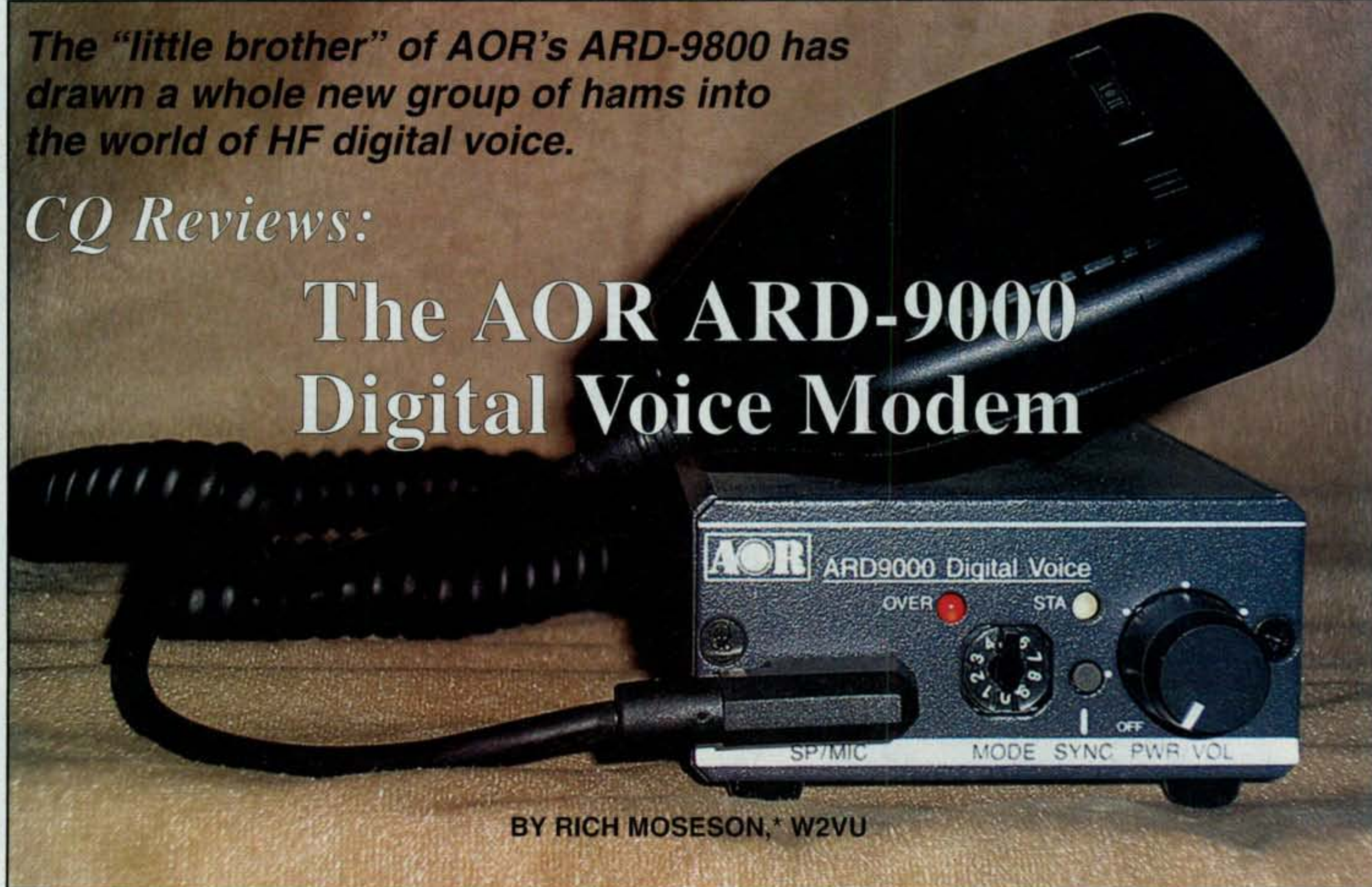


The "little brother" of AOR's ARD-9800 has drawn a whole new group of hams into the world of HF digital voice.

*CQ Reviews:*

## The AOR ARD-9000 Digital Voice Modem



BY RICH MOSESON,\* W2VU

It's been nearly two years since we reviewed AOR's ARD-9800 digital modem (June 2004 *CQ*), which is capable of producing very high-quality digital audio in an HF bandwidth, as well as transmitting digital image files (with an optional additional chip installed). One of the very few negatives about that unit was that it was kind of pricey (\$549 list) for a ham who is not yet totally committed to doing digital voice (DV) on HF. The folks at AOR listened to their customers (and potential customers) and developed a smaller, self-contained,

DV-only modem at a much more reasonable price (\$339 list), the ARD-9000. In doing so, they made a few other improvements and perhaps without realizing it, opened up the DV "window" to a whole new group of hams "HFPackers," who enjoy using small HF transceivers to keep in touch while hiking or mountain-climbing. But let's take a look at the unit itself before we "hit the trail."

### Bringing DV to HF

Until AOR introduced the ARD-9800 at Dayton in 2003, the few options for using digital voice on the ham bands were available only on VHF and UHF, where there was more bandwidth available to support a robust DV signal. But AOR combined

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The ARD-9000 (left) is considerably smaller and more portable than the earlier ARD-9800.



← Close-up of the ARD-9000 front panel. There are only two controls—power/volume and a “sync” button to try to force synchronization with another signal if there have been dropouts. The LEDs are explained in the sidebar “If it’s Orange, it Must Be Digital.”

### ARD-9000 Specs

Modulation method	OFDM (Orthogonal Frequency Division Modulation)
Bandwidth	300 Hz – 2500 Hz, 36 carriers
Symbol rate	20 mS (50 baud)
Guard interval	4 mS
Tone steps	62.5 Hz
Modulation method	36 carriers: DQPSK (Differential Quadrature Phase Shift Keying) (3.6k)
AFC	±125 Hz
Error correction	Voice: Golay + Hamming
Header	1 sec., 3 tones + BPSK training pattern for synchronization
Digital voice	AMBE coder/decoder
Signal detection	Automatic digital detect, automatic switching between analog and digital modes
Power requirements	10–16 VDC, approximately 100 mA (@ 12 VDC); 6 VDC by setting internal jumper
Dimensions (excluding projections)	2.8" (w) × 1.3" (h) × 3.9" (d)
Connectors	Radio: Microphone output (level adjustable) Speaker input (200 mV – 5 V p-p), external speaker output DC input connectors Speaker Microphone (with PTT)
Others	Force synchronization switch

the G4GUO digital protocol with the compression of a high-grade AMBE vocoder (voice encoder) to produce a DV signal within the same approximately 3-kHz-wide bandwidth used by a standard single-sideband signal. Keeping the signal to an SSB bandwidth made it feasible to bring DV to HF. (By the way, this unit is not limited to HF; it is an out-board unit that plugs into the mic and speaker jacks on virtually any ham rig, so it is just as usable on VHF and higher as it is on HF.)

As with any digital signal, a listener to an analog-only receiver will hear only noise. But when you plug in one of the AOR modems (or another brand should anyone else choose to use this open protocol), that “noise” is translated into crystal-clear FM-quality audio with absolutely no background noise. Of course, you need a good, strong signal to accomplish that, and when we reviewed the ARD-9800, we determined that the signal needed to be two S-units above the noise in order to provide a very solid link. AOR says the upgraded software in the 9000 permits clear reception on weaker signals, but as we’ll explain later, we were unable to test that particular aspect.

### The ARD-9000

There are several other, and more obvious, differences between the 9800 and the 9000. First of all, the 9000 is for digital voice only, no photos or other file transfers (but most people weren’t using that feature anyway). It is physically smaller and operates on a range of voltages from 10 to 16 volts. According to the spec sheet on the AOR website, internal jumpers can be configured to drop the operating voltage to 6 VDC, and HFPack users have found that you can operate on 9 volts without making any adjustments. Plus, the 9000 comes



← Close-up of the ARD-9000 rear panel. Connectors are (from left) for DC power, speaker out and in (from rig), and the connecting cable to the radio’s mic input. The tape next to the DC input jack covers a jack for a battery charger, a feature that is not yet available.

## DV on the Trail

By Ken Chong, DDS, WB6MLC

At the 2005 TAPR Digital Communications Conference in Santa Ana, CA, I saw the ARD-9000 on display along with the 9800. I had always admired the 9800 after seeing it demonstrated over the last two years at conventions, but never thought it would work for HFpack. When I saw the small battery-powered ARD-9000, though, a light bulb went on above my head. This was small enough to pack along when pedestrian portable (/PP) or pedestrian mobile (/PM).

Always willing to try something new to push the envelope for the HFpack group, I

bought an ARD-9000 at HRO after sneaking out of the DCC. Two other HFpackers, Oliver, KB6BA, and Glenn, WB6W, were also sufficiently impressed to buy their own 9000s at the same store. We headed back to the hotel, and snuck back into the TAPR DCC with very suspicious-looking AOR bags at our sides. (Folks figured out that we had just been to the candy store!)

The ARD-9000 is very easy to hook up when portable. Most of us HFpack DV users have done DV when pedestrian portable. It was recently determined that the ARD-9000 can operate on as low as 7.0 volts before it begins to motorboat. There is a mystery internal battery charging connector on the back of the 9000. The AOR Users' Group found out that this was for an internal bat-

tery accessory that is not yet available in either the USA or Japan. Presently, I am using a Lithium Ion 9-volt battery for my own 9000 for light weight. We all use the AOR accessory cables for the particular brand of radio to simplify the hookups. The build quality of the AOR provided cables is very high, and they are properly shielded.

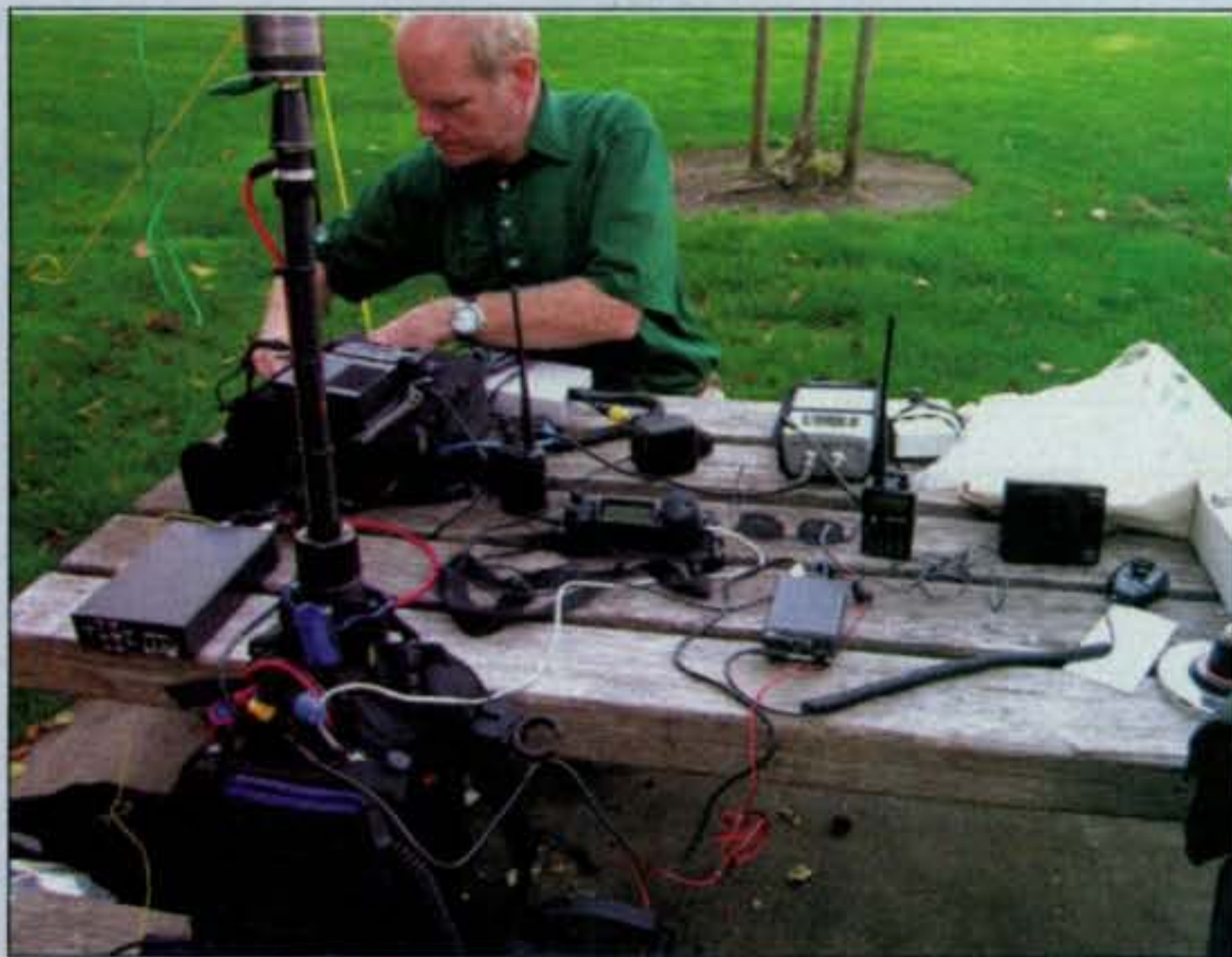
Pedestrian-mobile operation is still a work in progress. RFI and feedback have to be eliminated by making sure that the radio and AOR box's power packs are kept separate. Ferrites must be snapped onto both the mic cable and all interconnects. Also, one must be very careful not to overdrive the rig when running AOR DV. Due to the high crest factor of OFDM modulation, only a couple of watts are necessary to put out a full 25 watts, for example. I have used both my FT-817 and FT-857D successfully on AOR DV.

### What's It Like To Use an ARD-9000 on the Trail?

The supplied speaker microphone can be set up to toggle back and forth between DV and analog, as explained in the user manual. For example, to go digital, one squeeze of the PTT button and you are in DV mode. You can proceed to speak immediately. To go to analog mode, you do two quick squeezes before speaking (keeping the button held down on the second squeeze). In the field, it was easy to forget at first, but eventually we all got the hang of it. The ARD-9000 has a built-in memory, so it is not necessary to wait for the sync tone to complete. You just begin speaking naturally and the unit will buffer your speech until it is ready to transmit its data.



This must have been an interesting sight for non-ham park visitors, as HFpackers at Pacificon 2005 in San Ramon, California set up a "Day in the Park" of pedestrian portable operating, including digital voice with the ARD-9000. (Pacificon photos courtesy of Ken Chong, WB6MLC)



WB6MLC's HFpack digital station is centered around his Camelbak pack, containing the body of his FT-857D and his W3FF Jumbo Buddistick /PM antenna. On the table, from the left, are his LDG Z11PRO auto tuner, FT-857 control head, ARD-9000 DV, and a Kenwood F6A HT used for monitoring the digital signal for any RF feedback. The antenna mount is homebrewed with a Delrin rod and pipe insulation foam to stabilize it inside the pack.



The HFpackers in attendance had a good time working stations with their own setups and antennas, but they also enjoyed trying out Ken's DV setup, as in this photo. Not realizing at the time that these photos would be published, Ken didn't get the names or calls of the hams pictured.

Receiving AOR DV does require careful tuning, but there is a resync button if you are initially far enough off to hear only the raw OFDM modulation (which sounds a lot like noise to others). When out on the trail, the band noise is very low, so decoding an AOR DV signal is very easy. This is not a QRP mode, however, and at least an S5 signal is necessary to sync up properly.

Since these stations are out in the clear away from high man-made noise, AOR DV does sync up reasonably well for clear communications. When the DV syncs up, the result is sometimes startling. All band noise and static are gone and replaced with an FM quality voice. It was much fun and can become addictive at times. A good application for DV is especially between HFpackers who are /PM or /PP on different mountaintops or other locations. The ARD-9000 was designed to allow one-hand operation with the speaker microphone, and it does work well while on the trail.

### My Setup

To go /PM, I bought a small leather pouch with a belt loop that is just the right size to hold the ARD-9000 on my fanny pack. The rest of my gear is contained in a CamelBak with a Buddistick for an antenna. The FT-857D has a homebrewed remote head platform connected to the body of the rig (inside a pouch attached to the pack) with a 3-foot data cable. The AOR unit connects to the front of the rig's body at the mic input.

The 9-volt Lithium Ion battery is attached to the top of the ARD-9000 with hook-and-loop fasteners. At about 100 ma current draw, one has just enough juice for a few good contacts when in a good location. To preserve battery power, I keep the AOR turned off until the top of the trail is reached. If I were to need more DV power, I also have a 12-volt AA pack that can be attached to the AOR pouch.

The AOR DV HFpackers conduct a net around 3:00 PM PST (2300 UTC) on 7.296 MHz USB every Sunday. 7.296 MHz USB is a standard HFpack frequency used for the sunset HFpack net, which begins after we are finished. Many members of the AOR user's group show up to say hello and to exchange information.

### What About the Future?

I hope to keep using my AOR ARD-9000 when /PM and /PP. At the next HFpack Forum at Pacificon 2006 (October 13-15, see <[www.pacificon.org](http://www.pacificon.org)>), the HFpack group will be conducting a live demonstration of AOR DV in action. The highlight of the evening will be the famous HFpack pedestrian mobile "Zombie Walk," which takes place near midnight. I will be AOR DV equipped this next Zombie Walk. (What is a Zombie Walk? It is when HFpackers get on the air /PM in the dead of night to talk to other HFpackers on the low bands. Many are /PM in other states listening for other HFpack Zombies.)

with a magnet that you can attach to the bottom for physical stability on top of your transceiver or other piece of metal equipment in your shack.

Switching between analog and digital is simple. In fact, on receive, it's automatic. Your receiver will operate in its normal analog mode until a digital signal is detected. At that point, the ARD-9000 automatically switches into digital mode to read the "header" information and attempt to decode the incoming signal. On transmit, from the analog mode, you simply give a quick click to the mic button and it switches you into digital. Another quick click brings you back to analog. You may also choose to switch over by pressing the mic button halfway, pausing, then pressing it the rest of the way and continuing to talk. An LED on the front panel tells you which mode you're in (see sidebar "If It's Orange, It Must Be Digital"). Plus, the supplied microphone is actually a speaker-mic, making an external speaker unnecessary for portable use.

On the receive side, the unit includes a button to "force" re-synchronization when the signal has briefly been lost during a transmission and no new header has been sent. Plus, it has built-in AFC (automatic frequency control) to lock in a signal within 125 Hz of your VFO setting (above or below), making the tuning a little less critical.

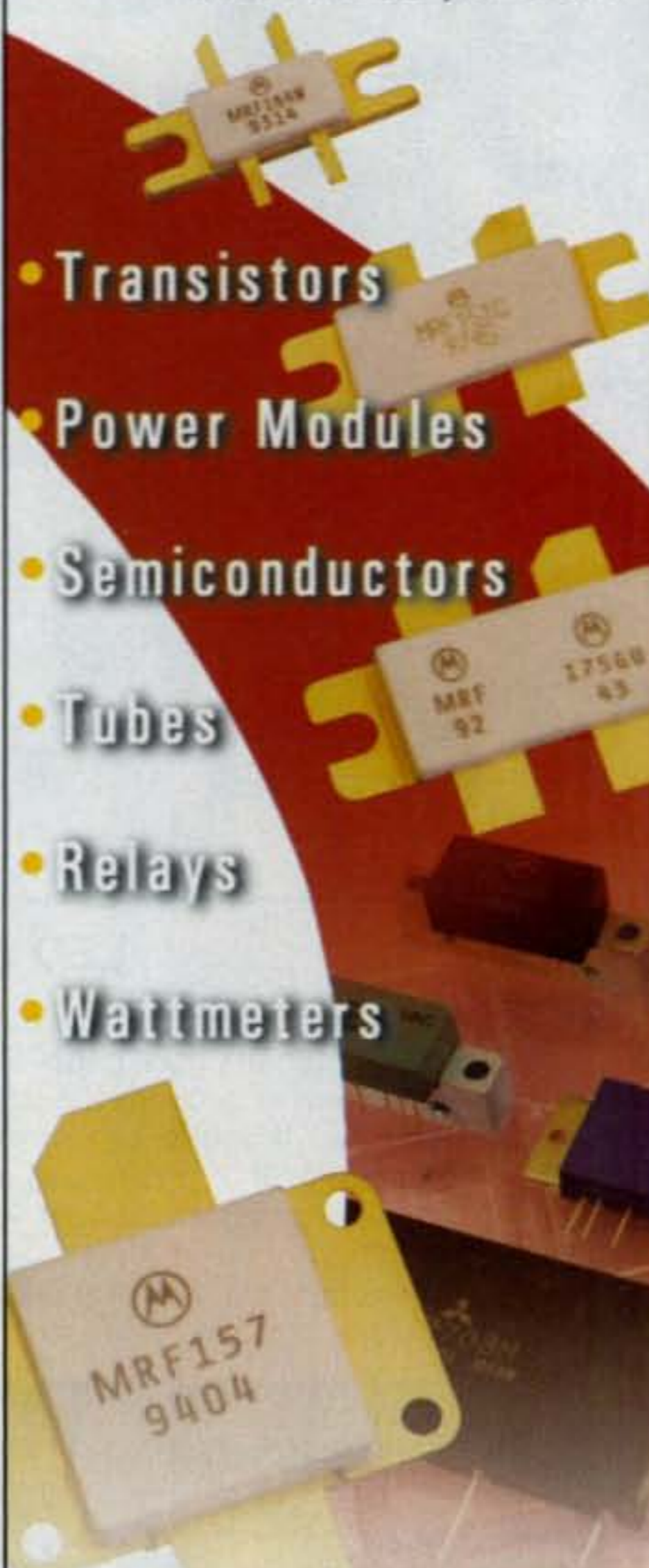
The audio input to the 9000 comes via a cable from the external speaker jack on your radio. There is a speaker jack on the 9000 into which you can then plug a speaker. *One note:* The power source to the ARD-9000 must be turned on for a speaker connected in this manner to work, even if the unit itself is not turned on. More than once, I've flipped on my rig, planning to use another mode, and gotten silence from the speaker until I turn on the power supply for the ARD-9000. Obviously, this is not a problem if your power for the 9000 comes from the same supply that powers your rig, and it's not a "problem-problem" in any event, just a minor annoyance.

### DV and HFpack

The ability to use the ARD-9000 without external power and without an external speaker has brought DV to a growing group of hams who enjoy operating HF while walking, hiking, or biking (generally known as pedestrian mobile or /PM), or while at a location to which they've walked, hiked, or biked (pedestrian portable or /PP). The group is known as HFpack, and more informa-

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Removing two screws on the back of the 9000 allows you to slide out the circuit board. An optional magnet attaches to the bottom of the cabinet to hold the small unit in place on any metal surface.

tion can be found at <http://www.hfpack.com/>. One of the pioneers of DV for HFpackers, Ken Chong, WB6MLC, explained the appeal:

"Out on the trail, the lower noise floor makes AOR DV a pleasure to use. Those of us pedestrian mobile and portable are using the 9000 running on a separate 12-volt battery pack. I am not sure who actually started AOR DV on HFpack, but I think I am the first one to announce it on the HFpack Group."

Ken added that the unique nature of operating from a backpack created some problems you probably wouldn't find at a home station, such as issues with RFI and feedback prevention. (See the sidebar "DV on the Trail" for more

### LED Colors: If It's Orange, It Must Be Digital

You can tell at a glance which mode you're in on the ARD-9000. There are two LEDs on the front panel. The red one on the left, labeled "Over," is used for properly adjusting the audio levels. On transmit, it lights up if you're overmodulating; on receive, it flashes if the audio level of a digital signal is too low, goes on steady if it's too high, and goes off if it's "just right," as Goldilocks might say.

The LED on the right can be three different colors and deliver

five different messages. If it's off, you're in analog mode on receive. When you transmit in analog, it glows red. If you switch to digital mode, it turns green, and it flashes when it's receiving a signal. Finally, it glows orange when you're transmitting in digital mode. The other giveaway that you're transmitting in digital is that when you release the PTT button on the mic, the transmitter stays on for another second or two, while it finishes transmitting whatever you've been saying.



In analog receive mode, the LED marked "STA" is not lit.



In analog transmit, the LED glows red.



In digital mode—the default startup mode—the LED glows green in receive and flashes when a digital signal is being received.



In digital transmit mode, the "STA" LED glows orange.

details). Ken notes that the rigs most commonly used right now for /PM and /PP operating are the Yaesu FT-817 and FT-857D.

### Sunspot Blues

The bottom of the sunspot cycle is a rotten time to try to field-test anything on the HF ham bands. Propagation during the time I was testing the ARD-9000 was just plain awful . . . on days when there was any propagation at all! As a result, I was able to make only a handful of contacts. Those that I did make were strong enough that I couldn't test for any improvement in the unit's ability to copy weak or marginal signals. In a last-ditch effort to make some more contacts before writing this review, I put out a notice on the AOR-DV message board (<http://groups.yahoo.com/group/ARD9800/>) looking for skeds. I got replies from hams in England, Norway, and Italy, but when the time came to try to hook up, there just wasn't any propagation. Such is life at the bottom of the sunspot cycle.

### Lots of Support

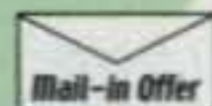
One thing that has not changed from the 9800 to the 9000 is the great group of people and websites out there to help newcomers to the mode. If anything, the number of resources on the internet has grown along with the number of hams using DV on HF. Two of the most knowledgeable and most helpful people are Mel, KØPFX, in St. Louis, and Paul, KQ6EH, in California.

The main gathering point for ARD-9800/9000 users is the Yahoo! Groups site, <<http://groups.yahoo.com/group/ARD9800/>>. You have to join or register to access most of the resources, but it's free. Other web resources include <<http://www.rfelectronics.com>> and <<http://www.hamradio-dv.org>> (mirror sites with the same info); the AOR ARD DV Modem Chat Room at <<http://client0.sigmachat.com/sc.pl?id=118636>>; and the "AOR Online Finder" at <[http://n1su.com/aor\\_online.html](http://n1su.com/aor_online.html)> (N1SU's site also has information on other ham radio digital modes, including WinDRM, HamDReaM, DIGTRX, and Olivia MFSK). In addition, you can hear a recording of a DV QSO between KØPFX in Missouri and LA4LN in Finland at <<http://folk.uio.no/tomvs/la4ln/k0pfx4ln.mp3>>. The QSO is in English. Plus, of course, there is the AOR website at <<http://www.aorusa.com>>.

Again, the ARD-9000 lists for \$339 and may have a slightly lower "street price." Contact your favorite dealer or AOR for more details. ■

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