The Newbie's Guide to Using D-Star

How to get the most out of your new D-Star transceiver

V2.0

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Forward to Version 2

It is 5 years since I wrote the original version of this document. In that time there has been a new generation of commercial D-Star radios come out (that feature the DR mode amongst other things) and a number of new devices (e.g. the DVAPs) that were not covered previously in this booklet. Also there has been an upsurge in the number of reflectors available and these were not adequately covered in the original version. The basics still remain but it is time to revise and expand the booklet.

I have also added a “Quick Start” guide at the front. One of the frequently heard comments from people who have bought a new D-Star radio is that they cannot get it working. The “Quick Start” guide lists the things that need to be done but does not explain the ‘how’ or ‘why’; that is the job of the rest of the booklet.

If you read this booklet, I hope that you would find everything you need to get going but, if you are like me, then the manuals and guides come out when all else fails.

Purpose of this booklet (Forward to Version 1)

This is the booklet I needed when I bought my first D-Star transceiver.

D-Star is sufficiently different to the standard analog means of communication to make it a rather frustrating experience if you don’t go about it the right way.

You must first read the manual[1] that came with the radio. It will tell you how to use the various features of the radio. Unfortunately the radio’s manual told me EVERYTHING the radio can do, but not when to use a particular feature, or why, or even if using a feature was necessary.

Therefore this booklet is intended to give you a gentle introduction to D-Star, let you know what is important, especially to get you started, and to let you then understand what the manual is telling you about your radio. It should also help you understand your DV Dongle, DVAP or other device that you have.

While I have used examples based on the Australian D-Star setup and repeater naming conventions etc., you will need to apply the rules and conventions from your local area. This includes who can legally transmit using D-Star as there may be restrictions – there are in Australian where the Foundation License holders currently not allowed to transmit using the D-Star system.

Layout of the Booklet

To understand D-Star requires a bit of theory and a definition of terms, concepts and protocols that, by themselves, might not make much sense. We need to build on these later to provide a full understanding of the abilities and capabilities of the radio. We’ll start with a few of the necessary foundations.

1 See Appendix 2

We begin with a “Quick Start” guide that should (!!) let you get on the air fairly quickly. This part just mentions the tasks you need to perform without going into any of the “whys’ and wherefores’” which are all covered later on.

Read Section 1 (D-Star Basics); do not skip or skim read it. It doesn’t matter if you think you know some of it already. Read and understand this section before you go on.

Section 2 (D-Star Usage Scenarios) takes a ‘play as you read’ approach to build up your knowledge and experience in bringing the various bits of information from the first section together. It starts with some basic uses of the D-Star network and builds up to more advanced configurations.

Section 3 (Technical Aspects of D-Star) brings in content from several other documents that I’ve written that cover the more technical aspects of how D-Star works. None of this is necessary if you simply want to use a D-Star radio, DVAP or Dongle. However I find that an understanding of what goes into a D-Star device provides a better appreciation of how D-Star works and what can be done with it.

At the end, you will find several appendices that provide additional information. A reference is made where an appendix augments that main text[2].

Strangely enough, the use of D-Star radios for simplex communications is relegated to an appendix. This is not because simplex is not that good or is a ‘poor cousin’ but because the real power of D-Star is its ability to use the internationally linked repeater and reflector network. Unfortunately with real power comes real complexity and confusion if you are not careful and methodical in your approach.

Recently some of the commercial radios have allowed the “DV” (Digital Voice) mode on the HF bands. The D-Star repeaters are all on the VHF/UHF and SHF bands and many of the older D-Star radios restricted DV mode to those frequencies. However allowing D-Star on the HF bands has opened up a lot of experimenting with HF simplex contacts but also raised the question of the legitimacy of using the D-Star modulation (and in particular the 6.5KHz bandwidth) on some of the lower frequencies. The regulations around this vary from country to country and also what is permitted in different bands. I’m not going to comment on this other than to say you should check the regulations that apply to your region and band allocation.

I have deliberately been repetitive in this document, so that after reading through the whole thing once, you can read individual sections for reference.

OK, let’s get started.....

[2] See footnote 1 for an example

Quick Start Guide

Step 1 – Register!

While you can use a D-Star radio as a simplex device and also to use the local repeater for local, non-gateway access (much the same as a non-D-Star repeater) you cannot use the more advanced features of the D-Star network without being registered.

BE WARNED that registration can take a number of days to complete, and that there are 2 parts that you need to do. Therefore start as soon as you can – you don't need your D-Star device to register but you can't really use it without registration.

Part 1:

1) Locate a nearby and convenient gateway
   Google and other Internet search tools can assist you here

2) Create an account on the gateway
   Remember the gateway and password that you have selected

You will be sent an email telling you that you have created an account and that the administrator will send another email when the account is confirmed.

Part 2:

3) When you have received the 2nd email from the gateway administrator approving your application, log back in to the gateway and create (at least) one "terminal" or "PC Name" (typically given a name of your call sign)

You are now registered and can use the D-Star system

Step 2 – Basic Radio Setup

This step will vary depending on what radio or other D-Star device you are using, particularly in the names of the various memories. However there are a couple of fundamental things you must set up

1) Enter your call sign in the "originator"[3] memory
   This is often called the "MY" or "MyCall" memory. This call sign is the same as you used to register on the D-Star system (in Step 1) and lets D-Star know that you are allowed access.

2) Enter "CQCQCQ⌂⌂"[4] in the "destination" memory
   This is often called the "UR" or "UrCall" memory

3 I explain the terminology I use for the csall sign names in the main part of this document

4 "□" represents a space character

3) Enter the call sign of the local repeater along with the port identifier you are using (e.g. “C” is the port normally used for 2 metres) in the “Repeater 1” memory

4) Enter the call sign of the local repeater along with the port identifier of “G” in the “Repeater 2” memory

The radio is now ready to tune to the correct repeater input/output frequencies and then use to contact other D-Star users.

See the main section below about how to program the numerous memories in the radio to make changing from one repeater/reflector to another.

Step 3 – Basic DV-Dongle Setup

A DV-Dongle lets you access the D-Star intranet[5] without any RF involved. However you do need a computer and some software as well as the Dongle. As the usage of the software will vary from program to program, I recommend that you look to the “help” files and also to see if there are support web forums for the program. However, some things will always be required.

The software will have equivalent to the “originator” memory (somewhere!) and it may well be called “My Call” or similar. This has the same function as for a D-Star radio in that it identifies you to the system and lets you access it as a registered user.

Dongles typically connect you to a reflector but you can also connect to repeaters. However you generally need only refer to the reflector name/repeater call sign and the port name. There is no need for the “destination” setting as this is assumed to be “CQCQCQ⌂⌂” .

5 I told you I would not explain everything here – you have to read the rest of this document if you don’t know what terms like “intranet” mean.

Section 1
D-Star Basics

Introduction

Firstly, D-Star is a technical protocol, not a product! The D-Star protocol is publicly available and is non-proprietary. At the moment, Icom make a number of transceivers that use the D-Star protocol and other manufacturers may well follow in the future. There are also several amateur-driven projects underway to allow people to build their own equipment that will conform to the D-Star protocol, and the DV-Dongle is a commercial product that fits into this concept.

Just to confuse things, Icom have registered the “D-Star” name (at least in some countries).

I will not get into the technical details of the protocol itself; if you want to do that then there a number of web sites and discussion groups that will guide you as to where to find the information you need.

Rather, the approach here is biased towards how to use D-Star as it is embodied within various radios and other devices.

Unfortunately there is no nice, linear, way to approach the information in this section. You need to know about the structure of a call sign before you can register but you need to register before you can use your call sign on the D-Star network. Therefore I have tried to include all of the necessary information here but I suggest that you read it through twice: the first time you will see words and phrases that have not been explained but are discussed later on. The second time through should all make much better sense to you.

Guidelines for using D-Star

There are several guidelines that you are expected to follow when you use the D-Star system. These are above and beyond those specified by the various Amateur Radio guidelines and Government regulations established within a country or geographic region.

The D-Star guidelines are:

- Always listen for at least 10 seconds before you transmit
- Take note of the information on the display that the local repeater is sending to you immediately after you finish transmitting
- Make sure your transceiver/device is correctly set up with the (up to) 4 call sign values
- Leave at least a 4 second gap between overs
- Limit an over to less than 3 minutes (this is enforced by many D-Star repeaters and some reflectors which will drop your signal after 3 minutes)
- When establishing a contact, remember to set all of the necessary call signs (explained later in this document).

- ALWAYS make sure that your transceiver[6] is correctly reset after you have finished your QSO

These may not make a lot of sense right now, but they will as we go through how the D--Star network operates and how we use it to make a QSO.

Registering to use D-Star Repeaters and Reflectors

One area that often trips up new D-Star users is the need to register before you can access the repeater gateways and also many of the reflectors.

Registration is pretty much a necessity[7]. The real power of D-Star comes from being able to use a local repeater to access other repeaters and reflectors all around the world. Also, you can't use a DV-Dongle, DVAP or other similar device without registering as these devices use your registered call sign to let you get access to the D-Star Intranet. Registration is free and only needs to be done once so there is really no reason not to register.

Registration is something that can take a number of days to complete. Fortunately you do not need to actually have your D-Star device to begin the registration process; all you need to know is your call sign.

Registrations take place over the internet using your web browser by accessing a near-by gateway system. I suggest that you use the web site http://www.dstarusers.org/repeaters.php to locate a nearby repeater. You can click on the "Call sign" of the repeater and it will contain a URL in the "Gateway Registration URL" field in the "System Information" section:

6 This may also apply to any on-going repeater configuration that you have established.

7 You can, of course, use your radio in non-D-Star mode without registration. Also you can use D-Star voice in simplex mode. What we are talking about here is using the D-Star features of your radio and in particular, anything that requires your signal to pass through the local repeater gateway.

Click Here for the JFindu Repeater Listing for VK3RWN

System Information	
Callsign:	VK3RWN
City:	Melbourne
State:	Victoria
Country:	Australia
Website:	http://www.dstar.org.au
Gateway Registration URL:	http://www.dstar.org.au
Gateway Enabled:	YES
DSTARMonitor Enabled:	YES
ARRL Listed:	NO
Trust Server:	K5TIT

Clicking on the link will take you to another web page where you can either begin the registration process or follow the links to a suitable page.

Not all repeaters have an entry in the “Gateway Registration URL” field which means you cannot use that repeater to register. If that is the case, you can actually register on any gateway that does allow registrations but it is generally most convenient to choose one that is close to you. The only ‘trick’ is that you must remember which gateway you used to make your registration as you must always used that gateway for any changes you wish to make.

The registration web page should contain the necessary details of how you can register and there are a number of web sites that Google (or similar web search engines) will find for you with a search term such as “dstar registration”, but the main steps are as follows.

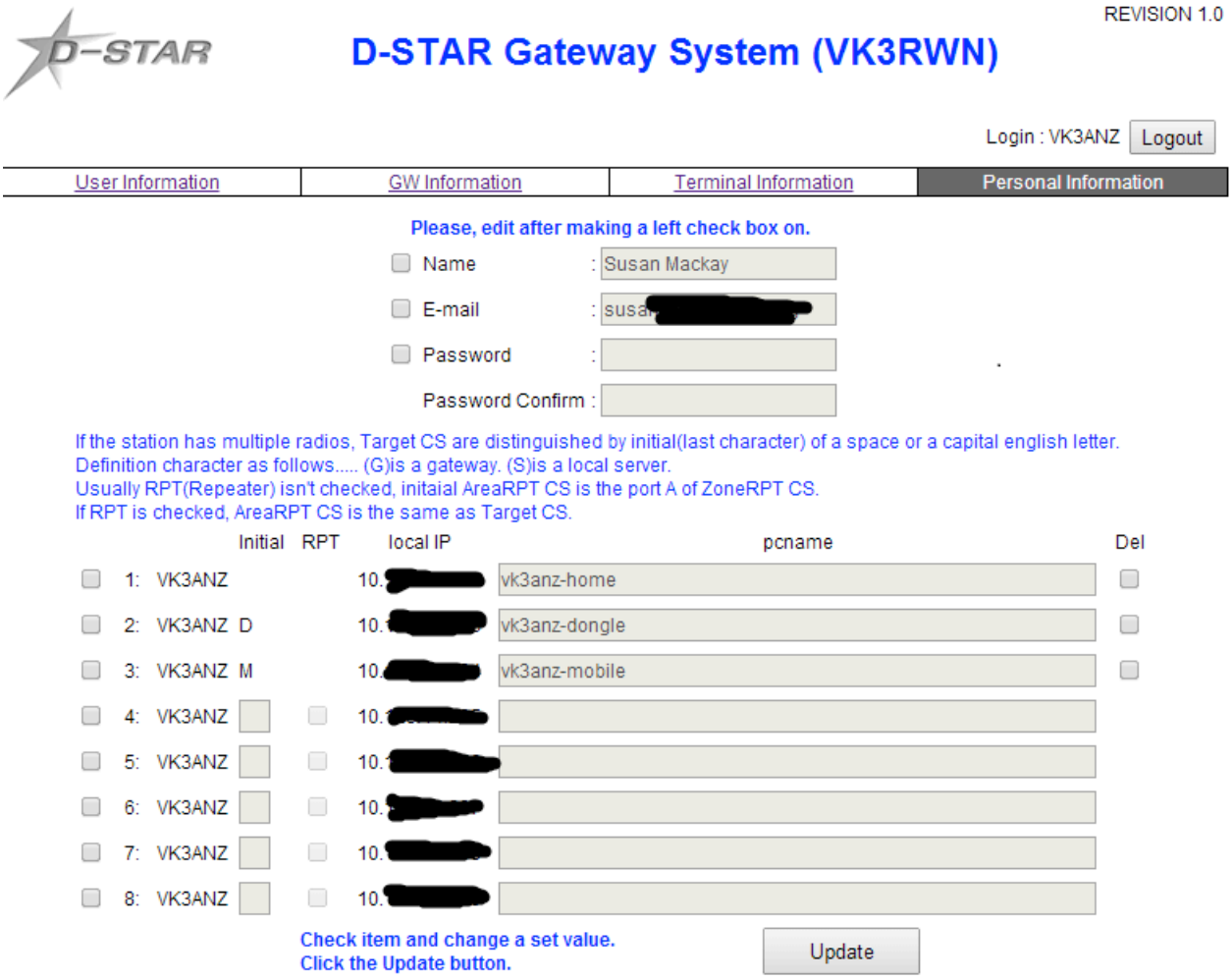
You need to create an account for yourself that is based on your call sign (in upper case characters). You can select your own password but you need to make sure that you remember it for later on. You will also need an email address of an active email account as you will be sent emails during the registration process (and possibly later).

That is the first part of the process. You should get an email saying that your registration request will be sent to an administrator for processing.

When the administrator has processed and approved your registration, you will receive another email. As I said, this processing can take a number of days to occur so be prepared for a bit of a wait.

When you get the approval email, your job is **not** yet finished and you will still **not** be able to use the D-Star system.

The second part is to log back on to the gateway you used before with your call sign and password. The important part of the next step takes place in the “Personal Information” section. You will see your name, call sign and password details (which you can edit if you need to later on) plus a (initially blank) list of “terminals”.



So what is a “terminal” and why is there something called a “pcname” with all of the IP addresses[8]? The simple answer is that this is all historical[9] but it all has to do with how your call sign is identified within the D-Star system for “call sign routing”.

Call sign routing is described in a later section but briefly it means that D-Star has the ability to automatically route any attempts to contact you by using your call sign to whatever was the last D-Star repeater that you used – anywhere in the world.

And this is why you can have multiple “terminals” or call sign variants registered with D-Star. The original idea is that you can assign your main call sign variant (without a trailing letter in the 8th place – see below for more details on the structure of call signs) to the radio you use most often. (In my case that might be “VK3ANZ⌂⌂”) You can also assign a separate variant when you use your dongle (e.g. “VK3ANZ⌂D” where the “D”

8 I’m not going to talk about IP addresses in this document other than to say that the D-Star network is an “Intranet” that uses “10-dot” addressing. If that makes sense then fine – if not then it really makes no difference to how you use D-Star unless you are still using an ID-1 for high speed data.

9 This is another way of saying “I don’t know”!

is for the dongle) and another for the D-Star radio in your car or the HT that you took overseas (say “VK3ANZ⌂M” for mobile).

Consider the situation where call sign routing could be very useful: when you take a trip overseas and your friends want to keep in contact, all you need to do is to access the D-Star repeater when you arrive in a new place and the network will then know where you are. Your friends can then enter your call sign into the “Destination” field of their radio and the D-Star network will automatically connect their local repeater to the last one you used. This works really well to let people contact you wherever you go.

But if you have different call sign variants for different radios, then which one should your friends use to contact you? If they use the one you normally use for your base station (say the one without any trailing letter) but you have taken your HT with you and you have set it up with a call sign that has the “M” (say) at the end, then the routing will go to the wrong place.

(By the way, this also explains the use of “terminal” – it identifies the actual device you are using at the time. The term “pcname” can be considered synonymous for our purposes I this booklet.)

The general usage these days is to have a single “terminal” and use that in all of your devices. This means that any call sign routing will take people to the last repeater that you used, regardless of the device you actually used.

So, we finally get around to creating a “terminal” entry so you can get onto the D-Star system. You will see that your call sign is listed against each of the 8 possible terminal names – that part cannot be changed. There is a check-box to the left of each terminal name entry and you will need to click on that to activate the editing for the line.

Next you should see a square when you can enter the letter for that terminal: **put in a space character (**or an upper case letter) and do not leave this without a character. (I know it is hard to see the difference between a space character and not character at all but you are dealing with a computer here and to it, a space and nothing are very different although they can look the same to you on the computer screen.)

Finally, put in some text under the “pcname” heading and click the “Update” button. The text can be anything you like but something has to be entered so I‘d suggest you put in something that makes sense (at least to you). Also you cannot have spaces; only lower case letters, numbers and the hyphen characters are allowed. I’ve used my call sign and a short word to describe its intended use (see the figure above).

If you make a mistake, you will see an error message telling you what needs to be corrected.

When all of that has been done, you will be registered on the D-Star system and can use the call sign (plus the trailing letter) in the “Originator” field of your device.

Of course, you can register as many call sign variants as you wish (up to 8) by using the same process but entering a letter in the box next to your call sign.

D-Star Call Sign Structure

Amateur radio call signs are up to 7 characters long (such as VK3AA, VK3MMM or VK3FZZZ[10]). Australian repeaters are also assigned call signs such as VK3RWN[11].

As we will see shortly, D-Star repeaters also need a reference to the various ports[12] they have. Each port has a single letter assigned to it which is always added in the **8th position** of the call sign. That means that there could be spaces within a repeater port call sign after the end of the repeater name and the port identifying letter.

For example, port C on the VK3RWN repeater has the call sign "VK3RWN⌂C". (Throughout this document I have used the '⌂' character to visually indicate a space within a call sign).

D-Star call signs are 8 characters long. The general structure of a call sign used in the D-Star network is the basic user or repeater call sign in the first (up to) 6 or 7 places, and any special command or port indicator is in the 8th position.

If the call sign is less than 8 characters (e.g. VK3ANZ is only 6 characters) and no port or command letter is needed, then you only need to enter the call sign. (The D-Star radios and most computer programs will add trailing spaces to make the call signs always 8 characters long; so you don't need to add the trailing spaces yourself.)

D-Star uses the 8th character position to identify a repeater port (see later), call sign variants (see the section on registering your call sign) or to specify a command to the repeater or network. In such cases, when the call sign is 6 or fewer characters long, it is ***very important*** that you put spaces after the call sign so that the special character occurs in the 8th character position.

Some examples are:

Basic Call Sign	D-Star Call Sign	Usage	Comment
VK3ANZ	VK3ANZ	This is a user call sign and can be used to identify you or to refer to a specific person you are trying to contact	Any required trailing spaces will (generally) be added automatically

10 My apologies to anyone who has these actual call signs - I'm just trying to make a point, not be specific about any call sign

11 Repeaters have the letter "R" as the 4th character. Other countries have their own schemes to name repeaters.

12 See the "D-Star Repeater Structure" section in a few pages for the explanation of a "port"

Basic Call Sign	D-Star Call Sign	Usage	Comment
VK3ANZ Mobile	VK3ANZ⌂M	In effect the same as above but refers to a variant 'terminal' name (see above)	The 'M' must in column 8 so add padding spaces
VK9ZZ variant C	VK9ZZ⌂⌂C	A made up example to show how to handle referring to a call sign variant when call sign is shorter than 6 letters	Short call signs need more padding to refer to a call sign 'variant'
VK3RWN port C	VK3RWN⌂C	In Australia this is the name of a repeater (VK3RWM) and the specific port (C)	The context where a call sign is used will determine how the D-Star system will interpret the last character
Reflector REF003 port C	REF003CL	Command to request a repeater link (the "L" in the 8th position) to reflector REF003 port C	Note in this case that the command ("L") is in the 8th position and so the reflector port ("C") needs to be in position 7

Throughout this document, I've not shown the trailing spaces where they are not required[13]. However, I have shown the spaces when they exist between the call sign and the 8th character.

Reflector Naming Structure

The way reflectors and their associated ports are named is very similar to the outline of the repeater names above. However there are some significant differences.

All reflectors (by convention) have a 3 letter name followed by 3 digits. The three "sets" of reflectors in use are:

1) REFnnn – these reflectors are connected to the same D-Plus intranet as many repeaters and use the US Trust as their source for registered users. Basically if you register to access a repeater then you can access these reflectors

2) DCSnnn – these reflectors run the ircDDB software and do not require users to register (although the reflectors themselves **are** registered)

13 Some of the Icom radios and software written by various people automatically add in the trailing spaces to call signs. However this is not a "universal" situation and if you are having problems with getting a call sign recognised, make sure that the trailing spaces have been entered.

3) XRFnnn – These reflectors run the DExtra software which have their own “trust” servers[14]

Depending on the software in use on your computer or on the local repeater, you may or may not have access to any or all of the sets of reflectors[15]. Also, there is no “standard” set of software that runs on all repeaters and so the commands that are used to link a repeater to a reflector (covered later) may or may not work with each type of repeater.

Having said all that, all reflectors have a set of “ports” that (to some extent) mimic the ports in a repeater. There is, of course, a major difference in that the reflector port names are simply names and do not relate to any frequency band (as the port names do in repeaters by convention). The REFnnn and XRFnnn reflectors typically have 5 ports (labelled “A” to “E”) while the DCSnnn reflectors have up to 26 ports (“A” to “Z”).

A common practice is for the (say) “C” port on a repeater to link to the “C” port on a reflector but this is in no way required or enforced.

Analog Repeater Structure

When you use an analog (i.e. non-D-Star) repeater, you set the receive frequency (the frequency the repeater will transmit on) and then apply an offset to come up with your transmit frequency (the frequency the repeater will receive on). To use the repeater you just transmit; the repeater picks up the signal and re-broadcasts it on its output frequency.

Normally the transmit and receive frequencies are within the same band and normally have a consistent offset between them (600kHz in the 2m band, 5MHz in the 70cm band and so on but this can vary from country to country).

However, there are some places where the repeaters are linked together either so that there is greater geographic coverage or so that there are cross-band links. An example of the later is the VK3RHF repeater that spans the 10m, 6m, 70cm and 23cm bands (in the same geographical area) so transmitting on the input frequency of one will result in a transmission on all of the output frequencies of the others. In New Zealand, they have a ‘national link’ where any signal received on one repeater is simultaneously broadcast on all others throughout the country.

As more repeaters are added throughout the country, sometimes the local band plan requires different offsets and/or CCTSS tones to prevent interferences between repeater frequencies.

14 There are several different “trust” services that sit behind the D-Star repeaters and the various reflectors. However they all inter-operate behind the scenes which makes the differences transparent to the average D-Star user

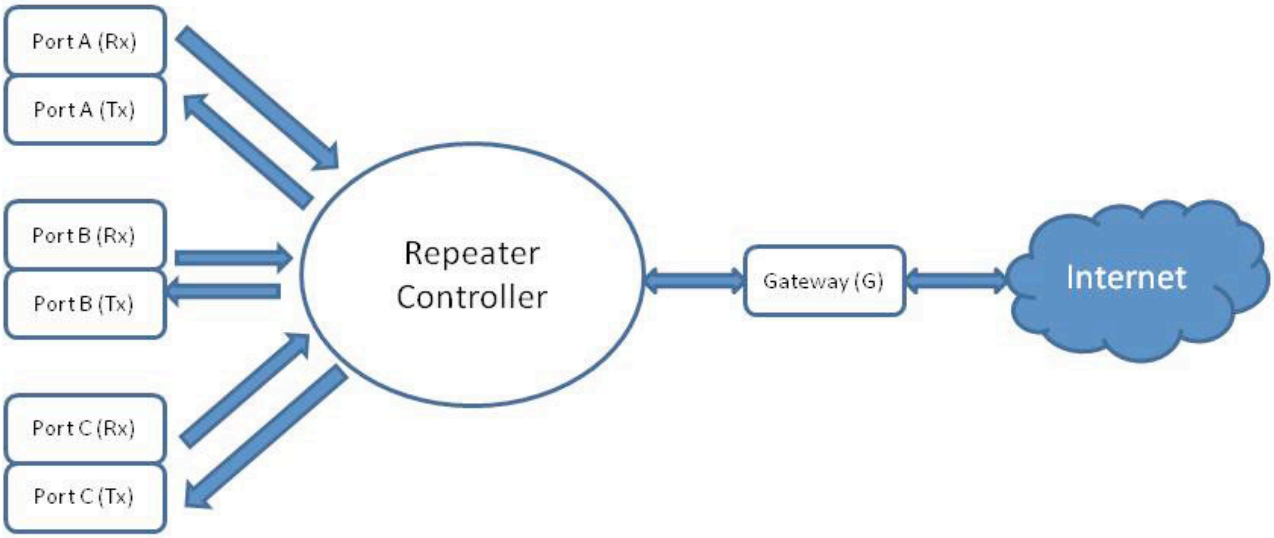
15 See Appendix 6 “Layer upon Layer” about the various types of software used in repeaters.

D-Star Repeater Structure

A D-Star repeater comprises (up to) 5 connections, grouped as follows:

- RF voice ports (typically between1 and 3) used to receive and transmit voice communications with transceivers
- An RF data port used to receive and transmit high speed data with transceivers[16]
- A network gateway that connect a repeater to the rest of the D-Star network

Not all repeaters have all ports but most repeaters have at least one RF port and a network gateway.



This figure shows 3 RF voice ports (labelled A, B and C - see below) and the gateway connecting the repeater controller (which connects all of the repeater ports together) to the Internet which is used to carry the D-Star network. The figure does not show a data port but (logically) it operates the in the same way as the other RF ports but only carries high speed data streams that are not intended to be converted to voice.

Port labelling and function

Each RF port on the left of the above figure represents the two parts of an ordinary RF repeater - the receiver and transmitter. Each of these ports operates in a different frequency band with a common labelling protocol being[17]:

- the 23cm RF transceiver is Port A
- the 70cm RF transceiver is Port B
- the 2m RF transceiver is Port C

16 This actually refers to the high-speed data transfers over D-Star. Such data transfers occur over a dedicated data port, often referred to as the "AD" port as it operates in the 1.2GHz (or 'A' port) frequency range but handles data and not voice. This is not to be confused with the slow data that is associated with all of the digital voice transmissions and is used by programs such as "D-Rats"

17 While this is the general labelling scheme used in Australia, it is possible that the RF port on any band be given any letter identifier, and even possible for there to be several RF ports in the same band. If you are using a repeater from overseas, make sure that you understand the port labelling scheme used there.

On the right of the above diagram is the gateway between the repeater and the internet[18].

If a RF data port is available it is always in the 23cm band due to the bandwidth requirements of sending data at high speeds.

Each repeater will have a configuration that suits the intended purposes as established by the repeaters administrators. When they publish the repeaters frequencies, they will also specify the port labelling they have adopted.

Repeater Controller's function

Each repeater has a controller that coordinates the activities of the ports.

When you set the various call signs in your radio's Destination, Originator, Repeater1 and Repeater2 call sign fields (see below), it is the repeater controller of your local repeater that interprets these and performs the necessary operations to send your signal to the correct place in the D-Star network[19].

When you press the PTT button of your D-Star radio, your voice is digitally encoded in your radio and is transmitted together with other digital information[20]. A repeater port receiver picks up this RF digital data stream and passes it directly to the repeater controller.

The repeater controller receives data streams from each of the port receivers and (possibly multiple data streams) from the Internet gateway. Its main function is to interpret parts of the data streams (specifically the various call signs which we will talk about next) to see where they should be passed on to.

One of the repeater controller's critical tasks is to make sure that an RF transmitter only ever receives one stream of data at a time. Therefore the controller acts as an arbitrator and will allow the first data stream for an RF transmitter to pass, but will reject any other that is received while the first one is going.

A key concept to understand is that you use the D-Star network by asking the *local* repeater controller to make the various connections for you.

There are two main types of connections that can be made, called "routing" and "linking". Each style has its strengths and weaknesses which are discussed in the following sections. Which you use will depend on the circumstances at the time.

"Routing" connections are established for you by the controller when you press the PTT button, and are removed when you release it. Each person who participates in the

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18 Just to be clear, D-Star uses the Internet as a transport mechanism to allow it to connect the various repeater and reflectors together via its own Intranet. Also some 'remote management' of repeaters can be possible using an Internet connection. D-Star does not provide open access to the Internet. This is true even of the high speed data connection where this is available on a repeater – any information presented over that channel is specifically provided via a portal, even if that portal opens up specific links.

19 This statement is not quite technically correct in that the controller connects the RF ports together and also interacts with a separate gateway controller which performs the necessary operations to link the repeater to the outside world. However what I've said is close enough to understand what is going on.

20 See Section 3 for information on how this is done

conversation must set up their radios correctly and keep the correct settings for every transmission they make. “Routing” is the original way D-Star repeaters connected together and is the arrangement generally described in the Icom radio manuals.

On the other hand, “linking” connections are established when you send special commands to the repeater controller, and the links are maintained by the D-Star network until you send a corresponding command to remove them (or they time out after a period of inactivity). “Linking” is performed using an additional ‘layer’ of software on top of the standard controller software[21] and may or may not be installed on a repeater.

The majority of the descriptions in Section 2 are “routing” connections and they are named as such.

D-Star Reflector Structure

All reflectors are just computers systems and have no RF capability at all.

As mentioned above, reflectors have multiple port names but all of these are connected to the intranet and their usage is defined more by convention than anything else.

There is one major difference, however, between the way reflectors and repeaters connect to the intranet. A repeater can link each of its RF ports to a single other repeater or reflector at a time. This means that (for example) repeater VK3RWN Port C might link to reflector REF003 Port C but it must be unlinked from that reflector before being linked to another reflector or repeater. On the other hand, reflectors can be connected to by many other devices.

Also, repeaters are often located in places that are good for RF coverage (e.g. at the top of a hill) but these locations can have poor (and/or expensive!) access to internet connections for their gateway.

Reflectors do not have such a limitation as they are often located in a data centre somewhere which has good network connectivity. Also, because it is really just a computer, a reflector can handle many connections to each port at the same time.

By way of example, a random snapshot of the REF001 reflector taken at the time I’m writing this, shows that there are 29 repeater ports connected to REF001 Port C, plus 30 individual devices (DV Dongles, DVAPs etc.) and another 58 devices that are monitoring the reflector across multiple ports.

A major difference between repeaters and reflectors is that a repeater can link **to** other repeaters or reflectors whereas reflectors are the targets (and never the source) of any linking. In other words, you can link to a reflector but for cannot link from a reflector to somewhere else.

Another difference is that reflectors are very good at broadcasting to many other systems. When you access a local repeater port that is not linked to anything, then your RF signal is sent back just to the local area. Even when you use connection techniques such as ‘call

21 See Appendix 6 “Layer Upon Layer”

sign routing' and 'multicasting', your signal is routed to one or only a few[22] other repeaters. However when you link to a reflector, then your signal is routed to (potentially) hundreds of locations anywhere around the world.

D-Star Radio Call Sign Usage

A D-Star radio requires up to 4 call sign fields to be entered and manipulated as you use the device. There are a number of different names and abbreviations for these call sign fields in various radios[23]. In this document I'm going to use the following names for the call sign fields:

- Originator - this is the call sign you are using
- Repeater1 - the call sign of the repeater port you use to access the **local** repeater
- Repeater2 - the call sign of the repeater port you use to leave the **local** repeater
- Destination - this is the call sign of the person, multicast group[24] or repeater you want to talk to

These are **not** the same names as you will see on your radio. Believe me, you can really get yourself confused when using names such as "My Call", "RxRpt1" and "Your Call" in some circumstances.

To make matters worse, different models of commercial radios use different abbreviations for these call sign fields. You can look in Appendix 1 to see a table of how these terms are used in various radios and how they relate to the names I'm using here.

I'll briefly mention what each of these do.

Originator's Call Sign

The radio regulations say that we have to give our call signs at the beginning and end of a QSO (and sometimes during a long over). Using D-Star does not change that, but it also sends out the originator's call sign and all other call signs in digital form when we start transmitting. Think of this as an automatic "this is me" signal.

Also, the D-Star network provides ways for users to manage the connections that can be made through the repeater's controller (more on that later).

The controller in the local repeater needs to know who you are. Therefore you can think of the Originators call sign as your electronic identity (ID) into the system. For this to happen, you will need to register your call sign(s) with the D-Star network. (See the above section on registration for details on how to do this.)

Actually it goes beyond that. You might have several D-Star radios (say, one in the shack, one in the car and a "DV Dongle"[25] that you use on business trips). Because your call sign

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22 Multicasting has a limit of 10 destinations is the pre-defined group; see Appendix 3 for more details of Multicasting

23 See Appendix 1

24 See the description of Multicasting in Appendix 3

25 A "DV Dongle" is a separate product you can buy to let you get access to the D-Star network through a computer and broadband Internet connection. By the way, the "DV" part stands for "Digital Voice" and is

does not use all 8 spaces available, you are able to use the 8th position to indicate which radio you are using and for what purpose.

See the “Registration” section above about registering call sign variants. It is recommended that you only use your base call sign for D-Star unless you specifically require separate identification (by others) of different radios at the same time. However any registered variant can be used to identify you to the D-Star system.

Repeater1 and Repeater2 Call Signs

These fields tell the local repeater how you want to enter (Repeater1) and exit (Repeater2) the **local** repeater.

Strangely, if you want you transmission to be sent to another repeater, you don’t use the Repeater2 field to specify that repeater. Rather the Repeater2 field is used to specify the port used to leave the local repeater. We’ll get to the details later on.

However the important thing to remember is that the “repeater” being referred to by these two call sign fields is the one that **you** are interacting with locally, not some other remote repeater.

Destination Call Sign

This field defines who or where you want to talk to. The Destination call sign is the real workhorse of the 4 fields.

It is used to specify that you want to:

- talk locally,
- to a specific call sign wherever it is in the world,
- to a specific repeater or reflector
- to a named group of repeaters
- send various commands to the local repeater

The commands can be used to establish and break on-going “linking” connections between repeaters and reflectors, enquire about the current state of any link and to perform an “echo” test. All of these commands and operations are discussed later on.

Enough - let’s see how to use the radio.

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used to distinguish between voice and “Digital Data” (DD) uses of the D-Star network. More on DD in Appendix 4.

Section 2
D-Star Usage Scenarios

Introductory Note

This section discusses first how to set up your radio in various configurations, and later briefly mentions usage by DV Dongles, DVAPs and similar devices.

RF access into the D-Star system can be a bit more difficult than using a non-RF device and so we will handle that first.

For the communication to succeed, the radio will need to have the frequency set correctly and may well need to have the duplex setting and offset, tone access values and other things set as well. I'm going to assume that you know how to do these as they are part of the normal operation of your radio and are explained in the radio's instruction manual. You will also need to know the correct frequencies and other settings for the repeater you are accessing.

Here I'll only talk about the D-Star specific setup options.

Much of the following discussion is based on one person making a call either to a specific person, location, or to CQ[26], with one person responding. However, you need to keep in mind that there could be many people who want to join in the conversation. The examples illustrate the correct set-up of a radio and do not imply that they limit the conversation to only between 2 people.

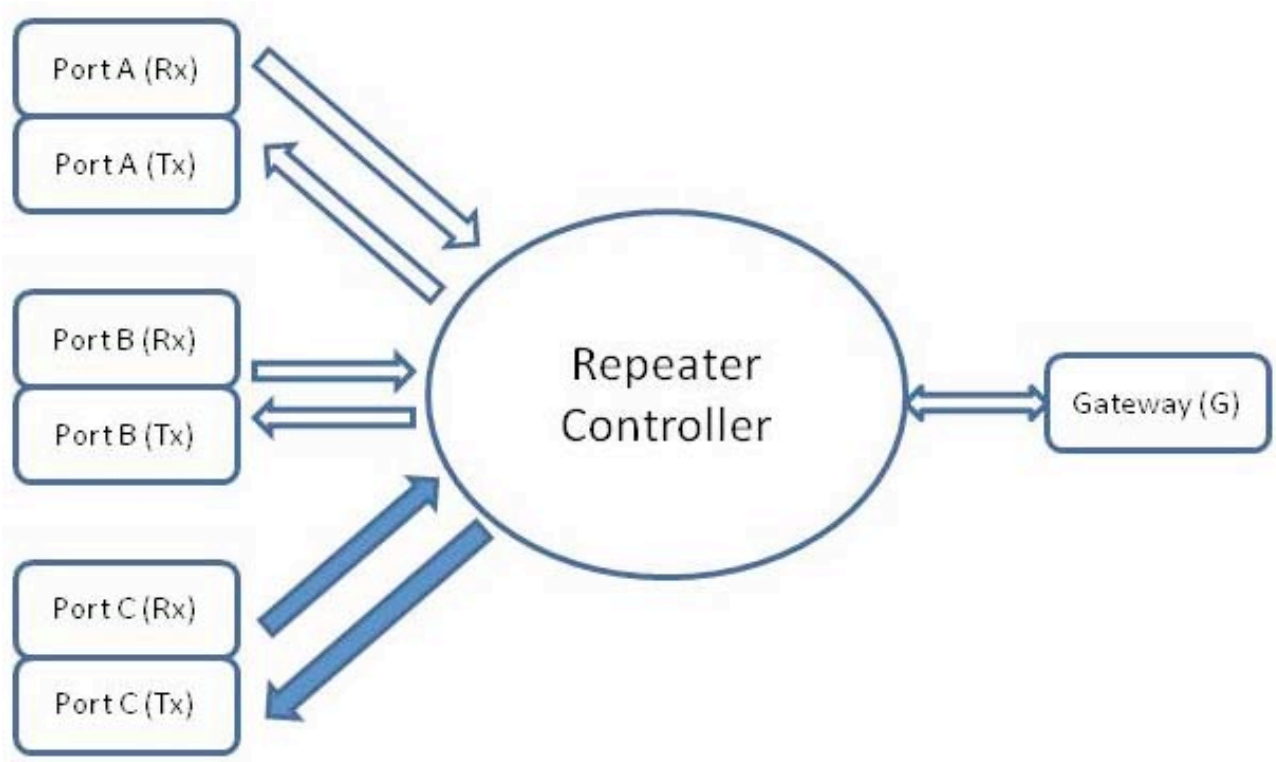
In the scenarios that follow, I will not consider the situation where the local repeater port is linked. This will be covered later on in this section under "Using a linked repeater or reflector". The way the flowing scenarios work is not really changed by having the local repeater port linked, but you do need to consider that there may well be another path to other users while you are having your QSO.

Local Repeater, Same Band

Let's look at the simplest case - to transmit on (say) the 2m port input frequency and have the signal rebroadcast on the same band. This is the default way each port is set up - it will (almost) always rebroadcast what it receives on an RF port back via that same port.

This is sometimes referred to as "making a local call".

26 When we talk, we generally use the term "CQ". However, the D-Star protocol actually uses the 'call sign' "CQCQCQ⌂⌂" when referring to a general call that is not a command or to a specific (set of) destination(s). When you see "CQ" written here, I'm using the verbal short-hand to refer to the full call sign version.



Making the contact

Even in this simple case I need to make sure that my radio is set up correctly.

Call Sign Field	Example Entry
Originator	VK3ANZ
Repeater1	VK3RWN⌂C
Repeater2	VK3RWN⌂C or VK3RWN⌂G or NOT⌂USE*
Destination	CQCQCQ

It is best to set the Originator call sign field to my call sign that I use most commonly right from the start. This field is not changed very often and many people never change this at all.

In this scenario, I don't need to have my call sign registered as I'm not using the D-Star network. However, because I generally don't need to change this field's call sign, it pays to use one of the call signs I have registered so as to avoid problems later on.

Next I set the Repeater1 call sign field to the name of the local repeater port that I will be transmitting to. It is important to get this right, because the repeater will reject your transmission if this is not set correctly.

Then I set the Repeater2 field call sign to one of the local output repeater port (in this scenario, that's the same one as I use for Repeater1), the repeaters gateway call sign (see later). Some radios have a "Not Used"[27] value that they can put in here for this purpose. I prefer to use the Repeater2 field the same way as it is used for all other usage scenarios that involve the repeater, so I set it to the repeaters gateway but you do have an option.

In this situation, the Destination call sign field should be set to "CQCQCQ" as we are not trying to find any particular person or any other repeater in the network.

Now when I press the PTT button, my radio will transmit this information to the local repeater along with my digitized voice.

In keeping with the radio regulations and the D-Star usage guidelines given above I should now say:

"This is VK3ANZ calling CQ on VK3RWN Port C"

Answering the contact

(By the way, this section applies to responding to any call in any situation.)

For now, let's imagine that I'm someone else - say VK3AAA - and I want to monitor my local repeater (say VK3RWN Port C). To do this I need to firstly set my radio to the correct repeater port output frequency. Then I should set the call sign fields in preparation for any responses I might want to make. Therefore I put my own call sign as the Originator call sign and, because I'm listening on, and likely to transmit to, VK3RWN Port C, that is what I should put into the Repeater1 call sign field.[28]

At this point I hear VK3ANZ calling on the local repeater port and I would like to respond. VK3ANZ has said their call sign and the repeater port they are transmitting to so I now have all of the information I need to return the contact.

Option 1 - Manual configuration

I listen to what the other person has said and set up my radio accordingly. The caller has told me that they are also listening on VK3RWN port C and so I have a choice as to how I set the Repeater2 call sign field. Because they are using the same repeater as I am, I don't need to set the Repeater2 field to anything (for the same reasons as described in the 'Making the contact' section above) or I could set it to the repeater's gateway (preferred as it generally involves changing fewer call sign fields) or to the same as the Repeater1 field.

They have also given me their call sign. If I want to I can enter their call sign (plus any necessary spaces and call sign variant letter) into the Destination call sign field. However,

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27 This can be written in a variety of ways depending on the actual model of radio, but generally it is "NOT USE*" so as to fit into 8 characters. Another alternative is 8 spaces.

28 If you think about it, this is actually the same configuration as you would use to transmit to the same repeater port.

because I have already set up the Repeater2 field with the repeater port that they used, I can also simply put (or keep) "CQCQCQ⌂⌂" as the destination call sign.

Call Sign Field	Example Entry
Originator	VK3AAA
Repeater1	VK3RWN⌂C
Repeater2	VK3RWN⌂G or VK3RWN⌂C or NOT⌂USE*
Destination	CQCQCQ

Option 2 - 'One Touch Reply' configuration

This method relies on the digital information that the repeater sends out along with each transmission. The call sign of the person who sent the last transmission as well as the Repeater1 and Repeater2 call sign values of the repeater I am listening to are automatically sent to me at the start of each transmission from the repeater port.

Many commercial D-Star radios have the ability to capture this information and store the values from the last few transmissions. They also have the ability to retrieve this information and to set the call sign fields correctly for me. This is often referred to as a "one touch" or "one button" reply function. By pressing the appropriate button[29] you can have the Repeater1, Repeater2 and Destination call sign fields set up automatically. (The Originator call sign field remains unaltered by this function at whatever I have it set to).

Call Sign Field	Example Entry
Originator	VK3AAA
Repeater1	VK3RWN⌂C
Repeater2	VK3RWN⌂C

29 This is yet another area where radios differ. Some radios require that you press the "one touch" button or select the corresponding menu option while the other party is still transmitting, but other radios save this information and allow you to press the button any time before you receive another transmission. Yet others allow you to retrieve any of the last few received call signs. Also the label on the button can vary, including "Rx>Cs", "R>CS"

Call Sign Field	Example Entry
Destination	VK3ANZ

Please note that this does not always work on some radios, especially those that have a 'power save' feature as these radios can rapidly turn the power on and off to the receiver and so cut down on the overall power consumption. This rapid switching stops as soon as a signal is detected. The time the radio spends off is negligible in comparison to the time it takes to listen to even a brief call by an operator. Unfortunately, if the radio is off when a transmission begins, the radio will miss the very first part which contains the information needed for the "one touch replay" function[30]. If this happens, then the details of the current/last call will not be available and you must set the various D-Star call sign fields manually as described above.

Once the radio is correctly configured, I can make my response to the original caller. Because we both now have our radios set up, we can continue our conversation back and forth without further configuration of the D-Star call sign fields.

Finishing the contact

After the contact is over, you should get into the habit of resetting the Destination call sign field to "CQCQCQ". On most radios this simply involves pressing a button.

Usage issues

Why should you bother resetting the configuration after your QSO? The radio configuration described in the "Making the contact" subsection above already has the Destination field set correctly so there is no problem. However the configuration described in the "Answering the contact" sub-section may well have the other persons' call sign in this field. This is almost the necessary set-up for the D-Star network to perform "Call Sign Routing" (described a bit later) and your transmission could well suddenly come out somewhere else in the network.

Therefore it is a good habit to get into to **always** reset the Destination call sign field to "CQCQCQ" when you have finished.

Status Messages

Whenever you finish a transmission to a repeater port, the repeater controller will send back a very brief status message to you. The status message is actually telling you whether your transmission was received (there will be no status message if it wasn't), and how far it got through the network to its destination.

I have described the status messages in more detail in the "Status Messages" part of the "Repeater Routing" section below.

[30] This was certainly true for Version 1 of this document and can be still be true today but many of the newer transceivers and reflector systems etc. now re-transmit the contact information throughout the transmission which overcomes this situation.

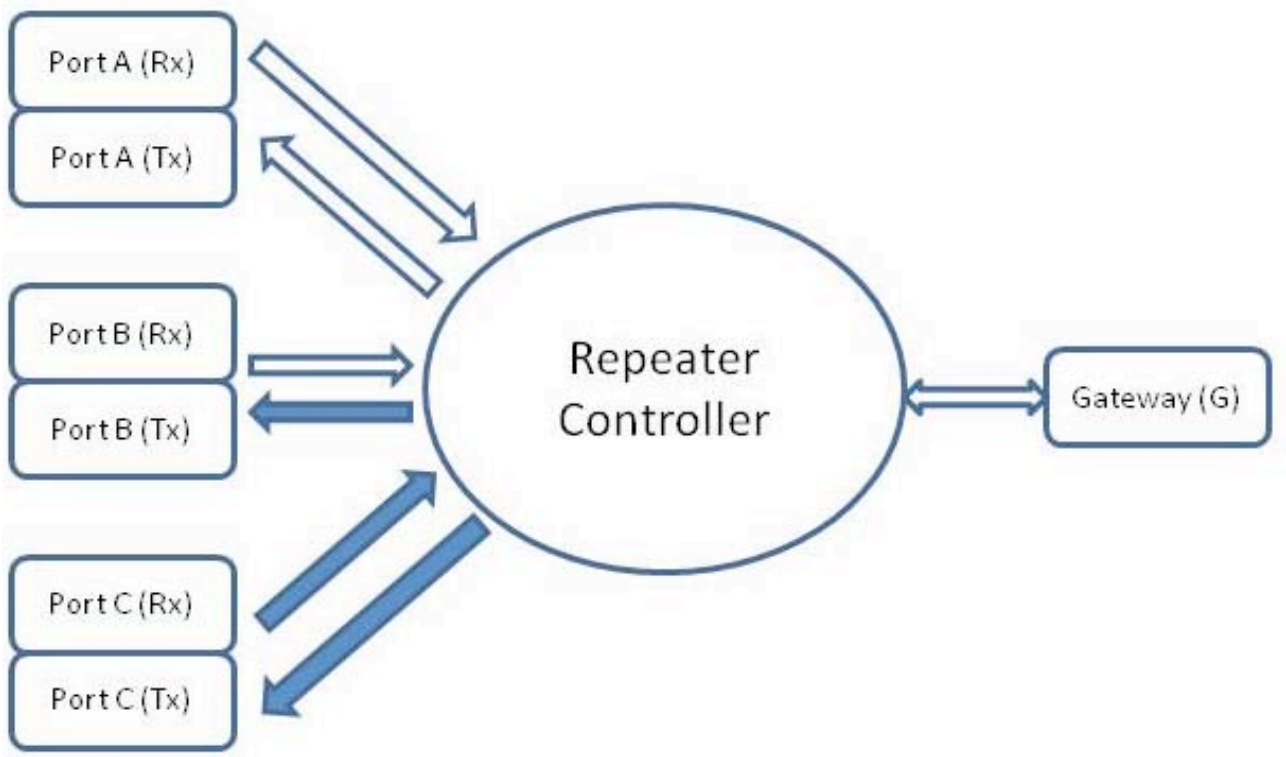
Local Repeater, Cross Band

In this scenario, you are transmitting to one RF port on the local repeater and also having your transmission routed to an additional port on the same repeater. This provides a useful way of accessing a frequency band that (for example) your radio does not have.

However, you should also be aware that it ties up two of the RF ports on the repeater for the one QSO and so reduces the availability of the repeater to other users. Therefore I advise that you use this style of operation with due consideration for other users.

Making the contact

Now let's say I want to transmit to the 2m C port and also have the signal come out on the 70cm B port; i.e. cross-band the local repeater.



To do this I have to tell the local repeater that I want to send my signal within the repeater from the C port to the B port. I do this by setting the Repeater1 call sign to the C port of the local repeater, and the 'Repeater2' call sign to the call sign of the B port.

I need to set the Originator call sign field to my call sign and, because I want to make a general call, I set the Destination call sign field to "CQCQCQ".

Call Sign Field	Example Entry
Originator	VK3ANZ
Repeater1	VK3RWN⌂C

Call Sign Field	Example Entry
Repeater2	VK3RWN⌂B
Destination	CQCQCQ

This is very similar to the “same band” scenario discussed above, but in this case the Repeater2 call sign field **must** be set correctly to the local repeater’s output port (before I could leave it “not used” or set it to the call sign of the local repeater’s gateway).

With the radio configured, I can now make my call:

“This is VK3ANZ on repeater VK3RWN Port C calling CQ on VK3RWN Port B”

Answering a contact

Now imagine that I am VK3AAA and I’ve been listening on VK3RWN Port B when I hear VK3ANZ make their call. I want to respond so I need to set up my radio appropriately.

This is very similar to the situation described in “Making the contact” in that I need to set up the correct Repeater1 and Repeater2 call sign fields so that my transmission will be routed back to wherever they are listening. I can also set up the Destination call sign field with either “CQCQCQ” or the caller’s call sign.

As before, I can do this in 2 ways - automatically by pressing the appropriate “one touch reply” function button on my radio, or manually based on the information they have just provided to me verbally. If I use the “one touch reply” method, then all of the Repeater1, Repeater 2 and Destination call sign fields will be set for me. On the other hand, if I use the manual method, then I know that the Repeater1 field should be set to the repeater port that I was listening to and so I need to set the Repeater2 and Destination call sign fields based on what I heard the caller say.

As always, my Originator call sign field is my own call sign.

Call Sign Field	Example Entry
Originator	VK3AAA
Repeater1	VK3RWN⌂B
Repeater2	VK3RWN⌂C

Call Sign Field	Example Entry
Destination	VK3ANZ or CQCQCQ

Now both the original caller and I have our radios set up properly, we can talk away to each other.

Finishing the call

As before, when you have finished your QSO, you should reset the Destination call sign field to “CQCQCQ”.

However, the difference to the “same band” scenario described above is that now you have your Repeater2 call sign field set to the other port. If you start transmitting without making any changes to this field, then you will also have your signal sent out over both ports. This implies that you should reset the Repeater2 call sign field to one of “not used”, the local repeater’s gateway call sign (preferred) or the same as the Repeater1 call sign field.

Most commercial radios have lots of memories (typically many hundreds) and so it is not unreasonable to have one memory set up so that it has this default ‘reset’ configuration. Further, it should be easily set so having a memory slot such as number 0 set up this way would be useful. Also see the explanation of the “DR Mode” later on in this section.

Usage issues

The situation just described brings up a couple of points about the use of D-Star that are not (usually) found in the operation of other repeaters.

Normally, if analog repeaters are linked together, then you can hear any transmission being picked up by any repeater on all of the others. Therefore it is easy to tell if the repeater is in use so that you don’t double with someone else.

However, the connection between the port you use to access the repeater (Repeater1) and the port you use to leave the repeater (Repeater2) is only established for the duration of your single transmission. Someone could well be talking away on (say) Port B when you, on Port C, try to make a cross-band connection. You will have no idea beforehand that they are talking on Port B.

Yes, I know that in this case I could say to listen on the other band, but what if I don’t have a radio capable of receiving the other band (the IC-91AD can’t access the 23cm band and the ID-31A is UHF only). And we will shortly see usage scenarios where the other repeater can be anywhere else in the world.

So, how do you get around this?

The D-Star system is set up so that a port will only accept a single data stream at a time. This is managed by the Repeater Controller and applies equally to transmissions received via an RF port's receiver and data streams from remote repeater sites.

If you try to route a transmission between ports and the destination port is in use, your call will not go through.

OK, but how do you know if your transmission has not gone through to its intended destination? The connection is only half-duplex so you can't necessarily hear yourself talking.

When you finish transmitting to a port, the repeater will send back a short message to you; in effect it calls you back for a split second to send some status information. These status messages are discussed more fully in the "Status Message" part of the "Repeater Routing" section below

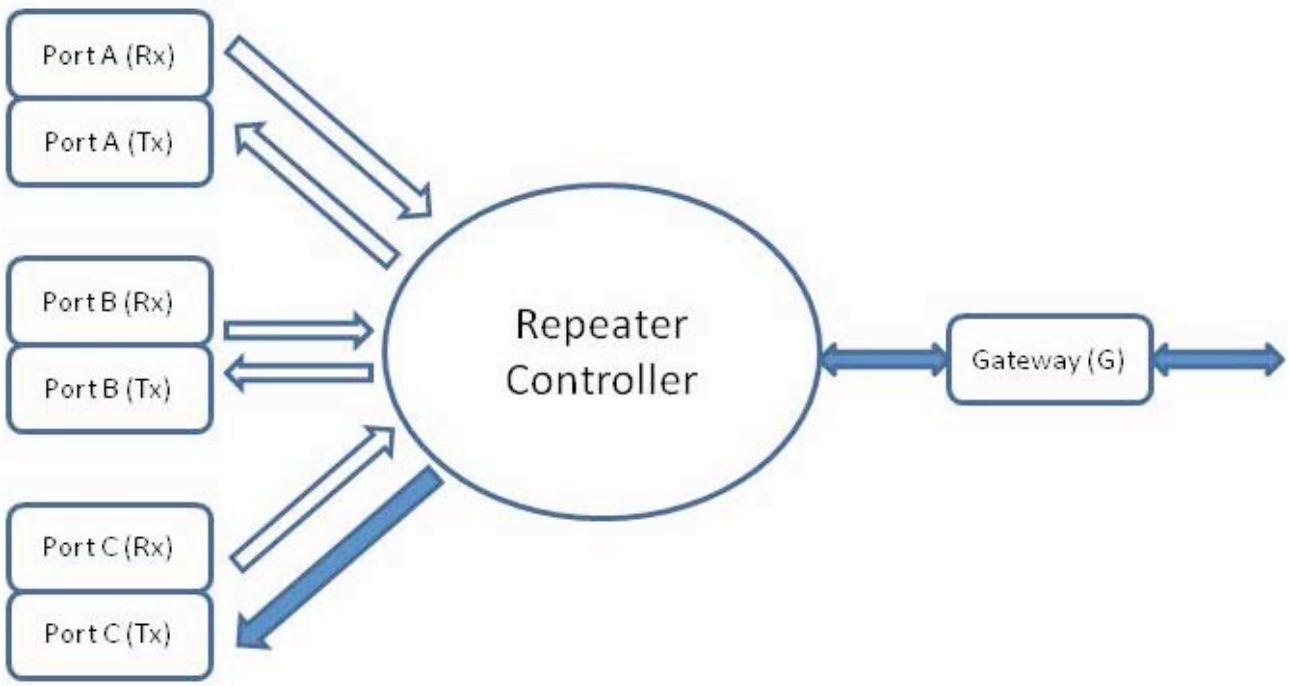
Because your transmission may or may not get through is why you should listen before you transmit, why your over should be short, why you need to check the returned status message and why you need to leave at least a 4 second gap before you respond. Just because you have just been listening to someone on another repeater port, doesn't mean that the repeater will hold the connection open for your response. Remember, the routing occurs for each individual transmission only. Someone else may have 'got in' before you on the other port and be transmitting - but of course you won't be aware of that and so you start talking away, only to have the D-Star system blocking your signal somewhere along the path. It would be a pity to be talking for a couple of minutes (short overs remember!) only to find that no one has been able to hear you.

Call Sign Routing

Now we are starting to get into areas where D-Star shows its true abilities.

Making the contact

Because you send your call sign in digital form in every transmission, the D-Star network "knows who and where you are" - or at least the last repeater you used. This information is stored and is available throughout the whole network and is also listed on the D-Star web sites. (I won't go into this here - but I recommend that you have a look at www.dstarusers.org sometime).



Let's say I (VK3ANZ) want to talk to AA0BBB. I know they have a D-Star radio, which they have taken with them on their holidays. But they could be anywhere!

Firstly I need to tell my local repeater that I want to be able to connect to another repeater somewhere else in the network. I do this by setting my Repeater2 call sign to the local repeater gateway - that's the local repeater's call sign that ends in G. This tells the repeater that it is to route my transmission from the incoming repeater port (Repeater1 - that's the one I will be transmitting and listening on) through the D-Star to somewhere else.

In this situation I set the Destination field on my radio to "AA0BBB"[31].

Call Sign Field	Example Entry
Originator	VK3ANZ
Repeater1	VK3RWN⌂C
Repeater2	VK3RWN⌂G
Destination	AA0BBB

With this configuration set, I can send out a call:

"This is VK3ANZ on VK3RWN Port C calling AA0BBB using call sign routing"

31 Please see the "Usage Issues" section below regarding the use of any call sign registered by a person.

So who is listening to that!

Well, as soon as I press the PTT button, I send out the 4 call sign fields to the local repeater. It sees the Destination call sign and does a lookup to see where that call sign was last used. The local repeater will then send my transmission through the D-Star network to that remote repeater port. (Of course it also transmits my signal back out through the same repeater port I'm using.)

That's it.

Answering a contact

This is the same as before (and always really!). Let's assume that I (AA0BBB in this example) have been using the GB0ZZZ repeater recently and I hear someone calling me.

The person making the call has provided me with the necessary information in 2 ways. Firstly, they have told me who they are and where they are calling from. I can then set up my radio using the necessary information. Repeater1 will be the port of the local repeater I will be transmitting to. Repeater2 will be the gateway port of the same repeater (**not** the repeater the other person is using). I can put their call sign (or the call sign of the repeater port they are using - more on this in the next section) into the Destination call sign field of my radio.

Alternatively, I can use the information that the D-Star network will have sent me when I received their call. It will have sent me the caller's call sign and the necessary repeater setting so I can call them back. Most radios have a button that can automatically transfer this information into the appropriate call sign fields.

Call Sign Field	Example Entry
Originator	AA0BBB
Repeater1	GB0ZZZ⌂A
Repeater2	GB0ZZZ⌂G
Destination	VK3ANZ or /VK3RWNC[32]

Then I just hit the PTT and reply. The network will use the same process described above in 'Making the contact' to use call sign routing (or repeater routing - see below) of my transmission back to the original caller.

32 The "/VK3RWNC" format tells the D-Star system that it should look for a repeater with the given call sign and port rather than a user's call sign. See the 'Repeater Routing' section below.

Both radios are now set up and so the QSO can continue.

Finishing the contact

Again I hope you can see why the Usage Guidelines section refers to resetting your radio after you have finished your QSO. In this scenario, I could have been talking through the D-Star network to anywhere in the world. If I don't reset my radio, my next transmission will also be routed through the D-Star network to whichever repeater the other party last used. This means that others will be blessed with my side of some other conversation, possibly cutting across other users of that repeater.

The simplest way to avoid this is to set the Destination field call sign to "CQCQCQ". Most commercial radios have a button that will do this for you.

The "CQCQCQ" call sign is treated as 'special' by the repeater and will not be used for call sign routing, even if you still have Repeater2 set to the local repeater gateway.

Usage Issues

The comments made previously about needing to check the status information that the local repeater sends back to you after each transmission apply here as well. In this case there are more links in the chain where the transmission can fail.

This also brings up why you need to leave a 4 second pause between overs on the D-Star system, apart from being a good repeater user and allowing others time to break in.

The D-Star network does a lot of house-keeping for each transmission. It needs time to look up call signs for call sign routing, establish its own intranet connections and then start sending the data packets (that's what your voice has become, remember) to the remote repeater. Additionally it also takes time for the system to clean up after each transmission.[33]

There could be a delay of up to several seconds between you speaking your words of wisdom into your microphone before they are broadcast by the remote repeater[34]. If the person on the other end replies almost immediately and there is the same delay, it could be several seconds before you begin to hear their response. If you jump in too quickly with "QSL???" then all you will do is block their response (remember the repeaters are half-duplex and will only accept a single transmission - from any source - at a time).

Use the time to gather your thoughts so that what you have to say is really thoughtful and profound!

In the "making the contact" section above, I put in the call sign of the person I wanted to talk with in the 'Destination' field. However, earlier on I mentioned that everyone can register up to 8 call signs with the D-Star network, one with just their call sign, and others

33 This may be a bit simplistic, but going deeper into details would only cloud and not clarify the issue.

34 You do not need to worry that part of your QSO will be lost while all of this housekeeping is going on. Your data stream will be buffered while the destination point is determined and the necessary intranet linkages made. Of course that also means that your signal can still be coming out at the far end for a few moments after you have stopped transmitting.

with a letter in the 8th position to indicate if they were mobile, portable, using a dongle etc.. So, which call sign should I use to contact someone?

The D-Star network remembers the last repeater that each ***separate*** call sign accessed. Say I use my VK3ANZ call sign in Melbourne and then fly to Sydney where, to show that I'm 'portable' I use my "VK3ANZ⌂P" call sign which I have also registered on the D-Star network. If someone uses call sign routing to contact me, and they use my VK3ANZ call sign, then the signal will be routed to the Melbourne repeater that I last use, even though I used the Sydney repeater more recently. The problem is that I used the "VK3ANZ⌂P" call sign in Sydney - to have the transmission routed to Sydney, the other person would have had to know that I had used the "VK3ANZ⌂P" variant of my call sign there, and set that into their Destination call sign field.

To avoid this, the general recommendation is to always use the same (base) call sign in the Originator field of any D-Star radio you use, unless you specifically want the variant call sign to be recognised elsewhere.

Repeater Routing

Let's say I want to talk to anyone who is on a specific remote repeater. This is very similar to the case above, except that I don't need to know a person's call sign, but rather the call sign of the remote repeater port[35].

Making the contact

I will need to set up my radio to have the call sign of the port I will be entering the local repeater on in the Repeater1 call sign field. I also need to set the **local** repeater's gateway port call sign in Repeater2.

You should now see an emerging pattern: you can generally set the Repeater1 call sign to the local repeater port when you start using the repeater, and almost always leave Repeater2 set to the gateway port of the local repeater.

OK, so how do I specify the destination repeater I want to access? That's what the Destination call sign is for, but there is a slight twist in this case. When I wanted to talk to a specific person, I just put their call sign into this field. When I want to refer to a repeater port, I use the repeater ports call sign but prefixed with a slash ("/") character: VK5RWN Port B would be entered as "/VK5RWNB". Note that the slash character counts towards the overall 8 character requirement for a call sign and so there is no space between the repeater call sign and the port letter in this case. Of course, if the repeater was XX2AB Port C then I would need to enter "/XX2AB⌂C".

My radio call sign setup now becomes:

35 I'm assuming here that the other repeater port is not on my local repeater - if it were then this is a 'single band' or 'cross band' situation and covered in the preceding sections.

Call Sign Field	Example Entry
Originator	VK3ANZ
Repeater1	VK3RWN⌂C
Repeater2	VK3RWN⌂G
Destination	/VK5RWNB

As always, I then need to tell the listeners who I am, where I'm calling from and to, as in:

"This is VK3ANZ on VK3RWN Port C calling CQ on VK5RWN Port B"

Also see the explanation of Multicasting in Appendix 3.

Answering a contact

If I hear a call such as the one in the previous section and I want to respond, I need to set my radio up appropriately. Again this should be very familiar to you by now as it is really the same as above[36].

Most commercial radios have a button I can press that will use the received call sign data of the last[37] call my radio received to set up it up correctly so I can answer.

If I want to do this manually, then I set the Repeater1 and Repeater2 values to be the local repeater port call sign I will be transmitting to, and the local repeater's gateway call sign respectively. Nothing new there and I may not have to make any adjustments at all.

The Destination call sign field needs to be set up so that my transmission back to the caller will be routed through the network to the correct repeater port. Therefore I can either set the caller's call sign (which is what pushing the button does) or I can use the caller's repeater port call sign with the slash prefix.

Call Sign Field	Example Entry
Originator	VK5SSS
Repeater1	VK5RWN⌂B

36 I did say that there were repetitions in this document, but it also shows how responding to a call is almost identical in all situations.

37 Some radios allow you to retrieve several recently received call signs.

Call Sign Field	Example Entry
Repeater2	VK5RWN⌂G
Destination	VK3ANZ or /VK3RWNC

The end result is that my transmission will then be routed back through the D-Star network to the caller's repeater port and broadcast there. From then on we can both carry on our conversation, taking into account the necessary breaks between overs.

Finishing the contact

Does this really need to be said by now? Simply set the Destination call sign field of your radio to "CQCQCQ" so that any further transmissions will not be routed through the network to somewhere else.

Usage Issues

There is nothing really new here apart from the "/" prefix to specify repeater routing. Remember that each transmission you make will be separately routed through the D-Star network. This involves not only the normal transmission delays between repeaters, but also the time required to look up the call sign of the remote repeater port. Then there is the time for the system to determine how to make the connection to that repeater.

Status Messages

Because you are trying to access a repeater that could be anywhere in the world, you are not able to check that the remote repeater port is in use before you transmit. You will recall from Section 1 that the controller in each repeater will only allow one connection to an RF ports transmitter at a time. Therefore it is possible for your signal to get all the way to the remote repeater only to find that the repeater port is in use and you whole transmission[38] will be dropped.

When a repeater controller rejects a transmission, it will send back a status report to the originating repeater which will, in turn pass this on to you when you finish transmitting. If the transmission got through OK, the status report will refer to your local repeater. However if it was rejected anywhere along the line, the status report will refer to the rejecting repeater. (Remember that you will only receive this status message when you finish your transmission.)

The status report is sent as a short message that is displayed on the screen of your radio. You should always check the status message after each transmission as this will tell you if

38 The access conflict is detected as soon as the second stream is seen by the remote repeater's controller. However, once it has detected the conflict and rejected the subsequent connections, even if the first connection finishes while the subsequent streams continue to be received, they will not be accepted. Once a data stream is rejected, it is rejected completely.

you got through to your intended destination or not. (Of course, if you 'doubled' with someone else on the local RF repeater input frequency or were otherwise not received by the local repeater, then you will not get a status message back - itself an indication that your transmission was not received correctly).

Different radios display the status message slightly differently, but the following are some of the responses you can get:

Radio	Message transmitted OK	Target Station not accessible	Linked repeater not known	Repeater port busy
ID-1	UR? {CS1}	UR? {CS2}	RPT?	RPT UP
ID-800	YOUR? {CS1}	UR? {CS2}	UR*	UR? {CS2}
IC-91AD/ IC-92AD	UR? {CS1}	UR? {CS2}	UR*	UR? {CS2}
IC2820	UR? {CS1}	CR? {CS2}	RPT?{CS2}[39]	RPT?{CS2}[39]
IC9100	UR? {CS1}	RPT?	RPT?{CS2}[39]	RPT?{CS2}[39]
IC5100	UR? {CS1}	RPT? {CS2} or RX	RPT? {CS2} or RX	RPT? {CS2} or RX
IC7100	UR? {CS1}	RPT? {CS2} or RX	RPT? {CS2} or Rx	RPT? {CS2} or Rx
ID31A/E ID51A/E	UR? {CS1}	RPT? {CS2} or Rx	RPT? {CS2} or Rx	RPT? {CS2} or Rx

where "{CS1}" is the same call sign as you had set in your Repeater1 call sign field, and "{CS2}" will be a call sign of the repeater port where the data stream was rejected.

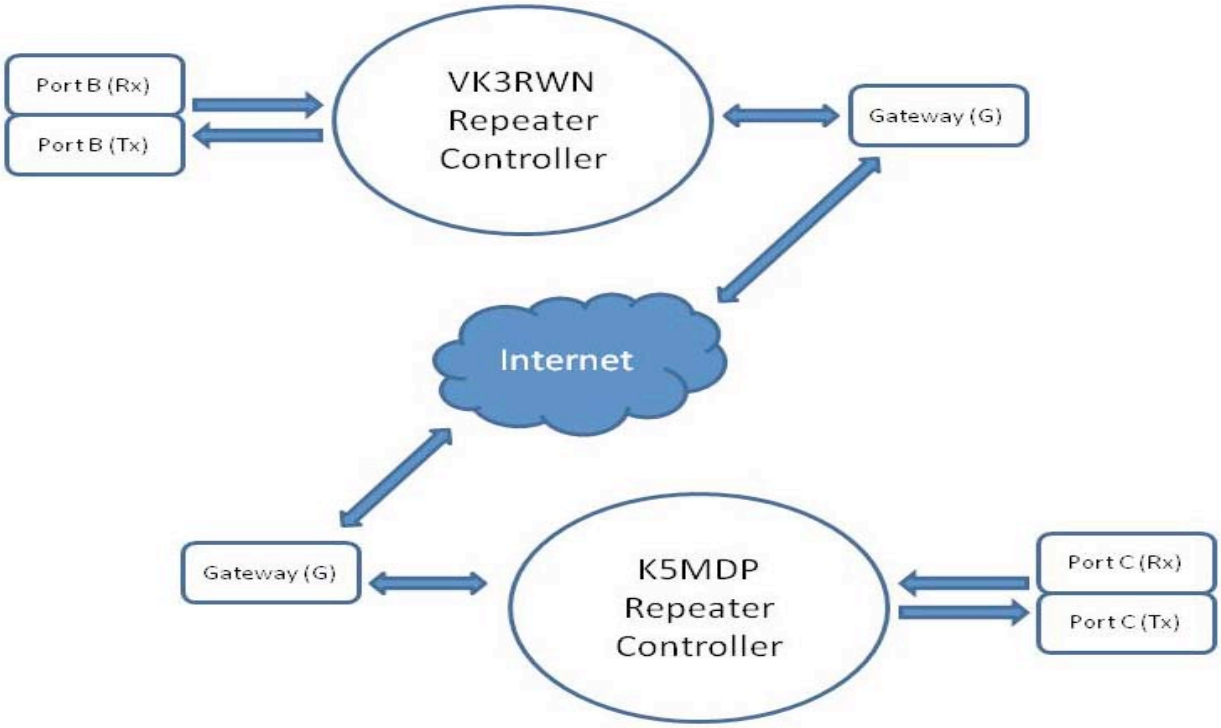
Don't be fooled by the "?" in "UR?" – it doesn't mean there was a problem[40].

Also, when a repeater is linked to another repeater or reflector, and you are using the "CQ" as the destination call sign, you may well get a "RPT?" response. This response comes from the standard Icom repeater controller software to tell you that you have specified the gateway in "Repeater2" but not a specific "destination". In reality, the layered "linking"

39 I have not been able to independently verify this response. Please let me know if this is wrong. However it is what I would expect

40 Some of the Icom manuals state that the question mark is sent because "the call was successful but no station replied immediately", and that you should "wait a while and try it again". This does not sit well with the D-Star usage guidelines that you should leave 4 seconds between overs. Therefore, you can treat this message as a "success" indicator.

software (which the standard software does not know about) will have sent your transmission to the linked destination[41].



The way the status message is formed is a little unusual in that is generally tells you at what point the transmission **failed**. If the local repeater port didn't get you transmission, then you won't get back a status message at all. Once the local repeater port has received your transmission, it will always try to pass it further down the line. This means that your local repeater port is not a possible point of failure of your received transmission, but everywhere else is. The D-Star system therefore uses your local repeater port call sign as its way of signalling success.

Take the situation where shown above where I am using VK3RWN port B to call someone on K5TIT port C. If my transmission gets through to the far end and is transmitted on the remote port, then the status I receive will be "UR? VK3RWN B". However, the transmission could be blocked at several places along the path: at the VK3RWN gateway; at the K5TIT gateway; and at K5TIT port C. Let's say the Port C on K5TIT is in use, then I would receive a status of "UR? K5TIT C" or "RPT? K5TIT C" which means that the remote port was the point of failure.

Finally, to flog that poor dead horse some more, it is important that you reset the Destination call sign field to "CQCQCQ" when you have finished your QSO. If you don't, then any future transmissions will be routed through the network and pop up at the remote repeater location. This means that they will be hearing one side (yours) of your next conversation and will just be annoying to them. (If you don't believe me, just wait until someone does it by mistake to your local repeater and keeps breaking in to a QSO you are trying to have with someone else!!!!)

41 See Appendix 6 – "Layer upon Layer" for a more in-depth explanation of this.

Repeater Linking

Until now, all of the ways we have discussed of routing your transmission from one repeater port to another have been on a transmission-by-transmission basis. When you press the PTT button, the connection is established and then removed when you stop transmitting. Typically this is very useful when two people want to have a QSO.

Repeater Linking is a way to have two repeater[42] ports connected together until you (or someone else) unlinks them. Linking is not limited to a single transmission (as routing is) and it works both ways between the linked devices.

In this way it is very similar to the way analog repeaters can be connected together: a transmission received by any one is re-broadcast by all of the other linked repeaters. This means that you only need to have your radio set up refer to your local repeater - the linking takes care of the rest.

Repeater linking can be set up on an ad-hoc basis by a user (on either repeater) or it can be set up automatically at predefined days and times by the repeater gateways. (The computer that manages the gateway can be programmed to establish links by the repeater administrator. This can be useful for regular nets or other “official” uses of the repeater.)

An important distinction between ‘routing’ (as covered by the previous sections) and ‘linking’ is that routing is performed for the duration of each transmission and is designed for individual users to contact other people. Everyone who wants to participate in a conversation must set up their radios correctly.

On the other hand, linking impacts on all users of both of the linked repeater ports. Without anyone needing to do more than gain access to their local linked repeater port, their transmission is automatically carried to the linked remote repeater port. The flip side is that linking affects all users of both repeater ports, and linking ports at inappropriate times can interrupt important communications. (The trouble is that you are never quite sure when it is ‘inappropriate’!)

I won’t go into the details of how to link repeaters here as the details are available on a number of web sites[43] and I believe that repeater linking should not be done indiscriminately.

The protocol is that you should listen first (as always!) and then put out a call to say that you are about to link/unlink a repeater port and where you will create the link to. This gives other users of the port a chance to let you know if they are using the link for some other purpose.

If you do create a link, you should always unlink again when you have finished.

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42 Of course these are ports on different repeaters! Also a repeater can link to a reflector so please keep this possibility in mind while you are reading this part.

43 Basically it involves putting the repeater port in the 7th position of the Destination call sign, and an “L” into the 8th position to establish a link, and putting a “U” into the 8th character position with 7 leading spaces to unlink a repeater

Also note that some repeater ports are configured to automatically link to a specific (typically) reflector port if no link has been established for a pre-set period of time.

Linking is made available by a separate layer of software that can be installed on the repeaters controller[44]. The original gateway software is not aware of the additional software layer and this can lead to unexpected situations. I will not go into this further here but it does mean you may get an “error” status back from the original repeater software when the linking layer has successfully passed on your transmission.

Reflector Linking

You can link from a repeater to a reflector in the same way that you link from one repeater to another. The difference is that you need to use the reflectors name and port in the “link” command that you send to the local repeater.

Using a linked Repeater or Reflector

As far as a general D-Star user is concerned, neither repeater linking nor reflector usage requires any special configuration or knowledge other than how to establish and terminate the link - once the link is established, then any signal picked up by a linked RF port will be sent through to the linked repeater/reflector[45]. However it helps to be aware that the linkages exist[46] and that the reflectors are in use so that you know the area of coverage of any transmission, and also how to respond to any call you may hear.

Basically to use a linked repeater, you only need to set your Repeater1 call sign to the local repeater port you are transmitting to, and your Repeater2 to your local repeater’s gateway port. Even messages transmitted with “CQCQCQ” in the Destination field will be passed on to the linked repeater/reflector and this is generally the standard setting that should be used for the Destination call sign.

44 See Appendix 6

45 Remember, reflector ports can have multiple links and can connect to many repeater ports anywhere in the world.

46 And this is why linked repeaters can have automated announcements every so often. You can enquire as to the current linkage state by making a short transmission to the local repeater port with “□□□□□□□I” (capital letter “I”) in the Destination call sign. You will then get a voice transmission from the repeater port stating if the report is linked or unlinked, but not where the port is linked to – perhaps in a future software release!

Call Sign Field	Example Entry
Originator	VK3ANZ
Repeater1	VK3RWN⌂C
Repeater2	VK3RWN⌂G
Destination	CQCQCQ

Have a look on the Internet for the correct commands (all entered through the Destination field) to establishing and closing the links from a repeater to other repeaters and reflectors.

Let us now see how repeater linking can alter the various usage scenarios that have been discussed above. In the following, I assume that the user is accessing VK3RWN port B which is linked to REF003 port C.

Usage Scenario	User call sign registered	User call sign not registered
Local repeater, same band	The QSO will also be sent via the link to REF003 C. This is the most common way for people to use a linked repeater port.	The QSO will be heard only on the local RF port B as the gateway will reject signals from an unregistered call sign
Local repeater, cross band	The QSO will also be sent via the link to REF003 as well as to the cross-band RF port. Note that any reply will *not* be heard via the link unless the reply is also being sent to a port that is linked to the same destination. This can result in a “one sided” conversation being heard via the link which often causes annoyance	The QSO will be heard only on the local RF port B as the gateway will reject signals from an unregistered call sign
Call sign routing	The QSO will be sent via the link to REF003 C as well as to the routing target. This can lead to an issue when the routing target happens to be the same as the linked system. In this case the	This scenario requires the sender to be using a registered call sign. The local RF port B will carry the signal but it will not go anywhere else

	target system will see two simultaneous QSOs and will reject one or both of them. The sender may therefore see a return message that indicates a failure whereas the transmission may or may not have been received via the other path. It is recommended that call sign routing not be used on linked repeater port[47]	
Repeater Routing	As for Call sign Routing	As for Call sign routing

DV Dongles

Digital Voice (DV) Dongles are devices that you connect to a computer that provide the voice encoding/decoding that occurs within your D-Star radio. The computer also needs to be connected to the Internet so that it can make a network connection to a reflector[48]. In this way, dongle users appear to the reflector (or repeater) like any other D-Star connection.

An advantage of a DV Dongle is that the user only needs an Internet connection (with reasonable broadband access –dialup connections can be too slow) to get into the D-Star network, even if they are out of range of an RF repeater.

A down side is that DV Dongles lose some of the call sign routing and other features because the software does not allow you to specify anything in the Destination call sign field. This means that dongle users can talk with anyone who uses a reflector (and any connected repeaters) but they cannot initiate links or routes to other repeaters.

When you buy a DV Dongle, you get instructions and web links to the software needed to set up a computer and use the D-Star network using a dongle.

DVAPs and Hot Spots

A Hot Spot is a device that lets you use a D-Star radio to communicate with a local analog radio which in turn is connected to a “node adapter” and through to the Internet. Hot Spots rely on the fact that a D-Star RF signal is still basically an FM signal that has a narrower bandwidth and a specific encoding structure[49]. Therefore the local FM analog radio is simply being used to pick up the RF signal and pass it on to the “node adapter” device that

47 The underlying problem is that you may not know that the user given as the destination of call sign routing happens to also be on the linked repeater. In this case, all you can do is try the call sign routing to make the initial contact with the person and then look to an alternative means of routing if there are issues at either end.

48 Dongles can also connect to a repeater but this makes unnecessary demands on the repeater’s network bandwidth and is discouraged.

49 GMSK for those interested. See Section 3

demodulates the digital part of the signal and then passes this on to the Intranet (typically via a PC or similar device) without further interpretation.

A DVAP is a device that acts a bit like your own personal repeater in that it lets you use a D-Star radio which it connects into the D-Star intranet, typically via a local computer of some sort[50]. This is very useful when you are out of range of a D-Star repeater but when you do have an internet connection.

When you are using a DVAP to access the D-Star network, you use the same instructions given above in terms of linking and routing. You treat the DVAP as a very simple “local” repeater that is just for you[51].

You can think of a DVAP as a “hot spot” that has all of the various parts in one device.

Memories

Many commercial radios of any type these days have multiple memories to let you save frequencies, modes (AM, FM, LSB etc.), CTCSS frequencies, split offsets and the like.

The same is true for D-Star radios where the memories also include things like the “Originator”, “Destination” and Repeater call signs. This comes in very handy when you have several repeaters nearby or you like to work your friends on D-Star simplex. All you need to do is to group the memory entries into a convenient set and then flick from one to the next.

Each radio has its own way of arranging the memories; some use “banks” (or “groups”) of memories that can be given suitable names with a number of possible entries in each bank while others let you provide names for each of the memory locations. You will need to look at the manual for your radio to see how the memories are organized.

However one thing is common: programming a memory location using the radio itself is generally a tedious process at best. This is where it really pays to use software running on a computer to assist you.

Some of the newer commercial radios come with an SD memory card that can be used to transfer the memory contents between the radio and a computer. All commercial D-Star radios (as far as I know) also have some way of connecting via a serial port to a computer – it might be an RS232 (or similar) link or it might be a USB connection.

Regardless of how the software passes the memory information on to the radio, there is one significant issue that needs to be addressed: how to get the information for all of the repeaters (D-Star and analog) that you are interested in. There are many sources of information that you can go to – for example the Wireless Institute of Australia (the WIA) publishes a list of all of the voice, D-Star, P25 an ATV repeaters in Australia that includes the repeater call signs, input and output frequencies and other details such as CCTSS

50 People have had success with using the Raspberry Pi and similar computers that can be dedicated to this task

51 Actually it can be used by any other D-Star radio that is within RF range but the DVAP typically has a very low power transmitter which limits the range to a few hundred metres or so.

frequencies and a description of where the repeater is. The list is only(!!) just under 700 entries long.

Also, many new D-Star radios can use GPS locations to identify “near-by” repeaters for you, but the actual location information is not necessarily easily available; especially for non-D-Star repeaters.

Fortunately there is an option: “.icf” files. These files can be read by the various computer programs and also be placed onto the SD cards[52]. There are several sites that make ICF files available, but one that tries to cover all of the generally available Icom radio models and much of the world is “http://www.dstarinfo.com/icom-import-files.aspx”. There are links for that page to forms that let you select the model of radio, the type of information you are interested in and the part of the world you are in. It then creates a suitable “.icf” file (or “.csv” file – a slightly more “human readable” format that many programs know how to read) that you can import into your program and then, after any suitable additions of your own, save to the radio.

DR Mode

Most of the recent commercial D-Star radios have included what is called “DR Mode” where the “DR” stands for “D-Star Repeater”.

To really understand DR Mode, you need to understand what problem is with using memories that the DR mode is trying to solve. We have seen how the radio stores the frequency and other bits of information needed to let you quickly set the radio up for a particular repeater (or other purposes). With D-Star, you need to also include the “Destination”, “Repeater 1”, “Repeater 2” and the “Originator” call sign information that is associated with each repeater.

The reason DR Mode was introduced is because of those additional call sign parts of the memory entry.

Imagine that you live in an area where you have 2 D-Star repeaters within range and each has both a 2m and 70cm RF port. So far so good in that you could set that up with 4 memory entries as long as each one has the “destination” call sign as “CQ”.

It is quite common to want some alternatives in the “destination” call sign such as “⌂⌂⌂⌂⌂⌂⌂E” (for an echo-test) or “⌂⌂⌂⌂⌂⌂⌂I” (to inquire about the current linking) and also “⌂⌂⌂⌂⌂⌂⌂U” to unlink any current repeater linkage. Along with the “CQ” entry that makes 4 common destination call signs.

Now let’s say you want to be able to link to a couple of reflectors. Each of those will need a destination call sign along the lines of “REF001CL” (that is read as “L”ink to reflector “REF001” port “C”).

52 But beware: the format of the “.icf” files must match exactly what the radio expects – and it can change form one model to the next. I recommend going via the computer software to make sure that the information sent to your radio is correctly formatted.

If we were to store all of these in the normal radio memory, you would need 6 x 4 = 24 memories (6 “destination” call signs and 4 local repeater combinations).

Now consider that there are about 30 REFnnn reflectors (running the D-Plus software), a similar number each of DCSnnn (running the ircDDB software) and XRFnnn reflectors (DExtra software), and you rapidly build up a very large number of memory locations.

If you want to use call sign routing then you will need a memory location for each callsign variant that you are interested in – for each repeater you want to use.

Worse still if you like to travel around the place or have a D-Star HT and would like to use the repeaters you will encounter on your travels…. Suddenly those 500 memories in your radio are not enough!

And then you can double that again if your OM or (X)YL wants their “Originator” call sign included for when they use the radio.

The solution that DR Mode offers is to separate the memory into 3 parts: the “Originator”, “Destination” and “Repeater” sets. You are able to then separately select whatever combination of the “Destination” (in the “To:” list) and “Repeater” (in the “From:” list) instead of needing a separate memory for each possible combination.

This means that you can use only 1 or 2 “Originator” memories for your call sign and that of your OM; one “Destination” memory for each of the “CQ”, echo, inquiry, unlink and each repeater/reflector link entry, each call sign routing entry, and one of the “Repeater” memories for the local repeater you want to access..

Typically the DR memories are separate from the main memories in your radio which means that are still free for all of the non-D-Star settings you want to keep. You access the DR Mode by selecting it on the controls of your radio. When you do, you get access to the DR memories but loose access to the main radio memories.

DR Mode typically also selects the DV[53] modulation mode and some other D-Star related settings for you. The actual frequencies used by the radio are set in conjunction with the repeater entries.

When you are in DR Mode, you can separately select the “destination” call sign (or command as the case may be) and the local repeater port you are using.

There appears to be a bit more consistency between the different radio models with respect to how the various call signs are labelled within DR Mode. In general the “Destination” call sign is labelled “To:” and the local repeater setting is labelled “From:”. However some of the early radios with the DR Mode still retain some of the old “Rpt1” style of labelling.

53 “Digital Voice”

There is a “trap for young players” with the way the “To:” settings are implemented that can stop you from getting out from the local repeater. There are 3 ways to select the “CQ” setting in the “To:” field:

- selecting the “To:” list and then selecting the “Local CQ” entry
- alternatively selecting the “Gateway CQ” entry
- selecting your own list of destination call signs and selecting a “CQ” entry that you have put there.

The “Local CQ” entry will set the “Repeater 2” entry to “Not Used” which means that any transmission you send out will not go through the repeater gateway. This makes sense as you selected the “Local CQ” entry, but the final display on the radio display is often just “CQCQCQ”.

This is the same display as when you select the “Gateway CQ” entry which **does** use the repeater gateway setting and therefore lets your transmission pass through to the intranet. Therefore it is easy to select the “Local” entry and wonder why no one outside the local repeater area ever hears you.

The third way is to create a “CQ” entry in your own “To:” list (confusingly called “Your Call Sign List” on some radios – this is **not** your call sign but your own selection of other peoples’ or repeater/reflector call signs). This is where it is easy to get into trouble because the default in DR Mode for the direct entry of “CQ” to **turn off** the Repeater2 setting. For newer DR Mode radios there is a “Use(From)”[54] setting that needs to be set to “Yes” to tell the radio that you want to use the repeaters gateway setting (which you still need to set in the “Repeater2” location).

In some older DR Mode radios, you need to set the “Repeater2” setting to “GW” (for gateway).

The point here is that you need to look at the manual for your particular radio to make sure that you set things up correctly to use the repeater gateway when in DR Mode. Once you have it sorted, then it is fairly straight forward from there.

Using DR mode is relatively straight forward. There is normally a button that you can press or menu option you can select that will take you into DR mode. Form there you can select the “To:” part of the display and (generally) select the “Gateway CQ” entry, and the “From:” part of the display where you can select the local repeater port.

Typically you can set your own “Originator” call sign once and forget about it.

If you want to link to a reflector, unlink, or otherwise change the “Destination” call sign, simply go to the “To:” field and select the item you want. Your “Originator” callsign and the

54 The rather strange name for this setting comes from the fact that setting it to “No” stops the repeater entry being listed in the “From:” repeater list. It also means the entry is skipped when you are using the list as a ‘scan’ list.

“From:” (Repeater1 and Repeater2 call signs) all stay the same as they are in separate memory areas in DR mode.[55]

Use of Computer Software

Many modern commercial radios can be programmed and even operated via software running on a computer (be it running Windows, Mac OS X or Linux).

While it is possible to do everything necessary to configure and operate a commercial D-Star radio from the control panel, especially when it comes to programming the various memories it can be a lot easier to use suitable computer software.

For example, typically you need to select a letter for a call sign or memory name by moving to the required character position and then turning the tuning knob until the required character appears. On the computer you simply type the character on the keyboard!

I’m not going to go into the various software packages that are available (some that are generic across multiple radios and other that are specific to a make and/or model) other than to say that it makes life a lot simpler if it is available (and you can afford it as the case may be).

55 If you were to use the main memories for this, you would have to scan through all of the memories to find the correct combination of all 4 call signs. How hard this is depends on how you have organised your memories and how many repeaters and commands you want to issue to each.

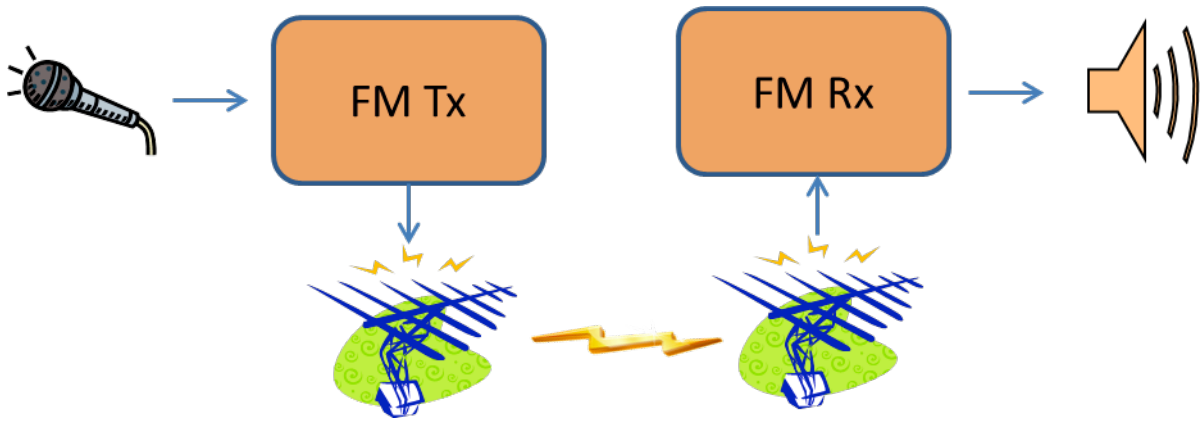
Section 3
D-Star Technical Overview

Introduction

Let me say right up front that this is **not** necessarily an accurate description of how D-Star works at a technical level. These notes have come from a couple of presentations I made to the local Eastern and Mountain Districts Radio Club (EMDRC) where I was trying to describe what D-Star was and how it differs from analog radio.

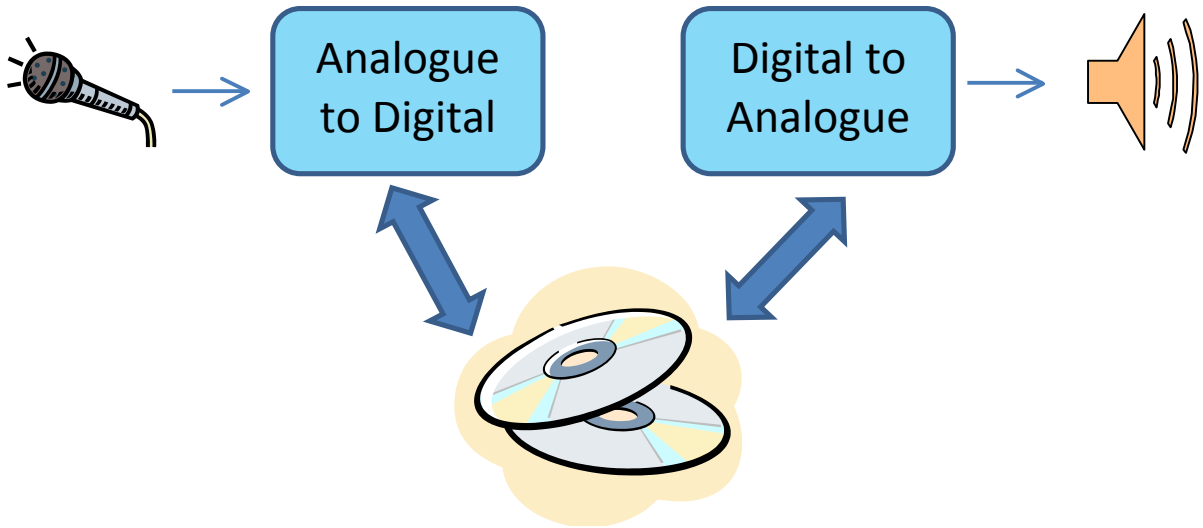
Let's Design a D-Star Radio

We are all familiar with the way an FM (or similar analog) radio works:



Of course there may be a repeater in the RF side of things but basically that is it.

One of the first things we want to do is to digitally encode the voice and then decode it at the receiver. Just for now, let's encode the voice, transfer it somehow (could be via DVD etc.) and then decode it again:



Typically, voice quality digital requires that we can sample at least to 4KHz and that therefore means 8KHz digital sampling of the audio[56]. With each sample being 16 bits long that gives us 128,000 bits that we need to transmit from one end to the other.

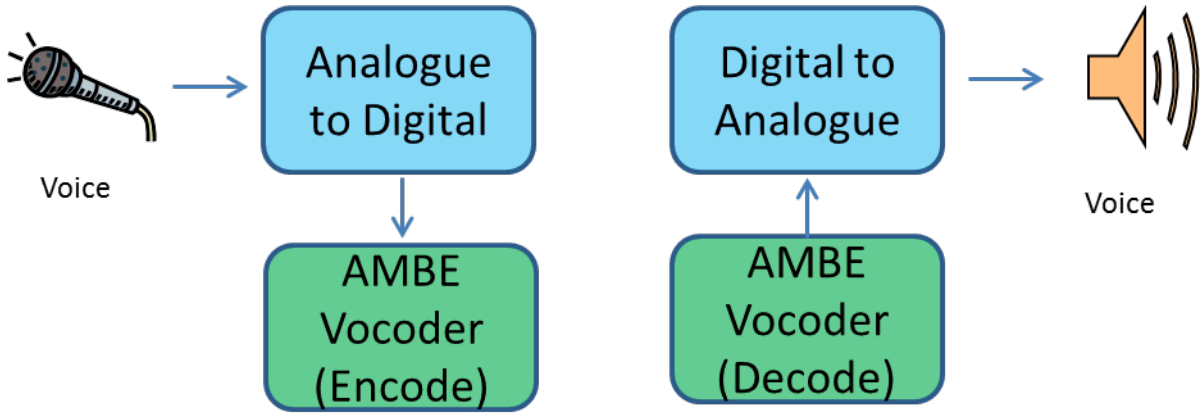
While that is not as bad as typical CD quality audio (which is generally sampled at 44.1KHz or 48KHz for each channel), it still represents a large bandwidth if we were to try to send that via an RF signal.

Normal FM channel bandwidths are 25KHz or 12.5KHz wide and there is pressure on the spectrum usage to reduce this further – say to 6.25KHz. To fit in that bandwidth, we have to send less than 6250 bits each second. By convention, the highest "standard" transfer rate below that is approximately 4800 Baud.

Therefore we need to find a way of reducing the number of samples. If we sample at a lower frequency, then we begin to make the audio difficult to listen to. The other approach is to compress the 128Kbits/second to something more manageable.

The D-Star approach is to use a device from DVSI called the AMBE2000[57] chip (called a "Vocoder" which is a contraction of "voice encoder and decoder") that can compress the audio bitstream from128Kbits/second down to something much smaller. The D-Star protocol specifies 3600bits/second which does fit into the range of the AMBE2000's capabilities. That's approximately a 35:1[58] compression ratio!

This gives us a structure that looks like this:



"But hang on" you say, "3600 bits/second is less than the 4800 bits/second that we can have. Why not use all of the bandwidth?" With D-Star we can also add in a "slow data" channel that uses the remaining 1200 bits/second to transfer the call signs, messages, GPS locations and other information we may want to add in.

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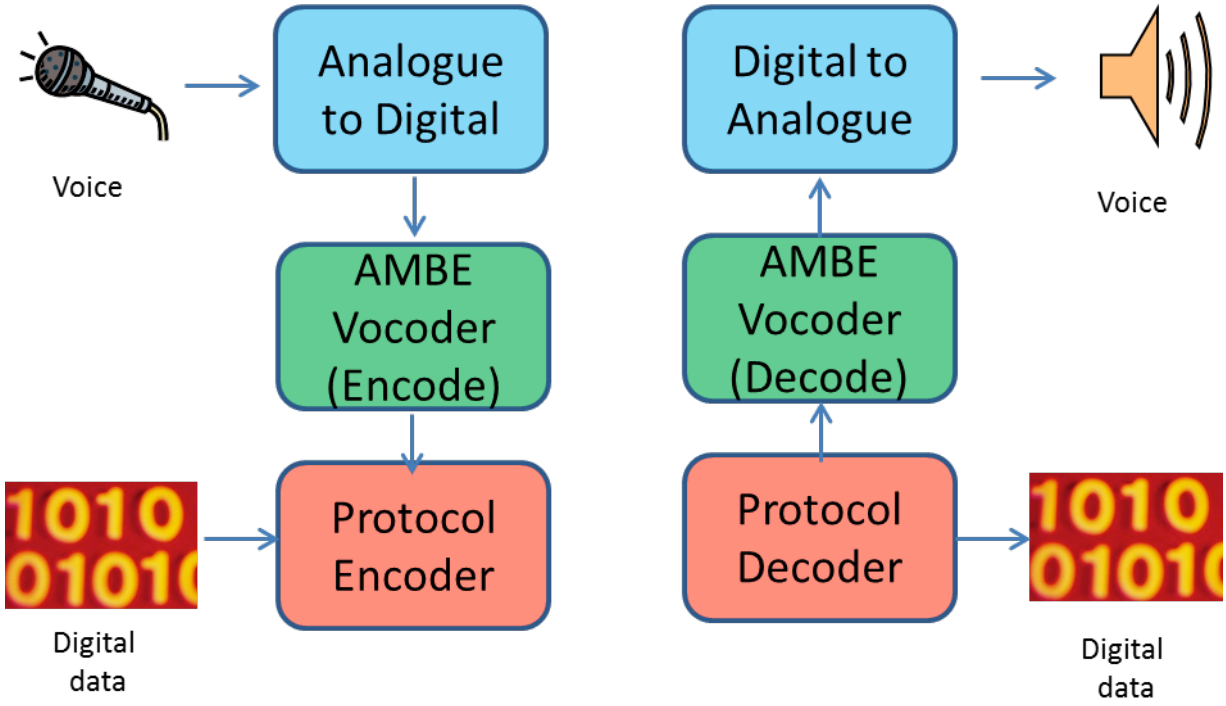
56 Blame Harry Nyquist and Claude Shannon

57 Or the later AMBE2020 or AMBE3000. This is the proprietary part of the D-Star system that many people complain about. While it is very expensive to license the algorithms (Icom have apparently done this for some of the recent D-Star radios) a chip can be purchased for about $20 form DVSI if you want to 'home brew' a D-Star system. There is one of these in the DV-Dongle for example.

58 See a bit later in Appendix 3 when we discuss FEC – the compression is actually more like 53:1

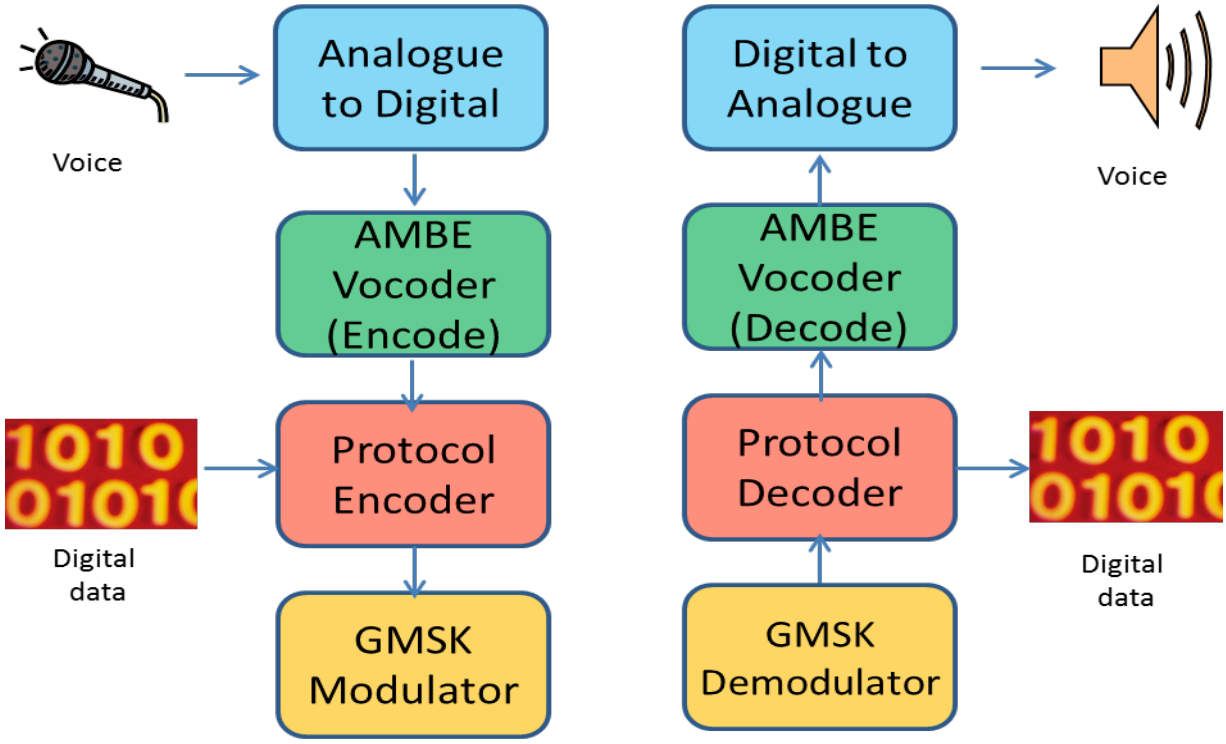
Therefore the 3600 bits/second voice and 1200 bits/second data combine to make the 4800 bits/second data stream.

These bits are packaged up in accordance with the D-Star protocol that also adds in the extra bits needed to detect the start and end of the RF bitstream.

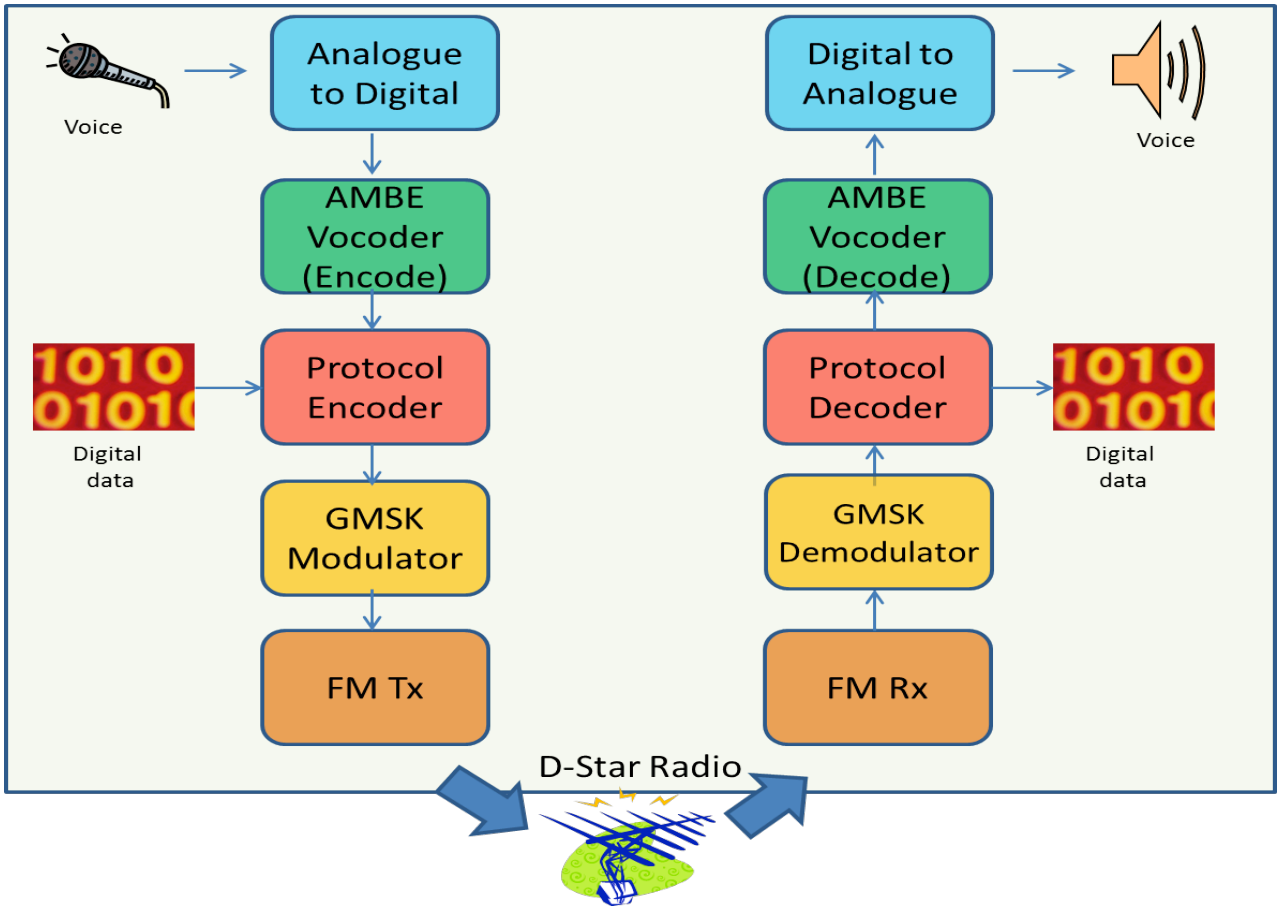


At this point, I'll probably have all of you that know about these things screaming that you can't have the sharp transitions between the "0"s and "1" in the data stream without expanding the bandwidth (theoretically) indefinitely. And that is very true.

Therefore we need to find a way to "smooth out" the transitions but still make sure that we can tell one bit from the next. To do this we use a modulation technique called "Gaussian Minimum Shift Keying" (or GMSK as it is generally known). This form of modulation does exactly what we want: smooth out the transitions between the frequencies that represent the bits in a way that still lets us reconstruct the transitions later on but stay within a fairly narrow RF bandwidth.

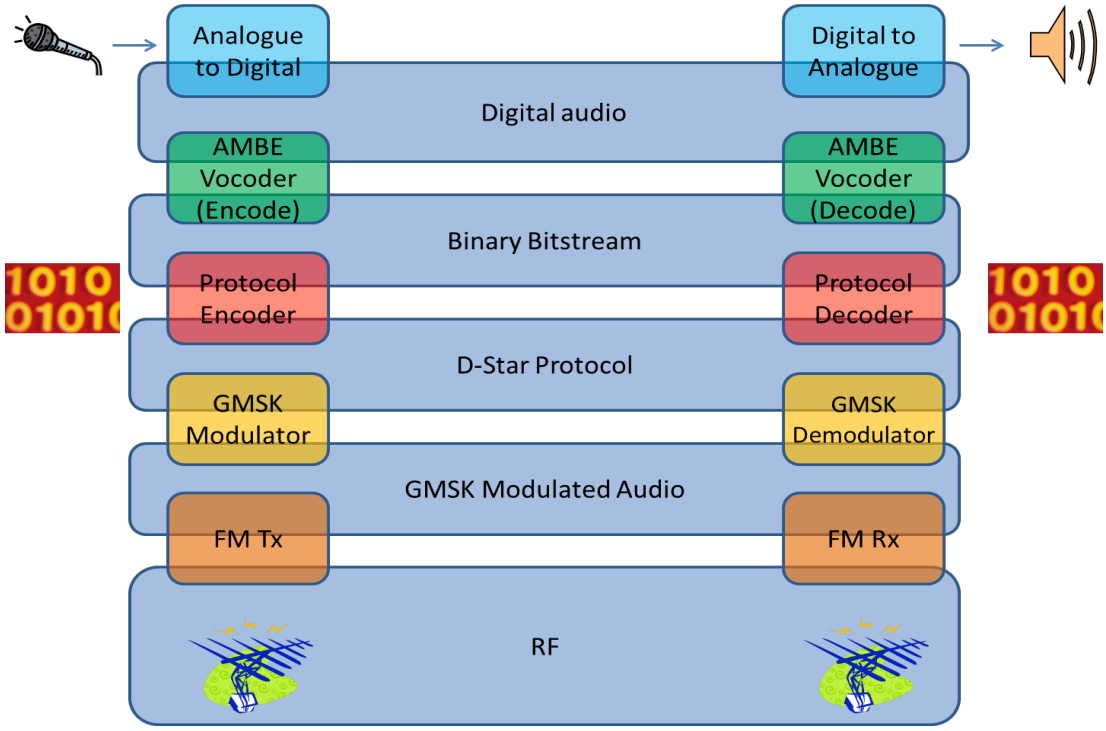


There is, of course, one final step and that is to convert all of this to an RF signal that we can transmit.



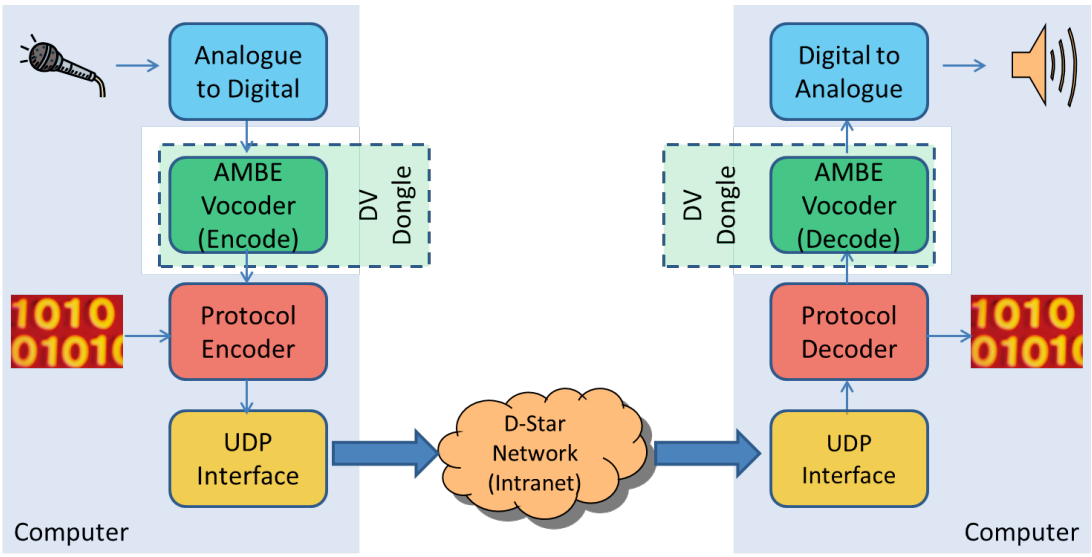
And there we have our D-Star radio!

As you can see it is made up of a number of complimentary layers:



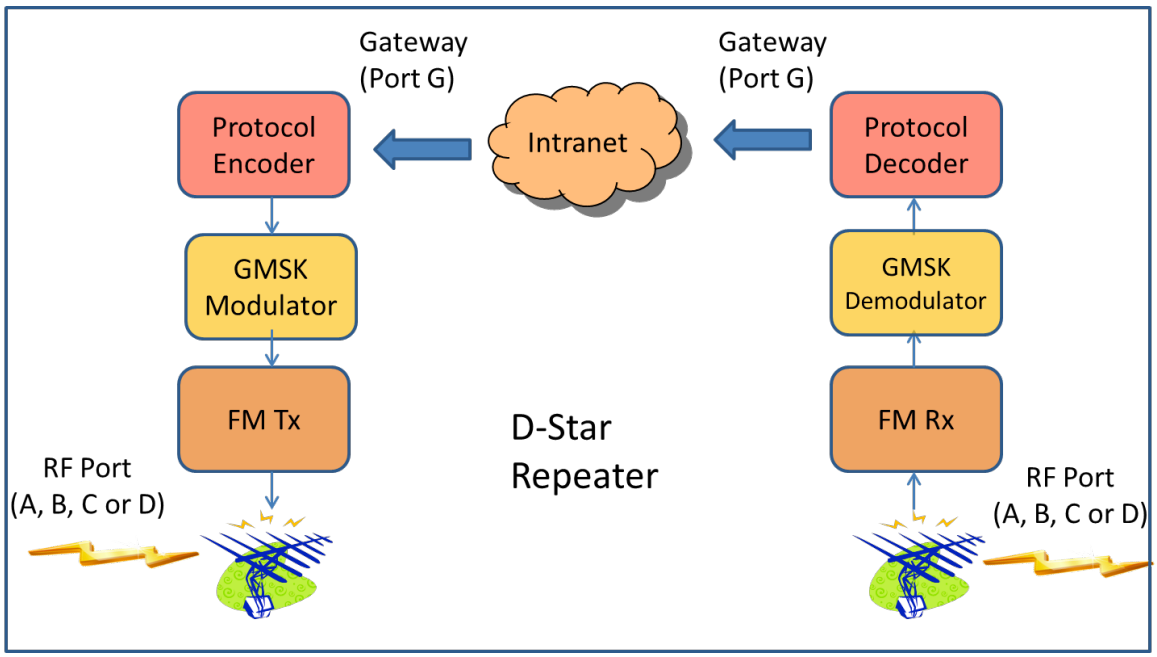
What else can we do with these layers?

For a start we could make a DV-Dongle that holds the AMBE Vocoder chip and lets us use a computer and an internet connection to communicate using the computers soundcard and the D-Star intranet.



DV Dongle

We can also see how a repeater goes together:



By the way, that is very similar to the structure of a DVAP except that a DVAP has a single RF frequency (or “port”).

Appendix 1 - Your Call, My Call etc. as used by various radios

All of the ‘commands’ that you need to use to access the power of the D-Star network are contained in 4 call sign fields that throughout this booklet I have referred to as Originator, Destination, Repeater1 and Repeater2.

The various commercial transceivers that are available use different abbreviations for these fields, partly due to the physical size and layout of their various screens, but also as experience has been gained in the ‘ease of use’ features.

Although the abbreviations should be fairly obvious, the following table will help you relate the common terms used here with the actual fields on your radio.

Radio	Originator	Repeater1	Repeater2	Destination
Icom ID-1	MyCall	Rpt1	Rpt2	UR
Icom ID-800H	MyCall	Rpt1	Rpt2	UR
Icom 2200H	MYC	R1C	R2C	YUC
Icom 2820H	MY	RPT1	RPT2	YOUR
Icom 91AD/92AD	MY	R1	R2	UR
Icom ID880H	MY	RPT1	RPT2	UR
Icom IC-80AD	MY	RPT1	RPT2	UR
Icom IC9100	MY	R1	R2	UR
	The IC-9100 also has a DR Mode. However it displays the information using the above code and does not use the “To:” and “From:” fields.			
Icom IC7100	MY	R1	R2	UR
	The IC7100 is intended to be used in DR mode. As such the “To:” and “From:” fields are typically displayed. However the direct viewing of call signs uses the above abbreviations			

Radio	Originator	Repeater1	Repeater2	Destination
Icom 31 A/E and Icom 51 A/E	MY	R1	R2	UR
	The ID-31/ID-51 is intended to be used in DR. As such the “To:” and “From:” fields are typically displayed. However the direct viewing of call signs uses the above abbreviations			
Icom 5100	MY	R1	R2	UR
	The IC5100 is intended to be used in DR mode. As such the “To:” and “From:” fields are typically displayed. However the direct viewing of call signs uses the above abbreviations			

The above list is (roughly) in order of the various radios being made available. As you can see there is a gradual standardisation of the naming conventions of the various call signs.

Appendix 2 - Additional D-Star radio features

When I got my first D-Star rig, I read the manual. Yes - I'm one of the strange ones who do that. While it is an essential thing to, in some ways it was a bit of a mistake. The manual told me *everything* about the radio, including all of the capabilities that are only used in special circumstances.

Worse, it tried to warn me too much that using a D-Star radio was not the same as using any other analog rig.

For example, when talking about the squelch, it says "One of the differences is in digital mode the squelch does not function as in FM mode. ….. It only activates for digital squelch functions such as CSQL (Digital code squelch) or DSQL (Digital call sign squelch)" This made me think that I had to use one of these in order to be able to receive anything - otherwise the squelch would stay shut.

I was wrong![59]

I'm not going to discuss how all of the various additional features of D-Star radios work and how they are used. Rather this short appendix is here to let you know that, while all of the extra features such as break-in, EMR communications, digital call sign and code squelch, GPS, voice recording and automatic playback and digital data transfers are all available (on various radios) they are ***not*** needed for normal operation of D-Star.

Once you have learned the basics as outlined in the main part of this booklet, then you will be in a better position to start to use the additional features. Until then, you will be able to use the D-Star voice communications and get a lot out of your rig.

The original concept for the D-Star protocol allowed for the use of D-Star radios in several specific circumstances that are not typical of Amateur Radio usage. This is part of the reason why there are the CSQL (only listen to calls that include a specific code – a bit like trunking radio systems) and DSQL (only listen to calls that are directed to my call sign) options mentioned above.

Also the D-Star radios have an "EMR" (or Enhanced Monitor Receive) that lets the caller open the digital squelch of all radios which might be useful for urgent broadcast messages. They also have a similar mode called "BK" (break in) that lets two stations that are communicating using DSQL know that another station is trying to contact one of them.

These special capabilities are generally used in simplex mode rather than when using repeaters and reflectors.

Many of the commercial D-Star radios have ability (called Auto Reply) to automatically transmit a message (that might also include the GPS location of the HT) when they receive a transmission directed to their call sign and also to record (voice) messages that are received while the operator is away.

59 Please note this statement - you won't hear it very often!!!!

Appendix 3 - Other Comments

Simplex use

Simplex operation is also possible, mainly by ignoring all of the rest of this booklet and its talk of the Destination and Repeater1 fields etc..

Using a D-Star radio in simplex mode is much like using any (analog) radio in simplex: agree on the frequency, line up the antenna (if necessary), push the button and talk.

There is none of this “4 seconds between overs” protocol, because there is no network in between that requires the delay[60].

Signal clarity (R2D2 effect)

One issue that may arise is what is sometimes referred to as “R2D2”. When receiving an analog signal, you might get hiss, crackles and other interference, but unless conditions are fairly bad, you can often get the overall message, even if some words are missing. With digital radio, it is far more important that all of the digital information is received so that the ‘digital to analog’ conversion will be accurate.

Just as FM gets around the interference that AM and SSB signals suffer from, by ignoring the amplitude of the signal and using its shifting frequency, so the digital modulation of a signal overcomes some of the problems with FM. However, the price that is paid is that all of the signal transitions must be accurately received or the reconstructed version of the digital value will not be the same one that originally sent.

The digital values that are transmitted are compressed and encoded, which is one of the reasons why D-Star has such a narrow bandwidth. The decoding and decompression process (back to the original numeric data stream) relies on receiving accurate information so that it can restore the original data; any missed data signal transition will result in bad data being received.

The device that does the voice compression also includes additional codes that are referred to as “forward error correcting” (or FEC) bits. These let the decoding part of the device try to reconstruct the bit stream despite errors. However it can only go so far before the receiver will reconstruct an incorrect bitstream. The output of the AMBE2000 Vocoder is actually made up of 2400 bps of the speech data plus 1200 bps of the FEC data making a total of a 3600 bps bitstream.

However the FEC algorithm cannot correct everything and any ‘bad data’ will still be decoded by the receiver as though it were accurate and the resulting audio will be output from the rig, usually resulting in strange sounds that are a bit like the noises of the R2D2 character in the Star Wars movies.

This is also an issue when using repeaters, and is the reason why repeaters are normally situated on a site with good all-round coverage.[61]

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60 However, please don’t get into the habit of not leaving the minimum 4-second gap so that you don’t have the re-learn this when you get back on the repeaters/reflectors

When a radio detects that packets are missing or have become corrupted, it typically drops that packet, mutes the output (very briefly) and tries to recover by using the next one it receives. When it can successfully do this it will also display an “L” (for Lost Packet) on the display.

Of course there are times when it does not detect the corruption and you get the garbled noise.

The solution is to make sure that the signals into the receiving antenna are strong enough for there to be few (if any) bit-level errors. When operating in simplex mode this may mean using directional aerials on rotators so as to get the best signal.

However, once you have reliable digital communication established between two stations, then the narrow bandwidth of the D-Star signal and the data-based nature of the modulation means that you are able to pass any information that can be digitally encoded.

Signal Dropout

The audio from SSB and AM modulated signals tend to gradually degrade as the distance from the transmitter increases. FM modulated signals can often be clearly heard for a greater distance but then tend to drop away fairly fast. As the audio drops away, so the background “hiss” becomes more prominent.

The D-Star digital encoding is used to modulate an FM signal and therefore it gets the advantages of FM mentioned above. Further the D-Star and other digitally encoded signals have a characteristic that the audio can be heard without any background hiss at all (after all the signal is digitally encoded in the transmitting device and not decoded until inside the receiver).

However this requires that the bitstream be correctly received and interpreted. I’ve discussed the R2D2 effect as the bit stream starts to become corrupted.

Therefore, D-Star signals tend to be heard perfectly until the R2D2 effect begins and shortly after that the signal drops out entirely as there are too many detected decoding errors and the radio simply mutes the signal as though there was no signal there at all.

Multicasting

There is something similar to repeater routing called Multicasting which allows you to route your transmission to a pre-defined group of repeaters. The key word there is ‘pre-defined’ - the group must be set up by a D-Star administrator and list all of the repeaters in the group.

However, once the group is set up, it is given a name that can be accessed in much the same way as repeater routing - by prefixing the multicast group name with a slash (e.g. for a hypothetical multicast group called “VKWIA”, you would put “/VKWIA”) into the Destination call sign field.

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61 Some experiments have shown that the digital signal can be successfully used over a greater distance than an FM signal. However, whereas the FM signal gradually degrades with increasing distance, the digital signal either works or it doesn’t.

Before you use this feature, you need to get onto the Internet and find out what multicast groups have been set up and which are appropriate for your use.

Echo test transmission

This process is very useful when you are attempting to reach a repeater, especially when you are mobile or not sure of the reception characteristics from your location. You will be able to hear back if there is any corruption in the data stream (which shows up as the 'R2D2' sounds in the resulting audio).

You request that the repeater port record your transmission and then echo it back to you by putting the blanks into the Destination call sign field with the 8th position being an "E".

For example, to get an echo from port C of the VK3RWN repeater, you would set up the Repeater1 and Repeater2 fields as described in the "Local Repeater, Same band" section and put "⌂⌂⌂⌂⌂⌂E" in the Destination field.

You then press the PTT button and make a short announcement such as:

"This is VK3ANZ making an echo test of the VK3RWN repeater on Port C"

When you release the PTT button, you will then receive your voice message back again.

Using the echo test facility of a repeater that is linked does ***not*** result in your test transmission being passed any further than the local RF port.

Appendix 4 - D-Star Data

D-Star works by converting your voice into a digital data stream which is then transmitted by the radio. This data stream can be received by repeaters, transferred through the D-Star network and generally moved all around the place until it is finally received by another radio where the digital data stream is converted back into analog form and fed to a speaker. (This is fundamentally the same for DV Dongles but without the RF aspects).

Therefore it should come as no surprise that it is possible to insert any other form of digital data into the overall data stream and have this passed around the network as well.

D-Star operates on 3 RF bands: 2 meters (C), 70 centimetres (B) and 23 centimetres (A). The RF spectrum needed by the D-Star **digital voice** protocol is fairly narrow; much narrower than for a comparable FM signal[62]. The narrowness of the bandwidth limits the speed at which data can be exchanged.

Basically this means that the digital data capabilities of D-Star DV system are about the same as those of an SMS message - short bursts of data.

Have a look at software products such as D-RATS which take advantage of the D-Star 'digital data' capabilities and open up a new 'layer' of involvement possible with the D-Star protocol.

Please note that there are often local restrictions and guidelines as to which repeater ports and modes can be used for digital data. Please make yourself aware of these restrictions and guidelines before you start your data transmissions.

However, remember that - just like a voice transmission over RF - the digital data that is transferred can be seen and interpreted by anyone with a correctly configured radio and computer. Unlike your Internet and other network connections to your computer, the data that is transferred over D-Star is not private.

By contrast, the **DD fast data** service offered in the 23cm band has much wider bandwidth and so can accommodate faster data connections. It is realistic to connect a computer and, with the appropriate cables, connections and software, you can transfer web pages from servers within the D-Star network at about dial-up speeds. (Note: most repeaters that offer this level of service have a separate 23cm band repeater port dedicated to digital data. Often the digital data repeater port carries the "A" designation but is on a different frequency to the 23cm digital voice port).

(Short aside: When you put the ability to transfer web pages together with the use of the Internet to connect the D-Star repeaters and reflectors together, the common misconception is that you can access the Internet via D-Star. This is ***not*** the case. The internet is **only** used as a transport infrastructure. It is possible for a D-Star to Internet gateway to be established but this is not done in Australia because this would breach the Australian Telecommunications Act).

62 D-Star digital voice and low speed digital data use a bandwidth of 6.25 kHz regardless of the RF band being used.

Appendix 5 - GPS, Beaconing and other D-Star features

Some D-Star radios (especially the newer ones) have integrated GPS capabilities, and others can have a GPS unit plugged into them (provided the information is transferred in the required format).

This means that your geographical location can be broadcast every so often to the repeater that your radio is currently tuned to. The location information can be recorded in a world-wide database which is available to anyone with an Internet connection so that they can plot your position.

Some radios also have the ability to receive the GPS data from other D-Star radios and so calculate and display the relative direction and distance between them. This is particularly useful on those radios that can also store the geographical location of repeaters and so notify you when you are approaching one when you are mobile.

I don't want to say much more about the GPS capabilities (and possibilities) of D-Star other than this warning: Please don't allow your D-Star radio to transmit your GPS position by itself[63] too often - a process known as 'beaconing'.

Just as with any other D-Star transmission that is processed by a repeater, the repeater controller can only handle 1 data stream at a time on each RF port. Because your beacon transmission is automatic, your radio does not 'listen' first to make sure the repeater port frequency is not being used - it simply makes the transmission.

This can interfere with other signals is 2 ways. It can "double" with another caller and the data streams can interfere. The end result is that the other caller's data stream will become corrupted and their signal may be lost.

The second way it can interfere is that the repeater will reject any other data stream that arrives while the beacon information is being received. While this beacon data is only a very short burst, it can still be enough to block a voice transmission that is part of an on-going QSO.

The recommended period of GPS beaconing transmission is a minimum of once every 30 minutes for stationary radios, and once every 10 minutes for mobile use and preferably much longer.

Some radios can be set to transmit their GPS coordinates as part of each over. This can provide a 'best of both worlds' situation in that you broadcast your position only when you are actively using the D-Star network. Others can see where you are but you are not generating a lot of unintended transmissions.

GPS data can be passed between radios using simplex with each radio being responsible for interpreting the information that is sent.

63 By all means have the GPS data sent along with your normal voice transmission. This comment is more about the ability of a D-Star radio to automatically broadcast its location every so often.

You may hear the terms APRS and DPRS being used in connection with D-Star and GPS data transfers. APRS uses packet radio to transmit information where the GPS information is normally received by dedicated APRS Digipeaters and fed into the APRS-IS network.

DPRS uses the D-Star low-speed Digital Data component to transmit information across the D-Star network alongside voice transmissions. Specialist DPRS Gateway software can be installed on a D-Star gateway which interprets the GPS information and feeds it into the APRS-IS network.

Appendix 6 – Layer upon layer

One area that causes confusion is the various layers of software that can be used within a D-Star repeater. You will see references to D-Plus and RP2C as well as see people mentioning that they run their own software on their (often home-brew) repeater systems.

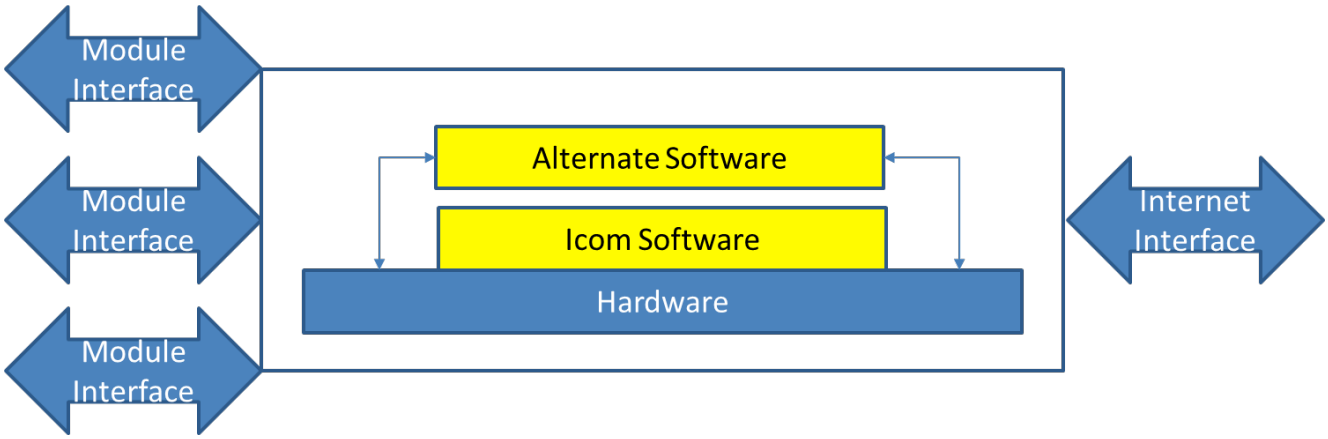
For the most part you can ignore all of this. In the body of this document I have discussed call sign routing and repeater/reflector linking and how you need to set up your radio to use these and, in general, that is as much as you need to understand to use the D-Star system's capabilities.

On the other hand, there are people like me that want to know about these things! They also want to know why you get responses from a D-Star RF port that indicate the transmission failed to be routed, but you are still talking to the other person on the other side of the world!

Therefore, what follows is my way of understanding how all of this works. It is NOT necessarily technically accurate but I hope that it does show how things work inside a repeater.

Inside a D-Star repeater there are a set of hardware modules that contain computers. Each RF port (the part that handles the RF transmission and reception for a particular frequency band) has a simple computer that handles the operation of the module. Nothing really fancy but one of its main tasks is to communicate with the main controller system (computer) that also handles the gateway operation.[64]

For now, we need to just talk about the gateway computer as it handles all of the traffic in and out of the repeater to the internet.



Think of it as in the figure above: the gateway computer hardware lets it connect to the various RF modules that are present and also with the Internet. The hardware runs the Icom software (called RS-RP2C and the latest version is V2.0 which often leads to it being called "Gateway 2.0") which is monitoring the data streams for the various call sign information and performing the necessary lookup functions and connections to other repeater gateways to handle call sign routing.

64 If you want to get technical, the RF modules have names such as ID-RP2V (23cm voice), ID-RP2D (23cm data), ID-RP2000V (2m voice) and ID-RP4000V (70cm voice). The main controller/gateway is an ID-RP2C.

However, the repeater administrator can also load up other software and D-Plus (written by Robin Cutshaw AA2RC) is a common choice that also provides the repeater/reflector linking functionality.

So, how does this additional software fit in? After all, the Icom software can be configured to some extent butit is not designed so you can't just add on your own code to it!

The D-Plus software runs as a separate program on the gateway computer that monitors the data streams used by the Icom software and also interprets the header information (the call signs) and makes its own connections out to the Internet. It can also add its own data packets to the RF interface modules to pass on a data stream from a remote source.

Therefore, when you use call sign routing, this will be handled by the Icom software and the D-Plus software will ignore it.

When you link to a repeater/reflector, Icom software will look at the 'Destination' call sign and it will not be able to interpret it correctly and so it will return an error status message to the RF module (which is why you see these being returned from the repeater).

However, the D-Plus software **will** see the coded 'Destination' call sign and interpret it correctly. It will then establish (or break) the required link and also inject back its own data stream to the RF module to say that the link has been established (or whatever is the appropriate message).

Of course, there can be other software layers that the repeater administrator can add that provide additional functionality. I have just picked on the D-Plus software is it is very widely used. In all cases, the basic principle is the same that the layered software adds functionality to the repeater that the Icom repeater software knows nothing about and can therefore respond to the originating station some incorrect status messages.