

# PZ3 Low Impedance Amplifier

## PZ3 Overview

The PZ3 is a high channel count, low impedance amplifier well suited for ECOG, Evoked Potentials, EEGs, LFP's, EMGs, and other similar recording applications. Available in 32, 64, and 128 channel models, the PZ3 amplifier offers shared or true differential operation, low input referred noise, impedance checking, and an optional high input range mode.

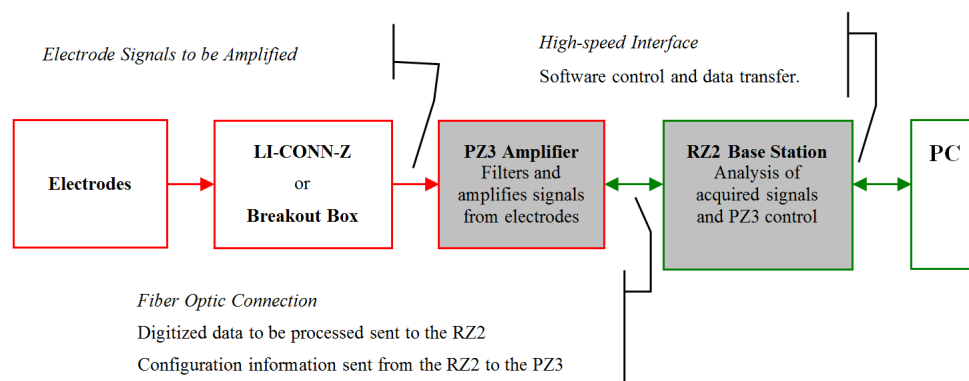


## System Hardware

A standard configuration for low sample rate, low impedance recordings includes 1.5 mm TouchProof connectors for electrodes, a PZ3 amplifier, and an RZ2 base station.

The battery powered PZ3 digitizes and amplifies signals recorded from each of the electrode channels. All digitized signals are sent via a single fiber optic connection to the RZ2 base station for further processing. The RZ2 also sends amplifier configuration information to the PZ3 across the fiber optics.

The diagram below illustrates this flow of data and control information through the system.

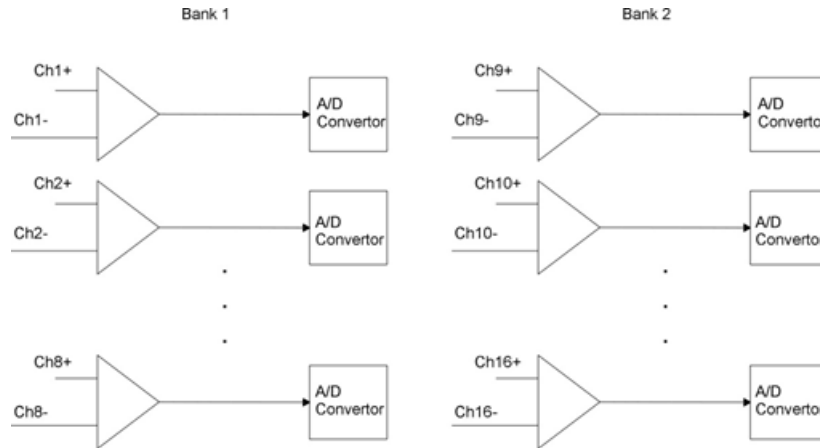


**PZ3 Data and Control Flow Diagram**

## Recording Modes

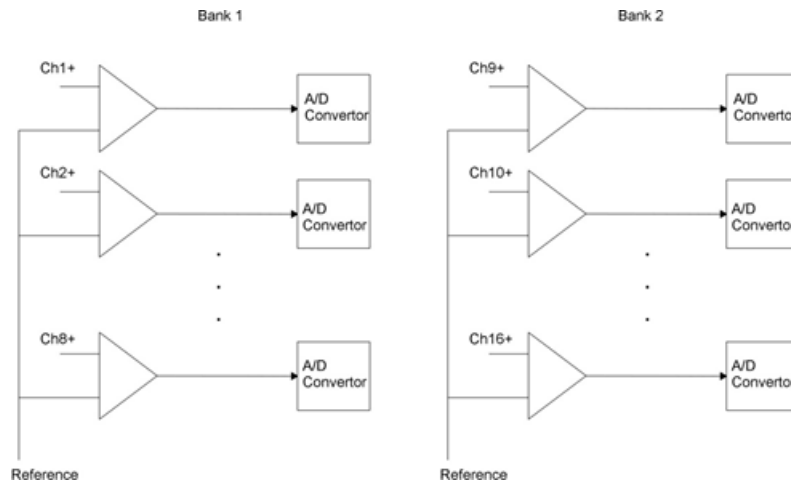
The PZ3 supports two recording modes: Individual Differential and Shared Differential.

For **Individual Differential** (true differential) operation, the amplifier inputs are grouped into banks of eight recording (+) channels, each with a paired alternate indifferent (-) channel (inverting channel).



**Individual (True) Differential, Bank 1 and 2 Functional Diagram**

For **Shared Differential** operation, each bank of channels uses a separate shared reference.



**Shared Differential, Bank 1 and 2 Functional Diagram**

The PZ3's impedance checking and a high voltage range features can be used in both true and shared differential modes.

It is also important to note that in the various modes of operation, the RZ2 processor may use the alternate channels to report information such as impedance values or RMS. This occurs at the software level on the RZ2. For example, in Shared Differential mode the RZ2 maps RMS levels for each channel to the alternate channels.

## Electrode Connectors

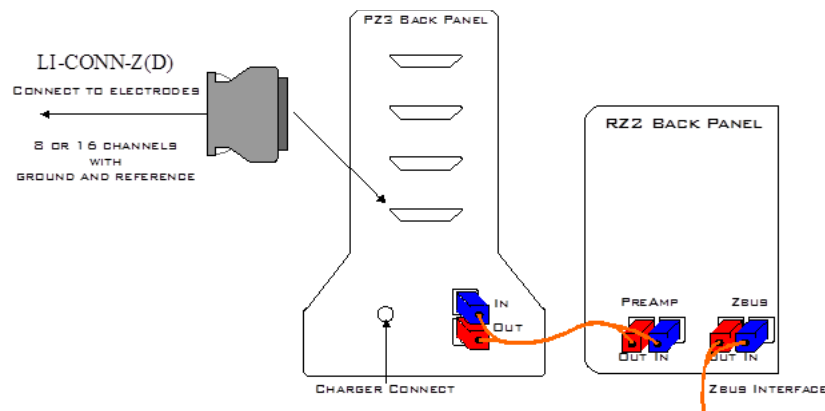
The PZ3 is designed to record from low impedance electrodes and electrode caps with input impedance less than 20 kOhm. Signals are input via multiple DB26

connectors on the PZ3 back panel. A break out box or connector(s) are required for electrode connection.

TDT provides a version of our LI-CONN connector for the PZ3: the LI-CONN-Z for Shared Differential mode. It features standard 1.5 mm safety connectors and provides easy connections between electrodes and the amplifier.

## Hardware Set-up

The diagram below illustrates the connections necessary for PZ3 amplifier operation.



One or more male connectors (such as the LI-CONN-Z) can be connected to the input connectors on the PZ3 back panel. Alternately, custom connectors and a breakout box can be used. If using custom connectors, see “Input Connectors” on page 6-22 for pinout.

**Note:** In Shared Differential mode no connection should be made to the indifferent (-) channels.

A 5 meter paired fiber optic cable is included to connect the preamp to the base station. The connectors are color coded and keyed to ensure proper connections.

The PZ3 battery charger connects to the round female connector located on the back panel of the PZ3 amplifier.

**Important!** To avoid introducing EMF noise, DO NOT connect the charger to the PZ3 while collecting data.

## PZ3 Software Control

The amplifier’s mode of operation (shared or individual differential), other options, and channel mapping tasks are handled using PZ3 specific macros within the RpvdsEx control circuits running on the RZ2 Signal Processor.

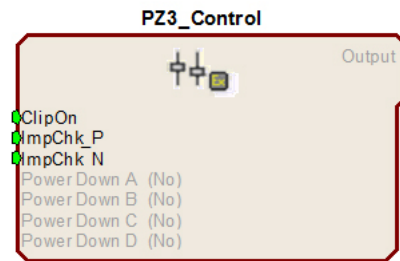
**RPvdsEx includes two PZ3 specific macros:**

PZ3\_Control macro

PZ3\_ChanMap macro

## PZ3\_Control Macro

The PZ3 Control macro should be added to your RPvdsEx circuit to configure all hardware features of the PZ3 amplifier.



Inputs are available on the macro for enabling/disabling the LED clip status lights, enabling Impedance mode for electrode (+) channels, enabling Impedance mode for alternate indifferent (-) channels, and dynamic power control for channel banks.

## Macro Options

Double-clicking the macro in RPvdsEx, displays the macro properties dialog box and allows users to easily modify macro properties.

### On the Options tab, in the properties dialog box:

Setting the **Clip LEDs On** to Yes or No enables or disables the LED clip warning indicators.

**Differential Mode** allows the user to select from Shared Differential) or Individual (True-Differential) modes.

**Input Range** may be set to either 3mV or 20mV input ranges.

The **Target Impedance** option allows the user to specify the impedance threshold for the status LEDs for each channel bank. Three inputs are available on the macro for enabling/disabling the LED clip status lights, enabling Impedance mode for electrode (+) channels, and enabling Impedance mode for indifferent (-) channels.

Under the **Power Control** tab are additional options that specify how the PZ3 channel banks are powered.

## Powering Down the Channel Banks

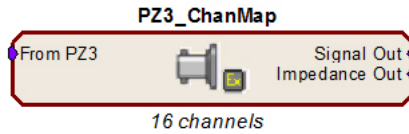
Channel banks may be powered down through the macro. As long as the *Power Control Mode* under the Power Control tab is set to *Static*, channel banks may only be powered up or down through the Power Control Mode options within the macro. Dynamic mode will allow channel banks to be powered on or off either through both the Power Control Mode options or by inputs on the macro through RPvdsEx components. Each of the letter indexed channel banks in the macro correspond to 32 channels of the PZ3. Selecting *No* will enable a bank of channels while selecting *Yes* will power down and disable that bank of channels.

### For Example:

If you are using a PZ3 with 128 channels, powering down Bank A (Select **Yes**) would power down the first four blocks of 8 channels of the PZ3, disabling channels 1 – 32.

## PZ3\_ChanMap Macro

In the data stream on the RZ2, the odd numbered channels are the recording channels and the even numbered channels can report impedance measurements or RMS values. The PZ3\_ChanMap should be added to your RPvdsEx circuit along with the RZ2\_Input\_MC macro to remap the data stream. The channel mapping macro selects the appropriate channels from the PZ3 input stream and builds two separate, sequential multichannel outputs containing either the amplified waveforms or alternate data (impedance or RMS values).



### Macro Options

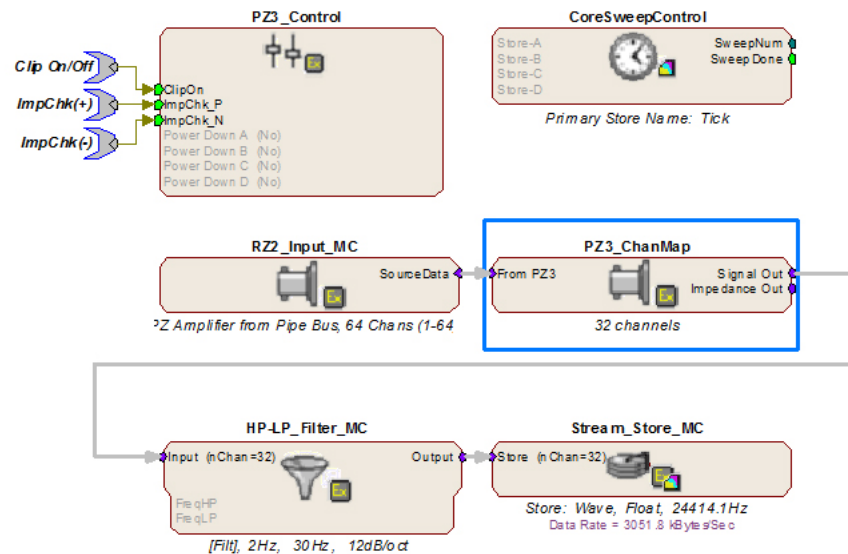
The user can set several different options under the Options tab.

The designated number of channels to map and output.

The ability to enable/disable the impedance measurement output.

## PZ3 Circuit Example

The following illustration shows how macros can be used to create a simple OpenEx acquisition and control circuit for the PZ3.



The RZ2\_Input\_MC macro feeds the circuit with each digitally amplified signal acquired using the PZ3 amplifier. The data is fed first through the PZ3\_ChanMap macro which separates the signals from their impedance (or RMS) values and builds the appropriate multi-channel data stream for further processing. In this case the signals are filtered and stored for post processing.

A CoreSweepControl macro is included to handle the required timing functions used by programs such as OpenEx and a PZ3\_Control macro configures the operation mode of the PZ3 as well as any additional options that may be necessary. Three

parameter inputs allow toggling of clipping LEDs and toggling (+) or (-) channel impedance measurements.

## PZ3 Operation

RCX control circuits running on the base station must include PZ3 specific macros to configure the amplifier's mode of operation; Shared Differential or Individual Differential and other configuration options such as input range and clip warning display. "PZ3 Software Control" on page 6-13, for more information. Impedance checking is also available from the front panel.

### Powering ON

To turn the amplifier on, move the three position battery switch to either the Bat-A or Bat-B position.

### Powering OFF

To turn the amplifier off, move the three position battery switch to the OFF position.

### Operation Modes

Recorded signals are acquired in Shared or Individual differential mode.

#### Shared Differential

In shared differential mode a single shared reference and a ground are used for each bank of eight recording channels.

**Note:** In this mode no connection should be made to the alternate indifferent (-) channels. Use the LI-CONN-Z connector to ensure proper connections.

#### Enabling Shared Differential Operation

To enable shared differential mode, use the PZ3 control macro and under the Options tab set the value of Differential Mode to Shared.

#### Individual Differential

When the PZ3 is operating in individual differential mode, each of the 8 (+) channels of an individual bank has a paired (-) differential reference.

**Note:** While operating in this mode no connections should be made to the Shared Reference (pin 5.)

#### Enabling Individual Differential Mode

To enable individual differential mode, use the PZ3 control macro and under the Options tab set the value of Differential Mode to Individual.

## Clip Warnings

Analog clipping occurs when the input signal is too large. If analog clipping occurs, TDT recommends switching the PZ3 into high input range mode. For more information see “Modifying the Input Voltage Range on the PZ3 ” on page 6-17.

While the amplifier is recording, the front panel LEDs can act as clip warning indicators (according to configuration settings set using the PZ3\_Control macro). If an analog signal approaches the PZ3s clipping range, the PZ3 LEDs for the corresponding channel are lit red.



**Note:** The LED Indicators are also mirrored on the RZ2 LCD display.

When recording, the status LED located below the Display Mode button indicates the status of the Clip Indicators. Solid green indicates that clip warning is disabled and orange indicates the clip warning is enabled.

To enable clip warning, press the **Display Mode** button on the PZ3 front panel.

Alternatively the PZ3\_Control macro can be used to enable or disable the clip warning indicators. For more information on the PZ3\_Control macro see “PZ3 Software Control” on page 6-13.

## External Ground

The external ground is optional and should only be used in cases where the subject must occasionally make contact with a metal surface that isn't tied to the animal ground, such as a lever press. When contact is made, a ground loop is formed that temporarily adds extra noise to the system. Grounding this metal surface directly to the TDT hardware removes this ground loop at the cost of raising the overall noise floor a small amount.

A banana jack located on the back of the PZ3 (directly to the right of the charger input) provides connections to common ground for the first bank of channels (1-16). A cable kit is also provided to ensure cables used with the external ground are suitable for this use. Each kit includes: one male banana plug to male banana plug pass through and one male banana plug to alligator clip pass through. 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.

## Modifying the Input Voltage Range on the PZ3

In the default mode, the PZ3 has an effective differential input range of  $\pm 3$  mV, which TDT recommends for EEG, LFP, and ECOG. If recordings demand a higher input range such as EMGs, the alternate High Input Range mode allows the input range to increase to  $\pm 20$  mV.

**Important!** The PZ3 automatically detects the gain setting and voltage range and scales the signal output accordingly.

**Note:** The signal to noise performance is better while operating in the  $\pm 3$  mV input range.

## Enabling the High Input Range Mode

The high input range mode can be enabled through the PZ3\_Control macro.

To enable the high range input mode, select **20 mV** from the **Input Range** option on the **Options** tab.

## Testing your Electrode Impedance

Impedance measurement may be enabled programmatically or using the *Display Mode* button.

### Enabling Impedance Mode

To enable impedance mode manually, push and hold down the Display Mode button on the PZ3 front panel.

During impedance checking all channels are tested in parallel using a  $\sim 375$  Hz test signal and the impedance is measured relative to a target impedance (1kW – 15kW) specified by the user (set using the PZ3\_Control macro). The LEDs on the PZ3 (and in the PZ3 display on the RZ2 LCD) will light green when the electrode impedance is less than or equal to the target impedance or red when electrode impedance is greater than the target impedance value.



Green: Less than or equal target impedance



Red: Greater than target impedance

### Impedance Checking For True Differential Mode

Impedance values of either recording (+) or alternate indifferent (-) channels can be tested.

To toggle between (+) and (-) channel impedance measurements, press the **Display Mode** button on the PZ3 front panel.

The status LED located below the *Display* button of the PZ3 will flash green while electrode (+) channel impedance is being tested or red while alternate indifferent (-) channel impedance are being tested.

### Returning to Signal Acquisition Modes

To leave Impedance mode, simply hold down the **Display Mode** button on the PZ3 front panel after enabling impedance mode.

## Battery Overview

The PZ3 amplifier features two Lithium ion batteries to allow for longer record times. A three-position switch selects the active battery between Bank-A, Bank-B, or both banks off.



## Battery Status LEDs



**Battery Level:** Eight LEDs indicate the voltage level of the selected battery bank. These LEDs can be found on the front of the PZ3 amplifier by the heading Level. When the battery is fully charged, all eight LEDs will be lit. When the battery voltage is low, only one green LED will be lit. If the voltage is allowed to drop further, the last LED will flash red. TDT recommends charging the battery before this flashing low-voltage indicator comes on. While charging, the Level LEDs will flash green.

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

## Charging the Batteries

Operate the amplifier with the charging cable disconnected. Connecting the PZ3 charger will simultaneously charge both batteries. Ensure that the three-position switch is in the OFF (middle) position while charging the PZ3.

### Charging Indicators

LEDs are also used for each bank to indicate which bank, if any, is charging. These LEDs are found next to the Level LEDs by the headings -A- and -B-. A green indicator denotes the battery bank is fully charged while a red indicator designates the bank is currently charging. When the device is in operation (charger is not connected) the A and B LEDs are not lit.

Status	Description
Red	Charging
Green	Fully Charged
Unlit	Operation Mode (charger not connected)

An external battery pack is also available to provide longer battery life for extended recording sessions. See “PZ-BAT External Battery Pack for the PZ Amplifiers” on page 6-23.

## PZ3-RZ2 Channel Data Charts

The following charts show what data the user can expect to be available on the RZ2 for each channel depending on whether the amplifier is in a recording mode or in

impedance checking mode. Please note that this does not necessarily reflect how the hardware channels are used on the PZ3. The RZ2 interprets input from the PZ3 then makes the data available as described below. To further simplify circuit design, the PZ3\_ChanMap macro can be used to build separate multichannel data streams for waveform data and impedance values.

Unmapped Channel Index	Recording Mode	
	Shared Differential	Individual Differential (True Differential)
Channel 1	Analog Input Channel 1	Analog Input Channel 1(+)
Channel 2	RMS of Channel 1	Reference Channel 1(-)
.	.	.
.	.	.
Channel 15	Analog Input Channel 8	Analog Input Channel 8(+)
Channel 16	RMS of Channel 8	Reference Channel 8(-)

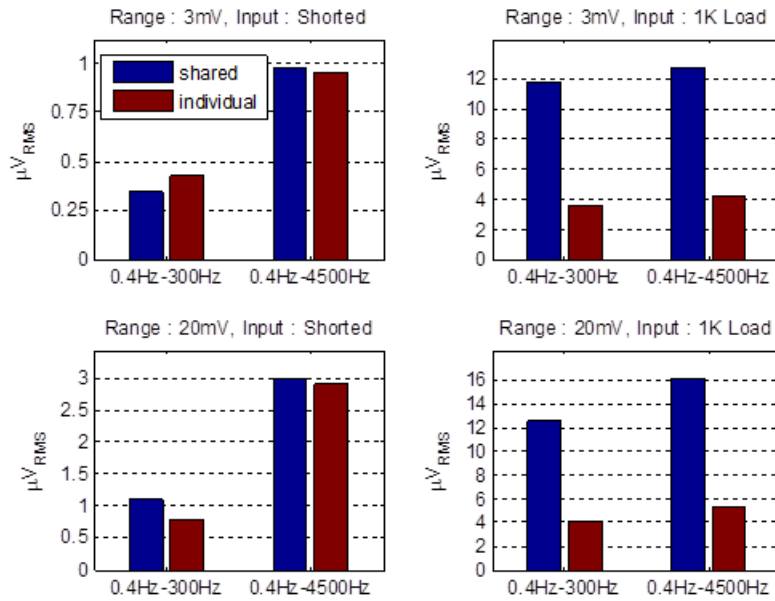
Unmapped Channel Index	Impedance Checking	
	Shared Differential	Individual Differential (True Differential)
Channel 1	NA	NA
Channel 2	Impedance of Channel 1	Impedance of Channel 1 (+) or (-)
.	.	.
.	.	.
Channel 15	NA	NA
Channel 16	Impedance of Channel 8	Impedance of Channel 8 (+) or (-)

## PZ3 Technical Specifications

<b>A/D</b>	Up to 128 channels 18-bit hybrid
<b>Maximum Voltage In</b>	+/- 3 mV - Default input range mode +/- 20 mV - High input range mode
<b>Frequency Response</b>	3 dB: 0.1 Hz - 5 kHz
<b>S/N (typical)</b>	72 dB - 3mV input range 79 dB - 20mV input range
<b>Distortion (typical)</b>	< 1%
<b>A/D Sample Rate</b>	Up to 48828.125 Hz
<b>Input Impedance</b>	10 <sup>6</sup> Ohms

<b>Power Requirements</b>	2 Lithium Ion cells at 10 AmpHours each
<b>Battery</b>	Eight hours to charge both cells Battery life between charges, per cell: 32 ch ~ 11 hrs 64 ch ~ 8 hrs 128 ch ~ 5 hrs
<b>Charger</b>	External 6 V, 3 A power supply
<b>Indicator LEDs</b>	Up to 128 status or clip warning, battery life, active battery bank
<b>Input referred noise</b>	See figures below
<b>Fiber Optic Cable</b>	5 meters standard, cable lengths up to 20 meters*

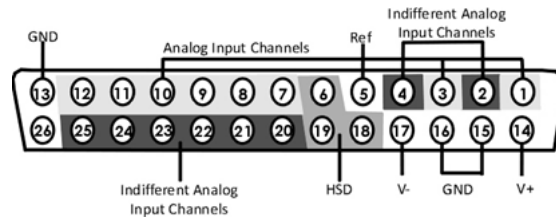
\*Note: If longer cable lengths are required, contact TDT.



## Input Connectors

PZ3 amplifiers have up to 16 26-pin headstage connectors on the back of the unit. The PZ3 channels are marked next to the respective connector on the amplifier.

### Pinout Diagram



**Note:** There are 8 (+) channels and 8 (-) channels per DB26 connector. Subsequent banks are indexed by an additional 8 channels.

Pin	Name	Description	Pin	Name	Description		
1	A1 (+)	Analog Input Channel	14	V+	Positive Voltage (+1.5V)		
2	A1 (-)	Indifferent Analog Input Channel	15	GND	Ground		
3	A2 (+)	Analog Input Channel	16	GND			
4	A2 (-)	Indifferent Analog Input Channel	17	V-	Negative Voltage (-1.5V)		
5*	Ref*	Shared Reference*	18	HSD	Headstage Detect		
6	HSD	Headstage Detect	19	HSD			
7	A3 (+)	Analog Input Channels	20	A3 (-)	Indifferent Analog Input Channels		
8	A4 (+)		21	A4 (-)			
9	A5 (+)		22	A5 (-)			
10	A6 (+)		23	A6 (-)			
11	A7 (+)		24	A7 (-)			
12	A8 (+)		25	A8 (-)			
13	GND		Ground	26		NA	Not Used

**\*Note:** No connections should be made to pin 5 while operating in True Differential mode.