University of Michigan FSCV System Manual

User Manual

v3.0

Release Date: 8-14-2022

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Table of Contents

Introduction

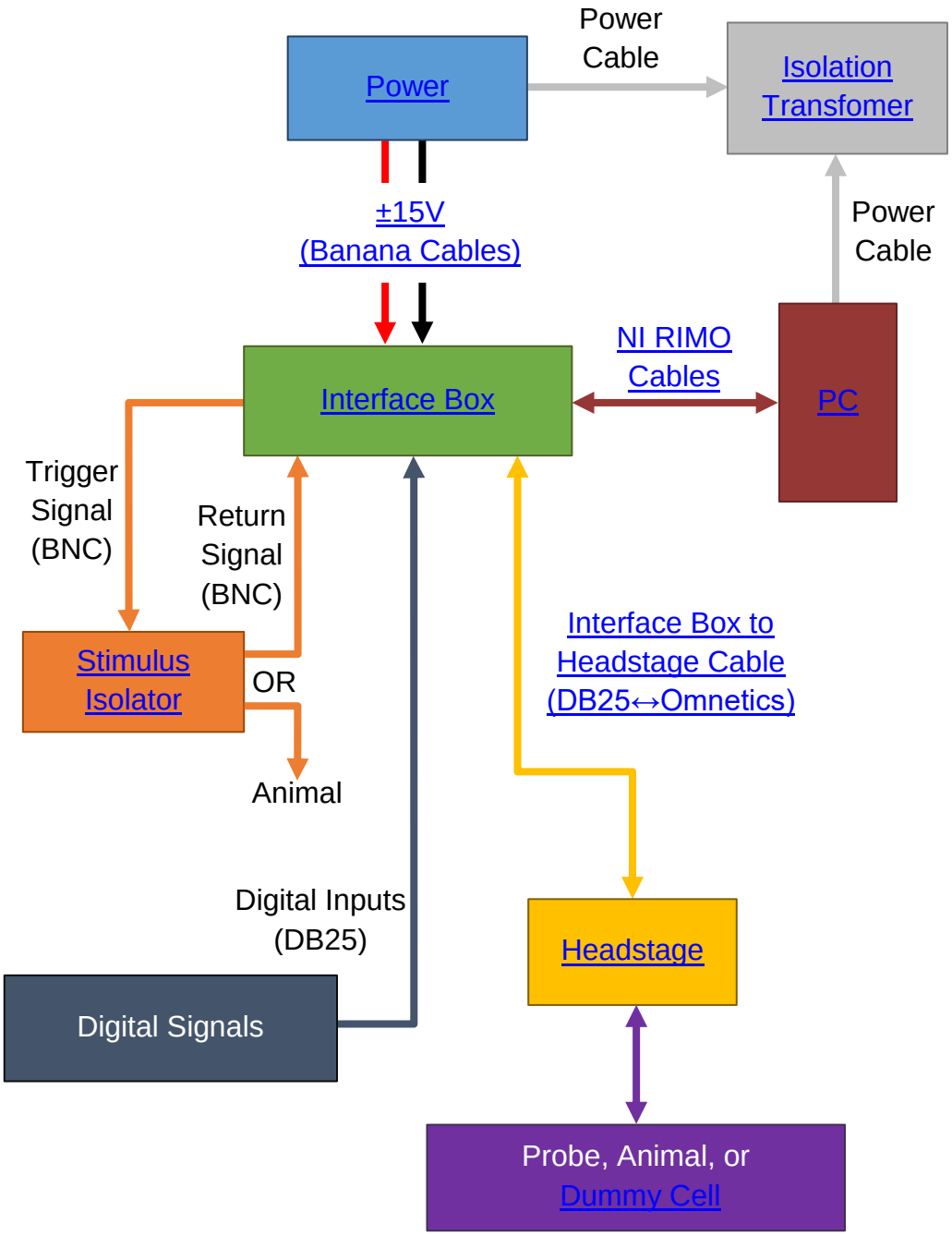
This describes all parts and instructions necessary to assemble a 16 or 32 channel fast scan cyclic voltammetry (FSCV) system.

System Setup

Below are the steps and any pertinent directions needed to set up your system. Also refer to the diagram below showing how all of the different FSCV system components are connected to each other.

1. Install your FSCV cards according to the steps in computer and LabVIEW.
2. Set up the power supply according to the steps in power.
3. Connect the ±15V from the power supply to the interface box. Also connect the RMIO cables from the FPGA cards' **connector 0** to the interface box. If you are recording from 32 channels, then the lower set of 68-pin connectors in the interface box are for FPGA cards 0 and 1. The upper set is for FPGA cards 2 and 3.
4. Connect the Stim Iso Out BNC from the interface box to the stimulus isolator unit. If the stimulation signal is going to be routed through the headstage cable, then connect the output of the stimulus isolator to the Stim Iso In BNC on the interface box.
5. Connect any digital input signals to the Digital Inputs DB25 on the interface box. **IMPORTANT:** If you are recording from 16 channels, then you must use the Digital Input DB25 connector on the lower level (i.e. where FGPA cards 0 and 1 connect). If you are recording from 32 channels, then you must use the Digital Input DB25 connector on the upper level (i.e. where FGPA cards 2 and 3 connect). The lower digital input connector is not functional when operating in 32 channel mode.
6. Connect the interface box to headstage cable to the Headstage DB25 connection on the interface box.
7. Connect the headstage to the Omnetics connector of the headstage cable.
8. Connect a dummy cell to the headstage and connect the reference pins with a reference jumper wire.

Below is a diagram showing how all the different FSCV system components are connected to each other.



Computer and LabVIEW

Parts List

The quantities listed below are for making a 16 channel system.

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
eBay or Newegg	n/a	HP Z420 Workstation E5-1620 Quad Core*	1	$600.00
National Instruments	781100-01	PCIe-7841 R Series Card‡	2	$5,035.00
National Instruments	776249-02 or 776249-04	RTSI Bus Cable (16 channel system) or RTSI Bus Cable (32 channel system)	1	$51.00 or $78.00
National Instruments	189588-02	SHC68-68-RMIO Multifunction Cable for R Series – 2 meters (used later)‡	2	$228.00

‡To build a 32 channel system, double the order for these parts.

*Note: We understand that the computer listed is a legacy model and will need to be ordered from a 3rd party vendor through Newegg, eBay, etc. We apologize for this inconvenience, but we have not found another computer model that is 100% compatible with our code. Other computers have worked, but after ~45 minutes of continuous recording the data becomes corrupted, which requires the program to be restarted.

Installation Instructions

Step 1: Plugging in the Computer

Plug the computer in to the isolation transformer.

Step 2: Installing the PCIe-7841r Cards and RTSI Cable

With the computer off, install the PCIe-7841r cards in to the appropriate PCIe slots in the computer. It helps to keep a slot between them as this makes installing the RTSI cable easier. Note the serial number of the cards (Figure 1, yellow arrow) and which position the cards are in relative to one another.

Next, install the RTSI cable (Figure 1, blue arrow) to connect the cards together. The choice of connectors to use and the overall orientation do not matter. The image here shows the installation of two cards, but four are possible for 32 channels; however, the 4-channel RTSI cable must be purchased instead (National Instruments #776249-04).

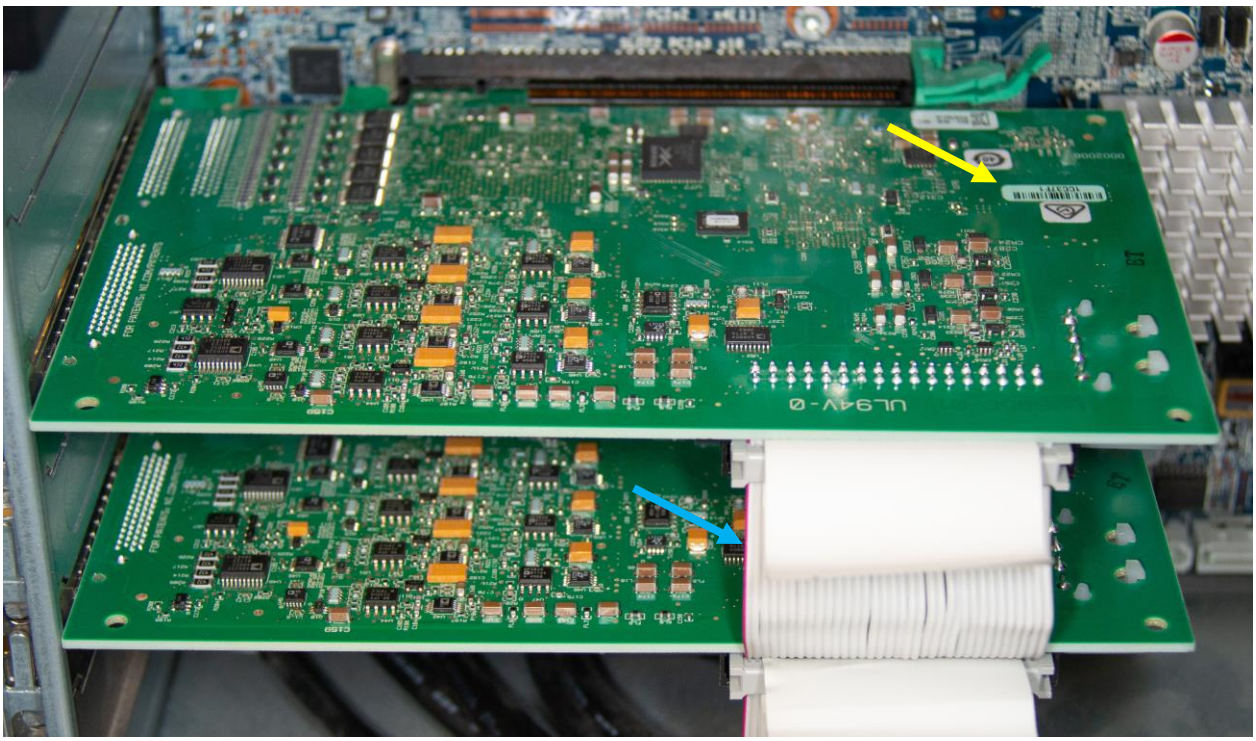


Figure 1 – Installed PCIe-7841r cards connected with a RTSI cable (blue arrow).

Step 3: Installing the Drivers

Visit, https://www.ni.com/en-us/support/downloads/drivers/download.ni-r-series-multifunction-rio.html and download the latest R-series drivers for Windows. If you don't have an account, then create one. Run the setup.exe file and use all of the default settings. Accept the license agreement when asked. Make sure at least one run-time

environment (2018 or later) is being installed when prompted with the list of drivers and packages.

After rebooting the computer run the NI MAX program. Click on the arrow next to “Devices and Interfaces”. Then, click on the “RIO0” entry and note the serial number. This will be Card/Board/Cable 0 when referenced throughout the manual. Any other entries listed will follow the same referencing system. Label the backside of the computer with the RIO number of each card using the previously documented serial numbers and physical positions.

For a 16 channel system the two boards in use will be numbered 0 and 1. For a 32 channel system, boards numbered 2 and 3 will also be used.

Power

The power supply unit provides power to the headstages, which routes through the interface box. The isolation transformer helps to diminish external line noise and leads to a cleaner overall signal.

Parts List

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
CDW	184802	Tripp Lite Isolation Transformer 1000W	1	$293.99
Digikey	BK1672-ND	B&K Precision 1672 Power Supply	1	$489.00
Digikey	501-1583-ND	Green Banana Plug Cable, 4"	2	$5.29
Digikey	501-1044-ND	Red Banana Plug Cable, 18" (choose best length for lab's setup)	1	$5.89
Digikey	501-1043-ND	Black Banana Plug Cable, 18" (choose best length for lab's setup)	1	$5.89

Assembly Instructions

Step 1: Plugging in the Isolation Transformer and Power Supply

Plug the isolation transformer into a standard 120V wall socket. Next, plug the power supply into one of the isolation transformer's sockets.

Step 2: Connecting the Banana Cables and Setting the Voltage

Replicate the banana plug cables and labeling as seen in Figure 2. Before powering up, set all four dials to their furthest counterclockwise position. Power up the unit and slowly increase each current knob until the respective red CC light turns off and the green CV light turns on. Next, set both voltage dials such that the display reads 15.0V, then power off the unit. Mark on the case where the dials line up with 15.0V (optional).

Figure 2 – Power supply configuration.

Interface Box

The interface box is the integrating interface between the NI cards, power supply, headstage/probe, digital inputs, and the stimulus isolator.

Parts List

The quantities listed below are for making a single 16 channel interface box. To build a 32 channel system, see the notes at the bottom of the table.

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
	Custom PCB	FSCV Interface Box* (click link to access files)	1	Will vary by manufacturer
Digikey	A33476-ND	Male D-Type 68-pin Connector*	2	$27.11
Digikey	2057-DB25-SL-24-ND	Male D-Sub (DB) 25-pin Connector*	2	$1.67
Digikey	116-40-98442F-ND	D-Sub (DB) Jack Screw*	2	$1.40
Digikey	2861-EK350A-06P-ND	6 Position Terminal Block*	1	$3.96
Digikey	399-14006-ND	0.1uF Ceramic Capacitor*	1	$6.40
Digikey	PTF651K0000BYEK-ND	1kΩ Metal Film Resistor*	1	$4.44
Digikey	BC4461CT-ND	3kΩ Film Resistor*	1	$0.29
Digikey	2183-2649-ND	22AWG Wire	1	$6.10
Digikey	S2011EC-01-ND	2 Position Jumper Pins	1	$0.08
Digikey	S9337-ND	Jumper	1	$0.10
Digikey	A32270-ND	BNC Connector Jack	2	$9.47
Digikey	501-1411-ND	Red Alligator Clip	1	$1.85
Digikey	501-1849-ND	Black Alligator Clip	1	$1.85
Digikey	36-25514-ND	M3 Hex Standoff, 20mm	6	$0.81
Digikey	HM1481-ND	Bumper Feet	1 pk	$9.06 (pk)
Grainger	6GE26	M2.5-0.45, 4mm Screw	1 pk	$2.98 (pk)
Grainger	61JF76	M3, 5mm Screw	1 pk	$6.85 (pk)
Digikey	36-25505-ND	M3 Hex Standoff, 20mm‡	6	$0.62

*To build a 32 channel system, double the order for these parts.

‡To build a 32 channel system order this part in addition to the other hex standoff.

Required Tools and Supplies:

- Soldering iron, solder, and flux (Grainger #1UYJ2)
- Masking tape
- Wire strippers (22 AWG) and cutters
- Phillips screwdriver (P0-P1)
- Flathead screwdriver (2-2.5mm)

Optional Tools and Supplies:

- Helping hands soldering aid
- 100% isopropyl alcohol (IPA)

Channel Mapping

Board/Card/Cable 0				Board/Card/Cable 1		
Connector 0 Terminal	DB25 Pin	System Channel		Connector 0 Terminal	DB25 Pin	System Channel
68	DB1-6	1		68	DB1-10	9
66	DB1-8	2		66	DB1-11	10
65	DB1-18	3		65	DB1-12	11
63	DB1-20	4		63	DB1-13	12
62	DB1-1	5		62	DB1-15	13
60	DB1-2	6		60	DB1-16	14
59	DB1-3	7		59	DB1-17	15
57	DB1-4	8		57	DB1-19	16
				37	DB2-1	DI1
				38	DB2-2	DI2
				39	DB2-3	DI3
				40	DB2-4	DI4
				41	DB2-5	DI5
				42	DB2-6	DI6
				43	DB2-7	DI7
				10	DB2-8	DI8

Board/Card/Cable 2				Board/Card/Cable 3		
Connector 0 Terminal	DB25 Pin	System Channel		Connector 0 Terminal	DB25 Pin	System Channel
68	DB3-6	17		68	DB3-10	25
66	DB3-8	18		66	DB3-11	26
65	DB3-18	19		65	DB3-12	27
63	DB3-20	20		63	DB3-13	28
62	DB3-1	21		62	DB3-15	29
60	DB3-2	22		60	DB3-16	30
59	DB3-3	23		59	DB3-17	31
57	DB3-4	24		57	DB3-19	32
				37	DB4-1	DI1
				38	DB4-2	DI2
				39	DB4-3	DI3
				40	DB4-4	DI4
				41	DB4-5	DI5
				42	DB4-6	DI6
				43	DB4-7	DI7
				10	DB4-8	DI8

Assembly Instructions

Step 1: Soldering the 68-Pin, DB25, and BNC Connectors

Use the M2.5 screws to secure the 68-pin connectors to the board, by attaching from the underside (Figure 3, red arrows). Snap the DB25 connector into the interface box board (Figure 3, blue arrows). Populate the TO_STIM and FROM_STIM holes with the BNC connectors (Figure 3, yellow arrows) and tape them to the board, so that they stay flat and do not fall out during soldering. Flip the board over, solder all of the connections, and remove the tape.

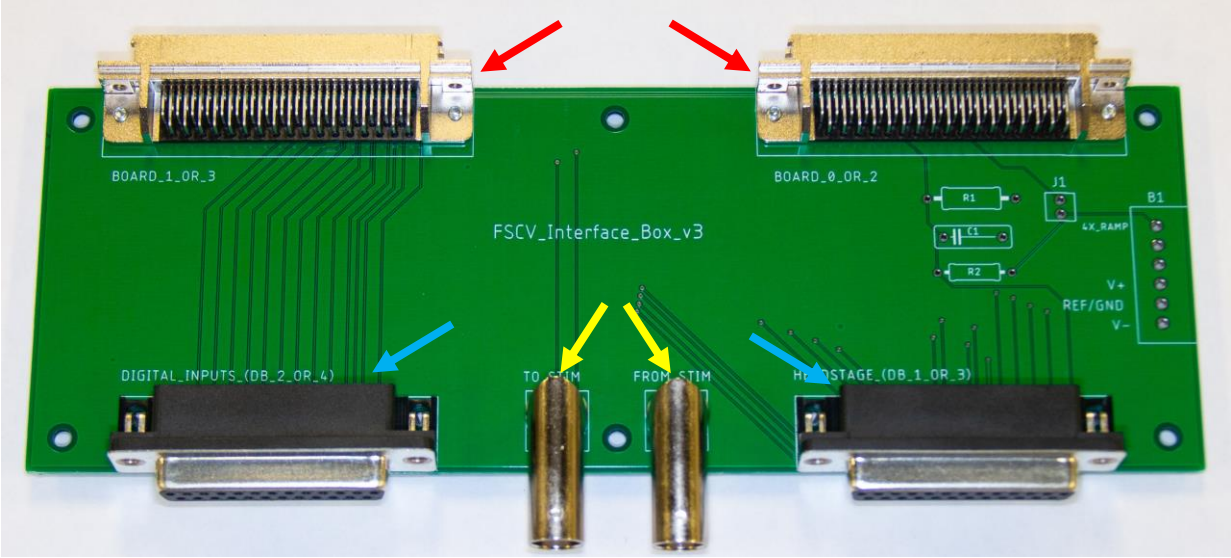


Figure 3 – Interface box board populated with 68-pin connectors secured by screws, BNC connectors, and DB25 connectors.

To the front of the DB25 connectors attach the D-sub jack screws (Figure 4).

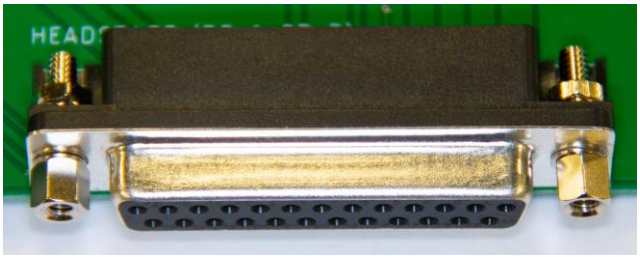


Figure 4 – A DB25 connector populated with jack screws.

Step 2: Soldering the Resistors, Capacitor, Jumper Pins, and Terminal Block

Populate R1 with the 1kΩ resistor, C1 with the 0.1uF capacitor, R2 with the 3kΩ resistor, J1 with the 2 position jumper pins, and B1 with the terminal block (Figure 5).

Tape any parts as needed to secure them, solder from the underside, cut away excess wires, and remove any tape.

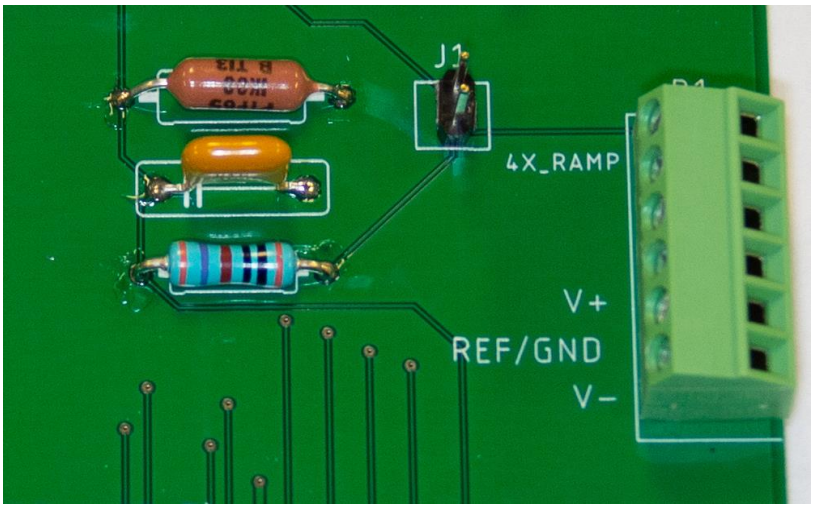


Figure 5 – Interface box board populated with resistors, capacitor, jumper pins, and terminal block.

Step 3a: Assembling a 16 Channel System

Use the jumper to connect the two jumper pins together (Figure 6, yellow arrow). Use the M3 screws to secure the hex standoffs to the interface board (Figure 6, red arrows).

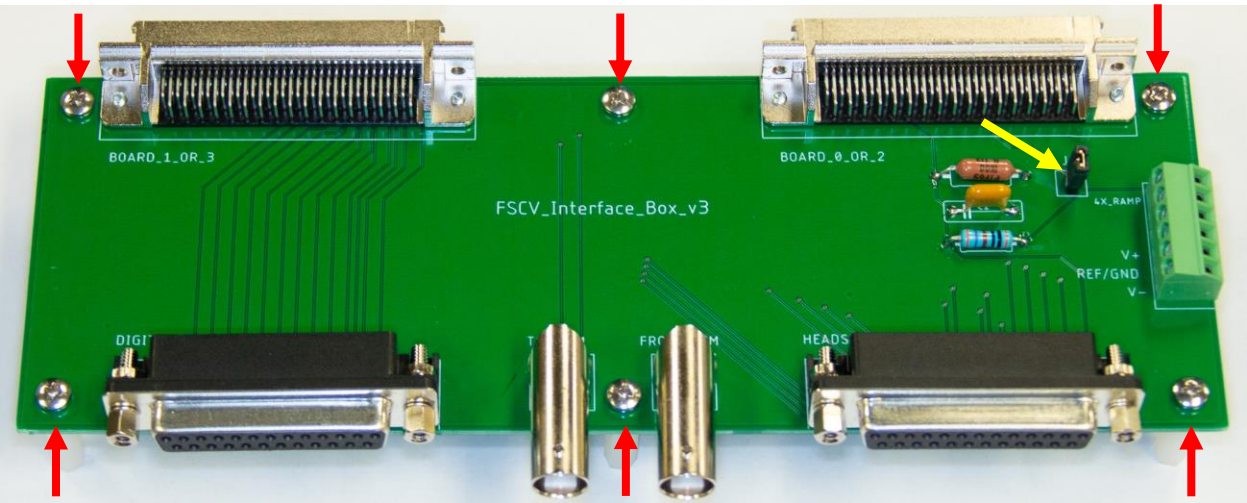


Figure 6 – Connected jumper pins and hex standoffs secured with screws.

Cut two lengths of wire approximately 4cm in length. From each end strip away approximately 5mm. Tin the exposed wire by twisting the ends, dipping them into flux, and applying a small amount of solder. Attach one wire to the terminal block connection V+, another to V-, and tighten the corresponding screws to secure the wires (Figure 7,

yellow arrows). Next, attach the banana plug cables from the power supply to the wires using the alligator clip connectors (Figure 7, blue arrows). Match V+ from the power supply to the V+ wire and V- to V-.

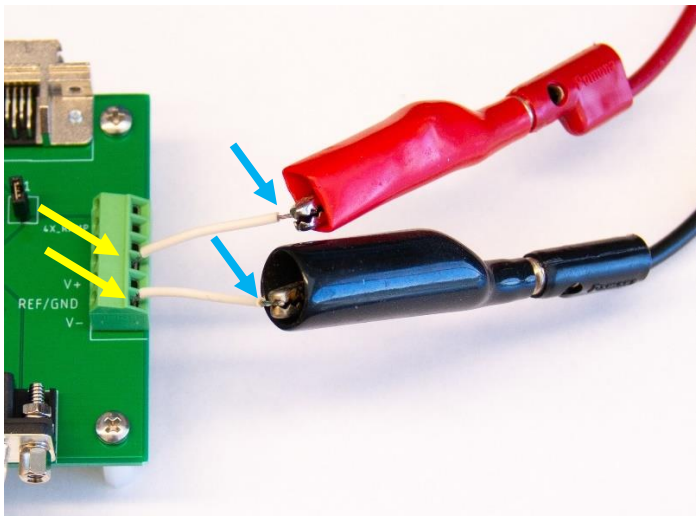


Figure 7 – Power supplied to the interface system.

Step 3b: Assembling a 32 Channel System

Solder the first board according to steps 1 and 2. Solder a second board also following steps 1 and 2; however, do not attach the BNC connectors or the jumper pins.

To the first board attach the hex standoffs, by using both types. The standoff on the underside should be the male/female version with the male end protruding through the board's holes. Connect the female/female one to the protruding end of the underside standoffs, effectively sandwiching the board (Figure 8, red arrows).

Cut three lengths of wire approximately 4cm in length. From each end strip away approximately 5mm. Tin the exposed wire by twisting the ends, dipping them into flux, and applying a small amount of solder. To the first board attach a wire to each of the following terminal block connections, 4X_RAMP, V+, and V-, and tighten the corresponding screws to secure the wires (Figure 8, blue arrows).

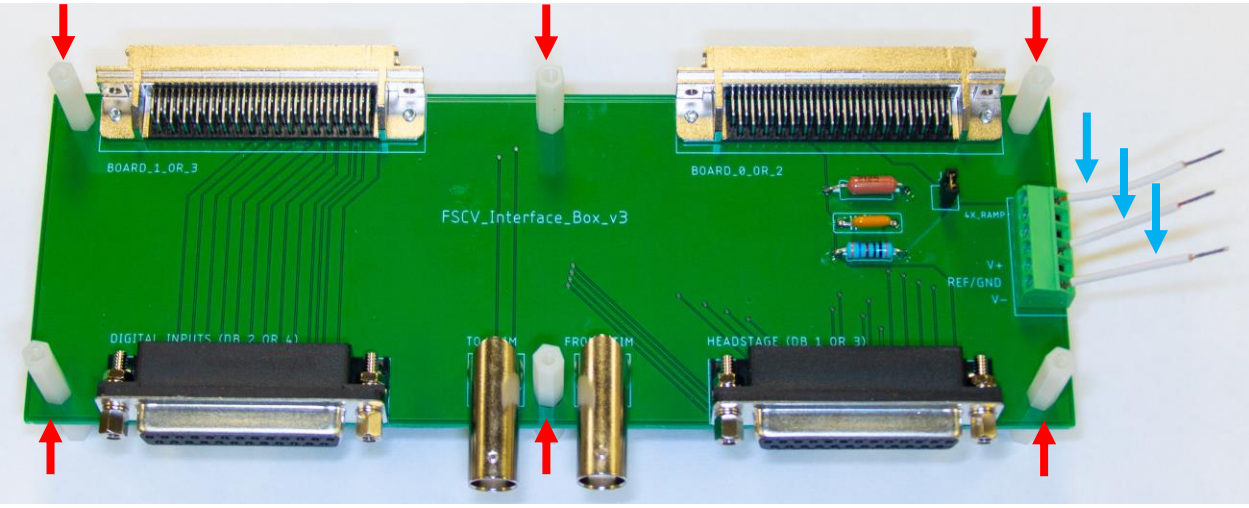


Figure 8 – Hex standoffs attached to each other and wires connected to the first board's terminal block.

Use the M3 screws to secure the second board to the top of the hex standoffs on the first board (Figure 9, red arrows). Connect and secure the three wire connections (4X_RAMP, V+, and V-) from the first board to the second board (Figure 9, blue arrows)

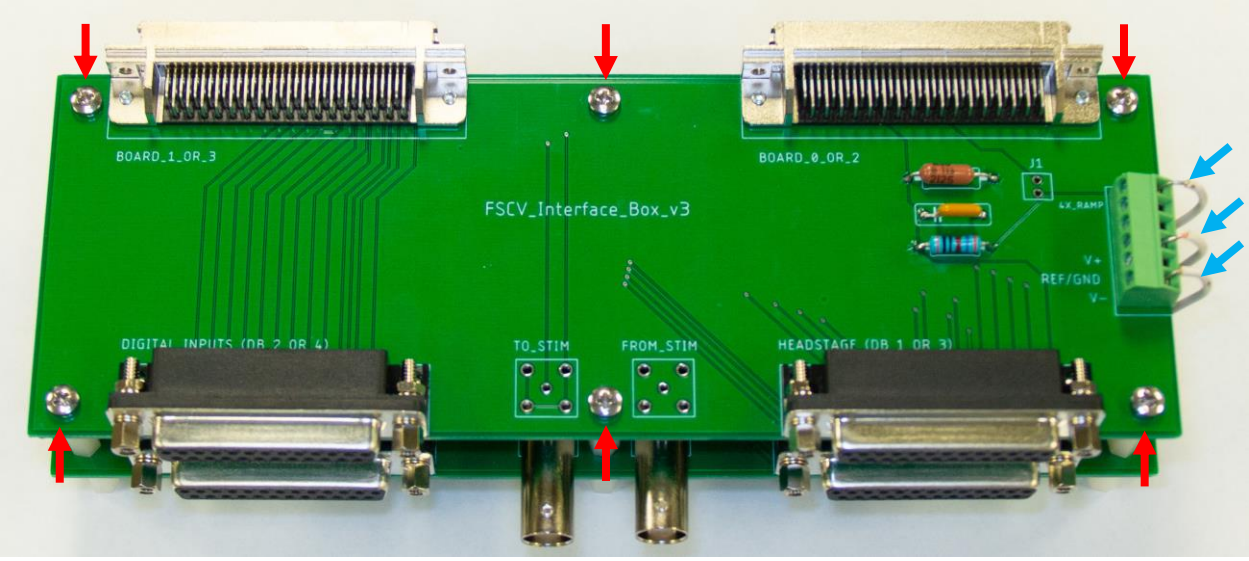


Figure 9 – Hex standoffs secured with screws and wires connected to the second board's terminal block.

Cut two more lengths of wire approximately 4cm in length. From each end strip away approximately 5mm. Tin the exposed wire by twisting the ends, dipping them into flux, and applying a small amount of solder. Attach one wire to the terminal block connection V+, another to V-, and tighten the corresponding screws to secure the wires (Figure 10, yellow arrows). Next, attach the banana plug cables from the power supply to the wires using the alligator clip connectors (Figure 10, blue arrows). Match V+ from the power supply to the V+ wire and V- to V-.

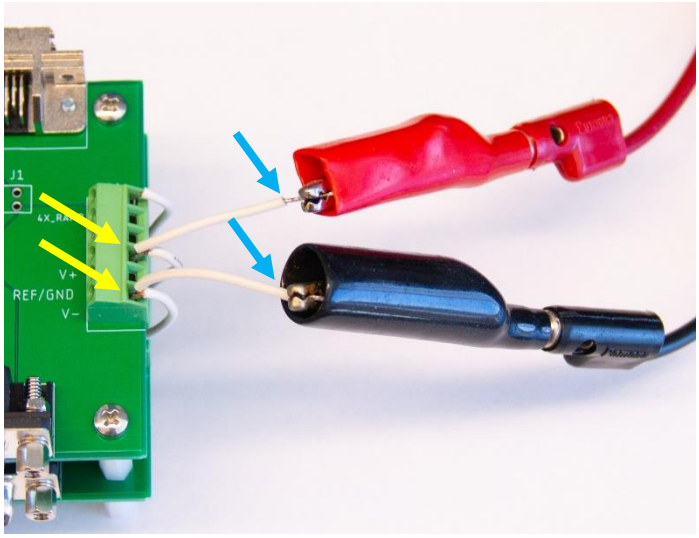


Figure 10 – Power supplied to the interface system.

Stimulus Isolator

The stimulus isolator is triggered by the FSCV software via a 5V trigger signal routed through the interface box. The output of the stimulus isolator can either go directly to the stimulating electrode implanted in the animal or back into the interface box. If the latter option is picked, then the stimulation pulses are then routed through the interface box to headstage cable.

Please note that the setup shown below is for this particular stimulus isolator, but other units can be used.

Parts List

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
MicroProbes	ISO-Flex	ISO-Flex Stimulus Isolator	1	$1,100.00
Digikey	3272-CO-058BNCX200-001-ND	Coaxial Cable BNC to BNC, 12” (choose best length for lab’s setup)	2	$14.55
Digikey	314-1294-ND	Banana Plug to BNC	1	$10.83

Assembly Instructions

Step 1: Attaching the BNC Cables

Attach the To Stim Iso BNC connection from the interface box to the input BNC (Figure 11, red arrow) on the stimulus isolator. Next, attach the banana plug to BNC connector to the two output connections (Figure 11, blue arrow). Lastly, connect the BNC output connection (Figure 11, green arrow) to the From Stim Iso BNC connection on the interface box.

Figure 11 – Stimulus isolator connections

Interface Box to Headstage Cable

This cable connects the interface box to the headstage. It carries the signals for the 16 individual channels, supply voltage, reference (GND), and input (Ramp). In addition, it can carry the stimulation signal supplied by an external source that routes through the interface box.

Parts List

The quantities listed below are for making a single cable.

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
Digikey	225ME-ND	Male D-Sub 25-pin Connector	1	$1.42
Digikey	925UAE-ND	D-Sub Enclosure	1	$10.93
Digikey	MB24S-50-ND	24 Conductor Wire Bundle (50')	1	$147.01
Grainger	22KY60	1/16” ID Heat Shrink Tubing (25’)	1	$11.45
Omnetics	A79029-001	36 Position Dual Row Female Nano-Miniature with 18.0" 34 AWG Lead-Wire – Omnetics Breakout‡	1	$104.44
Mouser	992-DB25F-TERM	DB25 Female Breakout Board	1	$15.74

‡Typically has a 6-8 week lead time. Prices are based on the minimum quantity needed to reach the vendor’s $200 per part minimum order. Contact the vendor directly for the most up to date pricing.

Required Tools and Supplies:

- Razor blade
- Small pointed scissors (Grainger #22UN25 or similar)
- Wire strippers (28 AWG) and cutters
- Source of fire (candle, blowtorch, Bunsen burner, etc.) or hot-tweezers
- Fine tip soldering iron, solder, and flux
- Multimeter capable of detecting continuity/shorts
- Heat gun

Optional Tools and Supplies:

- Interface Board
- Wooden block
- Removable mounting putty
- Hot glue gun

Cable Mapping

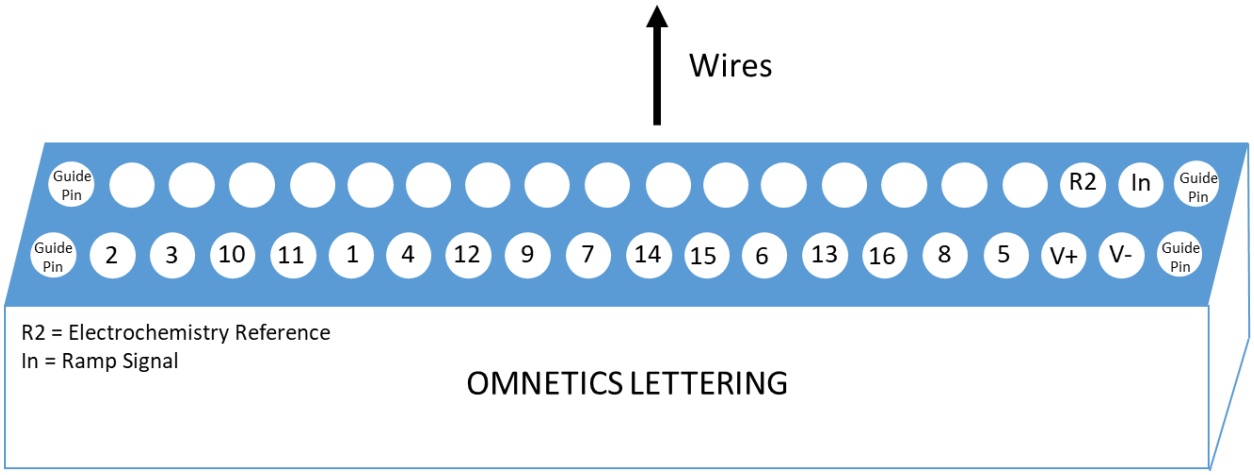
Below is the standard wire mapping for the cable. This mapping does not include the colors from the Omnetics connector cable as there are repetitions in the colors. How to properly map and connect this the Omnetics cable will be covered in the assembly instructions.

System Channel	24 Wire Bundle Color (Major – Minor)	DB25 Pin
5	Black – Blue	1
6	Red – Blue	2
7	Black – Red	3
8	Blue – Black	4
V+ (+15V)	Blue – Red	5
1	Black – Green	6
REF2 (GND)	Red – White	7
2	Brown – Black	8
V- (-15V)	Yellow – Black	9
9	White – Black	10
10	Black – Yellow	11
11	Green – Red	12
12	Green – Black	13
In (Ramp)	White – Red	14
13	Red – Black	15
14	Black – White	16
15	Orange – Black	17
3	Brown – Red	18
16	Red – Brown	19
4	Red – Green	20
–	–	21
–	–	22
From Stim +	Yellow – Red	23
From Stim -	Red – Yellow	24
–	–	25

Un-used wires: Black – Orange and Black – Brown.

Omnetics Breakout Connector Mapping

Below is the mapping for the Omnetics breakout connector. The numbering and lettering correspond to the system channels column in the cable mapping table.



Assembly Instructions

Step 1: Preparing the 24 Wire Bundle

First, cut the 24 wire bundle to the overall desired length. From one end remove 4cm of primary insulation (razor blade), braided mesh (scissors), and foil (scissors). Separate the wires and strip away 4-5mm of insulation from each individual wire. Cut away the black-orange and black-brown wires (major-minor colors). If the stimulation signal is not going to be routed through the cable then the yellow-red and red-yellow wires can be cut away. After stripping the insulation, tin the exposed wire by twisting the ends, dipping them into flux, and applying a small amount of solder (Figure 12).

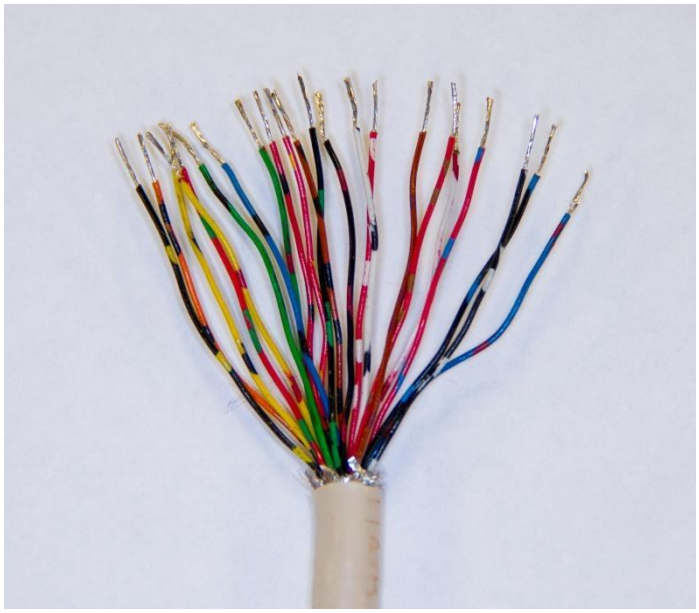


Figure 12 – Cut, stripped, and tinned wires for DB25 connector end.

At the other end of the 24-wire bundle, remove the desired length of primary insulation, braided mesh, and foil. For freely moving animal experiments we recommend exposing 8-12” as this minimizes the amount of torque on the animal. Separate the wires, **but leave the red-white and white-red pair twisted**, and strip away 4-5mm of insulation from each individual wire. Cut away the black-orange and black-brown wires (major-minor colors). If the stimulation signal is not going to be routed through the cable then the yellow-red and red-yellow wires can be cut away. After stripping the insulation, tin the exposed wire by twisting the ends, dipping them into flux, and applying a small amount of solder (Figure 13).

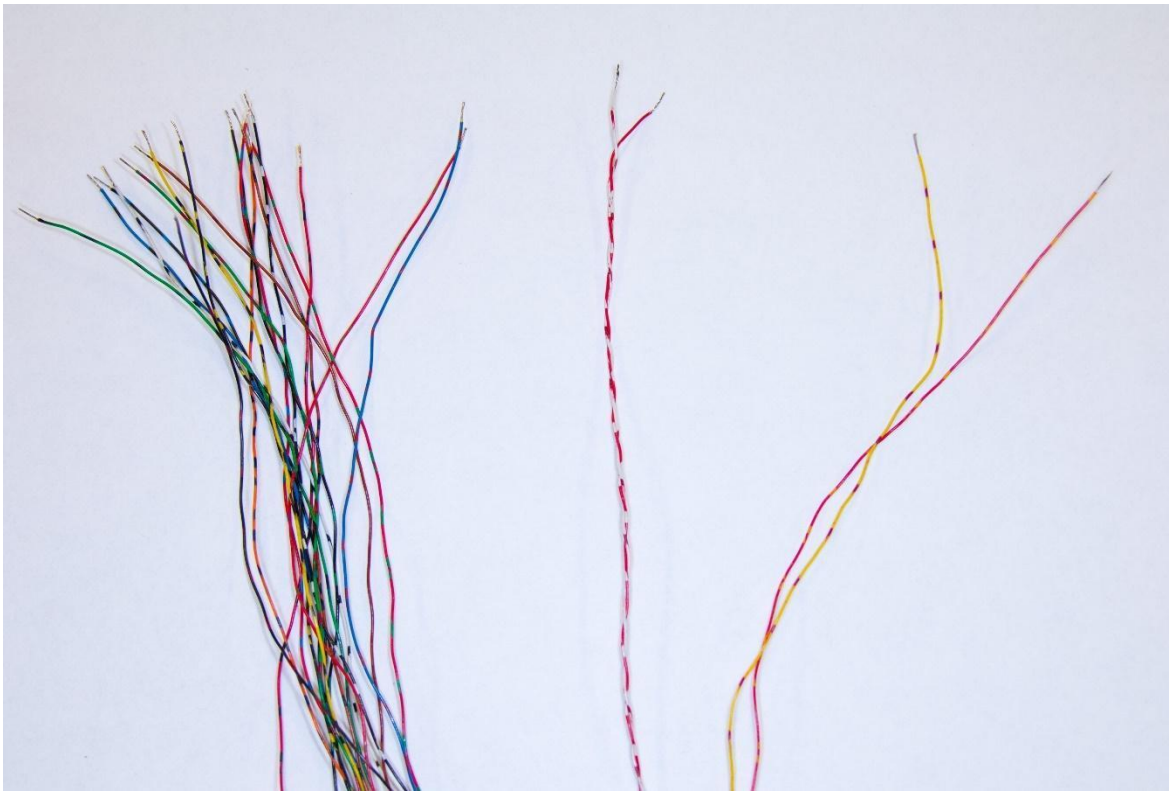


Figure 13 – Cut, stripped, and tinned wires for "headstage" end. Wires carrying channels 1-16, V+, and V- (left), twisted red-white and white-red wires carrying REF2 (GND) and In (Ramp) (middle), and From Stim +/- wires (right).

Step 2: Preparing the Omnetics Breakout Wires

To prepare the Omnetics breakout wires, first remove the unused wires. Flipping the connector to the backside (no lettering showing) remove all but the two left most wires (Figure 14). Save these cut wires to use for practice when removing insulation. Lastly, trim the remaining wires to the desired length. For freely moving animal experiments, we recommend leaving the wires at their original length as this minimizes the amount of torque on the animal.

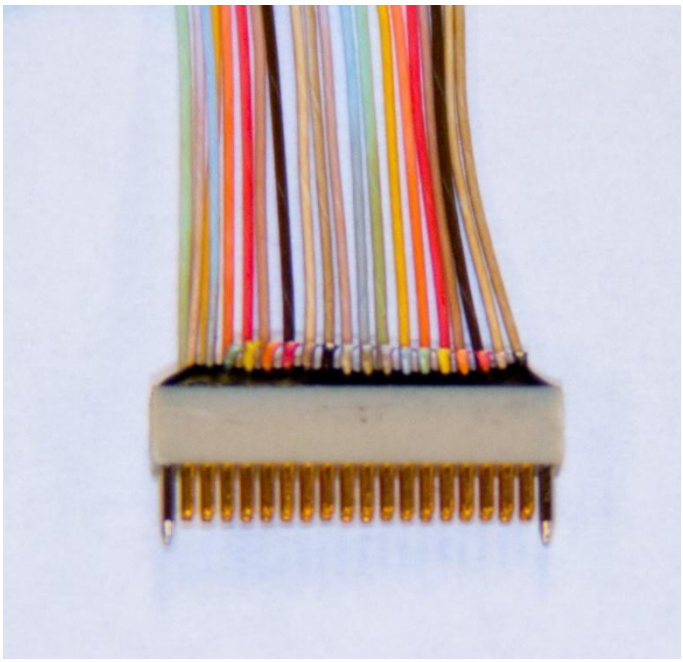


Figure 14 – Omnetics breakout connector with removed wires.

To remove the insulation from the Omnetics breakout wires a flame is the quickest method. This can be a small blowtorch, candle, Bunsen burner, etc.; the key requirement is that it is hands free once lit. Using the saved wires from before, practice removing the insulation by passing the wire through the flame. The extreme heat will cause the insulation to contract. Once 4-6mm can be consistently exposed, apply this technique to the actual bundle (Figure 15). Alternatively, use a set of hot-tweezers to strip away the insulation.

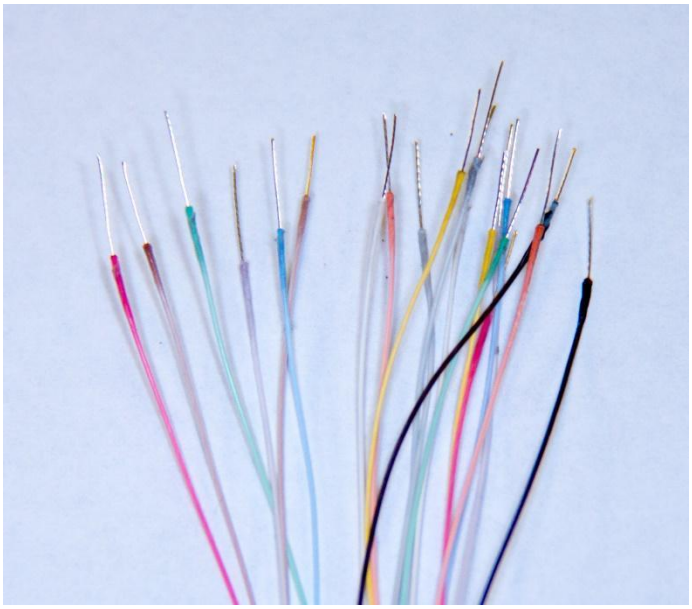


Figure 15 – Exposed Omnetics wires.

Step 3: Soldering the 24 Wire Bundle to the Male DB25 Connector

Before soldering the wires to the DB25 connector, thread on the D-sub enclosure's cable slot entry tab (Figure 16, red arrow). Using the cable mapping table, solder each colored wire to the corresponding DB25 connector pin. A wooden block with putty can help during soldering (Figure 16).

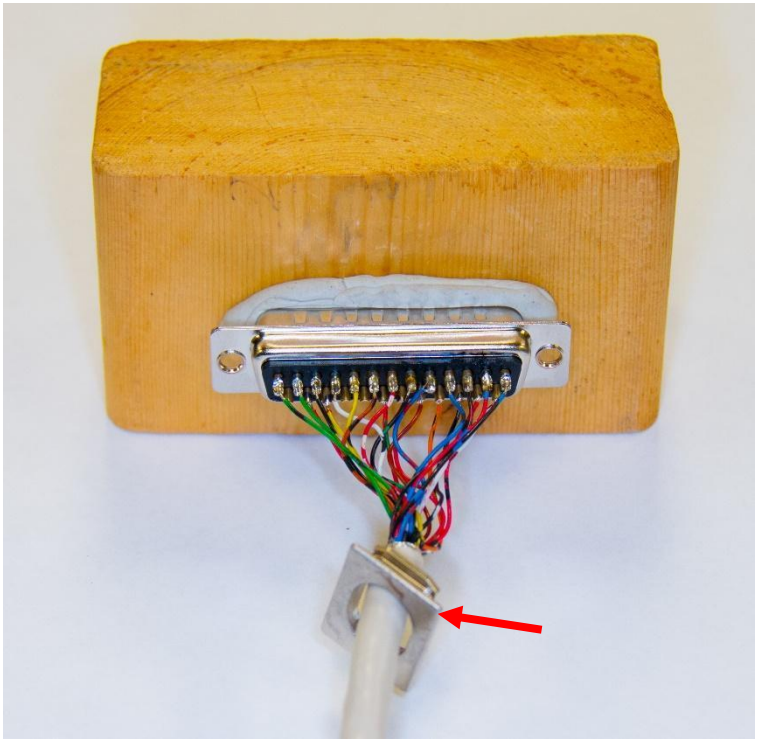


Figure 16 – Wires soldered to DB25 connector with threaded cable slot entry tab (red arrow).

Step 4a: Soldering System Channels 1-16, V+, and V-

Plug the DB25 male connector into the DB25 female breakout board, which will make checking for continuity easier. If the Interface Board is available, then plug the Omnetics breakout connector into that (lettering on both connectors should be facing in the same direction). For connections, reference the cable mapping table and interface board or the Omnetics breakout connector mapping diagram if the interface board is not available.

Pre-thread all wires (except for red-white and white-red wires) with 2cm pieces shrink tubing. If the wires are too short to do this without the tubing coming off, then thread each wire just before soldering.

Starting with the Omnetics wires, isolate system channel 2 wire. From the 24-wire bundle isolate the brown-black wire. Solder these two wires together (Figure 17). Using the multimeter's continuity setting (see the multimeter's manual for this information), check the continuity by touching one probe to the female breakout board's pin 8 and the

other probe to the interface board's via labeled 2 (Figure 18). Alternatively, touch the probe directly to the corresponding Omnetics pin. If touching just one Omnetics pin is problematic, then insert a 30GA needle into the pin and then touch the probe to the needle. If the meter beeps, then continue connecting the wires using the cable mapping table and interface board or the Omnetics breakout connector mapping diagram if the interface board is not available. DO NOT solder REF2 (GND) and In (Ramp), red-white and white-red, respectively. If the multimeter does not have a continuity setting, then measure the resistance and look for values less than 0.5Ω.

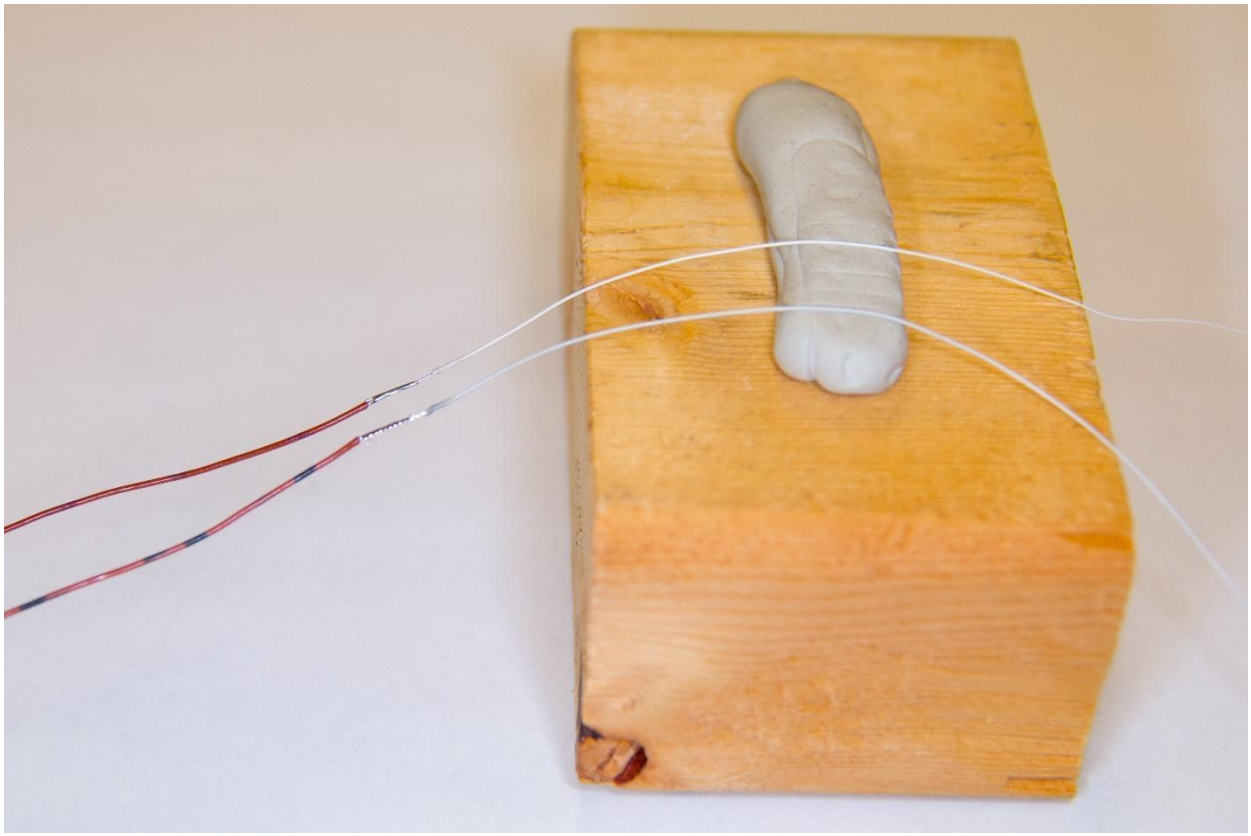


Figure 17 – System channels 2 and 3 connected to brown-black and brown-red wires, respectively. Once soldered, the Omnetics wires can be removed from the putty. Not shown, already threaded shrink tubing.

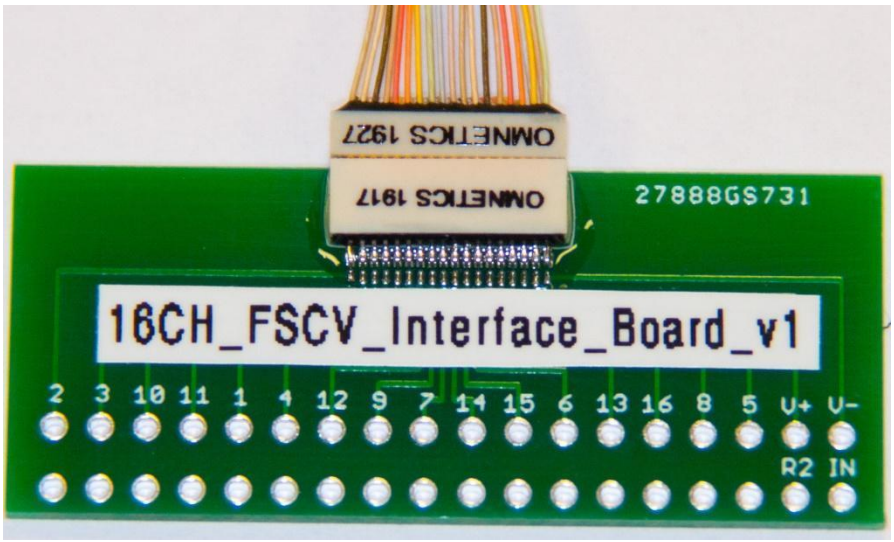


Figure 18 – Interface board attached to Omnetics connector.

Step 4b: Soldering System Channels REF2 (GND) and In (Ramp)

Before connecting REF2 (GND) and In (Ramp), the Omnetics wires for these signals need to be twisted together (Figure 19). This helps to reduce noise.

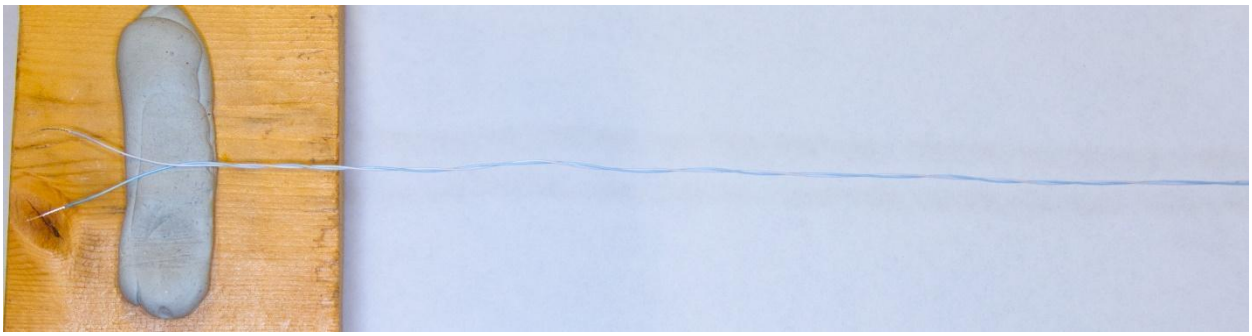


Figure 19 – REF2 (GND) and In (Ramp) Omnetics wires are twisted together before connecting to red-white and white-red wires, respectively.

Once the Omnetics wires are twisted together, thread the shrink tubing on the red-white and white-red wires, and make the appropriate solder connections.

Step 5: Attaching a Stimulation Electrode

If using a stimulation electrode follow the same procedure in the previous steps. Make sure the stimulation electrode reaches beyond the end of the Omnetics connector by about 2-3” to account for the height of the headstage. If necessary, add in additional wire (cut away black-brown and black-orange can be used here).

Step 6: Shrink the Tubing

After all continuity checks have been made, shrink the tubing around the solder joints using a heat gun (Figure 20).

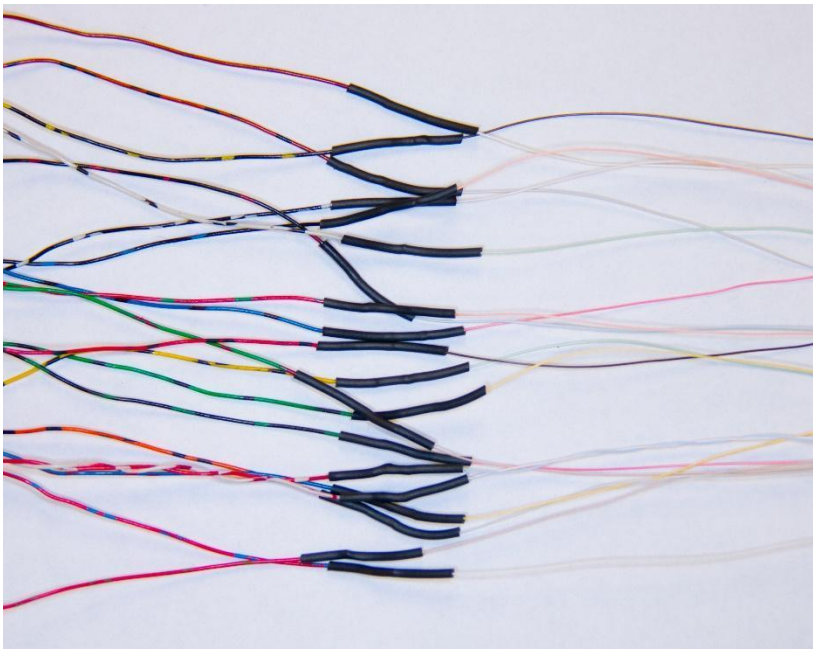


Figure 20 – All connections have been made and tubing shrunk.

Step 7: Testing the Cable

Test the cable functionality by using a dummy cell. If everything checks out, proceed to the next step. If not, double-check the connections which might require cutting away the tubing and re-soldering.

Step 8: Finalizing the Cable

After the cable has gone through the final checks, the ends can be secured with hot glue. At the DB25 end, after securing the cable slot entry tab in its slot and pushing the wires away from the screw holes, apply hot glue (Figure 21). Wait for the glue to harden before letting go of the cable. Before securing the cover, drop in the cable slot block tab and jackscrews. In this as0sembly, the strain relief screws and spring are not used, as this is accomplished by the hot glue.

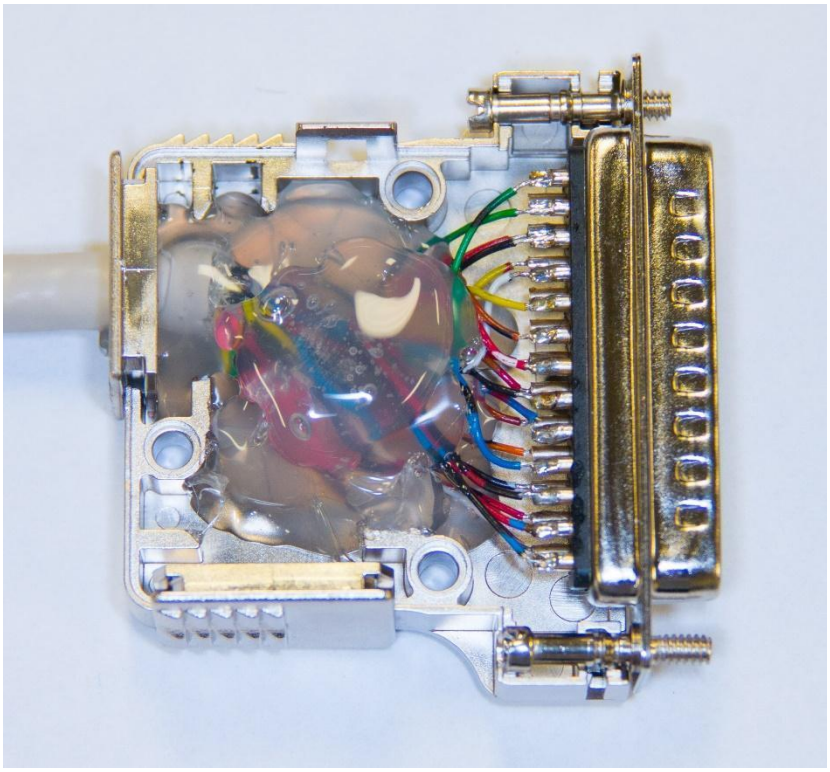


Figure 21 – Wires secured in D-Sub enclosure using hot glue. Also note the addition of the cable slot block tab (bottom left) and jackscrews (threaded through the DB25 connector).

After closing the housing, more hot glue can be applied where the cable exits, for additional reinforcement (Figure 22).

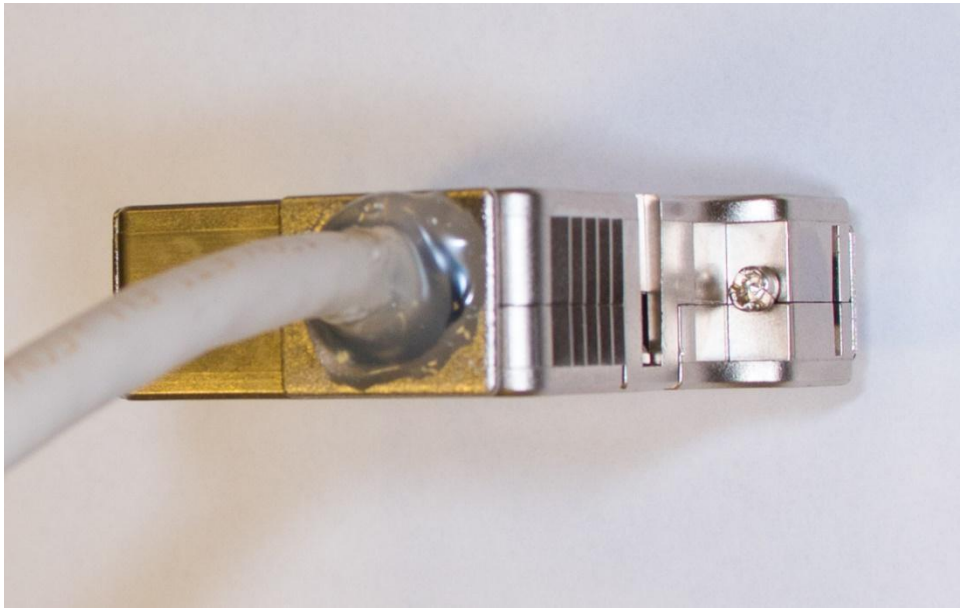


Figure 22 – Hot glue applied to cable slot entry tab for additional reinforcement.

At the Omnetics end, hot glue can be applied to provide both strain relief and a grasping point when handling the cable (Figure 23).

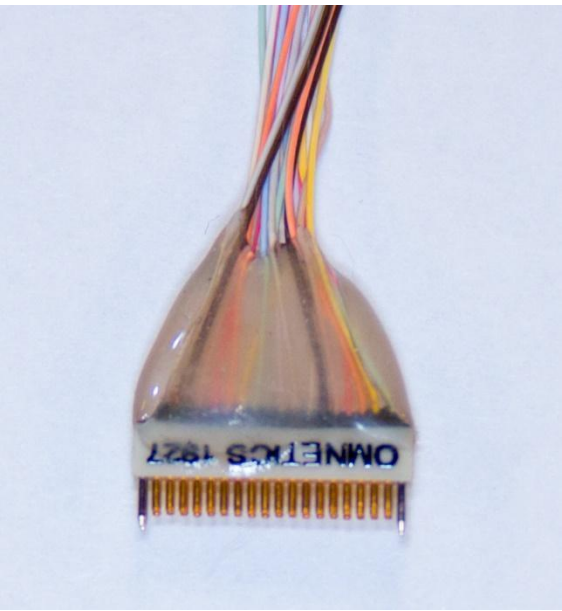


Figure 23 – Hot glue applied to Omnetics end of the cable to provide strain relief and a grasping point.

Interface Board

The interface board is used to test electrical connections when assembling the interface box to headstage cable.

Parts List

The quantities listed below are for making a single board.

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
	Custom PCB	16CH FSCV Interface Board (click link to access files)	1	Will vary by manufacturer
Omnetics	A79024-001	36 Position Dual Row Male Nano-Miniature Connector‡	1	$62.75

‡Typically has a 6-8 week lead time. Prices are based on the minimum quantity needed to reach the vendor's $200 per part minimum order. Contact the vendor directly for the most up to date pricing.

Required Tools and Supplies:

- Soldering iron with a fine tip (0.1-0.2mm), solder, and flux (Grainger #1UYJ2)
- 2-part epoxy (Grainger #1FBG8)
- Mixing dish
- 1mL syringe with a 23G needle or a cotton tip applicator

Optional Tools and Supplies:

- Forceps
- 100% isopropyl alcohol (IPA)
- Cleaning brush cut to ~5mm (Digikey #473-1048-ND)

Assembly Instructions

Step 1: Ordering the Custom PCB

If not already done so, order the custom PCB by following the link in the parts list. The download contains design files, specifications, and manufacturing instructions.

Step 2: Soldering the Omnetics Connector

Apply a small amount of solder to the lower row's (corresponding to the Omnetics connector's outer/top pins) two corner pads that lead to channel 2 and V-. Position the Omnetics connector on top of the soldered pads and reapply heat to solder the pins to their respective pads. Solder the remaining outer pins to their respective pads.

To solder the inner pins, first place some solder on the iron's tip. Then gently push the iron tip through the outer pins to reach the inner pins. Repeat this process for the remaining inner pins. If an outer pin bends out of place, reposition it using a pair of forceps. Clean the pins and pads with 100% IPA.

Step 3: Securing the Omnetics Pins

Mix up some 2-part epoxy. Pull the mixture into a 1mL syringe, wipe the excess from the tip and threads, and firmly attach a 23G needle. Gently push the epoxy out through the needle and apply it to the Omnetics pins (Figure 24, yellow arrow). Applying too much force will cause the needle to come off the syringe. Alternatively, use the wooden end of a cotton tip applicator to apply the epoxy. Let the epoxy cure overnight.

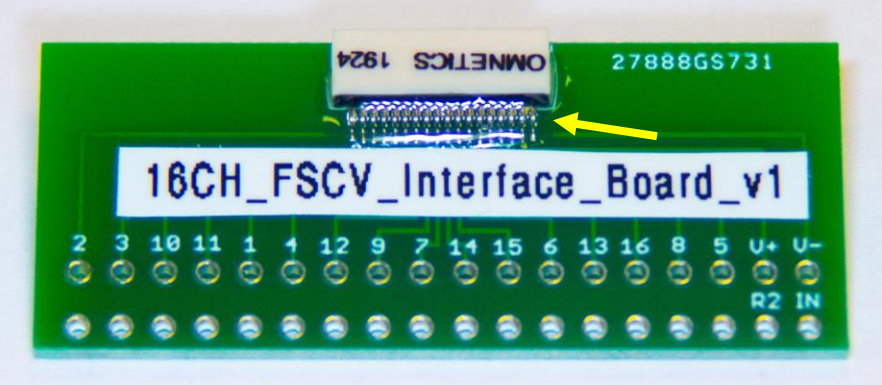


Figure 24 – Interface board with Omnetics pins secured with 2-part epoxy.

Headstage

This headstage connects to the array on one end and to the interface box to headstage cable on the other end.

Parts List

The quantities listed below are for making a single board. Quantities required may be greater than the number of boards being assembled as many assembly houses require extra parts.

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
	Custom PCB	16CH FSCV Headstage (click link to access files)	1	Will vary by manufacturer
Omnetics	A79024-001	36 Position Dual Row Male Nano-Miniature Connector‡	1	$87.18
Omnetics	A79041-001	18 Position Dual Row Female Nano-Miniature Connector‡	1	$34.63
Digikey	ADA4062-4ACPZ-R7DKR-ND	4 Channel J-FET Amplifier Circuit*	4	$3.21
Digikey	490-3104-6-ND	6pF Capacitor*	16	$0.085
Digikey	541-4.99MLDKR-ND	4.99MΩ Resistor*	16	$0.038
Digikey	490-5920-6-ND	0.1uF Capacitor*	2	$0.10
Newark	82K7797	Gold Pin	1 pk	$9.89 (pk)

‡Typically has a 6-8 week lead time. Prices are based on the minimum quantity needed to reach the vendor's $200 per part minimum order. Contact them directly for the most up to date pricing.
*Part numbers for these items are for Digi-Reel packaging, which is required by the assembly house.

Required Tools and Supplies:

- Soldering iron with a fine tip (0.1-0.2mm), solder, and flux (Grainger #1UYJ2)
- 2-part epoxy (Grainger #1FBG8)
- Mixing dish
- Stiff wire no larger than 0.5mm in diameter. An ideal source are the resistor and capacitor lead trimmings from the dummy cell assembly.
- Wire cutters
- 1mL syringe with a 23G needle or a cotton tip applicator

Optional Tools and Supplies:

- Helping hands soldering aid
- Forceps

Assembly Instructions

The instructions below assume that the boards were manufactured by PCBWay and that the assembly will be performed by Screaming Circuits.

Step 1: Ordering Supplies

If not already done so, order supplies according to the quantity of boards being assembled and following Scream Circuits' rules for extra parts.

Step 2: Ordering the Custom PCB

If not already done so, order the custom PCB by following the link in the parts list. The download contains design files, specifications, and manufacturing instructions.

Step 3: Requesting Panelized Gerber Files

After your boards have been made, message the manufacturer and ask for the panelized Gerber files. Once received, place these files in the folder **Assembly Files**, which can be found by following the custom PCB link in the parts list.

Step 4: Generating a Quote

Visit Scream Circuits' website and start a quote either directly through the link on the home page or create an account and then start. Enter the following technical information when prompted. Other fields not listed below (e.g. pricing, contact info, etc.) are to be entered by the individual generating the quote.

- **Assembly Quote**
  - **Quantity:** Multiples of 10 minus any PCBs marked as defective
  - **Unique Part Count (BOM Lines):** 6
  - **Total Placements:** 40
  - **Thru Hole Placements:** 0
  - **BGA / QFN:** Yes
  - **Double Sided:** Yes
    - **What part types apply to this?:** Check SMT
  - **RoHS, Class III, ITAR:** No
- **PCB Fabrication Quote**
  - Choose, *Or skip fabrication sourcing, I'll source my own boards*
- **Parts Quote**
  - Choose*, Or skip part sourcing, I'll provide my own parts*
- **Project Files**
  - **Please select your preference for sending your files:** *I will upload my files now.*
    - Zip the folder, **Assembly Files**, which must contain the panelized Gerber files and the existing parts lists, and upload.

- **Kitted Information**
  - **Describe the box's contents:** All components and panelized PCBs
- **Starting Your Order**
  - It is likely the purchase is being made through a university and a formal quote must be generated. If that is the case choose, '*request a formal quote*', at the bottom and proceed accordingly.

Step 5: Packaging and Mailing Supplies

Everything on the parts list except the gold pins will be mailed. Label the boxes of the A79041-001 and A79024-001 Omnetics connectors, S1 and S2, respectively. The remaining components should already have labels on them that indicate the manufacturer and manufacturer part number (not the Digikey part number). If this information is missing then add it.

Follow Screaming Circuits' instructions for packing parts. Send the items to the provided address and be sure to include the order number in the address.

Step 6: Inspecting the Headstages

After receiving the headstages back from the assembly house, check that the pins of the Omnetics connectors are properly soldered to the board. This can be done by gently pushing against the pins using a pair of forceps. If any of the pins are loose, try to repair the solder joint using a soldering iron. It is critical that the iron is applied to the pins for a minimal amount of time as excess heat can travel to the amplifiers and damage them.

After checking the solder joints, an optional check on the quality of the assembly is to connect the headstages to the FSCV system with a dummy cell. This test can sometimes, but not always, point to which channels are problematic and can be potentially fixed by repairing a poor solder connection. As the Omnetics pins have not been secured with epoxy at this stage, connecting and disconnecting of the headstage should be done with extreme care. In addition, the internal reference switch on the dummy cell should be utilized during this test as the external reference pin has yet to be attached.

Step 7: Securing the Omnetics Pins

Mix up some 2-part epoxy. Pull the mixture into a 1mL syringe, wipe the excess from the tip and threads, and firmly attach a 23G needle. Gently push the epoxy out through the needle and apply it to the Omnetics pins at both ends (Figure 25, red arrows). Applying too much force will cause the needle to come off the syringe. Alternatively, use the wooden end of a cotton tip applicator to apply the epoxy. Let the epoxy cure overnight.

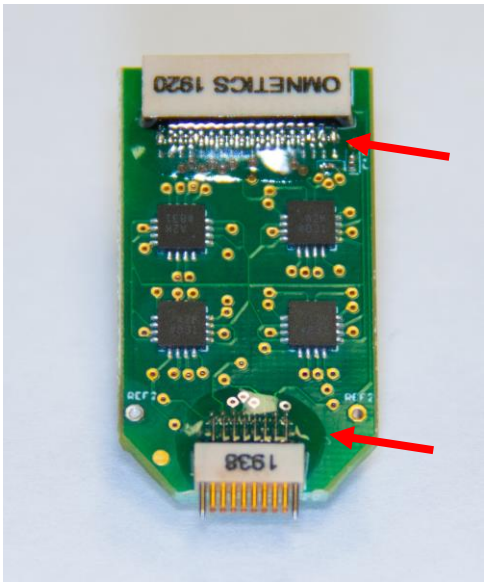


Figure 25 – Headstage with Omnetics pins secured with 2-part epoxy.

Step 8: Assembling and Attaching the Reference Pin

Insert a small piece of wire into the reference pin and solder the two together (Figure 26).

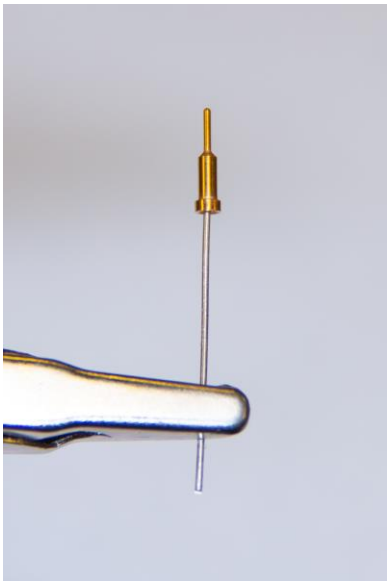


Figure 26 – Soldered reference pin and wire.

Next, insert the reference pin and wire assembly into either of the holes marked REF2 at the bottom of the headstage (Figure 27). Solder the assembly to the board from the underside and cut away the excess wire.

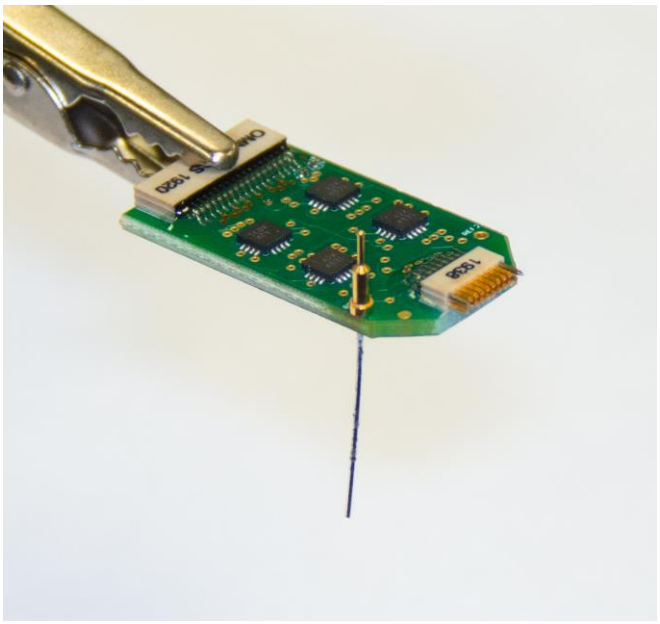


Figure 27 – Reference pin assembly attached to the headstage.

Dummy Cell

The dummy cell is used to simulate an array of electrodes. This can be useful for system debugging, headstage testing, and overall noise reduction.

Parts List

The quantities listed below are for making a single board.

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
	Custom PCB	16CH FSCV Dummy Cell (click link to access files)	1	Will vary by manufacturer
Omnetics	A79040-001	18 Position Dual Row Male Nano-Miniature Connector‡	1	$35.08
Digikey	CKN10721DKR-ND	Slide Switch SPDT	1	$0.81
Digikey	CF14JT33K0CT-ND	33kΩ Resistor	16	$0.40
Digikey	BC1072CT-ND	1000pF Capacitor	16	$0.167
Newark	82K7797	Gold Pin	1 pk	$9.89 (pk)

‡Typically has a 6-8 week lead time. Prices are based on the minimum quantity needed to reach the vendor's $200 per part minimum order. Contact them directly for the most up to date pricing.

Required Tools and Supplies:

- Soldering iron with a fine tip (0.1-0.2mm), solder, and flux (Grainger #1UYJ2)
- 2-part epoxy (Grainger #1FBG8)
- Mixing dish
- Wire cutters
- Masking tape

Optional Tools and Supplies:

- Helping hands soldering aid
- 100% isopropyl alcohol (IPA)
- Cleaning brush cut to ~5mm (Digikey #473-1048-ND)

Assembly Instructions

Step 1: Ordering the Custom PCB

If not already done so, order the custom PCB by following the link in the parts list. The download contains design files, specifications, and manufacturing instructions.

Step 2: Soldering the Omnetics Connector

Apply a small amount of solder to the lower row's (corresponding to the Omnetics connector's outer/top pins) two corner pads. Position the Omnetics connector on top of the soldered pads and reapply heat to solder the pins to their respective pads. Solder the remaining outer pins to their respective pads.

To solder the inner pins, first place some solder on the iron's tip. Then gently push the iron tip through the outer pins to reach the inner pins. Repeat this process for the remaining inner pins. If an outer pin bends out of place, reposition it using a pair of forceps. Clean the pins and pads with 100% IPA.

Step 3: Securing the Omnetics Pins

Mix up some 2-part epoxy. Pull the mixture into a 1mL syringe, wipe the excess from the tip and threads, and firmly attach a 23G needle. Gently push the epoxy out through the needle and apply it to the Omnetics pins (Figure 28, yellow arrow). Applying too much force will cause the needle to come off the syringe. Alternatively, use the wooden end of a cotton tip applicator to apply the epoxy. Let the epoxy cure overnight.

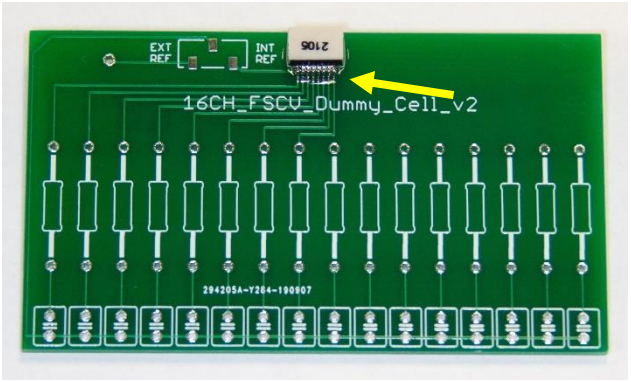


Figure 28 – Dummy cell with Omnetics pins secured with 2-part epoxy.

Step 4: Soldering the Slide Switch

Apply a small amount of solder to the single pad closest to the long edge of the board. Position the switch on the top of the pads and reapply heat to the soldered pad to secure the switch's pin. Solder the other two pins to their respective pads (Figure 29, yellow arrow).

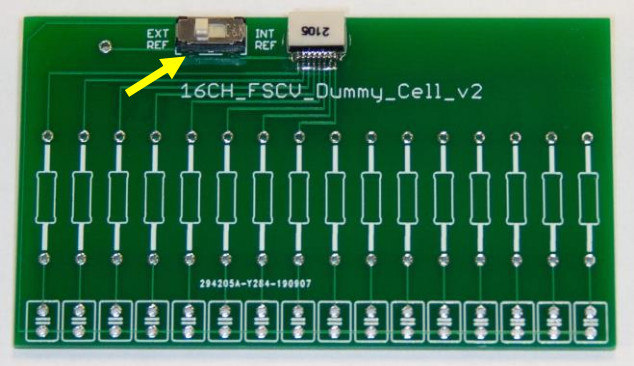


Figure 29 – Dummy cell with a soldered slide switch.

Step 5: Soldering the Resistors and Capacitors

Bend the legs of the resistors so that they easily fit through their respective holes and allow the resistor to lay flat (Figure 30).

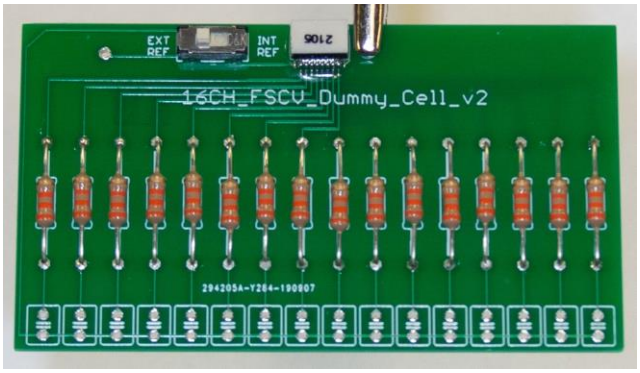


Figure 30 – Dummy cell populated with resistors.

Solder the resistors from the top side and then cut away excess wires from the bottom side. Next, push the capacitors through their respective holes which should not require any bending of the legs. After populating the capacitors, temporarily secure them to the board with a strip of tape (Figure 31). Flip the board over, solder the capacitors, cut away excess wires, and remove the tape.

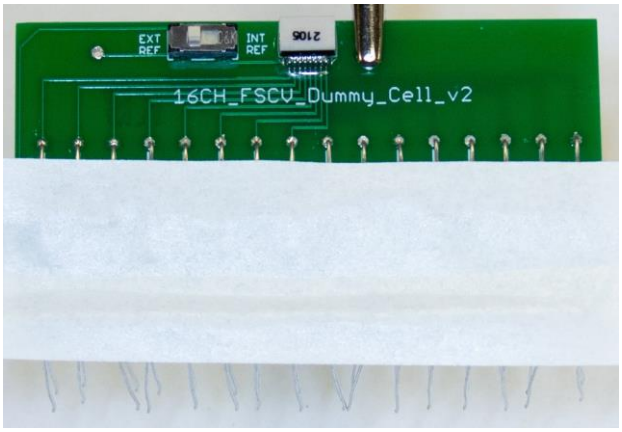


Figure 31 – Dummy cell populated with capacitors that have been temporarily secured with tape.

Step 6: Assembling and Attaching the Reference Pin

Insert a small piece of wire into the reference pin and solder the two together (Figure 32).

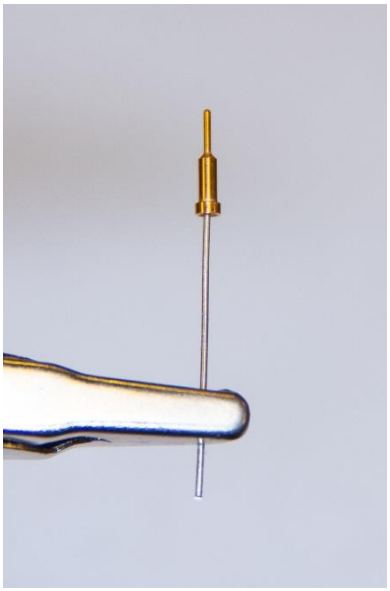


Figure 32 – Soldered reference pin and wire.

Next, insert the reference pin and wire assembly into the hole at the top left of the board (Figure 33, yellow arrow). Solder the assembly to the board from the underside and cut away the excess wire.

Figure 33 – Reference pin assembly attached to the dummy cell.

Reference Jumper Wire

The reference jumper wire connects the headstage's reference pin to an implanted reference electrode or to the reference pin on a dummy cell. The pins on both the headstage and reference electrode or dummy cell should be the type listed below.

Parts List

VENDOR	PART NUMBER	DESCRIPTION	QUANTITY	UNIT COST
Digikey	A3049R-100-ND	26 AWG Wire	1	$42.46
Grainger	22KY60	1/16" ID Heat Shrink Tubing (25'),	1	$11.45
Newark	82K7797	Gold Pin	1 pk	$9.89 (pk)

Required Tools and Supplies:

- Soldering iron, solder, and flux (Grainger #1UYJ2)
- Wire strippers (26 AWG) and cutters
- Heat gun
- Super glue
- Forceps or needle nose pliers

Optional Tools and Supplies:

- Wooden block
- Removable mounting putty

Assembly Instructions

Step 1: Preparing the Wire

First, cut the wire to the overall desired length, typically 6-7cm is enough. From each end, strip away 3-4mm of insulation. After stripping the insulation, tin the exposed wire by twisting the ends, dipping them into flux, and applying a small amount of solder (Figure 34). If the putty and wooden block are available, place the wire in the putty as this will be helpful for subsequent steps. A benefit to using the putty and wooden block is that multiple wires can be prepared simultaneously. Alternatively, use a set of helping hands, provided nothing cuts through or "bites" into the wire.

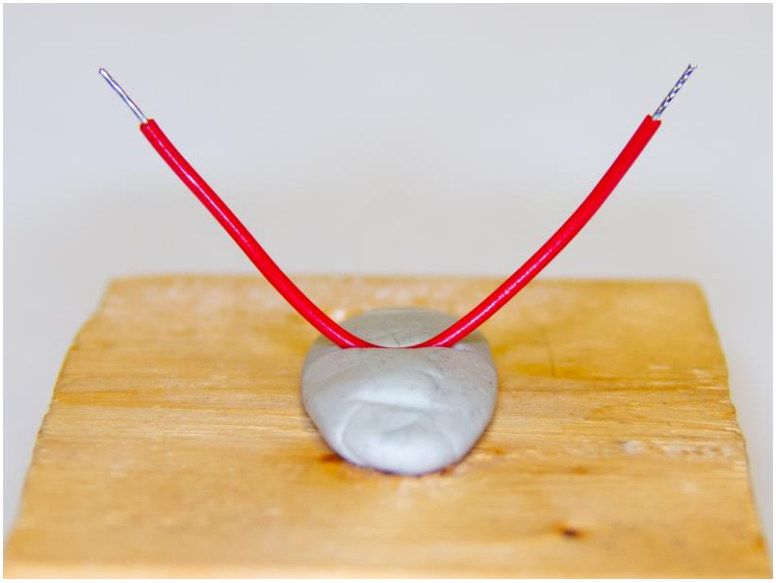


Figure 34 – Wire stripped of insulation and tinned ends.

Step 2: Attaching the Gold Pins

Dip the tips of the gold pins into flux and attach one pin to each end of the wire using additional solder (Figure 35).

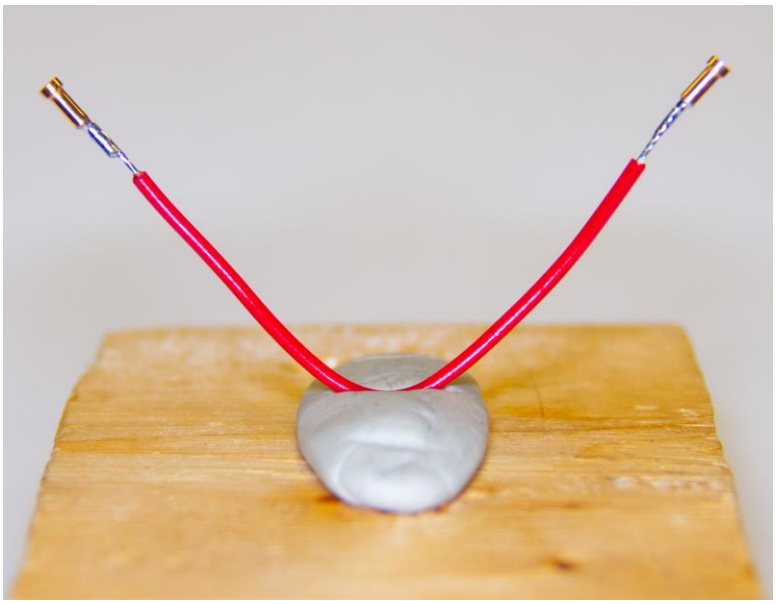


Figure 35 – Wire with soldered pins.

Step 3: Heat Shrink Tubing

Slip 1.5-2cm lengths of heat shrink tubing over each end of the wire/pin assembly to cover the solder joints. Make sure the end of the tubing and the circular/open portion of the pin are flush if not a bit lower than the opening (Figure 36, red arrows). Use the heat gun to shrink the tubing. Next, apply a small drop of super glue to the transition where the tubing ends and the exposed insulation begins (Figure 36, blue arrows). The glue will help to ensure that the tubing does not shift or loosen over time.

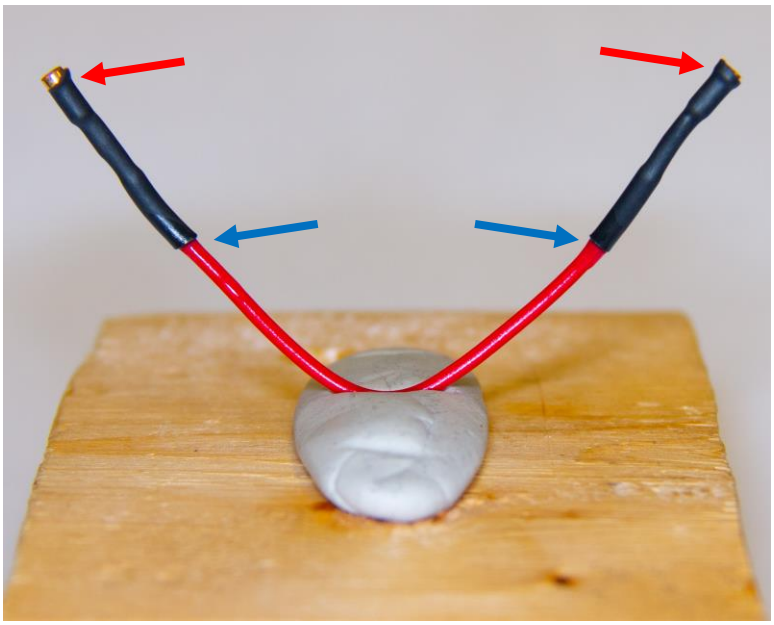


Figure 36 – Wire with shrink tubing and super glue.

Appendix

FSCV Circuit Diagram

Below is a circuit diagram of the connections between the ramp, fiber, headstage, and NI DAQ. This diagram represents one fibers worth of connections, but is repeated 16 times for a given 16-channel array and/or headstage.