Are You Ready for CCW and BPSK?
de Vic Black, AB6SO

There's been a lot of recent press concerning the rebirth of Ham Radio about every 11 years, coinciding with the sunspot cycle. All's gloom and doom during sunspot lows and nothing but DX, happiness and TVI at the peaks. At the 1957 sunspot high, QRM was so great that SSB was developed to save spectrum space. Using SSB was considered almost unsociable because of the racket it created compared to AM, even though there were fewer squeals and squawks from adjacent interfering carriers with SSB. The ensuing upheaval meant we had to upgrade equipment which had worked fine up until then, but in the long run it proved to be the best solution to the challenges of HF voice communications.

During the 1960's FM repeaters were introduced. I was working in Palo Alto at Hewlett-Packard when a PA system announcement was made that Varian had installed an FM repeater on Black Mountain for ham use. This was a revolutionary idea at the time. We now know it as the 147.315 repeater whose trusteeship recently changed to the HP club WW6HP.

Later developments included development and general use of SSTV, satellites and packet radio. During the last cycle, packet gave up ground to Amtor, Pactor, Pactor II, Clover and the Automatic Packet Reporting System (APRS). Predictions for the future are tough since we have no control over the future. Anyhow, I'll stick my neck out and predict that this next cycle will finally see wider acceptance of coherent CW, or variants such as BPSK, as viable digital modes.

Coherent CW (CCW) is a 25 year old Morse code mode that uses tight time and frequency control, very narrow bandwidth signals (less than 10 Hz), perfectly sent code and very tight CW filters to bring weak signals up out of the noise. Amateur Radio CCW inventor Ray Petit, W7GHM also invented the digital mode Clover. The first ham QSO was by Andy McCaskey, WA7ZVC using a Ten-Tec PM-1.

How does it work? First, the basic CW element, a "dit", is established as 100 milliseconds long (equivalent to 12 wpm). The receiving computer can then latch onto a dit and expect another dit, dah or space at multiples of exactly

100 msec. In other words, the more you know about a signal before it arrives, the less information you need to acquire from the signal itself. This is how we copy plain text Morse by ear. A couple of letters into a word is often sufficient to know, from context, what the word is probably going to be. A couple of words into a sentence is often enough to finish up the sentence. The rest is only validation of what we anticipated.

Secondly, if the receiver filter passband is too wide, the filter will pass through a lot of noise along with the desired signal. On the other hand, if the signal bandwidth and the filter passband are extremely narrow, the amount of noise passed through decreases and the ratio of signal-to-noise is increased tremendously. The effect is similar to raising the power at the transmitter.

Until now this hardware based system, which relies on tight frequency control and detection of varying amplitude, has been difficult to achieve by most hams because the infrastructure didn't exist to support it adequately. With the advent of extremely stable VFO's, GPS for time control and inexpensive microprocessors and excellent software to send perfect keyboard code and do the necessary digital signal processing (DSP), we may see the mode flourish.

Why would anyone want to use an "outdated" mode like CW in this day of computers, packet, Pactor, etc.? Mainly because you can work around the world on 40 meters during daylight hours using only a few milliwatts of power with CCW. You may not be able to hear the signals by ear on an ordinary receiver, but the DSP can bring them up out of the noise so you can easily copy the code by ear.

Early CCW proponent Professor "Woody" Woodson W6NEY told me he used to carry a 40 meter QRPp beacon on European lecture trips. A prearranged set of dits and dahs would allow his wife, who was monitoring in Berkeley, to know if he was going to be on time getting home or whether he would be delayed by a day or two. The weak signal wasn't heard by anyone else.

This time around CCW will probably be reincarnated as Binary Phase Shift Keying (BPSK), a form of radio teletype. Several groups are working on kits to build standardized rigs analogous to the Tucson Amateur Packet Radio (TAPR) TNC's that allowed easy packet radio access. Johan Forrer

KC7WW, TAPR moderator for the HF special interest group, is involved with BPSK experiments. G3PLX Peter Martinez, who created Amtor by adding error detection and correction to the commercial SITOR, has joined BPSK nets on 20 meters. Incidentally, Amtor is pretty much obsolete now that Pactor and newer modes have replaced it during the past two years.

The original CCW scheme relies heavily on the fact that two signals with the same 100 milliseconds mark length and space length will stay in lock step indefinitely if they both start at the same time. Accurate timing and element length control are extremely critical requiring tight frequency and time control at each end of the path. This hardware dependent system is replaced by DSP software control with BPSK.

Receiving CW depends on differentiating the signal from surrounding noise. We can hear frequency and amplitude changes by ear and use those to receive ordinary CW. We are accustomed to thinking of RF signals as having both a frequency and amplitude, but they also have phase relationships. The human ear cannot differentiate phase differences. In fact, quadrature modulation allows us to modulate one signal starting at zero degrees, for instance, and another at 90 degrees on the same carrier sine wave and then differentially detect, or separate, the two signals at the receiver. When the transmitted and received signals are in phase, or synchronized, we say they are “coherent”.

BPSK is a modulation scheme which shifts the phase of an RF carrier with respect to a digital bit stream. It requires a simple transmit interface board which mixes a stable audio reference tone derived from a crystal controlled clock with an 800Hz digital signal through a double balanced mixer or an exclusive-OR gate to produce the binary phase modulation and then inputs the signal into an SSB transceiver audio input. The interface board can be built on perfboard for as little as $10.

The receiver compares the phase of each bit with the phase of the preceding bit to perform the differential coherent (i.e. synchronized) detection. A receive interface board accepts the 800 Hz audio tone from the receiver, performs an analog to digital conversion and feeds the signal to the computer where the software does the rest. A simple 12 MHz AT computer is sufficient to handle the software under DOS control. The shareware, called “Coherent” is used by the low frequency and very low frequency

experimenters (LowFERS) all the way up the spectrum to ham use with lasers. Setting up the software is similar to setting the parameters for a computer modem (start and stop bits, parity and baud rate).

LowFERS are especially interested in raising signal-to-noise ratios since they are restricted to low power using antennas only 50 feet long (including feedline!) on a band with a wavelength of 1750 meters. That's the definition of "inefficient".

Results are best with stable frequency control, but this is nowhere as important as with hardware dependent CCW since we're comparing phase, not frequency or amplitude. Receiving requires setting the BFO to exactly 800 Hz, displaying frequency in 1 Hz steps and having a single frequency reference for internal oscillators. The currently preferred transceiver is the ICOM 706, especially with the optional temperature controlled crystal oscillator, although this is not an absolute requirement.

On-air operation is done with the transceiver in the split frequency mode, receiving in CW and transmitting in SSB up 1800 Hz on the lower side band. Note that the transmitted signal is data, not phone. Bill de Carle VE2IQ produces freeware which allows you to compare your receiver's frequency counter to WWV and apply a correction to accurately set your receive frequency to the standard BPSK calling frequencies, if desired. The software also sets the received CW audio sidetone to exactly 800 Hz.

If this mode catches your fancy you can check the progress of cutting edge work by going to the web site in Aitkin, MN of Lyle Koehler K0LR at http://www.qsl.net/k0lr/watsbpsk.html. For schematics, & freeware see Bill de Carle VE2IQ's site http://www.ietc.ca/home/bill/bbs.htm. For a BPSK reflector, subscribe to bpsk@qth.net. Thanks to Andreas Junge KF6NEB for these addresses. Bill de Carle's new program, AFRICA, uses a tracking filter so the signals don't have to be at exactly 800 Hz so long as any drift is at a constant rate. It will run on faster, modern PC's. For PCB's and kits see http://users.aol.com/part15/readccw.txt.

George Heron N2APB of Sparta, NJ reports by e-mail that he and fellow New Jersey QRP members Joe Everhart N2CX and Clark Fishman WA2UNN are working on a modular R2/T2 transceiver with integrated DSP board for audio phasing and CCW processing. George calls this "hot stuff!"

and says to expect an important announcement at Dayton Hamvention in May.

Jim Mortensen N2HOS of Indian Rock Beach, FL has a nifty newsletter at http://www.n2hos.com/digital/frontpage.html. “Jim’s Gazette” is dedicated to digital modes including CCW and BPSK and should appeal to anyone who likes digital communications.

CCW didn’t catch on earlier because it was dependent on highly stable standard oscillators and transceivers at both ends. Some early experimenters went so far as burying oscillators underground in order to control temperature and thus frequency drift. Now, only reasonably stable transceivers and frequency standards are required because of modern computer program development, although results are better if highly stable hardware is used. You don’t need special equipment to join in if you can hear the CCW stations (listen for “CQ CCW” in perfectly sent code). Daily QSO’s are now routine with unmodified rigs such as the ICOM 706.

There is daily activity on 3591, 7081, 10141, 14081 and 18081 kHz. Some of the same weak signal and QRP groups responsible for getting thousands of new users on the air with simple, inexpensive kit radios and on FM packet with inexpensive TNC’s are now working on BPSK in conjunction with the LowFERS, or very low frequency fraternity. Time will tell if their efforts will achieve wide spread acceptance of this new (old) binary mode.