

## NXU RS-232 Control of Devices over Ethernet

### Purpose

This application note will describe a feature of the Network Extension Unit (NXU) that will provide control of RS-232 devices over an Ethernet network in conjunction with the transport of VoIP / RoIP.

### Introduction

RS-232 (Recommended Standard – 232) is a protocol or standard created to provide a means to transmit and receive serial data through a cable connected between a single terminal and a single device.

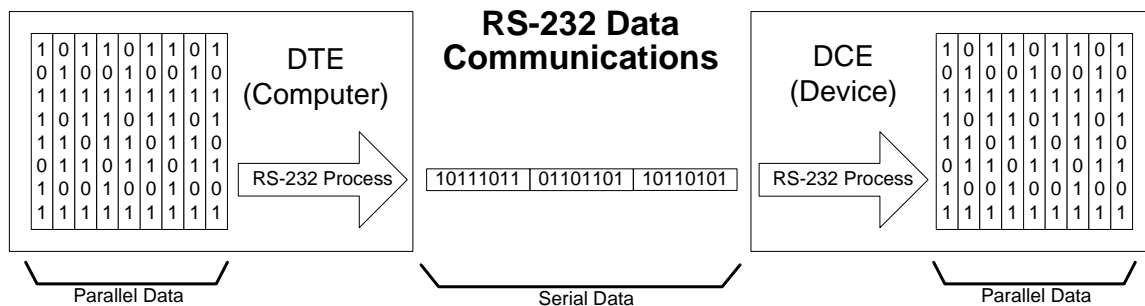
RS-232, also known as: EIA/TIA-232, RS-232C, CCITT V.24/V.28, X.20bis/X.21bis, ISO IS2110 or Serial Port, was first introduced in 1962 to provide an explicit wired communications link between a computer and a remote device. Although there are many more progressive protocols emerging in the data control world (USB, Firewire, Ethernet, etc), the RS-232 standard remains popular as a means of controlling and configuring many devices found in the land mobile radio environment.

The RS-232 standard defines the controlling device and device to be control as, DTE and DCE, respectively.

- DTE – Data Terminal Equipment – are devices, which provide control information, such as computers and terminals.
- DCE – Data Communication Equipment – are devices, which accept control information, such as modems and other equipment. This includes the ACU-1000, SNV-12 and NXU.

### Serial Communications

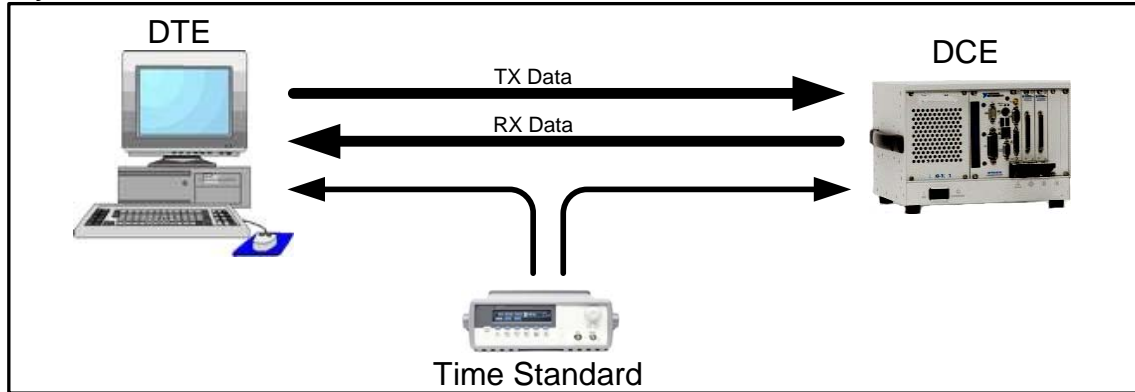
RS-232 serial communications takes place by converting 4, 8, 16, 34 or 64 bit parallel data at the DTE (computer) into a sequential stream of 4, 8, 16, 34 or 64 bit serial data. This serial data is then transported on a single TX line to the DCE (modem or device). The DCE at the far-end then reverses the conversion, thus formatting the data to the original parallel format. This conversion makes RS-232 serial communications convenient, because the link requires only one copper wire to transport data in one direction. Naturally, this transmission is bidirectional between the DTE and the DCE.



### Synchronous Serial Communications

Synchronous communications requires that the DTE and DCE be synchronized with a shared timing standards or clock pulses when transmitting and receiving data. If the timing between the DTE and DCE is skewed, all subsequent data will be lost. Synchronous communications complicates the link because, in order to share a clock there must be an additional signal lines between the DTE and DCE, which in some applications may not be practical or cost effective.

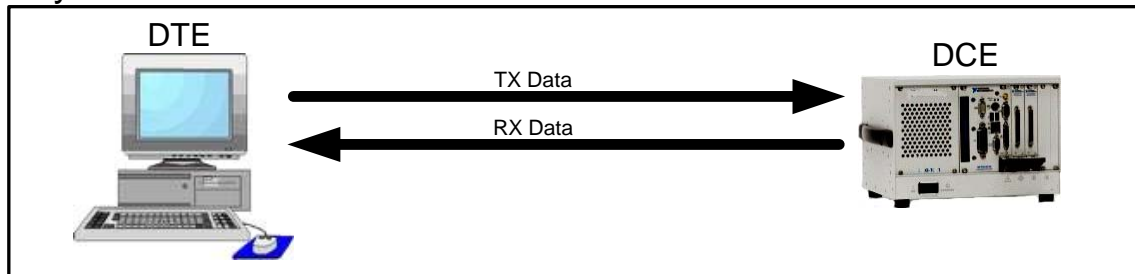
### Synchronous Serial Communications



### Asynchronous Serial Communications

Asynchronous Communications, used by RS-232, does not rely on a common timing standard or shared clock pulse. Instead the DTE and the DCE can function on dissimilar timing standards. In asynchronous communications data is transmitted in small data streams that are bound by a *Start Bit* and *Stop Bit*. The DTE will transmit a “chunk” of data, and the DCE will be expected to receive the “chunk” of data. Data integrity can be maintained if the “chunk” of data is kept small enough, such that a slight skewing of the local clock speed between the DTE and the DCE is managed by using *Star Bits* and *Stop Bits*. Asynchronous communications in RS-232 does not require a separate clock signal line, thus simplifying the cable.

### Asynchronous Serial Communications



There are many devices used in public safety and commercial land mobile communications systems that can be remotely controlled by a computer, or provide transmission of data over an RS-232 communications link. These remote devices may include the following:

- Base Stations
- Repeater
- Mobile or Portable Radios
- IDEN Handsets with Data
- Military Radios
- Paging Systems
- Receiver Voters and Comparators

- Supervisory Control And Data Acquisition (SCADA)
- CAD System Interface
- Logging Printer
- "Rip &Run" Dispatch Printer
- Dispatch Consoles
- ACU-1000 Intelligent Interconnect
- SNV-12 Voter

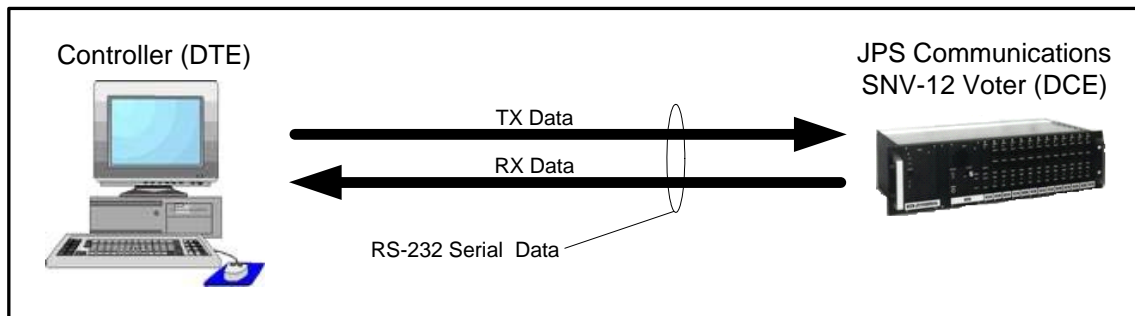
For example, some of the operational parameters of a basestation or repeater can be controlled from a remotely located computer. The follow are some of the parameters that might be controlled:

- CTCSS
- DCS
- Transmit Power
- TX / RX Frequencies
- Frequency Band of Operations
- Bandwidth

The control of these remote repeaters or base stations can be performed using software applications or scripts provided by the equipment manufactures, third-party vendors, or applications created by the end user that are specifically written to provide control of these devices by a computer.

Another example is the remote control of Raytheon's ACU-1000 and SNV-12 devices. Both of these devices can be controlled from their integrated RS-232 serial port by receiving the proper control commands from a computer or terminal over the RS-232 communications link. These low-level commands can be sent from the computer using a terminal emulator or hyperlink application residing on the computer. A more sophisticated method of control would be to use a Graphical User Interface (GUI) application that is specifically written to send and interpret these low-level commands in a user-friendly format (i.e. ACU Controller Software).

### SNV-12 Voter as DCE



One important specification with regards to RS-232 communications is that the protocol was designed to provide minimal separation between the DTE and DCE. The maximum RS-232 distance between a computer and another device is 15 meters at a data rate of 9600 baud (9600 bits per second). At 56,000 baud, the distance is reduced to 2.6 meters. Remember, serial data is transported on a single wire with a common ground. As the cable length increases, the signal lines become more susceptible to extraneous noise. Unlike other transport techniques that use twisted-pairs and common-mode rejection, RS-232 is vulnerable to external noise. Lowering the baud rate will help assure data is recovered at the far-end, but slow data rate may not be practical for the end process.

### Requirement

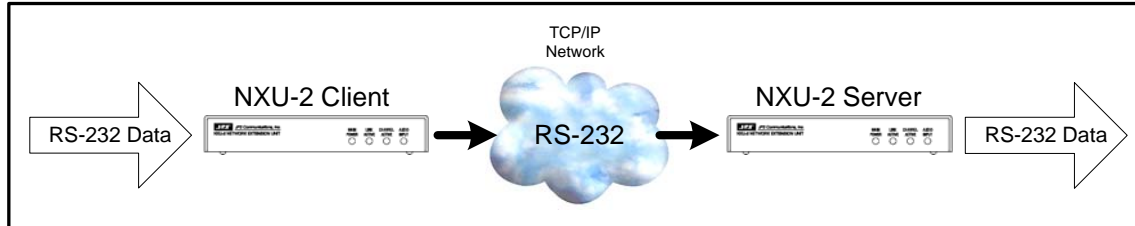
Increase the physical distance of serial RS-232 asynchronous communications link between a computer and a controlled device, while maintaining signal integrity and maximizing data rate.

### Solutions

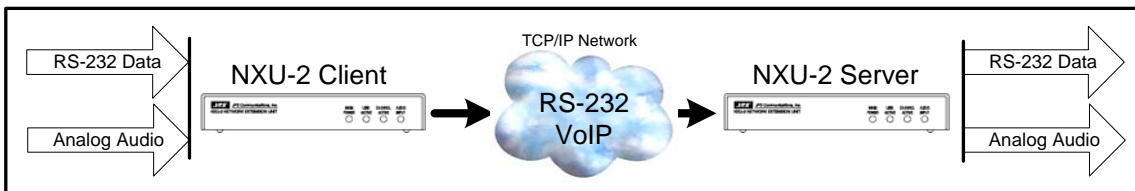
Raytheon's NXU Network Extension Unit is a standalone device that interfaces full-duplex baseband audio, (1) RS-232 port and (4) status bits onto a TCP/IP Ethernet network. The NXU uses RoIP (Radio Over Internet Protocol) to convert land-mobile radio baseband audio to datagram, which can then be routed over an existing digital network. The NXU can also address the essential control signals used by land-mobile radio systems. These control signals consist of the COR signal generated by a device when it is receiving a radio transmission, and the PTT signal which requests a device to begin a radio transmission. VoIP alone cannot handle these control signals, and that is why RoIP, used by Raytheon, is essential to providing compatibility to land-mobile radio systems.

By utilizing the RS-232 feature of the NXU, the distance at which data can be transported between a computer (DTE) and a controlled device (DCE) can effectively be extend by utilizing IEEE 802.3 Ethernet protocol of wired transport media. Without using repeaters, Ethernet can provide links up to 100 meters; and with repeaters, unlimited distances.

The NXU at the near-end simply encapsulates RS-232 data into Ethernet packets, which are easily transported over any TCP/IP compatible network. Another NXU at the far-end recovers the RS-232 data from the Ethernet packets and delivers them to the appropriate DTE or DCE device.



In conjunction with RS-232 data, the NXU will also simultaneously multiplex VoIP data within the same Ethernet data stream as the RS-232 data. This combination makes the NXU an ideal solution to control land mobile radio devices over the Ethernet, as well as support VoIP audio applications.

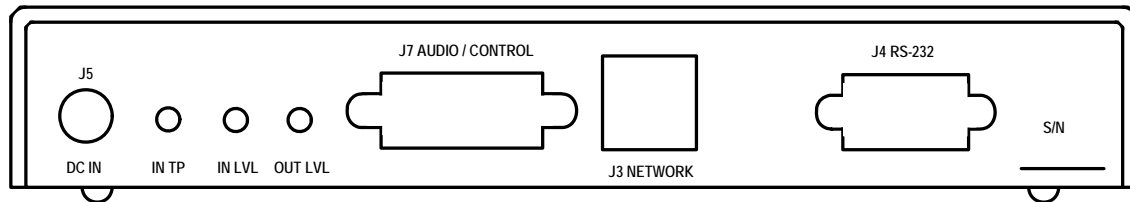


### The NXU has (3) primary connections

- J3 – RJ45 TCP/IP Network Connection, 10 mb/s Ethernet. Able to connect back-to-back NXU's using CAT5 Cross Over cable, or over a segmented network using CAT5 Straight-Thru cables.

- J4 – RS-232, Asynchronous, Full Duplex, DCE. DB-9 connection used for serial programming of the NXU, as well as means of transmitting RS-232 data from one NXU to another NXU at a maximum user selectable baud rate of 115200 bps. Depending upon whether the NXU is connected to a DTE or DCE, this connection will require a straight-through or null-modem serial cable.
- J7 – Audio / Control. DB-15 connection that will accept any Raytheon supplied or end-user built radio interface cable. All baseband audio, COR and PTT control signals from the land mobile radio device will interface to this connection.

### NXU Rear Panel Connectors



Any of the ACU Radio Interface Cables manufactured by Raytheon can be used to interface a radio to the NXU unit. However, the supplied crossover adapter must be inserted between the NXU J7 connector and the Raytheon Built Radio Interface Cable to “Crossover Adaptor” the proper control signals. Naturally, the end-user can fabricate similar cables and connect the leads to the associated pin on connector J7, thus eliminating the need to use the Crossover Adapter.

Although it is recommended that the audio input of the NXU be balanced, the unit can accommodate single-ended audio connections by grounding one of the balanced audio input leads of the NXU to the audio ground (Pin 6 to Pin 7, or Pin 14 to Pin 15). Conversely, the output audio of the NXU can accept only unbalanced connections between it and the external device. The COR and PTT control signal connections to and from the radio device is also accommodated by the J7 connector.

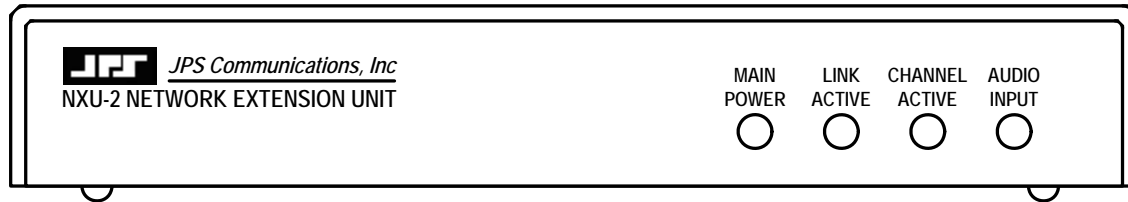
### Network Configuration of NXU:

It is imperative that the network be configured such that the Server and Client NXU's have network visibility between themselves, otherwise the link will not be possible.

- Server NXU: This NXU must have a unique IP Address, and be configured as a SERVER.
- Client NXU: This NXU must also have a unique IP Address, and be configured as a CLIENT. Additionally, this client NXU must have the “Serve IP Address” field entered with the IP address of the Server NXU that it will be associating with.

If the devices are configured correctly the Link Active LED on each of the NXU's will be lit.

### NXU Front Panel LED's



### Straight-Through vs. Null Modem Serial Cable

The RS-232 standard states that when connecting a DTE to a DCE, one must utilize a straight-through serial cable. This is because the DTE and DCE each have specific Transmit and Receive data connections. The direction of data movement is always with respect to the DTE. For instance

- The data line labeled RXD (Receive Data) is primary data being received by the DTE, from the DCE. The DTE is "Receiving" the data.
- The data line labeled TXD (Transmit Data) is primary data being transmitted by the DTE. The DTE is "Transmitting" the data.

In the RS-232 environment the NXU is defined as a DCE (communications devices), which characterizes the type of serial cable to be used between it and the device that it is supporting. For instance:

- Straight-Through Serial Cable – is used when connecting a computer to the NXU (DTE-to-DCE)
- Null-Modem Serial Cable – is used when connecting a device to the NXU (DCE-to-DCE). For example, NXU connected to the DB9 port of the ACU-1000 or basestation.

### NXU J4 Connector Description (DCE)

PIN	Signal	Description
2	TXD	Data Transmit
3	RXD	Data Receive
5	GND	Ground

The following table describes the signals of a DTE or computer RS-232 DB9 pin out. Note that transmit and receive pin numbers are 1:1, TXD to RXD, and RXD to TXD between the DTE and the DCE. This is why the DTE to DCE serial cable is called "Straight-Through".

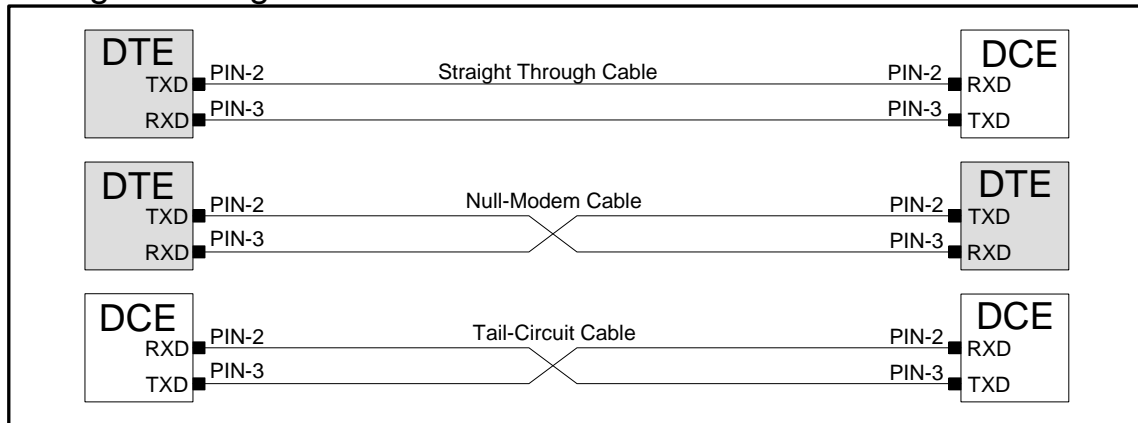
If we connect an NXU to a DCE, this is the same as connecting a DCE to another DCE. The pin out relationship is no longer 1:1, and a null-modem cable (cross-over cable) is used to "Cross-Over" the data lines (pin 2 to pin 3, pin 3 to pin 2).

### Computer Connector Description (DTE)

PIN	Signal	Description
2	RXD	Data Receive
3	TXD	Data Transmit
5	GND	Ground

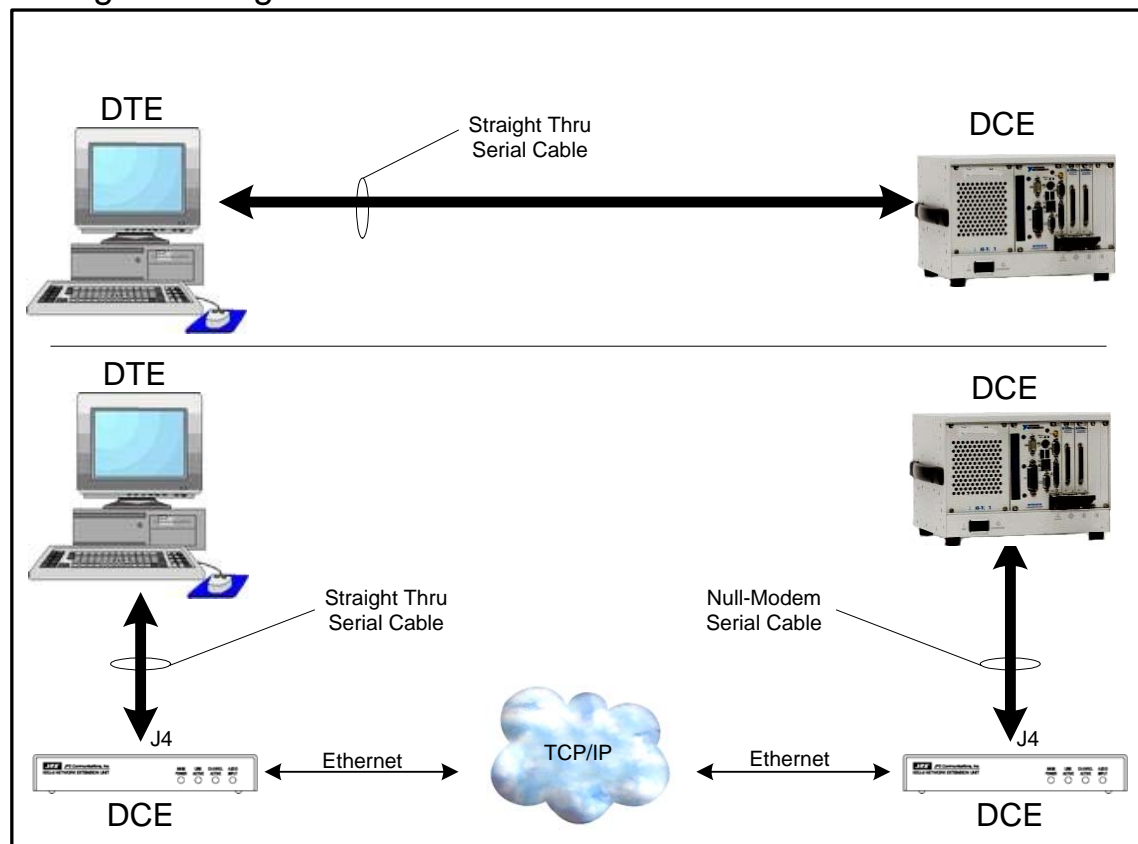
The following diagram illustrates the data path between the DTE and the DCE:

## Straight Through vs. Null-Modem Serial Cables



The following diagram illustrates how straight through and null-modem cables are specified when connecting devices to the NXU.

## Straight Through vs. Null-Modem Serial Cables





### Use of Software over NXU RS-232 Link

Since the conversion or encapsulation of the RS-232 data in the Ethernet data stream is transparent to the DTE and DCE devices, nearly any software application used at the terminal or computers (DTE) can be used to control or manage the remote device (DCE). This means terminal emulators, radio programming applications, basestation or repeater controller software, paging system software, dispatch console software, and CAD applications, to name a few, can be used over the NXU / RS-232 data link.

### Connection Timeout

A problem may occur when using the NXU to transport RS-232 data over the Ethernet. This is related to a programming *CONNECTION TIMEOUT* attribute of the software over the serial link. Since RS-232 links are relatively short (<50 meters) software applications to control devices over RS-232 links are based around the short propagation delay of these links.

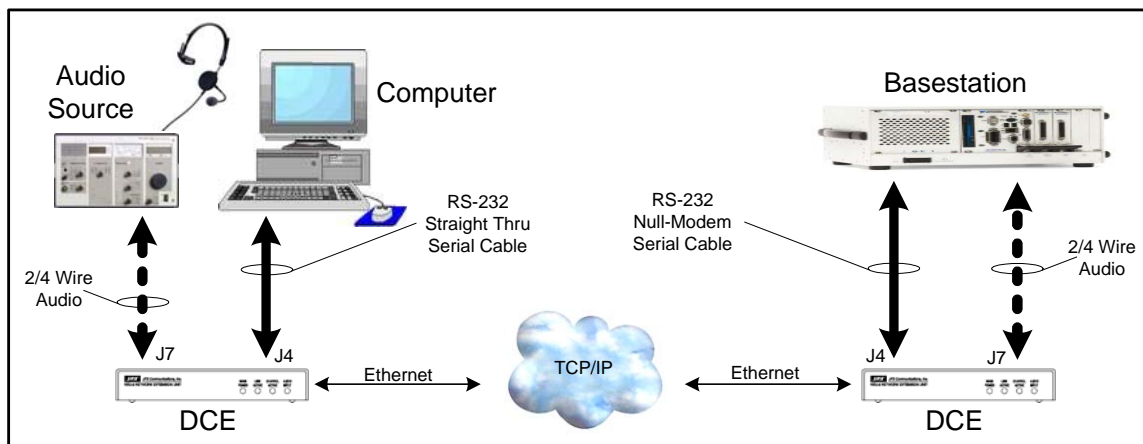
When a command is sent from the computer (DTE) to the remote device (DCE) data flows through the RS-232 data lines. Typically, the remote device immediately returns status information, data, or other useful information requested by the computer (DTE) using the RS-232 link. As long as there is data flow, *Connection Timeout* will not be a problem. However if an application requires an acknowledgement or data flow, and stipulates a short Timeout period (many applications do not), then the connection may timeout if these criteria are not met.

By nature, the NXU has an RS-232 data buffer that releases data into the TCP Ethernet stream every 100 milliseconds. If the RS-232 data buffer fills up before 100 milliseconds the data is immediately released. This 100 msec buffer period prevents unnecessary transport of TCP data onto the network, thus reducing needless use of the bandwidth.

Connection Timeout is a rare occurrence, and in most cases remote control of devices over the NXU RS-232 link should be successful.

### Conclusions

RS-232 data communications has always been purposeful in land mobile communications in terms of device control and configuration for many years, and as TCP/IP networks become more prevalent serial control of these devices over these networks has become more desirable. The Raytheon's NXU Network Extension Unit is an ideal solution to provide long distance serial control of devices in the land mobile radio environment.





As indicated in the previous illustration, the NXU, whose primary function is to provide a means to convert baseband audio into VoIP or RoIP data, has a built-in ancillary function that will also convert RS-232 data to TCP/IP data, and aggregate this data with the VoIP data, simultaneously.

## Acronyms

802.3: is a standard specification for Ethernet, a method of physical communication in a local area network supported by copper cable.

Baud: is a unit of measure for data transmission speed. 1-Baud is defined as one electronic state change per second. Also known as a "Bit-Per-Second".

CCITT: Consultive Committee for International Telephone and Telegraph, is a group responsible for determining international modem standards.

COR: Carrier Operated Relay is a signal from a receiver that indicates when a carrier or signal is being received and that the receiver is unsquelched.

DCE: Data Communications Equipment, also known as Data Circuit Termination Equipment, is an RS-232 terminology that describes a device (i.e. MODEM) that is controlled by a computer or terminal equipment.

DTE: Data Terminal Equipment, also known as a computer or terminal, controls data flow between itself and a DCE, or MODEM.

EIA: Electronic Industries Alliance promotes the market development and competitiveness of the U.S. high-tech industry.

GND: Ground, is an electrical potential that is equivalent to zero volts.

GSM: Global System for Mobile Communications is a form of Voice Coding and Decoding algorithm used by the NXU.

ISO: International Organization for Standardization is the world's largest developer of standards.

IEEE: Institute of Electrical and Electronics Engineers, is a technical organization that strives in the advancement of theory, practice and standards of applied electrical science.

NXU: Network Extension Unit, is a device used to connect a DSP-1 module or a land mobile radio device over an IP-based network. The unit creates a network link that passes both voice and control signals in the form of RoIP.

PTT: Push-to-Talk, A signal to a radio transmitter, which controls the actual transmission of radio frequency energy over the air.

RoIP: Radio over Internet Protocol, (compared to VoIP) not only converts voice to a digital format that can be sent over the Internet or other IP based network, but also convert PTT and COR control signals that are essential for seamless for radio interoperability. Also include are extra delay and jitter compensation.

RS232: Recommended Standard 232 is a specification for serial communications between a computer and modem, or computer to other device to be controlled.

RXD: Receive Data, is an RS-232 designation with respect to data flow.

TCP/IP: Transport Control Protocol / Internet Protocol, is an additional layer to the Internet Protocol, which ensures delivery of packets, sent across the network. It can handle situations such as lost packets or packets arriving out of order.

TIA: Telecommunications Industry Association is a trade association serving the communications and information technology industry.

TXD: Transmit Data, is an RS-232 designation with respect to data flow.

USB: Universal Serial Bus is a data transmission standard; similar to RS-232, in that it is based upon a point-to-point topology that has significantly higher data rates than RS-232.

VOCODER: Voice Coder / Decoder, is an algorithm use by the NXU that reduces speech signals to slowly varying signals transmittable over TCP/IP networks to conserve network bandwidth.

VoIP: Voice over Internet Protocol, is a method of sending voice communications across a digital network.

### References

*NXU Installation and Operation Manual*, P/N 5000-600200, Revision 3.1, Raytheon.