Coherent CW

Amateur Radio's New State of the Art?

BY RAYMOND C. PETIT,* W7GHM

IT HAS BEEN KNOWN for many years that the bandwidth used for cw reception in most all amateur applications is much, much wider than is needed for efficient reception of the signal. Today it is very common for an operator to use a receiving filter that is 100 times broader than needed, and this huge amount of extra bandwidth permits a great deal of QRM to pass which otherwise could be rejected.

There are several reasons why extremely narrow-bandwidth receiving systems have not been more widely used. The first is frequency stability. If a filter only 10 Hz wide were to be used in the receiver, the desired signal would soon drift out of the passband unless both the transmitter and the receiver were manufactured to standards greatly exceeding present designs. Even getting the signal tuned correctly in the first place would be difficult because of inadequate dial resolution and backlash. So far, no commercial manufacturer of amateur equipment has considered it worthwhile to provide frequency accuracy or stability exceeding about 100 Hz.

Another problem with narrow filters is ringing. In a typical audio-filter design, *Q*s must be kept low (and hence, bandwidths broad) to prevent random noise and even the signal itself from producing so much ringing that it masks the desired dots and dashes.

A Bold Leap in Frequency Stability

Recent advances in integrated-circuit technology now make it possible to *synthesize* all the local-oscillator signals needed for both transmission and reception – at a cost that is attractive to the amateur. With synthesis techniques, only one independent and highly stable crystal oscillator is used as a reference to generate all the other signals needed. The signals so generated are just as accurate and stable as this one master standard, and the standard can be set easily to within about 1 Hz of WWV at 10 MHz. With a synthesized transmitter and receiver, you can tune to the frequency you want and know that you will be within a few hertz of that frequency. If both stations in a QSO are operating with synthesized rigs, the problem of drift is eliminated.

* P.O. Box 51, Oak Harbor, WA 98277.

Nine Hertz Bandwidth and No Ringing

If enough is known about the incoming cw signal, it is possible to build what is known as a "matched filter" for this signal at the receiving end. Such a filter has the narrowest bandwidth possible (and therefore the best possible signal-to-noise ratio) for that particular signal, and it will not ring when correctly adjusted. For a Morse code speed of 12 wpm such a filter is 9 Hz wide, and its skirt selectivity can be best characterized as *spectacular*.

What needs to be known about the incoming signal? Naturally, you must know its frequency – which simply means that you must have the signal centered in the passband of the filter to within a few hertz. Here is where frequency-synthesized rigs are necessary. Operation of the matched filter also requires that the transmitted signal be synchronized in time. To do this, it is only necessary to generate a suitable timing signal by frequency division from the master-frequency standard. By using this precise clock signal as the speed-control signal in an electronic keyer, all transitions from mark (dots and dashes) to space and vice versa occur at extremely well-defined instants. For a 12-wpm Morse code signal the basic time interval is 100 milliseconds, and all dots and dashes begin and end at instants which are exact multiples of this

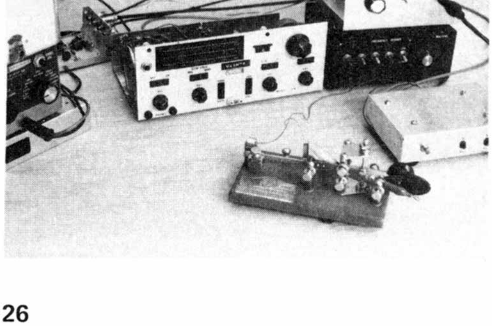

Fig. 1 – This is the first complete amateur station to be built for coherent-cw operation. Assembled by Andy McCaskey, WA7ZVC, it consists of a modified Ten-Tec PM-2 transceiver and homemade modules which provide for the control and processing of signals as required for coherent-cw operation.

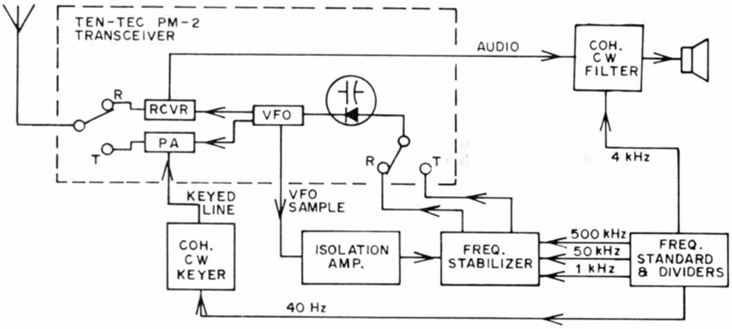

Fig. 2 — Block diagram of coherent-cw station complement at WA7ZVC. The functions of the various blocks are discussed in the text.

interval. All dots, dashes, and spaces can be thought of as being "blocked" into time segments of precise duration.

The matched filter recovers the signal by analyzing the receiver output, block by block, and presenting the receiving operator with a cw tone corresponding to each block. The intensity of each tone is proportional to the total signal energy that the filter received within its bandwidth during that time block. Adjustment of the phase of the filter timing signal at the receiver compensates for the propagation delay between the transmitter and the receiver.

Experiments Show 20-dB Signal Boost Over QRM

If a receiver using a 2-kHz bandwidth is provided with a matched filter having a 9-Hz bandwidth, theory indicates that a 23.5-dB improvement in signal-to-noise ratio will result. If your receiver uses a 500-Hz filter, the improvement is 17.4 dB. What does this mean in practice, in crowded conditions on the air? The author built an experimental matched filter for 12 wpm and a suitable Morse code test generator. A very weak signal from the generator was combined with severe 80-meter QRM including RTTY signals, other cw signals, and static. The test signal was buried in the QRM. When the matched filter was switched in, the signal stood out distinctly, almost like a code practice oscillator alone. Clearly, here is a technique which could be a great help on our congested bands! Similar experiments by WA7ZVC have given equally worthwhile results.

Coherent CW on the Air

Several amateurs, mostly in the U.S. Northwest, are building coherent-cw stations using simple designs worked out by the author. Nets are being formed on 80 and 20 meters for on-the-air experimentation and contacts via coherent cw. The first complete ccw station to go on the air has been built by Andy McCaskey, WA7ZVC. As shown in Figs. 1 and 2, he assembled his station from a Ten-Tec PM-2 transceiver and a number of home built models made especially for ccw operation.

Andy's frequency standard generates the 4-MHz, 500-, 4-, and 1-kHz, and 40-Hz clock signals that are required for the various other station components. For transmitting, the Ten-Tec VFO is phase locked to the standard and operates at 3550.000 kHz. For receiving, the VFO is phase locked to 3551.000 kHz to provide a 1-kHz beat note for the incoming ccw signal. The isolation amplifier (a carefully shielded cascode stage) and the frequency-stabilizer unit are used in accomplishing these functions. The isolation amplifier is required to prevent a coherent spurious signal at 3550.000 kHz from getting back into the receiver and blocking the system.

The ccw keyer uses CMOS ICs. Instead of an internal clock, the clock is a 40-Hz signal derived directly from the 4-MHz standard, and this preserves the timing required for ccw operation. The experimental ccw filter which Andy constructed is shown in Fig. 3. It provides a bandwidth of less than 10 Hz at a 1-kHz center frequency, and has no ringing in the output. A 10-position phase-setting switch is visible in the lower right corner of Fig. 3. Ready-made circuit boards for a similar filter are now available, as are kits of parts. This filter uses two quad op amps and eight CMOS ICs, plus a few resistors and capacitors. For information write to Charles Woodson, W6NEY, 2301 Oak St., Berkeley, CA 94708. "Woody" also edits the *Coherent CW Newsletter* (CCWN), which contains full technical information and diagrams, and complete ccw information. A current subscription will be provided to any amateur who is willing to build his own coherent-cw station. QST

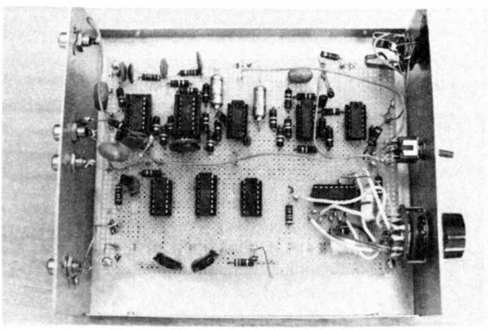

Fig. 3 — Home-built experimental coherent-cw filter constructed by WA7ZVC. It has a bandwidth of less than 10 Hz at a bandpass frequency of 1 kHz. Ready-made circuit boards and a kit of parts are now available for the construction of a similar filter, as described in the text.