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ICOM IC-775DSP MF/HF Transceiver

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ICOM has launched its IC-775DSP into an atmosphere of ever-expanding expectations, especially as the major players tout improved digital offerings. Situated near the high end of the price/performance spectrum—where expectations naturally are greatest—the IC-775DSP represents ICOM's latest effort to push digital technology and performance in the challenging Amateur Radio consumer market. As a new-generation radio built along the lines of the venerable IC-765 and the IC-781, the IC-775DSP clearly aims to satisfy the demands of technologically sophisticated, performance-minded hams who have the discretionary dollars to support their equipment desires.

Is the IC-775DSP a worthy successor to the '765? Absolutely! Its smoothly integrated DSP features are a treat. In addition to noise reduction, the IC-775DSP's digital signal processing circuitry lets you independently tailor transmit and receive audio and permits super-sharp selectivity on CW. The radio also offers an AGC with a continuously adjustable time constant, twin passband tuning (one for each of two IFs), and a CW "reverse" mode. Software switches available via the front panel vastly augment operational flexibility.

We ran the IC-775DSP through its paces in casual CW and SSB operating plus some hot-and-heavy contest action. For the most part, the IC-775DSP took it all in stride and offered the necessary tools for nearly every on-air situation. Let's take a closer look.

Feature Highlights

It almost would be easier to tell you what the IC-775DSP *doesn't* offer. As you'd expect, it transceives on SSB, CW, AM, RTTY (AFSK or FSK) and FM, on 160 through 10, with 200 W maximum output (100% duty cycle). It has a general-coverage receiver, 101 tunable memory channels and three scanning modes, a built-in ac power supply (110 or 220 V) and MOSFETs in the final amplifier.

A clear, prominent monochrome display, a large, comfortable **MAIN** "VFO" control knob and a smaller **SUB** control knob grace a black, plastic front panel that's awash with predominately black (plastic) knobs and buttons—more than 90 in all! Add in 26 main categories of software switches (in two menus), and you have lots to tinker with! The **MAIN** frequency readout features black characters on an amber background with 7/16-inch-high digits, while the **SUB** readout characters are 5/8 inch high. A large analog multimeter displays signal strength or other parameters at the turn of a rotary switch. Some reviewers felt contrasting colors would make it easier to spot certain front-panel controls, while a couple of testers felt ICOM could have shifted a few of the less-frequently used functions to software for a less-cluttered look. In any event, the number of controls could be reduced without compromising performance. After several months of testing by various reviewers, the **MAIN** knob mechanism on our '775 failed. Closer inspection revealed the optical encoder had seized. ICOM says it will repair such problems under the warranty.

The IC-775DSP replaces the familiar dual VFO A/B concept with **DUALWATCH**, which consists of the **MAIN** and **SUB** frequency readouts and control knobs. As it does on the IC-781, **DUALWATCH** lets you listen to two signals in the same band. The **MAIN** display is always on (except when you're using the menus); a press of the **DUALWATCH** button brings up the **SUB** display. You press the **CHANGE** button (it's like an A/B button) to swap the two readouts, or press the **EQUAL** button (it's like an A=B button) to equalize the two readouts.

> **BOTTOM LINE**
>
> The IC-775DSP is a capable—if somewhat complex—high-end performer. Its smoothly integrated DSP and other enhancements provide superior selectivity and noise reduction for the serious DXer or contester.

Some reviewers questioned why ICOM chose to abandon the more familiar—and intuitive—A=B and A/B VFO scheme (used in the '765) in favor of the **EQUAL** button and the even more obscure **CHANGE** button. A normally centered **BALANCE** control determines whether you hear the **MAIN** channel, the **SUB** channel or a mix of both, but some reviewers faulted it for *not* offering stereo. A single **VOLUME** control sets the audio level for both sides. With headphones on and the **BALANCE** control at 12 o'clock, you hear both **MAIN** and **SUB** signals in *both* ears, at the same time, at the same audio level.

DUALWATCH is *not* like having dual receivers. The Dualwatch system splits the signal at the first IF—at VHF, where the "balance" function is implemented—then recombines it and sends it through the rest of the receive chain. Since both readouts *must* share the same mode, IF filters, audio and AGC circuitry, you *can't* select one IF filter for the **MAIN** and another for the **SUB** frequency. While it *is* possible to put the Sub readout on a *different band* from the main readout in the split mode, you won't hear much unless it's a very loud signal. Of course, you can use **DUALWATCH** to operate "split," using the **MAIN** and **SUB** readouts in conjunction with the **BALANCE** control—one side to listen to the receive frequency, the other to check in-band transmit frequency activity.

Alternatively, operating split is as simple as momentarily pressing the **SPLIT** button. Hold it in for two seconds, and the **SUB** frequency equalizes to that of the **MAIN** readout. In addition, a "quick-split" function allows you to program a split offset—say, up 5 kHz—for instant recall. While in split, the IC-775DSP lets you listen to or

Table 1

ICOM IC-775DSP, serial no. 01179

Manufacturer's Claimed Specifications	***Measured in the ARRL Lab***
Frequency coverage. Transmitter: 1.8-2, 3.5-4, 7-7.3, 10.1-10.15, 14-14.35, 18.068-18.168, 21-21.45, 24.89-24.99, 28-29.7 MHz. Receiver: 100 kHz-30 MHz.	As specified. Transmitter operates several kilohertz above and below the band edges except on 1.8-2.0 MHz.
Modes of operation: SSB, CW, AM, FM, RTTY.	As specified.
Power requirement: Receive, 150 VA (max). Transmit, 760 VA (max).	As specified. Tested at 120 V ac.
Receiver	*Receiver Dynamic Testing*
SSB/CW/RTTY sensitivity (preamp 1 on, bandwidth not specified, 10 dB S/N): 0.1-0.5 MHz, <2.0 µV; 1.8-30 MHz, <0.16 µV.	Minimum discernible signal (noise floor) with 500-Hz IF filters: (see below)

	Preamp off	*Preamp 1 on*	*Preamp 2 on**
1.0 MHz	–131 dBm	–131 dBm	n/a
3.5 MHz	–139 dBm	–143 dBm	n/a
14 MHz	–138 dBm	–143 dBm	n/a
28 MHz	–137 dBm	–141 dBm	–145 dBm

AM sensitivity (preamp 1 on, bandwidth not specified, 10 dB S/N): 0.5-1.8 MHz, <13 µV; 1.8-30 MHz, <2.0 µV.

10 dB(S+N)/N (signal 30% modulated with a 1-kHz tone) with 6-kHz IF filter:

	Preamp off	*Preamp 1 on*	*Preamp 2 on**
1.0 MHz	2.8 µV	2.8 µV	n/a
3.8 MHz	1.0 µV	0.6 µV	n/a

FM sensitivity (preamp 1 on, for 12 dB SINAD): 28-30 MHz, <0.5 µV.

For 12 dB SINAD (IF filters at widest setting):

	Preamp off	*Preamp 1 on*	*Preamp 2 on**
29 MHz	0.6 µV	0.3 µV	0.2 µV

Blocking dynamic range: Not specified.

Blocking dynamic range with 500-Hz IF filters:†

	Preamp off	*Preamp 1 on*	*Preamp 2 on**
1.0 MHz	141 dB	141 dB	n/a
3.5 MHz	139 dB	135 dB	n/a
14 MHz	137 dB	132 dB	n/a
28 MHz	138 dB	133 dB	129 dB

Two-tone, third-order IMD dynamic range: Not specified.

Two-tone, third-order IMD dynamic range with 500-Hz IF filters:†

	Preamp off	*Preamp 1 on*	*Preamp 2 on**
1.0 MHz	105 dB	105 dB	n/a
3.5 MHz	106 dB	104 dB	n/a
14 MHz	106 dB	103 dB	n/a
28 MHz	92 dB	87 dB	85 dB

Third-order input intercept point: Not specified.

	Preamp off	*Preamp 1 on*	*Preamp 2 on**
1.0 MHz	+26 dBm	+26 dBm	n/a
3.5 MHz	+20 dBm	+13 dBm	n/a
14 MHz	+21 dBm	+12 dBm	n/a
28 MHz	+1 dBm	–10 dBm	–18 dBm

Second-order intercept point: Not specified.	+56 dBm, preamp off; +55 dBm, preamp 1 on.
FM adjacent channel rejection: Not specified.	≥89 dB at 20-kHz channel spacing, preamp 1 on.
FM two-tone, third-order IMD dynamic range: Not specified.	Preamp 1 on: ≥72 dB at 20- kHz channel spacing; preamp 2 on: ≥71 dB at 20-kHz channel spacing.
S-meter sensitivity: Not specified.	S9 signal at 14 MHz: preamp off, 53 µV; preamp 1 on, 19 µV.
Squelch sensitivity at threshold: SSB/CW <3.2 µV, preamp 1 on; FM: <0.32 µV at threshold, preamp 1 on.	At threshold: FM, 0.3 µV or less, preamp 1 on; 0.2 µV, preamp 2 on.* SSB, 1.5 µV or less, preamp 1 on.
Receiver audio output: ≥2.6 W at 10% THD into 8 Ω.	As specified.
IF/audio response: Not specified.	Range at –6 dB points (bandwidth): CW-N, 360-836 Hz (476 Hz); CW-W, 249-2639 Hz (2390 Hz); USB-W, 254-2671 Hz (2417 Hz); LSB-W, 252-2628 Hz (2376 Hz); AM-W, 102-2580 Hz (2478 Hz).
Manual IF Notch filter depth: Not specified.	>45 dB.
DSP Auto Notch depth: Not specified.	>40 dB (with one or two tones).
Spurious and image rejection: >70 dB.	As specified. First IF image, >114 dB; first IF rejection, >116 dB.
Transmitter	*Transmitter Dynamic Testing*
Power output: SSB/CW/FM, 5-200 W; AM, 5-20 W continuously adjustable.	SSB/CW/FM: typically 200 W maximum, <1 W minimum, but varies slightly from band to band. AM: typically 47 W maximum, 1 W minimum.
Spurious-signal and harmonic suppression: 60 dB or more.	As specified. 60 dB or better on all bands. Meets FCC specifications for equipment in its power output class and frequency range.
SSB carrier suppression: 40 dB or more.	>50 dB.
Undesired sideband suppression: 55 dB or more.	>60 dB.
Third-order intermodulation distortion products: Not specified.	See Figure 1.
CW keying characteristics: Not specified.	See Figure 2.
Transmit-receive turnaround time (PTT release to 50% audio output): Not specified.	S9 signal, 18 ms.
Composite transmitted noise: Not specified.	See Figure 3.

Size (height, width, depth): 6×17×16 inches; weight, 37 pounds.

*Preamp 2 is for 21 MHz and higher.

†Dynamic-range measurements were made at the ARRL Lab standard signal spacing of 20 kHz.

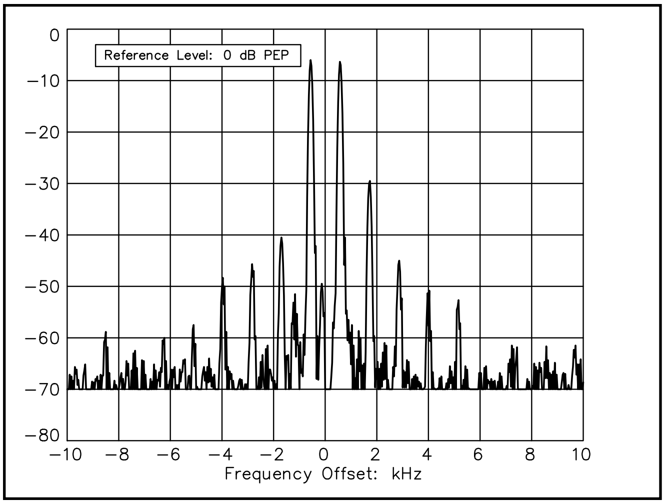


Figure 1—Worst-case spectral display of the IC-775DSP transmitter during two-tone intermodulation distortion (IMD) testing. Worst-case third-order product is approximately 30 dB below PEP output, and the fifth-order product is approximately 45 dB down. The transceiver was being operated at 200 W PEP output at 14.2 MHz.

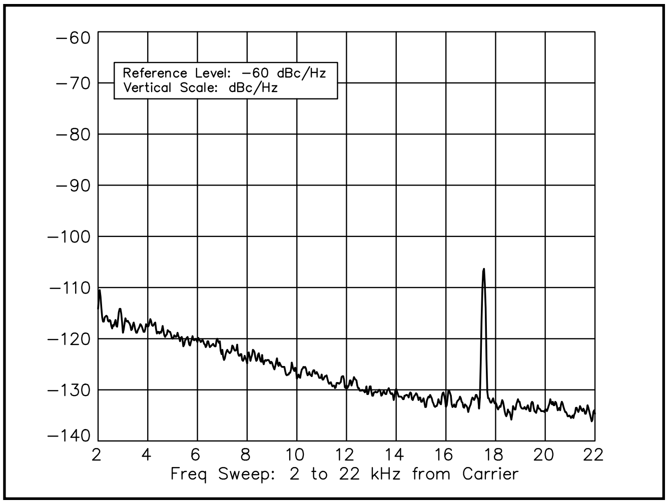


Figure 3—Worst-case spectral display of the IC-775DSP transmitter output during composite-noise testing. Power output is 200 W at 3.5 MHz. The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 2 to 22 kHz from the carrier.

adjust your transmitted output by holding in the **XFC** button on the front panel. During HF DXing, split-frequency operation was easy to initiate, but with a potential pitfall: when you press the **SPLIT** button, the **SUB** frequency readout appears and blinks four times—your *only* clue that the **SUB** frequency will be your transmit frequency. When you transmit split, a tiny, inconspicuous "Sub" LED—to the left of the main VFO knob—turns from green to red. Prior to that, the display does not indicate which "VFO" you'll be transmitting on. One operator said he found it too easy to transmit on the "wrong" VFO in the heat of a contest. An icon on the display to indicate which is the transmit "VFO" would be a welcome addition!

It's a cinch to get around with the IC-775DSP. Besides the **DUALWATCH** (**MAIN** and **SUB**) system, you can enter Main or Sub frequencies directly via a front-panel keypad that's similar to the one on the '765. Press the desired band key, and the radio returns to the last-used frequency and mode.

ICOM's triple band-stacking registers make it a breeze to recover band configurations, saving up to three frequencies and three modes for each band. Press the 14-MHz key once to return to the last-used mode and frequency (say SSB on 14.250 MHz). Press it again to bring up the frequency and mode used before that (on CW, for example); press a third time to recall the frequency and mode used before that (maybe an RTTY frequency or another CW frequency). However, triple band-stacking registers were not a hit with everyone. One reviewer suggested the number of registers be software settable, to avoid having to rotate among three settings when, most times, he only needed one or two. In the triple-stacking system, filters follow modes. This means CW filter settings are

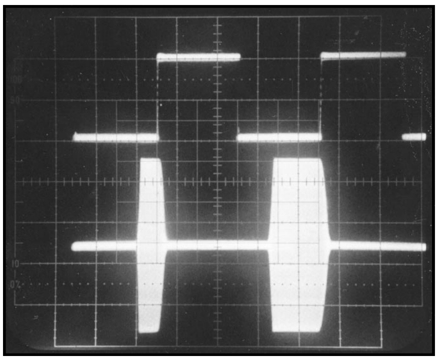


Figure 2—CW keying waveform for the IC-775DSP in the semi-break-in mode. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transceiver was being operated at 200 W output at 14 MHz. Note the significant shortening (approximately 50%) of the first transmitted character during semi-break-in operation. This does *not* occur during full-break-in (QSK). Keying speed is approximately 60 wpm.

the same for all CW-mode settings, and SSB filter settings are the same for all SSB-mode settings in the "stack." The antenna ports do not track frequency and mode changes in the triple-stacking system.

Again reminiscent of the '765, large, front panel **UP** and **DOWN** buttons change the main frequency in preprogrammed steps, anywhere from 1 kHz to 1 MHz per button press. You can use the **MAIN M-CH** (**UP** and **DOWN**) buttons to select a memory channel when in that mode. Store and recall information for the **SUB** readout via the separate (small) Sub memory channel **UP** and **DOWN** keys.)

The **TS** button sets main-dial tuning rate for incremental steps of 10, 20, or 50 Hz. (Also, the faster you turn the **MAIN** knob, the greater the rate of frequency change.) Holding in the **TS** button until the radio beeps *twice* sets the tuning step size to 1-Hz and displays the 1-Hz digit on the Main readout (the Sub readout does not display the 1-Hz digit). We found the 1-Hz tuning step a good way to slowly sweep a portion of a band hunting for signals.

The IC-775DSP's 101 memories offer yet another way to navigate the spectrum, and its three scan modes should satisfy anyone using this radio to scan the MF/HF bands. A "memo pad" allows you to store and recall up to 10 frequencies and modes independent of the 101. Say you come across a couple of stations you want to return to. Press the **MP-W** (memo pad-write) button as you tune to each one. Later, you can press the **MP-R** (memo pad-read) button to recall each one.

Two levels of receiver preamplification and three levels of RF attenuation are available via a rotary **PREAMP/ATT** knob. The first preamp works on *all* bands, while the second preamp is designed for use at or above 21 MHz. One reviewer lauded the two preamp levels and said he found himself using a preamp all the time, partly because of conditions but mostly "because I could."

A top-firing, 2.5-inch speaker is built in, and a **TONE** control lets you customize the receiver's audio response. A tiny **MIC TONE** knob also lets you similarly tweak your transmitted audio. (You can further define and *re*fine transmit and receive audio via software-selectable DSP unit settings. More on these later.)

AGC Performance

A front-panel **AGC** control on the IC-775DSP lets you *continuously adjust* the AGC time constant, instead of having to step through predetermined choices with a switch. This is certainly a nice touch and provides lots of flexibility. While the fastest setting of the AGC range is not really optimum for either SSB or CW, it may be useful for data modes.

Users were less thrilled with the high degree of "receiver audio intermodulation distortion" (IMD) they experienced, a problem we tracked down to the AGC. While the receiver seemed to hold up well under the strong-signal conditions I encountered, the IMD becomes especially apparent when using a "wide" filter bandwidth on a crowded band. One reviewer reported "a good deal of high-frequency distortion" even on moderately strong SSB signals and a "mushy" sound on strong CW signals, especially with more than one signal in the passband. Such audio distortion—making the receiver very noisy on a crowded band—is irritating and distracting, particularly when you're engaged in long-term listening (during a long contest weekend, for example).

This IMD problem seemed similar to one discovered in the IC-765 (see Technical Correspondence by Dean Straw, N6BV, *QST*, December, 1995, page 78) where the culprit appeared to be inadequate filtering of the AGC line, resulting in "reverse modulation" of the IF chain.

In an effort to resolve the IC-775DSP's AGC problem, we contacted ICOM, who shipped a modified radio for us to evaluate. ARRL Lab checks confirmed the second unit was a considerable improvement, even at its fastest AGC setting, and the modified radio performed as well in this regard as other radios in its price class. At an optimal SSB setting, third-order IMD was down approximately 32 dB and fifth-order by approximately 35 dB with S9 signals— approximately 7 to 13 dB better than the unmodified radio. (It degrades by about 3 dB with 40 dB over S9 signals.) ICOM will modify existing IC-775DSPs at the owner's request during the warranty period. The manufacturer expects to implement the AGC modification in production in early 1996. ICOM also will issue an addendum to the instruction manual describing how to best use the variable AGC.

DSP Highlights

The IC-775DSP offers six main categories of digital signal processing: noise reduction, automatic notch, audio low-pass and high-pass filters for both transmitting and receiving, an "ultra narrow" CW filter and a phase shift network (PSN). All DSP functions are configurable via the menus. You can even turn off DSP altogether, if you desire. With DSP enabled, you can use the digital CW filter, automatic notch, CW audio peak filter, and noise reduction via front-panel controls.

The *noise reduction* circuit can produce dramatic results. Turn the front-panel **NR LEVEL** knob clockwise and background noise melts away! Not *all* background noise, mind you, but the DSP unit removes

Inside the IC-775DSP's DSP

Is the IC-775DSP DSP unit operating at IF or AF in receive? In a word, the answer is: "Yes." In AM or FM mode, it operates on the recovered audio signal from the analog AM or FM detector circuits. However, in SSB, CW or RTTY, you can select either PSN (phase-shift network) demodulation of the incoming signal, performed by the DSP unit at an IF of about 15 kHz, or product-detector demodulation, performed by analog circuitry. In both cases, though, the radio performs much of its "smart" processing on the recovered *audio* signal.

What difference does it makes whether the processing is done on the IF signal or the AF signal? A good question, to which the practical answer in this case is: not much. To understand why, think about what we don't like about outboard audio DSP units. Sure, they can have razor-sharp filters, slick noise reduction and automatic notching, but they can't change the way the radio itself operates. This is most noticeable when you use a DSP unit to help you hear that weak one: the interfering signal is reduced or eliminated in your speaker or headphones, but the radio's still hearing it, and—this is the key point—it's still affecting the AGC (just check your S meter). A strong interfering signal can "pump" the AGC, with disastrous effects on the signal you're trying to hear. This all happens because the DSP filter is *outside* the radio's AGC loop. *And so is the DSP in this radio.*

Here's why. The IC-775DSP was originally designed to offer DSP as an option. That constrained the ICOM engineers, since the design had to be fully functional *without* the DSP unit installed. This meant AGC circuits had to be independent of the DSP, and the radio had to employ analog SSB demodulation. Since the AGC is independent of the DSP unit, the internal DSP suffers from the same deficiency as an external unit. This is perfectly clear if, for example, you tune in a carrier and turn on the automatic notch filter. The carrier disappears, but the S-meter reading—the AGC voltage—remains unchanged.

One advantage of having the DSP inside the radio is that the radio's control computer can coordinate DSP functions with other control functions. In the case of the IC-775DSP, this means that when you adjust the CW tone frequency, the very-narrow DSP CW filter is adjusted accordingly, to match the selected CW tone.

What about the vaunted PSN demodulation? Is it a boon to the operator? It could be, but it's hard to conceive of circumstances where it would add much value. A product-detector SSB receiver design uses filters to provide single-signal reception (elimination of the unwanted sideband). The PSN approach—particularly as implemented in DSP—uses clever mathematics to eliminate the unwanted signal. This means you don't need to depend on sharp-sided filters. But this radio has filters anyway, to support *non*-DSP demodulation.

So what's the advantage of DSP demodulation? If you want to experience the difference between PSN and product-detector demodulation in the IC-775DSP, here's a way to do so. In SSB mode, tune in an AM broadcast signal. Tune off of the station's frequency by about 500 Hz in the direction where you hear no carrier (so it's being eliminated by the radio's IF filters). With the PSN disabled, adjust the PBT controls (you'll probably have to adjust both) until you again hear the carrier. You've shifted the filters to allow the carrier through. Now, enable PSN, and the carrier will disappear: the DSP phase-shift demodulation is eliminating the unwanted "sideband."

That's pretty neat, but is it *useful*? After all, with independent control of two IF filters you can achieve about the same signal response as with the PSN detector. But, with the IF filters, you adjust the radio's response *inside* the AGC loop—far superior to after-the-fact signal processing. Another way to use the PSN detection is to switch in the radio's wide filters, which are apt to have less phase distortion. This can result in a cleaner received signal using the PSN detection to provide single-signal reception. But now you've got a wide response inside the AGC loop. On anything but a dead-quiet band, this is likely to be a problem. In fact, it's hard to think of a real-world situation in which the PSN detector would provide a significant advantage. So, to analyze the IC-775DSP's DSP receive performance, compare it to your favorite external add-on DSP unit. That's essentially what ICOM has packaged into the IC-775DSP, even if it *does* do some of its processing at IF.

The IC-775DSP also uses DSP in transmit. You can choose if you want to generate an SSB signal the "old-fashioned" analog mixer-filter way or by using the DSP's phase-shift techniques. In the ARRL Lab, we found that with PSN turned off, the transmitter's opposite sideband rejection for low-frequency audio signals is about 50 dB. With PSN turned on, it's about 60 dB. For real-world audio signals, however, transmitter IMD products likely would render this small improvement in opposite sideband suppression moot; the IMD products that appear in the area of the opposite sideband will be substantially greater in amplitude than the suppressed sideband signal. (This doesn't mean the radio has poor IMD performance. IMD products dominate over suppressed sideband signals in any modern radio.) The DSP does allow you to apply adjustable high- and low-pass filters to the transmitted modulation. Depending on your voice characteristics, you could use these to give your transmitted audio a bit more "punch."—*Jon Bloom, KE3Z* enough noise to make copy more comfortable. Measurements in the ARRL Lab indicate the digital noise-reduction system that can cut random noise by up to 15 dB. However, more is not necessarily better. Turn the knob beyond an optimal level and the noise reduction algorithm becomes so aggressive it deteriorates the very signal you're trying to hear. Most users found the digital noise reduction system especially helpful during casual QSOs. Those who like to hear every "peep" a band has to offer might leave the noise reduction off a lot. For added convenience, you can assign the **NB WIDE** button to turn on noise reduction. This allows instant recall of your last—or favorite—noise reduction level setting.

The *automatic notch filter* is, in a word, terrific! This is one DSP function *every* radio should have. If a carrier appears in the receiver's passband, a quick press of the **AUTO-NOTCH** button makes it go away! From then on, any carriers that dare encroach on your frequency are automatically notched, period (although the carrier will continue to activate the AGC). The "manual" IF notch and peak filters work whether or not DSP is enabled. The "automatic" notch filter works on DSP only. Both filters can notch to a depth of better than 40 dB.

Lowpass filters and *highpass filters* let you adjust the audio characteristics of your transmit and/or receive audio for different types of operating, (casual versus contest, for instance). For transmit, the radio offers seven low-pass and 18 high-pass frequency-cutoff adjustments. You also can tailor receiver audio to your liking with 14 low-pass and 18 high-pass choices, set from the software menu. While these cutoff filters are effective, there's a lot of stuff to fiddle with: If you change these settings for different operating modes or conditions, you might keep notes—there are 57 choices to wade through and keep track of!

The digital *narrow CW filter*, boasting an 80-Hz bandwidth, proved *too* narrow for at least one operator's tastes. Nevertheless, this digital narrow CW filter could be useful to those who would use the '775 as an IF—transverting up to VHF for some moonbounce QSOs, for instance. The *audio peak filter* (APF) "boosts" any CW signal appearing at its center frequency, for enhanced readability. When the **APF** key is activated, this filter automatically peaks CW signals appearing in the filter passband, and its center frequency automatically tracks the CW pitch value you have dialed in. You can also activate it manually.

Finally, the digital package includes a *phase shift network* (PSN) modulation and demodulation feature, the digital facet that ICOM considers "the heart" of its DSP. Long-time hams may recall that phase shift networks once were used to generate SSB, a method that was "unreliable, and prone to drift," or so I'm told. The DSP phase shifter works *much* better than the old analog design, and ARRL Lab tests and most on-air reports confirm it's just as good as the current filter method used to generate SSB. (For details, see the sidebar "Inside the IC-775DSP's DSP.")

IF Filters

The range of available IF filters in the '775 gives the serious amateur additional ways to ferret out signals within today's crowded bands. Standard filters include a 2.4-kHz SSB filter, a pair of 500-kHz narrow CW filters, and a 15-kHz AM filter. Optional ICOM filters for the second (9 MHz) and third (455 kHz) IFs include a pair of 250-Hz CW filters, two 1.9-kHz SSB filters, and a single 6-kHz filter. You can install two sets of narrow CW filters. Our review radio had the stock 500-Hz CW filters, a single 1.9-kHz SSB narrow filter (in the second IF), and a 6-kHz AM filter (in the second IF).

Filter installation involves removing the radio's black-metal covers, plugging the filters into the appropriate sockets and telling the radio via software which filters are installed. Accommodating more than one narrow filter at each IF certainly gives you flexibility in filter choices. However, our pleasure at the wide array of filtering possibilities available via the three front-panel **FILTERS** buttons was tempered somewhat by our difficulty in figuring out which filter mode we were in. Tiny LEDs adorn the three small **FILTERS** buttons (**WIDE**, **9M**, and **455k**). I certainly agree with one op who said: "I couldn't tell if the LED being 'on' meant that the corresponding IF filter was in or out!"

On CW, the cascaded 500-Hz narrow filters worked well, but there were instances when a close-in station got past them, and it was handy to bring the passband tuning into play. Concentric passband tuning (**PBT**) knobs allow you to electronically narrow the receiver passband from one or both sides of the IF center frequency. While the PBT allowed us to copy the preferred station, some users felt that these controls were a bit "touchy." (The passband tuning works best when filters are installed at *both* IFs.)

Using the IC-775DSP to make some RTTY contacts turned up a welcome change from earlier ICOM radios: the narrow CW IF filters *are* available for data modes. When nearby interference became a problem, these filters were valuable assets!

On 10-meter FM, the IC-775DSP worked just fine. When the rear-panel-mounted fan occasionally turned on, it was whisper-quiet! (Actually, the radio has *three* cooling fans—two are internal.) A *built-in* programmable tone encoder unit allows you to gain access to FM repeaters that require sub-audible tone access.

One snag: the backlighting for the LCD display and S-meter dims (or flickers) noticeably during transmit, especially on CW. It's not pleasant to look at. A couple of reviewers judged it "not acceptable." ICOM says it will fix this problem under its warranty policy.

Software Menus and Switches

The IC-775DSP has 26 main categories of user-definable parameters, available via two main menus. Some sub-menu "branches" access arrays of more-detailed choices, and it's easy to become "lost" the first few times out! After groping around for awhile, we finally began to get the hang of it. However, the primitive bar segment alphanumeric display for the menus—which replaces the Main and Sub frequency readouts—was sometimes difficult to decipher and didn't make things any easier. We kept the manual at hand to help "translate" the gibberish that appeared on the radio.

Computer Control

To control the IC-775DSP via a personal computer, you need ICOM's optional CT-17 (CI-V) level converter and appropriate software. I used the CT-17 to interface my IBM-compatible PC to the radio and fired up *CT* (version 9.25), the contest logging software by Ken Wolf, K1EA. The software and radio worked superbly together. It would be nice if the '775 had a *built-in* PC-interface, a feature starting to show up as standard on radios by other manufacturers. That would leave one less accessory to buy! However, ICOM points out that the CT-17 interface supports up to four radios from one computer.

Miscellaneous Features

As the fast-talking TV pitchmen like to say: "But wait, there's more!" For your own fast talking during a contest, the IC-775DSP's built-in RF-level speech compressor is available via a front-panel push-button. Using a Heil ProSet headset and an Azden HS-3 headset yielded reports of "good audio" from most stations. Once properly set up, the RF speech compressor added *lots* of punch to my transmitted signal. But the audio from the speech monitor sounded rather harsh (the same was true on CW).

An internal automatic antenna tuner uses a high-speed stepping motor and covers 160 through 10 meters, promptly and quietly matching unbalanced loads from 17 Ω to 150 Ω. When the tuner encounters an SWR higher than 1.5:1, it seeks a match. If it achieves one, the radio memorizes the tuner's variable settings (including the frequency and antenna port), and returns to those settings the next time you tune there while using the same antenna port. In actual use, it was virtually transparent.

The built-in CW memory keyer front-panel speed control spans the range from appropriately 8 to 86 wpm. The keyer's three memories hold some 40 characters apiece, more than enough for a 3×3 "CQ." However, a couple of CW operators judged the memory keyer inconvenient to program and use. You access the memories for recording and playback on the keypad, which disables it for other uses.

Separate jacks accept keying connections: the front-panel **ELEC-KEY** jack is tied to the internal keyer. The software-reversible polarity means lefties and righties can share the same paddles. A rear-panel **KEY** jack accommodates an external keying device—handy if you use a computer to send CW but occasionally want to use a hand key or your own keyer. Full break-in (QSK) and semi-break-in are selectable at the push of front-panel buttons. You can adjust the dot-dash ratio within a relatively narrow range via the software. A couple of hams who put the '775 through its paces on CW described the full break-in (QSK) as "noisy and choppy" on the operator's end.

Another software switch lets you set the CW pitch (and tracking sidetone) in 20-Hz steps, from 300 to 900 Hz (the default is 600 Hz). On the '765, CW pitch was a front-panel control, but on the '775, you can use another software switch to redefine the squelch (**SQL**) control to act as the CW pitch control. Of course, this disables the squelch.

The IC-775DSP has two rear-apron antenna jacks, and you can switch between them using separate front-panel buttons. You can deactivate one port (when using only one antenna), or the radio can select the antenna jack last used on a band and recall the correct antenna jack when you return to that band. To the delight of the more serious operators who used the radio, a rear-panel jack can accommodate a separate receive antenna (for that 80 or 160-meter Beverage?).

The radio provides both receive and transmit incremental tuning via the **RIT** and **ΔTX** buttons. Worth noting is the fact that you *can* clear the RIT while transmitting.

A rear-panel **X-VERTER** port outputs a low-level RF signal to drive an external transverter or other device. Measured power output into a 50 Ω load varied from 0.096 mW at 14 MHz to 0.062 mW at 28 MHz. This might not be sufficient for all transverters.

A handy, rear-panel **DC OUT** port provides 13.8 V at up to 2 A—ideal to power your TNC, for example.

Accessories were minimal and did *not* include a microphone or the DIN plugs required for some rear-panel connections. However, the box did contain a nearly seven-foot-long ac power cable; a $^{1}/_{4}$-inch stereo phone plug (for the key jacks); four spare fuses; two pin-type dc connectors (for the rear-panel 12-V port); and a $^{1}/_{8}$-inch plug (for the external speaker port).

The 63-page *Instruction Manual* contains 12 sections, and ICOM inserted separate loose schematic pages. Diagrams outline the front-panel controls, and detailed tables report on such things as the rear-panel accessory jacks. For a radio this complex, we would like to see a *theory of operation*; there's also precious little explanation of the phase-shift network (PSN) feature. A separate section devoted exclusively to DSP features would be helpful.

New, Expanded Test Result Report Available

The ARRL Laboratory offers a 30-page test result report on the IC-775DSP that gives in-depth, detailed technical data on the transceiver's performance, outlines our test methods and helps you to interpret the numbers and graphs. Among other things, it includes spectral purity charts and receiver sensitivity figures for all bands plus all CW keying waveforms (not just worst-case) and other facts to help you make an informed choice. The report even includes a summary of how this radio stacks up with similar, previously tested units.

Request the *IC-775DSP Test Result Report*. It's available from the ARRL Technical Department at $7.50 for ARRL members and $12.50for non-members, postpaid. We plan to offer similar in-depth reports for future equipment we review in *QST.*

Conclusions

Does the IC-775DSP demonstrate that ICOM is "tuned in" to the desires of demanding Amateur Radio operators? I'd say they're close, but a bit of "fine tuning" would improve the radio. As mentioned, the multitude of front-panel controls was an issue for several reviewers. Other gripes included the confusing IF filter selection scheme, the flickering display backlighting and the AGC action and resultant audio IMD in the original review radio, which ICOM's modification cured.

ICOM deserves praise for including many useful and improved features in the IC-775DSP. We liked the nicely integrated DSP features, the adjustable CW pitch with tracking sidetone, the 200-W output power, the dual antenna ports, selectable narrow filtering in data modes and the Sub display and knob. If you're looking for a full-sized MF/HF transceiver that offers solid performance along with *plenty* of bells and whistles, then the ICOM IC-775DSP just may be your next radio.

Thanks to these hams who contributed to this review: Dean Straw, N6BV; Randy Thompson, K5ZD; Rick Lindquist, KX4V; Rich Assarabowski, K1CC; Jon Bloom, KE3Z; Peter Budnik, KB1HY; and Mike Gruber, WA1SVF.

Manufacturer's suggested retail prices: IC-775DSP, $4760; SM-20 Desktop Microphone, $207; FL-102 6-kHz 2nd IF filter, $75; FL-101 250-Hz 2nd IF filter, $106; FL-53A 250-Hz 3rd IF filter. $196; FL-222 1.9-kHz 3rd IF filter, $199; FL-223 1.9-kHz 2nd IF filter, $84; CT-17 computer interface, $135. Manufacturer: ICOM America Inc., 2380 116th Ave NE, Bellevue, WA 98004, tel 206-454-8155; fax 206-454-1509.

MFJ-784B Tunable DSP Filter

Reviewed by Rick Lindquist, KX4V
Assistant Technical Editor

The advent of digital signal processing (DSP) has generated one of those sea changes in the hobby. Equipment manufacturers are tripping over themselves to incorporate DSP into their high-end boxes, just as they did a decade or so ago when audio filters were all the rage. If you'd like to hop aboard the DSP juggernaut but aren't ready to spring for a whole new radio, MFJ offers the MFJ-784B Tunable DSP Filter, a flexible, outboard DSP unit with appeal to everyone from DXers and contesters to rag chewers and digital-mode enthusiasts.

Like its predecessor, the MFJ-784 *Super* DSP Filter, the unit is built around the Analog Devices ADSP-2105, a 16-bit chip that runs at 12 MHz. The differences between the '784 and the slightly more expensive '784B mostly boil down to additional bells and whistles—literally in the latter case (a firmware upgrade for the '784 is available). Besides jumper-settable DSP filters for RTTY, HF packet, AMTOR and PACTOR, and a fixed filter for SSTV and fax modes, the '784B has tunable filters for SSB and CW plus tunable high-cut, low-cut and bandpass settings. It also can memorize your top ten favorite custom filters. Noise reduction, notches (manual and auto), AGC, the new *Spotting Tone* and *Filter Talk* features (the "whistles") and a built-in diagnostic routine round out the package. A compact but complete *Instruction Manual* covers everything from "fast start" to "advanced features." Wisely, it includes down-to-earth explanations of DSP and filter theory, making it a good learning tool.

BOTTOM LINE

The MFJ-784B is a convenient, economical tunable DSP add-on that's especially effective for CW and data modes. This unit can add new life to older transceivers and might even boost the performance of newer, non-DSP gear.

The unit is easy to hook up but needs a 12-V power source. Like any outboard audio filter, it goes between your transceiver's audio output and your speaker or headphones (or your TNC). MFJ recommends a second connection to route the CW sidetone around the filter, but the unit also

Table 2
MFJ-784B Tunable DSP Filter

Manufacturer's Claimed Specifications	***Measured in the ARRL Lab***
Power requirements: 10-16 V dc, 500 mA (max).	As specified (tested at 13.8 V dc).
Input-to-output delay: 23 ms	As specified.
Bandwidth (min/max): CW, 30-700 Hz; SSB, 1000-2500 Hz; RTTY, HF packet, AMTOR and PACTOR, optimized for 2125/2295-Hz mark/space frequencies; SSTV/FAX, 1050-1350Hz and 1450-2350 Hz (dual bandpass).	As specified.
SSB/CW filter shape factors: Not specified.	SSB, 1.08 typical; CW, <1.3 at ≈300 Hz bandwidth.
Low-cut/high-cut and bandpass frequency ranges: Low reject cutoff frequency, 200-2200 Hz; high-reject cutoff frequency, 1400-3400 Hz; bandpass filter bandwidth, 30-2100 Hz.	As specified.
Random noise reduction: up to 20 dB.	As specified.
Manual notch depth: ≥40 dB; auto notch depth, up to 50 dB.	As specified.
Time to notch: Not specified.	≈8 ms.
Audio input requirements: 1-2.8 V P-P.	As specified.
Audio output: filtered audio output, ≈1.5 V P-P across 600 Ω; speaker output, ≈2.5 W into 6 Ω.	Filtered audio output, 3 V P-P at 1% THD across 600 Ω; speaker output, 2.7 W at 1% THD into 6 Ω.
Size (height, width, depth): 2.4×10×5.8 inches (exclusive of projections).	

Note: All measurements were taken at factory-default jumper settings.

has a sidetone filter. A front-panel **INPUT LEVEL** LED (also new on the '784B) helps you calibrate the audio input level using a screwdriver pot on the rear apron. The unit's four, smallish, fluted front-panel knobs have a "tight" feel. The **FILTERS** switch moves easily, but the panel labeling surrounding it is a bit busy for such a small area. Same goes for the labels above the twin **TUNABLE FILTERS** controls.

Rear apron 1/4-inch and 3.5-mm phone jacks accommodate both stereo or mono headphones and a speaker (which you can disable with a front-panel button). Other audio connections—including a separate "filtered output" level for your TNC or other device—are via the familiar phono jacks. You also can wire the filter to your TNC and transceiver via separate rear-apron five-pin DIN connectors which include "filtered output" audio and a PTT line connection. A front-panel **VOLUME** control sets a comfortable speaker or headphone level. However, ARRL Lab tests showed that speaker/headphone audio output rolled off sharply above approximately 1700 Hz with the DSP switched off. MFJ says that this was done to eliminate noise and hiss from the chip when DSP is switched out, to make it easier on the listener. Turning the unit off altogether eliminates the rolloff. "Filtered output" AF response was essentially flat across the amplifier's usable range.

An avid CW op, I first applied the MFJ-784B to my favorite mode on a somewhat noisy 40 meters. The '784B shines on CW. Finding a weaker signal somewhat down in the noise, I used the Spotting Tone to "zero beat" the station. This neat feature helps you center the signal in the filter bandpass by using the left-hand control to match the signal's pitch with an internally generated tone. If you're not tone deaf, you'll find it handy. Then, I used the right-hand control to narrow the bandwidth. Wow! This unit hoisted the watery signal right to the surface while deep-sixing the QRM and noise! Switching in my transceiver's narrowest filter was hardly worth the effort.

SSB results were not quite as dramatic; it takes more practice to find the right trade-off between enhanced selectivity and speech intelligibility. I found using the **LR/HR** (low reject and high reject) position to be quite useful on voice signals. Another user who tilted at 75-meter QRM with the MFJ-784 reports: "With an LSB signal on my listening frequency of 3839 kHz, I could use the tunable filters to make QRM on 3837 kHz go away. But a signal on 3840 kHz was still a bother—no matter what I did."

Digital-mode enthusiasts—especially those lacking IF filters tailored for such modes—might find the MFJ-784B a real plus to combat QRM and high noise levels. The unit considerably improved readability of troubled signals on HF packet (an already-problematic mode) and easily isolated battered RTTY and AMTOR signals from the noise and QRM and sent them into my TNC.

The unit's **AGC** is commendable, especially for an outboard DSP device. I expected a lot of pumping, but it's fairly smooth and helps bring low-level signals up so you can hear them better. However, under certain conditions, it can dredge up a lot of background noise, as the instruction manual warns. The **NOISE REDUCTION** button and control apply a special filter algorithm to random noise. A variable front-panel control determines how aggressively it attacks. The immediate impression is that it just drops your audio output level, but a closer listen reveals it works well on high-frequency "hiss" or band noise. On weak signals, however, it can add a hollow or "sizzling" noise of its own. While not a panacea against random noise, it helps reduce listener fatigue, if nothing else.

The **MANUAL NOTCH** and **AUTO NOTCH** modes were phenomenal. With the manual notch on, you tweak the **TUNABLE FILTERS** controls to make the offending QRM just disappear. It's *very* easy to get deep notches (one or two) without much dial twiddling. The auto notch is especially effective against heterodynes (up to four) like those encountered on 40 meters at night. An internal jumper lets you set three additional levels of aggression, but the manual warns that the highest setting might impair intelligibility.

Filter Talk is both convenient and cute: push the **PROGRAM** button and it plays back your custom filter memory settings in Morse code (the default speed is a sluggish 5 wpm, but you can bump it up to as high as 30 wpm using internal jumpers). For those who prefer the more prosaic pencil-and-paper approach, the instruction manual includes fill-in-the-blank charts.

The MFJ-784B Tunable DSP Filter would be a welcome complement to many ham shacks, especially if you're not quite ready to trade up to a transceiver with integral DSP. SWLs also would enjoy its features. The MFJ-784B lists for $249.95. The optional MFJ-1315 power supply is $14.95. The MFJ-55 firmware upgrade for the MFJ-784 (which, MFJ says, "gives you most features of the MFJ-784B") is $29.95. *Manufacturer*: MFJ Enterprises Inc., Box 494, Mississippi State, MS 39762; tel, 601-323-5869; fax, 601-323-6551; orders: 800-647-1800.

Thanks to Glenn Swanson, KB1GW, for helping with this review.

M² EB-432 Eggbeater Antenna

Reviewed by Steve Ford, WB8IMY
Managing Editor

Two years ago I had an opportunity to try the M² EB-144 2-meter *eggbeater* antenna (*QST*, Sep 1993, p 75). At the time I needed an omnidirectional antenna that would give me overhead circular polarization on 2 meters for uplinks to RS-10, *Mir* and the space shuttle, as well as horizontal polarization for local SSB work. The EB-144 filled the bill perfectly. I was impressed by its performance and ease of installation.

Now I was about to explore the 1200-baud PACSATs, which use 2-meter uplinks and 70-centimeter downlinks (at approximately 437 MHz). The ideal antenna installation for these birds is a set of 11-element Yagis (or larger) and an azimuth/elevation rotator. That's great if you have the necessary cash and available space on your roof or in your yard. In my case, however, outdoor antennas are *verboten.*

That left the attic, such as it is. My tiny attic offers barely four feet of headroom and lots of imposing rafters. I quickly realized that it would be impossible to squeeze two beams into such cramped quarters, much less rotate them. Omnidirectional antennas were the only alternative.

I hung my homebrew 2-meter groundplane antenna in the attic using some leftover fishing line. Another hand-crafted groundplane for 70 centimeters was left dangling about five feet away. The performance of this slapdash system was underwhelming. The PACSATs heard my uplink pleas well enough, but reception on 437 MHz was erratic, to say the least. Many times their signals faded sharply as they passed through my groundplane's pattern.

I obviously needed a 70-centimeter antenna with a more nearly circular pattern. Once again it was time to call upon the eggbeaters.

The EB-432

The M² EB-432 eggbeater offers coverage throughout the *entire* 70-centimeter amateur band, not just the satellite subband. The antenna gets its name from its physical appearance: It looks like an old-fashioned kitchen eggbeater. Two loops of #10 Copperweld wire are supported vertically by a Fiberglass rod. At the base, the wires attach to a matching balun of unknown design. (I wasn't about to risk breaking into the Delrin case to take a peek.) The effect of the twin-loop configuration is a smooth, omnidirectional pattern with horizontal polarization at the horizon and right-hand circular polarization overhead.

The basic EB-432 features a Type N coaxial connector in the base along with a 3/8-24 female thread to accept common mobile masts. I opted to spend a little more and buy the RK-70CM radial reflector and base-mount kit. The radials offer improved circularity, producing a roughly hemispherical pattern (just what I needed for satellite work). The base-mount kit allows you to install the EB-432 on virtually any mast. For me this meant 3/4-inch copper plumbing pipe.

I assembled the EB-432 in less than 30 minutes. M² includes all the hardware you need, even a pair of Allen wrenches. The first task is to install the loops. For this step you need only decent hand strength and a good eye for proper proportion. (You want the finished loops to be of equal shape.) Then, the radials secure to the hexagonal radial plate with set screws. You simply push the aluminum rods into the holes and tighten the screws.

With the EB-432 in hand, I crawled into the attic and set up my mast. Minutes later I slipped the U bolts through the mounting bracket and tightened them on the pipe. Thirty feet of Belden 9913 coax snaked its way from the EB-432 to my radio. I left the 70-centimeter groundplane and its associated coax in place—for the moment.

Performance

That afternoon I monitored downlink signals from OSCARs 16, 18 and 19. Using a UHF coaxial switch, I bounced between the EB-432 and my faithful groundplane during each pass. The performance differences were astonishing. The EB-432 provided superior reception (peaking at S5) with far fewer fades. And those fades that I did hear were shallow and brief. As a bonus, the EB-432 enabled me to monitor signals at much lower elevations than the groundplane. Next, I tried Fuji-OSCAR 20. This satellite travels in a slightly elliptical orbit that places it 200 to 900 km higher than the PACSATs. Even so, I was able to monitor SSB conversations on the bird with good clarity. I was seeing S5 signals with the EB-432 and S1 signals with the groundplane.

As you'd expect, the groundplane was a particularly poor performer during overhead passes. Its deep vertical null was deadly for reception. On the other hand, the EB-432 kept the signals coming, even when satellite elevations approached 90°.

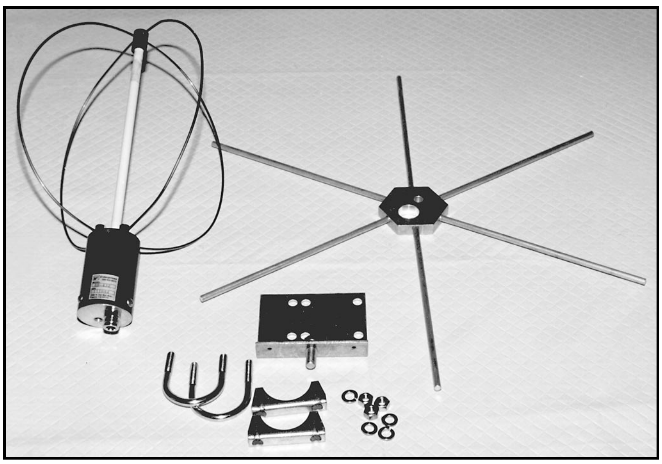
For a final test I tried my hand at some terrestrial SSB during the local 70-centimeter "activity night." I didn't expect much with 30 W to an indoor omnidirectional antenna, but again I was surprised. I received 59 reports out to about 50 miles. My farthest contact was with a station 90 miles distant. Not bad for an omnidirectional antenna on 70 centimeters!

Summary

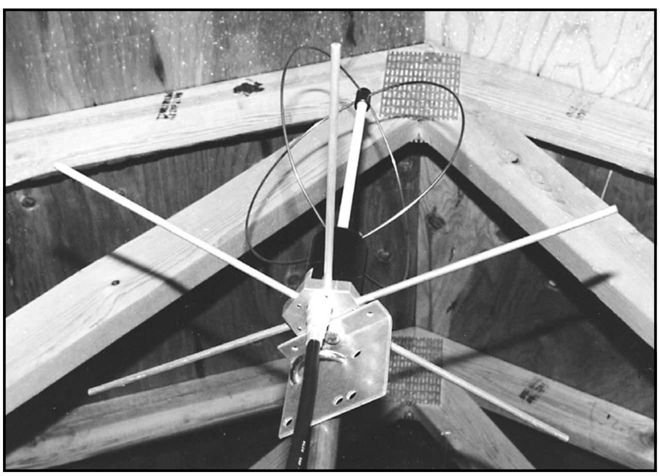
It's important to emphasize that the EB-432 antenna isn't a substitute for a good *directional* antenna system. For satellite or "weak signal" terrestrial activity on 70 centimeters, you're always better off with quads or Yagis. With a set of beams, the appropriate rotators and a little "altitude," you can copy signals all day long and hardly miss a beat—or a byte.

But if you're restricted to omnidirectional antennas (inside or out), you already have at least one strike against you. To get the most of what remains, it pays to use the best designs possible. The M² EB-432 with the optional radial reflector kit is clearly one of these.

Manufacturer: M², 7560 Del Mar Ave, Fresno, CA 93711; tel 209-432-8873, fax 209-432-3059. Suggested retail prices: EB-432 Eggbeater antenna, $109.95; RK-70CM radial reflector kit, $39.95.



Assembly of the EB-432 antenna and the RK-70CM radial kit is straightforward and quick. M² provides everything you need.



The EB-432 installed in my attic in a matter of minutes.