (s)

Ch1 -586
Ch2 -598
Ch3 -610
Ch4 447
Ch5 481
Ch6 -608
Ch7 -561
Ch8 -621
Ch9 -596
Ch10 -612
Ch11 -581
Ch12 -625
RPM 0
EncDegrees 0

Observe

[1] MUX state changes to from NOT Connected to Listening mode.

About 20 seconds after from power ON, changes from listening to streaming mode

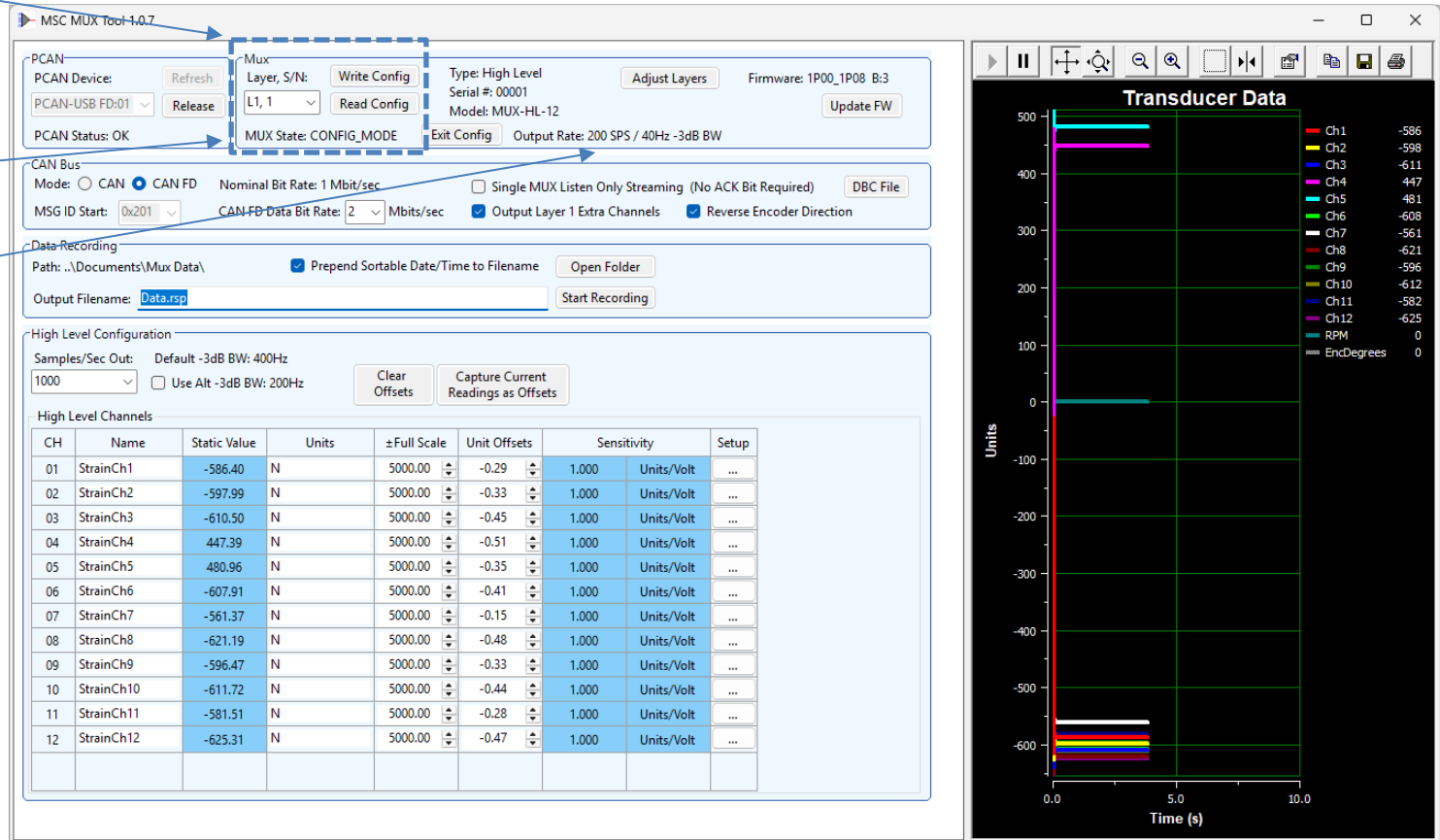


[1] Press “Read Config” button to view and edit device settings.

[2] Observe MUX state changes from LISTENING 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.

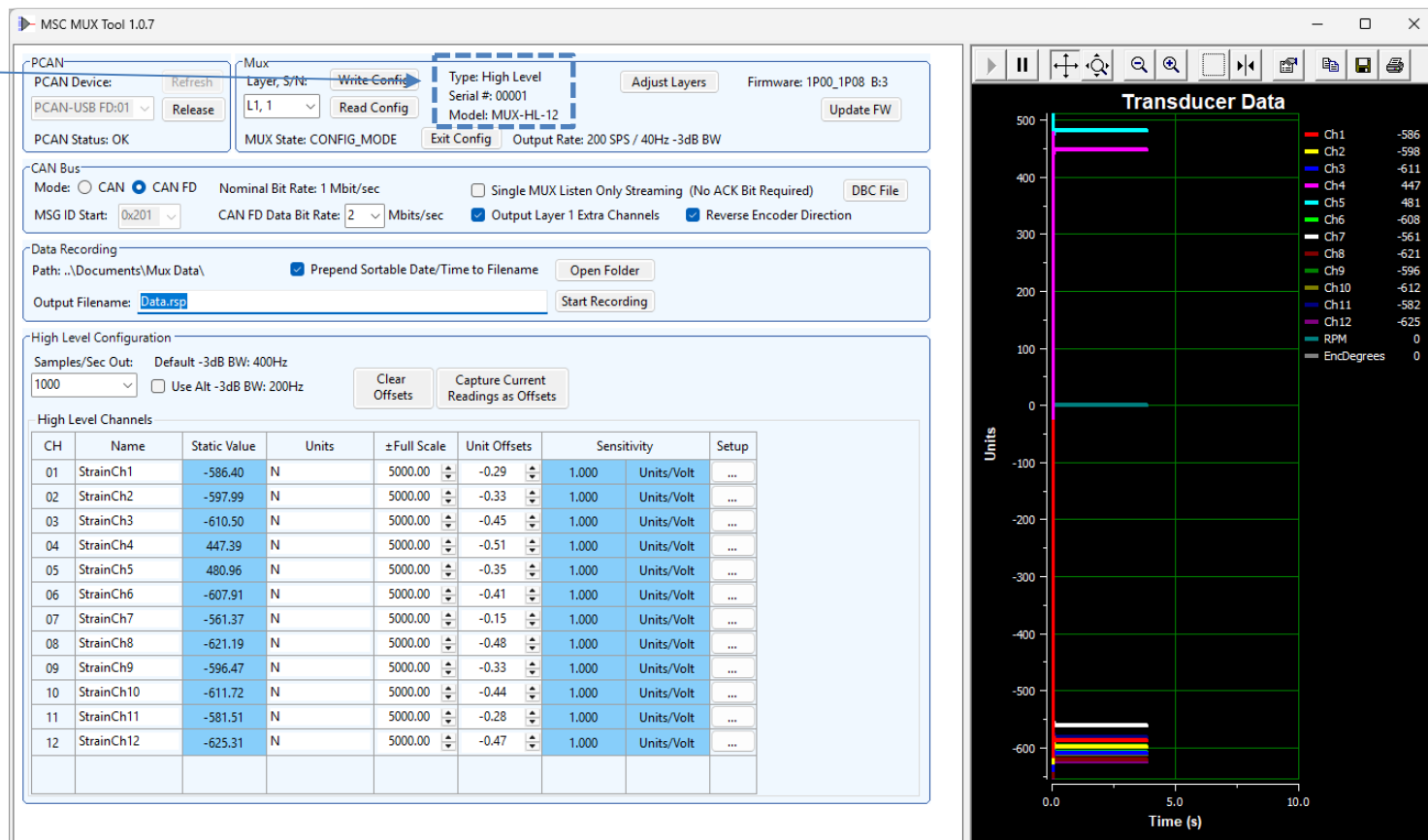


The MUX device model and serial numbers are displayed in top-middle of screen:

Select the particular MUX device to edit.

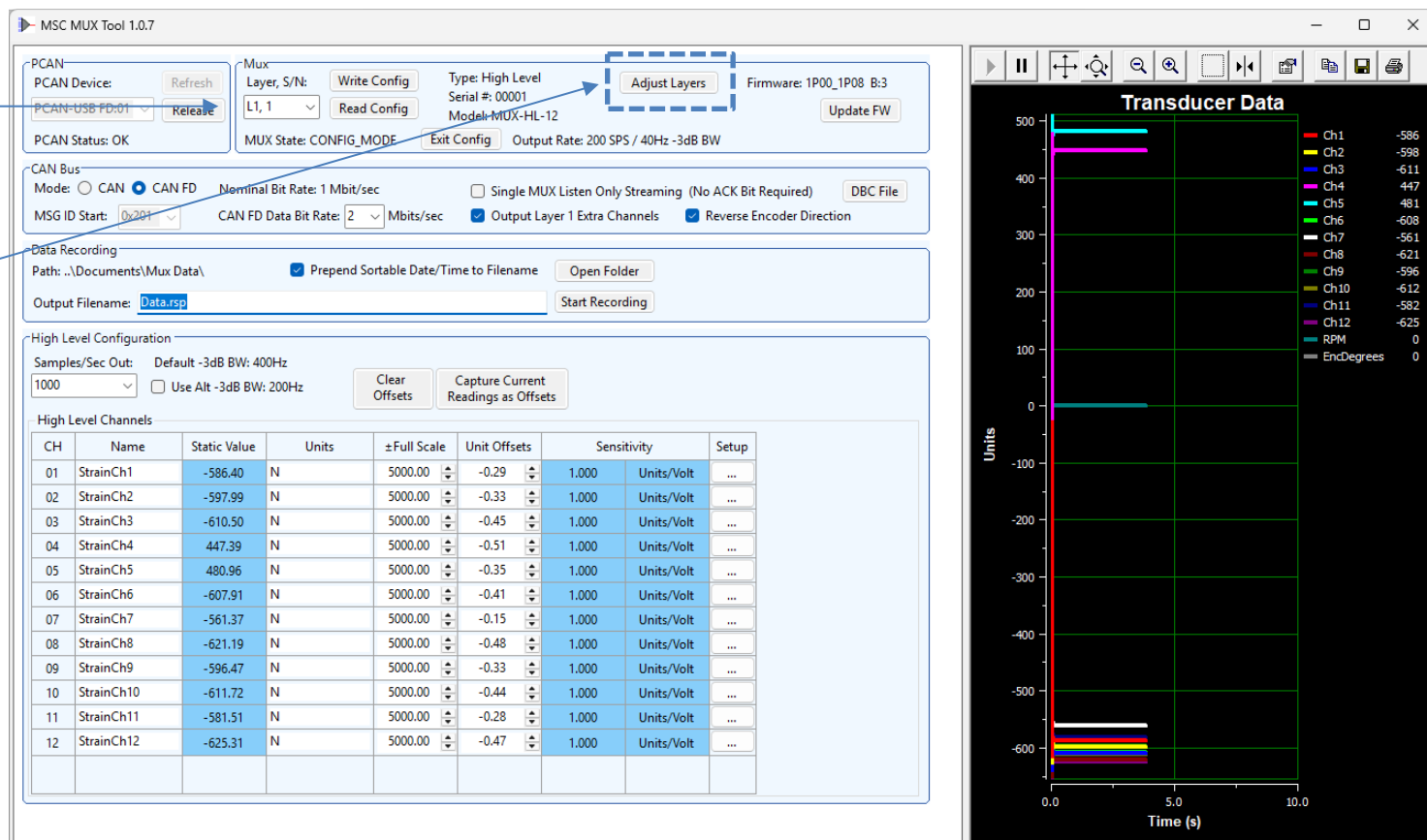
Once the MUX serial number (S/N) is selected, wait for data to refresh.

Note, each MUX module 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

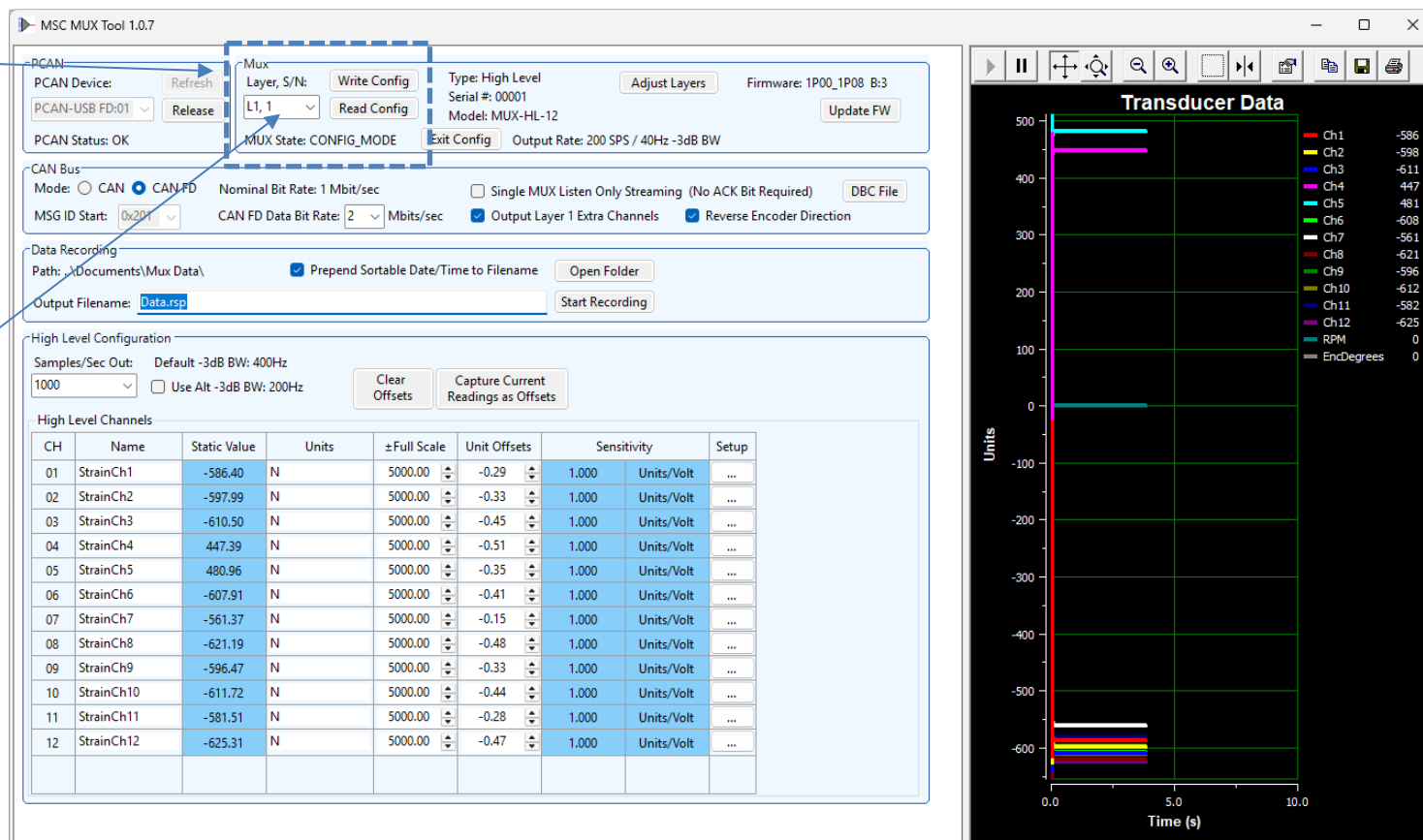
One MUX must always be set as a Layer 1 Sync Leader
Layers 2-4 are Sync Followers

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, High Level

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 module memory.

The screenshot displays the MSC MUX Tool 1.0.7 interface. The 'CAN Bus' section is highlighted with a dashed blue box, showing the 'Mode' set to 'CAN FD' and 'Nominal Bit Rate' at '1 Mbit/sec'. The 'Data Recording' section shows the 'Path' as '..\Documents\Mux Data\' and 'Output Filename' as 'Data.isp'. The 'High Level Configuration' section shows 'Samples/Sec Out' set to '1000'. The 'High Level Channels' table lists 12 channels (StrainCh1 to StrainCh12) with their respective static values, units, and sensitivities.

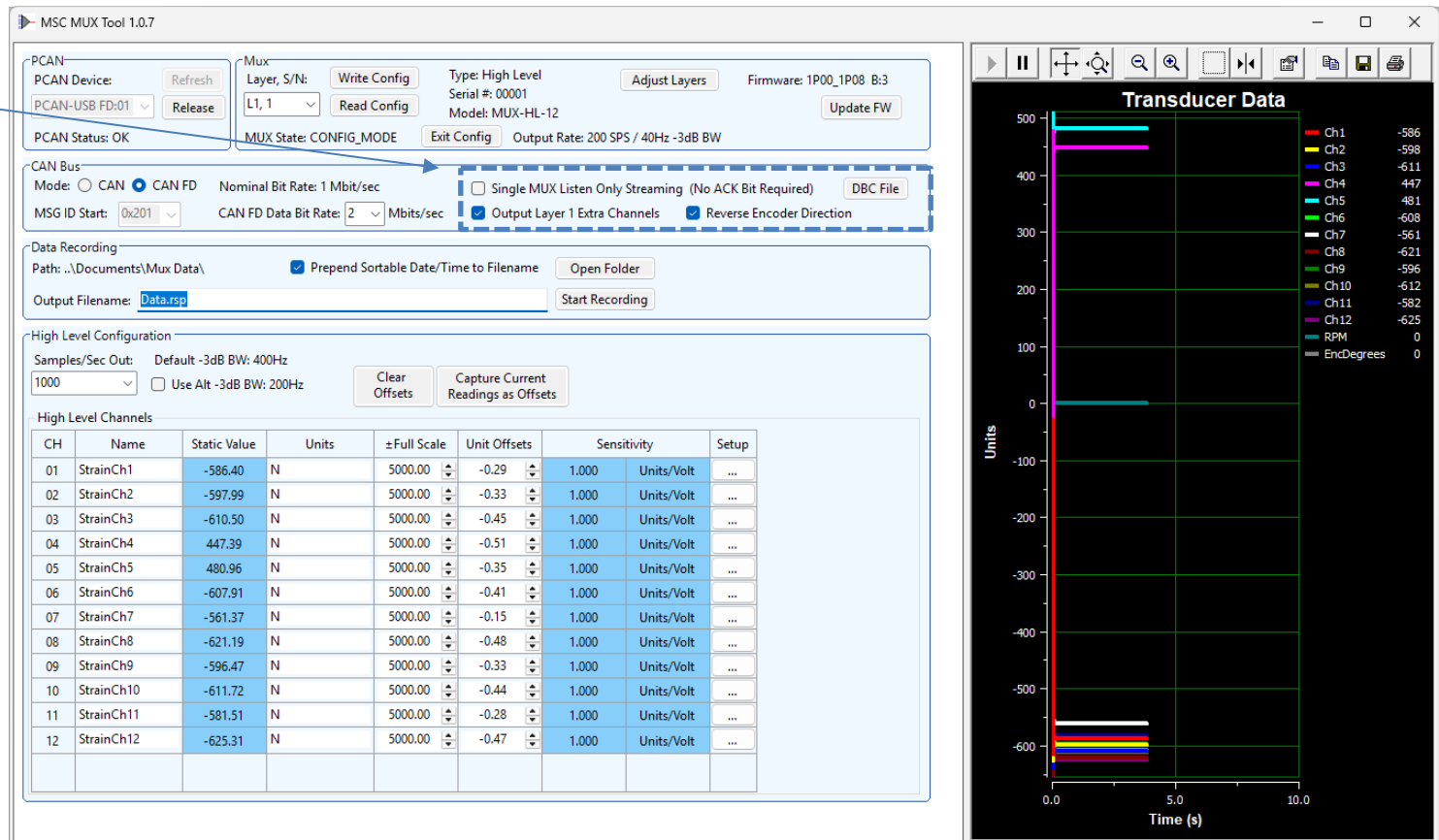
CH	Name	Static Value	Units	±Full Scale	Unit Offsets	Sensitivity	Setup
01	StrainCh1	-586.40	N	5000.00	-0.29	1.000	Units/Volt
02	StrainCh2	-597.99	N	5000.00	-0.33	1.000	Units/Volt
03	StrainCh3	-610.50	N	5000.00	-0.45	1.000	Units/Volt
04	StrainCh4	447.39	N	5000.00	-0.51	1.000	Units/Volt
05	StrainCh5	480.96	N	5000.00	-0.35	1.000	Units/Volt
06	StrainCh6	-607.91	N	5000.00	-0.41	1.000	Units/Volt
07	StrainCh7	-561.37	N	5000.00	-0.15	1.000	Units/Volt
08	StrainCh8	-621.19	N	5000.00	-0.48	1.000	Units/Volt
09	StrainCh9	-596.47	N	5000.00	-0.33	1.000	Units/Volt
10	StrainCh10	-611.72	N	5000.00	-0.44	1.000	Units/Volt
11	StrainCh11	-581.51	N	5000.00	-0.28	1.000	Units/Volt
12	StrainCh12	-625.31	N	5000.00	-0.47	1.000	Units/Volt

The right side of the image shows a 'Transducer Data' plot with 'Units' on the y-axis (ranging from -600 to 500) and 'Time (s)' on the x-axis (ranging from 0.0 to 10.0). The plot displays multiple colored lines representing different channels, with a legend on the right listing channels Ch1 through Ch12, RPM, and EncDegrees with their corresponding static values.

[1] With multiple devices stack 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, High Level

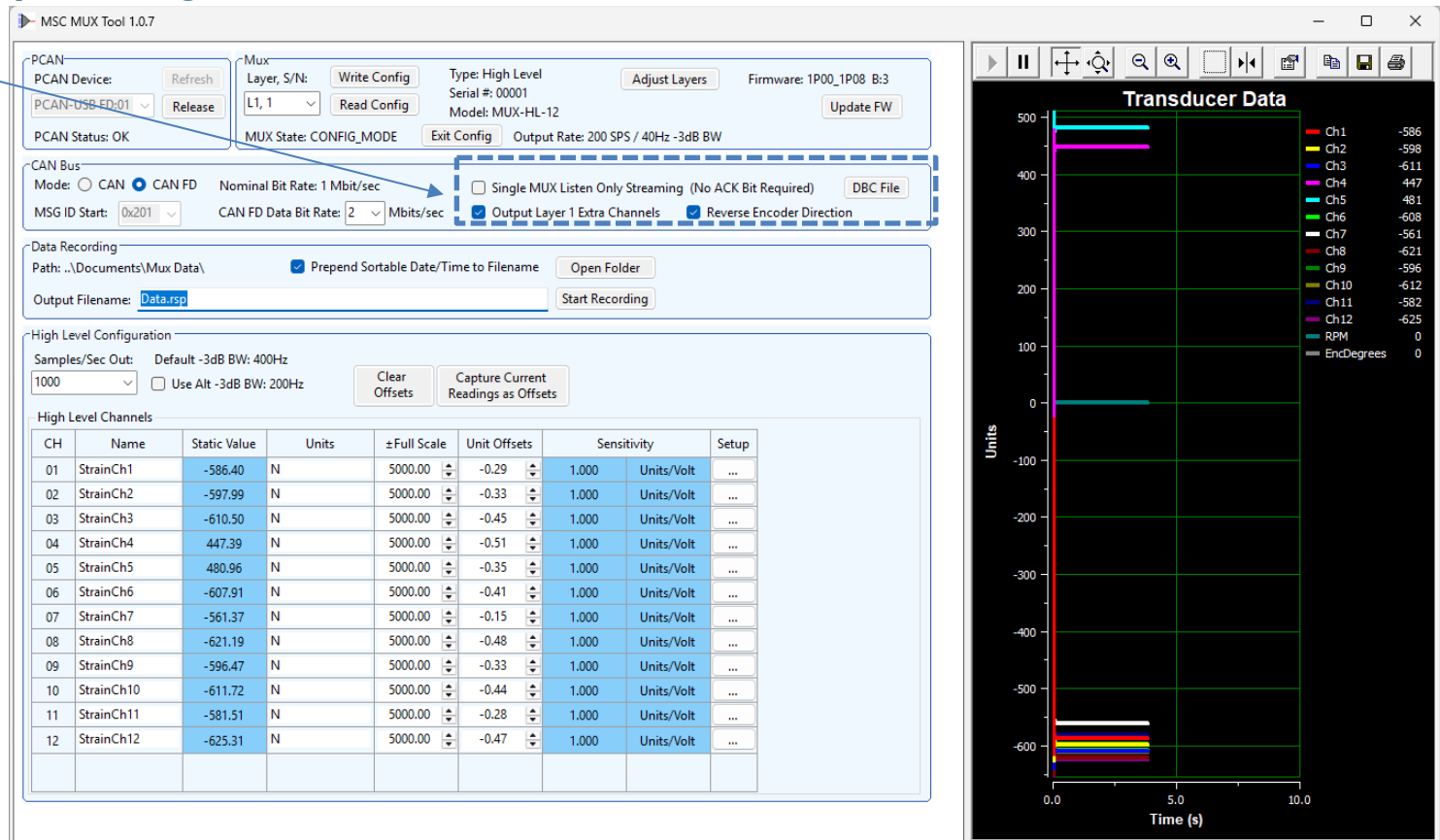
Check the box for 'Output Layer 1 Extra Channels' for devices which include a slip ring with encoder.

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, High Level

Configure the Sample rate using the drop-down menu.

See data sample rate limitations shown in table on page - 49 -.

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.

MSC MUX Tool 1.0.7

PCAN: PCAN Device: PCAN-USB FD:01 PCAN Status: OK

Mux: Layer, S/N: L1, 1 Type: High Level Serial #: 00001 Model: MUX-HL-12 Firmware: 1P00_1P08 B:3 MUX State: CONFIG_MODE Output Rate: 200 SPS / 40Hz -3dB BW

CAN Bus: Mode: ☐ CAN ☒ CAN FD Nominal Bit Rate: 1 Mbit/sec ☐ Single MUX Listen Only Streaming (No ACK Bit Required) MSG ID Start: 0x201 CAN FD Data Bit Rate: 2 Mbits/sec ☒ Output Layer 1 Extra Channels ☒ Reverse Encoder Direction

Data Recording: Path: ..\Documents\Mux Data\ ☒ Prepend Sortable Date/Time to Filename Output Filename: Data.isp

High Level Configuration: Samples/Sec Out: 1000 ☐ Use Alt -3dB BW: 200Hz

High Level Channels

CH	Name	Static Value	Units	±Full Scale	Unit Offsets	Sensitivity	Setup
01	StrainCh1	-586.40	N	5000.00	-0.29	1.000	Units/Volt
02	StrainCh2	-597.99	N	5000.00	-0.33	1.000	Units/Volt
03	StrainCh3	-610.50	N	5000.00	-0.45	1.000	Units/Volt
04	StrainCh4	447.39	N	5000.00	-0.51	1.000	Units/Volt
05	StrainCh5	480.96	N	5000.00	-0.35	1.000	Units/Volt
06	StrainCh6	-607.91	N	5000.00	-0.41	1.000	Units/Volt
07	StrainCh7	-561.37	N	5000.00	-0.15	1.000	Units/Volt
08	StrainCh8	-621.19	N	5000.00	-0.48	1.000	Units/Volt
09	StrainCh9	-596.47	N	5000.00	-0.33	1.000	Units/Volt
10	StrainCh10	-611.72	N	5000.00	-0.44	1.000	Units/Volt
11	StrainCh11	-581.51	N	5000.00	-0.28	1.000	Units/Volt
12	StrainCh12	-625.31	N	5000.00	-0.47	1.000	Units/Volt

Transducer Data

Units

Time (s)

Ch1 -586
Ch2 -598
Ch3 -611
Ch4 447
Ch5 481
Ch6 -608
Ch7 -561
Ch8 -621
Ch9 -596
Ch10 -612
Ch11 -582
Ch12 -625
RPM 0
EncDegrees 0

Channel Info, High Level

Configure the Channel Information:

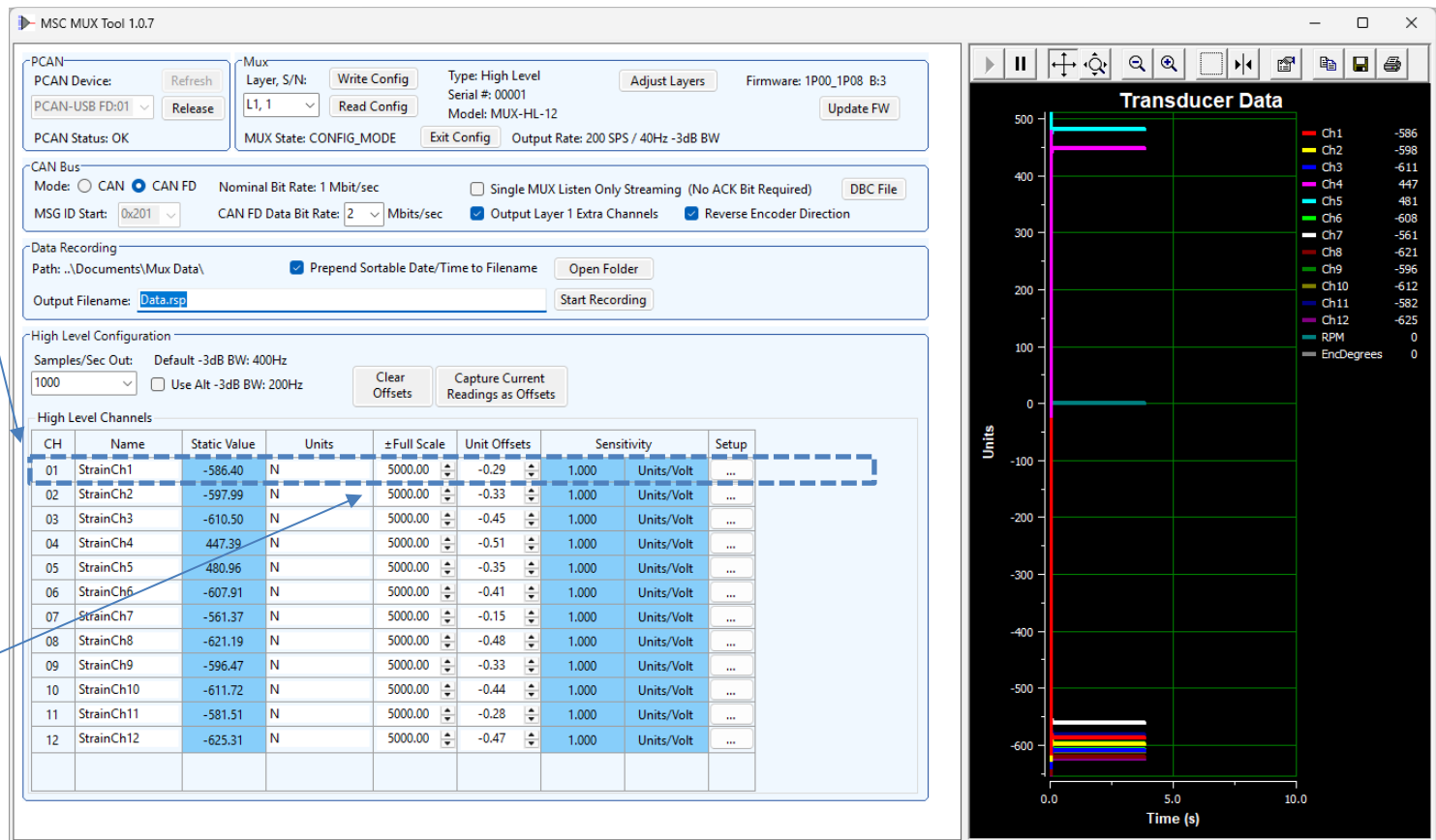
- [1] Name
- [2] Devices
- [3] Full Scale (magnitude)

Note, channels are numbered 1 to 12 on left side.

Assign a name for each channel number. Click the name field to 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.

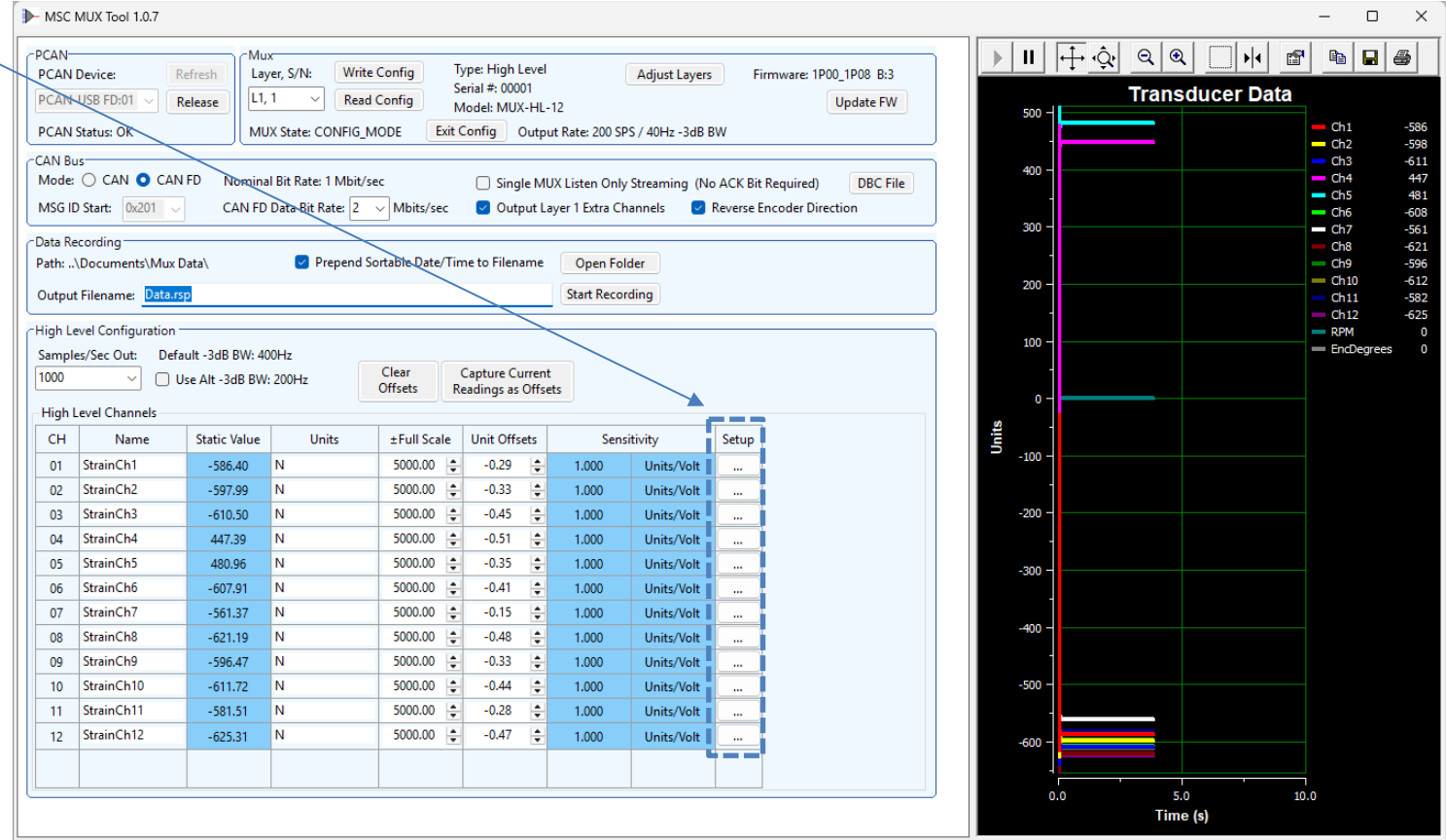
Repeat this for the Devices and Full Scale fields. Note, full scale is magnitude and not the span.

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



Channel Setup, High Level

Next, press the Setup button ‘...’
to enter the specific sensor
channel info.

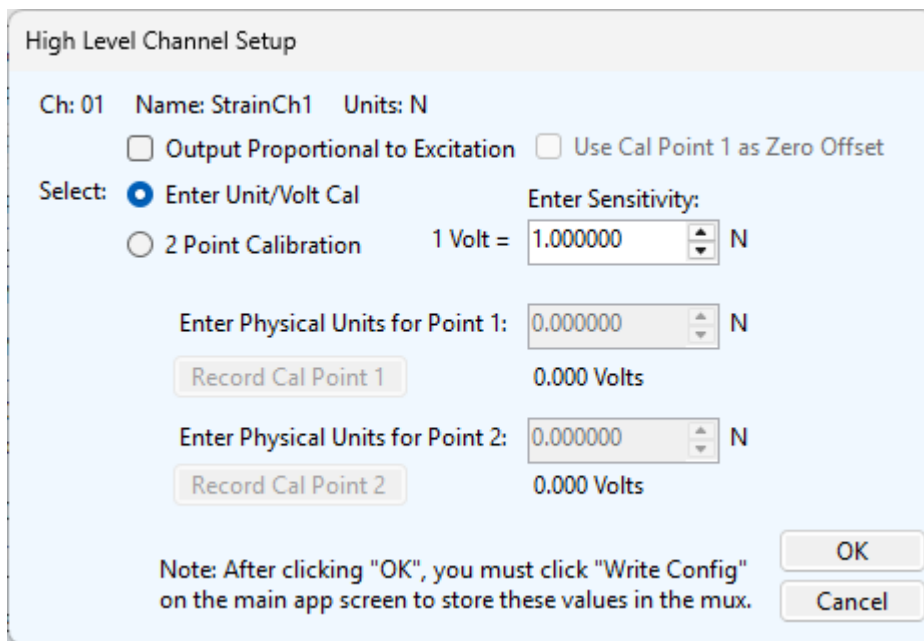


Once setup button is pressed, a pop-up window requests the sensor info.

Options exist for how to enter the sensor info, and options shown depend on the MUX variants:

[1] For ratiometric sensors, enable the option for output proportional to Excitation

[2] Select either to enter the sensitivity, OR perform a 2-point Calibration.



The image shows a 'High Level Channel Setup' dialog box. At the top, it displays 'Ch: 01', 'Name: StrainCh1', and 'Units: N'. Below this are two checkboxes: 'Output Proportional to Excitation' (unchecked) and 'Use Cal Point 1 as Zero Offset' (unchecked). A 'Select:' section contains two radio buttons: 'Enter Unit/Volt Cal' (selected) and '2 Point Calibration' (unselected). To the right of the '2 Point Calibration' option is a '1 Volt =' label followed by a text input field containing '1.000000' and a unit 'N'. Below these are two sections for 2-point calibration. The first section has a label 'Enter Physical Units for Point 1:', a text input field with '0.000000', a unit 'N', a 'Record Cal Point 1' button, and the text '0.000 Volts'. The second section has a label 'Enter Physical Units for Point 2:', a text input field with '0.000000', a unit 'N', a 'Record Cal Point 2' button, and the text '0.000 Volts'. At the bottom, there is a note: 'Note: After clicking "OK", you must click "Write Config" on the main app screen to store these values in the mux.' and two buttons: 'OK' and 'Cancel'.

High Level Channel Setup

Ch: 01 Name: StrainCh1 Units: N

☐ Output Proportional to Excitation ☐ Use Cal Point 1 as Zero Offset

Select: ☒ Enter Unit/Volt Cal ☐ 2 Point Calibration

Enter Sensitivity: 1 Volt = 1.000000 N

Enter Physical Units for Point 1: 0.000000 N
Record Cal Point 1 0.000 Volts

Enter Physical Units for Point 2: 0.000000 N
Record Cal Point 2 0.000 Volts

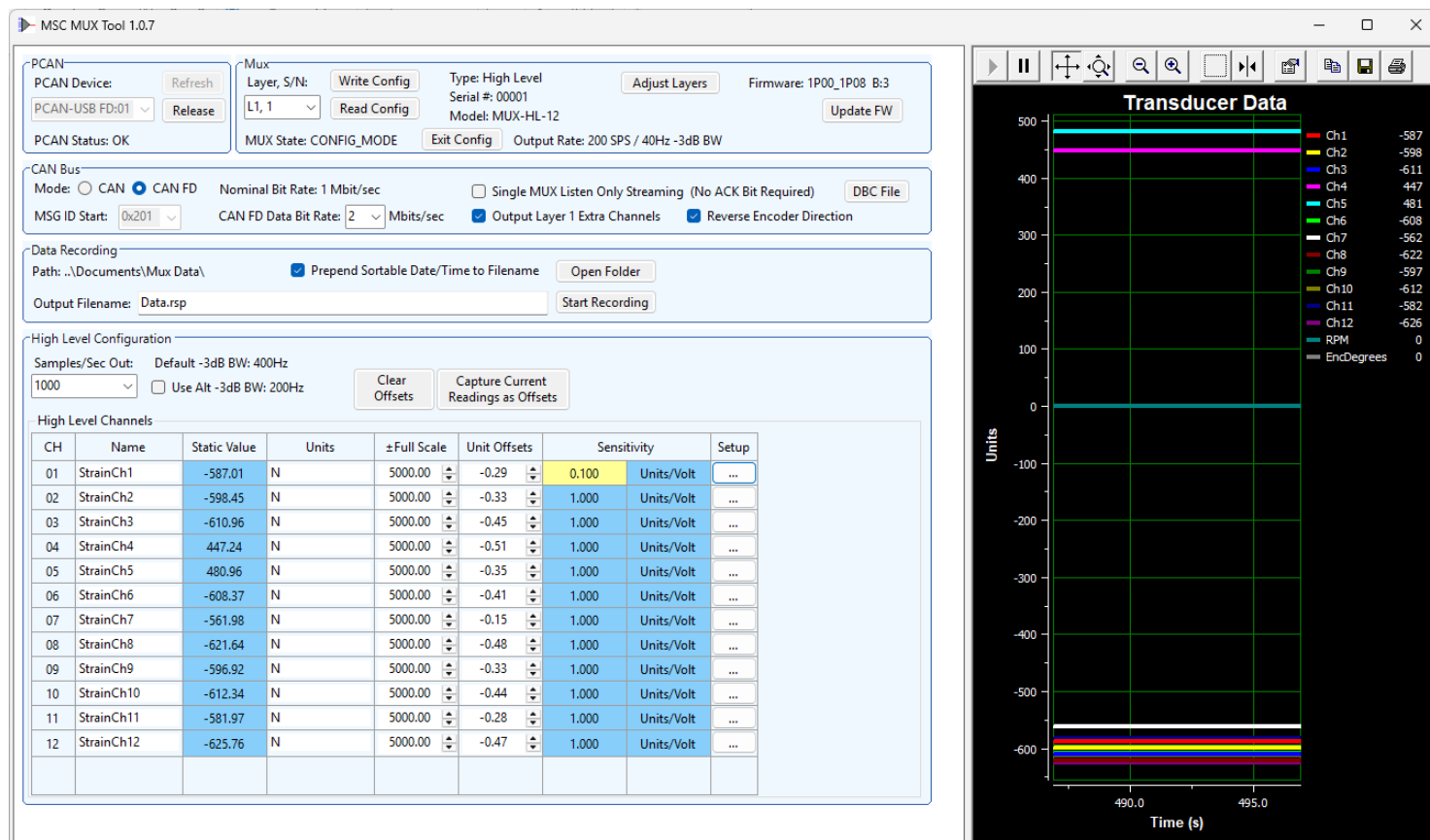
Note: After clicking "OK", you must click "Write Config" on the main app screen to store these values in the mux.

OK Cancel

Once finished entering info, press OK to exit this window.

Notice the sensor sensitivity is not stored in memory, as indicated by highlighted yellow.

Press “Write Config” to store the new sensitivity value in MUX memory.



Channel Zero balance, High Level

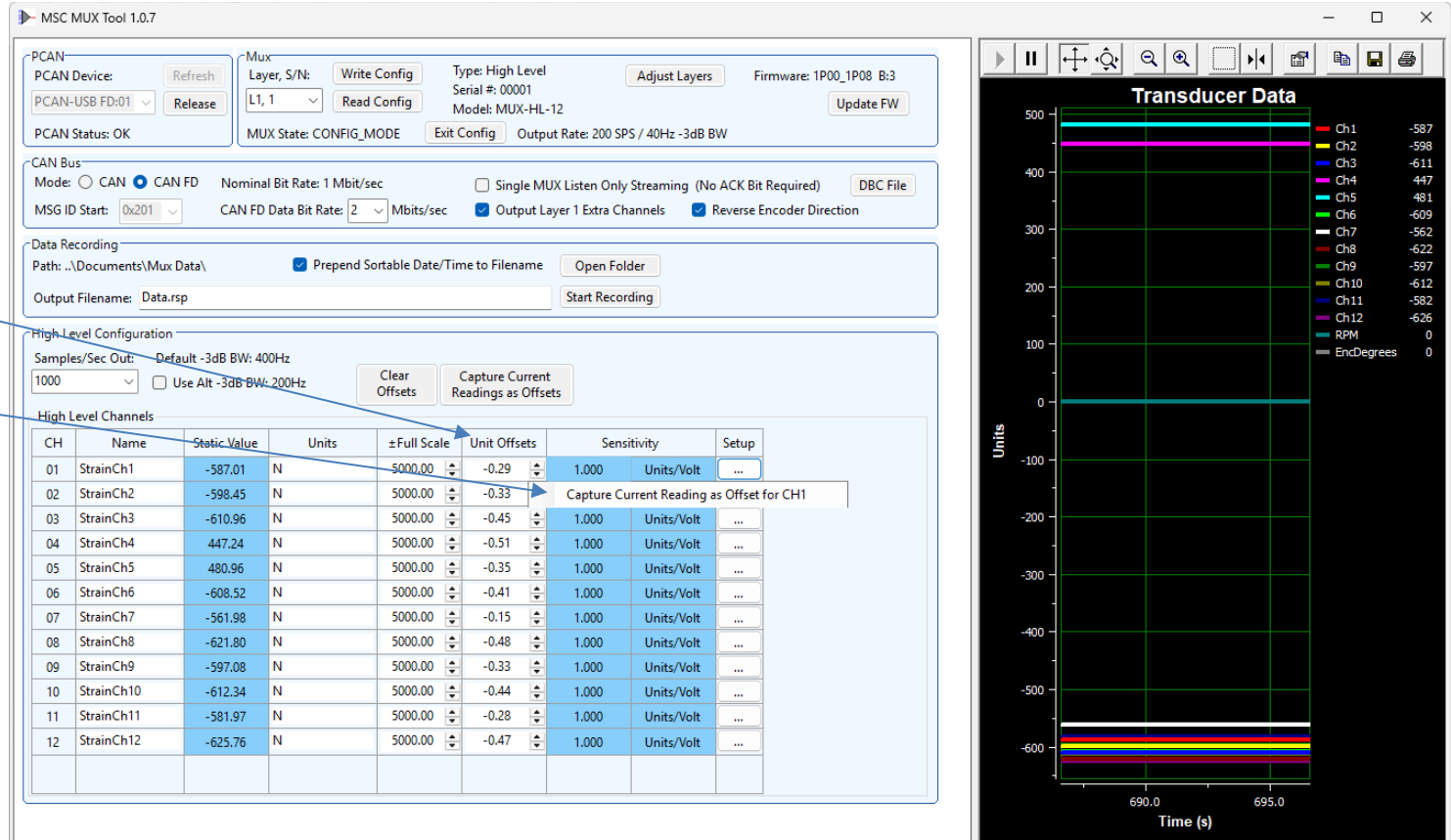
Place the sensor in balanced condition to null out any offset.

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

A pop-up dialogue appears.

Left-click on the new 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.

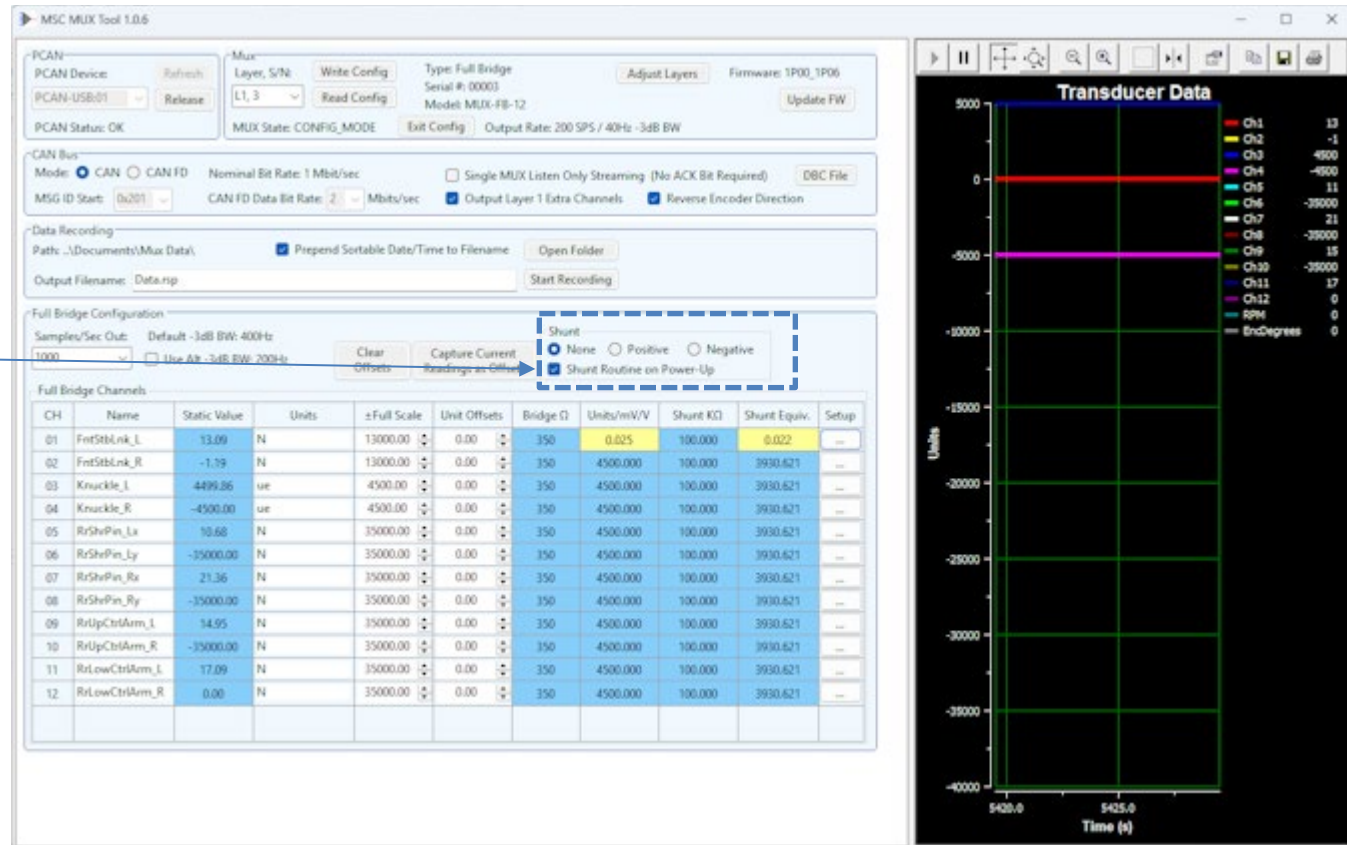


Channel Shunt Verification, High Level

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, High Level

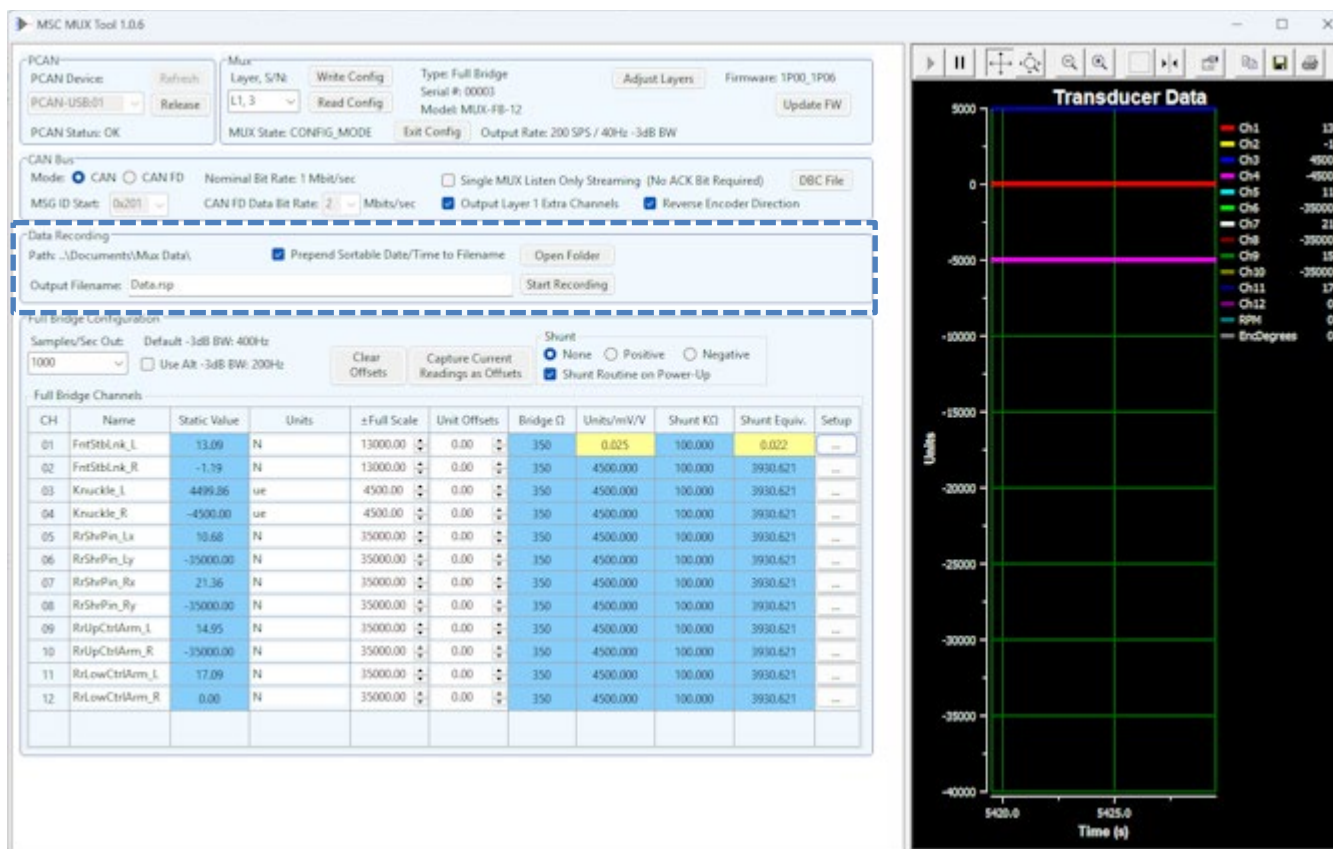
The MUX software can be used to view and record live data to a PC.

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.

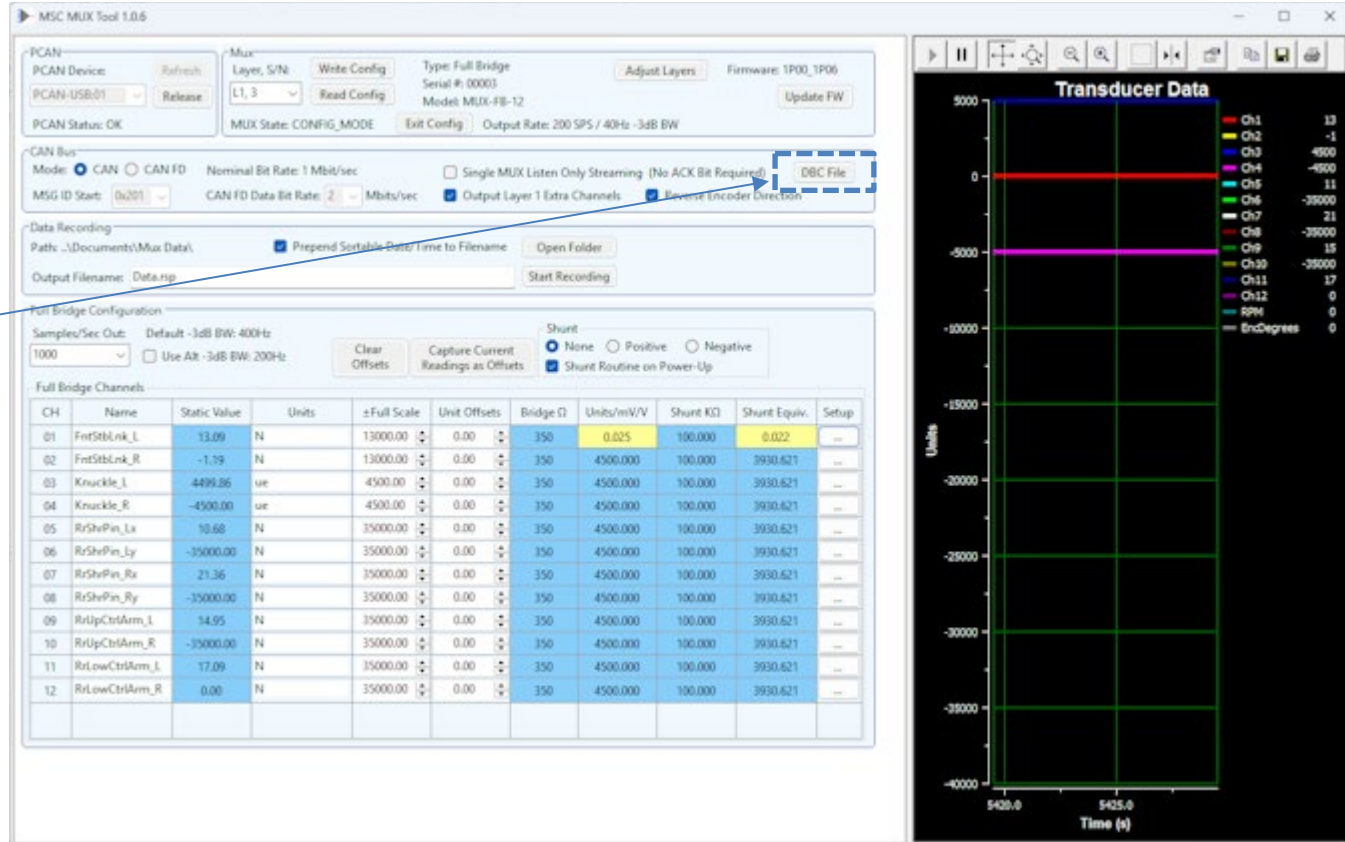


DBC file creation

When finished configuring the MUX module(s), the software can be used to generate a DBC file to be used with the data recorder.

Press the button named DBC File and select the location to store the file.

After generating the DBC file, the MUX module is ready to be used: press the Exit Config button or power cycle the module to begin streaming data.



Advanced Operation & Configuration Features

Signal Outputs

Each MUX outputs its data on the CAN bus. Any MUX module 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.

DBC file creation

A CAN database (.dbc) file is needed by the data acquisition to de-code the digital data sent by the MUX module. A .dbc file can be generated using the MUX software 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.

One consideration for using CAN signal outputs is the signal delay which is dependent on output rate. See page - 49 - for details on signal delays.

Shunt Verification 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 on a single CAN bus, use the software to configure one to be the leader, and others as followers. A unique CAN ID is assigned to each module.

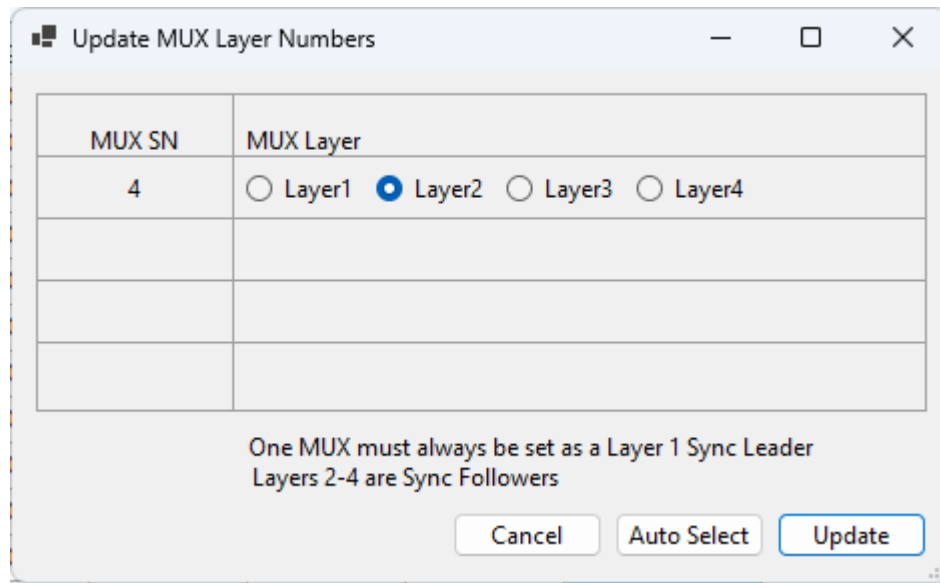


Figure 13: MUX stack synchronization layer select window.

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.

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

Figure 14: 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.

Output Sample Rates

Maximum Data Rates

The following output sampling rate limitations apply for single dedicated data bus. Note, CAN FD rates are shown with or without an encoder.

	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 15: MUX Max Output Data Rates.

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 16: 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 17: 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 18: MUX Filter Magnitude Response chart for input signal frequency 1250 to 3800Hz.

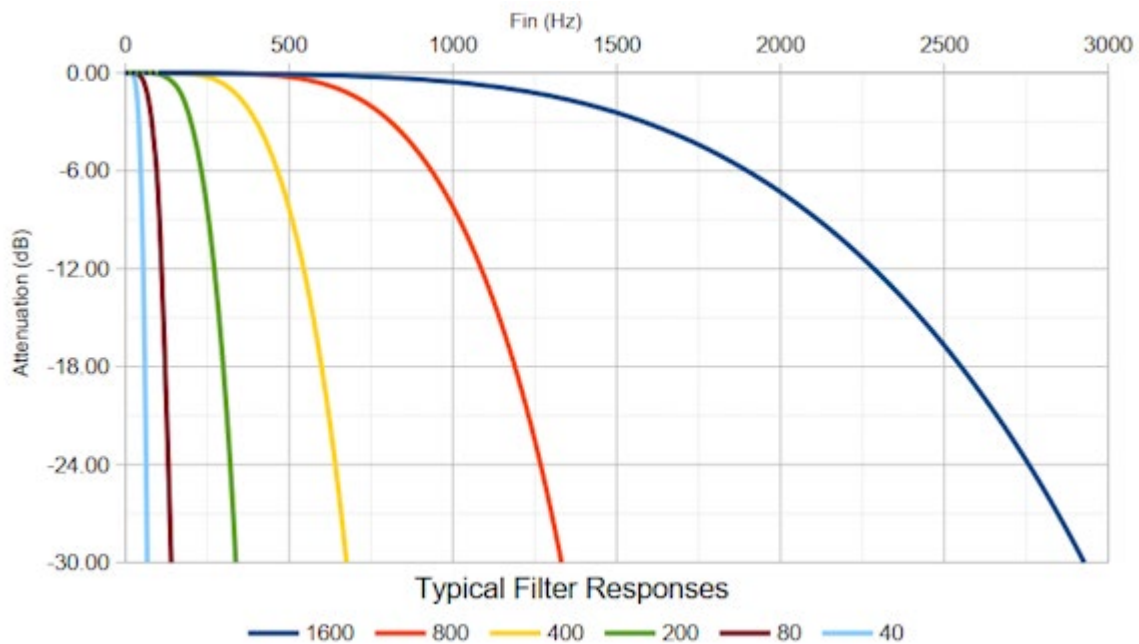


Figure 19: MUX Filter Magnitude Response plot.

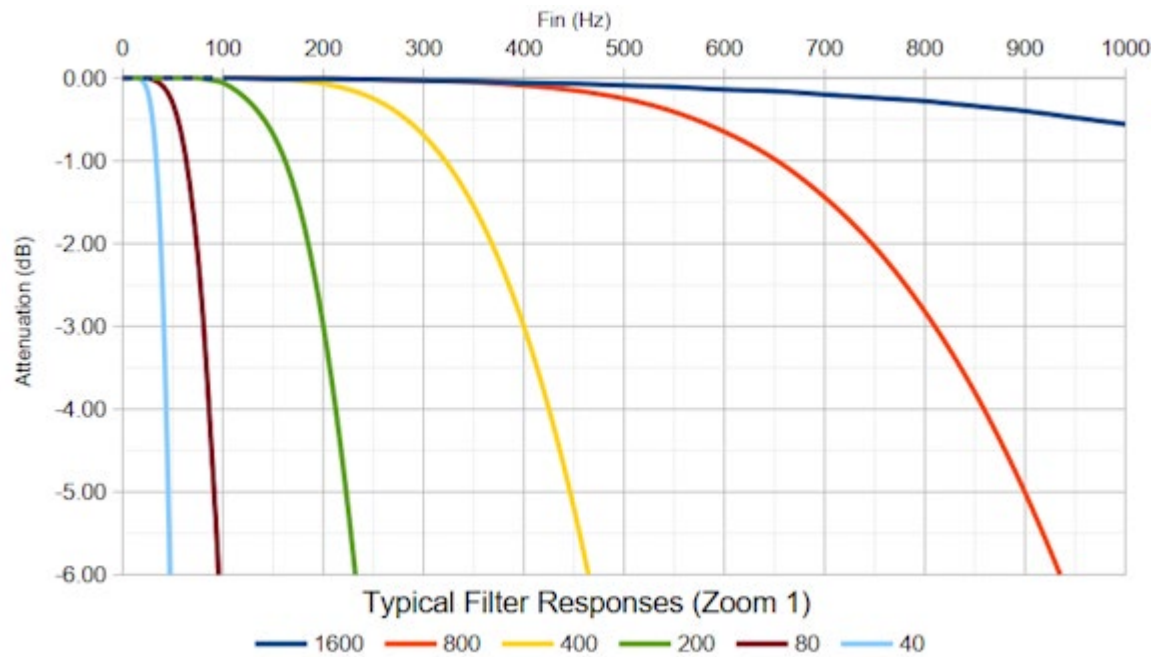


Figure 20: MUX Filter Magnitude Response plot (zoom1).

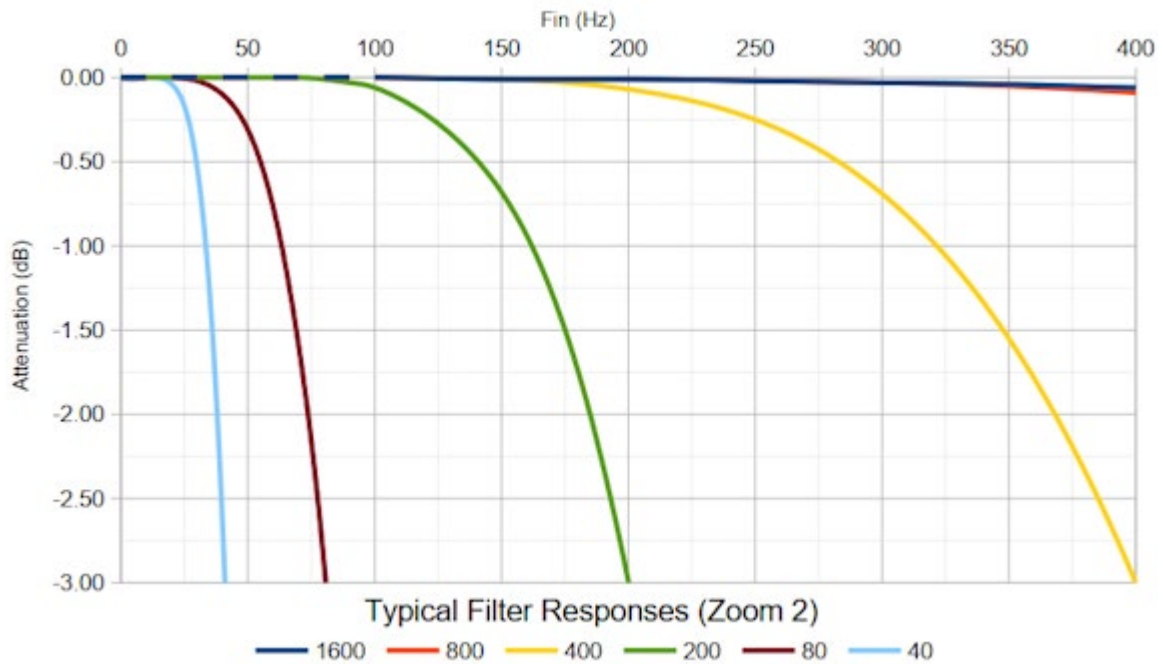


Figure 21: MUX Filter Magnitude Response plot (zoom2).

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

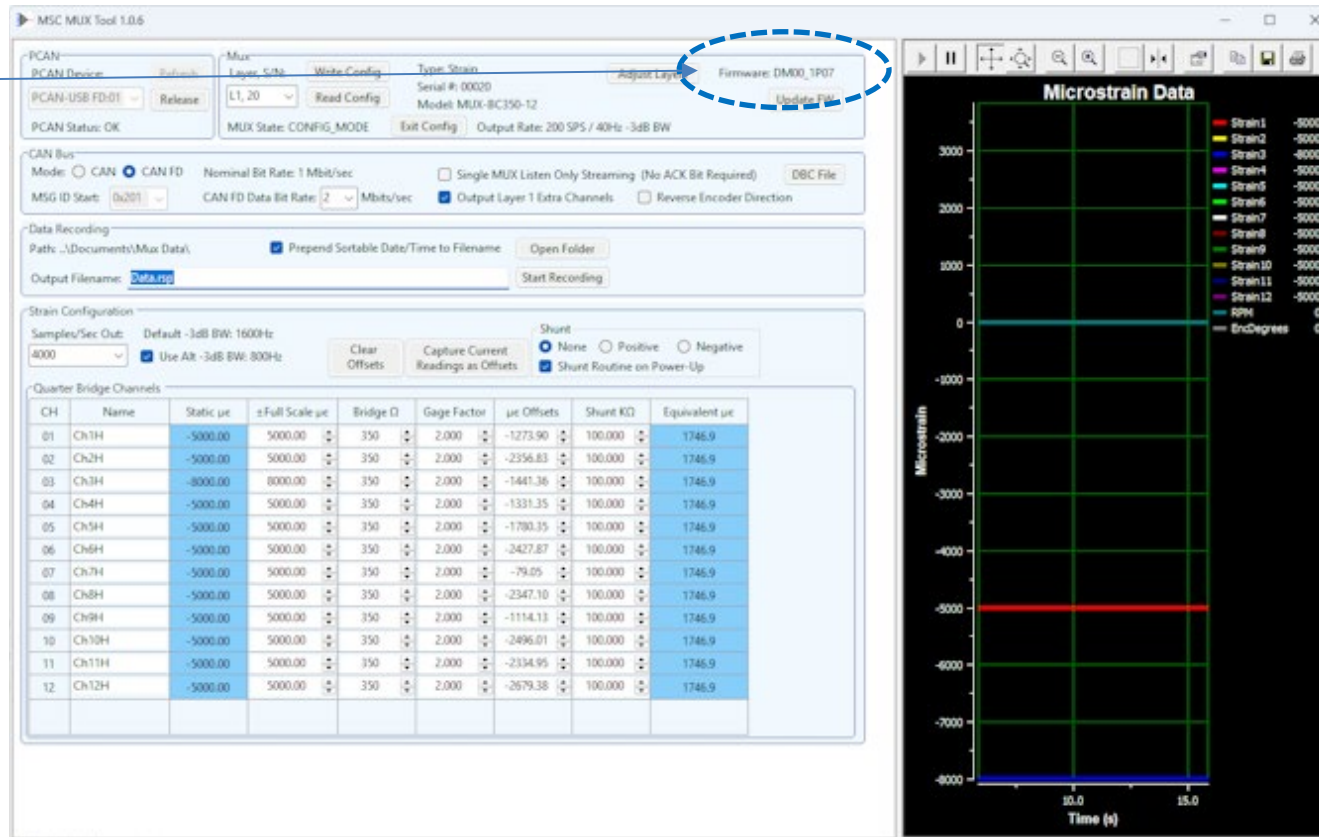


Figure 22: MUX Software Main Screen showing Firmware version.

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

Connection details are specified on page - 20 -.

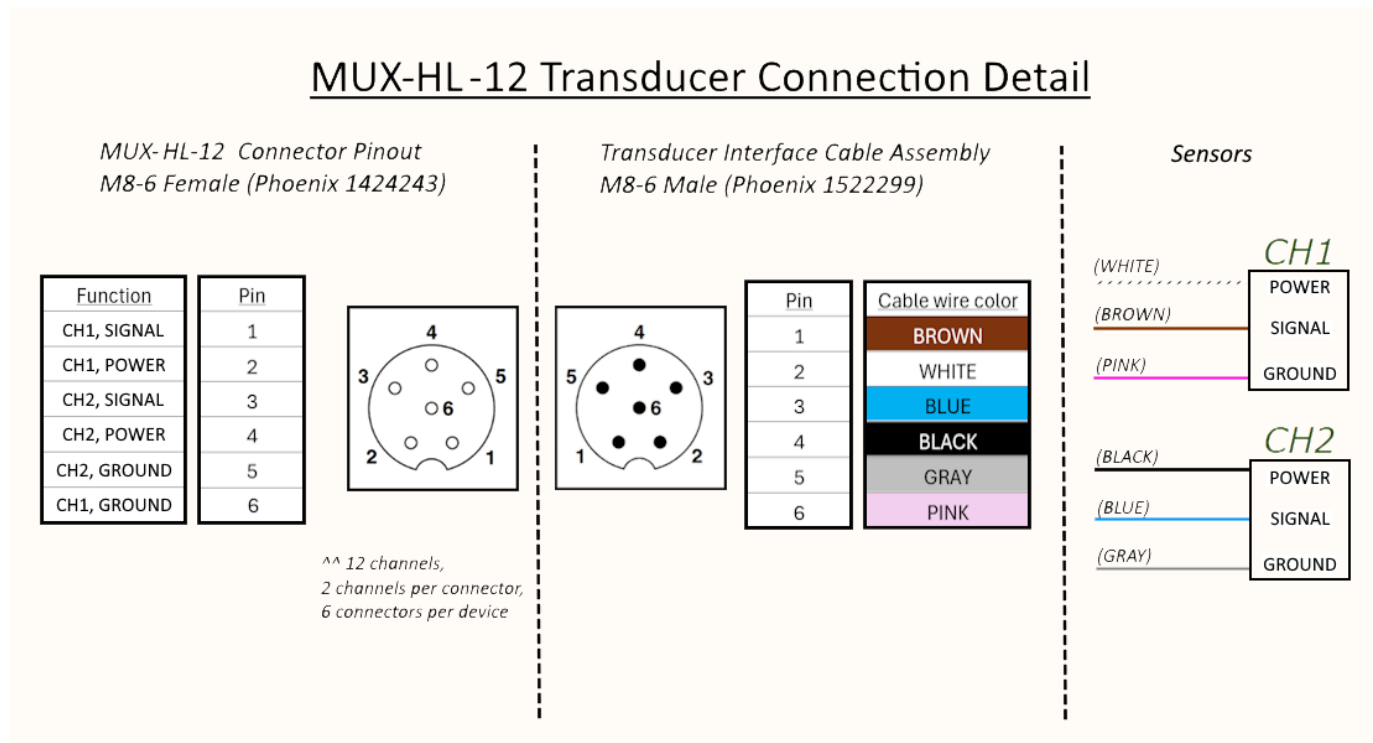


Figure 23: Transducer Connection Diagram.

Appendix B: Dimensional Drawing, Slip ring SR10AW/WFT

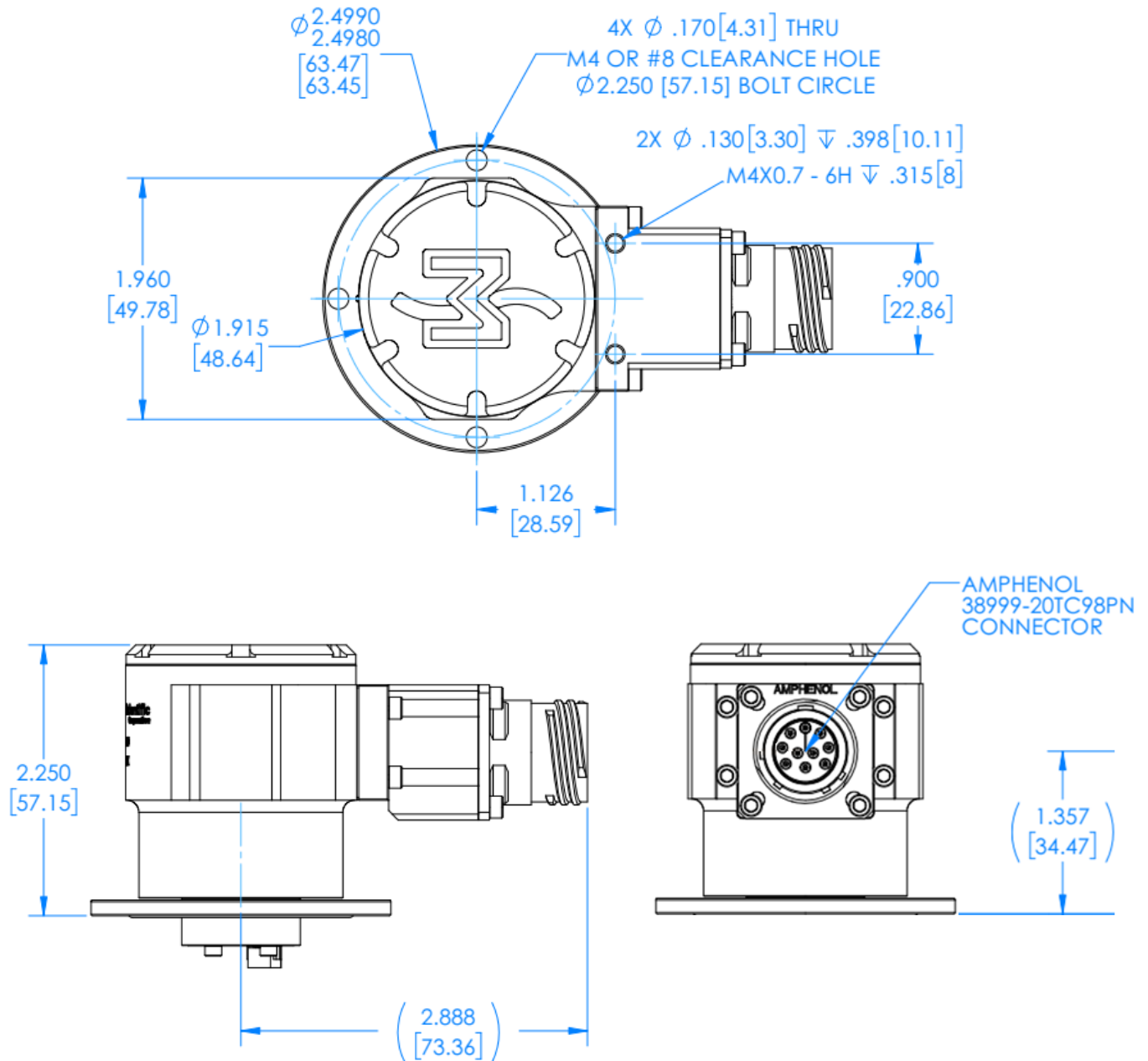


Figure 24: Dimensioned Drawing, Slip Ring Model SR10AW/WFT.

^^ units shown as inches [mm] ^^

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

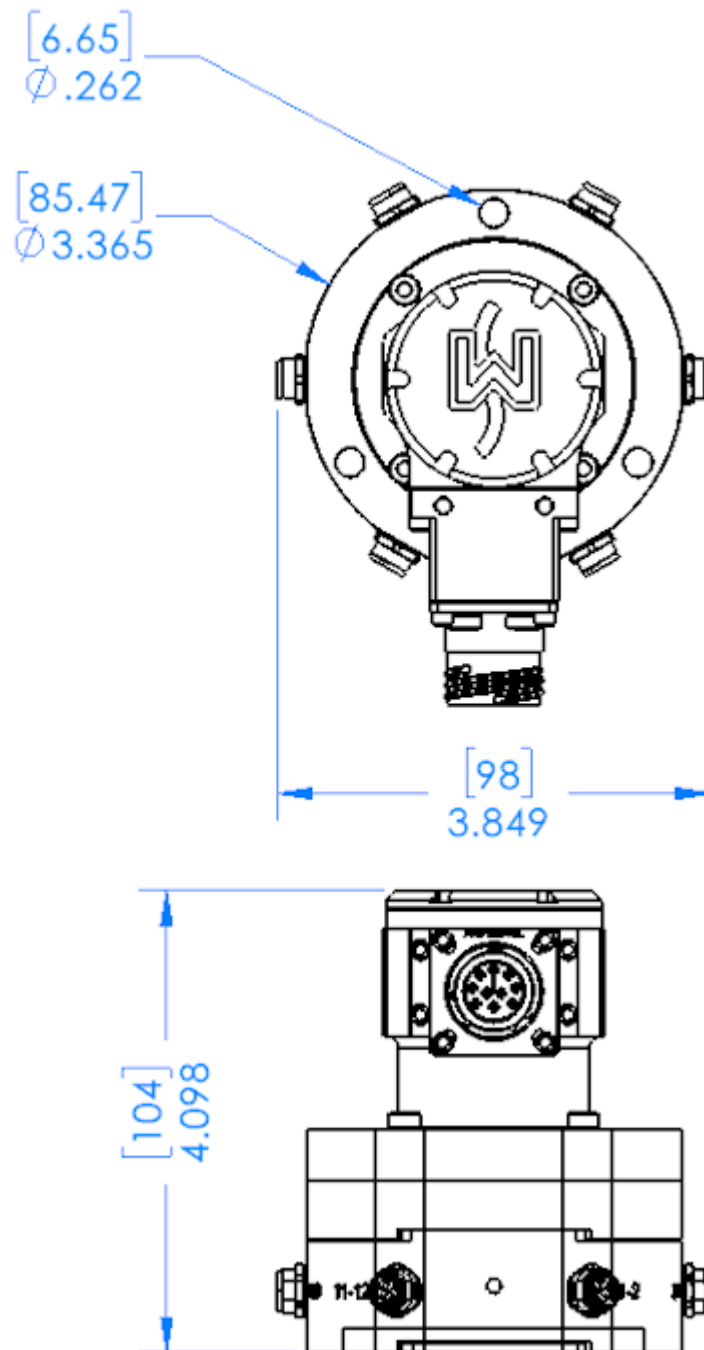


Figure 25: Dimensioned Drawing of MUX, slip ring and encoder adapter.

^^ 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

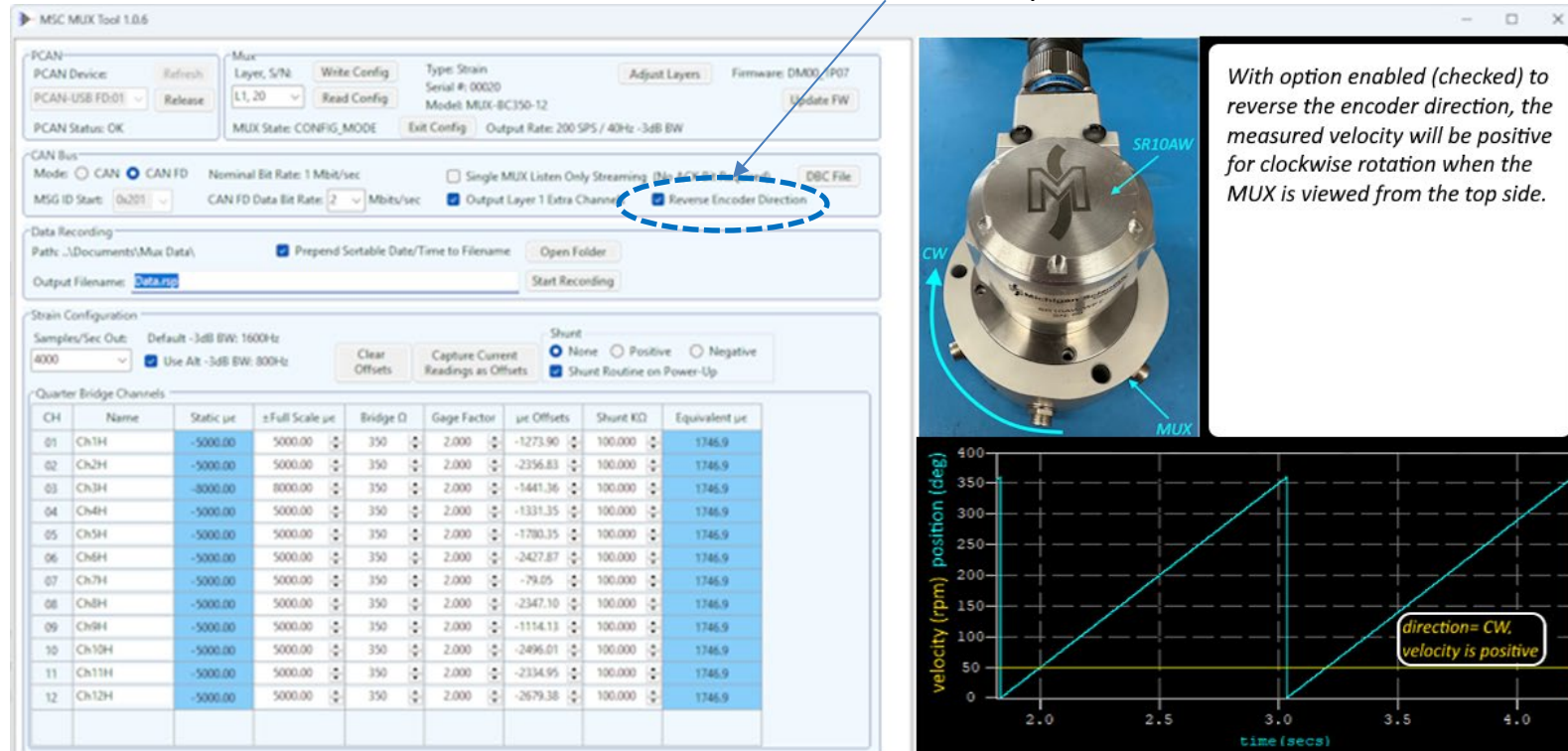


Figure 26: MUX software main screen showing encoder direction reverse option.