# Product Review Column from *QST* Magazine

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Hal Communications PCI-4000 CLOVER-II Data Controller

AlphaLab TriField Meter

# HAL Communications PCI-4000 CLOVER-II Data Controller

*Reviewed by Steve Ford, WB8IMY*

*CLOVER* has been on the lips of digital-communications enthusiasts recently—and for good reason. It's the latest advancement in the ongoing struggle to improve digital HF-band communications. Developed by Ray Petit, W7GHM, and HAL Communications, the PCI-4000 system offers outstanding binary and ASCII data-transfer capability despite the vagaries of HF propagation.

CLOVER accomplishes this feat with a claimed signal bandwidth of only 500 Hz (at –50 dBc). This measurement reflects the baseband audio the CLOVER board applies to a transmitter. The transmitter's characteristics may increase the bandwidth a CLOVER signal occupies on the air. ARRL Lab tests with a typical amateur transmitter show that final-amplifier intermodulation distortion significantly increases the CLOVER signal's actual –50-dBc bandwidth, which may affect how closely in frequency two CLOVER stations can operate. Other transmitter characteristics, principally composite noise, may also affect the necessary frequency spacing of two CLOVER data channels.

According to codeveloper W7GHM, CLOVER gets its name from the waveform shape that appears on a tuning indicator when a CLOVER signal is properly tuned.

CLOVER uses a four-tone modulation system. Depending on signal conditions, any of ten modulation formats can be selected manually or automatically (more about the automatic, adaptive nature of CLOVER a little later). Six of the modulation schemes employ phase-shift modulation (PSM); two use amplitude-shift modulation (ASM); and two use frequency-shift modulation (FSM). Each tone is phase- and/or amplitude-modulated as a separate, narrow-bandwidth data channel. As you might have guessed, the resulting CLOVER signal can be complex.

For example, when the tone pulses are modulated using quadrature phase-shift modulation (QPSM), the differential phase of each tone shifts in 90° increments. Two bits of data are carried by each tone for a total of eight bits in each 32-ms frame. The resulting block data rate is roughly 250 bits per second. CLOVER is capable of even higher data rates when using 16-phase, four-amplitude modulation (16P4A). In this format, CLOVER perks along at 750 bits/s.

On the other end of the scale, CLOVER can bring into play several slower (but more robust) formats under marginal conditions. Two-channel diversity frequency-shift modulation (2DFSM) operates at 31.25 symbols per second, the CLOVER base modulation rate. Although this data rate is much slower than what CLOVER is capable of using, its error detection and correction efficiency is improved.

Even with these ingenious modulation schemes, errors are bound to occur. That's where CLOVER's *Reed-Solomon* coding system fills the gaps—literally. Reed-Solomon forward-error-correcting (FEC) data coding is used in all CLOVER modes. Errors are detected at the receiving station by comparing *check bytes* that are inserted in each block of transmitted text. When operating in the ARQ mode, CLOVER's damaged data can often be reconstructed *without the need to request repeat transmissions.* This is a significant departure from the techniques used by packet, AMTOR and PacTOR, which require retransmission of damaged data. Of course, CLOVER can't always repair data; repeat transmissions—which CLOVER handles automatically—are sometimes required to get everything right.

### The Bottom Line

Using robust error-detection and -correction software and hardware, the PCI-4000 makes the most of DSP *and* valuable spectrum by adapting encoding methods and transmitter power to move data on the HF bands at high speed—and a high price.

## The Hardware

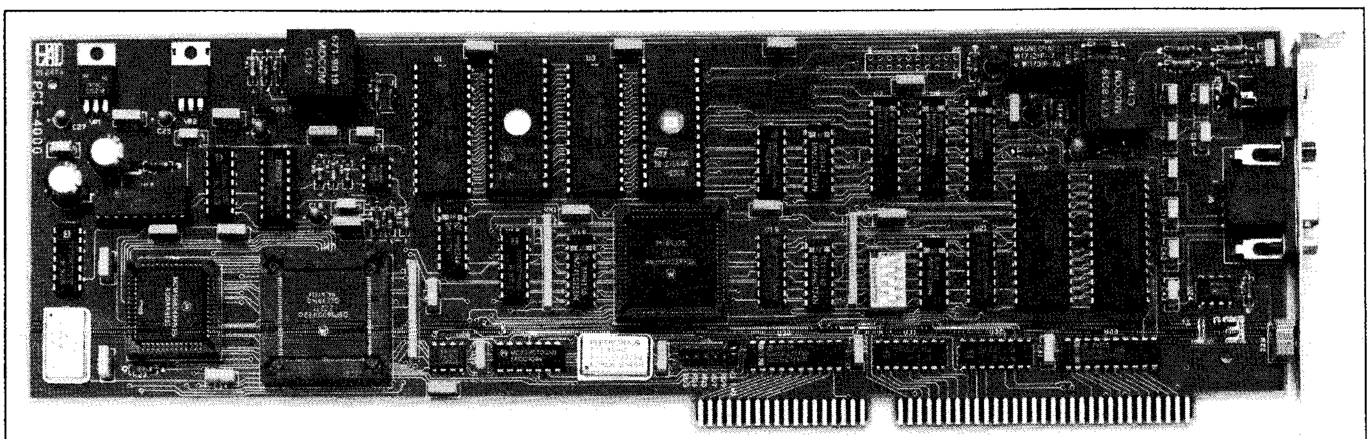
All of CLOVER's magic is accomplished on a card that plugs into a full-length expansion slot in an IBM PC-compatible 286, 386 or 486 computer. Signal modulation and demodulation are achieved via digital signal processing (DSP) technology. For maximum efficiency, the PCI-4000 uses a dual-processor design with a 16-bit microcontroller *and* a high-speed digital signal processor. The PCI-4000 gets power from the computer and the input/output connections to the radio are made with a single DB9 connector on the board's rear mounting bracket.

### *Installation*

Despite the product's design complexity, the PCI-4000 is easy to install. I simply removed my PC's cabinet and gently pushed the board into the card-edge connector. The board holds several DIP switches, but these are preset at the factory.

Next I installed the cable set supplied with the PCI-4000. It uses a connector that mates with the PCI-4000, from which four cables originate: **SELCAL**, **AUDIO IN**, **AUDIO OUT** and **PTT**. Each of these terminates in a phono plug. The cables are clearly labeled with small plastic tags. They're a big help when you're threading cables through a maze of shelves and other wiring.

For optimum performance, CLOVER requires a stable SSB rig (no more than 30 Hz drift per hour) with the ability to tune in small increments. My battered Kenwood TS-820S transceiver is far from optimal, but I wanted to present the PCI-4000 with a true challenge.



The results were surprisingly good.

I did not use the **SELCAL** cable. It is intended primarily for use with scanning receivers as a means to detect when your station is being called. This is of most importance to hams using the PCI-4000 as the heart of a CLOVER bulletin-board system (BBS).

When all the hardware was in place, I loaded the software supplied with the PCI-4000. It's important to note that every time the PCI-4000 system is activated, it looks for the microprocessor and DSP operating software on the computer's hard disk. Why not simply store the software as permanent *firmware* on the board? Answer: *flexibility*.

By keeping the software on disk, users can update their PCI-4000s without opening their computer cabinets. In most cases, all that's required is obtaining the new software. In fact, the latest software versions can be downloaded from the HAL Communications telephone BBS.

After the microprocessor and DSP controller software are loaded, the *PC-CLOVER* program takes over. This is the user interface for the PCI-4000.

## The Manual

The PCI-4000 manual is well written. It explains the system in a friendly, easy-to-understand style. The manual guides you through every operation. It tells you what keys to press and shows you what you'll see on the screen as you go.

The manual describes how to set the transmit-audio level with a *single-tone* test. This is an important step. You must make sure that your transceiver's ALC threshold is not exceeded during transmission, or the CLOVER waveforms will be distorted. With my TS-820S, I simply activated the test mode and watched the ALC meter, adjusting the **MIC GAIN** control until the needle slipped below the threshold level. If you can't control your audio level in this fashion, you can set it via a pot on the PCI-4000 board, just below the connector. By adjusting this potentiometer, you can increase or decrease the audio level to your radio as necessary.

## The *PC-CLOVER* Screen

The screen is somewhat confusing to behold—at least at first. If you're experienced with more sophisticated TNC and MCP software packages, you'll notice some similarities. The display is divided into seven sections:

- Receive buffer
- Status line
- Command line
- Transmit buffer
- Information line
- Tuning indicators (relative amplitude or frequency)
- Receive/transmit status table

The receive buffer displays the incoming text or data. If the tuning indicator and status table are disabled, the buffer displays up to 24 lines of text. (Nine lines are displayed when the indicator and table are visible.) The buffer holds up to 250 lines. You can scroll through them at any time.

The status line indicates 10 *PC-CLOVER* parameters, including mode, TX/RX data state, data rate, transmit-buffer state, printer state and so on. Especially noteworthy here is the transmit-buffer state. When the buffer is enabled, the PCI-4000 immediately sends whatever is in the buffer. When it's disabled, you can type ahead (or load a file) and send the information when you're ready. Enabling or disabling the buffer is a simple matter of pressing the **F10** key.

Various *PC-CLOVER* options are chosen from the command line. By repeatedly pressing the **TAB** key, you can select menus that control software operation. To call CQ, for example, you highlight **MODE** on the command line and press **ENTER**. A small window appears and you are prompted to make your selection (CQ, in this case). You can also use shortcut keys to directly access these menus.

The transmit buffer uses the lower screen area to display the data that's ready for transmission. Like the receive buffer, you can scroll through it at will. If you're typing from the keyboard, your text appears in the transmit buffer. The information line lists several commands and control-key functions for easy reference.

CLOVER tuning is extremely critical. If you're off the center frequency by more than 15 Hz, you'll lose the link. To assist CLOVER operators, the *PC-CLOVER* screen offers two tuning indicators: amplitude and frequency. When the amplitude display is active, you'll see four horizontal bars on the upper left side of the screen. Each bar represents the amplitude of a CLOVER tone. To tune in a CLOVER signal, you adjust your receive frequency until the bars are roughly equal in length.

During QSOs, I found the software's frequency indicator to be the most useful tuning display. It lets you know the frequency differential (in hertz) between you and the other station. A small block functions as a pointer to help you keep the other station properly tuned. The idea is to keep the pointer as close as possible to the center of the scale. This is easier said than done. The indicator's response is sluggish and it has a tendency to hop up and down the scale. When you're attempting to make small frequency corrections, this sluggishness can be frustrating. The key is to make *slight* corrections and wait until the pointer settles down. This would be less of a problem when using a transceiver with a 10-Hz frequency readout.

In my opinion, the receive/transmit status table is the most intriguing area of the *PC-CLOVER* screen. During QSOs, I often became distracted because I was so busy watching the table! Not only do you see your own parameters changing, you see the changes taking place at the *other station*! (CLOVER accomplishes this by periodically swapping station data during the QSO.)

The receive/transmit status table displays the modulation format, signal-to-noise ratio, tuning error, phase dispersion, error-correction capacity and transmitter power (as a percentage of full output). The table is split into horizontal rows labeled "MY" and "HIS." Who is enjoying the best receive conditions? Which station is doing the greatest amount of error correcting at the moment? Just have a look at the table!

## On the Air

As soon as I felt comfortable with the *PC-CLOVER* software, I sent my first CLOVER CQ. I tuned my transceiver to 7.081 MHz, selected LSB and toggled the AGC switch to **SLOW**. From the *PC-CLOVER* **MODE** menu, I highlighted CQ and pressed **ENTER**.

The PCI-4000 quickly sent my call sign in CW and then proceeded to call CQ. My transceiver began sending bursts of tones that sounded like a chorus of manic frogs. Nothing resembling a CQ appeared in my transmit buffer and I started to wonder what was going on. As I later found, this is completely normal. The proper data was indeed being sent, but not in the text format I was accustomed to seeing on RTTY, AMTOR and PacTOR.

It took a couple of calls to get a response—and then the fun began. My text was transmitted as soon as I typed it, which made for some confusing situations! Sometimes the other station would respond to the first part of my sentence without realizing that more text was on the way. (As with packet QSOs, it helps to use *K*, *BTU*, >>> or some such signal to tell the other station that it's his or her turn to talk.) As long as neither of us typed fast enough to fill our transmit buffers, the PCI-4000 remained in the *chat* mode, sending data in small chunks. The throughput in this mode seems similar to PacTOR.

At one point, I disabled the transmit buffer and used the **FILE** menu to load a large text file from disk. When I reenabled the buffer, the PCI-4000 jumped to the *block* mode. Data throughput soared! Since signal conditions were good, the file was sent at an impressive speed—far faster than I could read, let alone type!

### *Adaptive Operating*

The PCI-4000's adaptive behavior is fascinating. As signal conditions fluctuate during QSOs, for example, the PCI-4000 raises and lowers the audio level to my transceiver, which causes a corresponding change in transmitter output power. At times, the status table indicated that I was running only 6% of full output—less than 6 watts! At other times, my output power would automatically increase to 50% or 100%. In other words, CLOVER uses only as much power as it needs to maintain the link at any given time. Imagine how our bands would sound if every mode had this capability!

CLOVER also selects modulation formats to suit conditions. As conditions worsen, the software selects slower, more robust formats. As conditions improve, faster, less robust modulation schemes are used—all automatically. I should point out that these adaptive functions *can* be disabled for operators who prefer manual control.

CLOVER's performance in the presence of interference is excellent. During many of my contacts, RTTY or AMTOR signals appeared on frequency. The PCI-4000 would respond by increasing power or changing modulation formats to maintain a decent throughput level. I noticed that the PCI-4000 is susceptible to interference from other CLOVER signals (I lost a link once due to interference from another CLOVER station on the frequency), but this is to be expected. After all, the DSP system is designed to enhance the reception of CLOVER signals. If one appears close enough to your frequency, it will be received along with the CLOVER signal you're trying to copy.

With the relative instability of my TS-820S, I often had to make minor frequency adjustments during QSOs. The manual warns against this, but I found that the system would tolerate *slight* adjustments. If you intend to use CLOVER with an older transceiver such as mine, I recommend letting the radio warm up for half an hour or so before operating.

*Eavesdropping on CLOVER*

Using the PCI-4000 to copy other CLOVER signals is not easy. A *Listen* mode is supported, but it does not perform with the reliability and ease you may expect with AMTOR or PacTOR controllers.

If you're attempting to copy an ARQ QSO, you must first use the amplitude display and tune the signal until the tone bars are roughly equal. If you're close to the proper frequency, the station's call sign appears in the upper left-hand corner of the screen. If the station is conversing in the *chat* mode, you may see sporadic bursts of text. I was unable to copy text from stations running in the block mode, however. FEC performance is much better, although tuning is still critical.

I didn't find the Listen mode's relatively poor performance to be a serious liability, but HAL Communications is working toward improving it. This mode's primary purpose is to identify which stations are on the frequency—and it does this. You may not be able to easily eavesdrop on a conversation, but at least you'll be able to enter the appropriate call sign and establish a link when the QSO has ended.

When you tune across a station calling CQ, you see the station's call sign along with a message telling you that he or she is requesting a link. How do you respond? Not by entering the transmit mode and typing call signs or SELCALs. With the PCI-4000, all you have to do is press **Ctrl-F9**. The system keys your transmitter and attempts to establish a link.

**Summary**

The PCI-4000 CLOVER system is undoubtedly the most efficient HF digital communications mode yet devised for Amateur Radio. The *PC-CLOVER* software, easy installation and the well-written manual make CLOVER practical for those with little digital communications experience. Digital veterans will enjoy CLOVER's flexibility. I know many will be intrigued by its ability to store channel statistics during QSOs. You can activate this storage option and use spreadsheet software to create interesting graphs.

For most HF digital-mode enthusiasts, the PCI-4000's price may now be the greatest barrier. Those who enjoy live keyboard conversations will probably lean toward PacTOR since it offers good efficiency and the ability to transfer binary data at about a quarter of the cost of CLOVER. CLOVER is unsurpassed, however, when it comes to handling large volumes of data on the HF bands. Hams who are presently operating HF packet forwarding systems are taking a close look at CLOVER. From my experience with the system, it's apparent that CLOVER could easily outstrip packet in this application. CLOVER may also find a niche in BBS operations. (Imagine connecting to an HF BBS and downloading files at many times the speed of AMTOR or even PacTOR.)

When cost is weighed against throughput and reliability, the PCI-4000 is well worth the price for some applications. For the true mainstream digital-HF-communications crowd, however, waiting for a lower-priced CLOVER package may be the only reasonable alternative. After all, $1000 buys a really nice MF/HF transceiver, antenna or hamshack computer.

Manufacturer: HAL Communications Corp, PO Box 365, Urbana, IL 61801, tel 217-367-7373. Manufacturer's suggested retail price: $995.

# AlphaLab TriField Meter

*Reviewed by Wayne Overbeck, N6NB, PhD, JD; Member, ARRL Bio-Effects Committee*[1]

In recent years, the possible health hazards of electromagnetic energy have been widely discussed in medical journals, the mass media and in ARRL publications.[2] Although there are many uncertainties in this area, there is growing medical evidence that both low-frequency fields and RF energy may cause biological effects if the energy level is sufficiently high.

The current editions of *The ARRL Handbook*, *The ARRL Antenna Book* and *The ARRL UHF/Microwave Experimenter's Manual* address this question, offering practical suggestions to help radio amateurs avoid potentially hazardous electromagnetic fields. These suggestions, prepared by the ARRL Committee on the Biological Effects of RF Energy, emphasize a philosophy of *prudent avoidance*—the idea that it is wise to avoid unnecessary exposure to potentially hazardous levels of electromagnetic energy until medical researchers reach more definitive conclusions about safe exposure levels.

In 1990, the Federal Communications Commission and the Environmental Protection Agency jointly conducted measurements of the fields at a number of Amateur Radio stations. They concluded that most amateur operations do not expose anyone to fields strong enough to constitute a health hazard. However, the FCC/EPA findings suggested that indoor antennas and other antennas in close proximity to inhabited areas may pose hazards.

The FCC/EPA study was done with professional measuring equipment—instruments priced far beyond the means of most radio amateurs. The Bio-Effects Committee has long believed that there is a need for low-cost meters to measure electromagnetic fields—meters inexpensive enough that large numbers of amateurs could purchase them and determine whether the fields in their ham shacks and homes are strong enough to warrant concern. Ideally, such a meter must be reasonably accurate and capable of measuring both low-frequency magnetic fields and RF-power densities in the HF, VHF and UHF regions. This would enable amateurs to measure the 60-Hz magnetic fields emanating from such devices as power transformers and equipment fans, as well as the RF fields radiated by their antennas. Perhaps more importantly, it would also help amateurs identify unintended RF sources in their shacks, such as poorly shielded equipment or defective feed lines.

AlphaLab, a small company based in Salt Lake City, Utah, recently entered the market with its TriField Meter—an instrument capable of measuring both low-frequency and RF fields. Because this product, which has a retail price below $150, might satisfy a long-unmet need, one of these meters was purchased by the League and tested by members of the Bio-Effects Committee.

A first glance, the AlphaLab TriField Meter appears to be an ideal product for amateurs wishing to measure the electromagnetic fields around their ham shacks. It has separate sensors to measure low-frequency electric fields and magnetic fields. In addition, it has a built-in RF probe capable of detecting energy across a broad frequency range: 50 MHz to 3 GHz. The meter's claimed accuracy is ±20% for 60-Hz magnetic fields and ±30% for 60-Hz electric fields. However, its claimed accuracy is not as high in the RF mode: –50% to +100%.

**The Bottom Line**

This electromagnetic-field meter, though compact and inexpensive, gives misleading results.

[1]Please direct correspondence to the Bio-Effects Committee Staff Liaison at ARRL Headquarters.

[2]A handout called the Bio-Effects Package is also available free of charge. Send your request to the ARRL Technical Information Service at ARRL Headquarters.

The TriField Meter has calibrated scales for high-level magnetic fields (0-100 milligauss), low-level magnetic fields (0-3 milligauss), electric fields (0-100 kilovolts/meter) and RF power densities (0.01-1 milliwatt per square centimeter). In addition to the calibration markings, it has a red arc on each scale to indicate field intensities that the manufacturer believes may prove hazardous. The meter's indicated hazard thresholds are generally in line with currently recognized standards for electromagnetic field exposure. A small, hand-held unit, the TriField Meter is powered by a 9-volt battery.

### Testing

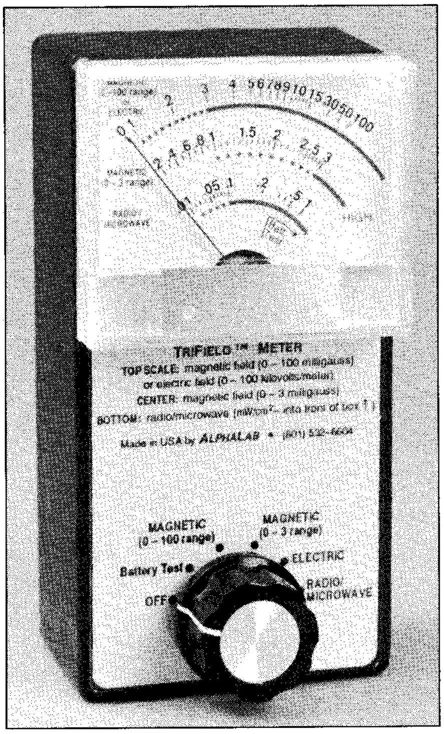
I accompanied the FCC/EPA team on many of their field measurements of Amateur Radio stations in 1990. To check out the TriField Meter, we set out to use it to replicate a number of the FCC/EPA team's measurements, since those measurements were made with high-quality professional instruments. Unfortunately, it turned out to be impossible to repeat many of the FCC/EPA measurements because of shortcomings in the TriField Meter that quickly became apparent.

In its low-frequency magnetic-field modes, the TriField Meter gave consistently higher readings than the FCC/EPA team obtained. However, the TriField Meter's well-written instruction sheet offers an explanation of this phenomenon: although it is calibrated to give accurate readings of 60-Hz fields, readings at other frequencies are weighted. A 3-milligauss field at 120 Hz will read 6 milligauss on the meter, while a 3-milligauss field at 240 Hz will read 12 milligauss, etc. Because the meter offers no means of determining the frequency of a field that the meter is detecting, it is impossible to know the true strength of any field.

For example, as this is written the TriField Meter is indicating the presence of a 100 milligauss magnetic field where I am sitting, about 12 inches from a computer and monitor, a generic MS-DOS system. In contrast, a professional meter indicates a 60-Hz field of less than 2 milligauss in the same position. To anyone who is familiar with the epidemiological and laboratory research on low-frequency fields, the idea of sitting in a 100 milligauss field when using a computer is a little frightening. And yet, there is no way to know the frequency (and thus the true strength) of whatever field the TriField Meter is detecting here.

The TriField Meter was also used to measure the low-frequency magnetic fields near a new NEC MultiSync 3FGx monitor, which has been widely touted as meeting the strict Swedish standards for electromagnetic radiation. The TriField meter indicated a surprising 5-milligauss magnetic field 12 inches in front of the monitor, and 30 milligauss along the front of the display screen—numbers far in excess of the Swedish standard (which is 2.5 milligauss in the 5-Hz to 2-kHz range)! But when the fields surrounding the NEC MultiSync monitor were measured with a professional meter, the 60-Hz magnetic fields turned out to be below 0.3 milligauss 12 inches from the monitor and below 1 milligauss along the screen. The NEC monitor appears to perform just as the Swedish laboratory tests indicated that it does. The problem is that the TriField Meter's frequency-weighted readings can be misleading—and a source of undue alarm.

The TriField Meter's instruction sheet justifies this frequency weighting feature by stating, "This is to gauge the currents induced inside the body, which are proportional to field strength multiplied by frequency." Be that as it may, this design feature makes it impossible to be confident in the accuracy of any measurement of a low-frequency field, which may or may not include components at frequencies other than 60 Hz. Moreover, some medical evidence suggests that extremely low-frequency magnetic fields (those below 100 Hz), may pose more serious health hazards than higher-frequency fields.




In its RF-power-density mode, the TriField Meter yields results that may be even more disconcerting. The first meter we tested gave wildly fluctuating readings whenever the unit was placed in a field stronger than about 0.3 mW/cm$^2$. In such a field, the meter would pin, drop back to midscale, and then pin again at a rate of about two complete cycles per second. This seemed to be a serious problem because fields stronger than that are commonly encountered near antennas, even with a transmitter power of only a few watts.

We contacted Bill Lee of AlphaLab about this problem. He indicated that he had not seen it before, and he sent us a second TriField Meter to test. It, too, produced erratic readings in fields stronger than 0.3 mW per square centimeter. This second meter tended not to repeatedly fluctuate from midscale to full scale, but rather to abruptly pin as it was gradually moved closer to a signal source—and then to remain pinned when returned to the point where it previously gave a much lower reading. While near-field measurements are notoriously difficult because of the presence of "hot spots," nothing like the erratic behavior of the TriField Meter was observed by the FCC/EPA team or the author when professional-quality RF power density meters were used in similar tests.

In short, the TriField Meter is not particularly usable in RF fields as strong as those found several wavelengths away from a vehicular antenna, for example. Even in weaker fields, its accuracy leaves something to be desired. Perhaps recognizing this fact, the instruction sheet offers this advice to users:

"The meter should be used so that simple steps (such as moving furniture) can be taken to reduce relative exposure within a home or office....Consult expert advice before taking more drastic steps, and perform independent tests with another type of meter. Remember that the TriField meter is frequency-weighted, so in most environments, it will read higher in the magnetic field setting than a more traditional meter of the type used in epidemiological studies to set possible hazard thresholds."

Although the TriField Meter may be useful in identifying unexpected sources of low-frequency or RF energy in a home or ham shack, its readings are almost certain to be misleading, creating a false sense of security or—more likely—causing undue alarm. It's not hard to envision groups of concerned citizens armed with these meters patrolling their neighborhoods in search of "radiation"—and finding hazards behind every bush!

After testing the TriField Meter, it is tempting to fall back on the old adage, "You get what you pay for." For the time being, at least, that appears to be true when it comes to electromagnetic-field-measuring equipment.

Manufacturer: AlphaLab, Inc, 1272 Alameda Ave, Salt Lake City, UT 84102-1703, tel 801-532-6604. Manufacturer's price: $145. QST

# Feedback

◊ Several errors in April 1993 *QST* Product Review have come to our attention. The list price of the AEA DSP-2232 is $999, not $899. Also, the DSP-2232's Doppler-shift correction feature has not yet been enabled; measurements reported in the review were a result of induced RF voltage, not signals generated by the '2232.

The Outbacker antenna reviewed in April *QST* was the Perth model, not the JR8. These models cover the same bands, but the Perth is longer (4-foot main shaft and 3-foot whip, as opposed to the JR8's 4-foot overall length). On 75 meters, the OB-JR8 resonates only between 3.9 and 4 MHz, whereas the Perth model resonates down to 3.6 MHz as reported in the review. Only the Perth model incorporates the built-in base matching network discussed in the review. *QST* regrets these errors. QST