The Digital Ham Radio Revolution!

Communication technologies that are specifically designed to improve "live" HF keyboard operation can now be achieved that were previously only theory or too complex to be practical. Thanks to the generosity of radio hams with programming knowledge, and to the World Wide Web, new and powerful communications tools are available to all hams. The evolution and wide spread use of the Personal Computer with a digital sound card for DSP, is allowing us to use these tools to "push the envelope". The distinguishing features of live HF digital operation today are the use of lower power, compact or indoor antennas and courteous operating technique. This reverses the trend of several years ago...

PSK31 mode led the way starting in 1997, and since then experimentation has shown that incremental improvements can be made. The popularity of a single mode, like PSK31, over other new modes seems to be driven at this time by how many freeware programs are available for the mode. It is possible that a more advanced mode like MFSK16 will emerge as a standard for HF band operation in the future. We can all participate in the revolution by trying out the other modes and judging their performance on all of the HF bands. Fortunately, the interface needed to operate these new PC sound card programs is the same for all the modes. The next challenge for the ham programmers out there is to create a single program that will incorporate modules for all the new sound card modes.

Confusion over band space is the obvious down-side as new and old modes compete for band space. Crowding on a single band like 20 meters is partly to blame for this issue. Fortunately, the new modes, like MFSK16, are designed to improve performance inside a wide range of operating conditions. This should allow for increased ham band usage to relieve crowding and extend contact opportunities as propagation changes to favor different bands. I don't know what is going on with the phone portion of the ham bands, but these are exciting times for us digital operators!

TOR is an acronym for Teleprinting Over Radio. It is traditionally used to describe the three popular "error free" operating modes, AMTOR, PACTOR and G-TOR. The main method for error correction is from a technique called ARQ (automatic repeat request) which is sent by the receiving station to verify any missed data. Since they share the same method of transmission (FSK), they can be economically provided together in one TNC modem and easily operated with any modern radio transceiver. TOR methods that do not use the ARQ hand-shake can be easily operated with readily available software programs for personal computers. For these less complex modes, the TNC (terminal node controller) is replaced by an on-board sound card or out-board audio device. These modes may use redundancy or "human processing" to achieve a level of error correction.

AMTOR is an FSK mode that has been fading into history. While a robust mode, it only has 5 bits (as did its predecessor RTTY) and can not transfer extended ASCII or any binary data. With a set operating rate of 100 baud, it does not effectively compete with the speed and error correction of more modern ARQ modes. The non-ARQ version of this mode is known as FEC, and known as SITOR-B by the Marine Information services.

PACTOR is an FSK mode and is a standard on modern TNCs. It is designed with a combination of packet and Amtor Techniques. It is the most popular ARQ digital mode on amateur HF today. This mode is a major advancement over AMTOR, with its 200 baud operating rate, Huffman compression technique and true binary data transfer capability.

PACTOR-II is a robust and powerful PSK mode which operates well under varying conditions. It uses strong logic, automatic frequency tracking; it is DSP based and as much as 8 times faster then Pactor. Both PACTOR and PACTOR-2 use the same protocol handshake, making the modes compatible.

PACTOR-III is a proprietary mode used for message and traffic handling over an HF radio circuit. Use of Pactor-III protocol is limmitted for US hams and some other countries due to the very wide bandwidth of the Pactor-III signal. Presently digital signals that occupy the bandwidth of PCT-III are restricted to a few sub bands:
28.120-28.189 MHz, 24.925-24.930 MHz, 21.090-21.100 MHz, 18.105-18.110 MHz, 14.0950-14.0995 MHz, 14.1005-14.112 MHz, 10.140-10.150 MHz, 7.100-7.105 MHz, or 3.620-3.635 MHz.
Only the embedded hardware (modem) from the German company that owns the rights to this mode, is capable of operating Pactor-III.

G-TOR (Golay -TOR) is an FSK mode that offers a fast transfer rate compared to Pactor. It incorporates a data inter-leaving system that assists in minimizing the effects of atmospheric noise and has the ability to fix garbled data. G-tor tries to perform all transmissions at 300 baud but drops to 200 baud if difficulties are encountered and finally to 100 baud. (The protocol that brought back those good photos of Saturn and Jupiter from the Voyager space shots was devised by M.Golay and now adapted for ham radio use.) G-tor is found in only one manufacture's TNC and is rarely used today.

CLOVER is a PSK mode which provides a full duplex simulation. It is well suited for HF operation (especially under good conditions), however, there are differences between CLOVER modems. The original modem was named CLOVER-I, the latest DSP based modem is named CLOVER-II. Clovers key characteristics are band-width efficiency with high error-corrected data rates. Clover adapts to conditions by constantly monitoring the received signal. Based on this monitoring, Clover determines the best modulation scheme to use.

RTTY or "Radio Teletype" is an FSK mode that has been in use longer than any other digital mode (except for morse code). RTTY is a very simple technique which uses a five-bit code to represent all the letters of the alphabet, the numbers, some punctuation and some control characters. At 45 baud (typically) each bit is 1/45.45 seconds long, or 22 ms and corresponds to a typing speed of 60 WPM. There is no error correction provided in RTTY; noise and interference can have a seriously detrimental effect. Despite it's relative disadvantages, RTTY is still popular with die-hard operators.

PSK31 is the first new digital mode to find popularity on HF bands in many years. It combines the advantages of a simple variable length text code with a narrow bandwidth phase-shift keying (PSK) signal using DSP techniques. This mode is designed for "real time" keyboard operation

and at a 31 baud rate is only fast enough to keep up with the typical amateur typist. PSK31 enjoys great popularity on the HF bands today and is presently the standard for live keyboard communications. Most of the ASCII characters are supported. A second version having four (quad) phase shifts (QPSK) is available that provides Forward Error Correction (FEC) at the cost of reduced Signal to Noise ratio.

HF PACKET radio is a FSK mode that is an adaption of the very popular Packet radio used on VHF FM ham radio. Although the HF version of Packet Radio has a much reduced bandwidth due to the noise levels associated with HF operation, it maintains the same protocols and ability to "node" many stations on one frequency. Even with the reduced bandwidth (300 baud rate), this mode is unreliable for general HF ham communications and is mainly used to pass routine traffic and data between areas where VHF repeaters maybe lacking.

HELLSCHREIBER is a method of sending and receiving text using facsimile technology. This mode has been around along time; the recent use of PC sound cards as DSP units has increased the interest in Hellschreiber. The single-tone version (Feld-Hell) is the method of choice for HF operation. It is an on-off keyed system with 122.5 dots/second, or about a 35 WPM text rate, with a narrow bandwidth (about 75 Hz). Text characters are "painted" on the screen, as apposed to being decoded and printed. A new "designer" flavor of this mode called FM HELL has some advantage for providing better quality print, at the expence of a greater duty cycle. As with other "fuzzy modes" it has the advantage of using the "human processor" for error correction.

MT63 is a new DSP based mode for sending keyboard text over paths that experience fading and interference from other signals. It is accomplished by a complex scheme to encode text in a matrix of 64 tones over time and frequency. This overkill method provides a "cushion" of error correction at the receiving end while still providing a 100 WPM rate. The wide bandwidth (1Khz for the standard method) makes this mode less desirable on crowded ham bands such as 20 meters. A fast PC (166 Mhz or faster) is needed to use all functions of this mode.

THROB is yet another new DSP sound card mode that attempts to use Fast Fourier Transform technology (as used by waterfall displays) to decode a 5 tone signal. The THROB program is an attempt to push DSP into the area where other methods fail because of sensitivity or propagation difficulties and at the same time work at a reasonable speed. The text speed is slower than other modes but the author (G3PPT) has been improving his MFSK (Multiple Frequency Shift Keying) program. Check his web site for the latest developments.

MFSK16 is an advancement to the THROB mode and encodes 16 tones. The PC sound card for DSP uses Fast Fourier Transform technology to decode the ASCII characters, and Constant Phase Frequency Shift Keying to send the coded signal. Continuous Forward Error Correction (FEC) sends all data twice with an interleaving technique to reduce errors from impulse noise and static crashes. A new improved Varicode is used to increase the efficiency of sending extended ASCII characters, making it possible to transfer short data files between stations under fair to good conditions. The relatively wide bandwidth (316 Hz) for this mode allows faster baud rates (typing is about 42 WPM) and greater immunity to multi path phase shift. This mode is becoming a standard for reliable keyboard to keyboard operation and is available in several popular programs.

NOTES::
Frequency-shift keying (FSK) shifts between two known states. Phase-shift keying (PSK) changes PHASE of a signal against some reference. FSK is sent by either shifting a carrier frequency (F1B) or modulating SSB with two shifting audio tones (AFSK). When sending PSK, a complex audio waveform is transmitted by SSB. Tracking is much more critical for PSK, thus requiring more frequency stability.
DSP (Digital Signal Processing) techniques use high speed processing to convert audio into digital coding, so that a program can manipulate the coded audio in ways not possible with traditional hardware filters. The 16 and 32 bit sound cards found in modern PCs provide this capability.
FUZZY MODES are those modes that allow the human eye/ear/brain to be used to its maximum potential. In order to do this, a number of rules are required, to ensure that any electronics or logic circuitry is not allowed to make decisions which may be less inspired than human decisions. Examples of potentially Fuzzy modes are Morse Code, HFFAX, SSTV and Hellschreiber. The rules are:

- The transmissions must be uncoded. (The signal is sent as a real-time language.)
- The receiver must not decide when data is present. (Untouched by any prior decisions.)
- The receiver must not decide what data is present. (It must be presented as received.)