RZ6 Multi I/O Processor

Hardware Reference

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RZ6 Multi I/O Processor

RZ6 Overview

The RZ6 Multi I/O Processor is a high sample rate processor with flexible input/output capabilities. The RZ6 features up to four 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 RZ6. All cards are networked on a multiprocessor architecture that features efficient onboard communication and memory access. Two channels each of sigma-delta analog input and output provide a dynamic range of up to 115 dB and sampling rates up to ~200 kHz.

The single device form factor incorporates two channels of onboard programmable and manual attenuation and can drive headphones and standard, magnetic, or electrostatic speakers. It includes an onboard monitor speaker, two channels of amplification for analog inputs, and 24 bits of digital I/O. XLR, audio jack, and BNC connections are supported. Optionally, the RZ6 can be equipped with a fiber optic input, allowing it to support a four channel Medusa preamplifier.

The RZ6-A base version starts with a single DSP and makes an excellent all-in-one psychoacoustics system or can be added to any system to add audio stimulus generation to experiments.

The RZ6-A-P1 comes equipped with four DSPs for more processing power and includes the optional fiber optic input port, allowing it to serve as a BioAmp base station for ABR and OAE studies using TDT's BioSigRZ software.

Both configurations can be upgraded with additional single or quad-core DSP cards (up to a maximum of four DSP cards) for complex filtering and high frequency applications.

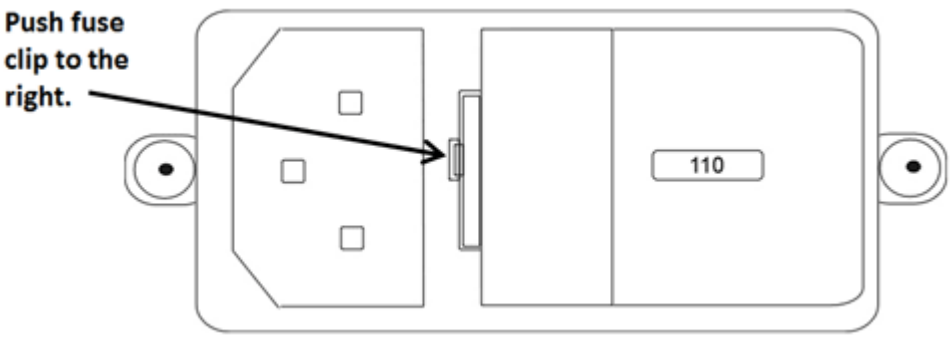
> **Note**
>
> RZ6-A-P1 serial number <3000 came with three DSPs in the standard configuration.

Power and Communication

The RZ6'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 RZ6'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 RZ6
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.

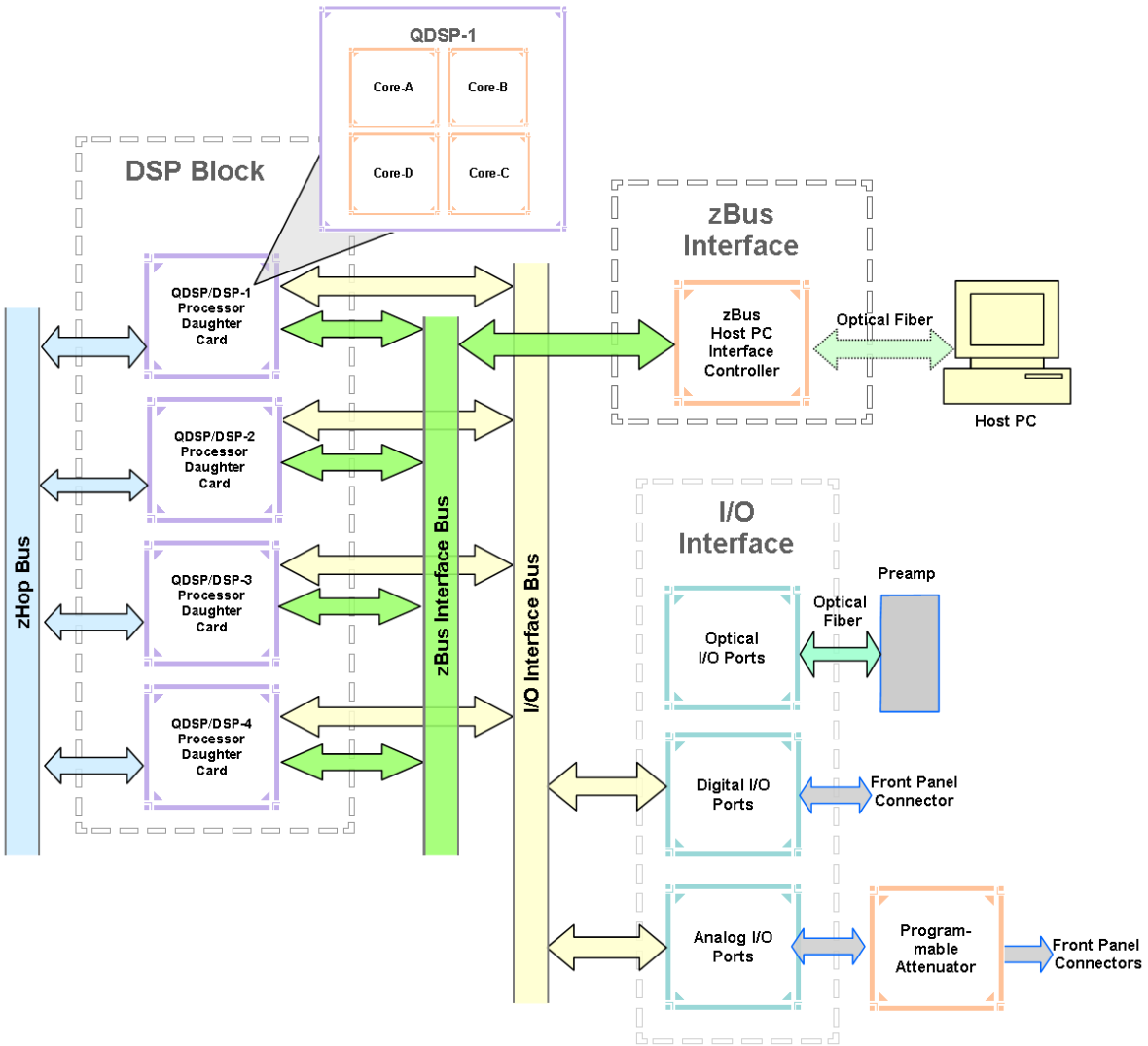
The RZ6 is UL compliant, see the RZ6 Operator's Manual for power and safety information.

Software Control

TDT's Synapse or BioSigRZ software controls the RZ6 and provides users a high level interface for device configuration. If using RPvdsEx to design circuits for the RZ6, see the Legacy System 3 Manual for information on what macros to use.

RZ6 Architecture

The RZ6 processor uses a multi-bus architecture and offers three 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.



RZ6 Architecture Diagram

As shown in the diagram above, the RZ6 architecture consists of three functional blocks:

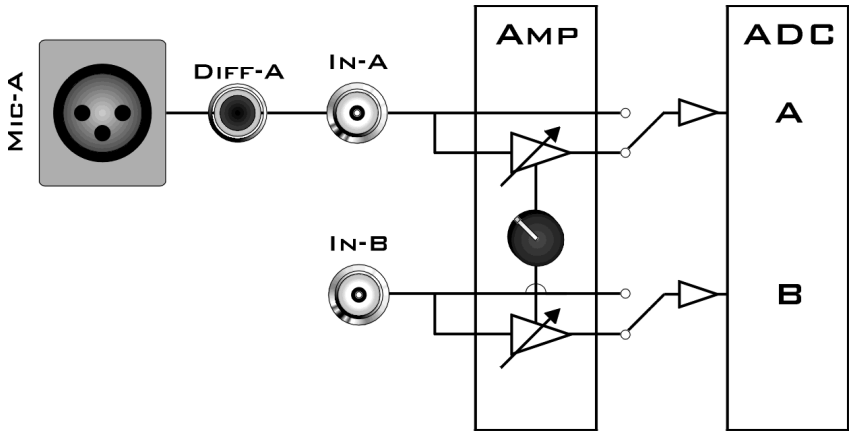
The DSPs	Each DSP in the DSP Block is connected to a local interface to the three data buses: two buses that connect each DSP to the other functional blocks and one that handles data transfer between the DSPs. Each standard DSP is connected to 64 MB SDRAM and each core in a QZDSP is connected to 256 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. The maximum number of circuit components for each RZ5D 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 to input data from the preamplifier inputs and digital and analog channels. The I/O interface bus provides a direct connection to each DSP.

Bus Related Delays

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

Functional Signal Flow Diagrams

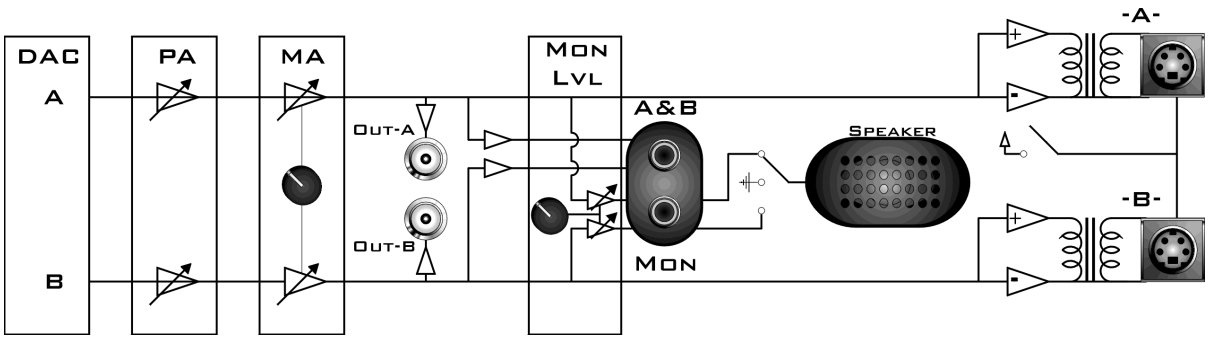
The following diagrams illustrate how analog signals for channels A and B flow through the RZ6 and its modules. For more information on analog input and output see Onboard Analog I/O and Optional Amplifier Input.



RZ6 Analog Input Flow Diagram

Input signals for channel A are input either through the XLR input (Mic-A), the audio jack input (Diff-A), or BNC (In-A). Input signals for channel B are input through the BNC (In-B).

A switch located to the left of the gain control knob allows a single gain setting for both channels to be applied or bypassed completely.



RZ6 Analog Output Flow Diagram

Signals A and B flow out of the DAC and pass through the programmable and manual attenuation modules prior to being output on the front panel BNC connectors (Out-A and Out-B).

The signals for channels A and B are also passed to two stereo headphone output ports labeled A&B and Mon. Individual stereo power amplifiers are used for the BNC and stereo headphone outputs.

A single channel monitor speaker is connected either to signal A, signal B, or disabled based on the monitor control switch setting. The monitor level knob controls the sound level of both the stereo headphone jack labeled Mon and the monitor speaker.

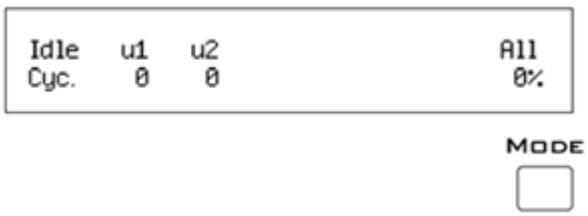
Finally, if the electrostatic speaker driver is enabled via its switch, located on the front panel, signals A and B are output from the mini-DIN ports located on the RZ6 front panel.

RZ6 Features

DSP Status Lights

These LEDs report the status of the multiprocessor's individual DSPs and will be lit solid green when the corresponding DSP is installed and running. The corresponding LED will be lit dim green if the cycle usage on a DSP is 0%. If the demands on a DSP exceed 99% of its capacity on any given cycle, the corresponding LED will flash red (~1 time per second). For QZDSPs, the LED indicates levels for the core with the highest cycle usage.

Front Panel Display Screen



The front panel display screen reports detailed information about the status of the system. The top line reports the system mode, Run!, Idle, or Reset. The second line reports the user's choice of status indicators for each DSP followed by an aggregate value.

The user can cycle through the various status indicators using the Mode button to the bottom right of the display. Push and release the button to change the display or push and hold the button for one second then release to automatically cycle through each of the display options. The display screen may also report system status such as booting status (Reset).

> **Note**
>
> When burning new microcode or if the firmware on the RZ is blank, the display screen will report a cycle usage of 99% and the processor status lights will flash red.

Indicator	Description
Cyc	Cycle usage. For QZDSPs, the highest core cycle usage is shown
Bus%	Percentage of internal device's bus capacity used
I/O%	Percentage of data transfer capacity used
DAC	Displays the current analog attenuator setting. Also displays bars according to the RMS level of DAC A and B using a logarithmic scale **Note:** Eight solid bars denote that the signal on DAC A or B is clipping.
ADC	Displays bars according to the RMS Level on ADC A and B using a logarithmic scale. **Note:** Eight solid bars denote that the signal on ADC A or B is clipping.

Onboard Analog I/O and Optional Amplifier Input

The RZ6 is equipped with onboard analog I/O and attenuators. It may also include a fiber optic port for Medusa preamplifier input.

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	RPvdsEx Access
In-A and In-B	Analog Inputs	ADC Tab	RZ6_AudioIn macro
Out-A and Out-B	Analog Outputs	DAC Tab	RZ6_AudioOut macro
Atten-A and Atten-B	Programmable Attenuators	DAC Tab	RZ6_AudioOut macro
Optical In	Medusa PreAmp Input	RAn Hal	RZ6_AmpIn (for RA4PA) or Medusa4Z_Input macro

Onboard Analog Inputs

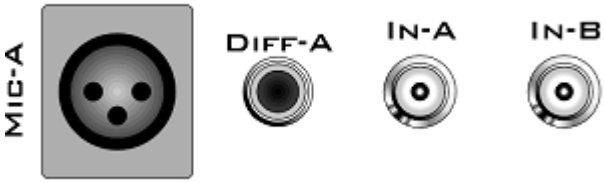
The RZ6 is equipped with two channels of 24-bit sigma-delta A/D converters. See RZ6 Technical Specifications for more information.

Analog signals can be input through several connectors on the RZ6 front panel.

Channel A has three possible sources:

- MIC-A (XLR microphone input)
- DIFF-A (¼" TRS microphone input)
- BNC labeled In-A

Channel B uses only the BNC labeled In-B:



Important

Use only one input for channel A at a time. Attempting to input signals from multiple sources will produce an erroneous signal.

A and B Microphone Amplifier

An onboard two channel amplifier provides gain for the onboard analog input signals (MIC-A, DIFF-A, In-A, and In-B). The switch located to the left of the gain control knob allows the current gain setting to be applied (if set to Amp) or bypassed completely (if set to Byp).

Important

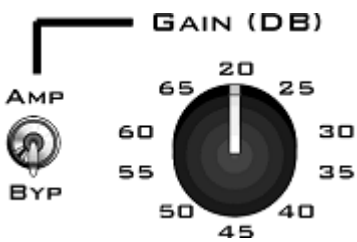
When the gain is enabled, analog input signals MIC-A and DIFF-A are differential. Since the differential signals are summed a signal gain of 6 dB will be inherently applied. If the amplifier is bypassed, common mode rejection is disabled.

Note

To prevent clipping caused by a DC offset, the amplifier is AC coupled when the gain amplification is in use.

Gain

The front panel gain control knob can be used to the control overall signal level of both channels from 20 to 65 dB in 5 dB steps.



Fiber Optic Port - Optional

The RZ6-A-P1 acquires digitized signals from a Medusa preamplifier over a fiber optic cable. The port can be used with the RA4PA or Medusa4Z to input up to 4 channels.

The fiber optic port (devices with serial number 1007 and greater) can also support the HTI3 Head Tracker Interface.

Fiber Oversampling (preamp input)

Signals are digitized on the Medusa preamplifier at a maximum sampling rate of ~25 kHz, however, the fiber optic port on the RZ6 can oversample the digitized signals up to 8X or ~200 kHz. This will allow the RZ6 to run a DSP chain at ~200 kHz and still sample data acquired through an optically connected preamplifier.

Oversampling is performed on the RZ6. The signals being acquired will still be sampled at ~25 kHz on the preamplifier. This means that, even with oversampling, signals acquired by an optically connected preamplifier are still governed by the bandwidth and frequency response of the preamplifier.

Onboard Analog Outputs

The RZ6 is equipped with two channels of 24-bit sigma-delta D/A converters. See RZ6 Technical Specifications for more information. Analog signals are output through a variety of connectors on the RZ6 front panel.

Programmable Attenuation

The RZ6 has two channels of programmable attenuation for precision control of analog output signal levels over a wide dynamic range.

Programmable attenuation in the RZ6 is achieved using both analog and digital attenuation methods. The device supports analog attenuation values of 0, 20, 40, and 60 dB. Attenuation values which lie in-between or exceed 60 dB are handled using digital attenuation.

For example, if you set an attenuation value of 66 dB, the analog attenuator will be set to 60 dB and the remaining 6 dB of attenuation will be applied by scaling the digital signal on the processor before it goes to the DAC.

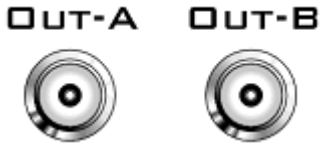
For the best results, you should use the maximum D/A voltage range and use the attenuators to reduce the output to the target voltage.

Manual Attenuator

The RZ6 includes another level of analog attenuation that can be controlled manually via the attenuator control knob from 0 to 27 dB in increments of 3 dB.

Manual attenuation is applied to both channels before the signals are output on any of the front panel connectors and is therefore applied in addition to any programmable attenuation.

Analog Output via BNCs

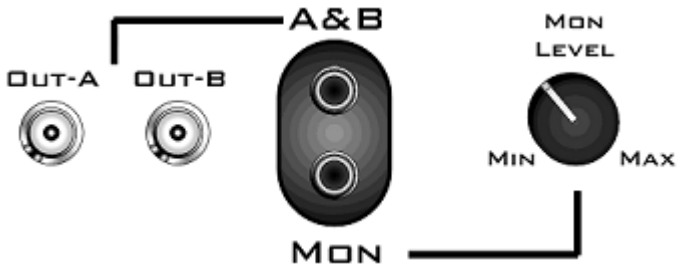


DAC channels A and B are output to BNCs labeled Out-A and Out-B after attenuation has been applied. These outputs use a stereo power amplifier to drive TDT's MF1 multi-function speakers.

A single signal generated or input from any of the RZ6 analog inputs can be ganged to reduce the spectral variation in power of the transducer across all frequencies. To do this, configure your signal to output from both DAC channels and connect your transducer to both channels.

Stereo Headphone Output

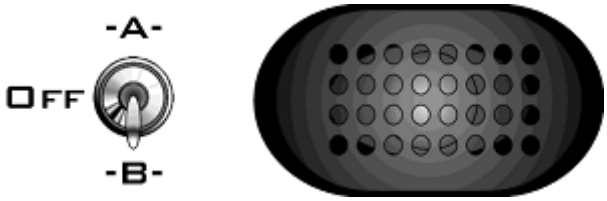
DAC channels A and B are also available as a stereo headphone output through two ⅛" audio jack connector ports (channel A is the left stereo output and channel B is the right stereo output). The port labeled A&B (top) provides a stereo headphone output suitable for experimental paradigms while the port labeled Mon (bottom) can be controlled by the Mon Level knob located directly to the right, making it more suitable for monitoring the experiment.



Audio Outputs

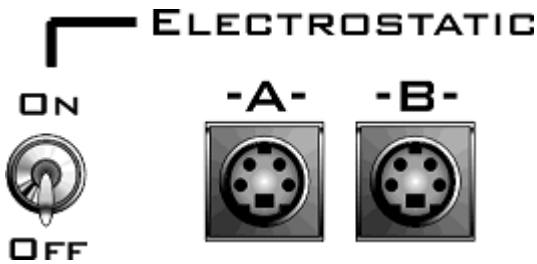
> **Note**
>
> All outputs use stereo power amplifiers

Monitor Speaker



The RZ6 is equipped with an onboard monitor speaker, provided for audio monitoring of a single channel. A switch located directly to the left of the monitor speaker is used to select between DAC channels A and B or to disable the monitor speaker. The monitor speaker output level is controlled by the Mon Level knob located directly to the right of the monitor stereo output.

Electrostatic Speaker Output



An onboard two channel broadband electrostatic speaker driver is provided, allowing direct connection of TDT's ES series electrostatic speakers. The driver produces flat frequency responses reaching far into the ultrasonic range, can drive two ES series speakers, and is powered using the onboard power supply. A switch located directly to the left of the two 4-pin, mini-DIN connectors is used to enable or disable output of DAC channels A and B.

Note

The electrostatic speaker driver is designed to work exclusively with TDT's [electrostatic series speakers]https://www.tdt.com/docs/hardware/ec1-es1-electrostatic-speaker/){:target="_blank"}. Do NOT attempt to use any other speaker.

Important

If the electrostatic speaker driver is not being used, make sure that the ON/OFF switch is in the OFF position to reduce noise on the RZ6 analog I/O.

Digital I/O

The digital I/O ports include 24 bits of programmable I/O. The digital I/O is divided into three bytes (A, B, and C) as described in the chart below. All digital I/O lines are accessed via the 25-pin connector on the front of the RZ6. Earlier versions (serial number <2000) were limited to 8 bits. See RZ6 Technical Specifications for the DB25 pinout.

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

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

The data direction for the Digital I/O is also configured in the Synapse RZn Hal, or in RPvdsEx with the RZ6_Control macro.

The RZ digital I/O ports have different voltage outputs and logic thresholds depending on the type. Below is a table listing 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

LED Indicators

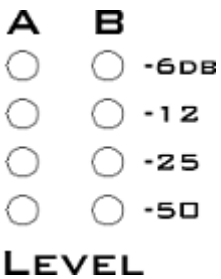
The RZ5D has 16 LED indicators for the analog and digital I/O located directly below the display screen and DSP status LEDs.

Digital I/O

These LEDs indicate the state of the 8 bit-addressable I/O of byte C.

Light Pattern	Description
Dim Green	Bit is configured for output and is currently a logical low (0)
Solid Green	Bit is configured for output and is currently a logical high (1)
Dim Red	Bit is configured for input and is currently a logical low (0)
Solid Red	Bit is configured for input and is currently a logical high (1)

Analog Input - ADC LED Indicators



The ADC LED indicators are labeled and located at the top right of the RZ6 front panel. The LEDs indicate the level of the signals on ADC channels A and B. This provides a useful indicator for adjusting the gain and to detect and prevent clipping. The following table describes the LED indicators' operation.

LEDs Lit	Description
4	Input is <=-6 dB down from max input voltage
3	Input is between -6 dB and -12 dB down from max input voltage
2	Input is between -12 dB and -25 dB down from max input voltage
1	Input is between -25 dB and -50 dB down from max input voltage

Fiber Optic Indicator

A single green LED indicator next to the fiber optic input port on the RZ6-A-P1 lights when a Medusa preamplifier is correctly synced with the RZ6.

RZ6 Technical Specifications

> **Note**
>
> The RZ6 can be equipped with a fiber optic input port and used with a four channel Medusa preamplifier. See the preamplifier's technical specifications for A/D converters.

DSP	Up to four 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
Fiber Optic Ports	Optional Input available on RZ6-A-P1 only. Supports: - Medusa4Z preamplifier (serial number 2400 and greater) - 4-channel RA4PA preamplifier - HTI3 Head Tracker Interface (serial number 1007 and greater)

D/A	2 channels, 24-bit sigma-delta
Sample Rate	Up to 195312.50 Hz
Frequency Response	DC - 0.44 * Fs (Fs = sample rate)
Voltage Out	±10.0 V
S/N (typical)	115 dB (20 Hz - 80 kHz at 5 Vrms)
THD (typical)	-90 dB (1 kHz output at 5 Vrms)
Sample Delay	31 (serial numbers >2000) 47 (serial numbers <2000)
Output Impedance	1 Ohm

A/D	2 channels, 24-bit sigma-delta
Sample Rate	Up to 195312.50 Hz
Frequency Response	DC - 0.44 * Fs (Fs = sample rate)
Voltage In	±10.0 V
S/N (typical)	115 dB (20 Hz - 80 kHz at 5 Vrms)
THD (typical)	-90 dB (1 kHz output at 5 Vrms)
Sample Delay	66 samples
Input Impedance	10 kOhms

A and B Microphone Amplifier	Single setting for both channels
High Pass Corner Frequency	3.6 Hz (Active only if the Amplifier is enabled)
Gain Settings	20 to 65 dB
Gain Step Size	5 dB

Programmable Attenuation	2 channels
Switching Time	1 sample
Settling Time	3 us
Transient Voltage	~370 mV
Hardware Attenuation Settings	0, 20, 40, 60 dB

Manual Attenuation	Single setting for both channels
Attenuation Settings	0 to 27 dB
Attenuation Step Size	3 dB

Output Amplifier	2 channels
Spectral Variation	<0.1 dB from 50 Hz to 200 kHz
Signal Noise	115 dB (20 Hz to 80 kHz)
THD	<0.02% at 1 Watt from 50 Hz to 100 kHz
Noise Floor	20 uVrms
Power Output	0.75 W/channel into 5.5 ohms

Headphone Output	2 channels
Output Impedance	1 Ohm
Power Output	0.75 W/channel into 5.5 ohms

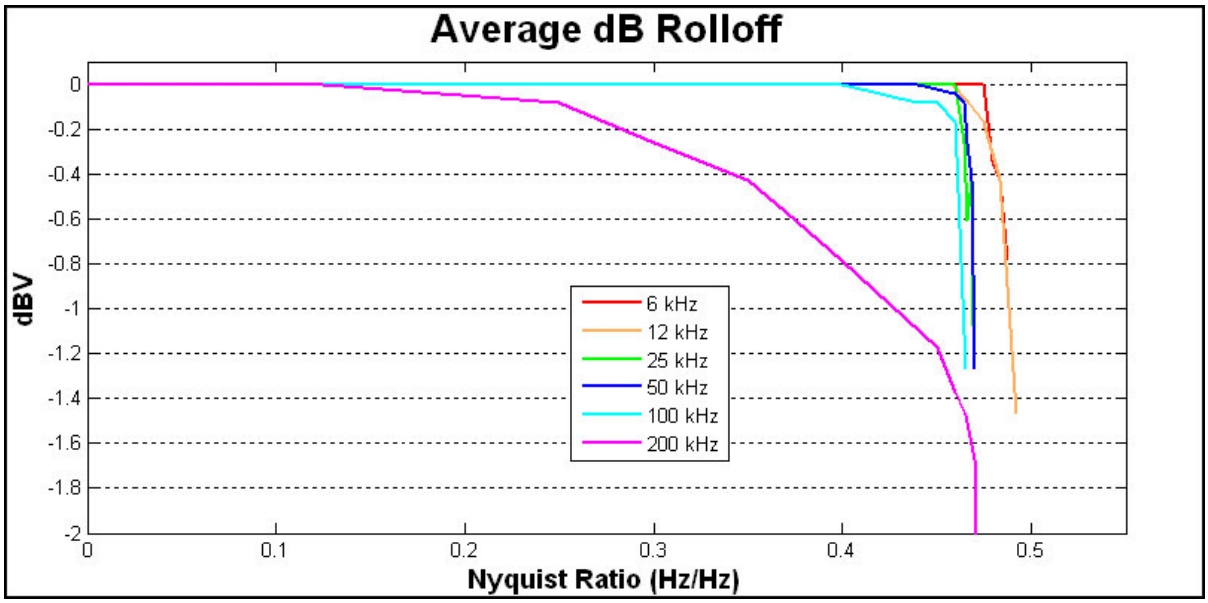
Electrostatic Speaker Output	2 channels

Note

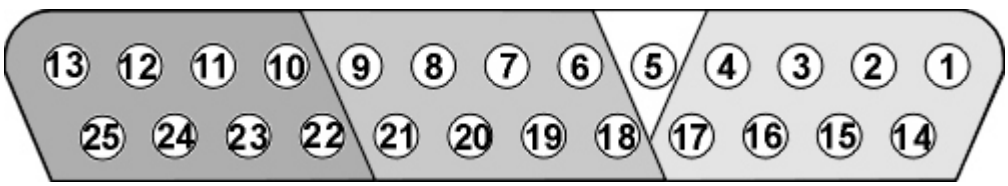
For further information on speaker specifications, see ES1/EC1 Technical Specifications and MF1 Technical Specifications.

D/A dB Rolloff Diagram

This graph shows the dB rolloff for the RZ6 with varying sampling frequencies for the D/A. The sample delay remains constant for varying frequencies.



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 RZ6 Digital I/O.