

# MS4/MS16 Stimulus Isolator



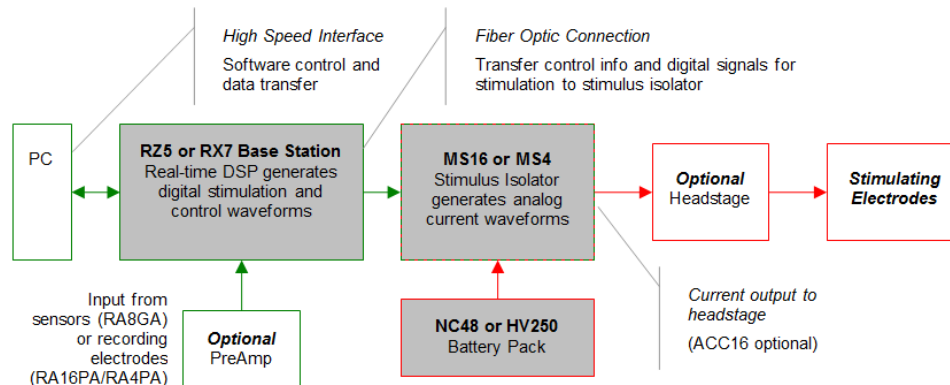
## MS4/MS16 Overview

The MS4/MS16 Stimulus Isolator converts digital waveforms into analog current waveforms as part of a computer controlled neural microstimulator system that delivers user-defined current waveforms through multichannel electrodes.

### The MicroStimulator System

A typical system consists of an RZ5 or RX7 processor base station (RX7 must be housed in a zBus Device Caddie with power supply and interface module), an MS4 or MS16 Stimulus Isolator, ACC16 AC Coupler (Optional) and NC48 or HV250 Battery Pack.

The block diagram below illustrates the functionality of the system.



**Multichannel MicroStimulator System Diagram**

As seen in the illustration above, stimulation control waveforms for each electrode channel are first defined on the base station and digitally transmitted over a fiber optic cable to the battery powered stimulus isolator. On the isolator, specialized circuitry for each electrode channel generates an analog current waveform as specified by the digital stimulation control waveform.

The final analog current output from the isolator is adjusted to match the stimulation control waveform by adjusting the isolator's driving voltage according to Ohm's law where:  $V=IR$ . That is, the driving voltage is adjusted for the stimulation control waveform level and the electrode impedance. In this way, the stimulation current specified by the user will be constant regardless of electrode impedance, within system limits.

The MicroStimulator System standard configuration is capable of delivering up to 100  $\mu\text{A}$  of current simultaneously across up to 16 stimulating electrodes (impedance up to 1 Mohm). See "Working with the MS16 MilliAmp Mode" on page 8-46, for information if your stimulus isolator has been configured for MilliAmp mode.

## The Stimulus Isolator

The stimulus isolator features either four or 16 D/A converters that can deliver arbitrary waveforms of up to 10 kHz bandwidth. PCM D/As are used to ensure sample delays of only 4-5 samples and square edges on pulse stimulation waveforms.

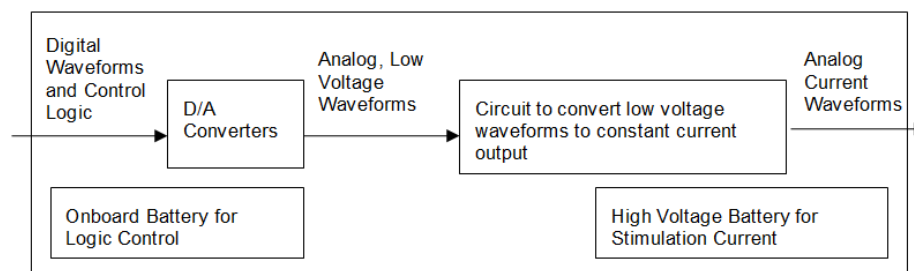
Each of the device's stimulation channels can be configured in one of three states:

**Stimulate:** Channels in stimulate mode pass current through the selected electrodes.

**Reference:** Channels in reference mode become part of the return path for the current. All channels in Reference mode use the same return path to analog ground on the stimulator. **Note:** Users can also use a dedicated global reference channel as a current return path. In this mode all channels can be used for stimulation.

**Open:** The Open mode is the default mode for all channels. In the open mode, the corresponding electrode channel is disconnected from output and internally grounded to eliminate noise and crosstalk. On multichannel electrodes, these electrodes might instead be connected to a recording preamp. In this mode a channel can be used to acquire neural signals.

The stimulus isolator utilizes an onboard, rechargeable Li-Ion battery for logic control and D/A converter operation. Special circuitry on the stimulus isolator draws on external high voltage battery packs to convert low voltage waveforms from the D/A converters to analog current waveforms as shown in the diagram below.



**Stimulus Isolator Diagram**

## The ACC16 AC Coupler

The stimulus isolator may generate a DC bias current of up to 0.2% of full scale (up to 0.2  $\mu\text{A}$  on 100  $\mu\text{A}$  device) on any stimulation channel, even during a quiescent state. While this may not have significant short-term effects, over time, it may cause unintended tissue damage. This problem primarily affects researchers using electrodes with impedance of more than 100 kOhms. Users may connect the ACC16

AC coupler (supplied with all MS4/MS16s) directly to the Stim Output connector on the stimulus isolator to block any bias present on the Stim Output lines.

**Note:** Single-ended operation (G and Ref jumper pins tied together) is the only mode supported on the ACC16.

Each channel of the ACC16 coupler includes an RC circuit with a 0.1 $\mu$ F capacitor in parallel with a one MOhm resistor. The coupler acts as a 1.6 Hz highpass filter, eliminating the DC bias current. It also acts as a voltage divider, decreasing the voltage and thus the current delivered through the electrode.

**Note:** When using the ACC16 you will NOT be able to deliver the MAXIMUM Rated current. See “Designing the Stimulus Signal” on page 8-37, for more information.

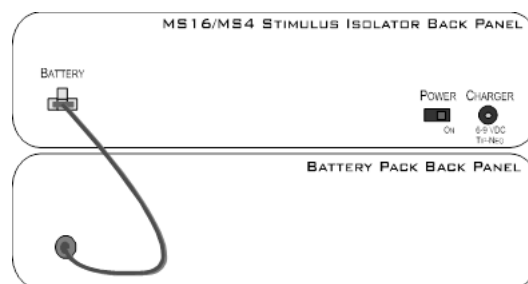
## Stimulus Isolator Batteries

Power for stimulation is supplied by one of TDT's battery packs. Power requirements are determined by the amount of current needed for stimulation and the impedance of the electrode being used. When using a high impedance electrode (approximately 1 MOhm), the HV250 Battery Pack will most likely be required. With lower impedance electrodes (100 kOhms to 200 kOhms), the NC48 Battery Pack may be more suitable. Users should contact TDT for further information before attempting to use an external power supply. See “Battery Reference” on page 8-49, technical specifications and for more information.

## Hardware Set-up

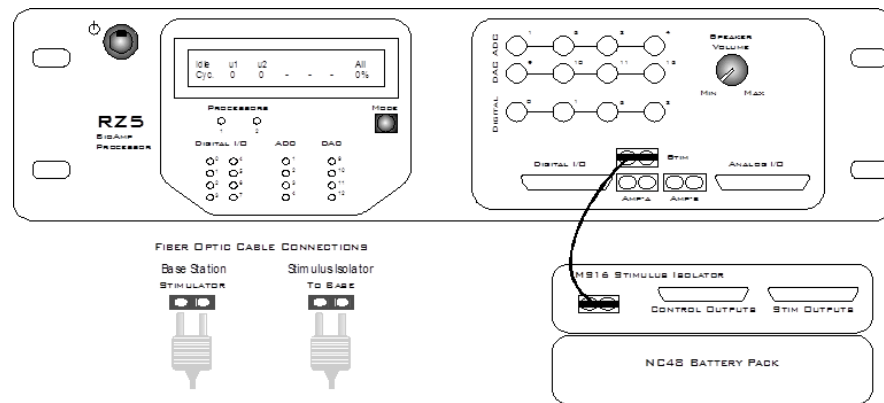
To connect the system hardware:

1. Ensure that the TDT drivers, PC interface, and device chassis are installed, setup, and configured according to the installation guide provided with your system.
2. Connect the battery pack to the back panel of the Stimulus Isolator via the connector labeled **Battery**, as shown in the diagram below.

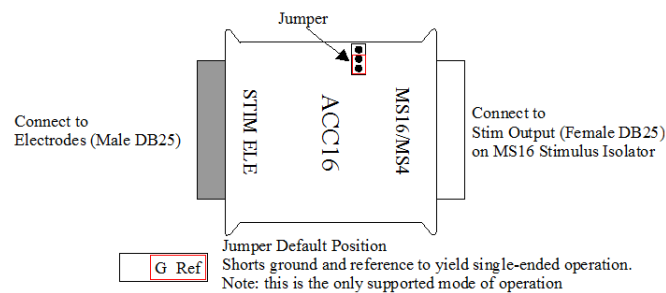


**WARNING!** The HV250 is a high voltage power source, capable of delivering up to 250 Volts DC at high currents. Shorting the battery connection pins can cause damage to the device and injury to the user. Always use caution when handling or connecting the devices.

3. Connect the Stimulus Isolator to the base station using the provided fiber optic cable.



4. Connect the fiber optic cable from the MS16 fiber optic port labeled **To Base** to the fiber optic port labeled **Stimulator** on either the RZ5 or the RX7 (not shown). Be sure to note the difference in the two sides of the fiber optic cable connectors and ensure they are inserted with the correct side up as shown under Fiber Optic Cable Connections above.
5. If desired, connect the ACC16 AC Coupler to the Stimulus Isolator's Stim Output port.



6. Connect the Stimulus Isolator's **Stim Output** or the ACC16's **Stim Ele** connector to the stimulating electrodes using your preferred method such as direct wiring, the SH16 switching headstage, or a custom pass through connector (available from TDT). See "MS4/MS16 Stimulus Isolator Technical Specifications" on page 8-47, for pinouts.
7. Power on the base station, then power on the stimulus isolator using the power switch on the isolator's back panel.

**Note:** Ensure that the rechargeable batteries (onboard Li-Ion and NC48) are fully charged before starting your protocol.

The hardware is ready for use.

If using the system with other devices, such as a switching headstage or preamplifiers, see the documentation for those devices for hardware connection information.

## Stimulus Isolator Features

### Analog Outputs (Stim Outputs)

The Stimulus Isolator is equipped with four or 16 analog current output channels, arranged in four-channel banks that can be powered down when not in use. Channels can operate in three modes: Stimulate, Reference, or Open. Simultaneously

setting any channel in a bank to both Stimulate and Reference mode turns off that entire bank of channels.

An ACC16 AC Coupler is supplied with all MS4/MS16 modules and may be connected directly to the Stim Output connector to block any DC current bias present on the Stim Output lines (this problem primarily affects researchers using electrodes with impedance of more than  $\sim 100$  kOhms) when set in stimulate mode.

**Note:** When using the ACC16 you will NOT be able to deliver the MAXIMUM current.

## Stim Lights

A Stim Light (one for each channel) indicates that a Stim Output channel is in use as a stimulus output. The Stim Lights are located above the Stim Output connector and are numbered 1 - 16, to indicate the active channel number. The LEDs will flash once every three seconds to indicate any bank of channels that has been powered off.

## Ref Lights

A Ref Light (one for each channel) indicates that a Stim Output channel is in use as a reference. The Ref Lights are located above the Stim Output connector and are numbered 1 - 16, to indicate the active channel number.

## Status Lights

**Sync:** Flashes once a second when the stimulator is not connected to a base station and glows steady when it is correctly connected.

**Stim Ref:** When lit, indicates that the stimulator has been configured to use a global reference.

**Battery:** When lit, indicates when the stimulator's onboard battery is low. The battery voltage decreases rapidly once the battery low light is on.

**Fast:** charging  
**Slow:** low battery

**High Voltage:** When lit, indicates that the stimulator is correctly connected to the designated Battery Pack.

**Solid:** correct working voltage  
**Flashing:** low voltage

## Digital Output (Control Outputs)

The Control Output connector provides access to the stimulator's 16 channels of Word addressable digital output. These outputs can control the relays on the SH16 switching headstage or other digital output device (maximum current 40 mA, maximum voltage 3.3 Volts).

## Control Output Lights

A Control Output Light (one for each digital I/O) indicates that the digital output channel is set high (or active). The Control Output Lights are located above the Control Output connector and are numbered 1 - 16, to indicate the active digital output channel.

## Fiber Optic Port (To Base)

The stimulator's fiber optic input port (labeled To Base) provides an isolated connection to the base station (RZ5 or RX7). The fiber optic cable carries digital signals to D/A's on the stimulator. It also carries control information and information about the state of the stimulation channels. One end of the fiber optic cable connects to the device using the To Base connection pair and the other end connects to the Stimulator input on the base station.

Keep in mind, because of the fiber optic cable data transfer rate, the corresponding Stimulator fiber optic output port on the base station (RZ5 or RX7) will be disabled if the system sampling rate is set to a value greater than 24.414 kHz.

## High Voltage Input (Back Panel)

The stimulator uses either the NC48 or the HV250 High voltage Battery Pack for stimulation. The battery pack should be connected via the Battery connection on the back panel.



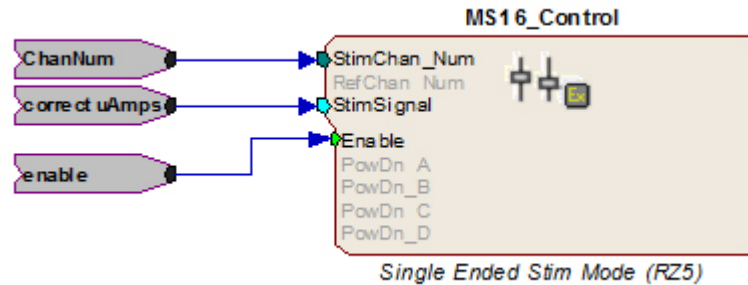
**WARNING!** The HV250 battery packs are capable of delivering up to 250 Volts DC at high currents. Shorting the device can cause damage to the device and injury to the user. Always use caution when handling or connecting the devices.

## Power Switch (Back Panel)

The Power switch turns the stimulator power off or on. The fiber connector on the front panel will be illuminated when the stimulator is on.

# Software Control

Operation of the MicroStimulator system is controlled via an RPvdsEx circuit loaded and run on the connected base station processor (RZ5 or RX7). TDT recommends using the MS16\_Control Macro (pictured below) in your control circuits. This macro simplifies setup of stimulus and reference channels, stimulus signal output, and power conservation. The macro is also used to configure the correct scale factors and poke addresses for the RZ5 or RX7 processor. Select the correct device in the macro settings dialog.



When the MS16\_Control macro is not sufficient for your task, a circuit can be designed using the Poke component to control the system. This component writes to special memory locations on System 3 devices and is intended primarily for TDT use. While both methods are described here, keep in mind that the Poke component should be used with caution.

## Important Circuit Design Considerations

### Sampling Rate

When using the RZ5 or RX7 with the stimulus isolator, the maximum sampling rate of the system is 24.414 kHz, a limitation of the fiber optic connection between the base station and the stimulus isolator.

### Signal Resolution

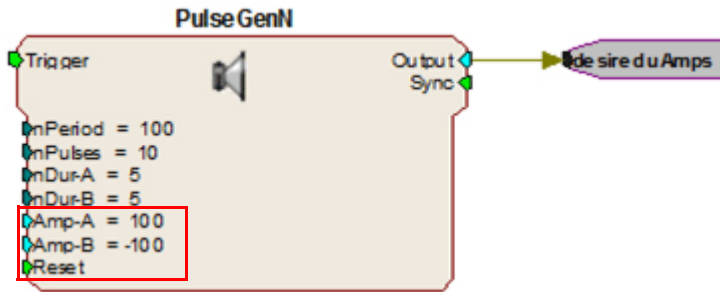
Signal resolution is dependent on the sampling rate used. The stimulus isolator's PCM D/A converters allow users to generate precise pulsed signals, including square waves with durations of only 1 sample. When using the maximum sampling rate of 24.414 kHz, the sample period is 40.96 microseconds. The stimulus isolator has an effective bandwidth of 10 kHz for continuous (non-pulsed) waveforms.

## Designing the Stimulus Signal

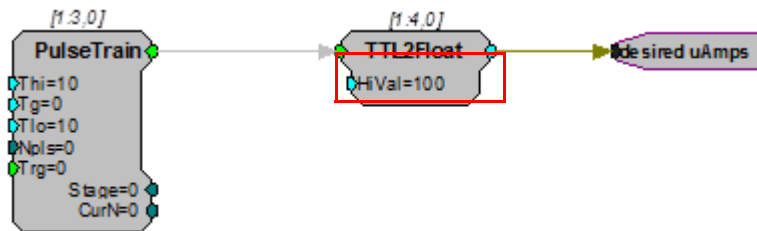
The MicroStimulator system offers flexible stimulus delivery capable of generating complex patterns of pulses or arbitrary waveforms. This allows you to make use of the full range of the waveform and pulse generators in the RPvdsEx component library, including the PulseGenN macro.

### Desired Signal Range

When adding and configuring waveform components you must consider the output range of the system. The default configuration of the stimulus isolator can deliver stimuli in the range of  $\pm 100 \mu\text{A}$ ; be sure to set component amplitude parameters with this output range in mind. In the figure below, the amplitude of a biphasic pulse is defined in the Amp-A and Amp-B parameters.



When using components that output a logical signal, such as a PulseTrain, the output range can be defined when the output is converted to the desired data type. In the figure below the PulseTrain component sends out a standard TTL signal with a fixed duration. A TTL2Float component is then used to convert the signal to a user specified value between 0 and 100. This value indicates the desired stimulator output in microAmps.



If the ACC16 is not in use the desired uAmps in floating point format can be fed directly to the MS16\_Control macro's Stim Signal input. If the ACC16 is being used a correction factor must be applied (see below).

## ACC16 Correction Factor

An ACC16 AC coupler can be used with the system in single-ended operation (global reference) to block any DC bias present on the Stim Output lines (a problem primarily affecting researchers using electrodes with impedance of more than 200 kOhms). When the ACC16 is in use, it acts as a voltage divider, decreasing the voltage and thus the current delivered through the electrode. The actual current delivered through the ACC16 depends on the ratio of the coupler impedance to the impedance of the electrode in use. For 50 kOhm electrodes the error is about 5%.

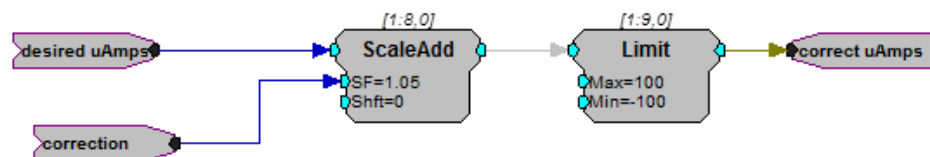
**To calculate a correction factor for actual current delivered:**

1. Determine the impedance of your stimulating electrode.
2. Calculate the following equation:

$$\text{Correction} = 1 / (1,000,000 / (\text{Electrode Imp} + 1,000,000))$$

$$= (\text{Electrode Imp} + 1,000,000) / 1,000,000$$

3. In your circuit, scale the current output by this value.





**In the example correction circuit above:**

- The value for “correction” represents the results of the calculation above.
- The value for “desired uAmps” represents the desired amplitude of the stimulus signal.
- The values for the “Limit” component should be set based on the actual limits of your systems. The MS4/MS16 is available in 100  $\mu$ A and 1 mA versions. **In either case, when using the ACC16 you will NOT be able to deliver the MAXIMUM current. The maximum current =  $1/\text{correction factor} \times 100$ . Calling for higher currents will deliver currents at the defined limit.**

If using the recommended MS16\_Control Macro, the *correct uAmps* value is fed to the macro’s **Stim Signal** input.

## Selecting Global or Local Reference Mode

The **MS16\_Control** macro should be included in all circuits for stimulus isolator control. The **Stimulation Mode** setting on the Setup tab of the macro properties dialog box determines whether the stimulus isolator is configured to use a global reference (*Single ended*) or a local reference(s) (*Differential*).

### Global Reference Mode

If a global reference is desired, set the MS16\_Control macro’s **Stimulation Mode** to *Single Ended* on the **Setup** tab of the macro properties dialog box. In this mode the **RefChan** input is disabled.

### Local Reference Mode

If local reference is desired, set the **MS16\_Control** macro’s **Stimulation Mode** to *Differential* on the **Setup** tab of the macro properties dialog box. In this mode the **RefChan** input is enabled.

**Note:** In Local Reference (*Differential*) mode, writing a 0 to the **RefChan\_Mask** macro input while the **Channel Select Method** is set to **With Chan Mask**, will disable all local reference channels and enable the global reference.

### Configuring Reference and Stimulation Channels

The **MS16\_Control** macro sets reference and stimulation channels. Feeding an integer value to the macro’s **StimChan** and **RefChan** inputs will *turn on* channels for stimulation or reference, respectively. The **Channel Select Method** on the **Setup** tab of the macro properties dialog box determines whether the integer is read as a single channel number or as a mask value representing multiple channels.

**Important!** Configuring a channel, as both stimulus and reference will cause the unit to automatically turn off that bank of channels.

### Setting a Single Channel for Stimulation or Local Reference

By default, the **Channel Select Method** on the **Setup** tab of the macro properties dialog box is set to **With Chan Number**. The **StimChan** and **RefChan** inputs accept an integer value of 0 through 16 and the macro will set the selected channel for stimulation or local reference.

**Note:** An integer value of 0 fed to StimChan disables all channels.

### Setting Multiple Channels for Stimulation or Local Reference

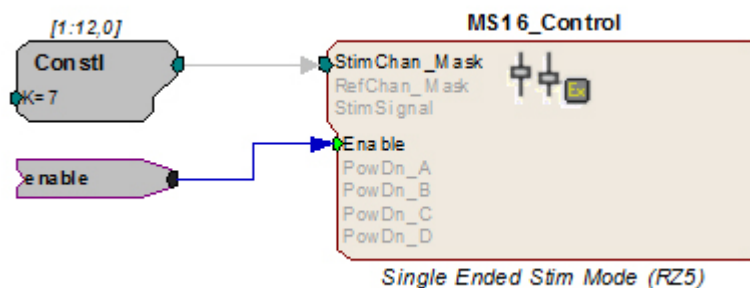
To configure multiple reference channels, the **Channel Select Method** on the **Setup** tab of the macros properties box must be set to **With Chan Mask**. In this mode, **StimChan** and **RefChan** inputs accept an integer value channel mask representative of the desired channels (shown in the table below). The integer value is the sum of the channel masks for the channels.

Channel Mask Table

Channel #	Channel Mask	Channel #	Channel Mask
1	1	9	256
2	2	10	512
3	4	11	1024
4	8	12	2048
5	16	13	4096
6	32	14	8192
7	64	15	16384
8	128	16	32768

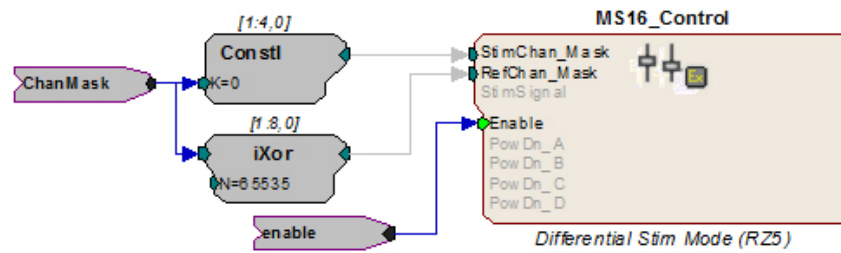
#### For example:

If you wish to simultaneously set channels 1 (channel mask 1), 2 (channel mask 2), and 3 (channel mask 4) to stimulation mode add their respective channel masks from the table above ( $1 + 2 + 4 = 7$ ), and send that sum (7) to the **StimChan\_Mask** input as shown in the figure below.



This example sets channels 1, 2, and 3 for stimulation. Unused banks of channels are powered down. The stimulus design and delivery are not included in this circuit segment.

The reference channels can be configured in the same way, using the integer values in the Channel Mask Table above. The iXor component can also be used to set all channels NOT set as stimulation to reference. In the figure below, an iXor is used to perform an **exclusive** bitwise OR function. The channel mask for stimulation is XORed with the integer mask value for all channels, resulting in a channel mask that sets all non-stimulus channels to reference channels.



**Important!** Writing a 0 to the **RefChan\_Mask** macro input while the **Channel Select Method** is set to **With Chan Mask**, will disable all local reference channels and enable the global reference.

## Delivering the Stimulation

The stimulus delivery segment of the circuit can be handled within the MS16\_Control macro or external to the macro using the Poke component. TDT recommends using the MS16\_Control macro whenever possible.

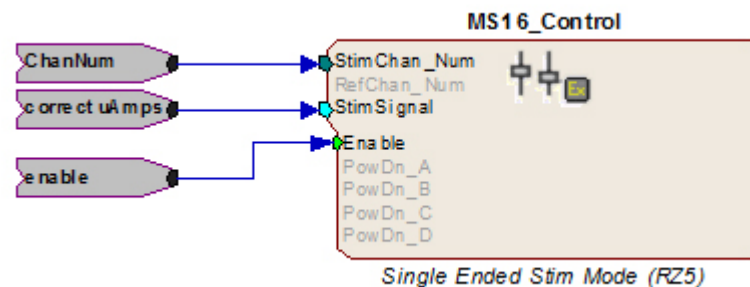
The Poke component should be used with caution; however, it is necessary for some tasks, including simultaneous stimulation on multiple channels.

**Important!** The memory addresses used with the Poke component are different for the RZ5 and RX7. See “Memory Address Reference for Using the Poke Component” on page 8-43, for more information.

### Single Channel Stimulation with Global Reference

When the global reference is used, the **MS16\_Control** macro can be used for single channel stimulation. The **Stimulation Mode** on the **Setup** tab of the macro’s properties box must be set to *Single Ended* and the **Channel Select Method** must be set to **With Chan Number** to enable the StimSignal input.

**StimSignal** accepts floating-point input, representative of the desired stimulus current waveform. The macro will send the stimulus signal to the channel set using the **StimChan\_Num** input.



This example sends floating point values representing the amplitude of the waveform in microAmps to a user-specified channel of the stimulator as long as the enable is high. If using the ACC16 be sure to scale the signal by the necessary correction factor. See “The ACC16 AC Coupler” on page 8-32, for more information.

**Note:** To conserve the life of the stimulus isolator's onboard and external batteries, remember to power down unused bank of channels on the **MS16\_Control** macro's **Power Control** tab.

### Simultaneous Stimulation on Multiple Channels and/or Local Reference Mode

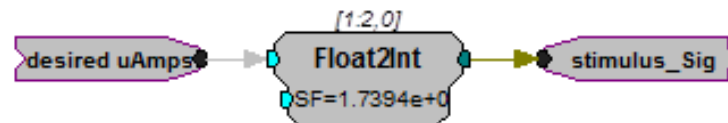
The MS16\_Control macro's StimSignal is disabled whenever the local reference mode is used or when a channel mask is used to set multiple stimulation channels. In these cases the macro should still be used to configure or turn on channels for stimulation (see "Configuring Reference and Stimulation Channels" on page 8-39), but stimulus delivery must be handled external to the macro.

### Converting the Signal to an Integer Value

When designing the stimulus signal it is convenient to work with floating point values that represents the desired current in microAmps (See "Designing the Stimulus Signal" on page 8-37), However, when the macro is not used the stimulus signal must be converted to an integer value representing a voltage level in the proper range for the stimulus isolator. The scale factor required to scale the current in the desired range of +/-100  $\mu$ A is dependent on the type of base station processor being used.

**RZ5** When using the RZ5, use a scale factor of: **1.7394e+007**

**RX7** When using the RX7, use a scale factor of: **265.41**



In this circuit segment, the desired floating point value in microAmps is fed to a Float2Int, which converts the data type and applies the scale factor.

### Signal Output to Stimulus Channels

Once output waveforms are converted to an integer value they are poked (written) to memory locations on the MS4/MS16, using the Poke component. Memory addresses vary by processor as described here. Reference tables are also provided below "Memory Address Reference for Using the Poke Component" on page 8-43.

**RZ5** When using the RZ5, output to channels 1-16 must be written to memory addresses 32-47, respectively. To do so, offset the channel number by 31 and enter this value in the address parameter of the Poke component.

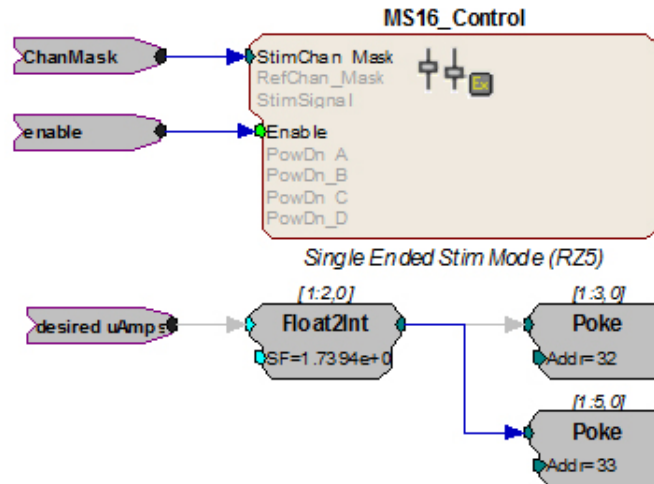


The circuit segment above sends out a stimulus signal to channel one of the stimulator.

**RX7** When using the RX7, output to channels 1-16 must be written to memory addresses 20-35, respectively. To do so, offset the channel number by 19 and enter this value in the address parameter of the Poke component.

### Summary: Simultaneous Stimulation on Multiple Channels

The example below shows a more complete picture, with the MS16\_Control macro used to set or *turn on* multiple channels using the ChanMask hop, “Setting Multiple Channels for Stimulation or Local Reference” on page 8-40, and the Poke used to write the signal value to the MS4/MS16 memory location for channels one and two with the RZ5.



### Circuit Design Using the Poke Component

Using the MS16\_Control macro simplifies circuit design for the MicroStimulator System. If the macro **cannot** be used, you can use the RPvdsEx Poke component to control the stimulus isolator by writing information to memory addresses on the RZ5 or RX7.

#### Memory Address Reference for Using the Poke Component

The table below summarizes each stimulus isolator control function and its memory address.

Control	Value Description	Memory Address	
		RZ5	RX7
Stimulus Channels	Mask for channels between none and 16; integer value between 0 and 65535	48	7
Signal Output	Integer representing current level scaled for D/A (varies depending on device).	32-47	20-35
Global Reference	0 (off) or 1 (on)	50	9
Reference Channels	Mask for channels between none and 16; integer value between 0 and 65535	49	8
Digital Out	Mask for channels between none and 16; integer value between 0 and 65535	51	3

#### Signal Output to Stimulus Channels

To generate signals on the stimulus isolator, the output waveforms are poked (written) to memory locations as integer values. See “Converting the Signal to an

Integer Value” on page 8-42. for more information.

The table below maps the output channels of the RZ5 and RX7 to their poke address.

Isolator Output Channel	Poke Waveform To Address		Isolator Output Channel	Poke Waveform To Address	
	RZ5	RX7		RZ	RX7
1	32	20	9	40	28
2	33	21	10	41	29
3	34	22	11	42	30
4	35	23	12	43	31
5	36	24	13	44	32
6	37	25	14	45	33
7	38	26	15	46	34
8	39	27	16	47	35

### Global Reference Enable

Global reference uses the analog ground to complete the stimulation circuit. The global reference feature can be enabled by setting the value of a specific memory address to one. The StimRef indicator light on the front panel of the stimulus isolator is illuminated when the global reference has been set.



**RZ5** To enable global reference when using an RZ5 **set the value of memory address 50 to one** as pictured above.

**RX7** To enable global reference when using the RX7 **set the value of address 9 to one**.

### Channel Masks

Memory addresses for stimulus, reference, or digital I/O channel setup expect an integer value between zero and 65535. Masked values for each channel are noted in the table below. Adding masked values together will set multiple channels.

The table below maps channel numbers to mask values:

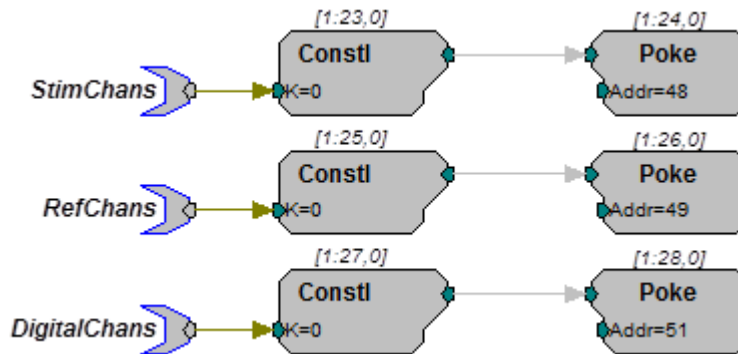
Channel #	Channel Mask	Channel #	Channel Mask
1	1	9	256
2	2	10	512
3	4	11	1024
4	8	12	2048
5	16	13	4096
6	32	14	8192
7	64	15	16384
8	128	16	32768

**For example:**

If channels 1 (channel mask 1), 2 (channel mask 2), and 3 (channel mask 4) are desired, use a channel mask of 7 (1 + 2 + 4 = 7).

**Stimulus, Reference, or Control Channel Setup**

To enable a given channel, an integer value is written to the appropriate memory address of the base station. The integer value is the sum of the channel masks (see table above for mask values) for all the stimulation channels that the user wishes to activate.



In the example circuit above, the StimChans parameter tag feeds a Const1 an integer value used to assign channels as stimulus channels, RefChans sets the reference channels, and DigitalChans sets the digital channels. This example above is configured for the RZ5.

**Important!** The memory addresses for the RZ5 and RX7 are different. See “Memory Address Reference for Using the Poke Component” on page 8-43, for more information.

**Note:** When using the SH16 switching headstage, the digital I/O channels on the MS4/MS16 are used to control the switching headstage. These are accessed via a DB25 connector labeled **Control**. For SH16 switching headstages (serial number 2000 and greater), channels 1-3 are used for communication and channels 4-8 are used to provide power to the SH16. When the SH16 is not being used, the MS4/MS16 digital I/O can be used for any type of digital control.

See “SH16 Switchable Headstages” on page 11-49, for more information about controlling the headstage.

## Working with the MS16 MilliAmp Mode

The MS16 can be modified at the factory to deliver stimuli in the  $\pm 1$  mA range. If your device has this modification, please note the following important differences in operation.

The HV250 battery pack **CANNOT** be used with milliAmp mode. This mode should only be used with the NC48 battery pack.

### Circuit Design for the MS16 in MilliAmp Mode

#### MS16\_Control Macro

When using the **MS16\_Control** macro set **High Current Range** on the **Setup** tab of the macro’s properties box to Yes. If High Current Range is set to Yes, all other circuit design considerations are handled automatically by the macro.

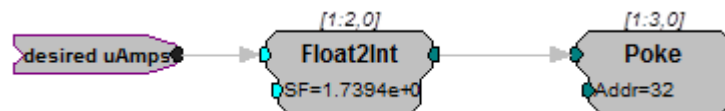
#### Scale Factor

When using the Poke component for stimulus delivery, use the appropriate scale factor for your processor to convert the signal in desired or corrected microAmps to the necessary voltage for A/Ds.

**RZ5** When using RZ5, use a scale factor of **1.7394e+006**.

**RX7** When using RX7, use a scale factor of **26.541**.

See “Converting the Signal to an Integer Value” on page 8-42, for more information.



In this circuit segment, the desired floating point value in microAmps is fed to a Float2Int, which converts the data type and applies the necessary scale factor for MilliAmp mode.

#### High Current Mode

When the MS16\_Control is not used at all, the high current mode can be set by sending a specific value to the appropriate memory address for your processor. This memory address is the same address used to turn on or off the global reference. The value used to set the high current mode can be added to the global reference values 0 (off) and 1(on).

**RZ5** When using the RZ5, the high current mode can be set by sending a value of **54784** to memory address **50**.

Therefore, poking 54784 to the address turns on high current mode and turns off the global reference; while poking 54785 to the address turns on high current mode and turns on the global reference.



**RX7** When using the RX7, the high current mode can be set by sending a value of 214 to memory address 9.

Therefore, poking 214 to address 9 turns on high current mode and turns off the global reference; while poking 215 to address 9 turns on high current mode and turns on the global reference.

## MS4/MS16 Stimulus Isolator Technical Specifications

<b>Stimulus Output Channels</b>	4 (MS4) or 16 (MS16)
<b>Sampling rate</b>	Up to 24.414 kHz
<b>Stimulus Output Current</b>	+/- 100 $\mu$ A up to 1 MOhm load with HV250 +/- 100 $\mu$ A up to 200 kOhms load with NC48*
<b>Offset Current</b>	Less than 0.2% of full range setting
<b>Digital Output Max Current</b>	40 mA
<b>Digital Output Max Voltage</b>	3.3 V
<b>Selectable Reference</b>	Local or Global
<b>Power</b>	
<b>Control</b>	Onboard Rechargeable Li-Ion battery
<b>Stimulation</b>	NC48 Rechargeable Battery with NiCad batteries* or HV250 Battery Pack with Carbon Zinc batteries

\***Note:** the Stimulus Isolator may be modified at the factory for 1 MilliAmp Mode.

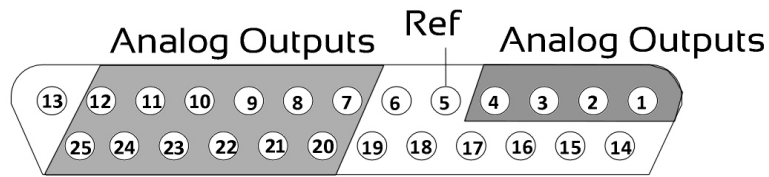
## DB25 Connector Pinouts

### STIM ELE Connector on the ACC16

The ACC16 AC Coupler is used to block DC bias and connects directly to this Stim Output Connector, passing signals through to its STIM ELE connector with the same pinout.

### Stim Output Connector

The Stim Output connector provides access to the analog output channels. These channels are used primarily for stimulus output.

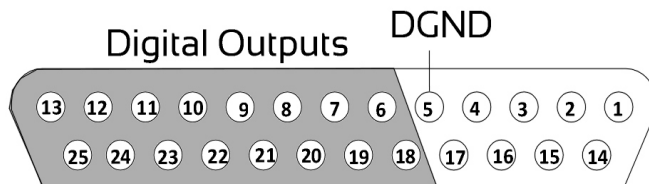


Pin	Name	Description	Pin	Name	Description
1	A1	Analog Channels Ch 1-4	14	NA	Not Used
2	A2		15		
3	A3		16		
4	A4		17		
5	Ref	Reference	18		
6	NA	Not Used	19		
7	A5	Analog Channels Ch 5, 7, 9, 11, 13, and 15	20	A6	Analog Channels Ch 6, 8, 10, 12, and 14, 16
8	A7		21	A8	
9	A9		22	A10	
10	A11		23	A12	
11	A13		24	A14	
12	A15		25	A16	
13	NA	Not Used			

**Note:** Channels 5 - 16 not available on the MS4.

### Control Output Connector

This connector provides access to control or relay output channels.



Pin	Name	Description	Pin	Name	Description
1	NA	Not Used	14	NA	Not Used
2					
3					
4					
5	DGND	Digital Ground	18	D0	Digital Outputs Bits 0, 2, 4, 6, 8, 10, 12, and 14
6	D1	Digital Output Bits 1, 3, 5, 7, 9, 11, 13, and 15	19	D2	
7	D3		20	D4	
8	D5		21	D6	
9	D7		22	D8	
10	D9		23	D10	
11	D11		24	D12	
12	D13		25	D14	
13	D15				

## Battery Reference

The stimulus isolator uses an onboard Lithium-Ion battery for general device operation. These batteries charge in four hours. A 6-9 Volt battery charger with 500 mA of current capacity is included with the stimulator and can be connected via the Charger connector on the stimulator's back panel. The charger tip is center negative. If it is necessary to replace the charger, ensure that the power supply has the correct polarity.

Issue	HV250	NC48	Onboard Li-Ion
<b>Battery life</b>	130 mAh (up to 27 hours stimulation)	1000 mAh (up to 240 hours of stimulation)	12-15 hours battery life between charges
<b>Rechargeable</b>	No	Yes	Yes
<b>Maximum impedance for delivering a 100 microAmp current</b>	1 MOhms	200 kOhms	N/A
<b>Usable in MilliAmp Mode</b>	No	Yes	Yes
<b>Ambient temperature</b>	Normal room temperatures	Normal room temperatures	Normal room temperatures

### HV250 Battery Pack

The HV250 Battery Pack uses four Carbon Zinc batteries, each delivering 67 Volts. Because the HV250 Battery Pack is non-rechargeable, it must be replaced periodically. The High Voltage LED on the front panel of the MS4/MS16 will flash to

alert the user of a low voltage condition. To extend the life of the battery, we recommend enabling only the desired channels for stimulation.



**WARNING!** The HV250 is a high-voltage power source, capable of delivering up to 250 Volts DC at high amperages. Shorting the device can cause damage to the device and injury to the user. Always use caution when handling or connecting the devices. Never attempt to charge the HV250.

## NC48 Battery Pack

The NC48 Battery Pack uses 32 Nickel Cadmium (NiCad) batteries to supply a peak-to-peak voltage of 48 Volts with a range of +/- 24 Volts.



**WARNING!** Just as with all batteries, shorting the NC48 Battery Pack can cause damage to the device and injury to the user. Always use caution when handling or connecting the devices.



**WARNING!** Overcharging the NC48 battery pack can cause the cells to rupture.

The NC48 Battery Pack should be connected to its charger for a maximum of 16 hours. Overcharging shortens battery life and may burn out the battery in extreme cases. Although the batteries used in the NC48 are designed to provide the user with dozens of charge/discharge cycles, the performance of all rechargeable batteries deteriorates over time. The major sign that a battery is deteriorating is a shortened use cycle between charges.

**Important!** Used NiCad batteries must be recycled.

The NC48 Battery pack should be stored at normal room temperatures. Temperature extremes can affect the operation of the batteries. Battery packs stored for longer than two months should be tested prior to use.

## MS4/MS16 Anomalies

If the stimulus isolator control bits and relay switching control bits do not work after power up, execute a hardware reset on the base station using zBusMon.

### Serial numbers 4000 and above

Previous versions of the stimulator automatically switched banks of channels off when not in use. A recent change to the microcode eliminates this feature, giving users control over when channels are turned off. By default, all channels are on and must be turned off manually.

### Serial numbers below 4008 (MS4) and 4015 (MS16)

When the NC48 is connected to the stimulus isolator, the High Voltage LED on the front panel of the MS4/MS16 will constantly flash even when the NC48 (+/- 24 V) is at full charge, because the voltage monitoring circuitry was designed to detect a low voltage of the HV250 battery pack.

### **Serial numbers below 4000**

The MS4/MS16 has undergone several design changes to improve performance and usability. TDT recommends that all users upgrade to the latest versions (serial numbers 4000 and above). Contact TDT for an RMA to upgrade your current module.

### **Serial numbers below 3000**

Noise on outputs is high when the output is in “Open” mode. The noise is especially evident during recording and stimulation events. Contact TDT for an RMA for upgrade of your current device.

### **Conservation of Power**

The stimulus isolator's analog channels are arranged in four-channel banks. Each of these banks is powered up on reset of the device and will remain powered on. To conserve power, TDT recommends powering down unused banks of channels. The MS16\_Control macro can be used to turn off unused banks of channels. When not using the macro, simultaneously setting any channel in a bank to both Stimulate and Reference mode turns off that four-channel bank.

### **Maximum Voltage Output**

The stimulus output channels drive a current signal that ranges from 0-100 microAmps. The maximum voltage output from the MicroStimulator system using the TDT NC48 battery is the 24 volts and the maximum voltage output using the TDT HV250 battery is 125 Volts. The actual voltage output depends on the current waveform specified and the impedance of your electrodes, that is,  $V = ZI$  where  $V$ =Volts,  $Z$  = impedance and  $I$  = current.

### **Using the MicroStimulator with TDT's Switching Headstage**

When using TDT's switching headstage, ensure that relays for channels used for stimulation have been switched to the correct position using the SH16\_Control macro. Any stimulus channel for which the corresponding control channel has not also been set will fail to generate a signal. See “SH16 Switchable Headstages” on page 11-49.

