

Icom D-STAR On-Line Course

Lesson 1

Lesson Title: D-STAR, An Introduction

Summary

Icom America, Inc. is the first manufacturer to produce equipment that supports the D-STAR digital voice and data standard for amateur radio. Digital techniques are new to Amateur Radio, so this course has been created by Icom for amateurs to educate themselves about the nature of this new technology and the D-STAR system, specifically.

By completing this course, the student will understand the following D-STAR concepts, many applicable to any digital wireless data system:

- How D-STAR exchanges data over the air
- How D-STAR radios and repeaters work
- How the D-STAR repeaters are linked together into a worldwide system
- How to use the D-STAR system
- How to configure D-STAR radios, repeaters and gateways

How This Course is Organized

The course consists of 11 units. Except for the Final Review and Final Examination, each unit begins with a summary, presents detailed material, follows with a glossary and review, and concludes with a five-question, multiple-choice exam. After passing the exam for each unit, the student is permitted to proceed to the next unit. Once the student has passed the final exam, ICOM is notified and a certificate is provided. Here is a list of the units:

1. Introduction (this unit)
2. D-STAR Characteristics
3. D-STAR Protocol Basics
4. D-STAR Network Operation
5. D-STAR Radios
6. D-STAR Use - Local
7. D-STAR Use - Gateway
8. The D-STAR Repeater
9. The D-STAR Repeater Gateway
10. D-STAR Review
11. D-STAR Final Exam

The text portion of each unit is available for downloading as a PDF file from the course Web site. No additional texts or references are required for the course, although you may want to download the operating manual for a D-STAR radio as a

source of examples. There are several Web sites that have additional information you may find useful:

ICOM America D-STAR Web site:

<http://www.icomamerica.com/amateur/d-star/>

Texas Interconnect Team (D-STAR Development Group):

<http://www.k5tit.org/>

D-STAR Introduction and Overview

What is D-STAR?

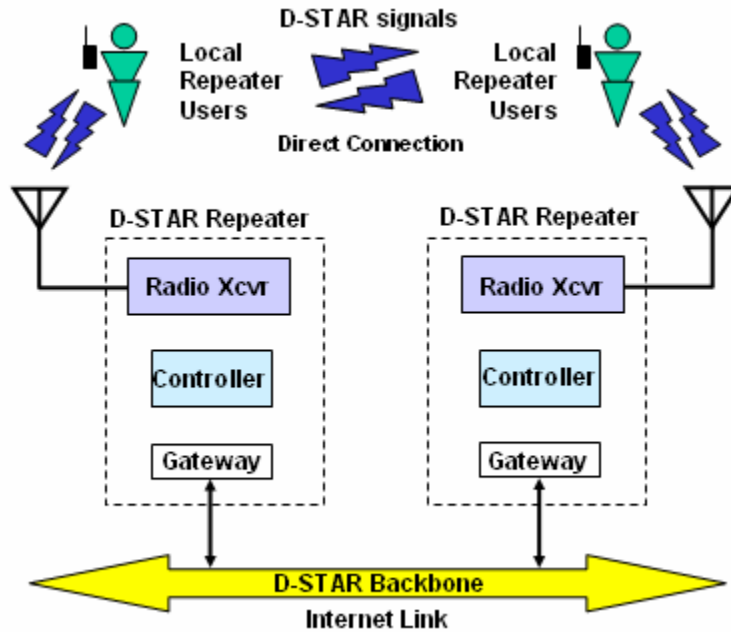
D-STAR is a communications standard--that is, it describes the methods of operation and necessary technical details for radio equipment to be constructed and operate successfully. D-STAR is not a brand name or limited to use by one manufacturer.

Released in 2001, D-STAR's development was funded by the Japanese Ministry of Posts and Telecommunications to investigate digital technologies for amateur radio. The research committee included representatives of the Japanese amateur radio manufacturers, including Icom, and other observers.

Although D-STAR is a standard published by JARL, it is available to be implemented by anyone. D-STAR is an *open system*, meaning that any equipment complying with the published standard can use the system.

What D-STAR Controls

As shown in Figure 1-1, D-STAR applies to two parts of a communications system. The first is the *air link* (represented by the blue lightning bolt), meaning the actual radio transmissions between radios. (An example of another amateur air link standard is packet radio that uses the AX.25 standard.) The second is the *backbone* (represented by the yellow arrow) by which D-STAR repeater *gateways* communicate using the Internet or direct radio links. D-STAR radios can also talk directly to each other without any intermediate equipment.



The D-STAR standard also controls the conversion of voice to and from digital signals (called *digitization*) in radios and repeaters. All voice signals in the D-STAR system must use the same type of encoding so that voices are reproduced properly. Digitization is performed by a device called a *codec*, short for coding-decoding.

For digital data, D-STAR radios present an RS-232 or USB interface for low-speed data and an Ethernet connection for high-speed data. This allows widely available software to use the D-STAR system without special software or electrical interface equipment. The digital data is transmitted in the D-STAR system without modification.

Most D-STAR repeaters will consist of one or more radio transceivers that handle the air link part of the system. An internal controller will manage the transceivers, just like analog FM repeaters. What's different is that the D-STAR radio transceivers handle a stream of digitized voice and digital data instead of the usual analog FM signals. The methods a D-STAR radio or repeater uses to handle those voices or data internally is up to the equipment designer.

D-STAR also specifies how a repeater communicates to other D-STAR systems through gateways that are connected to the repeater controller. Whether the gateways communicate via the Internet or a radio link is up to builders of the repeater system.

D-STAR's Status and Future

D-STAR repeaters are currently installed in a number of locations in Japan, North America, and Western Europe. For a directory of the growing number of D-STAR repeaters, check the Icom America D-STAR Web site. All of the repeaters are linked using the D-STAR system backbone.

Icom also produces several D-STAR radios, including:

- IC-V8 2-meter handheld transceiver

- IC-U8 70-cm handheld transceiver
- IC-91 2-meter/70-cm handheld transceiver
- IC-2200H 70-cm mobile transceiver
- ID-800 70-cm mobile transceiver
- ID-1 1.2 GHz mobile transceiver

Because D-STAR's digital system is so flexible, a number of new applications are being developed. Here are a few examples:

Emergency Communications

A large amount of communications in support of disaster and emergency response organizations concerns status and resources. This type of information can easily be handled in digital form, quickly and accurately. D-STAR supports keyboard-to-keyboard communications (not email) and Web page entry, making it a powerful tool for amateur emergency responders.

Information and services - the D-STAR Kiosk

There's no rule that says a D-STAR user must be a person! Digital data can just as well be received by a computer. If the computer stores information of interest to hams, such as event calendars or store locations, it can be retrieved over the D-STAR system. Weather and traffic reports could be made available, as well.

Location Reporting Systems - D-PRS®

The RS-232 data ports of D-STAR handheld radios are compatible with the GPS receiver NMEA data interface. GPS location data can be forwarded to a D-PRS server where gateway software connects you to the APRS® reporting system [URL for APRS].

IRLP and Echolink Gateway Connections

Since IRLP and Echolink already forward digitized voices of hams, D-STAR's digital voices can be linked to those popular repeater-sharing applications.

D-STAR Development

As additional D-STAR equipment is produced and more D-STAR repeater systems installed, the opportunities to build useful new systems increases. If you are interested in these new systems, we suggest that you join the D-STAR developers groups on the Web via the Icom America D-STAR Web site.

Icom D-STAR On-Line Course

Lesson 2

Lesson Title: D-STAR Characteristics

Summary

In this lesson the student is introduced to D-STAR terminology and the D-STAR system definitions. The different types of D-STAR communications, voice and data, are presented and compared. The student is made aware of regulations that place constraints on the frequencies where D-STAR signals can be transmitted. Finally, some common misconceptions about intended applications of D-STAR are discussed.

What D-STAR Is

Just as for any other communication system, one can become quite confused or reach the wrong conclusions if the right terms and definitions are not used when discussing or planning a D-STAR system. That's why this lesson is devoted to a review of important terms and ideas.

D-STAR's Modes

The D-STAR system carries digitized voice and digital data, but does the job in two different ways. There is a combined voice-and-data mode (DV), and a high-speed data-only stream (DD). From the perspective of the D-STAR user, data and voice are carried at different rates and managed in different ways, but over the air, they are contained in *packets*.

You may be familiar with the packet radio *AX.25 protocol* that governs the exchange of data between TNCs (Terminal Node Controllers) or the Ethernet protocol that is used by home and business computer networks. The D-STAR protocol is similar, using many of the same techniques.

Digital Voice and Low-Speed Data (DV)

Mobile phone systems and Voice-Over-Internet Protocol (VOIP) phone technologies, such as Skype, convert the speaker's voice to a stream of digital data so that it can be sent to the destination over computer networks. The type of digitization used must be the same as the speaker and receiver, so D-STAR requires that a specific codec be used.

Digital Voice

The D-STAR codec digitizes voice by using the AMBE 2020 codec. AMBE stands for Advanced Multiple Band Encoding and 2020 designates the particular

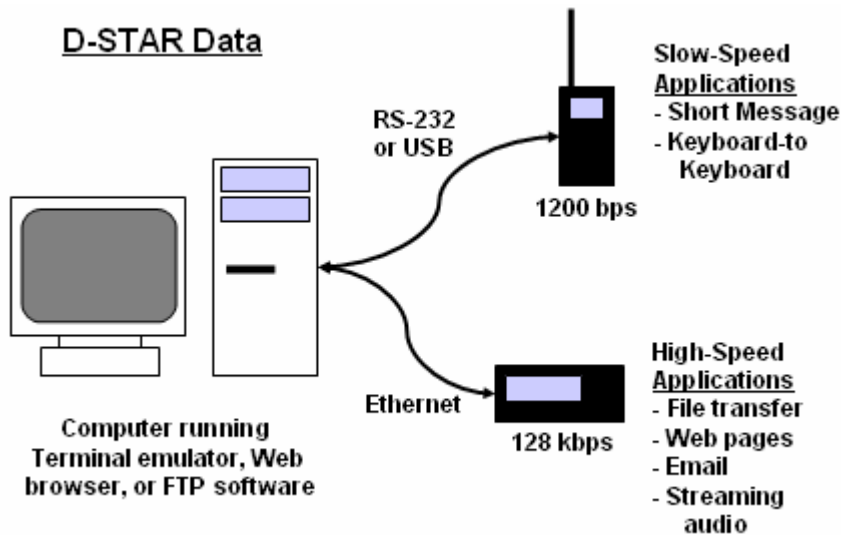
variation used by D-STAR. (Detailed technical information about AMBE 2020 is available at <http://www.dvsinc.com/products/a2020.htm>).

AMBE can digitize voice at several different rates. The D-STAR system uses a 2.4k bits per second (bps) rate which gives a good compromise between intelligibility and the speed at which data must be transmitted via the radio link. In addition, AMBE adds information to the voice data that allows the receiving codec to correct errors introduced during transmission. (The process of error correction will be covered in the next lesson.) The net result is that the digitized voice stream carries data at a rate of 3.6 kbps.

Low-Speed Data

Along with the digitized voice data, D-STAR's DV mode can also carry 8-bit digital data at 1200 bps. The data is not modified in any way as it is carried along with the voice stream and delivered to the receiving user.

Radios that support DV voice and data present an RS-232 or USB 1.1 interface to the user as shown in Figure 2-1. (The RS-232 interface is restricted to Rx/D, Tx/D, and ground - a "three-wire" connection.) Any computer terminal or program that can exchange data over those types of interfaces can use D-STAR's DV mode capabilities as a "radio cable." Figure 2-1 shows the data interfaces for both DV and DD mode connections.



Because D-STAR's DV mode handles the digital without any modifications, it is up to the equipment or programs that are exchanging data to manage its flow. For example, if one system is busy and can't accept data, it must be able to signal the sending system to stop sending data and then start again when ready again. This process is called *flow control*. D-STAR requires the sender and receiver to perform flow control by using special data characters. This is called software flow control.

Table 2.1 - Comparison of DV Mode and Packet Radio

| Feature | D-STAR DV | AX.25 Packet |
|----------------|------------------|---------------------|
| Voice Codec | 2.4k bps AMBE | None |
| Data Speed | 1200 bps | 1200 - 9600 bps |
| Data Format | 8-bit ASCII | 7-bit ASCII |
| Data Interface | RS-232 or USB | RS-232 |
| | 1.0 | |
| Bandwidth | 6.25 kHz | 25 kHz |
| Frequency | Any VHF/UHF band | Any VHF/UHF band |

Table 2.1 illustrates some important differences between D-STAR's DV mode and packet radio. Most obvious is that packet does not support voice in any form. High-speed packet can also reach 9600 bps. However, the bandwidth of a D-STAR signal is much smaller than that of an FM packet signal. Because of the low bandwidth, FCC bandwidth and data-rate regulations permit D-STAR DV signals to be transmitted on any VHF or UHF band. (See FCC regulations Part 97.305 and 97.307 for restrictions on bandwidth and signaling rates for data signals.)

High-Speed Data (DD)

D-STAR's high-speed data mode is called D-STAR DD. In this mode, the voice signal is dropped and the packets are dedicated completely to digital data. The packets sent across the air link at a raw data rate of 128k bps, but since that includes the packet header and the delay between packets, the *net data rate* is somewhat lower. (Sending data while in motion will further reduce the rate.) As with the DV mode, data is transmitted without modification so flow control is left to the users on each end. Radios supporting DD mode communications may also support DV mode.

Users connect to a radio supporting DD mode with an Ethernet interface via the usual RJ-45 modular jack found on computer networking equipment. (See Figure 2-1) The DD mode interface looks to computer equipment just like a customary network connection. Specifically, the DD mode interface is an Ethernet "bridge" between a pair of fixed network addresses. This allows Web browsers and other Internet software to run normally, as if they were connected to standard computer network.

The net data rate of DD mode is comparable to or better than a high-speed dial-up Internet connection. Voice transmission using DD mode connections can be effected by digitizing the voice separately and transmitting it as a stream of data via D-STAR. (Since DD mode just treats the digitized voice as data, any codec may be used.) Any streaming media mode that will run over dial-up Internet will likely perform well over D-STAR, as well.

Table 2.2 - Comparison of DD Mode and Packet Radio

| Feature | D-STAR DD | AX.25 Packet |
|----------------|------------------|---------------------|
| Data Format | 8-bit ASCII | 7-bit ASCII |
| Data Speed | 128k bps (raw) | 1200 - 9600 bps |

| | | |
|----------------|-----------------------|---------------------|
| Bandwidth | 130 kHz | 25 kHz |
| Data Interface | Ethernet bridge | RS-232 |
| Frequency | 902 MHz and higher | Any VHF/UHF band |

DD mode data outperforms high-speed packet radio by a considerable margin, although with a substantially higher bandwidth. FCC regulations restrict high-speed data signals like D-STAR DD to the 902 MHz and higher bands.

D-STAR Backbone

The “invisible” mode of D-STAR is the system backbone with which repeater systems are connected together. Backbone connections can be made by any combination of Internet (a broadband connection is required) or radio links. Users do not use the backbone directly, it is only used by the D-STAR repeater gateways.

Gateways communicate over the D-STAR backbone using the Asynchronous Transfer Mode (ATM) protocol. (Detailed information on ATM is available at [URL].) The backbone operates at data rates of up to 10 Mbps, depending on the connection available. If the radio link backbone is used, signal bandwidth can be as high as 10.5 MHz, so these links are restricted to the amateur microwave bands. (Icom currently provides a 10.7 GHz microwave point to point radio link.)

What D-STAR is Not

It is also important to understand what D-STAR systems can not or may not do, due to both technical and regulatory restrictions.

Amateur Mobile Phone

D-STAR uses many techniques that are derived from or seem similar to those of the mobile phone systems and the Internet. Nevertheless, D-STAR does not create a “Ham Radio Cell Phone” or an “Amateur Internet.” Most importantly, D-STAR communications are public and can be monitored by anyone with a D-STAR radio.

Streaming media are also quite constrained by D-STAR’s limited data rate. Anyone expecting to watch video or download music via a D-STAR DD mode connection will likely be disappointed. D-STAR supports reasonable amateur requirements, but is not a replacement for broadband Internet connections.

The intent of D-STAR is to provide amateurs with state-of-the-art digital communications to support traditional amateur communications and foster the development of new applications suitable for amateur radio.

Commercial Content

Hams using D-STAR’s DD mode can certainly connect to the Internet, send-and-receive email, use FTP servers, and so forth. Nevertheless, the FCC’s prohibition against using amateur radio for commercial purposes still applies. This means that

D-STAR users and system owners must be vigilant in keeping the many commercial aspects of the Internet off of the D-STAR system. For example, accessing your club's Web site may be OK, but reading a commercial newspaper's home page is not.

Icom D-STAR On-Line Course

Lesson 3

Lesson Title: D-STAR Protocol Basics

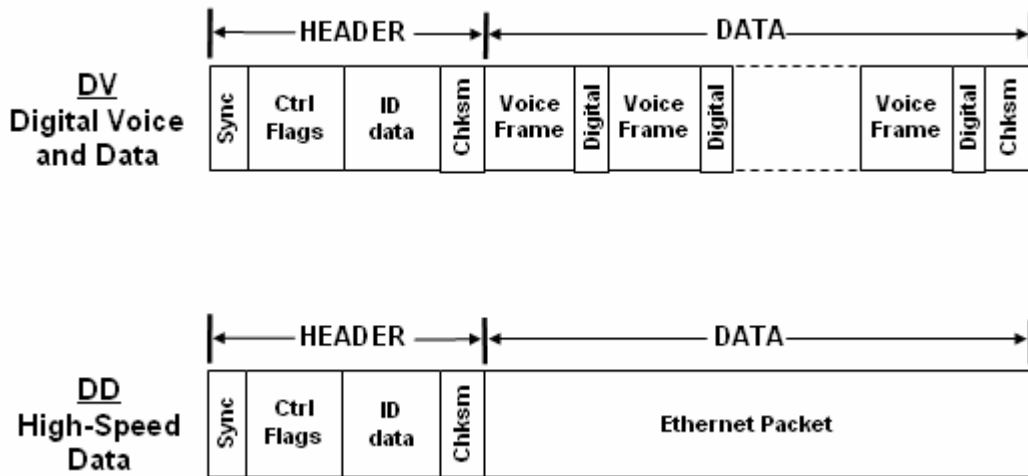
Summary

This lesson examines how the D-STAR protocol functions and how D-STAR packets are constructed. The DV and DD modes of D-STAR are compared. The student will learn about how protocols may be encapsulated and how D-STAR performs error detection and correction.

D-STAR Packets

D-STAR is a packet-based protocol. As you learned in the previous lesson that means the data is assembled into a package containing the data itself plus other information about the data and how the communications system should handle it. Packets are transmitted in their entirety and the receiving system processes the packet as a group.

There are two types of packets in the D-STAR air link protocol; DV (data and voice) and DD (high-speed data). Figure 3-1 shows the basic structure of each type of packet. Before examining the details, observe the similarities between the two packets. The packets consist of a *header* segment and a *data* segment. (Data segments are sometimes referred to as *payloads*.)



The header segment contains information about the packet; control *flags*, identification of the sender and destination, and D-STAR network routing directions. The header contains the information the receiving device needs to process the data, whether that means reading and acting on the data or just forwarding it on to another receiver elsewhere in the system.

The D-STAR backbone has its own protocol that carries the gateway-to-gateway information - the Asynchronous Transfer Mode (ATM) protocol. Because the method by which the gateways communicate is not public, the ATM protocol is not discussed in this course.

Overhead

The header and other information added to the original set of data creates a small amount of *packet overhead*. The additional information in the header is transmitted at the same rate as the data, reducing the net data rate. It is a challenge for protocol designers to minimize overhead, while still providing enough information to make the protocol useful.

Table 3.1 shows the amount of overhead for the DV and DD packets. The DV packets are always the same size with 11 pairs of voice and data frames (see below for DV packet structure). There are two situations for the DD packets. The first is for a packet carrying the minimum amount of data. This is not common and minimizes efficiency. The second, a packet with the largest allowed data payload, is closer to actual practice. Clearly, it is best to send the maximum amount of data if efficiency is the most important concern.

Table 3.1 - D-STAR Protocol Overhead

| Protocol | Header (bytes) ¹ | Data (bytes) | Packet Size (bytes) | Overhead | |
|----------------------------|-----------------------------|--------------|---------------------|----------|---------|
| | | | | Bytes | Pct (%) |
| DV | 51 | 1056 | 1107 | 51 | 4.6 |
| DD (min data) ² | 51 | 66 | 117 | 51 | 43.5 |
| DD (max data) ² | 51 | 1520 | 1571 | 51 | 3.2 |

- (1) - the header size is rounded up to the next full byte because of the 15-bit sync field
- (2) - data size includes the terminating checksum (see error detection)

Protocol Overhead

An important difference between packet radio and D-STAR is that packet radio (AX.25) requires an acknowledgement and the receiver can request retransmission if the packet is received with errors. The time it takes for the packet's receiver to process and acknowledge the packet adds to the overall time to transfer data. This waiting time is called *protocol overhead*. D-STAR is a one-way protocol--no response is required from the receiver to acknowledge that a packet was received. As you will learn, D-STAR does not require acknowledgement because error detection and correction are built-in to the data.

Encapsulation

D-STAR also employs a common technique of using one protocol to send data formatted according to another protocol. In the DV packet, voice data is contained in short segments (called *frames*) formatted according to the AMBE protocol. In the DD packet, the data segment is formatted according to the Ethernet protocol. This process of putting data from one protocol “inside” another protocol is called *encapsulation*. The encapsulating protocol (D-STAR in this case) acts as a wrapper or envelope for the packets from the encapsulated protocol, just as a paper envelope carries documents or letters.

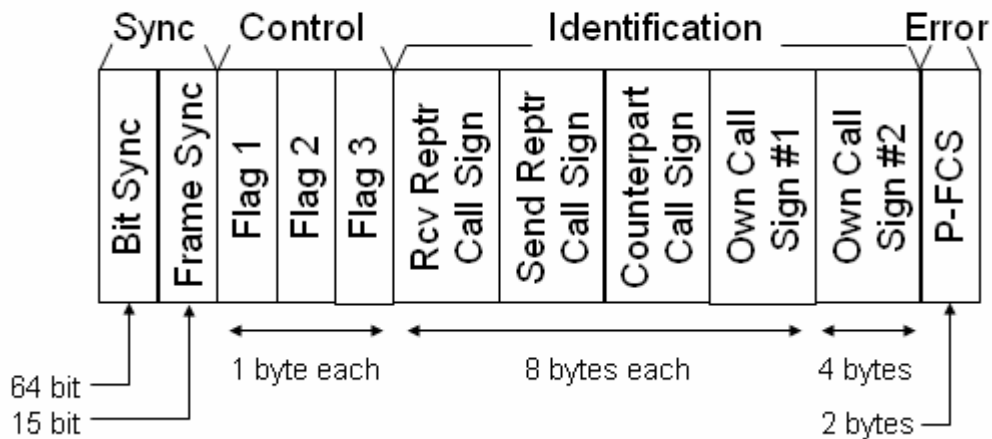
D-STAR Packet Structure

This section defines each element of the D-STAR packet header and data segments.

Header

The header segment is the same for both the DV and DD packets. Figure 3-2 shows the structure of the D-STAR packet header.

D-STAR Packet Header



Sync Frames

Because a packet can start at any time, it takes the receiver some time to detect and synchronize with the incoming packet data. Sync frames are unique patterns of bits that the receiver can use to unambiguously determine that a packet is beginning. The receiver is then ready to process the data elements that follow. D-STAR uses two sync frames

- Bit Sync is a standard pattern for the GMSK 1010 modulation used by D-STAR
- Frame Sync is ‘111011001010000’ - a unique bit pattern in D-STAR packets.

Control Flags

The bits in the control flag bytes are used to direct the processing of the packet. For a detailed description of the function of each bit, refer to the D-STAR protocol technical description document.

Flag 1

Flag 1 bits indicate whether the data is control data or user data, whether communications is simplex or repeater, set priority, etc.

Flag 2

Flag 2 is reserved for future use as identification data.

Flag 3

Flag 3 is reserved to indicate the version of the D-STAR protocol being used so that if new functions are added in the future, the receiver can apply them properly.

Identification Data

There are four *fields* of identification data. These carry information about the origin and destination of the packet.

Receive Repeater Call Sign

The call sign of the repeater that is to receive the packet

Send Repeater Call Sign

The call sign of the repeater that is sending the packet

Counterpart Call Sign

The call sign of the station that is to receive the data.

Own Call Sign #1 and Own Call Sign #2

The first field contains the call sign of the station that originated the data. The second field contains suffix information.

P-FCS Checksum

A *checksum* is used to detect errors as described below. The P-FCS checksum is computed from the Flag and ID data bytes. Any transmission errors in those bytes can be detected as a discrepancy in the P-FCS value.

D-STAR Error Detection and Correction

Transmission errors can occur in any digital data transmission, even those over wired networks. Somewhere along the way, a noise burst or a loose connection changes whatever represents a 0 bit to a 1 bit or vice versa. Depending on the bit's importance, the result can be insignificant or catastrophic.

How can D-STAR correct errors in digital voices? To combat transmission errors, D-STAR uses two techniques:

- *Error detection* codes are used to detect transmission errors. These only tell the receiver that the data is damaged, but not how. D-STAR checksums follow the CRC-CCITT standard.
- *Error correcting* codes contain information about the payload data. Because the codes are sent with the data to enable correction at the receiver, they are called *Forward Error Correcting* or FEC codes. FEC codes contain enough extra information for the receiver to repair most damage.

Both the DV and DD data packets in Figure 3-1 use the P_FCS checksum to protect the information in the header. The DD data packet also contains the Ethernet data packet checksum at the very end of the packet. It protects the Ethernet data payload.

In the DV packet data segment, each AMBE 2020 digitized voice frame contains its own FEC code to allow the receiver to repair errors in that 20 msec of speech. DV digital data frames are not protected, relying on the transmitting and receiving applications to detect and correct errors.

Icom D-STAR On-Line Course

Lesson #4

Lesson Title: D-STAR Network Operation

Summary

The student will learn how the D-STAR system uses call signs to route communications around the D-STAR network. The concept of a D-STAR zone is introduced along with the D-STAR gateway that connects zones together. The student will also be introduced to programming call signs in a D-STAR radio for simple communications tasks.

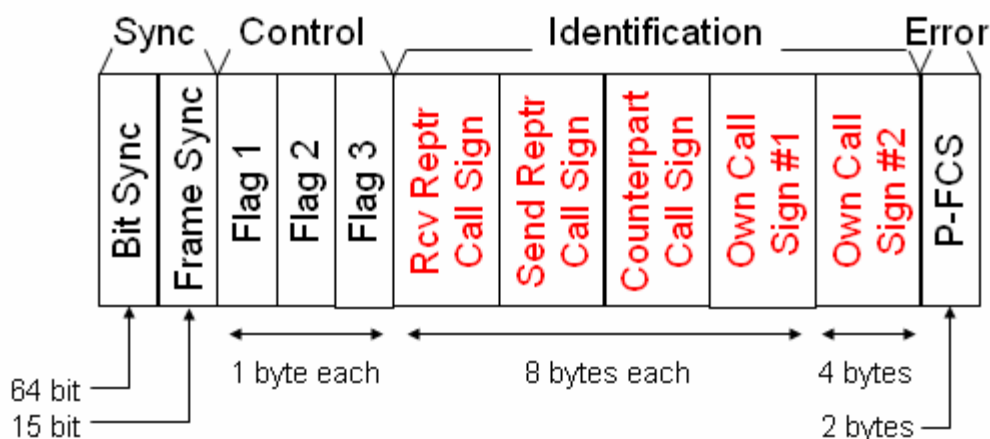
Call Signs

D-STAR packets contain call signs identifying the origin and destination of each transmission, as well as repeater stations through which the transmission is routed. Call signs are stored in the memories of each D-STAR transmitter, just as alphanumeric labels can be stored in many modern VHF/UHF transmitters.

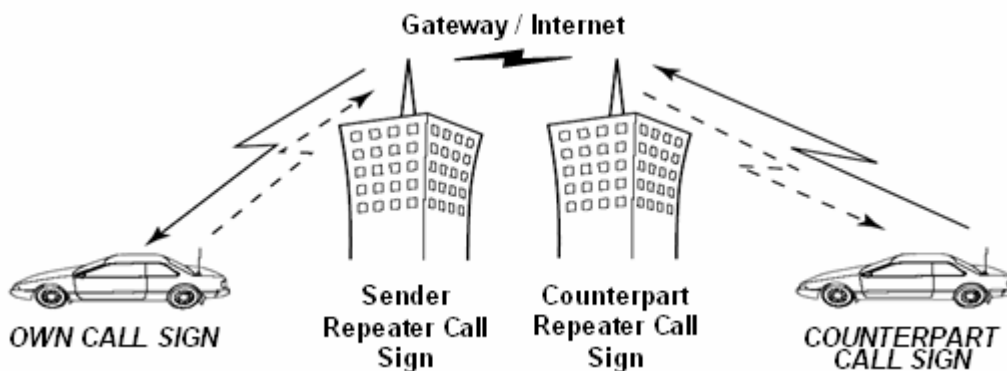
As you learned in the previous lesson, each D-STAR packet can carry up to four different call signs. The following list begins with the name of the field in the D-STAR packet (see Figure 1) for each of the four call signs:

- Own Call Sign - the call sign of the user making the transmission, referred to as “my call sign”
- Counterpart Call Sign - the call sign of the station the user wishes to or is in contact with, referred to as “your call sign”
- Sender Repeater Call Sign - the repeater and specific module (A-D) through which the user intends to communicate, referred to as “repeater 1”
- Receiver Repeater Call Sign - the repeater and specific module (A-D) through which the station identified by Counterpart Call Sign will communicate, referred to as “repeater 2”

D-STAR Call-Signs



The call signs provide the identity of the packet's origin, destination, and repeaters used. The D-STAR network needs this information to make sure that the packets from one station to another take the right path as illustrated in Figure 4-2 below. The repeaters can be located anywhere there is Internet access, so the users can be across town or on different continents.



Each D-STAR repeater can have up to four *modules* that handle voice or data, each identified by a letter; A, B, C or D. Each module acts as a separate repeater sharing a common controller with the other modules. By adding the module identifier letter in a repeater call sign, the information is routed only to that module.

It is important to remember that even though a transmission may be directed to a specific station, all D-STAR transmissions not over an Internet link are public and can be monitored by anyone, just as on analog repeaters. There are no "private conversations" on the D-STAR network.

D-STAR recognizes government-assigned call signs of users or repeaters up to 8 characters long, which is sufficient for a 6-character call, plus a slash and one numeric portable indicator digit. Extra information can be added as a suffix to the originating station's call sign in the Own Call Sign #2 field.

Note that any routing suffix letters must be in the 8th available space in the call sign. For example, if the repeater has a 4-character call sign, three spaces must be added before the routing suffix letter.

If the character string “CQCQCQ” is present in the Counterpart Call Sign field, it indicates that the calling station wishes to talk to any station. This is the same as saying “N9JA monitoring” or “W7JRL for a contact” on an analog repeater.

Prefixes and Suffixes

Prefixes and suffixes added to the call sign do not have the same meaning or format as in an analog transmission. These prefixes and suffixes are routing information for the D-STAR repeater controllers to tell them how to handle the packet. D-STAR suffix characters are separated from the call by spaces.

Point-to-Point Simplex

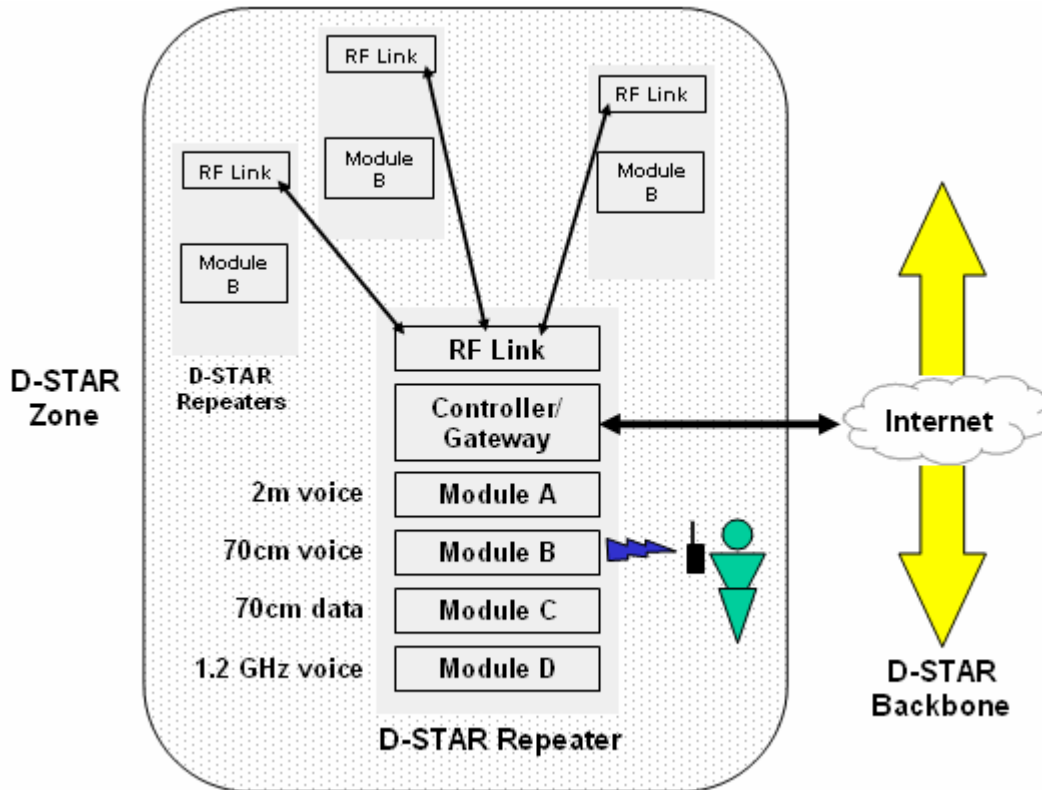
The simplest D-STAR contact is a simplex, user-to-user contact without any repeaters involved. To make a simplex contact, the calling station programs their call sign in the Own Call Sign field and “CQCQCQ” or the desired station’s call sign in the Counterpoint Call Sign field. Operation is then conducted just as it is on analog FM.

Repeater Operation

Using a local D-STAR repeater is very much like simplex communications except that the repeater’s call sign must be programmed into the Sender Repeater Call Sign field. For a repeater to relay a D-STAR signal, it must recognize its own call sign in the packets from the transmitting station. The transmitting station must also include the letter indentifying the repeater module being used in the repeater call sign.

D-STAR Zones

Just as analog repeaters can be linked together to extend the range of communications, D-STAR repeater modules can be linked into *zones*. A D-STAR Zone consists of all of the repeater modules that share a common *gateway*, the Internet connection for a D-STAR repeater. Figure 4-3 shows how this works.



Within the group of repeaters, modules identified with the same letter, such as 'B', form a D-STAR Zone. The zone may be a single repeater with a single module assigned the letter B or there may be several repeaters with B modules. The important thing to remember is that all of the repeaters must share a single, common gateway.

D-STAR Gateway

A D-STAR gateway is a broadband Internet connection from a D-STAR repeater controller to other D-STAR repeaters around the world. Using a gateway is how users in different zones can communicate. The user is required to know the call sign of the zone's repeater that provides the gateway.

Adding a "G" to a repeater call tells the D-STAR repeaters to send the transmission via the gateway. Note that the "G" must be in the 8th available space in the call sign, so if the repeater has a 4-character call sign, three spaces must be added before the "G."

Call Routing

What if the user does not know the call sign of the repeater on which the desired station is operating? The D-STAR network provides that information automatically through the D-STAR *registry*.

The registry is a database of user call signs registered on the D-STAR network by repeater system operators. Each D-STAR gateway has a copy of that database, which is maintained by several D-STAR *trusted servers* located around the world. Each D-STAR repeater gateway database is updated a number of times each day.

For a user to make use of the D-STAR network, his or her call sign must be added to the registry by a D-STAR repeater operator, just as you are assigned a password for a computer system. (Note that you can make simplex contacts without registering.) Once added to the list, each time the user transmits via a D-STAR repeater, the user's location is updated in the master registry where it will be provided to all D-STAR gateways.

To contact a registered station, the calling station enters that call sign into the UR call sign field and instructs the repeater to use the gateway by adding "G" after the R1 or R2 call sign as described above. The D-STAR controller will then look up the station's call in its database and route the call to the repeater on which the call last registered.

Icom D-STAR On-Line Course

Lesson #5

Lesson Title: D-STAR Radios

Summary

Having covered the basics of how the D-STAR system works, we'll now review the practical side--the radio equipment. The student will review a table of comparisons between available radios. A typical piece of equipment (IC-91AD) will be configured to operate on D-STAR repeaters and some exercises for operating the D-STAR radio will be performed.

D-STAR Radios

D-STAR is an open standard owned by the JARL and available to any manufacturer. At this time, Icom is the first manufacturer to offer radios and repeaters that implement the D-STAR system of protocols. A full line of equipment is available with different sets of features and functions.

The first step in using D-STAR is to be able to choose the appropriate radio, so we will review the available equipment. Table 1 shows the important characteristics in a table for easy comparison.

Table 1 - D-STAR Radios (as of 1 October 2006)

| | Bands | | | D V | D D | A V | Data Interface | | | Power (watts) | Notes |
|------------------------|-------------|-------------|--------------|--------|--------|--------|----------------|-----|---------------|------------------|---------------------|
| | 1 4 4 | 4 4 0 | 1. 2 G | | | | RS- 232 | USB | Ether -net | | |
| Mobile Radios | | | | | | | | | | | |
| ID-1 | | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | 10 | |
| IC-2200 | | ✓ | | ✓ | | ✓ | ✓ | | | 65 | Req's UT-118 module |
| ID-800 | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | 55/50 | |
| Handheld Radios | | | | | | | | | | | |
| IC-V82 | ✓ | | | ✓ | | ✓ | ✓ | | | 7 | Req's UT-118 module |
| IC-U82 | | ✓ | | ✓ | | ✓ | ✓ | | | 5 | Req's UT-118 module |
| IC-91AD | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | 5 | |

DV is the D-STAR digital voice and low-speed data mode

DD is the D-STAR high-speed digital data mode
AV stands for “Analog Voice”, the standard FM voice mode

To determine which is the best radio for an application, the first step is to understand what the requirements are:

- Is DD mode operation required (high-speed data)? If so, the only radio supporting DD mode is the ID-1.
- Is dual-band operation required?
- Is high-power required?
- If data is to be transmitted, what data interface does the computer have?

When adding up the costs, don't forget to include the UT-118 D-STAR module if the radio requires one for digital operation.

Key items to remember when choosing the right D-STAR technology:

- High-speed data (DD mode) can only be sent on the bands above 70 cm.
- Error correction for low-speed data (DV mode) is the responsibility of the data communications programs used to exchange data.
- RS-232 interfaces for D-STAR data do not provide data flow control hardware signals, such as RTS or CTS, but XON/XOFF software flow control is provided.
- Higher power radios will result in stronger signal strengths and fewer data transmission errors.
- If data is to be transmitted while in motion, higher frequencies will result in fewer transmission errors, improving the net data exchange rate.

Configuring a D-STAR Radio

This section will lead you through the *configuration* process for the IC-91AD, Icom's latest D-STAR handheld radio. D-STAR radios may all have slightly different *labels*, keys, and sequences of operation, but under the surface they all use the same sets of D-STAR information. By studying the IC-91AD configuration process, you'll be able to quickly learn to configure other D-STAR radios.

(The IC-91AD manual can be downloaded from Icom at <http://icomamerica.com/downloads/manuals.asp>. It is a 1.66 Mbyte PDF document.)

Call Signs

The most important D-STAR information is your own call sign. The IC-91AD stores this information labeled as MY CALL SIGN.\

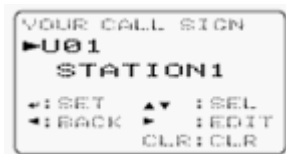
- Select MENU
- Select CALL SIGN
- Select MY

- Select which of the MY CALL SIGN memories (M01-M06) is to be programmed (the IC-91AD can store up to six different call signs)
- Enter up to 8 characters
- If a suffix is desired, select the “/” character and then follow it with up to 4 characters.
- Exit the MENU system

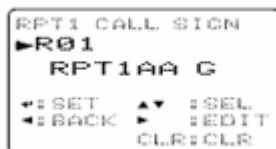
Figure 5-1 shows the result of programming “MYCALL/IC91” into the first (M01) memory for MY CALL SIGN. You might want multiple selections for MY CALL SIGN if the radio is shared by more than one operator or if you frequently operate away from home or with a club call sign.



Along with your own call, D-STAR’s ability to call other system users directly by call sign means you’ll want to set up a list of commonly contacted call signs. The IC-91AD labels these calls “YOUR CALL SIGN” and can store up to 60 8-character call signs in memories U01-U60. The process of accessing and entering the data is similar to that for “MY CALL SIGN”, selecting “UR” instead of “MY.” Figure 5-2 shows “STATION1” programmed into memory U01.



The D-STAR repeater call signs are part of establishing a D-STAR connection, so the IC-91AD can also store 60 8-character call signs for repeaters in memories R01-R60. These are labeled “RPT1/2 CALL SIGN”. Figure 5-3 shows “RPT1AA G” programmed into memory R01. You can store several variations of repeater call signs to make local calls (“RPT1AA”) or zone calls (“/RPT1AA”) through the same repeater without having to manually edit the call sign each time.



Useful Functions

D-STAR radios can also take advantage of the information contained in each packet to provide handy functions, such as automatically loading received call signs and repeater routing. Each of these IC-91AD functions can be enabled or disabled as part of the radio configuration. Other radios may provide a different set of configuration options.

- AUTO REPLY - a method of replying with a pre-recorded voice message
- BREAK IN - allows you to enter a conversation if the stations are using CALL SIGN SQUELCH (see next item)
- CALL SIGN SQUELCH - mutes the receiver output audio unless packets addressed to MY CALL SIGN are received
- EMR - enables full audio output whenever an EMR call is received
- RX CALL SIGN AUTO WRITE - temporarily acquires and stores the call sign of the calling station
- RPT CALL SIGN AUTO WRITE - temporarily acquires and stores the call sign of the repeaters used by the calling station

Operating a D-STAR Radio

As you have seen, configuring your radio to take advantage of the information stored in the D-STAR packets can make operating much simpler. Assuming that it's configured to use these "smart call" features, here's how to use the IC-91AD for common tasks.

Frequency Selection

There is nothing special about frequency selection on D-STAR radios--in VFO mode, just turn the VFO knob! You can store frequencies (including repeater offsets) in memory channels for later recall just on an analog radio.

Monitoring

The squelch function of digital radios does not function the same way as for an analog radio. DV mode offers the option of *CSS (Call Sign Squelch)* in which the radio remains silent until D-STAR packets are received containing the specified call sign. Selecting "no squelch" means that you will hear every signal that can be decoded from D-STAR packets. You can then monitor all conversations on the channel--there are no private contacts!

Calling CQ

First, select your simplex or repeater frequency as described above. Then select either of these two methods:

- Store "CQCQCQ" in one of the memories from U01 to U60 and retrieve it.
- Press and hold the "0 CQ" key to load "CQCQCQ" into YOUR CALL SIGN.

By setting YOUR CALL SIGN to "CQCQCQ" you can make transmissions that are not intended for a specific station, such as announcements, test transmissions, or soliciting a contact.

- PTT mode does not transmit until the PTT switch is closed on the radio or at the microphone jack (either by a microphone or an external circuit). While PTT is closed, the radio transmits whatever data it receives.
- AUTO mode transmits data as it is sent to the data interface.

The communications software used to generate and receive data should be set to:

- Specified by the radio - this is the speed of the data between the software host and the radio, not across the D-STAR link!
- 8 data bits
- 1 stop bit
- No parity bit
- Software flow control - XON/XOFF between the radio and computer

Icom D-STAR On-Line Course

Lesson #6

Lesson Title: D-STAR Use - Local

Summary

In this lesson, the student will learn how to use D-STAR to perform the same functions that a local, analog repeater provides. The material covers call sign entry and structure. The IC-91AD is used to provide examples of D-STAR operation. The student is encouraged to download the IC-91AD manual from icomamerica.com/amateur/ - click "Downloads".

Local D-STAR Operation

Whether digital or analog, the local simplex channel or repeater performs important functions for the amateur radio community. It's a meeting place, an intercom, a watering hole, and a bulletin board. Digital technology like D-STAR certainly provides many new features, but it's also important to support the functions ham find useful today. By learning how D-STAR provides and supports familiar functions, the student will find it easier to learn the new capabilities of D-STAR.

Listening In

The vast majority of time "on channel" is spent just listening or monitoring. New D-STAR users will find that monitoring works just the same on D-STAR as it does for analog FM. You do not have to enter any call signs for the radio to receive D-STAR packets. Once your radio is tuned to an active channel frequency, you'll hear every conversation. The only difference is the squelch function.

In the previous lesson you learned that the squelch function of digital radios does not function the same way as for an analog radio. Instead of "opening" the squelch to hear unmodulated white noise, your radio is silent until D-STAR packets are received, then the decoded digital voice will be heard over the speaker as long as the signal is strong enough to receive the packets properly.

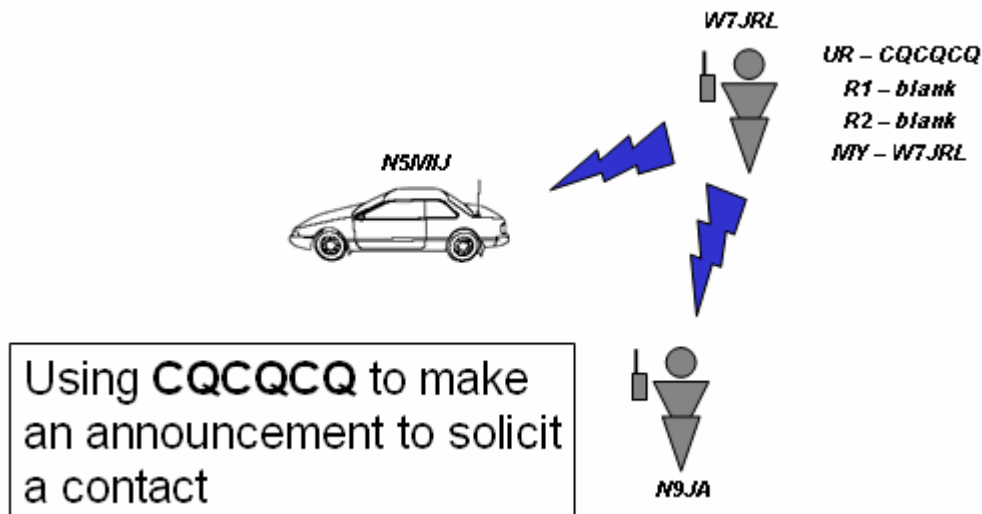
If D-STAR's DV mode is in use, the new feature CSS (Call Sign Squelch) is available. When CSS is turned ON and a call sign entered, the radio will remain silent until D-STAR packets containing the specified call sign are received. Since the transmitting station's call sign is contained in every D-STAR packet, CSS does away with having to agree on a special code as with analog Digitally Coded Squelch where tone sequences are transmitted.

Along with speech, D-STAR data and digital messages can also be received and displayed by a listener. All digital information is carried by the D-STAR packet as "plain text."

Making a Call & Responding

What if your transmissions are not directed specifically at another station? There are many instances in which you might want to simply have everyone listening hear your voice. Of course, the most common example is announcing that you are listening yourself and are available for a contact - "This is N9JA, monitoring." At other times, you might want to make an announcement about traffic conditions or as a net control station, make frequent transmissions to manage net functions.

In cases like this, you would not enter another station's call sign as YOUR CALL SIGN, nor would you leave it empty. D-STAR's solution is to use the special text string "CQCQCQ" as seen in Figure 6-1. This string can be stored in a call sign memory, just like regular call signs. Some radios will even have a "CQ" key to set YOUR CALL SIGN to "CQCQCQ" automatically.



It's worth noting that if MY CALL SIGN is set to your call sign, any transmission that you make will be identified in the D-STAR packet header. However, it is good amateur practice to announce your call sign by voice as well.

Here's how to enter the call signs in a D-STAR radio for a simplex contact using the IC-91AD call sign entry labels; UR, R1, R2, and MY:

Calling CQ (Calling Station)

UR: CQCQCQ
R1: Blank
R2: Blank
MY: [calling station's call sign]

Responding to a CQ and during the QSO (Responding Station)

UR: [calling station's call sign]
R1: Blank
R2: Blank
MY: [listening station's call sign]

During the Contact (Calling Station)

UR: [listening station's call sign]

R1: Blank

R2: Blank

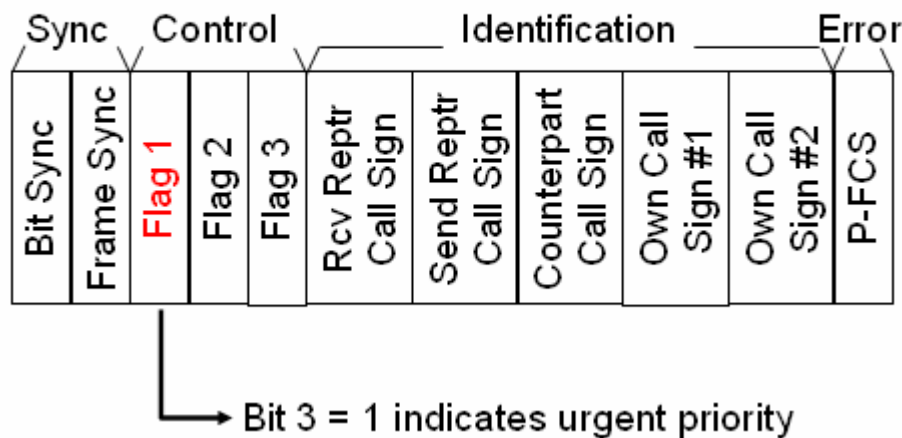
MY: [calling station's call sign]

Although this seems like a lot of call sign programming, the presence of the call signs in D-STAR packets lets the radio acquire them automatically. D-STAR radios have special keys to set up the radio to call CQ, respond to a caller, or use a repeater.

Emergencies

D-STAR also provides an “all-call” function to alert all stations within range that an urgent or emergency situation exists. Figure 6-1 shows the D-STAR header. There are three bytes that make up the control flags. Each bit of these three bytes has a separate meaning.

D-STAR Packet Header



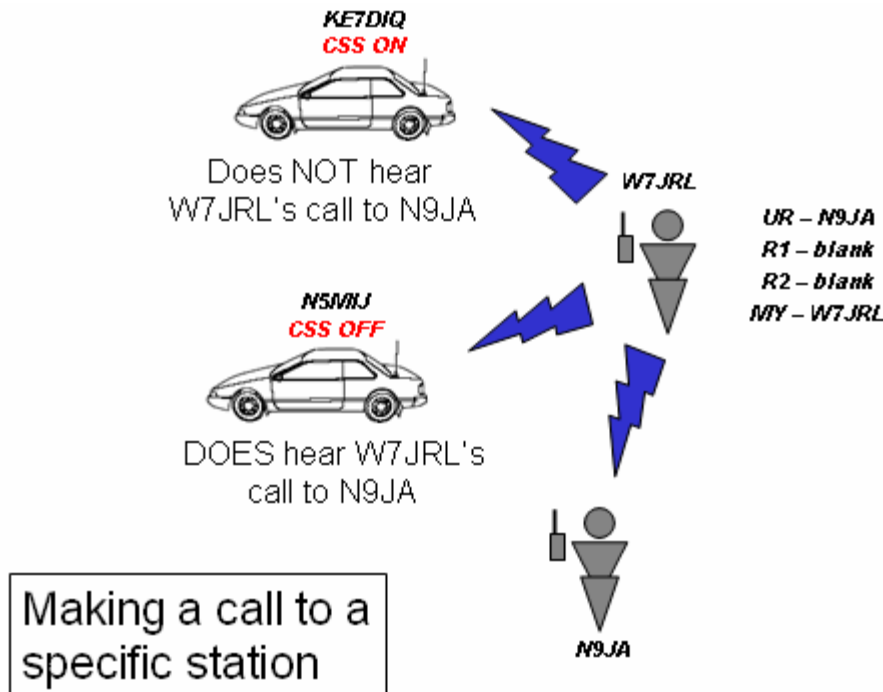
Bit 3 of the Flag byte 1 is used to indicate the emergency condition. Under normal conditions, bit 3 is *clear* (equal to 0). The bit can be *set* (equal to 1) to indicate that an emergency situation exists. Whenever a packet is received with this bit set to a 1 instead of a 0, the receiving radio ignores its current squelch settings and opens the speaker so that the received audio is heard.

The IC-91AD uses the “(decimal point)/EMR/DTMF” key to control the EMR function. If the key is pressed and held, three short and one long beeps are heard, the “EMR” indicator is shown on the display, and all further packets will carry the emergency flag. To turn off the EMR function, the key is pressed and held again.

Calling a Specific Station

There are two ways to call a specific station using a D-STAR radio. The first is to operate as if using analog FM. Set Counterpart Call Sign to “CQCQCQ” and call the station by voice. For example, “N9JA, N9JA, are you on frequency? This is W7JRL.” If N9JA is listening and does not have the special squelch functions DCS or CCS enabled, W7JRL’s call will be heard.

The second is to make a call directed specifically to N9JA by setting Counterpart Call Sign to N9JA as shown in Figure 6-3. That way, if N9JA has set his radio to use the Call Sign Squelch (CSS), the receiver will detect N9JA in the packets and output your voice.



Using a Repeater

In the analog FM world, sub-audible CTCSS or PL tones are used to control access to a repeater. You must know the correct tone or the repeater receiver will not relay your voice to the transmitter. The D-STAR equivalent is the call sign stored in R1 or R1. If R1 is left blank or the call sign does not match the D-STAR repeater on the selected frequency, the repeater will not relay your signal.

The following sets of call signs assumes that both users are using the same repeater--the most common type of repeater operation.

Calling CQ (Calling Station)

UR: CQCQCQ

R1: [Repeater’s call sign]

R2: Blank

MY: [calling station’s call sign]

Responding to a CQ and during the QSO (Responding Station)

UR: [calling station's call sign]
R1: [Repeater's call sign]
R2: Blank
MY: [listening station's call sign]

During the Contact (Calling Station)

UR: [listening station's call sign]
R1: [Repeater's call sign]
R2: Blank
MY: [calling station's call sign]

If R1 is blank then simplex communications is required as described in the previous section of this lesson.

Making a Contact Within a D-STAR Zone

In an analog system of linked repeaters, to make a call on the entire system the user might have to enter a special DTMF tone or sequence of tones to send the signal to all of the repeaters. In a D-STAR zone, the same function is performed by adding a slash character "/" before the repeater's call sign as follows:

Calling CQ (Calling Station)

UR: CQCQCQ
R1: /[Repeater's call sign] - note the slash in front of the call sign
R2: Blank
MY: [calling station's call sign]

Responding to a CQ and during the QSO (Responding Station)

UR: [calling station's call sign]
R1: [Responding station repeater's call sign] - note, no slash
R2: [Calling station repeater's call sign]
MY: [responding station's call sign]

During the Contact (Calling Station)

UR: [responding station's call sign]
R1: [Calling station repeater's call sign]
R2: [Responding station repeater's call sign]
MY: [calling station's call sign]

As before, the D-STAR radio will automatically acquire the necessary call signs from the packets, allowing the user to set up the radio in a few key presses.

Icom D-STAR On-Line Course

Lesson #7

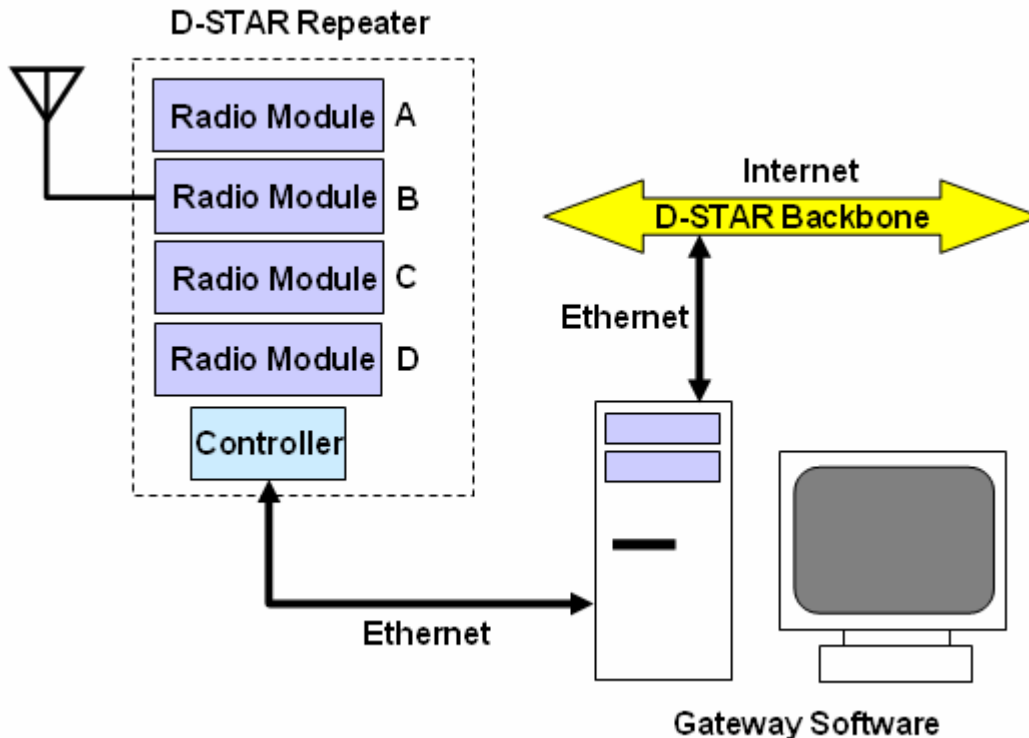
Lesson Title: D-STAR Gateway Use

Summary

This lesson introduces practical uses of the D-STAR gateway. The student will learn more about how the gateway functions in a D-STAR repeater and how cross-band operation works. Methods of using the gateway to route calls within the D-STAR network using an IC-91AD D-STAR radio are also presented.

The D-STAR Gateway

The D-STAR gateway is not a “thing”, but rather a “connection.” The gateway is software that runs on a PC connected to the controller of a D-STAR repeater as shown in Figure 7-1. (You’ll learn more about setting up the gateway in the final lesson.) The PC has to be supplied with a broadband Internet connection, through which it can exchange data with any other gateway or D-STAR server worldwide.



Automatic and Manual Functions

Some functions of the gateway are automatic. For example, you learned about the call sign registry in Lesson #4. The registry is accessed automatically to locate the

current repeater on which a specific call sign is registered. Another automatic function is the regular update of the database of the Internet Protocol (IP) addresses for other D-STAR gateways. That update occurs several times every day.

To the repeater user, though, most D-STAR functions that use the gateway require some kind of manual direction to be activated or initiated. For example, to call a friend using a different D-STAR repeater, you must direct your local D-STAR repeater to use its gateway to locate them. When making a CQ call outside the local D-STAR zone, you must direct your local repeater to the appropriate repeater system through the gateway.

The Directed Gateway

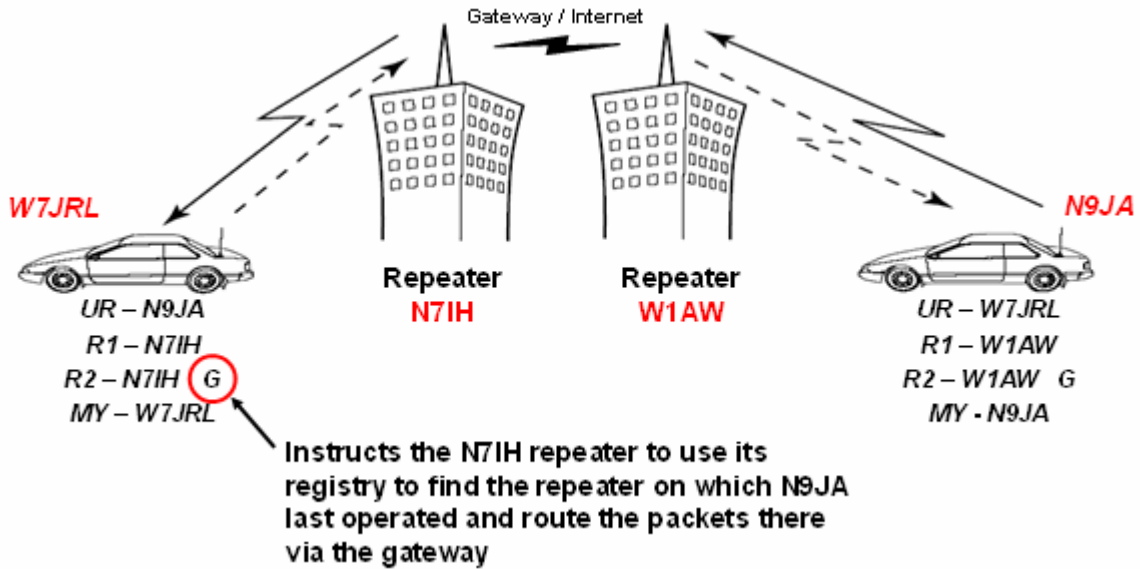
There are no “link control” signals required to connect and disconnect the repeaters. In a sense, all D-STAR repeaters are connected all the time and it is up to the users to decide when and where their signals should be heard! Unlike analog repeaters where linked systems share every signal they can hear, the D-STAR gateway only sends digitized signals to other repeaters when directed to do so by the information in a received D-STAR packet.

This also means that you can’t “listen in” on a remote D-STAR repeater by switching on a link. The only time you will hear a signal from a remote D-STAR system is when the station that generates the signal directs the gateway to send it to your repeater or repeater zone.

Gateway Call Sign Conventions

The Receiver Repeater Call Sign field contains the necessary information to route signals through the D-STAR network by using a gateway. D-STAR packets not being relayed to other repeaters aren’t handled by the gateway and so aren’t heard elsewhere.

Adding a “G” to a repeater call in the Receiver Repeater Call Sign field tells the D-STAR repeater to send the transmission via the gateway. The “G” must be in the 8th available space in the call sign, so if the repeater has a 4-character call sign, three spaces must be added before the “G.” Figure 7-2 shows the necessary call sign set up to make a call on a remote repeater by using a gateway.



In the figure, W7JRL is calling N9JA. W7JRL (My Call Sign, or MY) is sending D-STAR packets to the N7IH repeater. That requires W7JRL to have programmed Sender Repeater Call Sign (R1) with N7IH. Similarly, N9JA's R1 call sign is set to W1AW. N7IH and W1AW can be anywhere there is an Internet connection.

For W7JRL to call N9JA without knowing what repeater N9JA is using, W7JRL uses the automatic registry lookup of the N7IH gateway. This is accomplished by adding the "G" at the end of the R1 call sign. That tells the N7IH gateway software to look in its copy of the call sign registry (updated several times each day) for the repeater through which N9JA last made a transmission. When W7JRL calls N9JA, the N7IH repeater then knows to where to route the digitized audio signals. If N9JA is listening to the W1AW repeater, the call from W7JRL will be heard.

When W7JRL's call is heard, N9JA's radio should automatically save W7JRL's call along with W7JRL's repeater call sign - the Sender's Repeater Call Sign. This allows N9JA to reply immediately, without having to enter any call signs. The resulting set of call signs for W7JRL and N9JA to have a contact is shown in the figure.

What if W7JRL just wants to make a general call for a contact on the W1AW repeater? In that case, "CQCQCQ" is sent in the Your Call Sign (UR) field and the call is heard by everyone listening to the output of the W1AW repeater.

Cross-band Operation

D-STAR repeaters can support up to four radio modules as shown in Figure 7-1. The modules can be on any combination of bands. Currently, Icom supplies modules for 144 and 440 MHz and 1.2 GHz. More than one module can be on the same band, assuming that adequate filtering is available to prevent *desense*. Each module is assigned a unique letter identifier; A, B, C, or D.

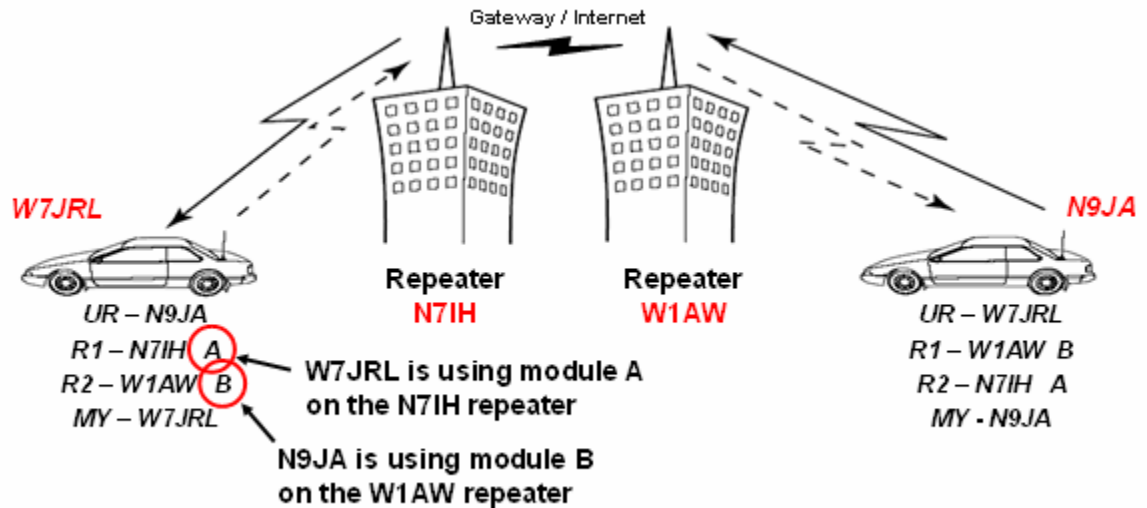
Usually, your signal and those of the stations you contact will be on the same band. In this case, no module identification letter needs to be added to the Sender Repeater Call Sign field. The controller will cause your repeated signal to be

transmitted on the same band on which it was received. This is the *default* mode of operation. [Jim - please check that statement.]

You may also choose to specify the output module explicitly and if the module chosen operates on a different band, you are then operating *cross-band*! This works similarly to an analog repeater system; the signal from one station is received and demodulated on one band and then routed to a transmitter whose output is on a different band. The other station's signal takes the opposite path.

In D-STAR systems, the modules (up to four) are selected by adding the module identification letter after the repeater call sign. The controller uses the letter to route the information between modules.

The D-STAR gateway allows cross-band operation across the D-STAR network just as if the modules were all in the same equipment cabinet. Figure 7-3 illustrates how two stations, W7JRL and N9JA, can have a contact even if they are operating on different repeaters on different bands. As with single-band gateway operation, the D-STAR radios should acquire the necessary call sign information from the received packets to make replying automatic.



Just as with analog repeater systems, however, if you choose to specify the module the station you are calling must be listening on that band. Otherwise, they will not hear your call. Unlike analog systems, you can allow the D-STAR gateway to determine the proper module by using the call sign registry as discussed in earlier lessons.

Icom D-STAR On-Line Course

Lesson #8

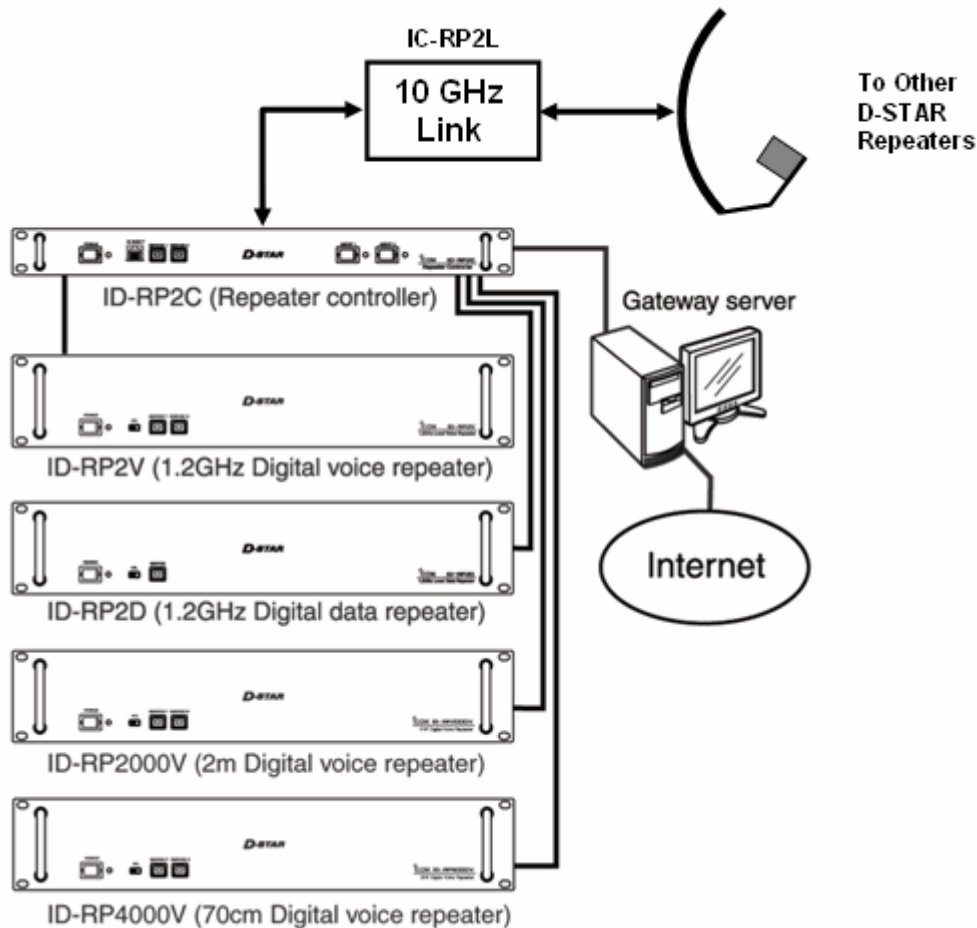
Lesson Title: The D-STAR Repeater

Summary

This lesson gives an overview of how a D-STAR repeater is constructed and the series of operations necessary to configure a repeater controller, modules, and gateway for operation. The lesson is not a step-by-step instruction manual for setting up a D-STAR repeater. The details of configuration will be found in the operating manuals for the various pieces of equipment and software. Configuration of the ID-RP2L microwave link is not covered.

The D-STAR Repeater

Like most repeaters, the actual equipment consists of several specialized pieces of hardware. Figure 8-1 shows a repeater that has four modules (the actual RF transceivers), a *controller*, an RF link, and a gateway PC with Internet link. This is a complete D-STAR repeater. (Antennas and other accessory equipment are not shown.)



At a minimum, a D-STAR repeater must have a controller and at least one module. The functionality of this isolated repeater would be quite limited because it would not have access to the D-STAR network for the call sign registry or any kind of zone communications with other D-STAR repeaters.

By adding the ID-RP2L RF link, the repeater can be linked to other D-STAR repeaters. As you learned in earlier lessons, if one of the linked repeaters has a gateway, a D-STAR zone is formed. So this simple repeater--controller, module, and link--can provide all of the D-STAR network services.

Repeater Call Sign

You will need a unique call sign for the repeater, such a club call sign. The same call sign can not be used in two different "roles" in the D-STAR network. (eg, the repeater call sign can not also be your individual call sign.) The call sign may not be used anywhere else in the D-STAR network. It is OK to reuse the call sign outside the D-STAR network, such as on HF or for an analog repeater.

D-STAR Repeater Components

ID-RP2C Controller

One ID-RP2C repeater controller is required for each D-STAR repeater. Modules can not function without a controller. The controller is a microprocessor-baser computer system that supervises the modules, routes digital voice and data signals amongst them, and provides the interface to the gateway or RF link that connects the repeater to others in the D-STAR network.

Repeater Modules

D-STAR repeater modules perform the same functions as do transmitters and receivers in an analog repeater system. Modules do not include the duplexers necessary for the receiver and transmitter to share the antenna. A separate antenna connection is required for each module. The modules process only D-STAR digital signals. An analog signal on a D-STAR module's input frequency is not demodulated or retransmitted.

The currently available D-STAR repeater modules are:

| | |
|---------|--------------------------------|
| RP2D | 1.2GHz, 128k Digital Data (DD) |
| RP2V | 1.2GHz Digital Voice (DV) |
| RP4000V | 440MHz Digital Voice (DV) |
| RP2000V | 144MHz Digital Voice (DV) |

Each module is connected to the controller at a separate *port*. There are four module ports on the controller and each can be connected to a DD or DV module. The recommended configuration for a full repeater system is:

| | |
|--------|---------|
| Port 1 | RP2D |
| Port 2 | RP4000V |
| Port 3 | RP2000V |
| Port 4 | RP2V |

Note that the interfaces between the controller and other Icom modules or equipment is proprietary to Icom equipment.

Configuring a D-STAR Repeater

To program the repeater controller and frequencies you will need:

- Windows®-based PC with at least 1 Ethernet and 1 USB port (1.1 or 2.0)
- USB A to B cable
- Ethernet cable (not a *crossover* cable)

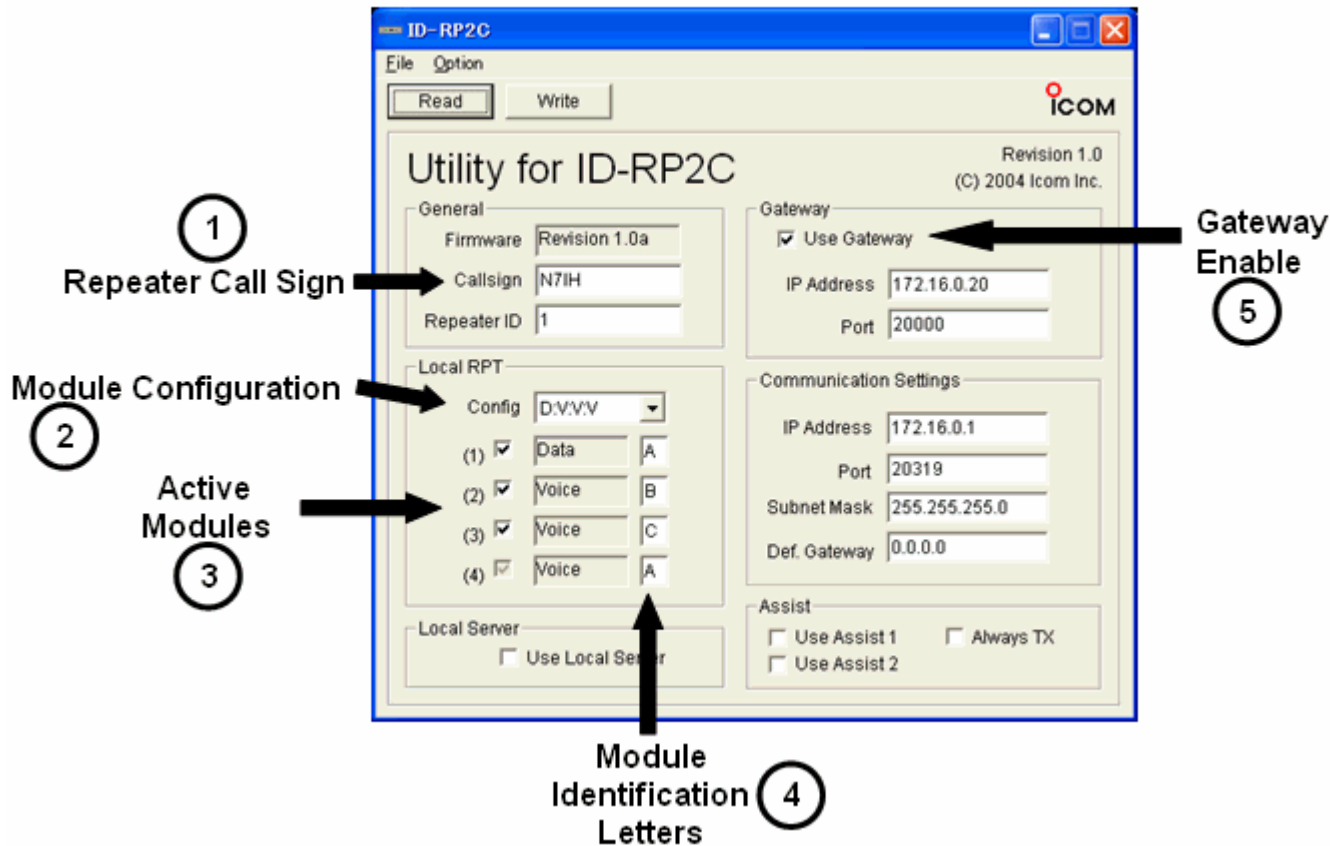
Configuring a D-STAR Repeater Controller

Connect the Ethernet cable to the 10-BASE-T jack (an RJ-45 modular connector) on the controller's front panel. Configure the PC's Internet TCP/IP protocol to manually enter an IP address for the connection. (This is done via the Windows Network Connections window.)

Start the IC-RP2C configuration software and enter the controller's IP address in the "Network Setup" screen. The default IP addresses for the controller as shipped from Icom are either 172.16.0.1 or 172.16.0.10. Click "OK". The ID-RP2C configuration software window will appear.

Click the "Read" button. In the subsequent "Network Password" window enter the password, which is "PASSWORD". You will now see the ID-RP2C configuration software window as shown in Figure 8-2.

RP2C Configuration Software



Step One - Enter the repeater's call sign. Remember that this must be a unique call sign within the entire D-STAR network. This is the repeater's D-STAR network identity to all D-STAR users.

Step Two - Select a “module configuration” from the drop down menu. The example shown is for a single DD module and three DV modules. Select the configuration that matches your repeater.

Step Three - Enable the active modules by clicking in the check box. If your repeater has fewer than four modules, the lower checkboxes and labels will be blank or greyed-out. The modules must be physically connected to Port 1 to 4 on the controller in exactly the same order as shown on this screen.

Step Four - Assign each active module a different identification letter. These are the letters by which users will identify the modules on which they want to operate. If an ID-RP2V or ID-RP2D module are included in the system, they must both be assigned the letter “A”. This is due to the controller’s internal software requirements.

Step Five - If the repeater will use a gateway, click “Enable Gateway” to tell the controller that the gateway interface will be active.

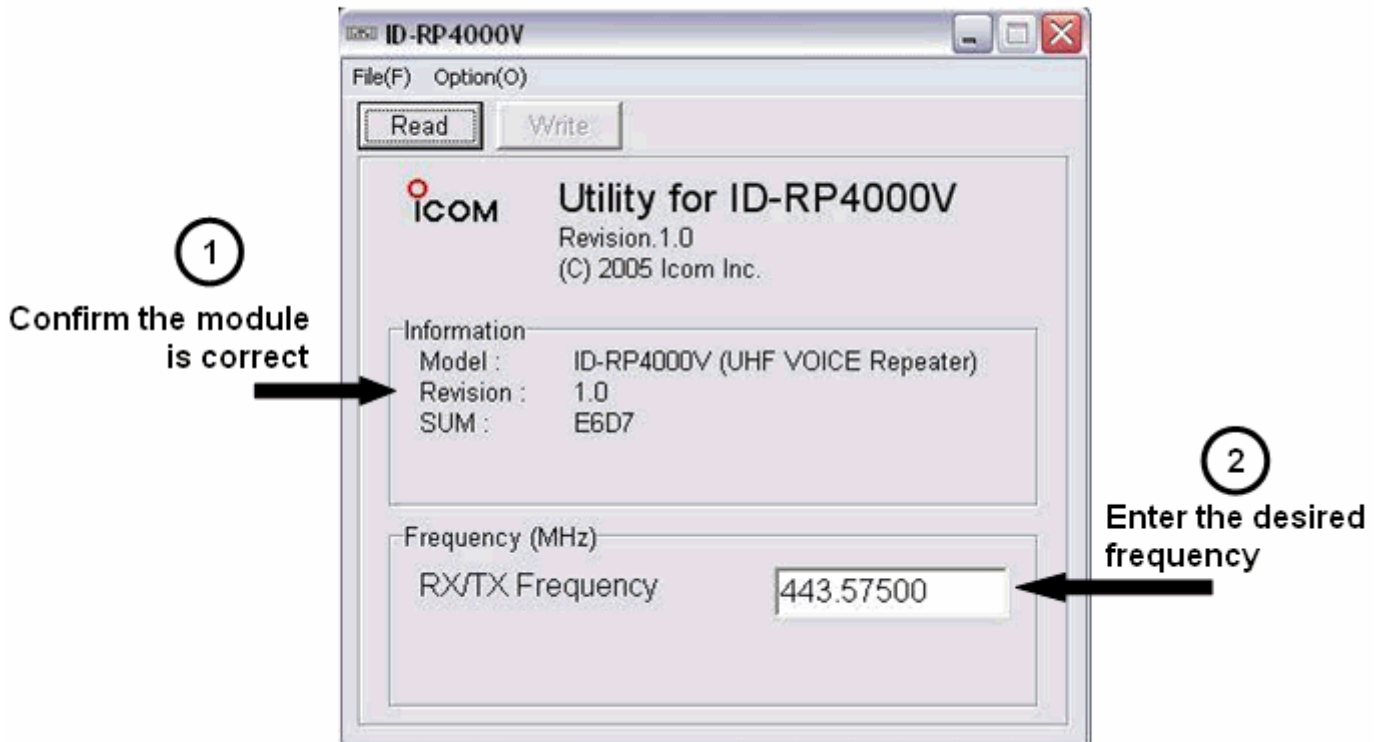
This completes controller configuration.

Configuring a D-STAR Repeater Module

The D-STAR repeater module’s control and programming is done using a USB interface on the module. There are two USB ports on each repeater module; one for the transmit (TX) frequency and the other for the receive (RX) frequency. Plug the USB A-B cable into the module and computer.

The Windows “Add New Hardware” wizard will be launched by your PC and the appropriate USB drivers will be installed. Launch the repeater modules software [Brian, please add the appropriate name for the software.] which will then interrogate the module and display the frequency programming window shown in Figure 8-3. Enter the desired frequency for the module and click OK. That’s easier than ordering a set of crystals, isn’t it?

Repeater Module Frequency Selection



Windows is a trademark of the Microsoft Corporation.

Icom D-STAR On-Line Course

Lesson #9

Lesson Title: The D-STAR Gateway - Configuration & Operation

Summary

In this final lesson, the student learns about the steps necessary to create the gateway and connect it to the D-STAR system. As with the previous lesson, this is not intended to be a step-by-step set of instructions. The details of configuration will be found in the operating manuals for the various pieces of equipment and software.

Basic Requirements

The D-STAR gateway must be assigned a fixed or *static IP address* and be provided with a broadband Internet connection, such as those provided by a DSL or cable connection. Whether your Internet connection router is a standalone device or included in a broadband gateway modem-router, it will need to provide or implement the following:

Class "A" internal *subnet* (LAN) 10.0.0.1 / 255.0.0.0

Port forwarding

Setting a fixed IP address, such as for *PPPoE* for *WAN*

Note also that Icom's gateway software is a proprietary, licensed vendor product, and can not be copied, shared or re-distributed. It is not part of the open D-STAR protocol.

If you are unfamiliar with the Linux operating system or with basic computer networking, it is strongly recommended that you obtain assistance before attempting to install or configure D-STAR gateway systems. For all of the following instructions and when editing or entering data, pay particularly close attention to detail. The syntax of the information is very important--errors will likely cause the software to fail or operate improperly. **Bold** text indicates a file name.

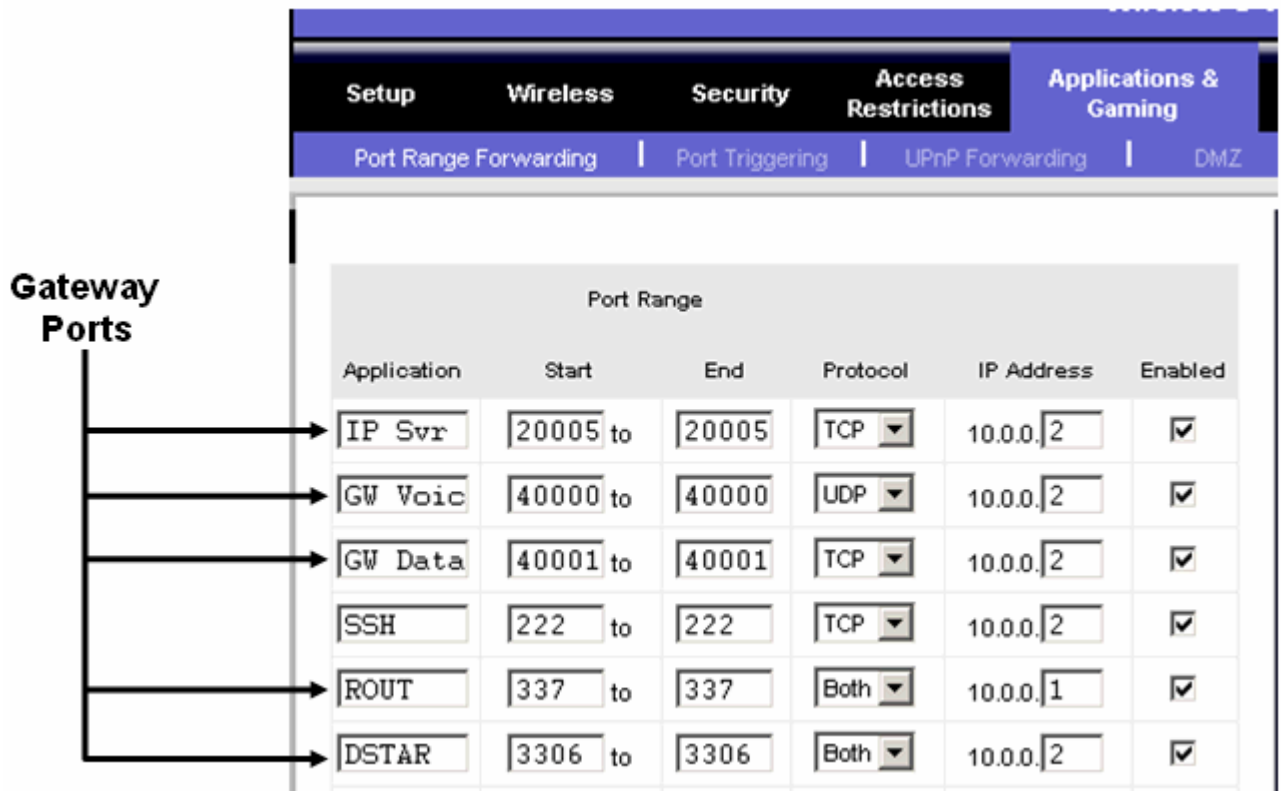
Gateway Router

The gateway router--the interface between the gateway server and the Internet--must be configured to support the server software as follows:

- 1) Make sure the router's "local IP" settings are set as follows:
Local IP address: 10.0.0.1
Subnet mask: 255.0.0.0
- 2) Set the router to forward the following ports:
Data sync: 20005, Protocol - TCP, IP Address - 10.0.0.2

Voice RX: 40000, Protocol - UDP, IP Address - 10.0.0.2
 Data RX: 40001, Protocol - TCP, IP Address - 10.0.0.2
 SSH: 222, Protocol - TCP, IP Address - 10.0.0.2
 Monitor: 3306, Protocol - TCP & UDP, IP Address - 10.0.0.2

Figure 9-1 shows the port forwarding configuration screen for the Linksys WRV54G router as an example. The router is then ready to support the gateway.



Gateway Server Configuration

The gateway software is hosted by a Linux®-based PC. All of the following instructions are based on the Fedora™ Core 3 or Fedora Core 4 version of Linux. The PC on which the gateway server and gateway software will run must meet the following minimum requirements:

- Linux OS (recommend Fedora Core 3 or 4)
- Pentium-grade 2.4 GHz or faster CPU
- At least 512MB RAM
- 2 LAN cards (NIC from Intel recommended)
- At least 10 Gb hard drive free space

Ethernet Port Configuration

The host PC must have two Ethernet ports, eth0 and eth1. Eth0 is configured as a LAN port and will be connected to the router. Eth1 is configured to connect to the ID-RP2C controller. Both ports will have static IP addresses. In the “Ethernet Port” configuration screen set up Eth0 and Eth1 as follows:

Eth0

Select “Statically Set IP Address”

Address: 10.0.0.2

Subnet Mask: 255.0.0.0

Default Gateway Address: 10.0.0.1

Select “static IP” for eth1 as well and enter the proper settings.

Eth1

Select “Statically Set IP Address”

Address: 172.16.0.20

Subnet Mask: 255.0.0.0

Default Gateway Address: none

The gateway server must be physically located at the repeater. The segment of the LAN that connects the controller to the gateway (Eth1 - 172.16.0.20) is very sensitive to latency!

Network Configuration

In the “Network Configuration” configuration screen, the DNS server’s address should be set to 127.0.0.1.

D-STAR Gateway Database

You will need to create the local database used to maintain connections with other repeaters and services on the D-STAR network. This requires the following steps:

- 1) Add the information shown in the configuration guide to the **named.conf** file as shown in the gateway software manual.
- 2) Create a folder named “dsipsvd” in the /var/named/chroot/var directory.
- 3) Create the local database, named **dstar.local.db** in the /var/named/chroot/var/named/ directory. The database file should contain the information shown in the configuration guide--syntax is critical. Errors in the “named” service configuration is a common cause for the gateway to not operate properly.
- 4) Re-start the Linux “named” service.
- 5) From the Edit Runlevel menu, select Runlevel 3
- 6) Click “named” and then Restart
- 7) From the Edit Runlevel menu, select Runlevel 5
- 8) Click “named” and then Restart

Use a terminal window to test the router and verify that the correct IP address has been entered by entering “dig router.dstar.local” In the “ANSWER SECTION” you should see the router’s IP address - 10.0.0.1.

Trust Servers

A trust server, USRoot, is provided as a service to the D-STAR community by K5TIT in Dallas TX. You can use your own private trust server to create your own D-STAR network or you can link to the USRoot trust server in Dallas, if desired. Any PC running the D-STAR gateway software can be configured to be a trust server to create your own private network.

Gateway Software

Installation

The D-STAR gateway software is supplied as a self-extracting file. Be sure to extract the program to the “dstar” folder in the “root” directory.

Configuration

Once the software has been installed, open the file **dsipsvd.conf** to set up the following pieces of information:

TRUST_SERVER - the IP address of the trust server you have chosen

ZR_CALLSIGN - the call sign of the zone repeater (the repeater with the D-STAR gateway for your zone)

IPSV_ADDR - the IP address of the gateway server

DNS_ZONE_FILE_PATH - the location of the **dstar.local.db** file

NAMED_PID_FILE - the location of the **named.pid** file

Next, acquire the MAC address of the Eth0 port by typing the command “arp” in a terminal window. Look for the line that shows Eth0 connected to an IP address of 10.0.0.1. Record the MAC address on that line. That is the MAC address of the NIC card of the Eth0 port.

Open the **dsgwd.conf** file and set up the following pieces of information:

ZR_ADDR - the address of the zone repeater server, set to 172.16.0.10

ZR_CALLSIGN - the call sign of the zone repeater

DNS_MAC - the MAC address of the Ethernet device used to connect to the DNS server.

In the **/etc/syslog.conf** file, add the following lines to set up the D-STAR log files (the first line, beginning with #, is a comment):

```
# for D-STAR
local0.* /var/log/dsgwd.log
local2.* /var/log/dsipsvd.log
```

Make sure to type “local” immediately before the number with no spaces.

Next, modify the startup script **/etc/rc.d/rc.local** to automatically run the D-STAR gateway software by adding this line anywhere in the file:

```
/dstar/exec-mgsv
```

Set the software’s default runlevel to “3” by opening the file **/etc/inittab** and changing the line

```
id:#:initdefault:
```

so that the pound sign (#) is replaced by “3”.

This completes the configuration of the D-STAR gateway software. Restart the Linux system.

Testing the Gateway

After the system starts, from the SSH Shell, type:

```
ps -ef | grep dstar
```

and you should see at least the following pair of programs running:

```
/dstar/dsipsvddsipsvd - this is the gateway server
/dstar/dsgwd/dsgwd - this is the gateway itself
```

Without both programs running, the gateway will not be functional! If the programs are not running, check the log file at:

```
/var/log
```

The log files from both programs should be being saved as:

```
dsipsvd.log
dsgwd.log
```

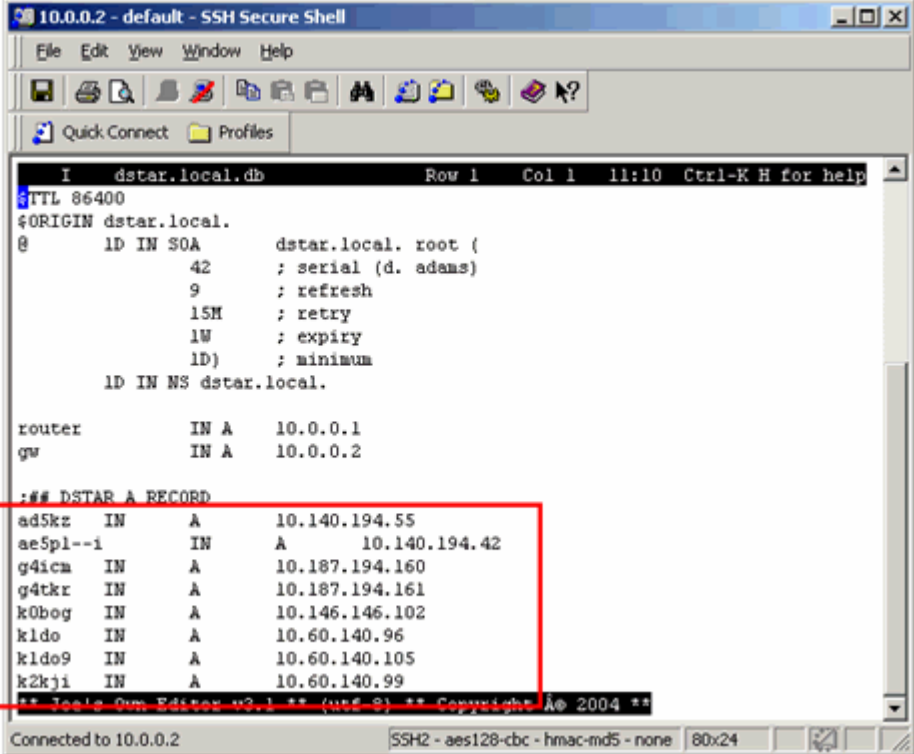
D-STAR System Sync

Once your gateway is up and running, it will synchronize itself with the rest of the D-STAR network. The easiest way to see if it synchronized is to look at the **dstar.local.db** file.

Open the file:

/var/named/chroot/var/named/dstar.local.db

If the gateway has been synchronized, you will see a list of other D-STAR gateway servers and their IP addresses as shown in Figure 9-2.



```
10.0.0.2 - default - SSH Secure Shell
File Edit View Window Help
Quick Connect Profiles
I  dstar.local.db  Row 1  Col 1  11:10  Ctrl-K H for help
$TTL 86400
$ORIGIN dstar.local.
@      IN  SOA      dstar.local. root (
        42      ; serial (d. adams)
        9       ; refresh
        15M     ; retry
        1W     ; expiry
        1D)    ; minimum
      IN  NS      dstar.local.

router  IN  A      10.0.0.1
gw      IN  A      10.0.0.2

;## DSTAR A RECORD
ad5kz  IN  A      10.140.194.55
ae5pl--i  IN  A      10.140.194.42
g4icm  IN  A      10.187.194.160
g4tkr  IN  A      10.187.194.161
k0bog  IN  A      10.146.146.102
k1do9  IN  A      10.60.140.96
k2kji  IN  A      10.60.140.99
** Tools: Sun Editor v3.1 ** (utf-8) ** Copyright A 2004 **
Connected to 10.0.0.2  SSH2 - aes128-cbc - hmac-md5 - none 80x24
```

The gateway software uses 3 tables:

- RIP – Reserved IP addresses
- GIP – Gateway IP addresses
- MNG – Call sign manage table

The backup tables are stored in the **/var/dsipsvd** folder. The files being used by the gateway are resident in memory after being downloaded from the trust server. You can “write” the tables to a text file to view, if desired. You can not edit them directly. All files are updated / merged automatically with the trust server and all the other gateways on the network at least once a day.

Adding Users to the D-STAR Network

Any user can operate locally on a D-STAR repeater, with or without their call sign in the registry. Only users that have been added to the gateway registry are allowed to cross the D-STAR gateway and access the D-STAR network. Once a user is added to the D-STAR gateway, they have gateway rights via any D-STAR gateway that is configured to use the same trust server.

Each user call sign is assigned a fixed IP address. The available IP addresses are assigned in blocks of 32 and can be viewed by entering the command

```
cat /tmp/dsipsvd-cmdout
```

Record the range of IP addresses for use in registering new calls.

The exact syntax of the “add user” command is shown in the gateway software manual. Along with the range of IP addresses, the following information is required:

User ID - the users call sign, it must be 8 characters long, add spaces to pad

Area Repeater Call Sign - the system call sign with the letter [A] in the 8th position, use spaces between the call sign and the [A]

Zone Repeater Call Sign - the zone repeater call sign, it must be 8 characters long, add spaces to pad

GW IP Address - the public fixed IP address of the gateway server

Users Assigned IP Address - the address assigned to the user by the local address coordinator (one of the IP addresses recorded earlier)

Alias Name for DNS - the user’s call sign, in lower case, padded with spaces at the end if necessary.

The following is an example of a “add user” command to add W7JRL to the N7IH registry. * represents a space in this example:

```
add W7JRL71*|N7IH9**A|N7IH9***|65.102.167.146|10.140.194.xxx|w7jrl71" >  
/tmp/dsipsvd-cmdin
```

Going Live!

Before attempting to go “live” on the D-STAR network you must verify that you are 100% functional on the Icom test system. If you have ANY questions, contact Icom. This will avoid corrupting the network databases that would inconvenience many D-STAR users.

Once operational on the “test” network, you need to “kill & clean” your gateway, change the TRUST_SERVER IP address, and re-boot the gateway PC. Simply re-starting the gateway software will not do the job!

To “clean” your system and start fresh (on the live network), begin by killing all active D-STAR services:

- 1) Execute a 'ps -ef | grep dstar' command. This will provide the process numbers for the dsgwd & dsipsvd processes.
- 2) Execute a 'kill xxx' command, where 'xxx' is the process number revealed in step one, for each of the two processes.
- 3) Execute a 'rm /var/dsipsvd/*.*' command. This should completely clear the /var/dsipsvd directory.
- 4) Edit the file /var/named/chroot/var/named/dstar.local.db with a text editor and delete any call sign entries after “#DSTAR A RECORD”.E
- 5) Execute a 'cat /etc/dsipsvd.conf' command, and ensure that your TRUST_SERVER points to the proper server IP for the desired network. Use a text editor to change the TRUST_SERVER IP, if needed.
- 6) If you are creating or cleaning your own D-STAR network, you can execute the cleanup on the TRUST_SERVER, and have it ready. (Do not perform this step if you are joining an existing D-STAR network.)
- 7) Execute a ‘reboot’ command on your gateway.
- 8) The gateway will run and download new database files from the TRUST_SERVER, then re-sync with each of the other gateways.

All gateways pointed to the same trust server share the same GIP, RIP and MNG tables. These tables can not be changed or “cleaned-up” independently. Going live requires that all connected gateways to be “killed” and “cleaned” first.

Once all connected gateways are “killed”, the trust server files can be edited, but only before any gateway is re-booted. When the gateways are “cleaned” and re-booted, they will download the new GIP, RIP and MNG tables from the TRUST_SERVER.

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Icom D-STAR On-Line Course

Lesson #10

Lesson Title: D-STAR Review & Final Exam

Summary

This lesson consists of a selection of items from the review sections of Lessons #1 - #9. The Final Exam consists of twenty questions selected from the individual lesson exams.

D-STAR Review

Lesson #1 - Introduction

D-STAR is a public communications standard owned by JARL.

D-STAR is an open system - any equipment complying with the published standard can use the system.

D-STAR applies to a communications system's air link and the repeater-to-repeater gateway interface.

D-STAR specifies the type of codec that performs digitization of analog signals.

Digital data is transmitted by the D-STAR system without modification.

The D-STAR gateway interface may use with the Internet or radio links.

Lesson #2 - D-STAR Characteristics

From the perspective of the D-STAR user, data and voice are carried at different rates and managed in different ways, but over the air, they are contained in *packets*.

D-STAR's DV mode combines digitized voice and digital data signals.

The D-STAR codec digitizes voice by using the AMBE 2020 codec.

AMBE stands for Advanced Multiple Band Encoding and 2020 designates the particular variation used by D-STAR.

D-STAR uses AMBE at 2.4k bits per second (bps) rate which gives a good compromise between intelligibility and the speed at which data must be transmitted via the radio link.

AMBE adds information to the voice data that allows the receiving codec to correct errors introduced during transmission.

D-STAR's DV mode carries 8-bit digital data at 1200 bps and uses a three-wire RS-232 or USB 1.1 interface.

D-STAR's DV and DD modes require the sender and receiver to perform flow control by using special data characters. This is called software flow control.

FCC bandwidth and data-rate regulations permit D-STAR DV signals to be transmitted on any VHF or UHF band.

D-STAR's high-speed data mode is called D-STAR DD. In this mode, the voice signal is dropped and the packets are dedicated completely to digital data.

The DD mode data interface is an Ethernet bridge between two fixed network addresses. The physical connection is a standard RJ-45 jack.

The net data rate of DD mode is comparable to or better than a high-speed dial-up Internet connection.

FCC regulations restrict high-speed data signals like D-STAR DD to the 902 MHz and higher bands.

Gateways communicate over the D-STAR backbone using the Asynchronous Transfer Mode (ATM) protocol at up to 10 Mbps.

Lesson #3 - D-STAR Protocol Basics

D-STAR packets consist of a *header* segment and a *data* segment.

Data segments are sometimes referred to as *payloads*.

The header segment contains information about the packet the receiving device needs to process the data, whether that means reading and acting on the data or just forwarding it on to another receiver elsewhere in the system.

The header and other information added to the original set of data creates packet overhead. It is most efficient to send the maximum amount of data in each packet.

Protocol overhead refers to the time it takes for a packet's receiver to process and acknowledge the packet. D-STAR does not incur protocol overhead.

D-STAR encapsulates data formatted according to the AMBE and Ethernet protocols.

The header segment is the same for both the DV and DD packets.

Sync frames are unique patterns of bits that the receiver can use to unambiguously determine that a packet is beginning.

The bits in the control flag bytes are used to direct the processing of the packet.

Identification fields carry information about the origin and destination of the packet and the data it carries.

Error detection codes such as checksums are used to detect transmission errors. These only tell the receiver that the data is damaged, but not how. D-STAR uses a checksum to protect the header data and the DD packet includes a checksum as part of the Ethernet data payload.

Error correcting codes contain information about the payload data. Because the codes are sent with the data to enable correction at the receiver, they are called Forward Error Correcting or FEC codes. FEC codes contain enough extra information for the receiver to repair most damage. D-STAR includes FEC codes in the AMBE 2020 digitized voice data.

Digital data sent via DV packets is not protected by error detection or correction.

Lesson #4 - D-STAR Network Operation

Each D-STAR packet can carry up to four different call signs. The types of call signs are:

- Own Call Sign - the call sign of the user making the transmission
- Counterpart Call Sign - the call sign of the station the user wishes to or is in contact with
- Sender Repeater Call Sign - the repeater and specific module (A-D) through which the user intends to communicate
- Receiver Repeater Call Sign - the repeater and specific module (A-D) through which the station identified by Counterpart Call Sign will communicate

All D-STAR transmissions not over an Internet link are public and can be monitored by anyone, just as on analog repeaters. There are no "private conversations" on the D-STAR network.

D-STAR call signs of users or repeaters may be up to 8 characters long.

If the character string “CQCQCQ” is present in the Counterpart Call Sign field, it indicates that the calling station wishes to talk to any station.

D-STAR suffix characters are separated from the call by spaces and must be in the 8th position of the call sign.

Each D-STAR repeater can have up to four modules that handle voice or data, each identified by a letter; A, B, C or D. By adding the module identifier after a repeater call sign, the packets are routed only to that module.

D-STAR repeater modules can be linked into zones.

A D-STAR gateway is the Internet connection for a D-STAR repeater.

A D-STAR Zone consists of all of the repeater modules that share a common gateway.

The slash character “/” added before a repeater call sign indicates that the information in the packet is to be distributed to all repeaters in the zone of which that repeater is a member.

Adding a “G” to a repeater call sign indicates that the communication is to take place via the repeater’s gateway.

The D-STAR registry is a database of user call signs registered on the D-STAR network by repeater system operators. Each D-STAR gateway has a copy of that database, which is maintained by several D-STAR *trusted servers* located around the world. Each D-STAR repeater gateway database is updated a number of times each day.

Each time a registered user transmits via a D-STAR repeater, the user’s location is updated in the master registry where it will be provided to all D-STAR gateways.

Lesson #5 - D-STAR Radios

To determine which is the best radio for an application, the first step is to understand what the requirements are:

- Is DD mode operation required (high-speed data)? If so, the only radio supporting DD mode is the ID-1.
- Is dual-band operation required?
- Is high-power required?
- If data is to be transmitted, what data interface does the computer have?

Key items to remember when choosing the right D-STAR technology:

- High-speed data (DD mode) can only be sent on the bands above 70 cm.
- Error correction for low-speed data (DV mode) is the responsibility of the data communications programs used to exchange data.
- RS-232 interfaces for D-STAR data do not provide data flow control hardware signals, such as RTS or CTS.
- Higher power radios will result in stronger signal strengths and fewer data transmission errors.
- If data is to be transmitted while in motion, higher frequencies will result in fewer transmission errors, improving the net data exchange rate.

D-STAR radios may all have slightly different labels, keys, and sequences of operation, but under the surface they all use the same sets of D-STAR information.

Multiple memories are available for MY CALL SIGN if the radio is shared by more than one operator or if you frequently operate away from home or with a club call sign.

D-STAR radios can take advantage of the information contained in each packet to provide functions based on the data.

- AUTO REPLY - automatically reads all of the calls in the received packet and sets the radio to reply correctly without any call sign entry being required.
- BREAK IN - allows you to enter a conversation if the stations are using CALL SIGN SQUELCH (see next item)
- CALL SIGN SQUELCH - mutes the receiver output audio unless packets addressed to MY CALL SIGN are received
- EMR - enables full audio output whenever an EMR call is received
- RX CALL SIGN AUTO WRITE - temporarily stores the call sign of the calling station
- RPT CALL SIGN AUTO WRITE - temporarily stores the call sign of the repeaters used by the calling station

The squelch function of digital radios does not function the same way as for an analog radio. Instead of “opening” the squelch to hear unmodulated white noise, the squelch selects between DCS (Digitally Coded Squelch), CSS (Call Sign Squelch), and no squelch.

D-STAR supports the exchange of short text messages, similar to Internet Messaging (IM) or a mobile phone’s Short Messaging Service (SMS).

Low-speed data transmission in the PTT mode does not occur until the PTT switch is closed on the radio or at the microphone jack (either by a microphone or an external circuit). While PTT is closed, the radio transmits whatever data it receives. In AUTO mode data is transmitted as soon it is sent to the data interface.

Lesson #6 - D-STAR Local Use

You do not have to enter any call signs for the radio to receive D-STAR packets. Once your radio is tuned to an active channel frequency, you can hear every conversation.

A D-STAR radio is silent until D-STAR packets are received, then the decoded digital voice will be heard over the speaker as long as the signal is strong enough to receive the packets properly.

When CSS is turned ON and a call sign entered, the radio will remain silent until D-STAR packets containing the specified call sign are received.

All digital information is carried by the D-STAR packet as “plain text.”

To make a transmission not directed to any specific station, use the special text string “CQCQCQ”.

The presence of call signs in D-STAR packets lets the radio acquire them automatically.

D-STAR uses the EMR function to alert all stations within range that an urgent or emergency situation exists. This function depends on the value of Bit 3 of the Flag 1 control byte of the D-STAR header.

A transmission can be directed to a specific station by storing that station’s call sign in the Counterpart Call Sign field.

To use a D-STAR repeater, you must store the repeater’s call sign in the Sender Repeater Call Sign field.

In a D-STAR zone, a call or transmission can be relayed to the entire zone by adding a slash character “/” before the repeater’s call sign.

Lesson #7 - D-STAR Gateway Use

The D-STAR gateway is not a “thing”, but rather a “connection.” The gateway is software that runs on a PC connected to the controller of a D-STAR repeater.

The D-STAR gateway only sends digitized signals to other repeaters when directed to do so by the information in a received D-STAR packet.

The only time you will hear a signal from a remote D-STAR system is when the station that generates the signal directs the gateway to send it to your repeater or repeater zone.

D-STAR packets not being relayed to other repeaters aren't handled by the gateway and so will not be heard elsewhere.

Adding a "G" to a repeater call in the Receiver Repeater Call Sign field tells the D-STAR repeater to send the transmission via the gateway.

The "G" must be in the 8th available space in the call sign.

D-STAR repeaters can support up to four radio modules.

Each module is assigned a unique letter identifier; A, B, C, or D.

If you do not specify a module, the controller will default to repeating your signal on the same band on which it was received.

If the module you specify operates on a different band, you will then be operating cross-band!

If you choose to specify the module the station you are calling must be listening on that band.

Lesson #8 - D-STAR Repeater

At a minimum, a D-STAR repeater must have a controller and at least one module.

The repeater consisting of a controller, module, and RF link can provide all of the D-STAR network services.

Each repeater must have a unique call sign for the repeater, such a club call sign.

One ID-RP2C repeater controller is required for each D-STAR repeater. Modules can not function without a controller.

D-STAR repeater modules perform the same functions as do transmitters and receivers in an analog repeater system.

A separate antenna connection is required for each module.

The modules process only D-STAR digital signals. An analog signal on a D-STAR module's input frequency is not demodulated or retransmitted.

Each module is connected to the controller at a separate port. There are four module ports on the controller and each can be connected to a DD or DV module.

The controller is configured via an Ethernet connection to a Windows-based PC running the ID-RP2C controller configuration software.

Each controller port must be configured to connect to a specific type of repeater module. The modules must be physically connected to Port 1 to 4 on the controller in exactly the same order as shown on this screen.

Each repeater module must be assigned a module identification letter. This letter allows D-STAR users to select a specific module within a repeater.

If the controller is to be attached to a gateway, that function must be enabled during configuration.

The D-STAR repeater module's control and programming is done using a USB interface on the module. There are two USB ports on each repeater module; one for the transmit (TX) frequency and the other for the receive (RX) frequency.

Lesson #9 - D-STAR Gateway Configuration

The D-STAR gateway must be assigned a fixed or static IP address and be provided with a broadband Internet connection, such as those provided by a DSL or cable connection.

Icom's gateway software is a proprietary, licensed vendor product, and can not be copied, shared or re-distributed. It is not part of the open D-STAR protocol.

The gateway software is hosted by a Linux®-based PC based on the Fedora□ Core 3 or Fedora Core 4 version of Linux.

The host PC must have two Ethernet ports, eth0 and eth1. Eth0 is configured as a LAN port and will be connected to the router. Eth1 is configured to connect to the ID-RP2C controller. Both ports will have static IP addresses.

The gateway server must be physically located at the repeater due to latency requirements.

The local D-STAR database is named `dstar.local.db` and is maintained on the gateway PC.

Several trust servers, such as USRoot, are maintained around the world to the D-STAR network. You can also use your own private trust server to create your own

D-STAR network. Any PC running the D-STAR gateway software can be configured to be a trust server to create your own private network.

Once your gateway is up and running, it will synchronize itself with the rest of the D-STAR network. The easiest way to see if it synchronized is to look at the **dstar.local.db** file for a list of other D-STAR gateway call signs and IP addresses.

D-STAR gateway database files are updated / merged automatically with the trust server and all the other gateways on the network at least once a day.

Any user can operate locally on a D-STAR repeater, with or without their call sign in the registry.

Only users that have been added to the gateway registry are allowed to cross the D-STAR gateway and access the D-STAR network. Once a user is added to the D-STAR gateway, they have gateway rights via any D-STAR gateway that is configured to use the same trust server.

The Icom test D-STAR system is provided to allow gateway administrators to test their system before “going live.” To go live on the full D-STAR network, it is necessary to “kill & clean” the gateway so that the D-STAR databases will be downloaded from the trust servers.