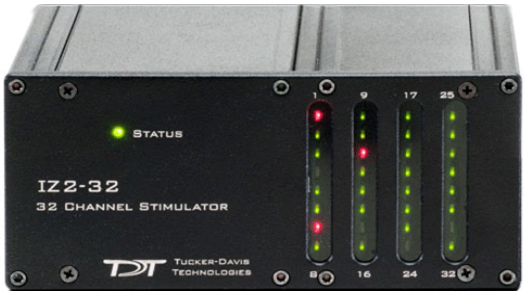
IZ2/IZ2H Stimulator



IZ2 Overview

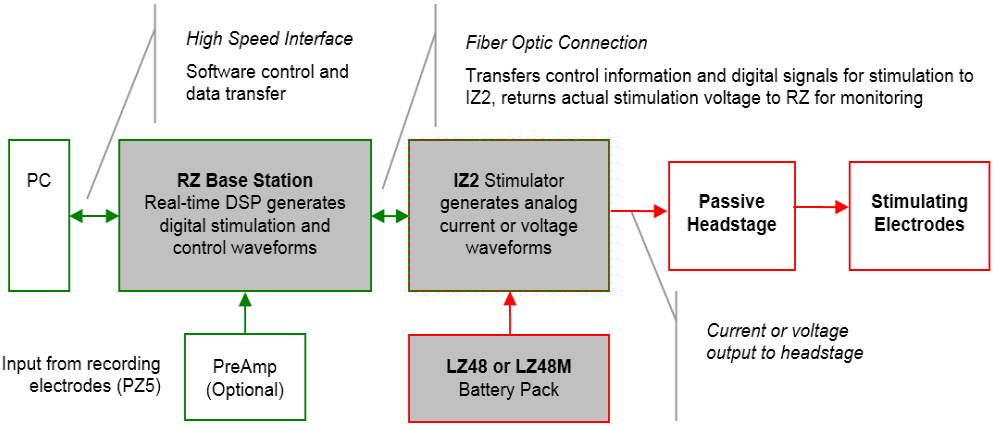
The IZ2 Stimulator converts digital waveforms into analog waveforms as part of a computer-controlled neural microstimulator system that delivers user-defined stimuli through up to 128 electrodes. The IZ2 can output either a voltage-controlled waveform or a current-controlled waveform and provides feedback of the actual voltages delivered to the electrodes.

The IZ2H is a high current range version of the IZ2.

The IZ2 Stimulator System

A typical system consists of a Stimulator (IZ2-32, IZ2-64, IZ2-128, or IZ2H-16); a Battery Pack (LZ48-200, LZ48-400, LZ48M-250, or LZ48M-500); and an RZ processor equipped with a specialized DSP (RZDSP-I) and additional fiber optic connector on the back panel.

The block diagram below illustrates the functionality of the system.



Multichannel IZ2/IZ2H Stimulator System Diagram

Stimulation control waveforms for each electrode channel are first defined on the RZ base station and digitally transmitted over a fiber optic cable to the battery powered stimulator. On the stimulator, specialized circuitry for each electrode channel generates an analog voltage waveform.

In Current mode, the driving voltage is adjusted to produce the desired current regardless of the electrode impedance, within bounds.

Onboard Analog-to-digital (A/D) converters on the IZ2/IZ2H read the output voltage and a chosen bank of eight channels is sent back to the RZ for monitoring.

In Current mode, the IZ2 Stimulator System can deliver up to 300 µA of current simultaneously across up to 128 stimulating electrodes (impedance up to 50 kOhm). The IZ2H Stimulator System can deliver up to 3 mA of current simultaneously across up to 16 stimulating electrodes (impedance up to 5 kOhm).

In Voltage mode, both the IZ2 and IZ2H can deliver up to +/-12V across each individual electrode.

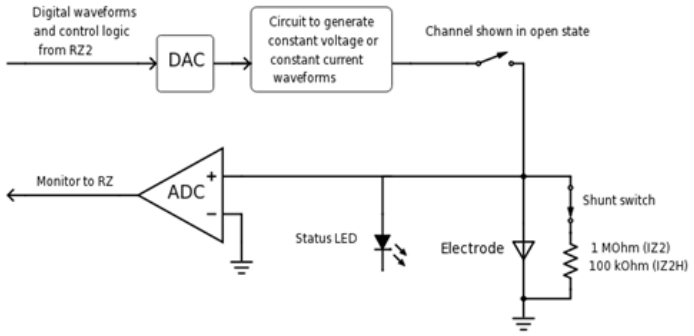
Special features for IZ2 serial numbers > 2000 and all IZ2H devices:

- Individual channels can be open circuited or shorted to ground.
- A shunt resistor to ground can optionally be switched on all channels. This is most useful for electrodes with very high impedance at DC that would normally produce large quiescent voltages when in Current mode. The IZ2 shunts are 1 MOhm each, the IZ2H shunts are 100 kOhm.

The Stimulator System

The IZ2 stimulator features 32, 64, or 128 channels that can deliver arbitrary waveforms of up to 80 kHz bandwidth. The IZ2H features 16 channels for high current range stimulation. Each channel uses PCM D/As to ensure sample delays of only 4 samples.

Special circuitry on the IZ draws on the LZ high voltage inputs to convert low voltage waveforms from the D/A converters to constant voltage or constant current waveforms as shown in the diagram below. The LZ battery pack also provides the power to run the IZ logic control.



Stimulator Diagram

Stimulator Batteries

There are two types of compatible battery packs, the LZ48 and the LZ48M that make up the four models of available batteries (LZ48-200, LZ48-400, LZ48M-250 or LZ48M-500). All batteries produce the same output voltage/current characteristics for powering the IZ2, but differ in battery life and features.

When using the LZ48 battery pack, the IZ2 uses the V_C battery for logic control. V_A and V_B batteries are used to drive the positive and negative stimulation waveforms.

The LZ48M battery pack is a single battery bank that drives both the logic control and the waveform output, and includes additional over-current fault protection. IZ2 and IZ2H devices manufactured before 07/13/2017 require a firmware update to operate with LZ48M batteries.

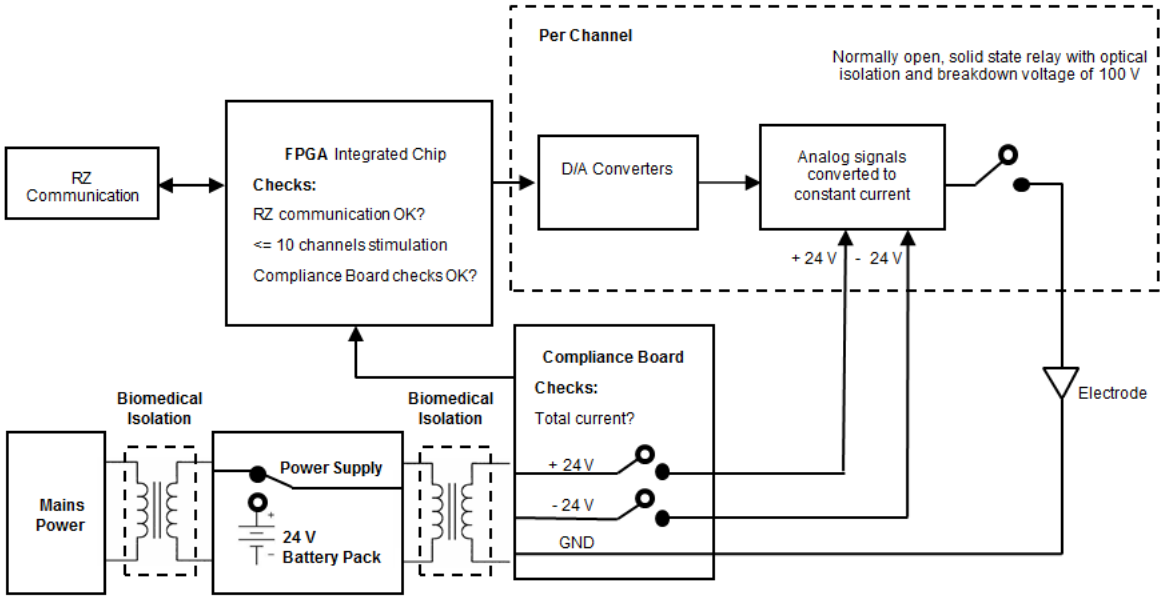
The number of channels needed for stimulation determines power requirements. The IZ2-128 and IZ2H-16 should only be used with the LZ48-400 or LZ48M-500. The IZ2-32 and IZ2-64 can be used with any LZ battery.

See "LZ48 Battery Reference" on page 8-18, for technical specifications and for more information.

Safety (LZ48M Version Only)

The LZ48M battery pack's robust safety profile includes both software and hardware components. Control software ensures that the device always boots in safe-mode, meaning all channels power up by default with their relays open. The relays are kept open until the device finishes booting, passes all internal safety checks, and is armed by the user. This ensures absolutely zero current can flow until proper software control is established. During operation, control software ensures that no more than 10 of the channels can be enabled for stimulation at the same time and that maximum output current is not exceeded.

At the hardware level, the stimulator features an air flow system to regulate temperature and a power supply monitoring system. These systems are controlled on an independent compliance board that will not allow stimulation currents to flow unless all safety checks are met.



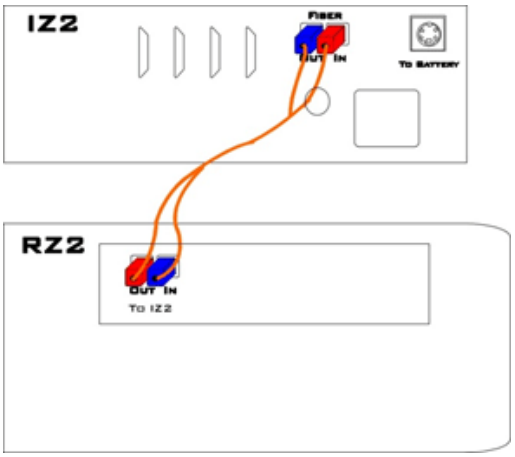
LZ48M Functional Safety Diagram (with IZ2 or IZ2H Stimulator)

The stimulator's power supply has been validated to ensure 4,000 volts of isolation between the input and output, 1,500 volts of isolation between the input and ground, and 500 volts of isolation between the output and ground.

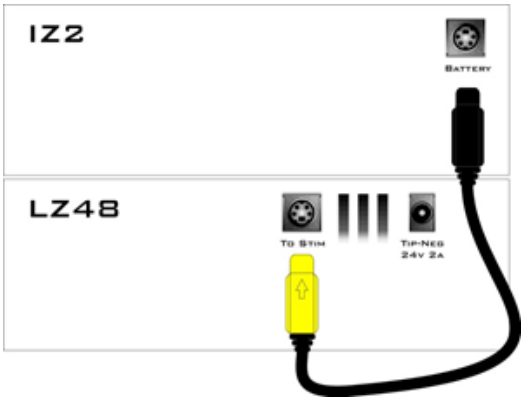
Hardware Set-up

The IZ2 Connection and Boot Procedure

1. Ensure that the TDT drivers, PC interface, RZ and zBus devices are installed, setup, and configured according to the installation guide provided with your system.
2. Connect the stimulator to the base station using the provided fiber optic cable. If using an RZ2 or RZ6 base station, connect the fiber optic cable from the IZ2 fiber optic port labeled 'Fiber' to the fiber optic port labeled 'To IZ2' on the back side of the RZ. If using an RZ5D base station, connect the fiber to the 'IZ' port on the front of the RZ5D. 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.



3. Power on the RZ base station.
4. Verify that the subject is NOT connected to the IZ2 stimulator.
5. Verify that the LZ48 battery is off and connect the battery pack cable to the back panel of the stimulator via the connector labeled **Battery**, as shown in the diagram below.



WARNING! 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.

6. Connect the DB26 output connectors on the stimulator to the stimulating electrodes using your preferred method such as direct wiring or a custom

pass through connector (available from TDT). See "IZ2 Stimulator Technical Specifications" on page 8-14, for pinouts.

7. If you are not using an LZ48M, skip to step 11. The LZ48M has configuration pins on the back of the device.

These switches must be correctly set according to **the number of channels currently connected to the IZ2 (NOT the total number of channels that the IZ2 supports)** and for the IZ2 device type (IZ2 vs IZ2H). The LZ48M uses this information to determine if the IZ2 is safe to operate. Start with all switches in the 'Off' position (down) and turn on switches according to the table below.

Device	# Banks	Channels	Pin Configuration
IZ2H	1	up to 8	Pin 6 ON
IZ2H	2	up to 16	Pins 1, 6 ON
IZ2	1	up to 16	Pin 1 ON
IZ2	2	up to 32	Pins 1, 2 ON
IZ2	3	up to 48	Pins 1, 3 ON
IZ2	4	up to 64	Pins 1, 2, 3 ON
IZ2	6	up to 96	Pins 1, 2, 4 ON
IZ2	8	up to 128	Pins 1, 2, 3, 4 ON

8. If operating the IZ in voltage mode, turn Pin 8 ON. This also bypasses the over-current fault detection in the LZ48M.
9. Press the LZ48M power button. The red Fault light should activate, after about five seconds the green Ready light should activate and the Status light on the IZ2 should turn orange. If Pin 8 is ON, the Ready light will flash green. If Pin 8 if OFF, the Ready light will be solid green.
10. If the Ready light is on but the IZ2 status light is blinking green, check the optical connection to the IZ2 and try again.
11. If using an LZ48, power on the LZ48 using the power switch on the LZ48's front panel. This will also power on the stimulator.

    Note: Ensure that the LZ48 rechargeable batteries are fully charged before starting your protocol.

12. Wait at least five minutes to ensure the IZ2 is at calibrated temperature. The IZ2 stimulation circuitry is heat sensitive and is calibrated at TDT after it has warmed up and reached temperature equilibrium.
13. Initiate your recording session in Synapse or OpenEx. By default, your protocol design should have zero current output and all IZ2 channels should be in the 'Open' state before you begin stimulation. If the IZ2 status light is blinking green when you start your experiment, it is in a fault state. This is because either there are more than 10 channels activated or you are running in Voltage mode (this includes using the "IZ2 Ground" option in the Signal Injector gizmo in Synapse). If you require Voltage mode or more than 10 stim channels, turn Pin 8 to the ON position and repeat the boot cycle. See "Software Control" on page 8-11 for more information.

14. Connect headstage to the subject.
15. The hardware is ready to 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 in the System 3 Manual.

Testing the System

The IZ2 system includes a resistor block that is used to verify stimulation output. The RB100 is a 100kOhm resistor block that is included with the IZ2. The RB10 is a 10kOhm resistor block that is included with the IZ2H. In Synapse, use the impedance test built into the IZ2n HAL object at run time to verify that the correct impedance is measured. Download the test files and instructions from http://www.tdt.com/files/tech/IZ2ImpedanceTest.zip. See "Software Control" on page 8-11 for more information.

Best Practices

We recommend enabling the shunt resistors via the IZ2 hardware setting in Synapse, or the IZ2_Control macro in OpenEx/RPvdsEx.

When a channel is not used for stimulation, TDT recommends setting it to "Open" unless a ground or zero state is specifically called for by the stimulation protocol. If a non-stimulating channel must be left connected, the user can use capacitive coupling (ACC16-Z device adapter) or enable the Shunt to minimize the effects of direct current on the electrode. This is highly recommended to reduce unnecessary current flow in the subject.

To minimize risk, never allow the LZ48 battery to fully discharge. When the battery charge indicator is getting low, stop the experiment (open all channels), disconnect the subject, and recharge before further use.

Always verify proper operation of your device before connecting to a research subject. If you observe a red Status light or blinking green Status light on your IZ2 during setup, do not connect a research subject or proceed with the experiment.

If you encounter any problems or need help verifying proper device operation, please contact TDT Technical Support for assistance at support@tdt.com.

Do's and Don'ts

Always follow the system power up sequence described above.

Always monitor indicator lights and electrode voltages to verify proper device operation.

Always connect only the channels needed for stimulation, extra connections are a path for inadvertent current.

Always have your default system state programmed for zero current delivery and all output relays open.

Always be aware of battery level and discontinue use when level gets low.

Never power the system on while it's connected to the subject.

Never connect the system to the subject while it's in an unknown state.

Never disconnect or reconnect the battery pack while the system is on or while the subject is connected.

Never disconnect or connect headstages while the system on or connected to the subject.

Never deliver more total current than is safe.

Common Problems with LZ48M

IZ2 Status light turns off after some time

After successfully powering up, the IZ2 may turn back off if banks of channels are added or removed on the back of the IZ2. It is important that bank connections are secure during operation. If you want to add or remove banks, they must be established prior to powering the IZ2 and the LZ48M configuration pins must be switched accordingly, then repeat the LZ48M boot procedure.

LZ48M will not attempt to power on IZ2

After initially turning on the LZ48M, with the Fault light on (red), the LZ48M can only attempt to power the IZ2 once. Try fully turning off (hold power button) and back on (press once) the LZ48M, then pressing the power button (once more) to reattempt powering the IZ2.

IZ2 Status light blinking green

IZ2 has successfully been powered by the LZ48M, but has not been properly connected to a compatible DSP. Ensure that the optical connection has properly been established.

IZ2 Features

Analog Outputs (Stim Outputs)

The IZ2 is equipped with 32, 64, or 128 analog output channels, arranged in sixteen-channel banks that are powered down when no headstage is connected.

The IZ2H is equipped with 16 analog output channels, arranged in eight-channel banks that are powered down when no headstage is connected.

Stim Lights

The Stim Lights are located on the front plate of the IZ2/IZ2H and are labeled by channel number. Each LED indicates the voltage at the corresponding electrode site. The Stim Light will turn green when a channel has greater than +/- 150 mV at the output and will turn red when a channel output is beyond +/- 10 V.

Status Light

This LED provides connection and output mode information.

Light Pattern	Description
Solid Red	IZ2/IZ2H is not properly connected to RZ base station or cannot sync.
Solid Green	IZ2/IZ2H is properly connected to RZ and is operating in current mode.
Solid Green, Slowly Flashing Red	IZ2/IZ2H is properly connected to RZ and is operating in voltage mode.
Solid Orange	IZ2/IZ2H is properly connected to RZ and LZ48M.
Blinking Green	IZ2/IZ2H is correctly powered by the LZ48M but is in a fault state. If this occurs during LZ48M boot-up, check the fiber optic connection. If this happens during the experiment, check your experiment settings Step 13 of the boot sequence above.

Fiber Optic Port (Fiber)

The IZ2 is battery powered and optically isolated from the RZ base station. One end of the fiber optic cable connects to the IZ2/IZ2H fiber optic input port and the other end connects to a fiber optic port on the RZ base station. See “Hardware Set-up” on page 8-6.

Battery Input (Back Panel)

The stimulator uses an LZ battery pack for stimulation and to power the logic circuitry. The battery pack should be connected via the Battery connection on the back panel using the battery pack cable provided. See “Hardware Set-up” on page 8-6.

Power Switch (Front Panel of LZ)

The Power switch turns the power on or off. The status lights on the front panel will be illuminated when the IZ2/IZ2H is on.

External Ground (Back Panel)

A banana jack below the fiber optics on the back panel provides a connection to analog ground. This connection was added with IZ2-32 serial number 3011, IZ2-64 serial number 3001, IZ2-128 serial number 3003, and IZ2-16H serial number 2017. This external ground is optional and should only be used if there is no other ground connection to the subject, or if you need to connect the IZ2 and recording amplifier grounds together for noise reduction.

A cable kit is also provided to ensure cables used with the external ground are suitable for this use. Each kit includes one male to male banana plug cable and one male banana to alligator clip cable. These cables also include ferrite beads to remove any potential RF noise that might travel through the cable. For best results position the ferrite bead close to the source of the RF noise.

An IZ2 Battery Interconnect cable with a ferrite bead is also included for use when using the external ground. For best results position the ferrite bead close to the LZ.

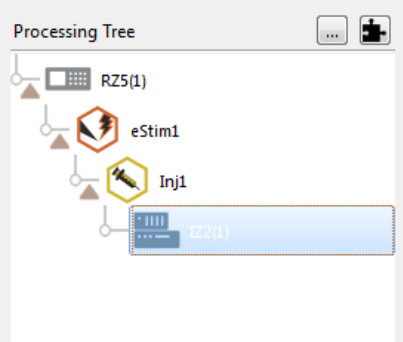
Software Control

Synapse

Operation of the stimulator system is controlled by an IZ2 object in the Synapse Rig and Processing Tree. Consult the Synapse Manual for more detailed information on general Synapse use.

Ensure that hardware your rig is properly set up in the Rig Editor (Menu > Edit Rig) and you have the required elements: RZ processor, DSPI (or DSPQ with optics) and IZ2 stimulator. Make sure the IZ2 object has the correct model selected (IZ2 or IZ2H) and channel count.

A typical electrical stimulation experiment includes an Electrical Stimulation gizmo to generate monophasic or biphasic pulses, then a Signal Injector gizmo which routes this single channel signal to one or more channels in a multi-channel stream and determines what the non-stim channels are doing (typically set to "IZ2 Open" mode), and then this multi-channel stream connects to the IZ2 object to control all channels on the IZ2 at once.



Important Experiment Design Considerations

Sampling Rate

The IZ2 can control 128 channels at up to 50 kHz, 64 channels at up to 100 kHz, and 32 channels at a maximum 200 kHz. The IZ2/IZ2H sampling rate is the same as the sampling rate of the RZ device, so the maximum sampling rate of the IZ2/IZ2H is also limited to the maximum sampling rate of the type of RZ device controlling it.

Note: When sampling at 200 kHz, the channel stim lights and output monitoring are not available, and stimulation is limited to the first five channels of each bank of channels.

Signal Resolution

Signal resolution is dependent on the sampling rate used. 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 ~200kHz, the sample period is 5.12 microseconds. The IZ2/IZ2H has an effective bandwidth of 80 kHz for continuous (non-pulsed) waveforms.

Designing the Stimulus Signal

The IZ2/IZ2H Stimulator 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 stimulation gizmos in the Synapse library, or create your own user gizmo for custom stimulation patterns.

IZ2 Serial Number > 2000 or any IZ2H

The Signal Injector gizmo provides default values for the non-stimulating channels. This can be zero voltage (or current), open circuit, or channel shorted to ground. Use the IZ2 object settings to enable the shunt resistors on all channels and to toggle voltage or current mode.

Monitoring the Stimulation

PCM A/D converters on the IZ2/IZ2H monitor the actual output voltage and a chosen bank of eight channels is sent back to the RZ. This information is available from the output of the IZ2 object. The IZ2 runtime UI allows you to select which bank of eight channels is updating on the Monitor output (the rest of the channels of the Monitor output will be latched) by clicking on the column of LEDs.

Note: There is a single pole 16kHz lowpass filter on these inputs. The filter can affect impedance checking beyond 10 kHz.

Note: The onboard A/D converters provide the feedback clip at +/-20V, which is higher than any possible output signal in either voltage or current mode.

Important Notes Regarding the Channel Indicator LEDs

In current mode, the IZ2 can stimulate a maximum 300 uA per channel (up to 15 V) and the IZ2H can stimulate up to 3 mA per channel (up to 15 V) through the electrode and the return path.

Channels connected to ground (Fill Value set to 'IZ2 Ground' in the Injector gizmo) are switched into voltage mode and set to output 0V, so the monitored voltage will always be 0V and the LED status lights for grounded channels will remain dim.

Channels that are open circuit (Fill Value set to 'IZ2 Open' in the Injector gizmo) in current mode will follow the voltage in the tissue. This must occur so that no current flows across the electrode. The open circuit electrode then acts like a recording electrode that is following the voltage at the electrode tip. This may cause the LED for an Open channel to light up. For example, if there is a 15V potential relative to ground at the tip of an open circuit electrode, there must also be a 15V potential on the stimulator side of the electrode so that no current is flowing across that electrode. Therefore, an open channel nearby the stimulating channel may show a non-zero voltage on the voltage monitor. If this measured voltage is greater than +/- 150mV (which is likely to be the case), this will light the LED status light on an open channel.

Similarly, if you hold one channel to 0 uA (Fill Value set to 'Zero' in the Injector gizmo) and stimulate through another nearby channel, the voltage on the channel held at 0 uA must rise so that no current flows across the electrode. This will also light the LED status light on a channel set to 0 uA output.

If the headstage/adapter/electrodes are not in the subject, then the electrical circuit is incomplete and the impedance that the IZ2 sees on its outputs is very high. This

is enough to raise the output voltage and turn on the LED status lights. This is also true of electrodes that have very high impedance at DC - even though the IZ2 output noise floor is low, a high enough impedance at DC will cause a non-negligible DC current on the outputs. Therefore, we recommend enabling the Shunt resistors to reduce the DC current flow to the subject when attempting to stimulate through very high impedance electrodes.

IZ2 Stimulator Technical Specifications

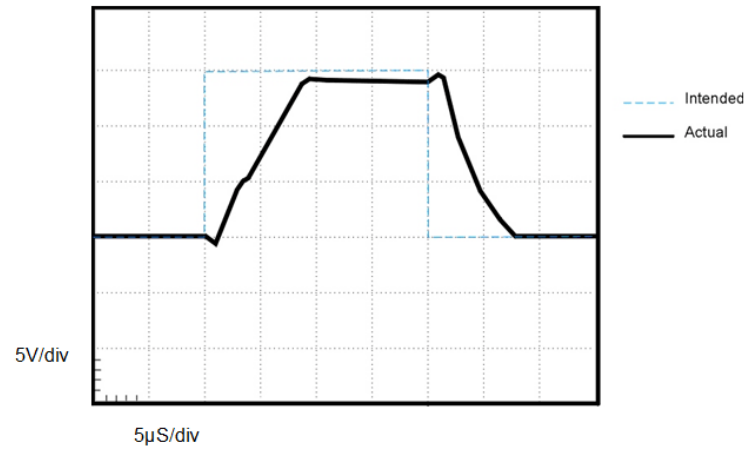
Includes specifications for the IZ2-32, IZ2-64, IZ2-128 and IZ2H-16.

Stimulus Output Channels	16 (IZ2H-16), 32 (IZ2-32), 64 (IZ2-64) or 128 (IZ2-128) PCM DACs
Sampling rate	IZ2H-16: Up to 195.3125 kHz^ IZ2-32: Up to 195.3125 kHz^ IZ2-64: Up to 97.65625 kHz^ IZ2-128: Up to 48.828125 kHz^
Stimulus Output Voltage	+/- 12 V in voltage-controlled mode
Stimulus Output Current	IZ2: +/- 300 µA up to 50 kOhm load IZ2H: +/- 3 mA up to 5 kOhm load
Offset Current	< 100 nA on active channels and < 3 nA on open channels
ADC Filter	Single pole 16kHz on voltage monitors
Power Control/Stimulation	LZ48 or LZ48M Rechargeable Battery Pack with Li-Poly batteries
Battery Life	LZ48-200 ~ 6-8 hours to charge LZ48-400 ~ 12-14 hours to charge Battery life between charges: LZ48-200 w/ IZ2: 2 banks (up to 32 ch) ~ 20 hrs 4 banks (up to 64 ch) ~ 10 hrs LZ48-400 w/ IZ2H: 1 bank (up to 8 ch) ~ 12 hrs 2 banks (up to 16 ch) ~ 6 hrs LZ48-400 w/ IZ2: 2 banks (up to 32 ch) ~ 30 hrs 4 banks (up to 64 ch) ~ 20 hrs 8 banks (up to 128 ch) ~ 10 hrs LZ48M-250 w/ IZ2: 2 banks (up to 32 ch) ~ 15hrs LZ48M-250 w/ IZ2H: 2 banks (up to 16 ch) ~ 15hrs LZ48M-500 w/ IZ2: 2 banks (up to 32 ch) ~ 30hrs LZ48M-500 w/ IZ2H: 2 banks (up to 16 ch) ~ 30hrs **Note:** The LZ48-200 is not recommended for use with the IZ2-128 or the IZ2H-16

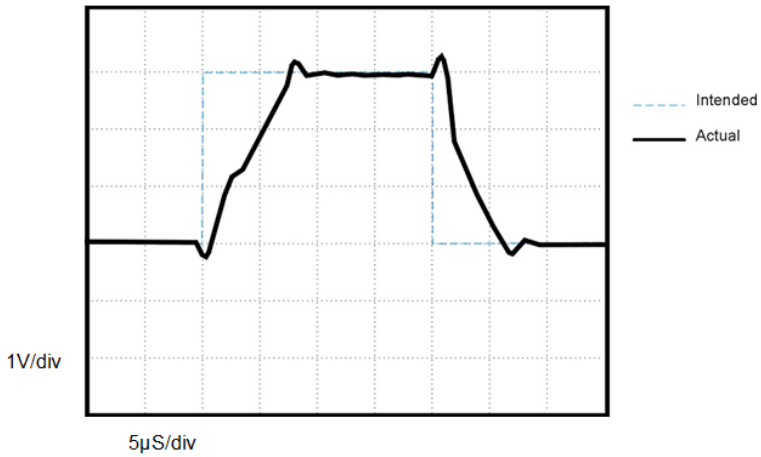
^Note: the sampling rate is also limited by the RZ processor used for stimulator control. When sampling at 195.3125 kHz, recording is limited to the first five channels on each bank of channels.

Slew Rate for the IZ2H-16

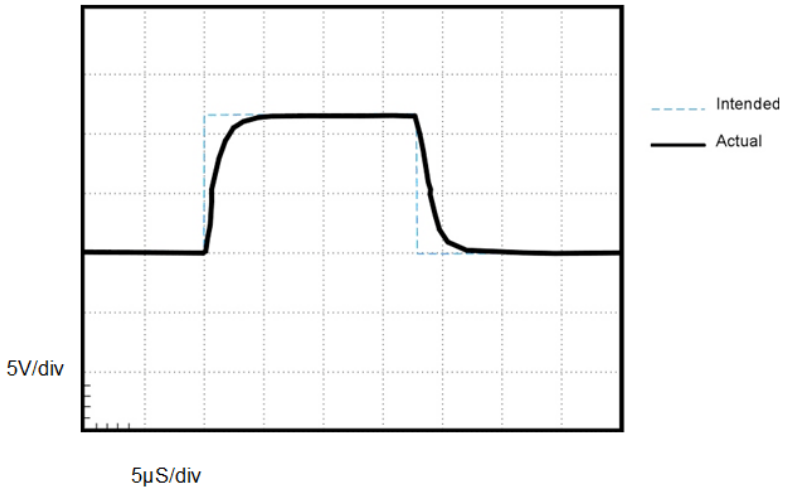
The slew rate is a measure of how quickly the output voltage of the device can change. The plots below show the effect of the slew rate on a square wave produced by the IZ2H at different loads and levels.



5k load, 3 mA stim, 50 kHz sampling rate. Slew rate: ~ 1.6 V/us
Devices SN < 2018: ~0.21V/us



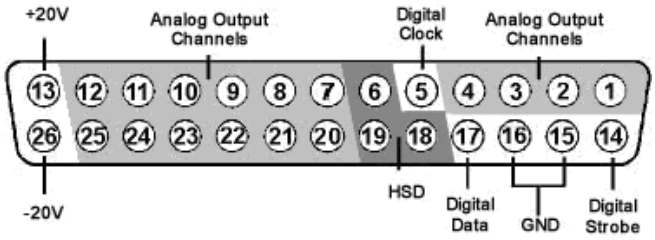
1k load, 3mA stim, 50kHz sampling rate. Slew rate: ~0.38V/us



5k load, 12V stim, 50kHz sampling rate. Slew rate: ~2.0V/us
Devices SN < 2018: ~ 0.16V/us

Note: Changes to the device improved the slew for IZH-16s, SN 2018 and greater.

Mini-DB26 Connector Pinouts for the IZ2

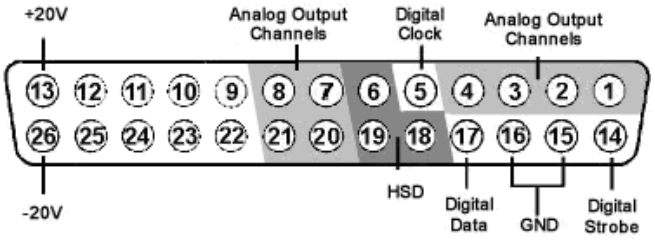


Pin	Name	Description		Pin	Name	Description
1	A1	Analog Output Channels		14		Digital Strobe
2	A2			15	GND	Ground
3	A3			16	GND	Ground
4	A4			17		Digital Data
5		Digital Clock		18	HSD	Headstage Detect
6	HSD	Headstage Detect		19	HSD	
7	A5	Analog Output Channels		20	A6	Analog Output Channels
8	A7			21	A8	
9	A9			22	A10	
10	A11			23	A12	
11	A13			24	A14	
12	A15			25	A16	
13	V+	+20 V		26	V-	-20 V

Note: See this tech note before attempting to make any custom connections.

https://www.tdt.com/technotes/#0896

Mini-DB26 Connector Pinouts for the IZ2H



Pin	Name	Description		Pin	Name	Description
1	A1	Analog Output Channels		14		Digital Strobe
2	A2			15	GND	Ground
3	A3			16	GND	Ground
4	A4			17		Digital Data
5		Digital Clock		18	HSD	Headstage Detect
6	HSD	Headstage Detect		19	HSD	
7	A5	Analog Output Channels		20	A6	Analog Output Channels
8	A7			21	A8	
9		Not Connected		22		Not Connected
10				23		
11				24		
12				25		
13	V+	+20 V		26	V-	-20 V

Note: See this tech note before attempting to make any custom connections.

https://www.tdt.com/technotes/#0896

LZ48M Battery Reference

The LZ48M battery pack powers both the stimulation and the IZ2 stimulator logic circuitry. The LZ48M has built in protection circuitry to prevent over-current faults. The LZ48M charges from a standard wall plug.

Battery Capacity	LZ48M-250: 250 Whr. Up to 15 hr continuous stim on 2 banks (32 channels for IZ2, 16 channels for IZ2-H). LZ48M-500: 500 Whr. Up to 30 hr continuous stim on 2 banks.

Rechargeable	Yes
Compliance voltage	+/- 15V

Important! The LZ48M has configuration switches that must be set correctly based on your desired channel count and IZ2 configuration (IZ2 vs IZ2H). See Step 7 of the boot sequence above.

LZ48M Status LEDs

Fault: LZ48M has detected a fault and is not supplying voltage to the IZ2.

Ready: Solid green when stimulation is ready. Flashing green when ready for stimulation and in safety bypass mode (Config switch 8 is in the ON position).

The LZ48M uses mains power for charging. Connect the power connector on the back panel to a mains power outlet, using the provided AC power cable. The battery is always charging when connected to the mains power, regardless of whether the LZ48M is turned on.

There is a row of five LEDs next to the power button. The first LED from the left indicates whether the LZ48M is being powered from mains or battery power. The next four LEDs indicate the power level of the battery.

When the battery is fully charged, all four LEDs will be lit green. When the battery voltage is low, only one green LED will be lit. If the voltage drops further, the last LED will flash red. TDT recommends charging the battery before this flashing low-voltage indicator comes on.

LZ48M Battery Pack

The LZ48M Battery Pack uses Lithium Polymer (LiPoly) batteries.

WARNING! Just as with all batteries, shorting the LZ48M Battery Pack can cause damage to the device and injury to the user. Always use caution when handling or connecting the devices.

Important! Used LiPoly batteries must be recycled.

The LZ48M 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.

LZ48 Battery Reference

The LZ48 has three batteries to both drive the stimulation and power the IZ2 stimulator logic circuitry. A 24 Volt battery charger with 2.7A of current capacity is included with the stimulator and can be connected via the connector on the LZ48'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.

	LZ48-200	LZ48-400
Battery Capacity	200 Wh	400 Wh
Rechargeable	Yes	Yes
Compliance Voltage	+/- 15V	+/- 15V
Maximum Impedance for a 300 microAmp Current	50 kOhms	50 kOhms
Ambient Temperature	Normal room temperatures	Normal room temperatures

LZ48 Status LEDs

V_A: Positive Battery Pole

V_B: Negative Battery Pole

V_C: Logic Battery Level

Eight LEDs indicate the voltage level of the currently displayed battery. When the battery is fully charged, all eight LEDs will be lit green. When the battery voltage is low, only one green LED will be lit. If the voltage drops further, the last LED will flash red. TDT recommends charging the battery before this flashing low-voltage indicator comes on. While charging, the Status LEDs will flash.

Status	Description
8 Green	Fully Charged
1 Green, 7 Unlit	Low Voltage
1 Flashing Red	Low Voltage - Charge Immediately!
8 Green Flashing	Charging in Progress

LZ48 Battery Pack

The LZ48 Battery Pack uses multiple Lithium Polymer (LiPoly) batteries.

WARNING! Just as with all batteries, shorting the LZ48 Battery Pack can cause damage to the device and injury to the user. Always use caution when handling or connecting the devices.

Important! Used LiPoly batteries must be recycled.

The LZ48 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.