

# PZ5 NeuroDigitizer

## PZ5 Overview

The PZ5 is a multi-modal neurodigitizer suitable for recording a broad range of biological potentials. Its analog input boards combine the functionality of the PZ2 and PZ3 amplifiers in a single device that can be used for both high and low impedance input signals simultaneously. The PZ5 may also include digital input boards for inputting signals from an [Intan RHD2000 amplifier board](#) with up to 128 channels.

Analog input boards oversample the signal with very fast instrumentation grade converters. TDT's custom hybrid A/D circuit yields 28 bits of resolution and unparalleled dynamic range. Optional DC coupling offers zero phase distortion across the signal bandwidth. Sampling rate and down-sampling filters can be optimized on each logical amplifier for the intended input type to optimize signal fidelity. The +/-500 mV input range is large enough to accept any biological potential and most stimulus artifacts without saturating.

The neurodigitizer analog inputs are organized into 16-channel banks. Each bank is electrically isolated, meaning the ground and reference channels are not inherently shared between banks. Multiple banks can be grouped into a single logical amplifier that shares the same settings and ground/reference among each bank in the logical amplifier. There are several different referencing modes; each logical amplifier can use the ground as a reference, use a shared reference, use a unique reference on each bank or implement full per-channel differential referencing.

Digital inputs are used exclusively with RHD2000 series amplifier boards and SPI Interface Cables, available from Intan Technologies. Each input serves as a bank of channels and may be up to 128 channels, depending on the connected amplifier board. Each digital board can be its own logical amplifier, isolated from the other boards, or be grouped with other digital boards in a larger logical amplifier configuration.

A touchscreen interface provides immediate preview of inputs, impedance checking and real-time control and configuration options for each amplifier bank.

PZ5 neurodigitizers are available in 32, 64, 96, or 128 analog channel models. The PZ5 is also available with 2 or 4 digital inputs and models that combine 32 or 64 analog input channels with 2 or 4 digital inputs. The PZ5 can support a total of up to 128 analog channels or up to 256 digital channels or up to 256 mixed channel types. The total number of channels is generally reduced to 128 at higher sampling rates, up to 50kHz. See "Sampling Rate and Digital Input Channels" on page 6-33, for more information.



**Note:** To record at ~50 kHz on 128 or more channels, see “PZ5 Software Control” on page 6-33, for more information.

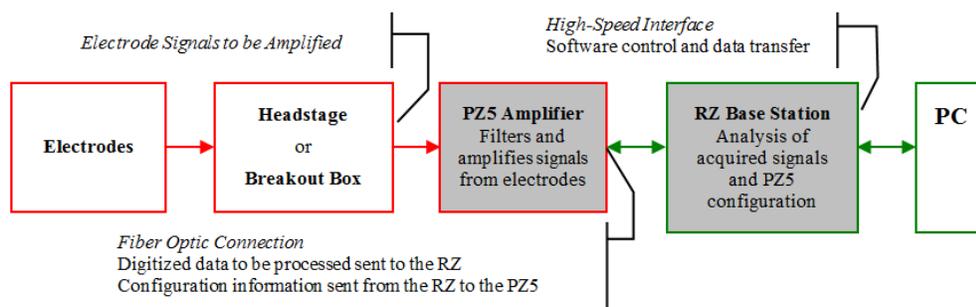
## System Hardware

The PZ5 neurodigitizer accepts inputs from a variety of electrode/headstage combinations via the back-panel mini-DB26 connectors. Each mini-DB26 connector inputs 16 recording channels (or 8 differential channels) along with ground and reference. Intan input connectors accept up to 128 digital channels.

Recorded analog signals are amplified and digitized. All channels are transmitted to the RZ base station for further processing via a single fiber optic connection. Configuration information is also sent from the RZ to the PZ5 neurodigitizer across the fiber optic connection. The PZ5 can connect to the ‘PZ’ fiber optic input on an RZ2 or RZ5D base station, or directly to an RZDSP\_P card on any RZ base station.

A standard configuration includes electrodes appropriate to the input signals, a breakout box or one or more Z-Series headstages, a PZ5 neurodigitizer and an RZ base station.

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



**PZ5 Data and Control Flow Diagram**

## Physical Amplifier

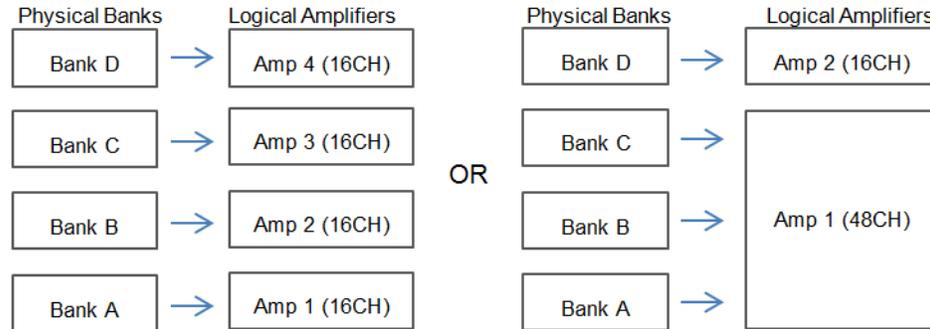
All PZ5 analog input channels are organized into groups of 16 channel banks, with each bank corresponding to a rear panel headstage connector (labeled alphabetically from bottom to top) and a front panel LED display.

Digital input channels are associated with a digital board corresponding to a rear panel digital input connector (labeled from bottom to top following, alphabetically, any analog input connectors). Each digital board is a bank that can comprise 16, 32, 64, 96, or 128 channels, depending on the connected Intan amplifier board(s).

Each bank is electrically isolated and can be independently configured or grouped with other banks and defined as a logical amplifier. Analog and digital boards cannot be combined together.

# Logical Amplifiers

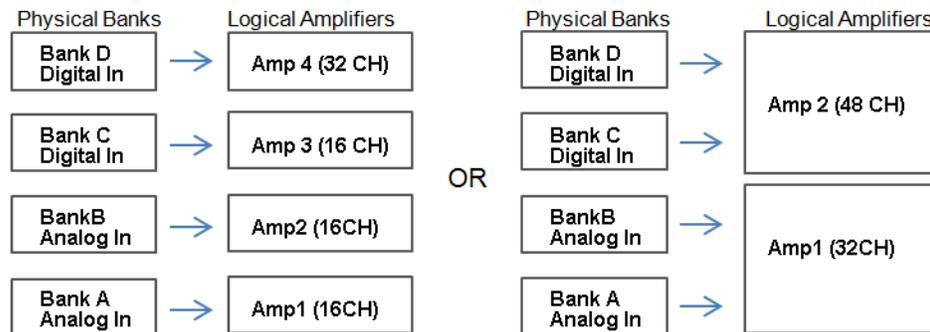
Though each bank has its own ground and reference, a single ground and reference can also be defined and shared across all banks of the logical amplifier. See Reference Modes for analog input banks below.



**Two Possible Logical Amplifier Configurations for a PZ5-64 64 Channel NeuroDigitizer (all analog input)**

Digital boards can be configured individually or grouped to share a single ground and use common filter settings and sampling rate.

**Note:** Channel numbering on digital input banks can be non-sequential when sampling at 50 kHz. See “Sampling Rate and Digital Input Channels” on page 6-33.



**Two Possible Logical Amplifier Configurations for a PZ5-64-2 (with two digital inputs)**

Logical amplifier configurations can be defined using the front panel interface (see “Using the PZ5 Front Panel Display” on page 6-36) or the PZ5\_Control macro. The PZ5-32 model can have a maximum of two logical amplifiers configured. All other PZ5s can have a maximum of four logical amplifiers.

## Reference Modes

The PZ5 supports four referencing modes for each analog input logical amplifier: Local, Shared, None and Differential. Reference and Ground configurations for each logical amplifier can be defined using the PZ5\_Control macro or via the touchscreen interface. See “Pinout Diagrams” on page 6-54.

### Local

In Local reference mode, each bank of channels in a logical amplifier uses its own reference input (pin 5) as the reference for that bank.

### Shared

In Shared mode, the reference (pin 5) of the first bank of the logical amplifier acts as a reference for all banks in the logical amplifier.

### None

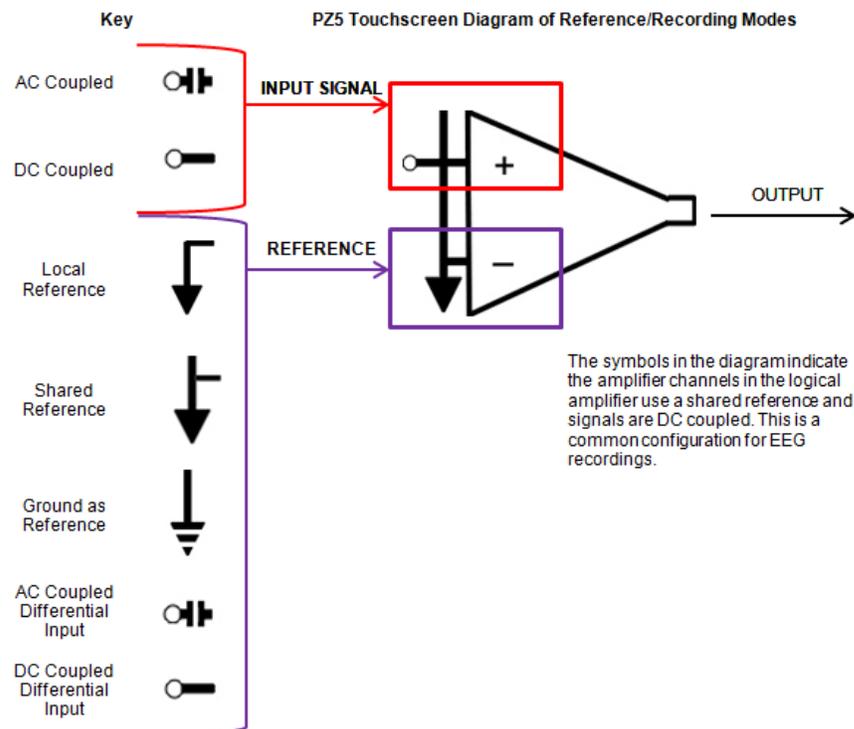
In None mode, the references for all banks of a logical amplifier are tied to the Ground (pins 13, 15, and 16).

### Differential

In Differential mode, the inputs in each bank of the logical amplifier are paired; odd channels serve as recording (+) channels and each even channel is used as an individual reference (-) channel for the preceding odd channel. No connections should be made to pin 5.

### The Signal/Reference Diagram

The PZ5 touchscreen interface uses representative diagrams to enable users to identify the configuration of the amplifier at a glance. The table below explains the parts of the diagram and what each represents.



## Sampling Rate and Onboard Filters

The sampling rate of each logical amplifier is adjustable (max 50 kHz, min 750 Hz) and should be set to a value appropriate for the signal of interest. Reducing the sampling rate when acquiring low-frequency analog signals yields higher bit resolution and improved signal-to-noise. Use the Amp Type presets as a guide for determining what sampling rate to use for each logical amplifier.

The onboard down-sampling filters are used to further reduce the noise from frequencies above the band of interest and can be set to a percentage of the sampling rate (max 45%, min 10%). Adjusting the sampling rate and filter for each logical amplifier to match your desired signal gives you the best possible signal fidelity.

## Sampling Rate and Digital Input Channels

When a logical amplifier contains digital inputs, the sampling rate should be set to a value appropriate for the connected Intan amplifier board. Sampling rates at or above 50 kHz reduce the number of channels available on the amplifier boards.

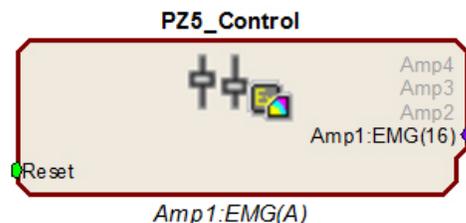
At 50 kHz the 32 channel amplifier board is limited to 20 channels and the 64 and 128 channel boards are limited to 40 channels, at the time of this writing. The maximum aggregate number of channels is 256 channels at up to 25kHz, or 128 channels at up to 50kHz.

It is also important to note that, while the Intan board channel numbers are normally sequential and offset by the number of analog inputs in the amplifier, sampling at or above 50 kHz may also affect channel numbering.

At 50 kHz the native channel numbers per board are 1-20 and 33-52. These channel numbers are then offset by the number of channels existing in the lower banks of the PZ5. Also see “Input Connectors” on page 6-53.

## PZ5 Software Control

The PZ5\_Control macro provides configuration and control of data acquisition and storage via the RCX control circuit running on the RZ base station. The PZ5\_Control macro sets the default logical amplifier configurations when the circuit first runs and retrieves waveforms/impedance values in real-time from each logical amplifier for further processing.



The macro configuration options are available in the macro properties dialog and can be accessed by double-clicking the macro in the RPvdsEx circuit diagram.

The macro outputs a multi-channel signal stream of the acquired signals for each logical amplifier. If the reference mode is Differential, then the 1st channel is Ch1 minus Ch2 and the second channel is

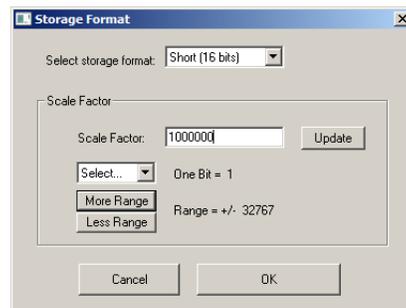
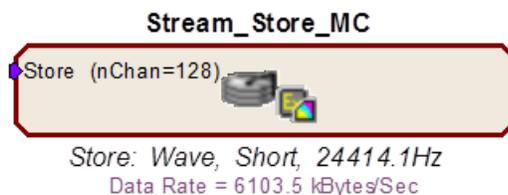
Ch2 minus Ch1 and so on. The output for any logical amplifier in impedance checking mode is the channel impedance, in MΩ.

**Important!** If connecting to an RZDSP\_P card, the PZ5\_Control macro must be assigned to the DSP slot occupied by the RZDSP\_P card. If connecting to an RZ5D the macro must be running on DSP-3.

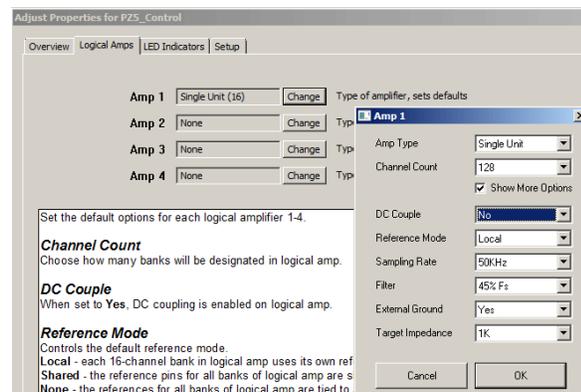
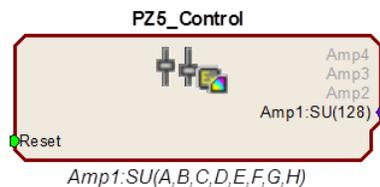
## Recording 128 Channels at 50 kHz

Due to the PZ5's high bit resolution and recording capabilities, data should always be stored as 32-bit floating point. However, when storing 128 channels at 50 kHz sampling rate, you must use the Short (16 bits) format due to bandwidth constraints. This means the data will be scaled and converted into an integer before storage, which narrows the dynamic range of the acquired signals. In this case, all DC offsets must be removed before the data is stored. You can either filter out the DC offset with a NeuroFilter or HP-LP\_Filter\_MC macro, or use AC coupling on the logical amplifier if you are storing the raw signal direct from the PZ5.

The data storage format is configured via a stream store macro in the RCX control circuit running on the RZ base station, such as Stream\_Store\_MC and Stream\_Store\_MC2 if writing into a data tank, and Stream\_Server\_MC or Stream\_Remote\_MC if streaming to an RS4 or PO8e. The configuration options are available in the macro properties dialog and can be accessed by double-clicking the macro in the RPvdsEx circuit diagram, then clicking the Store Format button on the Options tab.



AC coupling can be set using the touch screen configuration options or on the Logical Amp tab of the PZ5\_Control macro properties dialog.



These changes are required only when recording 128 channels at 50 kHz. In every other case, the Float (32 bits) format should be used to utilize the full bit resolution of the PZ5.

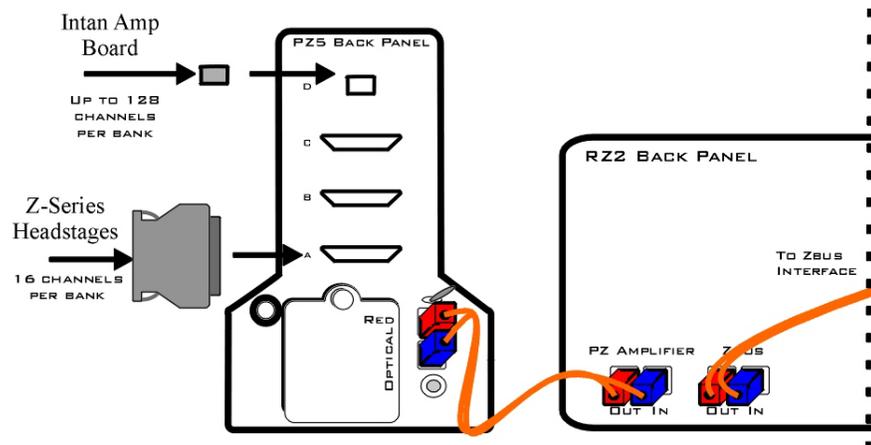
# Hardware Setup

TDT recommends fully charging the PZ5 neurodigitizer before use. The PZ5 battery charger connects to the round female connector located on the back panel.

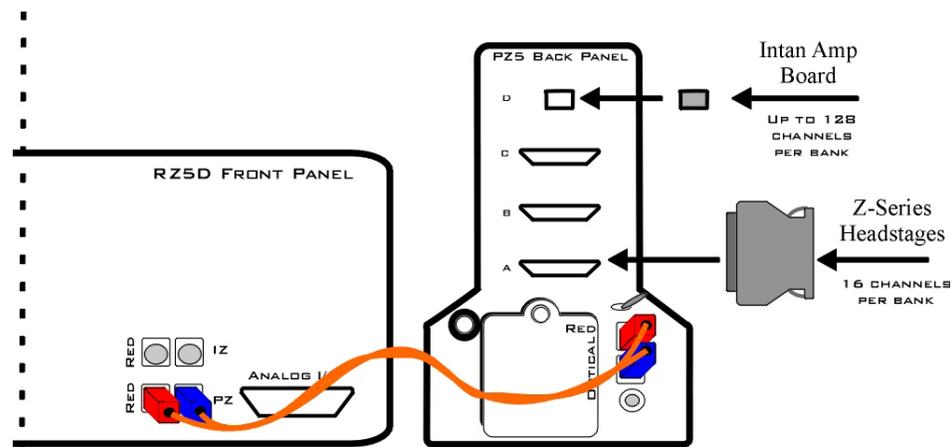
**Important!** To avoid introducing EMF noise, DO NOT connect the charger to the PZ5 while collecting data.

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

The diagram below illustrates the connections necessary for PZ5 neurodigitizer operation.



System Connection Diagram for PZ5 with RZ2



System Connection Diagram for PZ5 with RZ5D

## Connecting Headstages and Electrodes

Analog signals are input via multiple mini-DB26 connectors on the PZ5 back panel.

For high impedance recordings, one or more Z-Series headstages can be connected to the input connectors on the PZ5 back panel. For low impedance recordings, an S-BOX input splitter or LI-CONN low-impedance connector can be used. Alternately, custom connectors and a breakout box with a male mini-DB26 connector can be used. If using custom connectors, see “Pinout Diagrams” on page 6-54.

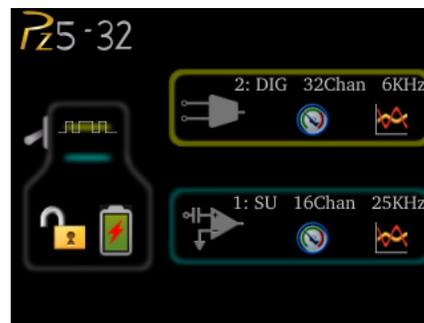
Digital signals are input via Intan connectors on the PZ5 back panel.

## Powering ON/OFF

To turn the neurodigitizer on, move the toggle switch located on the back panel of the PZ5 to the ON position.

## Using the PZ5 Front Panel Display

The front panel display is a touchscreen interface for impedance checking and waveform preview and can be used for on the fly device configuration. When the PZ5 is powered on, a splash screen is displayed on the touchscreen and a boot-up progress bar is displayed at the bottom of the screen. When the boot sequence is complete, the Main Configuration screen is displayed.



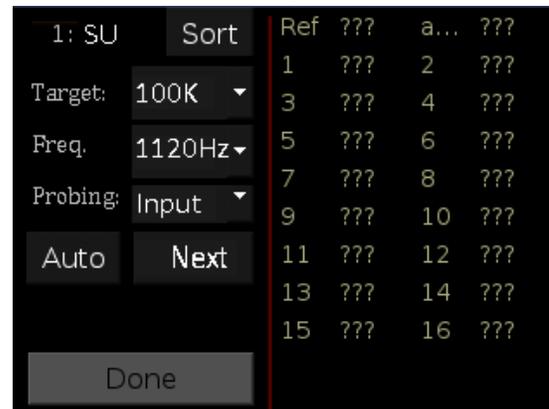
Amplifier boards are represented by horizontal bars in the PZ5 diagram. Digital input boards are overlaid with a digital signal representation. When the RZ device processing circuit runs, the logical amplifier configuration defined in the PZ5\_Control is sent to the PZ5 and applied.

### To test the impedance of your hardware set-up:

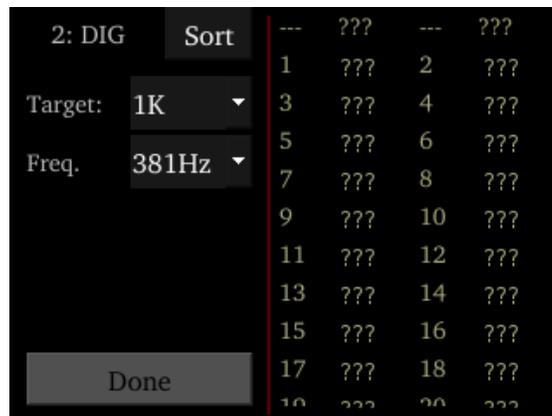
**Important!:** The impedance checking feature of the PZ5 can and should only be used with a passive headstage or direct connection to the electrodes.

1. Touch the  Test icon on the desired logical amplifier.

The Impedance Checking screen will be displayed.



or



2. In the **Target** field, select a target impedance value.
3. Set the probe signal frequency from the drop-down list.
4. For analog input channels, touch the **Next** button to cycle through each probing option for the selected logical amplifier type. “Probing Options” on page 6-46.

The impedance values of the currently tested set are updated on the right side of the screen and are color coded for easy identification of problem channels.



5. A limited set of channels is visible at any one time. Swipe vertically on the interface to scroll the visible channels or touch the Sort button to sort the list by channel number or by impedance value.

When the hardware connections have been made the incoming signals can be previewed on the front display.

#### To preview the data:

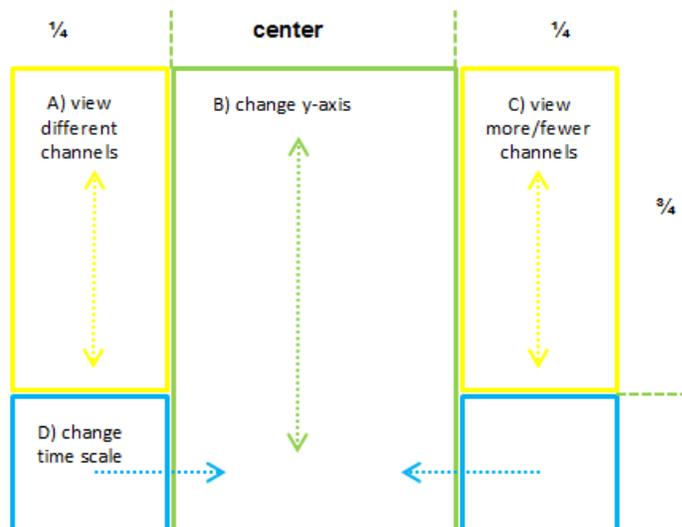


1. Touch the **Preview** icon on the desired logical amplifier to enter the Waveform Display screen.
2. To return to the Main Configuration screen from the Waveform Display screen, swipe three fingers across the screen in any direction.

## Waveform Display Screen



The Waveform Display screen is displayed by touching the Preview icon on an existing logical amplifier on the Main Configuration Option screen. The plot label includes the logical amplifier number, amp type, and voltage and time scales. The displayed waveform is decimated for plotting and high pass filtered so all channels can be shown on the same voltage scale. If the logical amplifier is DC Coupled, the DC offset is displayed as a value on the right side of each plot line (in mV). The screen view can be adjusted using touchscreen options.



### To view a different subset of channels:

- Swipe up or down on the left side of the screen. (A)

### To change the y-axis scale:

- Swipe up or down in the center of the screen. (B)

### To view more or fewer channels:

- Swipe down or up on the right side of the screen. (C)

### To change the time scale:

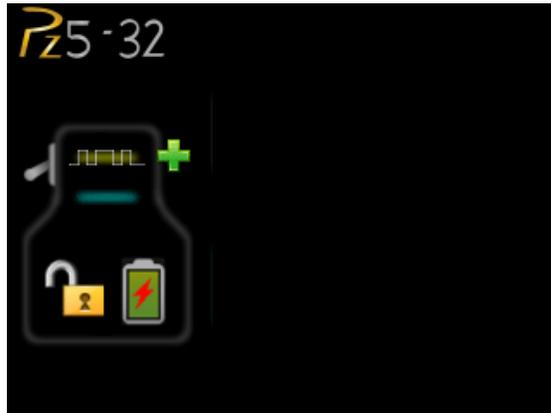
- Swipe left or right on the bottom of the screen. (D)

### To return to the Main Configuration screen:

- Swipe three fingers across the screen in any direction.

The touchscreen interface can also be used to configure logical amplifiers when the PZ5\_Control is not used or for on the fly device configuration.

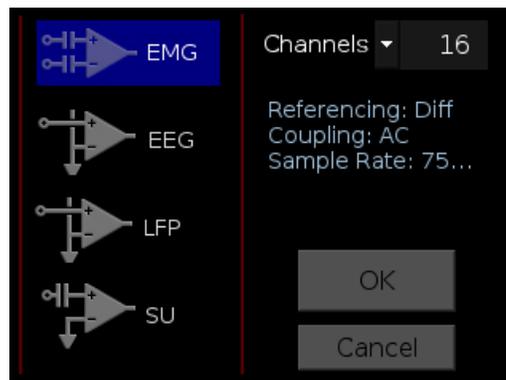
## Typical Steps to Configure a Logical Amplifier Using the Touchscreen



### To add a logical amplifier:

1. Touch the  **Plus Sign**.

The Amp Type Selection screen is displayed.



2. Touch the desired **Amp Type** icon  on the left side of the screen.

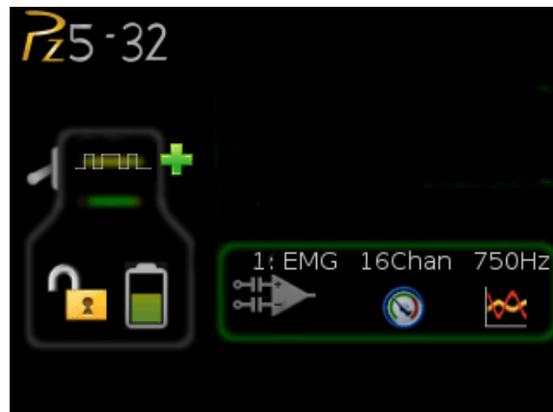
The text to the center right of the screen displays the default configuration information.

3. Touch the arrow next to **Channels** to display the drop-down list.
4. To configure the number of channels in the logical amplifier, touch the desired number in the list.

5. Touch the **OK** button. The Configuration Options screen is displayed.



6. Make any desired changes to the default settings then touch the **OK** button to save the selections and return to the Main Configuration screen.



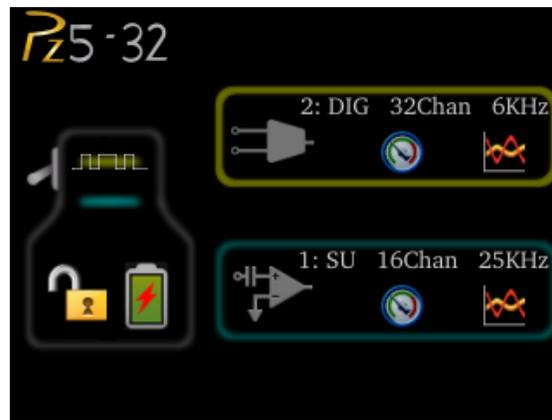
The logical amplifier is configured and a representative diagram is added to the screen.

7. To configure additional logical amplifiers, repeat these steps as needed.

The sections below provide additional information and serve as a reference for each screen.

## Main Configuration Screen

The Main Configuration screen provides a touchscreen interface for configuring logical amplifiers and previewing waveforms in real-time. It also provides access to the PZ5 settings, such as the screen auto lock and auto sleep features, as well as tools for viewing system information, such as battery status, and updating the device software.



All logical amplifiers that have been defined are represented on the right side of the screen and labeled in logical order from bottom to top. For example, 2:EMG is the second logical amplifier and is configured for EMG recordings. In the illustration above, this would correspond to the back panel input connector labeled 'B'. Configured digital inputs are displayed above logical amplifiers.

**The main configuration screen includes the following:**



Display the System Setup screen. See “System Setup Screen” on page 6-47, for more information.



**Toggle**

Toggle LED Indicators on or off. See “Clip Warnings and Activity Display” on page 6-50, for more information.



**Battery Status**

Display battery status information. A lightning bolt through the icon indicates that the PZ5 is charging.



**Lock/Unlock**

Lock to protect configuration settings. Unlock to allow changes to the configuration.



**Plus Sign**

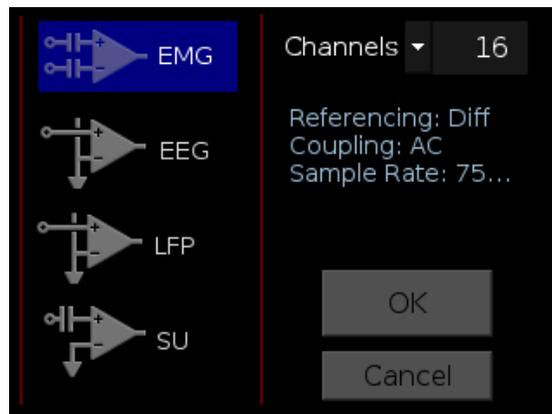
Create a new logical amplifier. As logical amplifiers are added they appear on the Main Configuration screen.

**Banks**

Color coded to indicate current configuration of each bank. A red outline indicates that the bank is configured as part of a logical amplifier but no headstage is currently detected on that bank. A gray bar indicates that the bank is not configured.

## Amp Type Selection Screen

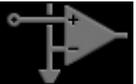
The Amp Type Selection screen is displayed by touching the  Plus Sign icon on the Main Configuration screen or by touching the  Amp Type button on the Configuration Options screen for an existing logical amplifier.



On the Amp Type Selection screen, users can set the number of channels in a logical amplifier or touch a configuration icon on the left side of the screen to select one of four amp types, each with configuration presets displayed to the right. These configuration options can be changed after the Amp Type is selected.

#### Options include

Select the number of channels in the logical amplifier (by banks of 16 channels).

Amp Types		Defaults
Icon	Label	
	EMG	Electromyography Referencing: Diff (true differential) Coupling: AC Sample Rate: 750Hz
	EEG	Electroencephalography Referencing: Shared Coupling: AC Sample Rate: 750Hz
	LFP	Local Field Potentials Referencing: Shared Coupling: AC Sample Rate: 3kHz
	SU	Single Unit Referencing: Local Coupling: AC Sample Rate: 25kHz

#### OK Button

Save selections and open the Configuration Options screen.

#### Delete Button

Delete the logical amplifier and display a confirmation screen before returning to the Main Configuration screen. **Note:** Only available after a logical amplifier has already been created.

#### Cancel Button

Return to Main Configuration screen without making changes.

## Configuration Options Screen

The Configuration Options screen is displayed after selecting the Amp Type when adding a new logical amplifier or it can be displayed by touching the  configuration icon on an existing logical amplifier on the Main Configuration Option screen. After all analog input banks have been configured, pressing the plus sign displays the configuration screen for digital inputs, when available.

### Analog Input Amp Configuration

#### Amp Type Button



The area at the top of the screen displays the Amp Type for the selected/new logical amplifier and includes the logical amplifier number, configuration type and number of channels.

#### To return to the Amp Type Selection screen:

- Touch the **Amp Type** button.



Each Amp Type includes preset values for each setting. The Configuration Options screen enables users to modify these settings.

#### Settings include:

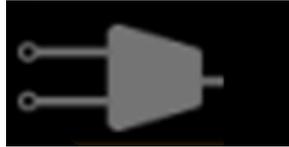
<b>Coupling</b>	Choose AC or DC. AC coupling implements a high pass filter with $\sim 0.4$ Hz cutoff frequency.
<b>Ref Mode</b>	Choose Local, Shared, None, or Differential Reference Mode. See “Reference Modes” on page 6-31, for more information on reference modes.
<b>Samp Rate</b>	Choose a sampling rate from a list of values: 750 Hz, 1.5 kHz, 3 kHz, 6 kHz, 12 kHz, 25 kHz, 50 kHz.
<b>Filtering</b>	Select a cutoff frequency for the anti-aliasing filter, as a percentage of the sampling rate. Choose from a list of values: 45%, 35%, 25%, 15%, or 10%.
<b>Ext. Ground</b>	Press ‘More’ button to access this. Set to Yes to connect amplifier ground to external ground plug.

**OK Button**

Save amp selections and return to Main Configuration screen.

**Cancel Button**

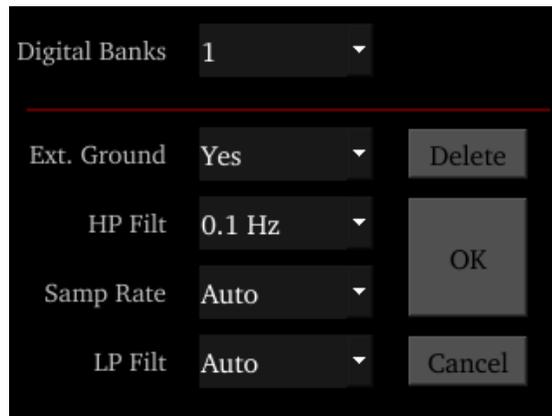
Return to Main Configuration screen without making changes.

**Digital Input Configuration****Amp Type Button**

The area at the top of the screen displays the Digital Banks drop-down list. Select the desired number of banks (boards) to include in this logical amplifier.

**To return to the Main configuration screen:**

- Touch the **Cancel** button.



The digital input configuration includes preset values for each setting. The Configuration Options screen enables users to modify these settings.

**Settings include:**

<b>Ext. Ground</b>	Yes to connect amplifier ground to external ground plug.
<b>HP Filt</b>	Select a cutoff frequency for the highpass filter.
<b>Samp Rate</b>	Choose a sampling rate from a list of values. Auto means it runs at whatever the RZ sampling rate is.
<b>LP Filt</b>	Select a cutoff frequency for the lowpass filter. Auto means it is matched to the sampling rate automatically.

PZ5 Sampling Rate	LP Auto Filter
750 Hz	300 Hz
1.5 kHz	750 Hz
3 kHz	1.5 kHz
6 kHz	3 kHz

PZ5 Sampling Rate	LP Auto Filter
12 kHz	5 kHz
25 kHz	10 kHz

**Delete Button**

Delete amp configuration and return to Main Configuration screen.

**OK Button**

Save selections and return to Main Configuration screen.

**Cancel Button**

Return to Main Configuration screen without making changes.

## Impedance Checking Screen

The Impedance Checking Screen is displayed by touching the  Test icon on an existing logical amplifier on the Main Configuration screen. The logical amplifier number and amp type are displayed in the top-left corner, for example 1:EEG.

Select the type of connections to measure (Probing options) and choose a target impedance value (Target) to color code the measured impedance value text. During impedance checking, all connections in the selected set are tested in parallel and the impedance is measured relative to the user-defined target impedance (1 kOhms – 100 kOhms). The impedance values of the currently tested set are updated on the right side of the screen. Toggle the Sort button to sort the list by channel number or by impedance value.

A limited set of channels are visible at any one time. Swipe vertically on the touchscreen to scroll the visible channels.

**Settings include:****Target**

Select the target impedance from a drop down list (1 kOhms –100 kOhms). This is used to color the impedance value text during/after probing. Impedance values above the target are colored red, values <75% below the target are green and all other values are yellow.

**Freq.**

Set the probe signal frequency from a drop down list. The frequency is adjustable from 35Hz, 70Hz, 140Hz, 280Hz, 560Hz, 1120Hz, and 2240Hz. This feature is only selectable in daughter board firmware v1.3 and above, and PZ5

software v1.1.1 and above. The frequency is fixed at 140Hz in prior versions.

<b>Probing</b>	(Analog input amps only) Select the set of connections to measure. The available options in this list change depending on the logical amp referencing mode. See Probing Options below.
<b>Sort Button</b>	Toggle button that displays the channels with the largest variation from the target impedance at the top of the screen.
<b>Auto Button</b>	Toggle button that cycles through each probing option every second.
<b>Next Button</b>	Select to advance to the next probing option set.

### Done Button

Return to Main Configuration screen.

## Probing Options

The referencing mode of the currently selected analog input logical amplifier determines the available Probing options.

### Differential Reference Mode

If the reference mode is Differential, the Probing options are *Inp(+)* for the positive input channels and *Inp(-)* for the differential channels. This is the default reference mode for the EMG amp type.

### Local Reference Mode

If the reference mode is Local, the options are *Input* for all the input channels, *Ref* to test the reference impedance to ground, or *AltRef* to test the alternative reference (pin 13, see “Pinout Diagrams” on page 6-54). *Ref* and *AltRef* impedance values are displayed on the top row. This is the default reference mode for the Single Unit amp type.

### Shared Reference Mode

If the reference mode is Shared, the options are *Input* for all the input channels, *Ref* for the reference channel, and *Gnd* to test the ground impedance. *Ref* and *Gnd* impedance values are displayed on the top row. This is the default reference mode for the EEG and LFP amp types.

### None

If the reference mode is None, the only option is *Input* for the input channels.

## Battery Status



The Battery Status is displayed after touching the Battery Status icon on the Main Configuration screen.



**Information displayed includes:**

<b>Charging</b>	Indicates if the charger is plugged into the PZ5 (Yes/No).
<b>Voltage</b>	Current voltage level of the battery pack.
<b>Level</b>	% battery life remaining.
<b>Endurance</b>	Estimated time of battery life remaining.

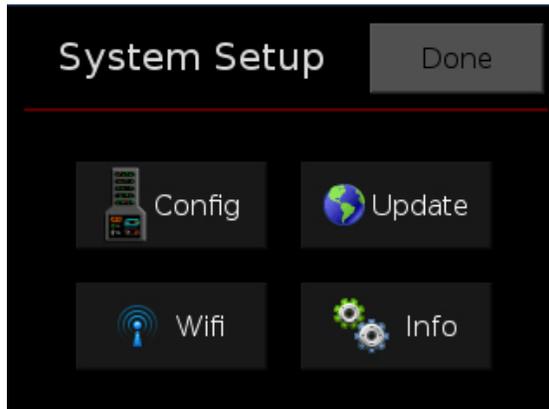
**OK Button**

Close Battery Status display.

**Note:** The Battery Level is also mirrored on the RZ2 LCD display.

## System Setup Screen

The System Setup screen is displayed by touching the PZ5 logo on the top-left of the Main Configuration screen.



**Settings include:**

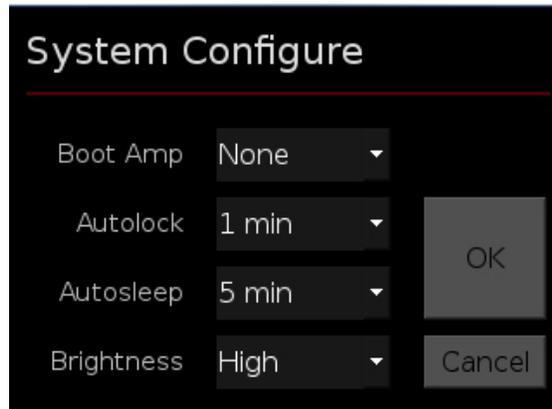
<b>Config</b>	Open the System Configure screen.
<b>Update</b>	Update onboard software over the Internet.
<b>Wifi</b>	Connect to a wireless network for system updates.
<b>Info</b>	Open the device System Info screen to view version numbers for various hardware, software and firmware components.

### Done Button

Return to the Main Configuration window.

## System Configure Screen

The System Configure screen is displayed by touching Config on the System Setup screen.



### Settings include:

- Boot Amp** Select the default logical amplifier settings when the PZ5 is first powered on.
- None** – boots with no logical amplifiers specified.
  - PZ2** – all banks configured as one Single Unit amplifier.
  - PZ3** – all banks configured as one EEG amplifier.
  - PZ3 Diff** – all channels configured as one EEG amplifier in differential referencing mode.
  - Last** – reboots into the last used configuration.
  - Smart** – Does not overwrite any existing logical amplifier configuration on boot. For example, if you configure the logical amplifiers via the PZ5\_Control macro before the PZ5 boots then the PZ5 will NOT overwrite that configuration. If the PZ5 boots and NO logical amplifiers are configured it will behave the same as Last.
- Autolock** Select an option to lock the configuration screen after 1, 2 or 5 min of screen inactivity or select Never to turn off autolocking.
- Autosleep** Select an option to turn off the screen after 5, 10 or 30 min of screen inactivity or select Never to turn off autosleep.
- Brightness** Select High, Medium, or Low to set touchscreen brightness.
- Wireless** Enable/disable the wireless connection.

### OK Button

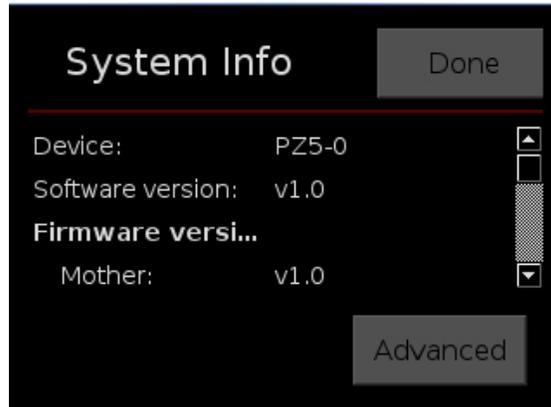
Save changes and return to the System Setup screen.

### Cancel Button

Return to the System Setup screen without saving changes.

## System Info Screen

The System Info screen is displayed by touching Info on the System Setup screen. Use the scroll bar to see all of the version numbers.



### Information displayed includes:

- Device** PZ5 model number (e.g. PZ5-32).
- Software version** Currently installed version of onboard software.
- Firmware version** Currently installed version of firmware.
- Hardware version** Version of hardware.
- Battery** Date and capacity of last battery calibration (in mAhr).

### Done Button

Return to the Main Configuration screen.

### Advanced Button

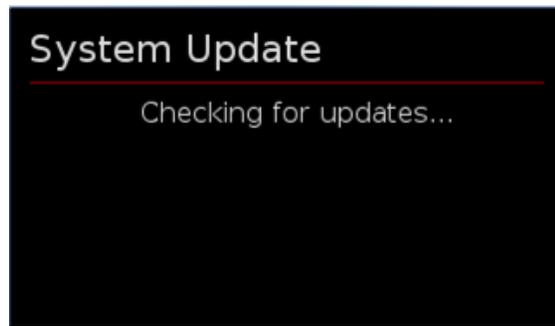
Password protected settings for TDT use only at this time.

## System Update Screen

The system updater connects to a TDT server to download the latest PZ5 software and automatically update the device. This requires an active and configured Internet connection. The PZ5 provides two options for network connection: WiFi and Ethernet. The WiFi connection can be configured on the Wireless Networks screen, see below. The Ethernet port is located on the back panel.

The System Update screen is displayed by touching Update on the System Setup screen.

- Important!** The update process can take up to an hour to complete. Make sure the PZ5 battery charger is plugged in during the update.



## Wireless Networks Screen

The Wireless Networks screen is displayed by touching WiFi on the System Setup screen. Available networks that have been used or previously configured are displayed in the main area of the screen. Selecting a network from the list displays network information and enables the user to connect to the network, forget the network, or cancel configuration of the network.



The wireless icon  shows if the wireless feature is enabled or disabled. A red 'x' will appear through the icon if wireless is disabled. Enable/disable wireless through the System Configure Screen.

**Show All** Shows all networks, including networks that have not been previously used or configured.

**IP Addr** Displays current IP Address when connected to a network.

### Done Button

Return to the Main Configuration screen.

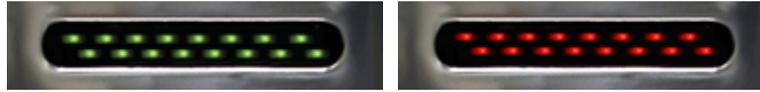
## PZ5 Features

### Clip Warnings and Activity Display

The front panel LEDs can be used to indicate spike activity and/or clip warning for analog input channels. They can be configured under software control using the PZ5\_Control macro or under manual control, using the touchscreen interface on the front of the PZ5.

### LED Indicators (analog)

When enabled, LEDs for each channel are lit green to indicate activity or red to indicate a clip warning. The top row indicates the odd channels (left to right). The bottom row indicates the even channels.



Green: Activity

Red: Clip Warning

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

#### *Clip Warning*

Analog clipping occurs when the input signal is too large. When the input to a channel is within 3 dB of the PZ5's maximum voltage input range the LED for the corresponding channel is lit red to indicate that clipping may occur.

#### *Activity*

When configured to indicate activity, LEDs are lit green whenever a unit (spike) occurs on the corresponding channel. The sensitivity threshold for the green LED is ~200  $\mu$ V.

### LED Indicators (digital)

LEDs that represent digital input boards, indicate the number of input channels with each LED indicating 16 channels. For example, four LEDs indicates 64 input channels have been detected on that connection.

### 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 PZ5 provides connection to common ground. Any logical amplifier configured through the PZ5 touchscreen has this shorted by default. The PZ5\_Control macro allows you to float that ground connection on individual logical amplifiers.

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.

## Battery Overview

The PZ5 neurodigitizer features a 32 Amp-hour Lithium ion battery pack.

## Charging the Batteries

Operate the neurodigitizer with the charging cable disconnected. An external battery pack (PZ-BAT) or external charger and extra battery is available to provide longer battery life for extended recording sessions. See “PZ-BAT External Battery Pack for the PZ Amplifiers” on page 6-23 and “PZ5-BAT External Charger” on page 6-57.

## PZ5 Technical Specifications

<b>A/D</b>	Up to 128 channels, hybrid																					
<b>Maximum Voltage In</b>	+/- 500 mV (+/- 5 mV with Intan RHD2000)																					
<b>A/D Sample Rate</b>	Up to 48828.125 Hz (adjustable in steps of approximately 750, 1500, 3000, 6000, 12000, 25000, and 50000 Hz)*																					
<b>Frequency Response</b>	<i>DC coupled:</i> 0 Hz - 0.45*Fs <i>AC coupled:</i> 0.4 Hz - 0.45*Fs With Intan RHD2000: 0.1 Hz - 10 kHz																					
<b>S/N (typical)</b>	104 dB, single unit, Fs = 25 kHz, 300-7000 Hz 116 dB, differential, Fs = 750 Hz, 0.4-300 Hz																					
<b>Sample Delay</b>	Dependent on PZ5 and RZ processor sample rates (RZ at 25 kHz) (RZ at 12 kHz)  <table> <thead> <tr> <th>PZ5 rate</th> <th>samples</th> <th>samples</th> </tr> </thead> <tbody> <tr> <td>25 kHz</td> <td>22</td> <td>x</td> </tr> <tr> <td>12 kHz</td> <td>40</td> <td>23</td> </tr> <tr> <td>6 kHz</td> <td>76</td> <td>42</td> </tr> <tr> <td>3 kHz</td> <td>141</td> <td>79</td> </tr> <tr> <td>1.5 kHz</td> <td>270</td> <td>152</td> </tr> <tr> <td>750 Hz</td> <td>543</td> <td>295</td> </tr> </tbody> </table>	PZ5 rate	samples	samples	25 kHz	22	x	12 kHz	40	23	6 kHz	76	42	3 kHz	141	79	1.5 kHz	270	152	750 Hz	543	295
PZ5 rate	samples	samples																				
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12 kHz	40	23																				
6 kHz	76	42																				
3 kHz	141	79																				
1.5 kHz	270	152																				
750 Hz	543	295																				
<b>DC offset</b>	< +/-10 $\mu$ V																					
<b>Input Referred Noise</b>	Single Ended: 3.0 $\mu$ Vrms, 300-7000 Hz, 25 kHz Differential: 0.75 $\mu$ Vrms, 0.4-300 Hz, 750 Hz																					
<b>Distortion (typical)</b>	< 1%																					
<b>Input Impedance</b>	10 <sup>9</sup> Ohms																					
<b>Battery Capacity</b>	32 Amp-hour																					
<b>Battery</b>	8-10 hours to charge to 95% capacity, 14 hours to fully charge. Battery life between charges: 2 amp boards ~ 50 hrs    4 amp boards ~ 35 hrs 6 amp boards ~ 27 hrs    8 amp boards ~ 22 hrs																					
<b>Charger</b>	External 12V, 2.5A power supply, center negative																					
<b>Indicator LEDs</b>	Up to 128 status/clip warning/digital input channel count																					
<b>Fiber Optic Cable</b>	5 meters standard, cable lengths up to 20 meters** If longer cable lengths are required, contact TDT.																					
<b>Ethernet Port</b>	100 Mbps																					

**\*Note:** If recording at ~50 kHz on 128 channels, see “PZ5 Software Control” on page 6-33, for more information.

RHD2000 series amplifier boards and SPI interface cables are available from Intan Technologies.

**Important!** The specifications below are dependent on the amplifier board. See [Intan RHD200 series](#) website for latest, full performance specifications.

<b>Supported Sampling Rates</b>	750 Hz, 1.5 3, 6, 12, 25, and 50 kHz
<b>Frequency Response</b>	0.1 Hz - 10 kHz
<b>Amp Input Range</b>	+/- 5 mV
<b>Allowable DC Offset</b>	+/- 0.4 V

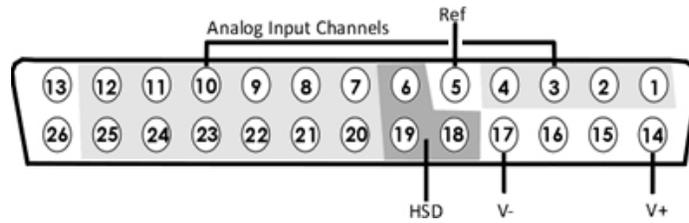
## Input Connectors

PZ5 NeuroDigitizers have up to eight 26-pin headstage connectors (analog) or up to four 12-pin Omnetics nano connectors (digital) on the back of the unit. The connectors are labeled alphabetically from bottom to top. Each connector carries signal for one bank of channels with ground and reference. The corresponding channel numbers depend on 1) the reference mode configurations or number of channels in a connected digital amplifier board and 2) the position of the bank in a logical amplifier.

For simplicity sake, the diagrams below assume channels for that connector begin with channel 1. For example, A1 – A16 represent the 16 channels coming from the connected headstage. The user must increment the channel numbers by 16 (or 8) according to the mode and position of the connector. So, for the connector labeled ‘A’, A1 is channel 1 while on the connector labeled ‘B’, A1 may be channel 17.

## Pinout Diagrams

### Local, None or Shared Reference Mode



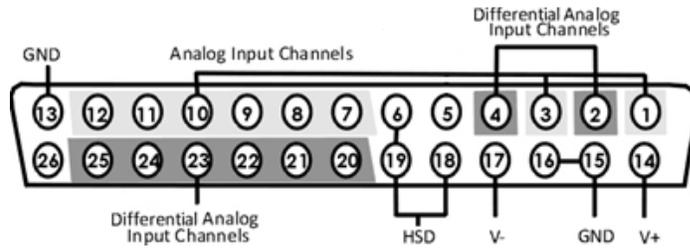
Pin	Name	Description	Pin	Name	Description		
1	A1	Analog Input Channels	14	V+	Positive Voltage (+2.5V)		
2	A2		15	GND	Ground		
3	A3		16	GND	Ground		
4	A4		17	V-	Negative Voltage (-2.5V)		
5*	Ref*		Reference*	18	HSD	Headstage Detect	
6	HSD	Headstage Detect	19	HSD			
7	A5	Analog Input Channels	20	A6	Analog Input Channels		
8	A7		21	A8			
9	A9		22	A10			
10	A11		23	A12			
11	A13		24	A14			
12	A15		25	A16			
13	^		See notes below	26		NA	Not Used

**^Note:** In Local reference mode, Pin 13 is AltRef. Otherwise, Pin 13 is Ground.

\* In Shared reference mode, only Pin 5 of the first bank of the logical amplifier is connected. It is shared internally among the other banks of the logical amplifier.

\* In None reference mode, Pin 5 is not connected.

### Differential Reference Mode



**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 (+2.5V)		
2	A1 (-)	Differential Analog Input Channel	15	GND	Ground		
3	A2 (+)	Analog Input Channel	16	GND			
4	A2 (-)	Differential Analog Input Channel	17	V-		Negative Voltage (-2.5V)	
5	NA	Not Used	18	HSD	Headstage Detect		
6	HSD	Headstage Detect	19	HSD			
7	A3 (+)	Analog Input Channels	20	A3 (-)	Differential 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:** Contact TDT technical support (386-462-9622 or [support@tdt.com](mailto:support@tdt.com)) before attempting to make any custom connections.

### Digital Connectors

The digital input connector is a self-aligning 12-pin Omnetics PZN-12 polarized nano connector that mates directly to an Intan RHD2000 SPI interface cable.

