If you've ever listened to single sideband on HF, you'll know that high-quality audio is NOT one of its best features. But if you hook up the AOR ARD-9800 modem to your HF SSB rig and make a digital voice contact, that all changes—radically.

CQ Reviews:

AOR ARD-9800 Digital Voice Modem

BY RICH MOSESON,* W2VU

It's been nearly two decades since I last had this feeling ... when, for the first time, I heard the BRAAAAP of a packet radio signal and saw my callsign appear on the computer screen. I can't really describe the feeling, except to say that I recognized it immediately when I felt it again, even after a gap of more than 18 years.

It was 1985. I'd had my TNC for several weeks, maybe even a couple of months, and while I had read all the articles about how packet works, I couldn't figure out how to work anyone with it! When I finally made that first contact, I felt like I was part of something new and special in amateur radio—and indeed, packet radio was the beginning of a revolution in our hobby that continues to this day, the integration of computers and digital technology into the fabric of amateur radio. I was privileged to be in a position to experience and report on the next step in that progression—the introduction of a digital voice option on commercial VHF and UHF radios[1]—and now, a digital voice modem that can be connected to virtually any HF amateur transceiver.

Getting on the air with the AOR ARD-9800 Fast Radio Modem was just like my experience two decades ago with getting onto packet—except that more help was more readily available (more on that later)—and very similar to the experience *CQ* Publisher Dick Ross, K2MGA, had with getting onto single sideband some 45 years ago (see "Just Like the Old Days!"). It's not plug-and-play. You have to make careful adjustments to the modem. You have to fiddle with adjustments on your transceiver. You have to try and fail several times in making contacts. But when you finally get it right, and get the right band conditions, you hear that packet-like BRAAAAP and the green light comes on and this FM-quality voice comes out of the speaker of your SSB receiver calling *you,* it's all worthwhile. But I'm getting ahead of myself...

The ARD-9800 Fast Radio Modem from AOR is capable of producing and decoding digital voice, text, and photos. It can be used with virtually any HF SSB transceiver, using the mic in and speaker out connectors. (W2VU photos)

The ARD-9800

AOR introduced the ARD-9800 Fast Radio Modem at the 2003 Dayton Hamvention®. As we approach the 2004 show, a small but growing cadre of hams is experimenting with these devices, learning the ins and outs of digital voice ... and even digital video. The box itself is pretty simple. It contains sockets for a microphone (one is provided, but you can substitute your own with a properly-wired connector), a cable to the mic input on your rig (build your own or buy one from them; I'd recommend the latter for reasons I'll explain later), an audio-in connector from the external speaker jack on your receiver, and a jack for connecting an external speaker of your choosing (there's also an internal speaker). In addition, there are connectors for a serial cable to your computer and video in/out (more on those later). As for controls, there's a power switch, a mic level adjustment, a switch to go between analog and digital, a transmit button that's used for non-voice modes, and a volume control for the speaker. That's it.

Here's how it works for digital voice: On transmit, when you key the mic, a 1 1/2 second data burst is generated (sounding much like the BRAAAP of packet or the tones you hear

*Editor, CQ, c/o CQ magazine
e-mail: <w2vu@cq-amateur-radio.com>

when connecting to the internet via a dial-up modem), then you talk into the microphone and an analog-to-digital (A/D) converter changes the electrical impulses from your voice into a digital datastream, which is then sent on to your rig's mic input. The digitized audio signal is tailored to fit in a typical SSB bandwidth of 3 kHz. In an analog receiver, the transmitted digital signal sounds like noise. The magic, though, is what happens at the receiver of a ham who has another ARD-9800 hooked up.

On receive, the 9800 automatically detects a digital voice signal (that header provides the information it needs to go, "Oh, this is digital, I'll switch over.") and automatically decodes it. You hear the header, you see the "mode" LED that's normally red and the "busy" LED that's normally off both turn green, and then this voice comes booming out of your speaker. It really is magic ... when it works the way it should. It doesn't always work the way it should, but most of the hams who are using 9800s realize that they're experimenters, that they're learning as they operate, and that what they learn will be used in the future to advance the state of the art in HF digital voice in amateur radio.

The Audio

This is what really jumps out and grabs your attention. The audio quality is what you'd expect to hear on FM, not SSB, but there it is—full fidelity, no noise, just the voice of the other station. This is the Holy Grail that ham radio audiophiles have been seeking for the past 50 years, ever since single sideband displaced AM as the predominant HF voice mode—the audio quality of AM with the bandwidth of SSB. It's been an elusive goal for a half-century, but it is now within reach. On a solid link, this audio is just as rich and full-bodied as anything coming out of an AM or FM transmitter, with absolutely no noise. We've come full circle with HF audio, as we see the return of clarity and quality to HF voice communications.

Making Adjustments

We're not used to this anymore, but you have to make adjustments to make this work. You need to start by turning off all the digital signal processing features in your rig (the 9800 does the DSP work for you), such as noise reduction, noise blanking, etc., along with the speech compressor on the transmit side. You'll have two mic gain adjustments to make—one on the 9800 with the front-panel "clicker" so you don't under-drive or over-drive the A/D converter, and then on your rig so that you don't under-drive or over-drive the outgoing RF signal. Like a packet signal, an audio level that's too low or too high won't work. The same applies on receive, and the adjustment here is quite simple. There's an LED marked "Over" on the ARD-9800 which flashes to let you know you're overmodulating on transmit (occasional flashing is OK; if it's on solid, you've got to back down the mic gain on the unit). On receive, if the incoming signal level is too low, the LED flashes; if it's too high, it comes on steady. In between, in the range that's "just right," to quote Goldilocks, the LED goes out. This is what you want (if the LED doesn't come on at all in receive, you've got a problem unit and you should contact your dealer or AOR about a replacement).

Some of the more advanced users are getting brave enough to turn their DSP back on and tailor their transmit audio settings to maximize the tones being transmitted by the 9800. This has to be done in conjunction with another user who can let you know when you've gone too far. At this point, the whole thing is an inexact science. For example, I borrowed an IC-706 from *CQ* Digital Editor Don Rotolo, N2IRZ, and have it set up for pretty reliable digital voice communications. My own IC-746, though, with more bells and whistles, still needs additional adjustments.

The ARD-9800 Fast Radio Modem hooked up to W2VU's borrowed (from N2IRZ) IC-706, along with the small power supply below for the 9800. It's essential to use a regulated, non-switching supply with the 9800.

Limitations

There are two categories of limitations here—limitations of the mode and limitations of the unit. Let's look at mode limitations first. This is digital, and if you're familiar with any other form of digital communications, from packet to your cell phone, then you know that there is no such thing as a noisy signal. It's either there or it's not. I commented to several folks I contacted that the traditional RS signal report is useless in digital voice. It's either 59 or not there! Actually, there is a curious kind of "noise" that does creep in when a signal is close to the noise level or there's QRM from adjacent analog stations—as the D/A converter tries to make sense of the noise, it throws out random sounds along with the desired voice signal. If it's really bad, the desired signal gets lost in this "noise" just as it would in analog. In addition, if the signal you want is not sufficiently above the noise level, then the unit will not fully decode the header and won't switch into digital at all. You can "force" it into digital by pressing the "transmit" button while receiving in analog, but you'll get just the beeps and bloops described above because there's not enough signal there for the unit to properly decode.

This sensitivity to the signal-to-noise ratio is perhaps the greatest limitation of the unit itself that I observed. As soon as things get noisy, either from adjacent stations or an overall increased noise level, it starts to lose the ability to decode the incoming signals. And with the variations in noise that are a constant on HF, this is a tricky area. There's a range within which it works beautifully, but if the band starts to change and the signal drops below a certain level in relation to the noise, then it's no-go. I had several instances when I was able communicate in analog with a station whose signals were weak and noisy, but not in digital. My rough estimate based on watching the S-meter was that the digital signal has to be at least two S-units above the noise in order to be decoded properly.

This was corroborated independently by at least one member of the ARD9800 Group on Yahoo.com (more about this group later). Butch Mason, W6KAG, reported that in tests

Just Like The Old Days!
Digital Voice and the Dawn of SSB

What in the world is a piece about the early days of SSB doing here in the midst of an article about digital voice transmission? It's the outgrowth of a conversation between W2VU and K2MGA regarding the experiences of some early users of the new AOR digital voice adapter. Being somewhat older and greyer of beard than W2VU, I was likening what Rich and others are experiencing with the new AOR Digital Voice Adapter to our experiences with SSB back in the 1950s, especially when we first began to tinker with it on 6 meters, a bastion of AM.

My first SSB encounters were about 1958. By then, SSB had been pretty well established as a viable means of HF voice communications, although it was still overshadowed by the dominant AM. A great deal of commercial equipment was available, and although much of it was costly, it wasn't so expensive that it was beyond the reach of a growing number of hams. Led by some milestone homebrew projects such as the W2EWL "Cheap and Easy SSB" exciter in 1956 which grew from the "SSB Jr." published in *GE Ham News* in 1950, these homebrew phasing-type exciters were capable of putting out about 10 or 20 watts on either 75 or 20 meters. From them grew early breakthrough products such as the Central Electronics 10A, 10B (75/20m, plug-in coils) and 20A (all band, bandswitching). But they all tended to be a bit finicky and drifty, and if you built your own phasing exciter, much of your shack time was spent nulling the carrier and adjusting the phasing to maximize the unwanted sideband suppression. But that was part of the fun!

Getting on 6-meter SSB involved mixing the 20-meter output of a 10A/B against a 36 Mc (no MHz then!) crystal-controlled signal, giving USB output on 6. Pretty early on, a product was introduced by a little company called P&H Electronics which was a complete package that went between the 10A/B and the coax relay and put out about 10 watts on 6. All the setup lacked was a VFO. Ahh, but that leads us back in time to a different part of the tale.

The earliest ham SSB exciters were often filter types using homebrew multi-pole lattice filters built from WW II surplus FT-243 crystals in the 455 kc range that were available by the bucketful on Radio Row (known today as Ground Zero) in New York City for almost no money at all. Sifting through hundreds of crystals would yield matched frequency pairs which would collectively yield the desired filter bandwidth, when properly applied. For the phasing enthusiasts, a milestone was the introduction of the B&W 350 plug-in audio phase shift network that took much of the heartache out of building and adjusting your own.

Regardless of how the SSB signal was generated, the 455 kc USB signal was mixed up to 9 Mc. Using a converted war-surplus BC-458 transmitter ($7.00 brand new from G&G Radio) as a VFO, the 4.0 to 5.3 Mc output was either added to or subtracted from the 9 Mc SSB signal. That produced a USB signal on 20 meters or an LSB signal on 75 meters. (That's the origin of the world-wide convention: LSB below 20 meters; USB on 20 meters and up. How many of you knew that?)

What About Digital Voice?

How does any of this relate to digital voice? Think about it. Our early SSB efforts were anything but perfect and reliable. We were able to communicate on the new mode, most of the time. And a good part of our shack time was spent trying to get the doggone lashup to work properly. And we suffered the catcalls of the diehard AMers about our "Donald Duck" signals. But we were doing what hams have always done: We were tinkering and learning and moving the state of the art forward. And that's what the early adopters of digital voice on HF are doing as we speak.

To those critics who say that it's not as good as it ought to be, that it's not perfect, that they're going to wait until it's perfected before they try it out, I say the following:

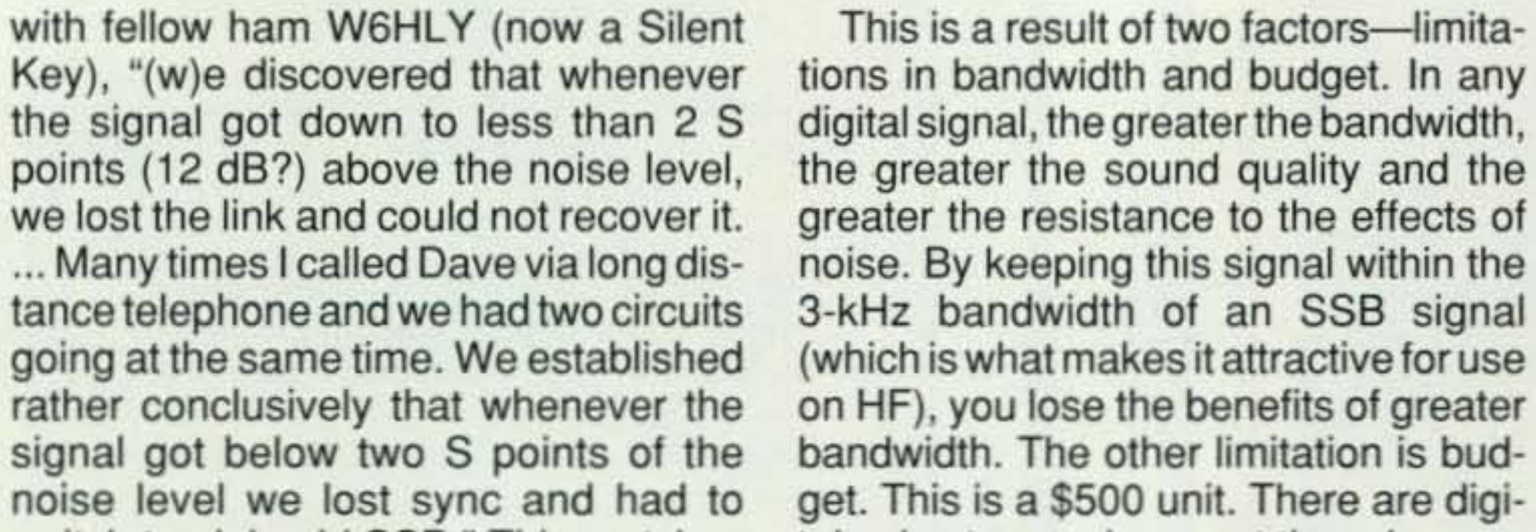
"Hooray for the folks who have the courage to reach beyond the conventional. They're the ones who have always made ham radio work, and they always will be." And as a significant side note, our appreciation of the commitment and the courage of AOR in developing this product and bringing it to market should not be taken lightly.

—Dick Ross, K2MGA, Publisher, CQ

with fellow ham W6HLY (now a Silent Key), "(w)e discovered that whenever the signal got down to less than 2 S points (12 dB?) above the noise level, we lost the link and could not recover it. ... Many times I called Dave via long distance telephone and we had two circuits going at the same time. We established rather conclusively that whenever the signal got below two S points of the noise level we lost sync and had to switch to plain old SSB." This matches my experience exactly.

This is a result of two factors—limitations in bandwidth and budget. In any digital signal, the greater the bandwidth, the greater the sound quality and the greater the resistance to the effects of noise. By keeping this signal within the 3-kHz bandwidth of an SSB signal (which is what makes it attractive for use on HF), you lose the benefits of greater bandwidth. The other limitation is budget. This is a $500 unit. There are digital voice transceivers out there in commercial and military use that aren't as sensitive to noise problems, but their cost is generally several thousand dollars per unit, well outside the budgets of most hams. What AOR has done here is to find some middle ground—a system that works very well when conditions are right and that fits within many ham budgets, and that gives those hams who are adventurous enough to try it and put up with the frustrations that go along with something experimental the means with which to make those experiments, to discover its strengths and limitations, and to build a body of knowledge that will help the next generation of digital voice equipment perform even better. Butch, W6KAG, suggests that the digital voice signal could be made more "robust" if the bandwidth was broadened to that of two, or even three or four, SSB signals. This would certainly help, of course, but would also defeat one of the primary goals here, that of providing digital voice within the bandwidth of a single SSB signal.

Butch also notes that he and W6HLY "were two of the first six hams on SSB and were students at the US Navy Postgraduate School at the time. ... Our experience during the SSB campaign



There are very few controls on the ARD-9800. On the front panel there's a connector for the included microphone, a volume control for the built-in speaker, and a mic gain control, plus a switch to toggle between analog and digital transmit modes (receive switching is automatic). There's also a "transmit" switch, which is active only for digital video.

Is it Voice or Is it Data?

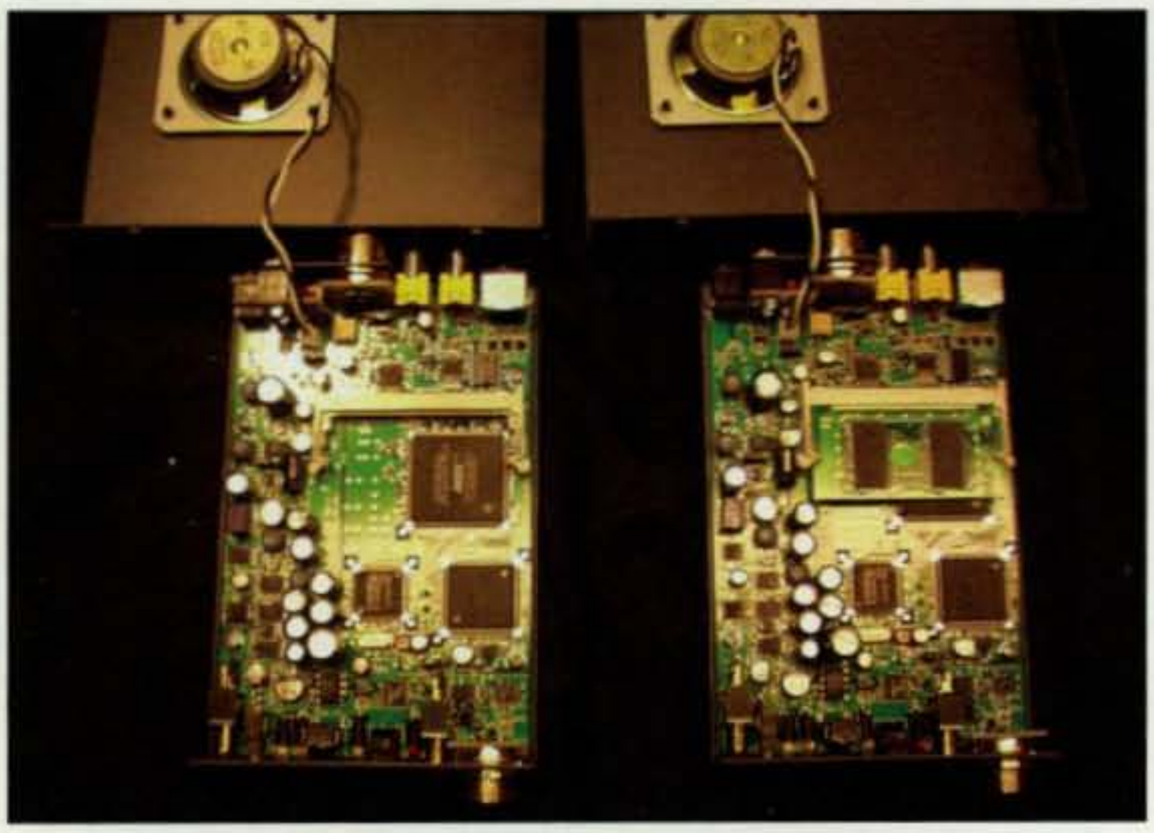
One item of ongoing discussion on the ARD9800 e-mail reflector is whether the output of your transmitter when using the device in digital mode is voice or data. This is an important discussion, because the bands and frequencies on which you may operate will depend on the answer. The majority feels that voice is voice, regardless of the method of transmission, and that digital voice may be used only on bands and subbands where voice is permitted. Same for the digital slow-scan TV images that the 9800 can transmit and receive. Image is image, and the method of transmission is irrelevant.

The data folks say method of transmission is everything, that what goes out on the air is all that should matter to the FCC, and that what goes out on the air is a digital bitstream, whether it's carrying a signal that will be translated at the receiving end into text on a screen, voice through a speaker, or an image on a TV monitor. Under this theory, there are several operators conducting digital voice QSOs on 30 meters, a band on which only CW and data are permitted. They say they're legal because they're only transmitting data. How that data is processed is irrelevant because that's not done on the air. The FCC has not weighed in with an opinion.

Both sides here have valid points, and as digital voice and image transmission becomes more widely used, it is an issue with which the FCC will need to deal in an intelligent way. Here at *CQ*, for several years we have been quietly promoting the concept of replacing mode-limited subbands with bandwidth-limited subbands. This way, anything that fits within a designated narrow bandwidth would be permitted in what are now the CW/data subbands; while the current voice/data subbands would allow wider signals, equivalent to the bandwidths of today's SSB or AM voice signals; while wider signals (FM, for example, or high-speed digital signals) would continue to be limited to frequencies above 29 MHz. This would encourage further experimentation in digital compression, etc. There is no reason, for example, to limit digital transmissions on HF to 300 baud if compression techniques permit you to pack a 2400- or 9600-baud signal into the same bandwidth. Recently, Bonnie Crystal, KQ6XA, proposed a comprehensive bandwidth-based approach to subband allocations. She suggests four subband categories, with maximum bandwidths of 500 Hz (similar to current CW), 3 kHz (similar to current SSB), 10 kHz (similar to current AM/narrow FM), and 25 kHz (similar to current wide FM and higher-speed digital signals). We haven't had a chance to examine it closely and are not endorsing it in anything more than its concept, but it's a good starting point for a discussion that needs to begin now, so the rules can be changed to accommodate new transmission modes before the rules themselves become obstacles to progress. For more on Crystal's bandplan proposal, see <http://www.qsl.net/kq6xa/freqplan/> on the web. —*W2VU*

(which took 10 years) indicated that any mode that could not hold its own and win any challenge from existing modes was doomed to failure on the HF bands. We had a clear 9-dB advantage with SSB and finally won the battle..." He's probably right, but as he notes, it was a battle that took ten years to win, and as K2MGA points out in his sidebar, the early years of SSB were anything but easy for those hams experimenting with the mode and trying to bring it into general use.

Another problem noted by several members of the Yahoo!Groups list is susceptibility to RF interference from the transmitter itself. I have not had any of these problems myself, but was aware of them before I started, and I made sure everything was properly grounded and I put ferrite cores on every wire I could. In addition, my antenna is out in my back yard, separated from my shack by a horizontal distance of at least 30–40 feet. People operating underneath rooftop antennas seemed to have more severe problems. There are suggestions on the Yahoo!Groups site, the ARD9800 Liaison site, and the AOR web page for dealing with this RFI problem. Regardless of whether the 9800 should be hardier in terms of RFI susceptibility, if you have RF in your shack, there are any number of good reasons why you should try to locate the source/cause and eliminate it.



Interior view of the ARD-9800. Unit on the right has the add-on memory board required for digital image transmission and reception.

Some people have also had power-supply related problems, mostly from not following the manufacturer's advice. AOR recommends *not* using a switching-type power supply and says it's essential that you *do* use a regulated supply.

One thing that will almost certainly have to wait for a future generation—immunity to BPL (Broadband over Power Lines) interference. We had hoped that digital voice might be a technical solution to the interference problem posed by the advent of BPL, and even considered driving to a BPL test area and trying to carry on a digital voice QSO in areas where an analog QSO would be impossible. Unfortunately, BPL signals appear primarily as noise, and the sensitivity of this unit to increases in the noise level doesn't make that test worthwhile. However, the potential is certainly there, particularly since digital noise is different from analog noise if you're a digital receiver, and in many cases that receiver should be able to separate out the desired signals from the others. Not yet, though. At least not with this technology in this price range. We'll see what inventions are born of necessity in the future.

Getting Help

Trying to get the ARD-9800 set up and operating on your own is a sure-fire recipe for frustration. The technology is still developing and the user base on the ham bands is just too small at this point to be able to plug it in, adjust everything so it "looks right" at your end, call "CQ digital voice," and expect to get an answer. You will need help, especially in the early going (and just about everyone is still at that stage, so everyone is learning together and sharing information).

One difference between the early days of packet and the early days of digital voice is the internet. Eighteen years ago, when I was trying to figure out how to work packet as opposed to how packet worked, I needed to make lots of long-distance phone calls, starting with the few people I knew who were involved with the mode and moving on to others who "knew the ropes" and could explain it all to me so I could explain it to others.[2] Today, the internet makes the process much easier,

and the ARD-9800 operators you'll find online are friendly and helpful (they want more people to contact!).

There are several sources of information on the internet, starting, of course, with AOR's own webpage for the unit, <http://www.aorusa.com/ard9800.html>. A good jumping-off point for finding other users is the "ARD-9800 Liaison Web Site" (not affiliated with AOR) at <http://www.rfelectronics.com>. This site includes a listing of active users, organized by location, with e-mail addresses, operating tips and info on the latest firmware upgrade, plus links to sites with all the technical information you could ever want.

Next is the ARD9800 group on Yahoo! at <http://groups.yahoo.com/group/ARD9800>. In order to access useful information here, you will need to set up a free Yahoo! account and join the group (it's easy; just click "Join This Group," then click "Sign Up Now" and follow the prompts). You can use your existing e-mail address or a new one, which will be the ID you set up on Yahoo! I chose to use the new address, even though it involves checking one more e-mail account every day, so I'd have a separate spot for all of my ARD-9800-related messages.

Part of the Yahoo! ARD9800 group is an e-mail reflector. You can either view the messages when you log into the group area, or see the messages in your own e-mail in-box. This is an extremely valuable way to keep in touch with other users and to set up skeds. The group site also includes a chat area (which I've never seen active—after all, we have the world's first and biggest chat room, called ham radio!), links and photos, and a very valuable tool called a database, which in this case is a table on which members can post when they're monitoring and on what frequency; just remember to change it when you turn off the radio! Using the information on this listing, I was able to make two random (non-scheduled) QSOs on one weekend afternoon.

When you're first starting out, though, plan on scheduled QSOs, and if your phone plan gives you free long distance, plan on some on-the-phone time as well. I used the operator listing on the RF Electronics site to discover another ARD-9800 user, John Marrin, KB2KH, just a few miles from where I live. John and I spent a long time on the phone and on the air trying to get things working properly, and he even loaned me a spare unit (his brother's) in order to compare performance of that one with the evaluation unit I'd received from

The rear panel of the 9800 has connectors for a computer serial cable (for text modes), video in and out (for digital video), the output cable to the transceiver mic connector, audio in and out, and DC power.

AOR. Another John, John Deegan, K9XT, in Indianapolis, also spent a long time on the phone and on the air with me as we tested things out over a longer-distance path. Their help has been invaluable. Thank you, John and John! I'm sure you'll find other operators to be equally helpful.

Operating Frequencies

There are no "established" digital voice frequencies as yet, although most of the activity is toward the top end of the SSB portions of the HF bands. Some of the more popular frequencies appear to be 14.320, 14.260, 18.163, 7.265, and 3.960 MHz, all plus or minus other band activity. Again, there is nothing formal and most of the time people will use the group site or e-mail to locate a vacant frequency and try to hook up. As this mode becomes more popular, though, some sort of "gentlemen's agreement" will have to be reached regarding commonly-used frequencies, as has been done for text-based digital modes (RTTY, PSK, packet, etc.) and slow-scan TV. Analog voice and digital voice are not particularly compatible, mostly because the analog station may not even realize there's a QSO in progress on the frequency you're using (he'll hear only noise) and may unknowingly transmit right on top of you and unintentionally interfere with you (a strong analog signal will prompt the "beeps and boops" discussed earlier, or if strong enough, cut off your link altogether). It's probably a good idea to start out in analog, announcing that you're going to digital voice, and to periodically return to analog to note that you are engaged in a digital voice QSO on the frequency.

Video and Text Modes

The ARD-9800 may also be connected to your personal computer to operate in text modes and, with added memory, to send and receive digital image files as well. I didn't have the opportunity to test these modes, and apparently, neither have any of the other people in the ARD9800 group. We'll have to defer any evaluation of those modes to a future article.

Conclusion

So, should you run out and spend $500 for an ARD-9800 to join the digital voice revolution? That all depends on what you're looking for. If you're looking for a plug-it-in-and-turn-it-on device with the dependability of a mature mode such as SSB or FM, then no, this probably will not be a good investment for you. You'll be too frustrated. If you're a real techie, working with cell-phone quality digital voice and the latest in DV codecs and algorithms, then no, you'll probably be disappointed in the lack of sophistication. But if you're a ham who wants to be in on the ground floor of something completely new and different—if you want to be able to talk about the early days of digital voice the way I talk about the early days of packet and K2MGA talks about the early days of SSB—if you want to help establish a beachhead for a new mode in ham radio, then yes, this will probably be a good investment for you, and you will get more than your money's worth in disappointment and elation, frustration and fun. And you'll be helping to set the course for our hobby's future.

Notes

1. See "*CQ* Reviews: Alinco DJ-596T Handheld With Digital Voice Option," *CQ*, June 2002.
2. See "Packet Radio—How to Work It (*Not* How it Works)," *CQ*, June/July, 1986.

To learn more...

Contact your favorite dealer or AOR USA, Inc., 20655 S. Western Ave., Suite 112, Torrance, CA 90501; phone: 310-787-8615; fax: 310-787-8619; e-mail: <info@aorusa.com>; on the web: <http://www.aorusa.com>.