RZ2 BioAmp Processor

Hardware Reference

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Notices

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RZ2 Overview

The RZ2 BioAmp Processor has been designed for high channel count neurophysiology recording and signal processing. The RZ2 features two (RZ2-2), four (RZ2-4), or eight (RZ2-8) digital signal processors cards. Any card can be either a single standard processor card (RZDSP) or a quad-core processor card (QZDSP). Standard single processor cards use a single Sharc DSP; quad-core processor cards use four Sharc DSPs Cores with the potential to more than double the power of the RZ2.

All cards are networked on a multiprocessor architecture that features efficient onboard communication and memory access. The highly optimized multi-bus architecture uses four dedicated data buses to eliminate data flow bottlenecks - all transparent to the user. This architecture yields an extremely powerful system capable of sophisticated real-time processing and simultaneous acquisition on all channels.

The RZ2 is typically used with a Z-Series Amplifier (such as the PZ5). High bandwidth data is streamed from the amplifier to the RZ2 over a lossless, fast, fiber optic connection. Both single and quad-core processors cards may include an optical interface for connection to devices such as the RS4 Data Streamer, an IZ2 Stimulator or a secondary PZ Amplifier (see Specialized Interface Boards for more information).

Each onboard optical connection can support 256 channels at sampling rates up to ~25 kHz and 128 channels at sampling rates up to ~50 kHz. The RZ2 also features 16 channels of analog I/O, 24 bits of digital I/O, two Legacy optical inputs for Medusa PreAmps, and an onboard LCD for system status display.

Power and Communication

The RZ2's Optibit optical interface connects to a PO5, PO5e, PO5c, or UZ3 computer interface card for fast and reliable data transfer from the RZ2 to the PC. Connectors on the back panel are color coded for correct wiring.

The RZ2's integrated power supply is shipped from TDT configured for the end user's regional voltage setting (110 V or 220 V). If you need to change the voltage setting:

1. Turn off the RZ2

2. Use a small flathead screwdriver to gently push the clip along the left side of the fuse plate to the right to remove it.
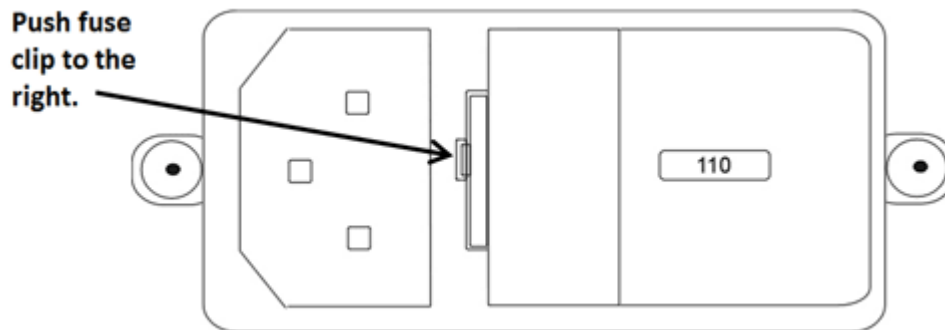
3. Remove the white AC voltage selector and rotate it until the desired voltage is displayed, then reinsert it and put the fuse plate back on.

The RZ2 is UL compliant, see the RZ2 Operator's Manual for power and safety information.

Software Control

TDT's Synapse software controls the RZ2 and provides users a high level interface for device configuration.

RZ2 TouchScreen

The touchscreen shows information about each DSP, the optical PC interface, a connected PZ preamplifier, and system I/O.
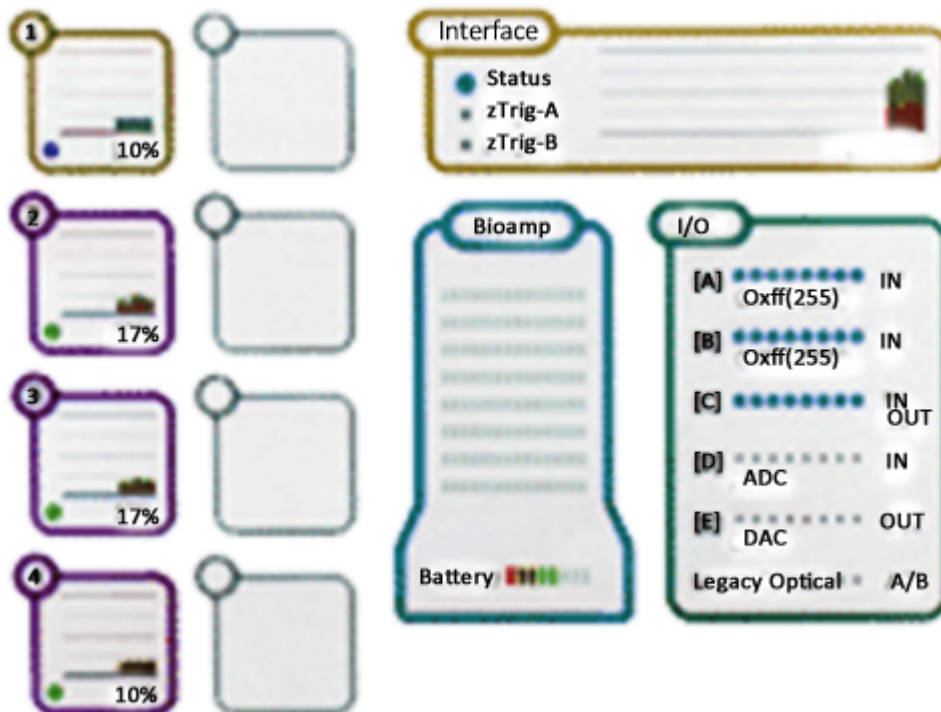
Touch a section of the screen to display more detailed information.

DSPs

A stacked bar plot shows cycle usage for each DSP with the bottom section (blue) showing the cycle usage taken up by circuit operation and the top section (pink) showing the cycle usage required for data transfer.

If the cycle usage surpasses 100%, a bar is drawn above the 100% line in the cycle use bar plot and will persist until the RZ2 is rebooted. For quad-core DSPs, the core with the highest cycle usage is displayed.

```
                    DSP  #1  Details
     ───────────────────────────────────────────────────

     Firmware  Version:        84
     Model:                    RZ2  Bioamp  Processor
     DSP  Type:                Quad  Core  DSP
     Sample  Rate:             12  kHz  (24414.0625  Hz)
     Time  Slice:)             10
     Component  Usage:         0  of  768  Max
     Core  Cycle  Use:         0%
     Optical  Config:          None
     Memory  Usage:
                   XM  =>  0  of  65536  kBytes
                   DM  =>  0  of  32768  Bytes
                   PM  =>  0  of  28672  Bytes

     Data  Pipe  Source:
                   Pipe[A]  =>  Inactive
                   Pipe[B]  =>  Inactive
```

Core-A | Core-B | Core-C | Core-D

Optical Config is the peripheral device supported by the DSP, if any.

Data memory (DM) is the amount of DM used for filter delay line and short delays.

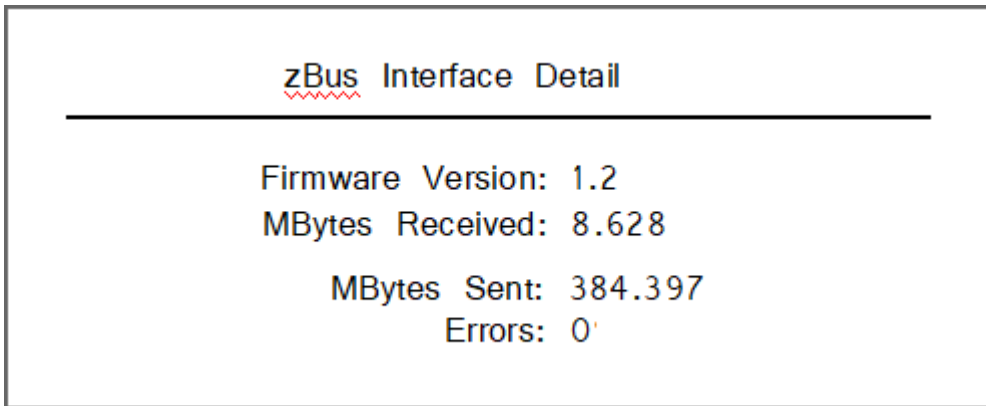**External Memory (XM)** is the amount of XM used for long delays and buffers.

Program Memory (PM) is the amount of PM used to hold filter coefficients.

Tabs are enabled for quad-core DSPs, with one Core per tab.

Interface

Virtual Status lights display status of the interface (Status), zTrig-A, and zTrig-B. A stacked bar chart shows data transfer rate in MB/s.
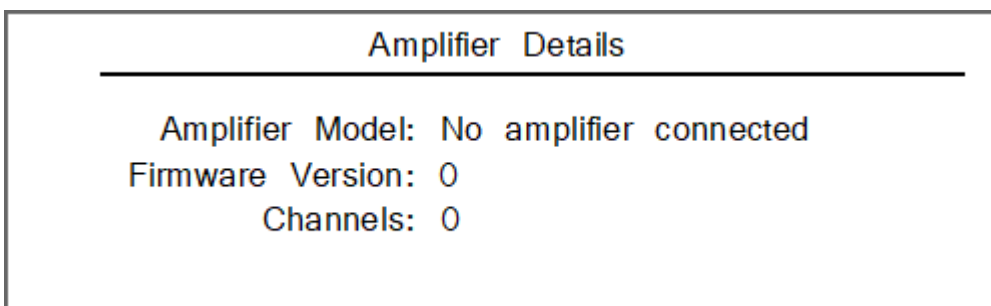
Touch to Display:

```
                    zBus  Interface  Detail
     _____

           Firmware  Version:  1.2
           MBytes  Received:  8.628
               MBytes  Sent:  384.397
                     Errors:  0
```

Firmware version, MB data received/sent and transfer errors.

Amp

Touch to Display: Amp model, number of channels and firmware version of connected PZ series amplifier to dedicated 'PZ Amplifier' fiber optic port on the back of the RZ2.

```
                  Amplifier  Details
     _____

       Amplifier  Model:  No  amplifier  connected
     Firmware  Version:  0
               Channels:  0
```

I/O

Virtual indicator lights.

[A], [B], and [C]: Digital I/O, LED will light for an input bit or it will show the logic level for an output bit.

[D] and [E]: Analog I/O, 16 lights indicate the signal level, green when a signal is present and red to warn that the signal is approaching the maximum voltage (at which point clipping would occur).

Legacy Optical: Amp Light For The Legacy Preamplifier Sync, Flashes yellow when no amp is connected and will be light green when the amplifier is correctly connected.

> ✎ **Note**
>
> Older versions of the RZ2 have a selection knob that allows the user to highlight a section of the screen. To display more detailed information, rotate the knob to select a system component and then push the knob to show the information view.

RZ2 Architecture

The RZ2 processor uses a highly optimized multi-bus architecture and offers four dedicated data buses for fast, efficient data handling. While the operation of the system architecture is largely transparent to the user, a general understanding is important when designing experiments.
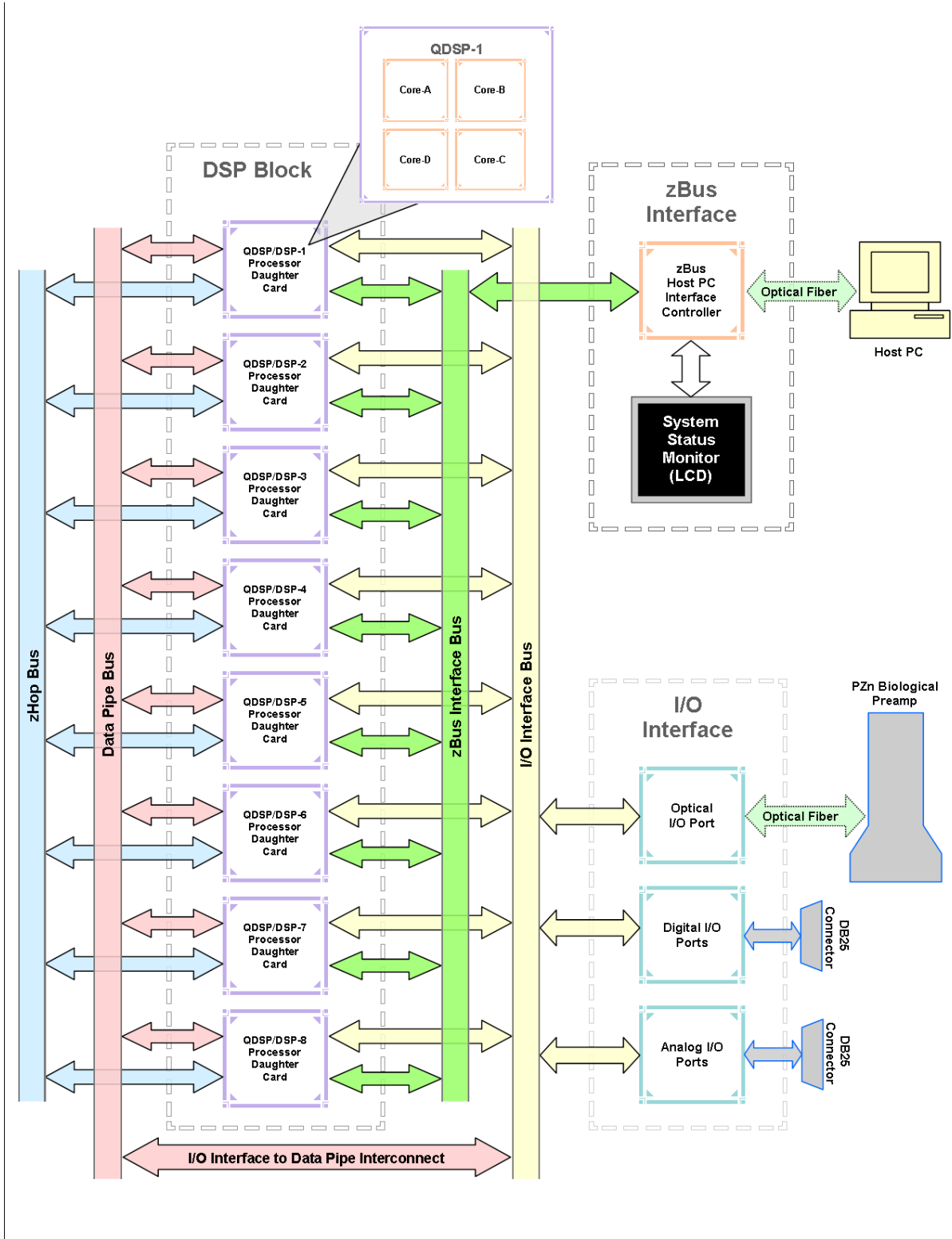
RZ2 Multi-DSP Architecture Functional Diagram

As shown in the diagram above, the RZ2 architecture consists of three functional blocks:

The DSPs	Each DSP in the DSP Block is connected to a local interface to the four data buses: two buses that connect each DSP to the other functional blocks and two that handle data transfer between the DSPs. Each standard DSP is connected to 64 MB SDRAM and each core in a QZDSP is connected to 256 MB DDR2. This architecture facilitates fast DSP-to-off-chip data handling.

Because each DSP has its own associated memory, access is very fast and efficient. However, large and complex circuits should be designed to balance memory needs (such as data buffers and filter coefficients) across processors. Memory use can be monitored on the RZ2 front panel display.

The maximum number of circuit components for each RZ2 standard RZDSP is 768 and 1000 for each QZDSP core. |
| The zBus Interface | The zBus interface provides a connection to the PC. Data and host PC control commands are transferred to and from the DSP Block through the zBus Interface Bus, allowing for large high-speed data reads and writes without interfering with other system processing. |
| The I/O Interface | The I/O interface serves as a connection to outside signal sources or output devices. It is used primarily to input data from a PZ amplifier via the high speed optical port, but also serves the Legacy amplifier inputs and digital and analog channels. The I/O Interface Bus provides a direct connection to each DSP and the Data Pipe Bus. |

For the best performance, processing tasks must be efficiently distributed across the available DSPs. Synapse software automatically handles this. For custom circuit programming, see the RPvdsEx manual.

Bus Related Delays

A standard two sample delay is associated with the zHop, and Data Pipe. However, these delays are managed for the user in Synapse software.

50 kHz Sampling Rate Acquisition with the PZ Amplifier

The RZ2 and PZ amplifier support sample rates from ~6 kHz to ~50 kHz. When sampling at a rate of ~50 kHz, only the first 128 PZ amplifier channels will be available.

Data Transfer Rate

As with other devices, your expected sustained RZ-to-Host PC data rate should not exceed ½ to ⅔ of the rated data transfer speed. For the RZ2 device this is 160 Mbits/second (Mbps) so your designs should have a sustained data rate of no more than ~100 Mbps. When the RZ2 is processing, the current data transfer rate (Mbps) is displayed in the top right corner of the LCD Screen. This maximum rate may be further limited by your PC's ability to store the data to disk.

RZ2 Features

Amplifier and Onboard Analog I/O

The RZ2 is equipped with both optical port amplifier input and onboard analog I/O capabilities. The high speed fiber optic port (located on the RZ2 back panel) allows a direct connection to a PZ5 amplifier. The Legacy fiber optic ports on the front panel allow a direct connection to Medusa preamplifiers. Physiological signals are digitized on the preamplifier and transferred across noiseless fiber optics.
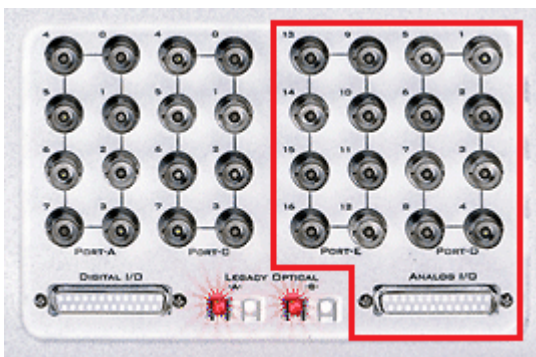
The RZ2 also includes onboard D/A for stimulus generation and experiment control, and A/D for input of signals from a variety of other analog sources.

The table below provides a quick overview of these I/O features and how they must be accessed during experiment design.

Analog I/O	Description	Synapse Access	Notes
Port D	Analog Inputs	ADC Tab	Port D front panel BNCs or Analog I/O labeled DB25
Port E	Analog Outputs	DAC Tab	Port E front panel BNCs or Analog I/O labeled DB25
PZ Amplifier Port	PZ5 Amplifier Input	PZn Hal	Port located on RZ back panel next to zBus Interface
Legacy Amp-A	Medusa PreAmp Input	RAn Hal	
Legacy Amp-B	Medusa PreAmp Input	RAn Hal	

Onboard Analog I/O

The RZ2 is equipped with eight channels of 16-bit PCM D/A and eight channels of 16-bit PCM A/D. All 16 channels can be accessed via front panel BNCs marked Port D and Port E or via a 25-pin analog I/O connector. See DB25 Analog I/O Pinout and BNC Channel Mapping.

PZ Amplifier Fiber Optic Port

This is the RZ2's primary amplifier input and is located on the back panel. The connectors on the fiber optic pair used for PZ amplifier communication are color coded for correct wiring. This port can read up to 256 channels at a maximum sampling rate of ~25 kHz or 128 channels at a maximum sampling rate of ~50 kHz.

Legacy Fiber Optic Ports

The RZ2 station has two Legacy fiber optic ports labeled -A- and -B- to acquire digitized signals from the Medusa4Z, RA16PA, RA8GA, or HTI3 interface. Each port can read up to 16 channels at a maximum sampling rate of ~25 kHz.

Digital I/O

The digital I/O ports include 24 bits of programmable I/O. The digital I/O is divided into three ports (A, B, and C) as described in the chart below. All digital I/O lines are accessible via the 25-pin connector on the front of the RZ2 and ports A and C are available through BNC connectors on the front panel. See DB25 Digital I/O Pinout and BNC Channel Mapping. If using a PP24 Patch Panel, see PP24 to RZ2 Digital I/O.

The digital I/O is configured in the Synapse RZn Hal.

Digital I/O	Description	DB25	BNCs	Notes
Port A	bits 0 - 7	Yes	Yes	byte addressable
Port B	bits 0 - 7	Yes	No	byte addressable
Port C	bits 0 - 7	Yes	Yes	bit addressable

The data direction for the Digital I/O is also configured in the Synapse RZn Hal.

The RZ digital I/O ports have different voltage outputs and logic thresholds depending on the type. The table below depicts the different voltage outputs and thresholds for both types.

Digital I/O Type	Output High	Output Low	Input High	Input Low
Port A & Port B	5 V	0 V	>=2.5 V	0-2.45 V
Port C	3.3 V	0 V	>=1.5 V	0-1.4 V

UDP Ethernet Interface

The RZ UDP Ethernet interface can transfer low bandwidth data directly to or from a PC. RZ devices equipped with a UDP interface have an additional Ethernet port and RS232 serial port located on the back panel. See RZ-UDP Communications Interface for more information.

> ✏️ **Note**
>
> If the RZ2 has 4 optical DSP cards (see below) installed, the RS232 serial port is not available.

Specialized DSP/Optical Interface Boards

The RZ standard DSP boards can be replaced with specialized DSP boards which include an optical interface for communication and control of RZ compatible devices, such as the Subject Interface and RS4 Data Streamer. RZ devices equipped with one or more specialized DSP boards include an optical port for each card. The ports are located on the back panel and labeled for easy identification.

DSP	Supported Peripheral
RZDSP-I	IZ2 Stimulators
RZDSP-M	Subject Interface, PZ5 amplifier, iCon Behavioral Controller
RZDSP-P	PZ amplifier. It can be used to expand the number of channels that can be acquired on any RZ processor.
RZDSP-S	RS4 Data Streamer, allowing the RZ device to stream data directly to the RS4's storage arrays.
RZDSP-U	PO8e interface card, allowing the RZ device to stream data directly to client software.
RZDSP-V	RV2 Video Tracking System
QZDSP_OPT	Supports all of the above devices.

RZ2 Technical Specifications

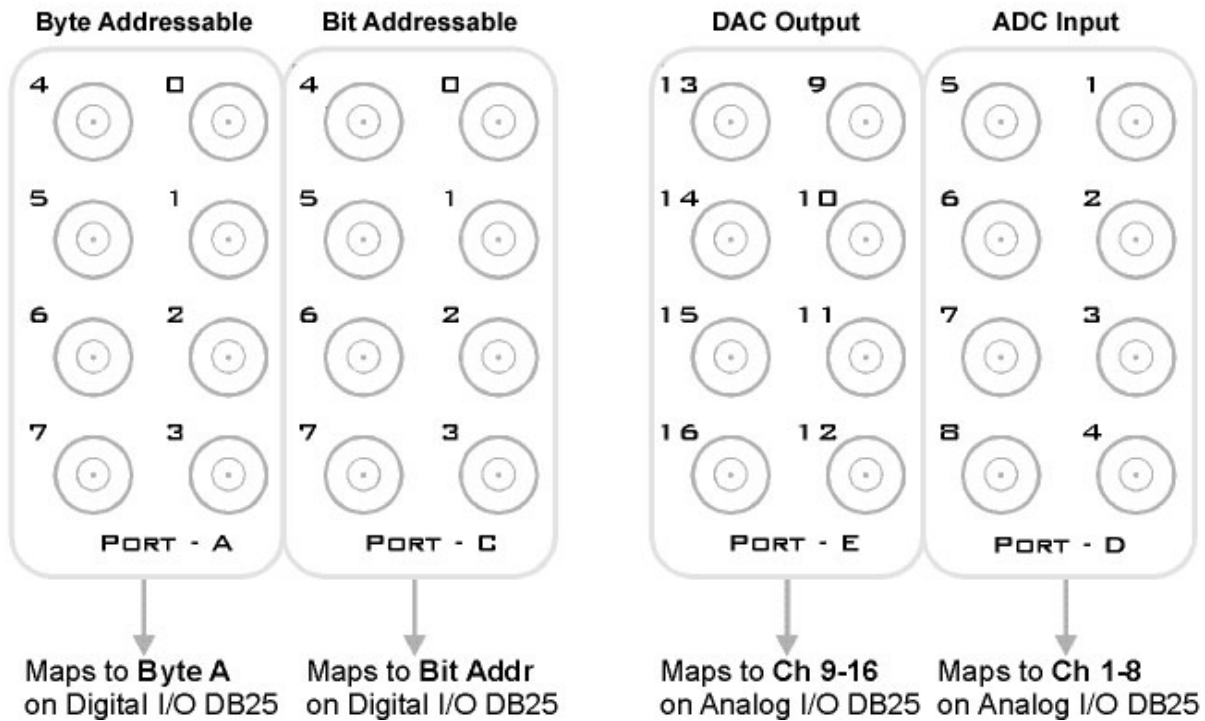|	
DSP	Up to eight standard DSPs and/or quad-core (QZDSP)
	DSP: 400 MHz DSPs, 2.4 GFLOPS peak per DSP
	QZDSP: Four 400 MHz DSPs, 2.4 GFLOPS per core
Memory	64 MB SDRAM per standard DSP
	256 MB DDR2 RAM per core, four cores per QZDSP
Digital I/O	8 programmable bits: 3.3 V (5.0 V max input), 25 mA max load
	2 programmable bytes (16 bits): 5.0 V (6.0 V max input), 35 mA max load
D/A	**8 channels, 16-bit PCM**
Sample Rate	Up to 48828.125 Hz
Frequency Response	DC - 0.44 * Fs (Fs = sample rate)
Voltage Out	±10.0 V, 175 mA max load
S/N (typical)	82 dB (20 Hz - 20 kHz at 9.9 V)
Output Impedance	10 Ohms
A/D	**8 channels, 16-bit PCM**
Sample Rate	Up to 48828.125 Hz
Frequency Response	DC - 7.5 kHz (3 dB corner, 2nd order, 12 dB per octave)
Voltage In	±10.0 V
S/N (typical)	82 dB (20 Hz - 20 kHz at 9.9 V)
Input Impedance	10 kOhms
Fiber Optic Ports	
PZ Amplifier	One 256-channel input
	The maximum sample rate is 48828.125 Hz when recording up to 128 channels or 24414.0625 Hz when recording 129 - 256 channels).
Legacy (Medusa)	Two 16-channel inputs
Add-on (Optional)	Up to four, one per QZDSP_Opt or Optical DSP card upgrade.

> ✏️ **Note**
>
> Technical specifications for preamplifier A/D converters are found in the specific preamplifier document.

BNC Channel Mapping

Please note channel numbering begins at the top right block of BNCs for each port and is printed on the face of the device.

Byte Addressable	Bit Addressable	DAC Output	ADC Input
4 □	4 □	13 9	5 1
5 1	5 1	14 10	6 2
6 2	6 2	15 11	7 3
7 3	7 3	16 12	8 4
PORT - A	PORT - C	PORT - E	PORT - D
Maps to **Byte A** on Digital I/O DB25	Maps to **Bit Addr** on Digital I/O DB25	Maps to **Ch 9-16** on Analog I/O DB25	Maps to **Ch 1-8** on Analog I/O DB25

DB25 Analog I/O Pinout
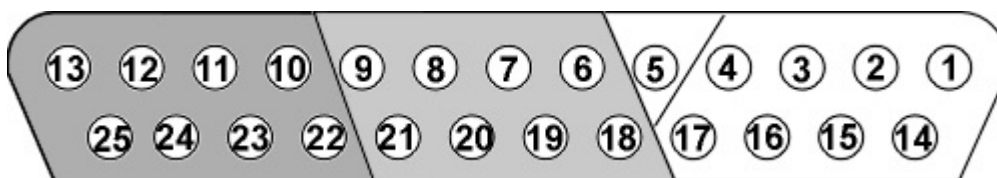
Pin	Name	Description	Pin	Name	Description
1	NA	Not Used	14	NA	Not Used
2	NA		15	NA	
3	NA		16	NA	
4	NA		17	NA	
5	AGND	Analog Ground	18	A1	Analog Input
6	A2	Analog Input	19	A3	
7	A4		20	A5	
8	A6		21	A7	
9	A8		22	A9	Analog Output
10	A10	Analog Output	23	A11	
11	A12		24	A13	
12	A14		25	A15	
13	A16				

DB25 Digital I/O Pinout

Pin	Name	Description		Pin	Name	Description
1	C0	Port C Bit Addressable		14	C1	Port C Bit Addressable
2	C2			15	C3	
3	C4			16	C5	
4	C6			17	C7	
5	GND	Digital I/O Ground		18	A0	Port A Word Addressable
6	A1	Port A Word Addressable		19	A2	
7	A3			20	A4	
8	A5			21	A6	
9	A7			22	B0	Port B Word Addressable
10	B1	Port B Word Addressable		23	B2	
11	B3			24	B4	
12	B5			25	B6	
13	B7					

If using a PP24 Patch Panel, see PP24 to RZ2 Digital I/O.