

Online Radio & Electronics Course

Reading 40

Ron Bertrand VK2DQ

<http://www.radioelectronicschool.com>

SPECIAL MODES

Apart from the usual voice modes of AM, FM and SSB, amateur radio operators can experiment with dozens of different modes of operation. There are not a great deal of questions in the exam on this topic. Unfortunately the examiner does have a few 'pet' questions and I will be covering those here.

So this reading will be an overview of some of the many 'extra' modes that an amateur station may use. Of course you may never use any of them. No doubt if you do, you will learn more about it.

Amateur radio communication has progressed in many ways since its beginning in the early 1900's. General communications has progressed from spark to CW and voice from AM to FM and SSB. Similarly, data communications as a mode of amateur communications has progressed from CW to FSK, and from RTTY to more 'modern' modes of data communications utilising packets etc.

Amateurs now communicate using fast and slow scan television. An exciting developing area is high speed wide bandwidth point to point links on the microwave bands.

I would like to encourage you to broaden your baseline in amateur radio once you have acquired your licence. There are just so many facets to this hobby. Thinking that it is all too hard often stops the beginner. It is not. Have a go and you will be surprised. There is a wealth of information available for free through special interest groups and the Internet.

BINARY

Binary is a method of representing numbers with only two states - on/off or high-volts/low-volts.

Using the characters 0-9 forms all decimal numbers. If electrical circuits were to use 10 states like this they would be very complex indeed. In the binary system all numbers can be represented by a combination of 1's and 0's, thus it is very easy to represent any number or characters as a string of high and low voltage states. Table 1 shows the binary representation of the decimal numbers from 0 to 15.

Table 1.

2^3	2^2	2^1	2^0	
8	4	2	1	Decimal
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

For example, a square wave digital data stream consisting of 1010 could represent decimal 10.

RADIO TELETYPE - RTTY (RITTY)

Baudot code is still the common denominator of digital modes, but is far from being 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 code types in practical systems are apparent in punctuation characters, and would not be noticed between two operators unless they used punctuation such as ! : % @ etc. Baudot is sent at different speeds in different areas. Early transmission speed in Australia was pretty much standardised at 45 baud. These days, computers have almost completely taken over from the mechanical teleprinter, [so baud rate changes are no longer the problem they once were](#).

ASCII

ASCII stands for [American Standard Code for Information Interchange](#).

This is used to a very small degree on amateur bands. The proliferation of personal computers in the ham shack, often with inbuilt 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, but faster rates such as 200 and 300 baud are used, with varying degrees of success.

ASCII has become the standard code for communication between computers. The code was authorised for amateur transmissions in the United States in September 1980 and authorisation was given to Australian amateur stations shortly after. The ASCII code contains seven bits which are used to represent numeric values, the alphabet, punctuation

marks, symbols, and special control characters for teleprinters and terminals. An extra eighth bit is used as a parity check. If even parity is used then the parity bit is set so that the sum of all the bits making up the character is even.

AMTOR - AMATEUR TELEPRINTING OVER RADIO

One common problem with direct printing RTTY (such as Baudot and ASCII) are 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 (eg. 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 amateurs but it is not satisfactory for commercial operations such as ship to shore teletype.

AMTOR can be thought of as a more advanced form of RTTY which includes [automatic acknowledgment 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 the 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 a 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 characteristically fast "chirp-chirp" sound.

There is another version of AMTOR (Mode B) which also uses the Moore code (ie. 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 acknowledgment 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 is also limited by propagation timing to short-path HF contacts, due to radio propagation time intervals for around the world contacts - so Mode B is necessary for some contacts.

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 which is either 100 or 200 respectively. 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 another using a 2.4 seconds cycle, a data frame 1.92 seconds, and acknowledgment of 0.16 seconds.

GTOR transmits either 24, 48 or 72 characters depending on baud rate of 100, 200 or 300 respectively. Errors are detected at the receiver using a CRC-16 checksum. The receiving station requests 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 a HF channel using various techniques, including data compression.

PACKET RADIO

Packet Radio is another error-free mode which has the added advantages of higher speed (if good radio signal is available), and increased economy of spectrum space 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 (sender's) callsign, information on the type of packet being sent (control, acknowledgment, etc.), data (where applicable), and a CRC

(Cyclic 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 the benefits of both the programming and TNC approach.

Packet Radio has traditionally been used at data rates of 1200bps using ASK modulation. With advances in applications and technology this has become a rather limiting factor, and 9600bps operation is becoming more common. Higher speeds are also becoming used on higher bands for networking applications, and speeds of 19200bps through to 2Mbps are not uncommon.

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.

PACKET - MORE ON FREQUENCY SHARING

Packet radio, like the commercial X.25 packet switched systems, allows several simultaneous point to point connections to share the same frequency.

In packet radio, whenever we send a message to another station, our TNC builds a packet (like an envelope) around our message, adding details such as the callsign of the station this message is addressed to. Then, if the frequency is clear, the packet is transmitted into the airwaves.

Our TNC listens to the audio coming from the radio receiver and, if there are any other packet radio stations using the frequency, waits until there is a lull in the transmissions before transmitting our packet. At first, you might wonder how long it has to wait, thinking the other stations might be going for hours! However, in practice, a packet might take only a fraction of a second to transmit - a relatively short burst of time compared to the time it takes us to type a message. Unless the frequency is really busy, you might not even notice the delay!

The packet radio frequency in use carries messages for many people at the same time. When receiving, your TNC looks at every packet received, checks the address on each packet, and identifies any packets addressed to you.

Any packets not intended for you may be ignored by your TNC so you see on your screen only those messages addressed to you. This way you need not concern yourself with all the other information flowing around on the frequency, and are free to concentrate on your contact with the other station.

If you wish, you can ask your TNC to display everything it receives. This is called monitoring. Every packet contains an AX.25 header ("envelope") which identifies the station who sent it and the station it is addressed to. The header contains other information too but we won't get into that just now. When monitoring, your TNC will send to the computer the header and content of all the messages, so you can see who sent what to whom. Then you will see how the AX.25 system is able to handle lots of different conversations on the same frequency at the same time. The other modes do not offer this capability.

FREQUENCY SHIFT KEYING (FSK) AUDIO FREQUENCY SHIFT KEYING (AFSK)

FSK is used on HF bands for RTTY (and other data modes). The transmitter frequency is taken as the mark condition. The space condition causes the transmitter to shift down in frequency, normally by 170 Hertz. **The frequency shift is usually produced by switching a varactor diode across the carrier oscillator crystal.**

AFSK is used on bands above 50 MHz. In this mode the RF carrier stays on all the time and a modulating audio tone is shifted in frequency. The standard frequencies are 2295 Hz for 'space' and 2127 Hz for 'mark', a separation of 170 Hz.

Many RTTY stations on HF use SSB transmitters and feed AFSK tones to the microphone socket. When an SSB transmitter is modulated with a single audio tone, it produces at its output a single upper or lower side frequency. The tone can change back and forth between the two audio frequencies but the transmitter will only produce a single carrier frequency output for each tone. On air, this type of emission cannot be distinguished from FSK.

An SSB transmitter is not meant to operate at 100% duty cycle as is the case when modulated with AFSK tones. Consequently the transmitter must be operated at reduced power.

DEMODULATING FSK AND AFSK

An RTTY (or other data) transmission consists of FSK or AFSK. The RTTY printer (or computer monitor) will not make any sense of such signals. The purpose of the RTTY demodulator is to convert the frequency shift signals to current pulses to operate the teletype machine. If a computer is used as the teletype decoder then the FSK still needs to be converted into a digital pulse train acceptable to the logic circuits of the computer - the demodulator takes care of this.

SLOW SCAN TELEVISION (SSTV)

Slow scan television produces a very slow scan frame rate (no moving pictures with SSTV). Slow scan TV is popular because its narrow bandwidth requirement means that it can be used on the HF bands, enabling long distance communication. The pictures sent back from many space probes are in slow scan. For slow scan the camera outputs a variable frequency audio tone. High tone is for bright picture information and low tone is for dark areas. SSTV is not difficult to produce with computer software. All that is needed is some way of getting the image you want to transmit into the computer from an external camera. This can be done with a video capture card and a simple web camera. It is easy for computer software to scan this image and produce the audio tones which are simply used to modulate the transmitter. At the receiver the demodulated audio tones can be fed into the computer's sound card and software will reconstruct the image on the remote computer monitor. It is a simple matter to transmit colour pictures in SSTV though the frame rate is slower.

With computers, SSTV is one of the easiest 'extra' modes to use with very limited cost. In fact, even if you do not have a camera you can transmit and receive images just using free software and your computer's sound card (and a radio transmitter of course).

Figure 1 shows a colour slow scan TV picture received from the MIR Space Station.



Figure 1.

AMATEUR (FAST SCAN) TELEVISION (ATV)

With ATV you can send and receive TV (often called fast scan TV) pictures, which are exactly the same as you view on your local broadcast station, cable or TV-satellite, live in colour with motion and audio.

You can see, hear and watch whom you are communicating with.

Helium balloons have carried ATV transmitters to about 33 km, to the edge of space. Try to imagine the fantastic live pictures!

Emergency service coordinators have found that live video from a site gives a better understanding of a situation than is possible from voice description only.

On the one hand ATV can be very demanding, because it combines various techniques from a simple power supply to audio and video techniques, and UHF or above transmission.

Some ATV stations resemble something more like commercial stations in their operation and performance. However, they are not commercial stations and they operate strictly in accordance with the regulations for amateur radio. In fact they have to, as the commercial broadcasters would soon jump up and down. Gladesville Television is one amateur radio club that maintains and operates an ATV station for educational purposes in amateur radio. There is a link to Television Gladesville from the WEB site you obtained this reading from.

It is not beyond the beginner to get involved in ATV, though you might have to settle for lower power output and limited coverage. Kits are available for ATV transmitters as are ready made transmitters.

THE TELEVISION SIGNAL - INTERCARRIER SOUND IF

A television signal consists of two carriers. One for the video information - the vision carrier which is amplitude modulated, the other for the sound - the sound carrier which is frequency modulated. The **vision and sound carrier are 5.5 MHz apart**. This is one fact you should try to remember. The examiner, as far as I know, only asks one question on ATV and that goes something like this: What is the intercarrier sound IF used in fast scan television (ATV)? The answer is 5.5 MHz. Why?

The question is really asking at what frequency does the intermediate amplifier for the sound operate on in a domestic television receiver.

The intermediate frequency used for the sound IF in a television takes advantage of the 5.5 MHz separation between the vision and sound carriers of the transmitted and received TV signal.

Since the frequency separation is established at the transmitter, it is fixed and very accurate. In the video detector (a non-linear device) the vision and sound carriers (now at the first IF but still separated by 5.5 MHz) are allowed to beat (mix, heterodyne) together producing a 5.5 MHz intercarrier (between carrier) sound IF. The 5.5 MHz FM sound signal is then processed like any other FM signal to produce audio output.

PSK31

There is no exam requirement for PSK31 but it's definitely worthy of a mention.

PSK31 ("Phase Shift Keying, 31 Baud") is currently the most popular digital HF mode for transmitting text only messages. It is a form of modulation (or "mode") that offers a higher level of performance in text communications (keyboard-to-keyboard) that radio amateurs can enjoy. It has enjoyed instant popularity, due in part to the proliferation of the personal computer, and also due to the superb and generous efforts of some very clever radio amateur/programmers.

In the short time that PSK31 has been in use, its popularity has grown by leaps and bounds. It may in time replace or at least greatly supplant RTTY and other modes for person-to-person communications. It's fun, easy, and well worth the effort to get set up, which is not very much at all.

PSK31 can be used with a "special interface" card between a PC and the microphone input and speaker output of your transceiver. However, these days much software is available free from the Internet which utilises the PC's sound card. You may have to add a simple resistive pad (like a volume control) to get the correct audio levels into your microphone input, and a single transistor to trigger the PTT (push to talk) button of your transmitter. Many modern transmitters already have AUX (auxillary) inputs for this purpose.

DOPPLER SHIFT

Doppler shift is an apparent change in frequency of the received signal due to **relative motion** between the transmitter and the receiver. The amount of Doppler shift can be several kilohertz when using an amateur satellite for communications.

When the satellite is moving **toward** the receiving station there will be an apparent **increase** in the frequency of the downlink signals as the satellite passes overhead, and as it begins to **move away** there will be a sudden **decrease** in the downlink frequency. The effect is the same as that created by a passing car with the horn sounding. Astronomers are able to tell that the universe is expanding by the red shift of the visible light radiated from stars, again due to Doppler shift.

Modern radio direction finders use the Doppler shift to work out the bearing, range and velocity of a station being tracked.

FARADAY ROTATION

Faraday rotation or more correctly 'Faraday effect' is the **rotation of the plane of polarisation of an electromagnetic wave** as it passes through the ionosphere. The process is a complex one involving interaction between ionised particles and the magnetic field.

As the ion density is variable, so is the Faraday effect upon any particular transmission. If the Faraday effect is ignored when commuting by a satellite, a reduction in signal (up to 30 dB) can occur due to cross polarisation. Amateur stations overcome the problem by using an antenna which is circularly polarised so that signals are received satisfactorily no matter how they have been rotated. Faraday rotation or effect is also responsible for better propagation in one direction and not the other on HF bands. This means the signal strengths in one direction on a HF path may differ greatly from those in the opposite direction.

End of Reading 40

Last revision: July 2002

Copyright © 1999-2002 Ron Bertrand

E-mail: manager@radioelectronicschool.com

<http://www.radioelectronicschool.com>

Free for non-commercial use with permission