

## Digital Modes

### RTTY

Digital communication modes represent one of the fastest growing areas of interest in amateur radio, with the past decade seeing many developments. While there are other digital modes that radio amateurs are experimenting with, RTTY, AMTOR, and Packet Radio are the main digital modes on amateur radio. Newer modes such as GTOR are also emerging as amateur radio continues to develop in the area of digital communications.

Baudot code is still the common denominator of digital modes, but it is far from standardised itself. While many use the term Baudot Code, others use the term Murray Code. These two names acknowledge two important telegraph pioneers, both of whom made major contributions in this field, however the correct term is CCITT International Alphabet No. 2. The differences between in practical systems is apparent in the punctuation characters and would not be noticed between two operators unless they used punctuation such as ! : % @ etc. Baudot is sent at differing speeds in different areas. Most US operation is at 45.45 baud (a hangover from a speed limitation by the FCC of 60 wpm for any coded operation), at 45 baud in Europe, while all operation in New Zealand is at 50 baud (after a collective decision to standardise to the commercial speed). Nowadays, computers have almost completely taken over from the mechanical teleprinter, so baud rate changes are no longer the problem they once were.



### ASCII

This is used to a very small degree on amateur bands. The proliferation of personal computers in the ham shack, often with in-built communications facilities designed to work on telephone networks, encourages this mode, however there are much more practical ways to use a computer on the air. Transmission speed is generally standardised at 110 baud, however faster rates, such as 200 and 300 baud, are used, with varying degrees of success.

### AMTOR

One common problem with direct printing RTTY (such as Baudot and ASCII) is errors in reception. If there is any slight disturbance to the received signal, it is quite likely that an incorrect character will be printed. This is not a major problem in the average amateur conversation, as the rest of the sentence will usually fill in the gaps. However, on all but the best contacts, important details (e.g. frequencies), must be repeated a couple of times to ensure that the other station gets what you want to say. This form of operation may be satisfactory for hams but it is not satisfactory for commercial operation such as ship to shore Teletype.

AMTOR can be thought of as a more advanced form of RTTY which includes automatic acknowledgement of each group of characters sent, or a request for repeat. This results in error-free communication (at the expense of speed, especially in poor conditions). The protocol is very specific so there is no variation in the transmission speed of 100 baud. As this mode requires more sophisticated equipment able to handle the error checking functions and a relatively fast receive/transmit changeover in your radio, the number of operators is a little down on the simpler modes.

The main feature of AMTOR is that it uses the Moore code, which is made up of seven unit characters (bits), but utilising a select few of the possible combinations, thus allowing a receiving station to tell if a received code is correct or not. AMTOR operation involves the transmitting station sending three characters, then waiting for a response from the receiving station. The response will either be "roger, go ahead", or "no go" (or perhaps nothing at all if the path has faded out). The transmitting station then either repeats the last three characters, or sends the next three. This operation is a form of ARQ (& Automatic ReQuest), known as AMTOR Mode A.

By sending text in bursts of three characters, awaiting one character reply, then sending three more, AMTOR requires radio equipment which can change from transmit to receive in a very short time. On-air AMTOR has a characteristic fast "chirp-chirp" sound.

There is another version of AMTOR (Mode B) which also uses the Moore code (i.e. has the ability to detect errors), but is an FEC (Forward Error Correction) system, rather than an ARQ system. Instead of a transmit and wait acknowledgement system, Mode B simply transmits every character twice, three characters apart. This allows the receiving station two goes at getting it right. As a result, Mode B AMTOR is more reliable than RTTY, but not as reliable as Mode A AMTOR. Mode B, as it does not require acknowledge responses from the receiving station, is used for news broadcasts, and CQ calls. Mode A also is limited by the specified timing to short-path HF contacts due to the radio propagation time around the world, so Mode B is necessary for some contacts.

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## **PACTOR**

Pactor is a hybrid between packet and AMTOR techniques to try and provide a faster and more robust protocol for HF data links.

PACTOR transmits either 12 or 24 characters, depending on the baud rate, either 100 or 200. Four characters are used for control including two checksum bytes. Errors are detected at the receiver by comparing the checksum with the accompanying data. PACTOR uses the AX-25 checksum (CRC-16). The receiver requests new data, a retransmission of data or a change in system baud rate.

PACTOR has become a popular HF mode, as it is more efficient than AMTOR or Packet in most situations. It is readily available in commercial data controllers, and is also available in software form for simple modem designs.

## **GTOR**

The protocol that brought back those good photos of Saturn and Jupiter from the Voyager space shots was devised by M.Golay in the USA. His protocol has now been adapted by Kantronics for Ham Radio use.

GTOR is a protocol about four times as fast as the next fastest and has good reliability, which it gets from  
1. 16 bit CRC error detection  
2. Golay encoding with ARQ for error detection  
3. Interleaved data for noise disbursement  
4. Huffman compression and run length encoding for improved throughput  
5. 300,200 OR 100 BAUD TO SUIT VARYING CONDITIONS

It can transmit a full ASCII set and callsigns of up to 10 characters GTOR is a linked mode between one station and one other using a 2.4 second cycle – data frame 1.92 sec and acknowledgement 0.16 sec.

GTOR transmits either 24, 48 or 72 characters depending on baud rate, either 100, 200 or 300 respectively. Errors are detected at the receiver using a CRC-16 checksum. The receiver request new data, a repeat of the last data or parity or a change in baud rate.

GTOR is gaining some ground in HF data communications, but as it is only available from one manufacturer, it has not taken off as quickly as its benefits would suggest.

## **CLOVER**

Clover is another high performance HF data protocol, but like GTOR is proprietary and is also quite expensive. It can achieve quite high data throughput on an HF channel using various techniques, including data compression.

## **RTTY/AMTOR Mailboxes**

There are a number of SELCAL/Mailbox stations operating, including ZL2HO and ZL1AMW which monitor 7045 kHz in Baudot, and VK2AGE who monitors 7045 kHz in AMTOR ARQ.

## **Packet Radio**

Packet Radio is another error-free mode, which has added advantages of higher speed (if good radio signal is available) and increased economy of spectrum by time-sharing a channel with other users.

Transmitted text is collected into "packets" before sending. Within this packet is the callsign of the packet destination, the source (i.e. sender's) callsign, control information on the type of packet being sent (control, acknowledgement, information), data (where applicable), and a CRC (Cyclical Redundancy Check) which enables the receiver to determine whether there are any errors in the received packet. The exact format of the packet is laid down by an agreed protocol. (A full explanation of packet radio can be found in recent editions of the ARRL Handbook, and other such publications.)

The first protocol widely used by amateurs was known as the VADCG V1 protocol. While this protocol facilitated early experimentation, it had a number of limitations. To overcome these limitations, a new protocol called AX.25 was developed. AX.25 is based on X.25, a commercial computer communications protocol.

Packet radio requires the use of a computer to handle the protocol and the exchange of data. This may be done by either programming a personal computer, or by using a dedicated computer called a TNC (Terminal Node Controller) connected between a computer/terminal and the radio. The TNC approach leaves the operator's computer free to handle application activities. A hybrid system that uses software and a computer I/O card is another alternative that has benefits of both the programming approach and the TNC approach.

Packet Radio has traditionally been used at data rates of 1200 bps using ASFK modulation. With advances in applications and technology this has become a rather limiting factor, and 9600 bps operation is becoming more common. Higher speeds are also becoming used on higher bands for networking applications, and speeds of 19200 bps through to 2 Mbps are becoming more common.

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## Packet Radio Glossary

- \***7PLUS:\*** **Seven Plus**, a file encoding program used to allow the transfer of non text data via the packet BBS network.(see last months column)
- \***AFSK:\*** **Audio Frequency Shift Keying**, a modulation technique used for digital communications, eg 1200 bps terrestrial packet.
- \***AMTOR:\*** A digital mode for HF use that is more efficient than Packet.
- \***APRS:\*** **Automatic Position Reporting System**. A program that uses packet radio to track the position of stations.
- \***ARP:\*** **Address Resolution Protocol**, a part of the TCP/IP suit of protocols.
- \***AX.25:\*** A modified version of the X.25 packet switch protocol for use by amateur radio on radio channels.
- \***Baud:\*** Changes per second, n baud will only equal n bps when the changes in question is a bit. Some modulation techniques may transmit more than one bit for each signal value.
- \***Baycom:\*** The name of a program that does most of the work that a TNC does, in software rather than in hardware. Also used as a reference to modems that are compatible with this program.
- \***BBS:\*** **Bulletin Board System**, a computer based system for posting information in the form of private messages or public bulletins for retrieval by others.
- \***BPQ or G8BPQ:\*** A program written by G8BPQ, that allows different programs to interface to different TNCs, and also provides some packet networking functions.
- \***BPS:\*** **Bits per second**.
- \***DRSI:\*** **Digital Radio Systems Inc**, a company that produces standalone TNCs and TNC cards.
- \***DSP:\*** **Digital Signal Processing**, a system where analogue signals are converted to digital signals and manipulated by software techniques. Used in modern filter, modem, and other circuit designs.
- \***FBB:\*** A packet radio bulletin board system (BBS) program, written by F6FBB.
- \***FSK:\*** **Frequency Shift Keying**, a modulation technique used for digital communications, eg 9600 bps packet.
- \***FTP:\*** **File Transfer Protocol**, a part of the TCP/IP suit of protocols.
- \***KISS:\*** **Keep It Simple Stupid**, a cut down version of the AX.25 protocol for use by computer programs and other protocols, such as TCP/IP.
- \***MODEM:\*** **Modulator/Demodulator**, used to modulate and demodulate digital signals for use on an analogue circuit, such as a radio channel.
- \***NETROM:\*** A packet networking firmware program used by dedicated network nodes or digipeaters.
- \***Packet:\*** General term for packet radio using AX.25.
- \***Pactor:\*** A digital mode based on a combination of the benefits of Packet and AMTOR.
- \***paKet:\*** A packet radio terminal program.
- \***PSK:\*** **Phase Shift Keying**, a modulation technique used for digital communications, eg 1200 bps satellite packet.
- \***R95:\*** **Radix 95**, a file encoding program used to allow the transfer of non text data via the packet BBS network.
- \***RUDAK:\*** Regenerative Transponder for Digital Amateur Communications (abbreviation comes from German translation)
- \***SCC:\*** **Serial Communications Controller**, a type of electronic chip used in most stand alone TNCs and TNC cards.
- \***SLIP:\*** **Serial Line Internet Protocol**, a part of the TCP/IP suit of protocols.
- \***TAPR:\*** **Tucson Amateur Packet Radio** corporation.
- \***TCP/IP:\*** **Transmission Control Protocol/ Internet Protocol**. A suit of protocols used for networking computers in many environments, including packet radio.
- \***TFPCR:\*** A program that allows software written to the WA8DED Host Mode specification to communicate with a TNC that supports KISS mode.
- \***TFPCX:\*** A program that allows software written to the WA8DED Host Mode specification to communicate with a Baycom compatible modem.
- \***TheNet:\*** A packet networking firmware program used by dedicated network nodes or digipeaters.
- \***TNC:\*** **Terminal Node Controller**, another name for a packet assembler/packet disassembler (PAD) as developed for amateur packet radio.
- \***TPK:\*** A very good packet terminal program that includes special features for use with the FBB BBS system.

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\***WA8DED**:\* A Host Mode protocol for programs to communicate with a TNC that has support for this mode.

\***X1J**:\* An improved version of the TheNet packet networking firmware program used by dedicated network nodes or digipeaters.

\***YAPP**:\* **Yet Another Packet Program**, a packet terminal program. Also a packet binary file transfer protocol used by many different packet terminal programs.

## **Common Operating Frequencies**

### **RTTY/AMTOR**

ZL net frequencies, 80 metres 3545 kHz and 40 metres 7045 kHz

### **International Operating Frequencies:**

80 metres 3610–3640 kHz, 40 metres 7040–7060 kHz, 20 metres 14080–14100 kHz and 10 metres 28080–28100 kHz

### **Packet Radio**

#### **ZL operating frequencies**

2 metres 144.650 MHz (most operation), 144.675 and 147.500

70 cms 432.650 and 432.675

As packet operation spreads and expands these allocations are being re-evaluated. It is also possible that some areas use frequencies other than those suggested.

### **International Operating Frequencies:**

40 metres 7030–7040 and 20 metres 14100–14150

## **Packet BBS Operation**

There are a large number of packet radio Bulletin Board Stations operating in ZL, mostly with access on 2 metres, and some with access on 70cms as well. To use these stations, simply connect, and enter your command. The command “H” for help responds with a list of features of that BBS.

Facilities available on a BBS are very comprehensive, however the most commonly used commands are:

**LM**—“**List Mine**” this will provide a list of message numbers, and subjects, for messages to you.

**Rxxxx**—“**Read message number xxxx**” After listing your messages, to read one, note the message number, and enter a read command for that number.

**KM**—“**Kill Mine**” Kill all messages addressed to me, that I have read. Note that you cannot kill a message until you have read it.

**L**—“**List messages**” This lists all new messages and bulletins on the BBS since you last listed messages. Note that if this is your first time on a BBS, or you have not checked in for some time, this command will result in a very long reply.

**SP ZL1XYZ**—“**Send a personal message to station callsign ZL1XYZ**” The BBS will then prompt you for a subject (one line of up to 60 characters), then the message content. End the message with either “/EX” or control “Z”.

**B**—“**Bye**” This logs you off the BBS, and it initiates a disconnect from you. In fact you can log off simply by disconnecting.

## **BBS forwarding**

The packet BBS network in ZL is capable of forwarding a message throughout New Zealand, and to most locations overseas.

A table of current main-centre bulletin boards is included in the “Operating Information” section of callbook. To send a message to a distant amateur, note the callsign of their local BBS, and use that as the message address. For example: If you reside in Auckland, and have a message for an amateur in Christchurch, all that is required is for you to enter an @ in the send command to the appropriate BBS, e.g.:

SP ZL3ABC @ ZL3AC

This will command the BBS network to forward your message to the ZL3AC BBS (In Christchurch). The forwarding is completely automatic, and often the message will pass through a number of BBS on the way.

Many BBS are operated by interested amateurs from their home, using their own computers, therefore new stations often appear, and some old stations go off the air. For this reason a current list of active BBS is difficult to maintain. A number of Branches of NZART have set up BBS, using Club resources. By their nature these stations are somewhat more permanent, so they are indicated in the table.

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## Forwarding mail overseas

To send mail overseas, you should know the destination operator's local BBS hierarchical address, then simply insert the destination address as usual. For example, to send a message to G1DIL at the GB7BBS BBS, simply enter this into your local BBS as:

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SP G1DIL @ GB7BBS.#28.GBR.EU
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The hierarchical address specifies the local BBS, the region that it is in, the Country that it is in, and the continent.

From this full address your local BBS can determine the best path to get your message to its destination.

It is possible that if your local BBS is running a recent version of FBB and it has the White Pages service turned on and someone else has had a message from the callsign that you wish to send a message to, then you will only need to specify the callsign of the recipient, as all the other information will be obtained from the White Pages database. However to be sure that your message will get through you should specify the full address.

## Digipeaters

A number of networking digipeaters have been installed on hilltops. These consist of standard TNCs operating special software, providing a store and forward packet repeater.

The most common software being operated currently is "TheNet", or "X1", which provides a form of networking based on "Nodes". Each digipeater regularly broadcasts a list of other digipeaters (nodes) it can hear, and that it has heard about from the next digipeater down the chain. This way all digipeaters in a network build up a list of all others, and the route to each other.

A user simply connects to his local digipeater, and enters the command "N", for nodes, and the digipeater will reply with the list of the nodes in the network. The user then issues a command to the digipeater to connect to the desired node, and the digipeater will automatically connect through all the required intermediate digipeaters to the destination. The user can then command the far end digipeater to connect to his destination home station.

Another type of digipeater software is called "Rose". This also provides network working, but in a very different way to "TheNet". While Rose is very widespread in Australia, its incompatibility (for automatic routine) with the more established "TheNet" means we are unlikely to see much of this system in New Zealand.

A number of home-station and BBS systems directly communicate with "TheNet" digipeaters, and announce themselves as "nodes" on the digipeater list. This allows simple direct connection to a far end user from your local digipeater. For example Hamilton ZL1UX BBS uses G8BPQ networking software, so appears in the nodes list of local digipeaters as "HAMBBS:ZL1UX". Hence all that is needed to connect with the BBS from away from Hamilton is to connect to your local digipeater, and enter a command to connect to HAMBBS, eg:

### **C HAMBBS**

As ZL1UX is known to the digipeater, it will automatically provide the intermediate connections through the network to the BBS for you. As a cautionary point, the BBS software is usually set up to ensure its identity is passed on to only a limited number of digipeaters away from home location, to discourage DX BBS operation, which unnecessarily ties up the digipeater network.

## Data Repeaters

Data Repeaters work in a similar way to a standard voice repeater, but are used for data to get extended coverage. The use of a duplex repeater has advantages over a digipeater for performance, but does not have any advanced network capabilities.

A hybrid of repeater technology and the intelligence of network capabilities of the digipeater is starting to become a new standard for packet networking.

## TCP/IP

TCP/IP is a protocol set that is used in commercial computer networking, and is also available for use over packet radio. It offers many services and facilities over and above those found on a standard packet BBS. There is growing interest in TCP/IP in New Zealand. For a starters kit contact Andy Hopkins ZL1VAH. For IP address allocations contact David Arnett ZL1UFO for details of your local IP address co-ordinator.

## Software

There is a wealth of software available for the different digital modes, but in particular for packet radio. Most software for amateur radio use is available free, or very cheap through the shareware principle, but there is also quite an amount of commercial software available as well. The software that you use will depend on the

hardware that you use, the computer system that you use, and your own preferences. For most users the main piece of software is a packet terminal program. To find out about available software ask around to see what others are using for the same equipment that you have.

### **Current Information**

See the Digital Modes column in Break-In for current information. If you have access to packet then much information is available as bulletins on the packet radio network.

A number of regions also have Packet or Data special interest groups which may have their own meetings and maybe a separate newsletter, so contact your local club or branch or other local hams to see if such a group exists.

There is also a regular weekly news broadcast on ZL digital mode happenings. The ZL Data News is prepared at the shack of ZL1AMW from contributions sent by post, RTTY and packet. Text is also obtained from packet BBS stations, and Selcals on 7045/3545 kHz. This news is transmitted weekly on Sunday mornings at 0930 hrs (local) and repeated at 1900 hrs. The morning transmission is on 7045 kHz and the evening transmission is on 3545 kHz. It is first sent in Baudot at 75 baud, then repeated in AMTOR mode B (FEC) on both occasions.

### **DX PacketCluster**

The DX PacketCluster is a packet BBS provided especially for DX operators. While it has the normal bulletins and mail facilities normally associated with a packet BBS, it also has many other features of interest to DX operators.

For example, if anyone logged on to the DX PacketCluster hears some interesting DX, this 'DX spot' can be put up on the Cluster for the benefit of any others who may be logged on. The others will see the DX spot in real time, and anyone interested can tune up and work the DX station. This is the prime purpose of the DX PacketCluster.

There are also other features such as WWV sunspot information which can be put up, a list of current DXCC countries with prefixes, headings and distances from your QTH, and sunrise and sunset information for each country.

Various DX bulletins are put up on the Clusters from time to time.

The following is the information for those interested in connecting to a DX PacketCluster::

#### **ZL1BN Auckland**

Access through the Klondyke node, 1200 baud on 145.625 MHz with negative split, or 9600 baud on 438.350 MHz with negative split.

#### **ZL1HY-10 Walton**

Access through the Klondyke node, 1200 baud on 145.625 with negative split, or 9600 baud on 438.350 MHz with negative split, or on the local port 144.725 MHz simplex.

#### **ZL2NX Martinborough**

Access through 6625 Wellington Data repeater, 7075 Wellington 2400 baud repeater, 5725 Manawatu Data repeater, 860 Mt Climie 70 cm Data repeater, 5425 Mt Climie, 144.6 MHz local port, 7035.5 kHz HF 300 baud packet access.

#### **ZL3DXC Christchurch Access through 144.650 MHz**

The ZL1BN and ZL1HY-10 Clusters are linked through the Klondyke node. These two are linked to ZL2NX through ZL2AQY at Stratford, however, the link is somewhat tenuous because of propagation variations on 2 metres. It is hoped that this link will be made more reliable in the near future, and that a link can be provided to ZL3DXC. Efforts will also be made to extend the network further, depending on the availability of resources.

If you are keen on DX on any band, including VHF and UHF, then the DX PacketCluster is for you. Even if you have no experience at packet, you will benefit from connecting to a Cluster, and staying connected while you are tuning the band – you will even be able to put up spots yourself for the benefit of others.

Further information is available from the sysops, Murray ZL1CN, Mike ZL1HY, Chris ZL2DX and Graham ZL3NZ.

By Murray Woodfield ZL1CN and Chris Hannigan ZL2DX