RZ-UDP Communications Interface

RZ2 Processor Back side with RZ-UDP Installed

RZ-UDP Overview

The RZ Communications Interface (RZ-UDP-20) is an optional interface for RZ processor devices that includes a UDP Ethernet connection and a serial port connection.

The serial port can support baud rates up to 115200. The port is a standard 9-pin RS232 connection located on the back of the RZ. The RS232 port can be directly connected to any device that communicates via serial port, such as head trackers, eye trackers, or a PC. Note: If installed in an RZ with 4 optical DSP cards, the serial port is not available.

The UDP interface is designed to transfer up to 200 data values at low rates to or from a PC. The PC may be directly connected through a dedicated Ethernet card located elsewhere on the user's network, or even in a remote location connected via the Internet. The RZ UDP interface is located on the back panel of the RZ processor and accepts a standard Ethernet cable.

Like all network devices the RZ UDP interface utilizes several network parameters such as a unique network address, appropriate network mask, and optionally a gateway (if operating across networks). The RZ UDP Ethernet interface supports the DHCP (Dynamic Host Configuration) protocol for automatic configuration of these network parameters, but these parameters may also be set manually, as described in "Network Settings" on page 1-60 The type and structure of data for the serial port must be manually configured through the same network interface.

Note: The RZ-UDP-20 is an updated version of the RZ-UDP-10 which had only an Ethernet interface. Configuration of the Ethernet interface is the same for both versions.

RZ-UDP Basics

Installation

Synapse has built-in objects for the Processing Tree to send and receive data from the UDP interface. These must be added to your Hardware Rig in Synapse and then simply connect the desired signal stream to the UDP object. See the Synapse manual for more information.

The TDT drivers installation provides the UDP test application here:

C:\TDT\RPvdsEx\Examples\RZ UDP\

For RPvdsEx circuit design, two macros designed for the UDP Ethernet interface and two macros for the serial interface are installed here:

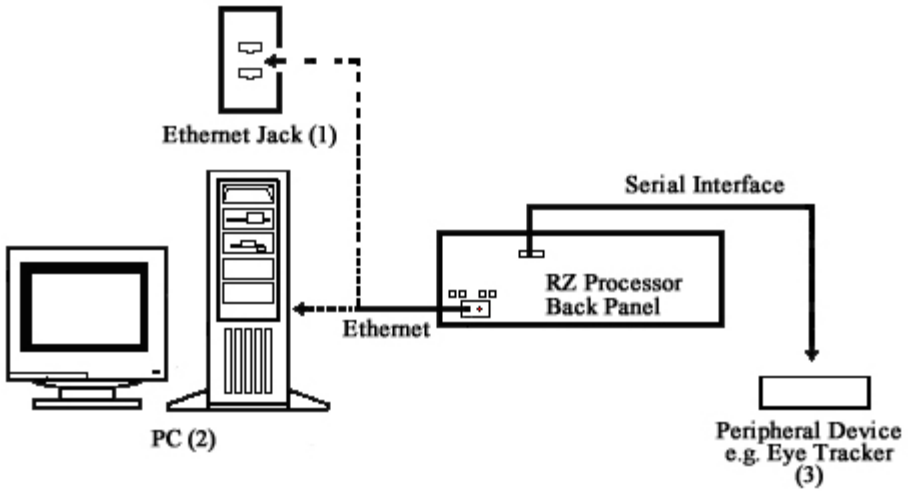
C:\TDT\RPvdsEx\Macros\Device\UDP Ethernet\

Hardware Requirements

Basic requirements include an Ethernet cable and an RZ processor equipped with the UDP interface. A PC equipped with an Ethernet port or an Ethernet jack connected to a local area network is required to send or receive data from an RZ processor. Optionally, a 9-pin RS232 cable is required to connect the serial port to an external device or a PC.

Setting-Up Your Hardware

To setup the UDP Ethernet interface, connect your Ethernet cable directly to a PC Ethernet port or standard Ethernet wall jack. For more information on setting up or configuring the RZ processor see the System 3 Installation Guide.



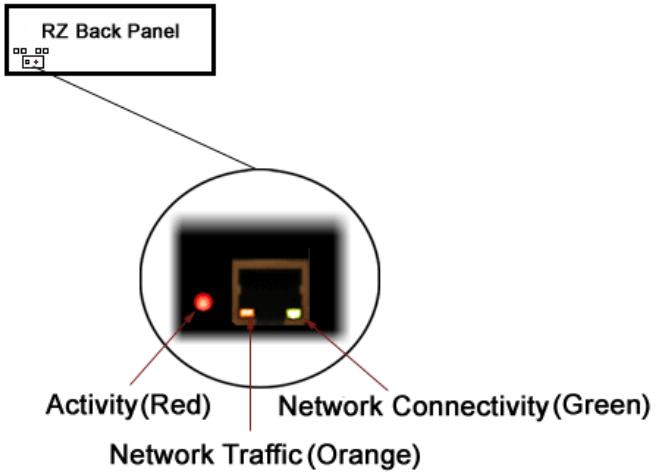
The diagram above illustrates the possible connections from the RZ processor to an active network (1) or PC (2), and an optional serial connection to a peripheral device (3).

Note: If you are only using the serial interface, you will still need a UDP Ethernet connection to configure the serial interface through the web interface. See "Configuring the UDP through the Web Interface" on page 1-58, for more

information.

Status LEDs

The UDP Ethernet interface provides several status indicators which are located on the back of the RZ processor. These status indicators are used to denote a proper connection to a network, activity or network traffic, or UDP activity such as sending or receiving packets.



The following table lists the possible status indicators for the UDP Ethernet interface.

Status	LED Color		
	Green	Orange	Red
Off	No network connectivity	No network traffic detected	Remote address set, no activity
Blinking slowly (once / sec)		Light network traffic is present	Power connected, waiting for remote address to be set
Blinking rapidly or solid glow (several times / sec)	Link connected	Heavy network traffic present	Packet activity present (send or receive)

Network Structure

In order to understand how the UDP interface works, a basic understanding of Internet Protocol (IP) networking is required. As mentioned above, all network devices require a unique network address, appropriate network mask, and if communicating between networks, a gateway. Data in IP networks is organized into discrete packets for transmission or reception. For our purposes, the packet size is equivalent to the number of channels being transmitted or received.

Network Address

All network devices utilize a network address commonly referred to as the "IP address". The IP address is a unique address given to any networked device and consists of four hexadecimal values that are used to locate a device from within a network. Multiple devices that are located within a common network use similar IP addresses.

For example:

Several office computers are connected to a network within an office.

IP address Computer 1:192.86.100.10

IP address Computer 2:192.86.100.11

IP address Computer 14:192.86.100.23

As shown above, IP addresses share a common prefix when located on a common network.

Subnet Mask

Just as the IP address is important for each device contained within a network, the subnet mask is used to classify the size of the network as well as determine the broadcasting address for a device. When an IP address is given to a device, the inverse of the subnet mask is ORed to the IP address to obtain the broadcast address.

For example:

To obtain the broadcast for an IP address with a subnet mask of 255.255.255.0 the IP address and inverse of the subnet mask value are ORed.

IP Address:

192.86.100.10 = 1100 0000 | 0101 0110 | 0110 0100 | 0000 1010

Subnet Mask^{-1}:

0.0.0.255 = 0000 0000 | 0000 0000 | 0000 0000 | 1111 1111

Broaast:

192.86.100.255 = 1100 0000 | 0101 0110 | 0110 0100 | 1111 1111

Several types of network protocols and services use broadcasts in different ways. Dynamic Host Configuration Protocol (DHCP), for instance, requires that broadcasts be used to dynamically assign a unique IP address to computers on a network.

Types of Networks

Several different classifications of networks exist and are organized by the number of possible network addresses (IP addresses) available. The previous example used a Class C network subnet mask.

The following table illustrates the bit ranges and classifications of common networks.

Class	Start	End	Default Subnet Mask
Class A	0.0.0.0	127.255.255.255	255.0.0.0
Class B	128.0.0.0	191.255.255.255	255.255.0.0

Class	Start	End	Default Subnet Mask
Class C	192.0.0.0	223.255.255.255	255.255.255.0

Class A defined networks contain a broad range of possible values since the subnet mask allows for 24 bits or 16,777,214 addresses per network. A Class C network contains 8 bits of IP addresses per network and so, allows up to 256 possibilities.

Gateway

Along with an IP address and subnet mask, networks may optionally use a gateway which is required to send or receive data from outside the network. You can think of a gateway as a node that serves as an access point to another network.

MAC Address

A device's MAC address or "Media Access Control" address is a unique number that acts like a name for a particular network adapter. On a shared medium such as Ethernet, this address is generally assigned to the hardware when it is constructed, but may be manually modified in the UDP Interface.

For example:

The network cards in two different computers will have different MAC addresses, as would an Ethernet adapter and a wireless adapter in the same computer.

The DHCP Protocol

DHCP or "Dynamic Host Configuration Protocol" is a protocol used by networked devices (clients) to obtain various parameters necessary for the clients to operate in an Internet Protocol (IP) network. By using this protocol, system administration workload greatly decreases, and devices can be added to the network with minimal or no manual configuration.

DHCP automates the assignment of IP addresses, subnet masks, default gateway, and other IP parameters. Three modes for allocating IP addresses exist: dynamic, reserved, and manual. The UDP interface relies primarily on dynamic mode for its IP configuration.

Dynamic

In dynamic mode a client is provided with a temporary IP address for a given length of time. This length of time is dependent on the server configuration and may range from a long time (months) to several hours.

The current IP address can be renewed at any time by the DHCP client. This renewal is used by properly functioning clients to maintain the same IP address throughout their connection to a network.

Reserved

In reserved mode, the IP address is permanently assigned to a client via DHCP server-side reservations. Please check the documentation for your DHCP server for more information.

Manual

In manual mode the IP address is selected by the client (manually by the user or any other means) and the DHCP protocol messages are used to inform the server that the address has been allocated.

The UDP Protocol

UDP or "User Datagram Protocol" is a core protocol of the Internet Protocol suite or more commonly known as the TCP/IP protocol suite. UDP allows programs and networked computers to send datagrams or data organized in a specific structure (commonly referred to as a packet).

Note: The UDP protocol is considered "connectionless" since devices send data to a defined IP address and are not actively connected to the destination device or PC. As such, the UDP Ethernet interface will send or receive data from the last IP address it is configured to communicate with.

When information from a data protocol (UDP or TCP) is sent, the information may get lost or delayed along the way. UDP protocol allows time critical data to be transmitted with very low latency since UDP protocol does not implement data tracking. Conversely, when TCP detects that information has been lost or received out of order, it resends the suspect information. This is insufficient for time dependent data found in most neuroscience applications.

Note: The UDP protocol does not account for data received out of order.

Process Layers

The UDP Ethernet interface operates on a structure of layers. These layers interact with each other as segments to produce the end result; to send data from one source and receive it intact on another source. Five layers of this structure are shown below.

Layer - Name	Entity or Protocol	Segment Task
1 – Physical	UDP Ethernet Interface	Encodes the data into packets.
2 – Data Link	Ethernet	Provides a means to move data packets.
3 – Network	IP	Provides a link between one or more data sources.
4 – Transmission	UDP	Manages the transfer of data packets to or from sources.
5 – Presentation	Application	Used to manipulate or analyze the data packets.

Each process begins with encoding in which the data is organized into packets before it is sent through the data link to a network. Once the device is recognized on the network (through an IP address) data transmission can occur. In order for the destination to be selected and the device to be recognized, the NetBIOS protocol translates any present NetBIOS names to IP addresses and the target source's application may receive the data packet for further processing. Once resolved, the

NetBIOS to IP address conversion is cached for future transmissions. All other processes repeat for each data packet sent.

UDP Configuration

Given this basic understanding of a Network (IP) address, subnet mask, gateway, MAC address, and the various protocols, we can now look at the default configuration of the UDP Ethernet interface.

Initialization

Upon initializing, the UDP interface will attempt to locate a DHCP server to dynamically assign an IP address to the device. If a DHCP server is available, a dynamically allocated IP address is assigned to the interface and NetBIOS is used to associate the interface IP address with a unique name, the NetBIOS name.

If no DHCP server responds, the device falls back on the following static IP configuration which is also associated with the NetBIOS name:

IP Address: 10.1.0.100

IP Mask: 255.0.0.0

Gateway: 10.1.0.1

NetBIOS Name

The default NetBIOS name associated with the IP address is set by TDT. All RZ processor devices equipped with the UDP Ethernet interface will use this standard NetBIOS Name structure:

TDT_UDP_MD_XXXX

M = the model of the device, e.g. '2' for an RZ2, '5' for an RZ5, '6' for an RZ6, 'D' for an RZ5D

D = the number of RZ processor DSPs

XXXX = last 4 digits the RZ processor device serial number

For Example:

An RZ2-4 (4 DSP) with a serial number of 1234 uses a NetBIOS name of:

TDT_UDP_24_1234

An RZ5D with a serial number of 1011 uses a NetBIOS name of:

TDT_UDP_D3_1011

Note: Devices equipped with a UDP interface that have a serial number less than 2012 use a different NetBIOS name format.

Although a default NetBIOS name is assigned. The name can be changed using the UDP Web Interface, see “Configuring the UDP through the Web Interface” on page 58 for more information.

Note: When connecting the RZ, be sure the network mask is set to a Class C or smaller network. A Class A network mask (255.0.0.0) will disable NetBIOS naming on the PC Ethernet interface. In such cases, the IP address of the UDP Ethernet interface must be specified instead.

Configuring the UDP through the Web Interface

Every RZ UDP interface contains a minimal web server which is used to configure the UDP and serial interfaces. Configuration options can be set here if no DHCP server is available. If a DHCP server exists, the NetBIOS name associated with the dynamically assigned IP address can be configured here.

Note: The web interface is only enabled for one minute after powering up the RZ, unless it is in use, in which case it remains enabled until the RZ is turned off. Loading pages through the web interface while collecting data is discouraged and may cause packet loss.

To connect to the UDP Ethernet interface server:

1. Make sure there is an active connection from the PC to the UDP Ethernet port on the back of the RZ then open an Internet browser such as Internet Explorer or Mozilla FireFox.
2. Enter the device's IP address (if known) as the web address (e.g. http://10.1.0.100) and click **Enter**.

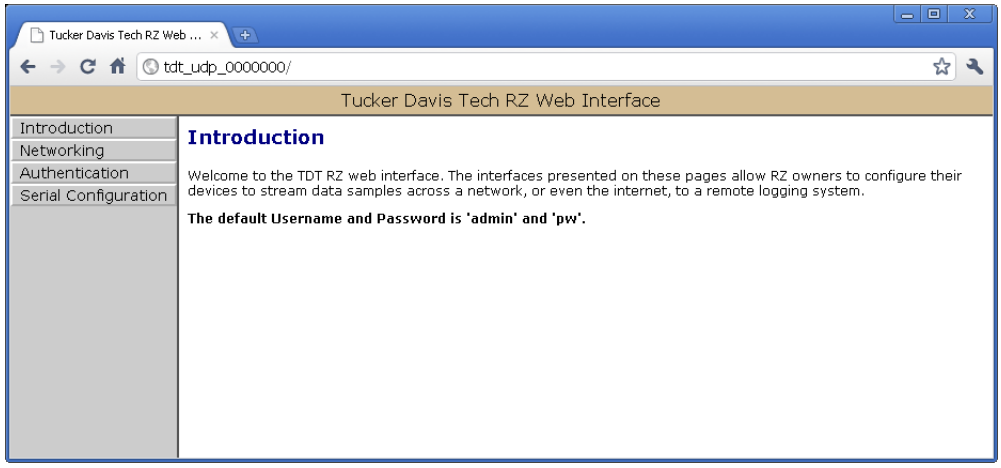
   or

   Enter the NetBIOS name as the web address (e.g. TDT_UDP_0000000) and click **Enter**.

Once properly connected, navigation to the UDP web interface loads the Introduction page. Clicking the links to the left of the web interface loads the corresponding page.

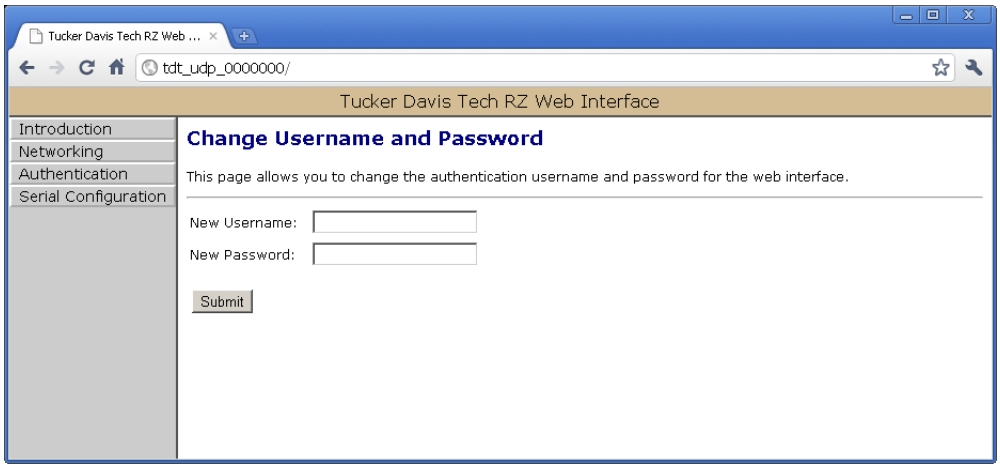
Introduction Page

The Introduction page provides basic information, including the default username and password. The login information can be changed on the Authentication page.



Authentication Page

The Authentication page allows users to change their username and password provided they enter the currently set username and password.



Note: Any server pages that modify the device configuration require a username and password.

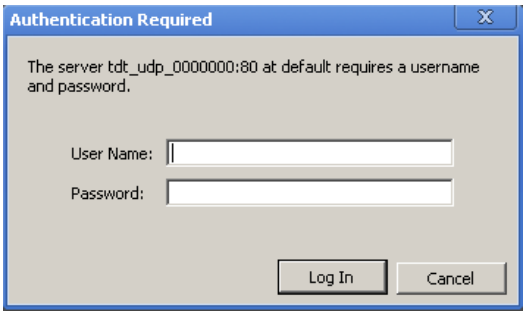
Default Username: **admin**

Default Password: **pw**

To change the Username and Password:

1. Click the **Authentication** link on the left side of the UDP server web page.

   You will be prompted to enter the current username and password.



2. Enter the current **username** and **password**.
3. Click **OK**.
4. Enter the desired new username and password.
5. Click the **Submit** button.

Note: Once changed, you may need to re-enter the new username and password to access the network configurations or Authentication pages.

Network Configurations Page

This page contains settings for configuring the UDP interface.

To change the network configuration:

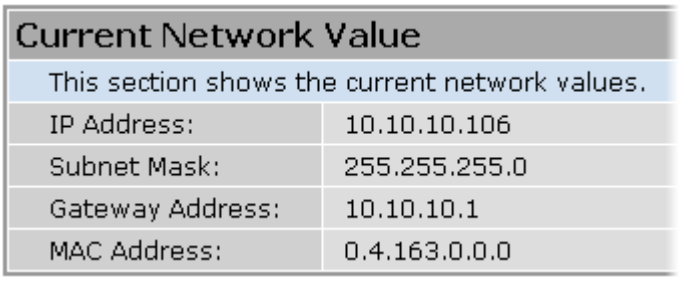
1. Click the **Networking** link on the left side of the UDP server web page.

   If you have not already entered the username and password, the authentication dialog box will prompt.

2. Enter the username and password to access the Networking page.

Current Network Value

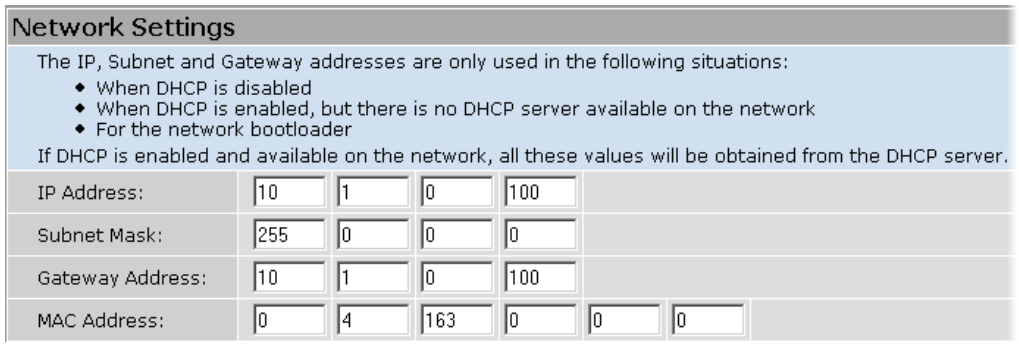
Current IP settings are displayed in this area.



Settings for configuring the static IP address, subnet mask, gateway address, and MAC address are located in the "Network Settings" area.

Network Settings

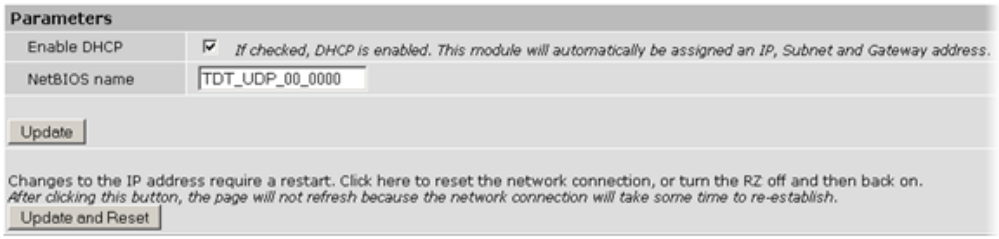
This area contains settings for configuring the UDP interface in the event that no DHCP server is detected. If the Enable DHCP check box is checked (see following Parameters diagram), the "IP Address", "Subnet Mask", and "Gateway Address" values are overridden and automatically configured by the DHCP server if available.



Note: These settings are reserved for connections that cannot locate a DHCP server. If no DHCP server can be detected contact your network administrator for applicable settings.

Parameters

This area contains settings for enabling DHCP or renaming the NetBIOS name.



To Change the NetBIOS name:

- Type the desired NetBIOS name in the **NetBIOS name** textbox and click the **Update** button.

  or

- Type the desired NetBIOS name in the **NetBIOS name** textbox and click the **Update and Reset** button.

The Update and Reset button saves the current configuration settings and performs a soft reset of the UDP interface to load the current settings.

Note: The NetBIOS name can be no greater than 15 characters long and cannot contain spaces or the following characters: \ / : * ? " ; | -

Note: A reset circuit is provided with the TDT driver installation and can be found in:

C:/TDT/RPvdsEx/Support/

Running this circuit on the device with the UDP interface will reset the NetBIOS name to the factory default setting described on "NetBIOS Name" on page 1-57.

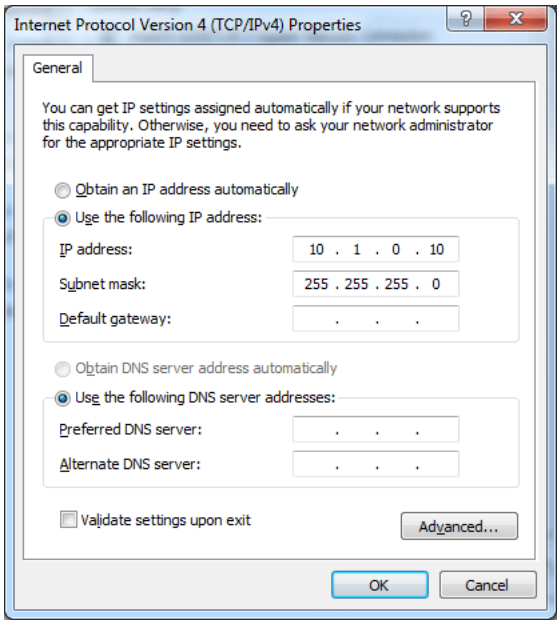
Direct Connection to a PC

The UDP interface can be connected directly to a PC or laptop; however, it is usually necessary to use an Ethernet crossover cable to connect the devices. Once connected, several steps are required in order for the PC to recognize to the UDP interface connection. This method may be performed on any operating system which supports TCP/IP.

To initialize the PC for a direct connection in Windows 7:

1. Physically connect the UDP interface and the PC via an Ethernet crossover cable.
2. Open **Control Panel** then double-click **Network and Sharing Center**.
3. Click the desired connection link (this is usually a Local Area Connection).
4. In the status dialog, click the **Properties** button.
5. In the item list, select Internet Protocol (TCP/IP) or if there are multiples, select Internet Protocol (TCP/IPv4).
6. Click the **Properties** button.
7. Select **Use the following IP address** and enter these values:

   IP address:10.1.0.x, where x can be any value, 1 to 254, except 100
   Subnet mask:255.255.255.0
   Default gateway:Leave empty



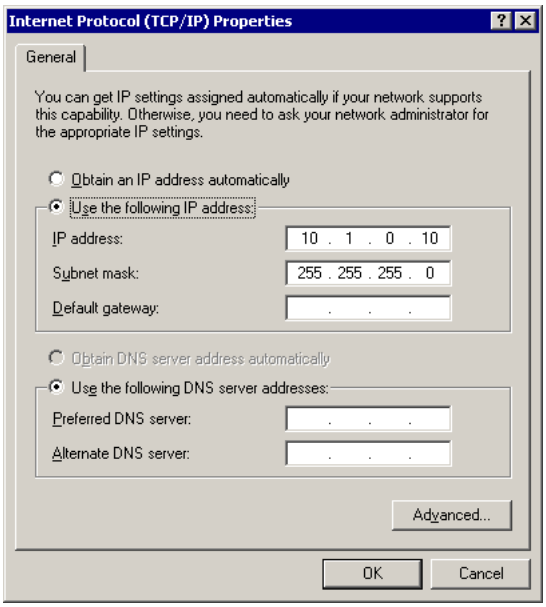
8. Click **OK**.

The UDP interface connection should now be recognized by the PC. Cycle power on the RZ device, the IP address of the RZ will be 10.1.0.100.

To initialize the PC for a direct connection in Windows XP:

1. Physically connect the UDP interface and the PC via an Ethernet crossover cable.
2. Click **Start | Control Panel** then double-click **Network Connections**.
3. Right-click the desired connection (this is usually a Local Area Connection) and select **Properties**.
4. Select Internet Protocol (TCP/IP) or if there are multiples, select Internet Protocol (TCP/IPv4).
5. Click the **Properties** button.
6. Select **Use the following IP address** and enter these values:

   IP address:10.1.0.x, where x can be any value, 1 to 254, except 100
   Subnet mask:255.255.255.0
   Default gateway:Leave empty



7. Click **OK**.

The UDP interface connection should now be recognized by the PC. Cycle power on the RZ device, the IP address of the RZ will be 10.1.0.100.

Serial Configuration

The Serial Configuration page on the web interface contains settings for configuring the serial interface.

Note: If installed in an RZ with 4 optical DSP cards, the serial port is not available.

To change the serial configuration:

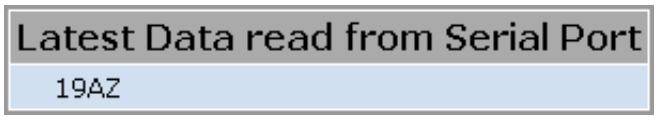
1. Click the **Serial Configuration** link on the left side of the UDP server web page.

   If you have not already entered the username and password, the authentication dialog box will prompt.

2. Enter the username and password to access the Serial Configurations page.

Latest Data Read from Serial Port

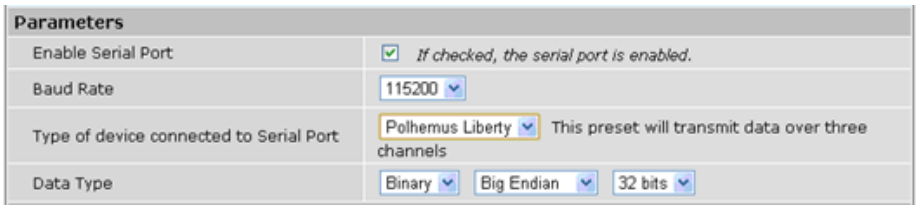
If any data has been sent to the RZ serial port, the latest value will be displayed in this area. ASCII characters represent each byte.



Settings for enabling the serial port, setting baud rate, setting data type and command formats are located in the Serial Port Settings area.

Parameters

The user can enable/disable the serial port, specify the baud rate, and select from a list of preset values.



Data Type

Big vs Little Endian

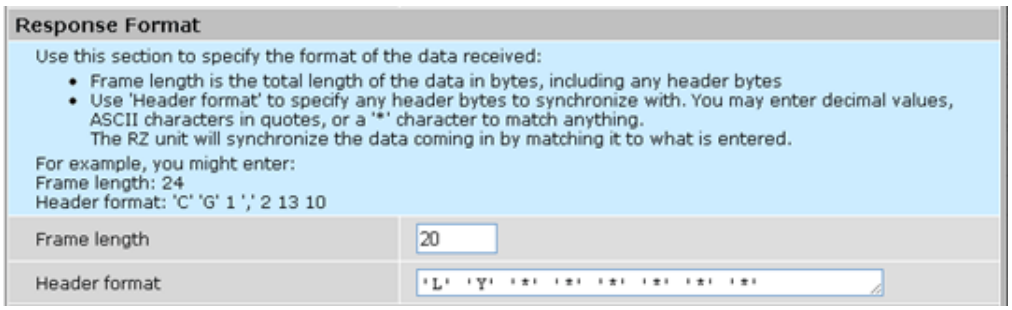
If the device attached to the RS232 connection sends the lower byte before the upper byte, set this to Little Endian. Otherwise, use Big Endian.

8 vs 16 vs 24 vs 32 bit words

This field specifies the length of the data words that the device attached to the RS232 connection is sending. If the data being received is less than 32 bits in length, it is 0 padded out to 32 bits.

Response Format

This area contains configuration settings for the data received from the peripheral device. As data is received over the RS232 connection, it is matched against a user-specified sequence of header bytes at user specified intervals. For example, the user could set the connection to match two specific header bytes, process the next four bytes as data and then start the process over again.



Frame Length

Enter the total length of a 'frame' of data, including any header bytes. In the example shown in the image above, three channels of 32 bit data are being sent, for a total of 12 data bytes (32 bits = 4 bytes). In addition, there are 8 'header' bytes that the user wants to synchronize with, bringing the total frame byte count to 20. The Frame Length, the word size, and the size of the header bytes are used to determine the number of channels being sent and which channel each data byte belongs to.

Header Format

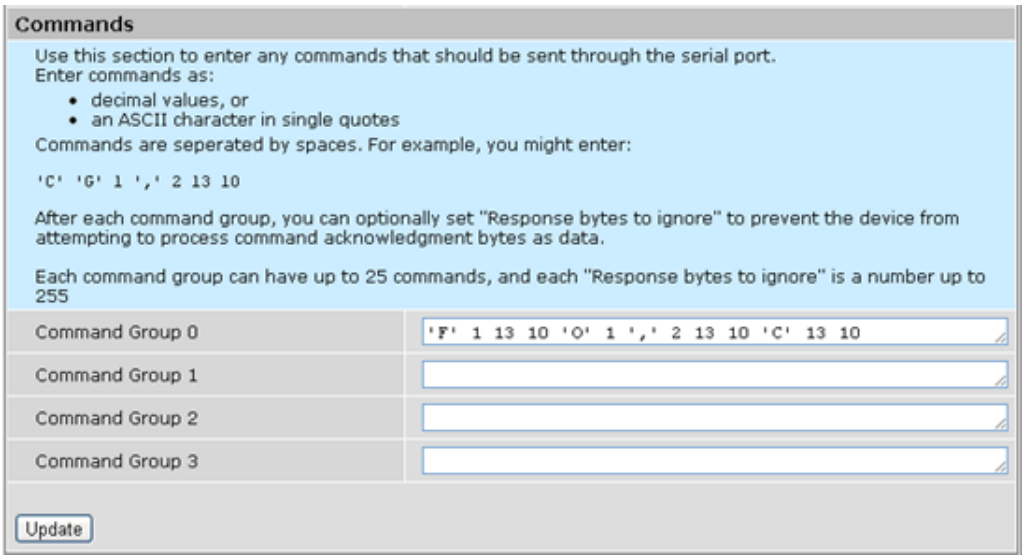
If this field is empty, no synchronization will occur, and everything sent over the RS232 connection will be processed. Otherwise, the RZ will look for the specified

sequence of bytes at the beginning of each frame. The user can enter a decimal value or any ASCII character in single quotes (e.g. 'A'). The '*' character is reserved as a wilard character that will match anything.

Note: If the received data/headers do not match the expected format, they are discarded and all synchronization information is reset. The RZ will then wait until 10 consecutive successful synchronizations before processing any further data bytes.

Commands

This area is used to configure any commands that the RZ needs to send over the serial port. Use this section if the peripheral device connected to the RS232 accepts special requests, such as an initialization command, start/stop command, or reset command.



Command Groups

The format of this section is similar to the header format. The user can enter a decimal value or any ASCII character in single quotes, but the '*' no longer takes on any special meaning here. Each of the command groups is tied to a trigger in the RZ_Serial_Rec or RZ_Serial_Send macros. When triggered, the specified sequence of bytes/characters will be sent over the RS232 connection.

The UDP Packet Structure

All data sent or received by the UDP Ethernet interface is in the form of a packet. Every packet has a standard structure which includes a 4 byte header followed by n x 4 bytes of data, where n is the total number of channels.

Note: The term packet refers to a header and number of single sample values sent. Each channel sends a single sample. The packet size is therefore equivalent to the number of channels and is measured in 32-bit words.

For Example:

Sending 16 channels (a packet size of 16, 32-bit words) will produce a packet of 68 bytes.

4 byte header + (16 channels x 4 bytes) = 68 bytes.

Header Format

The packet header precedes a new packet and stores information about the packet and its intended command for the UDP interface. The structure for the packet header is shown below.

4 Byte Packet Header (32 bits)

0x55	0xAA	Cmd	Num

The upper two bytes, "55AA" are reserved and required by hardware. The lower two bytes are used for specifying a UDP command (Cmd) and the number of 4 byte data packets (Num) that are to be expected following the header. For all data samples, "Cmd" must be set to 0.

For Example:

The previous example which sent a packet size of 16 channels would use the 32-bit header:

55 | AA | 0x00 | 0x10

Where the "Num" value 0x10 = 16 (the number of channels).

UDP Interface Commands

There are 4 commands that can be specified for the header byte labeled "Cmd".

Name	Hex Code	Description
DATA_SEND	0x00	Data is being sent, the byte labeled "Num" contains the number of data packets following the current header.
GET_VERSION	0x01	Retrieve the protocol version supported by the UDP interface.
SET_REMOTE_IP	0x02	Sets the target for receiving packets from the RZ. The IP and port of the machine sending this packet will be used as the new target.
FORGET_REMOTE_IP	0x03	Clears the target IP and port, thereby stopping the flow of packets.

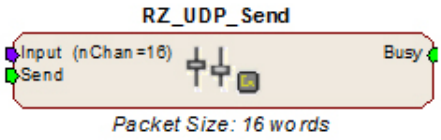
UDP Circuit Design

Access to the UDP interface is provided through two RPvdsEx macros: RZ_UDP_Send and RZ_UDP_Rec. Both macros operate on multi-channel data and can be configured to specify the number of channels. The channel count corresponds to the size of the underlying UDP packets.

RZ_UDP_Send Macro

The RZ_UDP_Send macro is used to send data from the RZ across a network. All data is organized into packets according to the number of words (specified by the

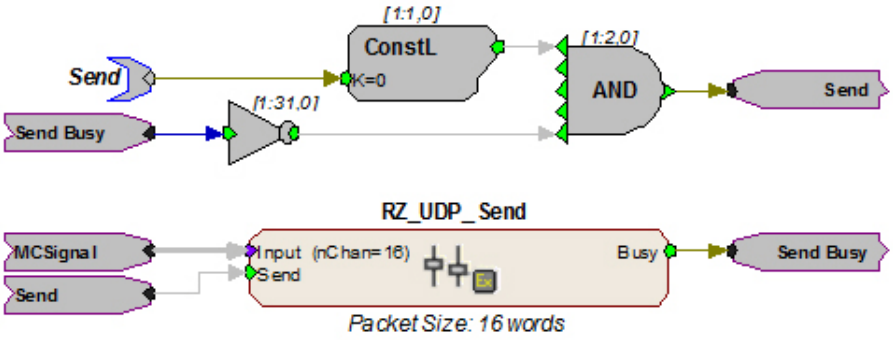
packet size) set in the macro setup properties dialog. The macro accepts a multi-channel data stream as well as a logic input that tells the macro to send out a packet. An output labeled "Busy" indicates if the macro is currently in the process of sending out a packet.



Sending Data Construct

Data is sent on the rising edge of the "Send" input. The duration of the busy signal is then dependent on the number of channels to send (packet size). It takes N+1samples to send a packet, where N is the packet size.

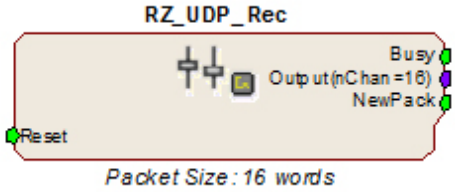
Note: Since the data packets are sent serially, multi-channel data is not sent at the same time. This means that there will be a time shift of multiple samples in multi-channel data.



In this construct, the parameter tag "Send" is used to enable data transmission. The Send input on the RZ_UDP_Send macro is only pulsed when the Send parameter tag is high (1) and the macro is not already sending a packet (Busy = low (0)). Data is input from the HopIn component labeled MCSignal.

RZ_UDP_Rec Macro

The RZ_UDP_Rec macro is used to receive data packets from across a network to the RZ. All data is organized into packets according to the number of words (specified by the packet size) set in the macro setup properties dialog. The macro outputs a latched multi-channel data stream and status lines. An output labeled "Busy" is used to determine if the macro is currently in the process of receiving a packet. Another output labeled "NewPack" is used to denote that a new packet header has been received. The "Reset" input can be used to reset the macro or halt any data transfer.

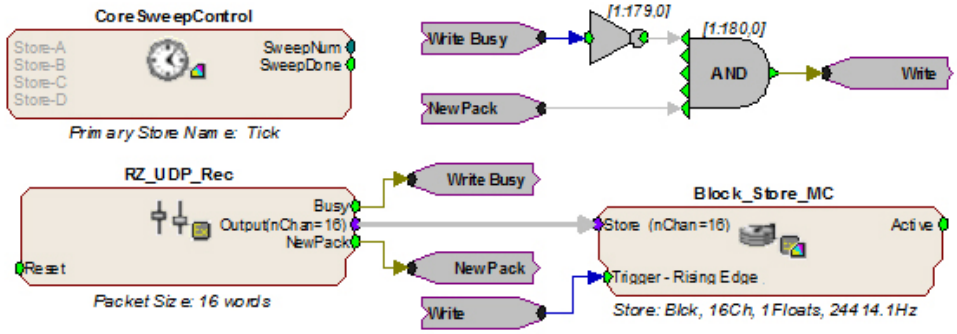


Receiving Scalar Data Construct

When data is received, the NewPack signal will output a logic high (1) for one sample denoting that a packet header has been found. As data is being received, the Busy signal will output logic high (1). The Busy signal will then remain high until the entire packet has been received. The duration of the busy signal is dependent on the number of channels (packet size).

If reset goes high (1) at any time, receiving data is halted and the macro will wait until a new header is found. Any data that was received will still be available on the multi-channel output.

Note: Since the channels are received serially, all channels are not received at the same time. Data received in later channels occurred several samples before it is available on the Output.



In this example, whenever a packet header is detected the Block_Store_MC macro saves the specified packet size as a single block. The Block_Store_MC macro is configured for 16 channels of 32-bit floats.

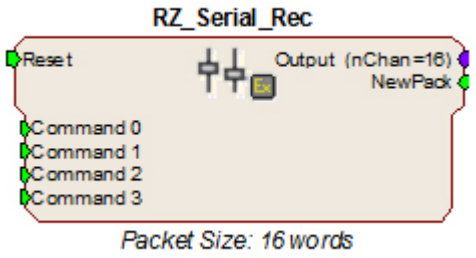
Note: To modify the number of channels received, edit the Packet Size parameter found in the RZ_UDP_Rec macro setup properties. Remember to also edit the number of channels in the Block_Store_MC macro.

Serial Circuit Design

Access to the Serial interface is provided through two RPvdsEx macros: RZ_Serial_Send and RZ_Serial_Rec. Both macros operate on multi-channel data and can be configured to specify the number of channels. This channel count corresponds to the size of the underlying serial stream.

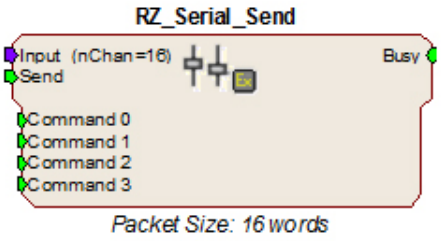
RZ_Serial_Rec Macro

The RZ_Serial_Rec macro is used to receive serial data from the RS232 connection and can also be triggered to send preset commands over the RS232 connection. The number of channels received by the hardware is set in the web configuration. Make sure the packet size set in the macro is at least as large as the value set in the web configuration, otherwise some channels will have missing or incorrect data. If packet size is larger than the number of channels being sent, any excess channels will simply read 0.



RZ_Serial_Send Macro

Use the RZ_Serial_Send macro to send more than just the preconfigured commands over RS232. If using both the RZ_Serial_Rec and RZ_Serial_Send in the same circuit you must disable the Commands in the RZ_Serial_Rec macro options.



Sending Data Construct

Data is sent whenever the "Send" input receives a rising trigger (logic high (1)). The duration of the busy signal is then dependent on the number of channels to send (packet size). Each logic high pulse sent to the send input results in one send packet request. This means that each packet sent results in one sample sent per channel.

Note: Since the data packets are sent serially, multi-channel, non-scalar data is not sent at the same time. Each time a packet is sent, the macro sends a single sample from each channel serially. This means that there will be a time shift present in multi-channel, non-scalar data consisting of multiple samples.

In this construct, the parameter tag "Send" is used to enable data transmission. The Send input on the RZ_UDP_Send macro is only pulsed when the Send parameter tag is high (1) and the macro is not already sending a packet (Busy = low (0)). Data is input from the HopIn component labeled MCSignal.

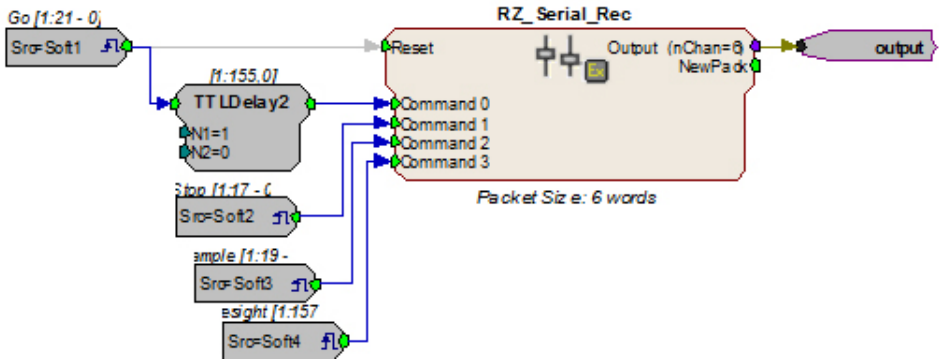
Note: To modify the number of channels sent, (packet size) edit the Packet Size parameter found in the RZ_UDP_Send macro setup properties.

Receiving Scalar Data Construct

When data is received, the NewPack signal will output a logic high (1) denoting that a packet header has been found. As data is being received, the Busy signal will output a logic high (1) and as soon as the header has been received, NewPack will go low (0). The Busy signal will then remain high until the entire packet has been received. The duration of the busy signal is then dependent on the number of channels to send (packet size). Each high duration of the Busy signal results in one received packet. This means a single packet received results in one sample received per channel.

If reset goes high (1) at any time, receiving data is halted and the macro will wait until a new header is found. Any data that was received will still be available on the multi-channel output.

Note: Since the data packets are received serially, multi-channel data is not received at the same time on the Output. There will be a time shift in channels two and higher directly proportional to the channel number.



In this circuit construct, software triggers are used to send commands to the peripheral device (head tracker). The multi-channel output contains the tracking information and can be further processed and/or stored to the data tank.

UDP Test Application

In addition to the RPvdsEx macros, the UDP Ethernet interface also provides a software test application which can be used to connect to a specified UDP interface in order to send or receive packets from an RZ multi-processor device. The UDP Test Application was written in MSVC++ to illustrate the portability of the UDP Ethernet interface.

The UDP Test Application is installed to: C:\TDT\RPvdsEx\Examples\RZ UDP\

Running the Application

Once the application is running, connecting to a UDP interface and sending, or receiving packets from an RZ processor is extremely easy.

Packets can be loaded, saved, and edited. Additionally, the packet format can be converted to double or integer format.

To load an existing packet configuration:

1. Select **Open** from the **File** menu.
2. Browse to the desired *.hex file and click the **Open** button.

   The specified *.hex file will now display any packet information.

To save a packet configuration:

1. Select **Save** or **Save As** from the **File** menu.
2. Type the desired name of the *.hex file and click the **Save** button.

To create a new packet:

1. Double-click anywhere in the packet window to access the **Edit Values** dialog box.

   or

   Right-click the packet window to access the **Packet Dialog** menu.
2. Select the **New Packet** option. This prompts the **Edit Values** dialog box.

To edit an existing packet:

1. Select the desired packet and right-click to access the **Packet Dialog** menu.
2. Select the **Edit Packet** option. This prompts the **Edit Values** dialog box.

To convert the Test Application packet format:

1. Right-click the packet window to access the **Packet Dialog** menu.
2. Select **Convert To**.
3. Select the desired format for the selected packet.

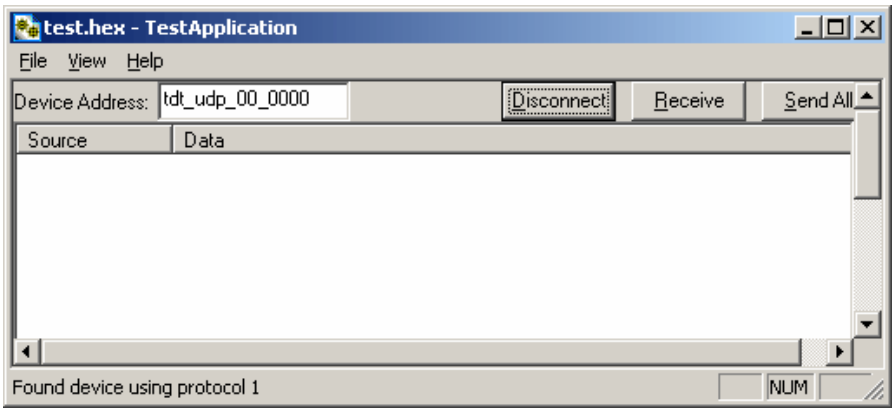
Example: Using the Test Application

In this example we will send packets from the PC to an RZ through the UDP interface.

To establish a connection to the RZ:

1. First, run the Test Application by double-clicking the **TestApplication.exe** icon.
2. Enter the **NetBIOS** name or **IP address** of the RZ processor you wish to send a packet to in the **Device Address** text box.
3. Click the **Check** button.

   A connection is established and the status bar indicates a device has been found. Packets may now be received or sent from this RZ processor.

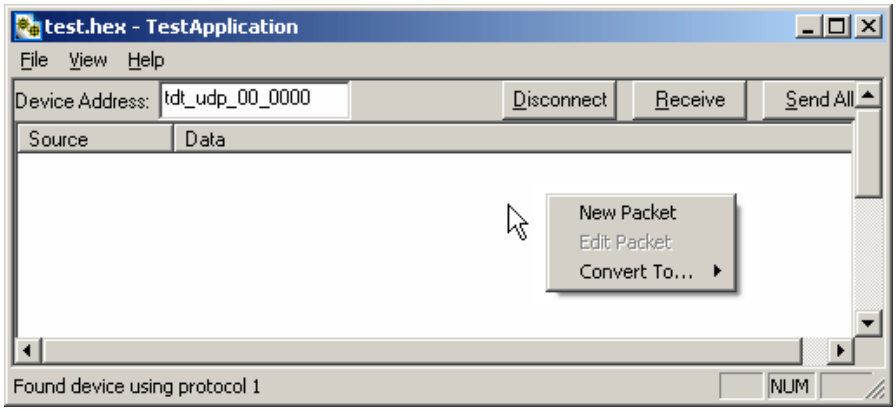


To send a data packet to the RZ processor:

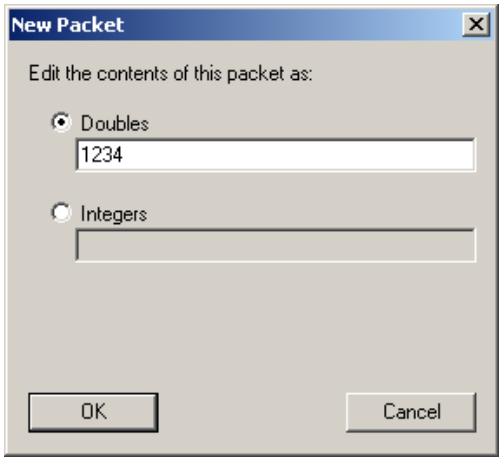
1. Double-click anywhere in the Test Application packet window.

   or

   Right-click to bring up a selection dialog box and select **New Packet**.

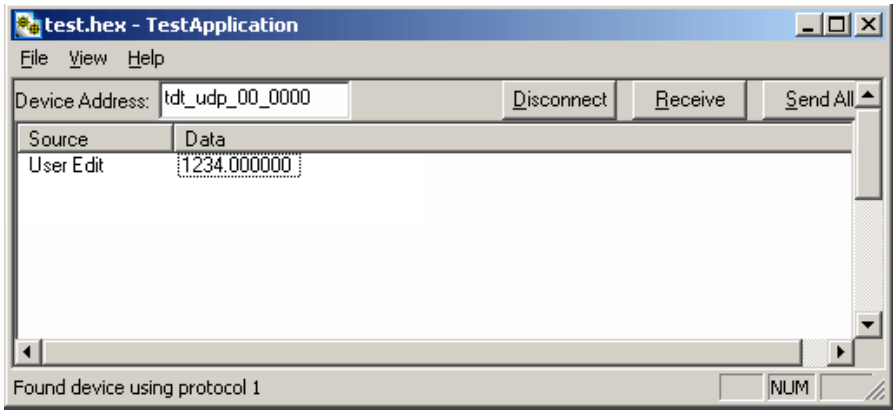


   This prompts a dialog box where values can be edited.



2. Click the **Doubles** radio button and enter "**1234**".
3. Click **OK**.

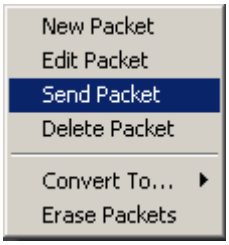
   The configured data packet is shown in the Test Application packet window.



4. Click the **Send All** button to send all data packets to the RZ processor.

   or

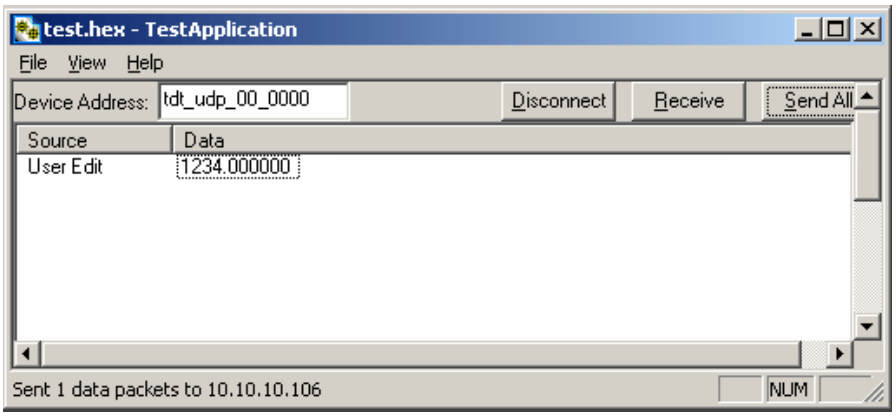
   Send an individual packet by right-clicking on the desired packet and selecting **Send Packet** from the Packet Dialog menu.



   The status bar displays that the packet was sent to the RZ processor. Data packets are received through RPvdsEx using the RZ_UDP_Rec macro.

To receive a data packet sent from the RZ processor:

1. First, run the Test Application by double-clicking the **TestApplication.exe** icon.

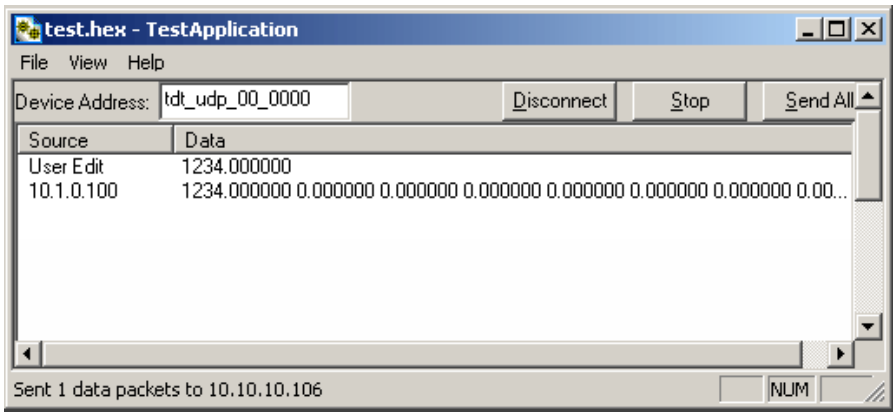


2. Enter the **NetBIOS** name or **IP address** of the RZ processor you wish to send a packet to in the **Device Address** text box.
3. Click the **Check** button.
4. Click the **Receive** button.

   The button changes to **Stop** in order to notify that it is waiting for a data packet to be sent from the RZ processor. Data packets are sent through RPvdsEx using the RZ_UDP_Send macro.

5. At this time you may configure the circuit to send a data packet from the RZ processor to the Test Application.

   Once received, the data packet will be displayed in the Test Application packet window. The Source column will display the IP address the data packet was received from while the Data column displays the data packet itself.



The Test Application runs separate threads for sending and receiving data so it is possible to listen (wait for a data packet to be received) while sending, connecting to a device, or disconnecting from a device.

Writing a Custom Software Application

The Test Application is designed to be used as a diagnostic tool for the UDP Ethernet Interface. Custom software applications are fully supported for any computer language that supports IP network protocols. Several basic steps are required in order to configure the UDP interface for sending and receiving data packets as illustrated in the following Python code.

The basic initialization script below must be included to initialize the UDP interface:

```
# import network methods
import socket

# UDP command constants
CMD_SEND_DATA          = 0x00
CMD_GET_VERSION        = 0x01
CMD_SET_REMOTE_IP      = 0x02
CMD_FORGET_REMOTE_IP   = 0x03

# enter RZ's IP address or NetBIOS name here:
TDT_UDP_HOSTNAME = 'TDT_UDP_0000000 '

# Important: the RZ UDP interface port is fixed at 22022
UDP_PORT = 22022

# create a UDP socket object
sock = socket.socket( socket.AF_INET,      # Internet
                      socket.SOCK_DGRAM ) # UDP

# bind preliminary IP address and port number to the PC
sock.bind(("0.0.0.0", UDP_PORT))

# connect the PC to the target UDP interface
sock.connect((TDT_UDP_HOSTNAME, UDP_PORT))
```

```
# configure the header. Notice that it includes the
header

# information followed by the command 2 (set remote IP)

# and 0 (no data packets for header).
packet = struct.pack('4B', 0x55, 0xAA, CMD_SET_REMOTE_IP,
0)

# Sends the packet to the UDP interface, setting the
remote IP

# address of the UDP interface to the host PC
sock.send(packet)
```

The code above simply sends a command packet to the UDP interface listening Port (22022) and tells it to set the UDP interface remote IP to the host PC IP address. Once this has been done, any data packets sent by the UDP Ethernet interface will go to this IP address.

Note: The listening port on the UDP Ethernet interface is 22022 and cannot be changed.

The code structure below is necessary to receive a packet from the UDP interface:

```
while 1:

    # Receive a data packet from the UDP interface
    packet = sock.recv(1024)

# Process received packet

    # ...
```

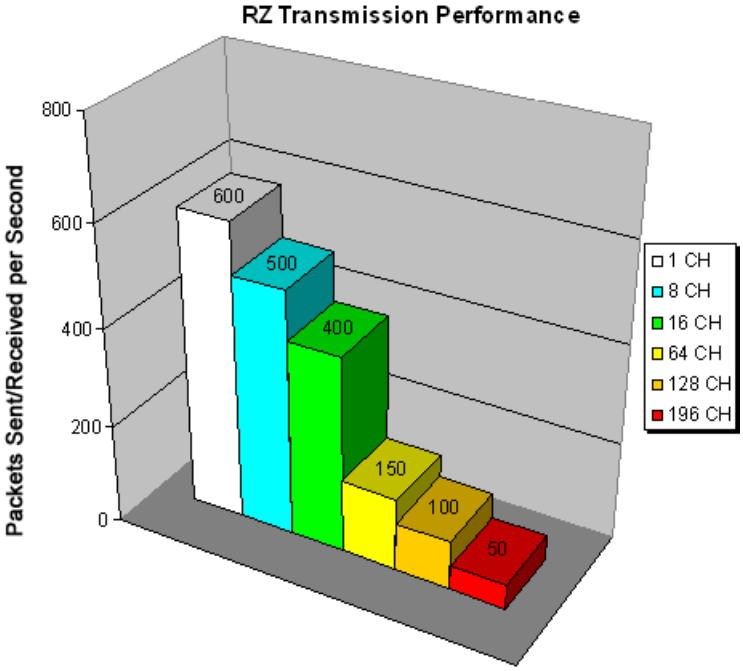
The code structure below is necessary to send a packet of 16 channels to the UDP interface:

```
# begin sending data
NPACKETS = 16

# configure the header. Notice that the command is now 0

# (sending data packets) and the number of packets
following is 16
header = struct.pack('4B', 0x55, 0xAA, CMD_SEND_DATA,
NPACKETS)
count = 0
while 1:

    # this example uses fake data
    fakeval = count % 10
    data = range(fakeval, NPACKETS + fakeval)
    # append sixteen 32-bit words to the header

   # '>' in the format string is used to force big-endian
```

```
    packet = struct.pack(">%di" % len(data), *(i for i in
data))
    # send the data packet to the UDP interface.
    print 'sending packet', count, '...'
    sock.send(header + packet)
count += 1
    # slow it down for demonstration purposes
    time.sleep(.2)
```

UDP Interface Performance

The UDP interface is a 10Mb Ethernet interface, but the usable bandwidth is significantly lower due to limitations of the Ethernet hardware. A graph below displays the expected throughput for different numbers of packets sent or received per second depending on the number of channels transmitted on an RZ processor.



The bandwidth for transmitting data from an RZ through the UDP interface decreases depending on the width (or number of channels) of packets sent or received. Transmission of a single packet (single channel) provides a high amount of data resolution since the packets are transmitted at a much higher rate and would respond quickly to abrupt changes in value. Transmitting multiple packets (large number of channels) allows more information to be sent in parallel but reduces data resolution.

Relative Performance

A typical application might involve sending a packet size of 16 channels 100 times per second or a packet size of 100 channels 10 times per second. As shown in the diagram above, the UDP interface will be able to send a packet size of 16 channels 400 times per second or a packet size of 128 channels 100 times per second.

As a result, the UDP performance is relative to the size of the packet, dictated by the number of channels transmitted.

Typical RZ Transmission Performance with the RZUDP-20 Table

The table below displays the expected throughput for different numbers of packets sent or received per second depending on the number of channels transmitted on an RZ processor.

Number of Channels (32-bit Words)	Packets Sent/Received per Second
1	600
8	500
16	400
32	300
64	150
128	100
192	50

Technical Specifications

Interfaces	Standard Ethernet (for direct connections to a PC an Ethernet crossover cable is required) RS-232 Serial Port (9-Pin)
Ethernet Speed	10 Mbps
Serial Speed	115,200 bits/sec
Supported Network DHCP (Dynamic Host Protocols	Configuration Protocol), UDP, HTTP (for configuration)
Transfer Rates	Dependent on data packet size (see Typical RZ Transmission Performance with the RZUDP-20 Table above)