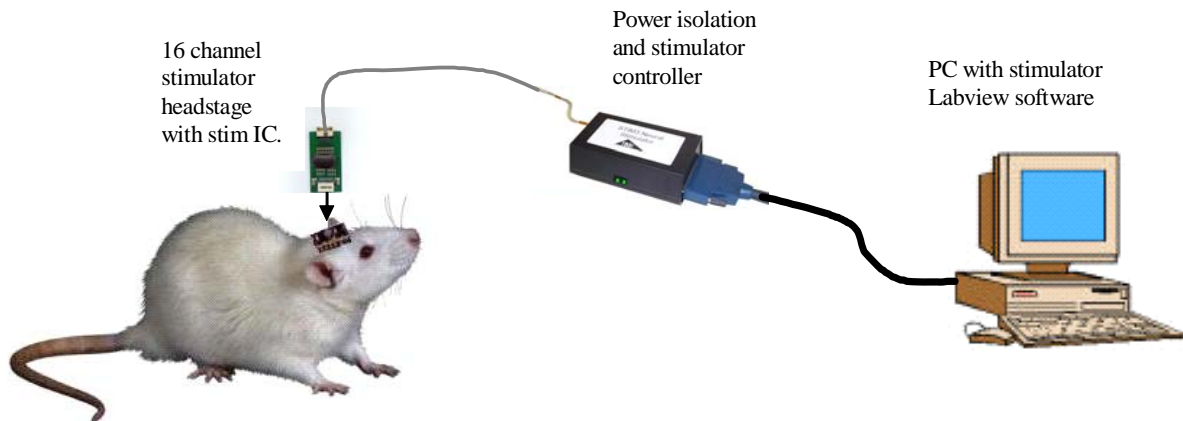


Triangle BioSystems, Int'l. Neural Stimulator 3 System

Description: The TBSI STIM3 Neural Stimulator consists of the STIM3 hardware assembly and the National Instruments (NI) Labview™ 7.1 control program. The Labview™ program dynamically controls the charge-balanced, biphasic timing and firing of up to 16 output channels. The output channels can be controlled to operate either simultaneously or independently. The STIM3 system configuration is shown below. A description of the system follows:

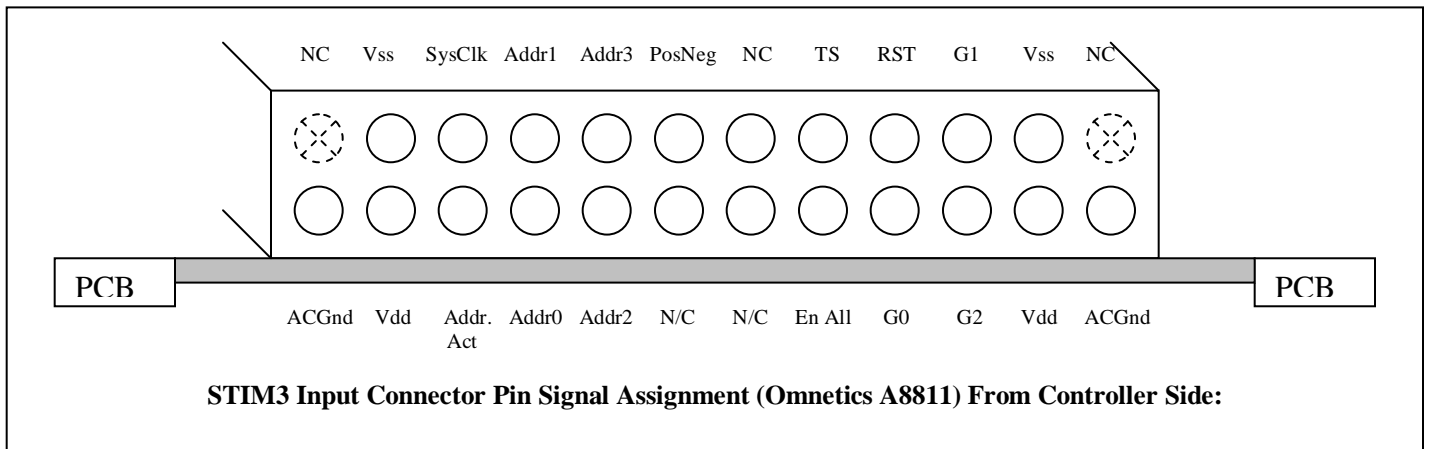
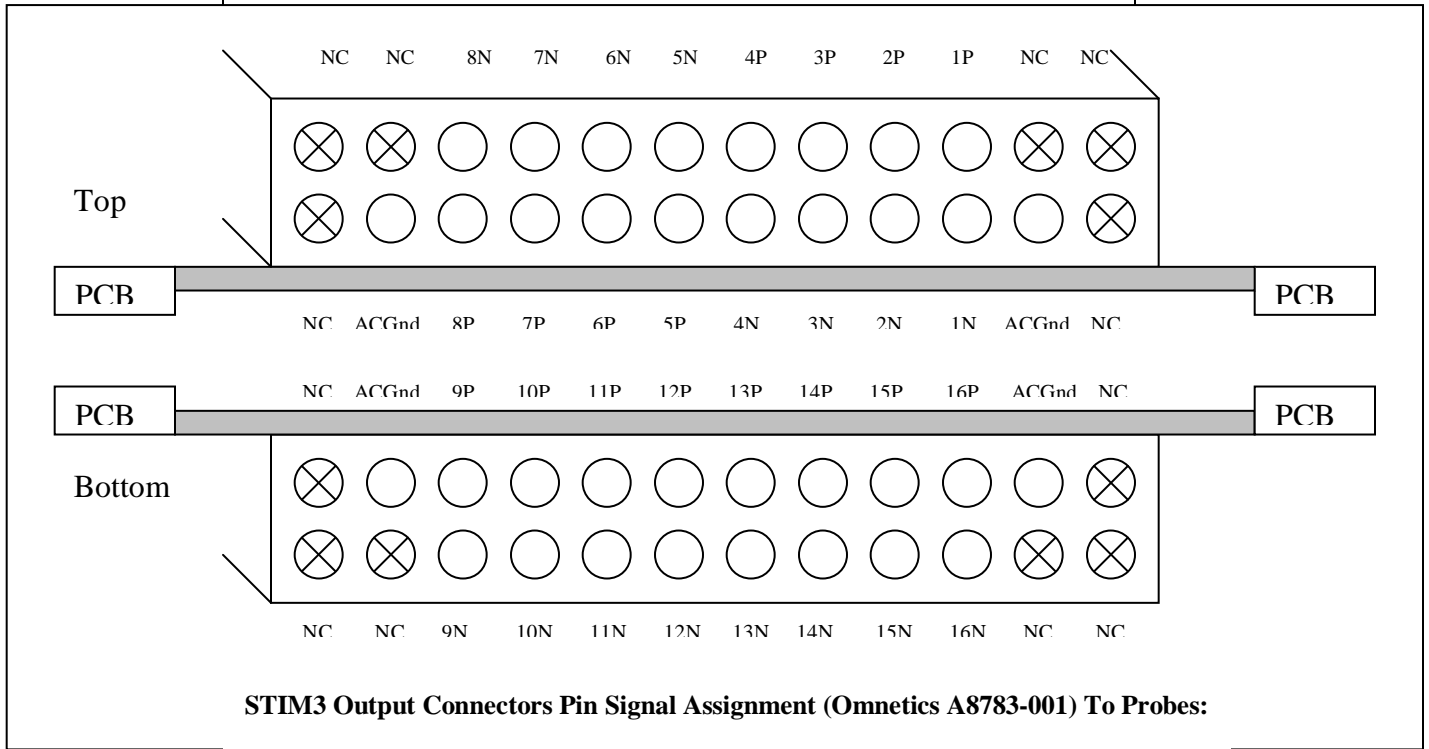


TBSI STIM3 Neural Stimulator System

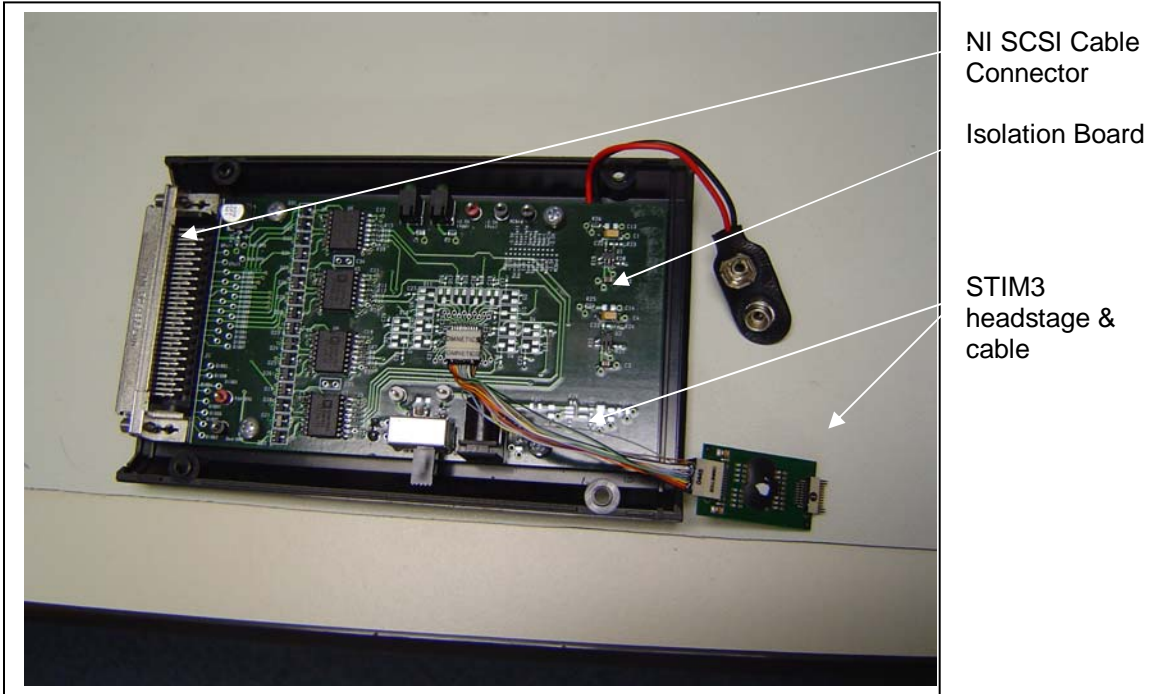
STIM3 IC: Contains mixed digital (input) and analog (output) circuitry. The digital input circuitry is dynamically controlled by external NI Labview™ software. The analog output circuitry is controlled by the digital portion and drives charge-balanced biphasic current, which stimulates neurons in the target brain. The IC has 13 digital control inputs, 16 differential analog current outputs, 5 power (+5VDC) and ground inputs, and two bias inputs. Through the selection of two external bias resistors (R_p and R_n), the bias inputs determine the output range of the device and what load values it can drive, linearly.

STIM3 Headstage Printed Circuit Board Assembly: The STIM3 IC is bonded to this PCB. The PCB assembly contains the STIM3 IC die, three Omnetics Nano™ connectors (1 input, 2 outputs), four bias resistors, 16 load resistors, and four power supply filter capacitors (two 22uf tantalum 0805, two 0.047uf ceramic 0805). Diagrams for the STIM3 printed circuit board assembly connector pin signal assignment are shown below.

Symbol Key: ⊗ Guide Pin ○ Signal Pin ⊗ Guide Pin Hole



STIM3 isolation Board Printed Circuit Board Assembly: The STIM3 Isolation PCB assembly isolates all power, control, and input signals between the PC and the STIM3 headstage. This ensures safety for the test subject. The primary of the isolation assembly is connected to a PC and Data Acquisition card. The secondary is powered from either a standard 9V battery or from an isolated, wall-mounted, linear 9V power supply. The user may select the secondary power option with a slide switch. The isolation PCB has two LEDs, which indicate the presence of 5VDC for both the primary and secondary power.



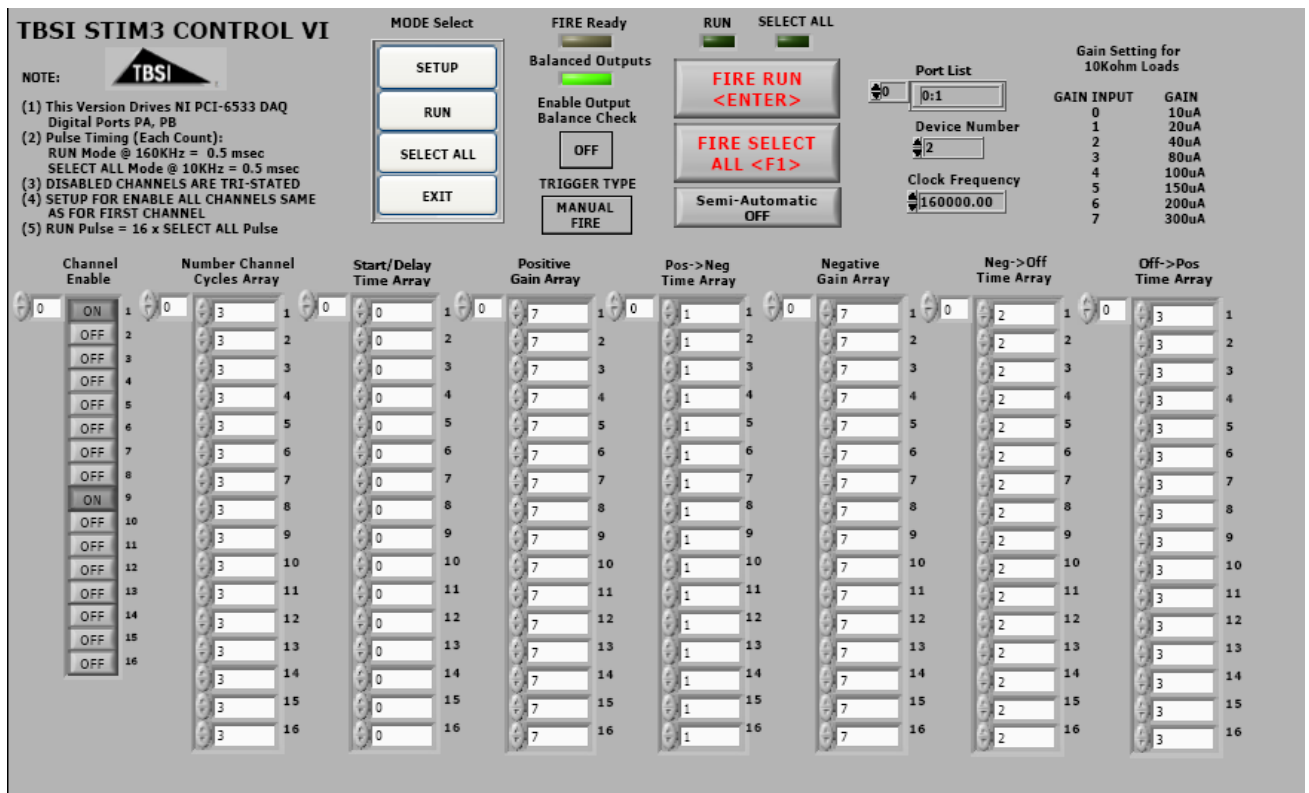
TBSI STIM3 Isolation Printed Circuit Board (PCB) Assembly

NI Data Acquisition (DAQ) Card Digital Interface: A DAQ card with at least 16 digital I/O pins, one ground pin, one +5VDC pin (at $\geq 100\text{mA}$), DMA timing control at 100KHz or faster, is required to control the STIM3 assembly with resulting stimulation pulses having a 1-2millisecond duration. It is necessary that the power and ground connection be sound otherwise timing inconsistencies may result. The DAQ card must have the drivers allowing for control by TBSI's NI Labview™ STIM3 control software. For 1 millisecond or faster stimulation pulse durations, TBSI uses a National Instruments PCI-6533 (PCI-DIO-32HS) DAQ card set for an output rate of 160KHz or higher. This card (and accompanying software) utilizes direct memory access (DMA) for faster control of the DAQ card digital outputs. In addition an NI shielded cable (NI P/N 776844-02) is used to directly interface to the STIM3 isolation PCB assembly. A thorough description of the interface is given in the following table:

Signal Name:	Labview Port Position:	DAQ PCI 6533 Signal Name:	NI CB-68LPR SCSI Connector Position:	STIM3 PCB Input Conn. Pinout:
Spare2	DI/O 15	DIOB7	22	7
Spare1	DI/O 14	DIOB6	21	18
Spare0	DI/O 13	DIOB5	54	6
Enable All	DI/O 12	DIOB4	53	8
Reset	DI/O 11	DIOB3	52	20
Tristate	DI/O 10	DIOB2	51	19
Activate Address	DI/O 9	DIOB1	17	3
System Clock	DI/O 8	DIOB0	16	14
Gain Select 2	DI/O 7	DIOA7	15	10
Gain Select 1	DI/O 6	DIOA6	48	21
Gain Select 0	DI/O 5	DIOA5	47	9
Polarity	DI/O 4	DIOA4	13	17

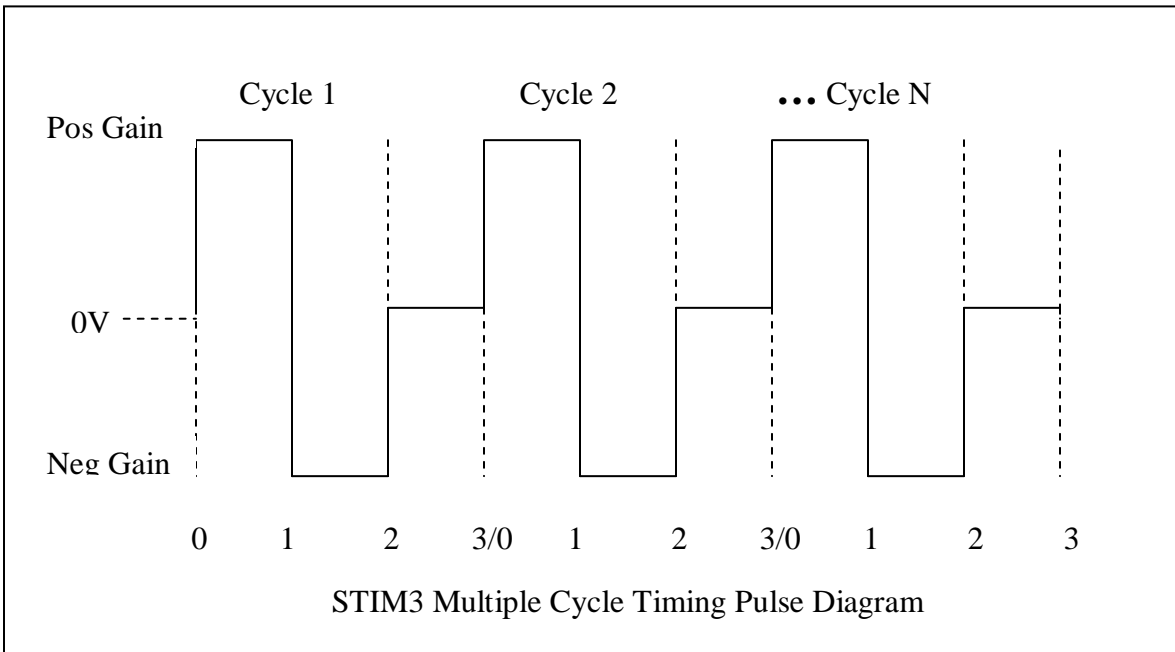
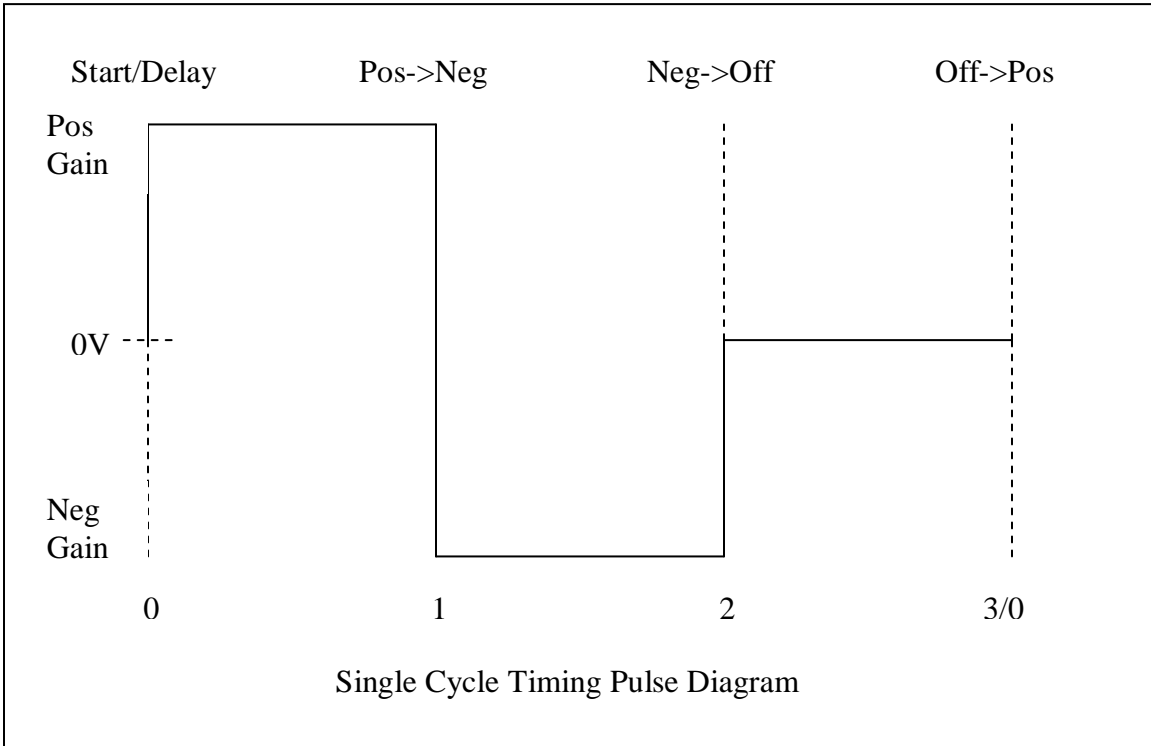
Addr3	DI/O 3	DIOA3	12	16
Addr2	DI/O 2	DIOA2	45	5
Addr1	DI/O 1	DIOA1	44	15
Addr0	DI/O 0	DIOA0	10	4
+2.5VDC (Vdd)		5VDC (Vdd)	1	2,11
-2.5VDC (Vss)		DC GND (Vss)	36,37,39,41,42,11,46,14,49,50,18,20,55,24,59,27,62,30,65,33,68	13,22
AC GND (Vdd/2)				1,12

NI Labview™ STIM3 Control Software: The TBSI STIM3 control software consists of a Labview™ graphic user interface (GUI). The GUI contains timing, level, and delay entries to be determined by the user. By manipulating the 13 STIM3 control signals (via the DAQ, isolation assembly, and various cables) the Labview software controls the STIM3 output levels and timing.



TBSI STIM3 Labview Graphic User Interface (GUI)

The STIM3 Timing diagrams for single and multiple pulse cycles are shown below:



Channel Output Configuration:

The Labview control software enables the user to select (1) the positive and negative output levels (2) the time, relative to time 0 (when select FIRE button), that the output of each channel transitions positive, negative, or off, (3) the number of Pos-Neg-Off cycles each channel fires, (4) whether each channel is enabled or disabled, (5) manual or semi-automatic firing, (6) internal or external FIRE triggering, (7) rate of the output clock (which increases-decreases pulse width), (8) channel output charge balance control, and (9) whether to operate in RUN mode (each channel

configured separately) or Select All Mode (all channels fired simultaneously with same timing and gain configuration as channel 1).

Enable Balance Check:

The Labview GUI always compares the area inside the positive pulse to the area inside the negative pulse. When any of the channel gain and timing configuration values result in unequal positive and negative pulse area, the GUI will set the Balanced Outputs LED to RED. When the positive and negative pulse areas are equal, the LED is set to GREEN. The user has the option to leave the Enable Output Balance Check button in the OFF position allowing the user to FIRE the unbalanced charge outputs. When the button is in the ON position, the GUI displays a warning message and prevents the user from firing the outputs.

Normal and Semi-Automatic Firing Options:

When the Semi-Automatic Button is in the OFF position, the user must first select the RUN Mode button or the Enable All Mode button to build and load the output configuration into memory that will be written to the DAQ card. This must be done each time before selecting the corresponding FIRE button. After each FIRE, the GUI waits for the user to select another mode, change the configuration settings, or to exit the program.

By selecting the semi-automatic firing option, the user needs only to select the desired mode once before performing repetitive firing of the STIM3. The user does not need to select the RUN or Enable-All mode select buttons before each time they select FIRE. Rather, the user only needs to continually select the FIRE Button or its keyboard equivalent button. The GUI will continue to fire the STIM3 each time the corresponding FIRE button is selected until the user disables the option then selects FIRE one more time, outputting one more set of pulses.

In addition to selecting the GUI FIRE keys to fire the STIM3, the user can conveniently use two keyboard keys rather than having to concentrate on where the mouse is pointing on the computer screen. When in RUN mode, depressing the enter key on the computer keyboard will also fire the output. When in Select All mode, depressing the F1 key on the computer keyboard will fire the output.

Trigger Type:

When Manual Fire is selected on the Trigger Type button, the Labview software fires the STIM3 when the GUI FIRE button is selected.

When External Trigger is selected on the Trigger Type button, the Labview software monitors digital inputs to the DAQ card (via the STIM3 isolation assembly). The user must first select the firing mode as before but does not select the corresponding firing button. Instead, a 0.5 microsecond or longer digital voltage level transitions (0VDC-to-5VDC) on the inputs trigger the software to fire desired STIM3 channel outputs as configured on the GUI. TBSI can write custom software correlating the firing of desired outputs to a given digital input. The external trigger pulses can originate from TBSI or third-party neural signal monitoring devices. The TBSI STIM3 isolation assembly allows for 2 isolated inputs or 8 non-isolated inputs to be used to trigger the STIM3 output firing.

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