BY DON ROTOLO,* N2IRZ

Digital Amateur Television (D-ATV)

Digital communications are as old as amateur radio (Morse code *is* digital, after all) and Amateur Television (ATV) is almost as old as image communications, with radio amateurs at the forefront even before the first commercial TV broadcast. Today, like just about everything else, the world of video and TV is moving rapidly towards more digital technology. These days you can't avoid hearing about the latest satellite receiver or high-definition television (HDTV) setup.

This month we'll have a look at how ATV is going digital, the building blocks and what they do, and some ideas for those wanting to get involved. The move to digital ATV, or D-ATV, began a few years ago when some talented hams in Europe, capitalizing on inexpensive satellite receivers, built a digital video transmitting system. Building a digital ATV transmitter from scratch isn't for the faint of heart, and detailed construction information is far beyond the scope of this column. My intent is to tell you about how this technology works and, just maybe, get you interested enough to pursue it further.

ATV

Today, virtually all Amateur Television (ATV) transmissions, especially here in the U.S., are analog, using either Amplitude Modulation (AM) or Frequency Modulation (FM). Regular broadcast TV uses a form of AM known as Vestigial Sideband, or VSB, which keeps only a small part of one sideband (by convention, the lower) and a complete upper sideband. This allows the receiver to demodulate the signal more like AM than Single Sideband (SSB), considerably simplifying receiver design. However, TV broadcasters are under FCC pressure to convert to digital transmissions before the end of this decade.

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Hams were there when Fast Scan TV became available, and so it is with digital TV as well. Here in the United States, few have not heard of High Definition Television, or HDTV. Some stations are already broadcasting HDTV signals. Its increased resolution—about that of a computer monitor, or triple what's available in analog broadcasts—combined with reduced noise and better color rendition provide for a much sharper and clearer picture. In fact, I read an article about some actors who were complaining about HDTV, as it shows all their flaws, such as caked-on makeup or skin blemishes, with excellent clarity. Perhaps they're afraid we'll learn they are just human like the rest of us.

Of course, when there's a transmitter involved, some hams will figure out a way to get involved. So it is with Digital ATV. At the close of the last century, I was privileged to witness a demonstration of a D-ATV setup designed and implemented by some friends in Germany. The hardware was ugly, the victim of many hand-soldered board revisions, but the picture was better than the TV we were using could display. While that system eventually was demonstrated in public, if you wanted one you'd have to build it yourself, since there were no kits or instructions available. More recently, two Dutch hams, Henk, PE1JOK, and Werner, PE1OBW, created a website to explain the system. As explained in the sidebar accompanying this article, at least one club has built a few board sets for sale, and some of the other links seem promising.

DVB Choices

A few years ago, when D-ATV was being developed, there were three major standards for Digital

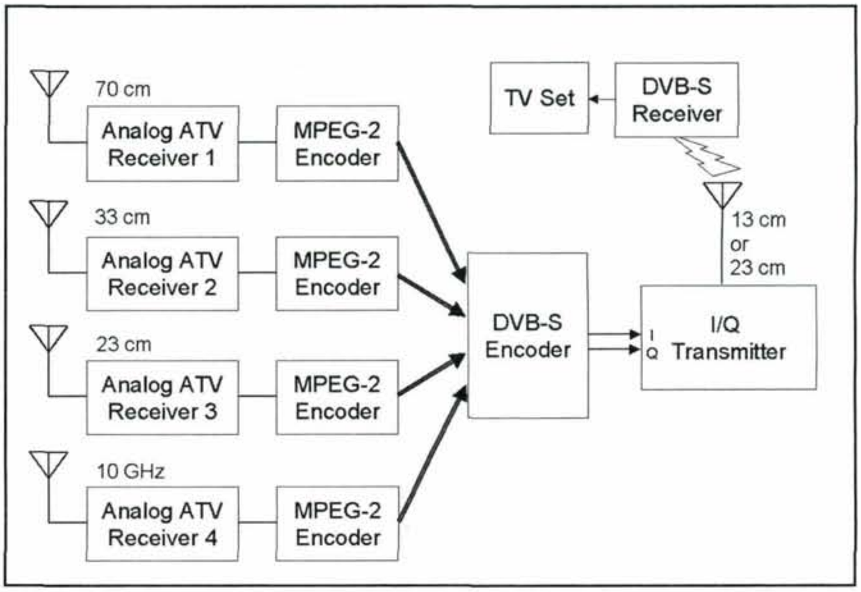

Fig. 1– A typical Digital ATV repeater site. The users uplink their video to the repeater as a regular analog signal, and it is repeated over a wide area as a digital signal. Each uplinked signal is carried on a different digital "channel" on the downlink, allowing many hams to use the repeater simultaneously.

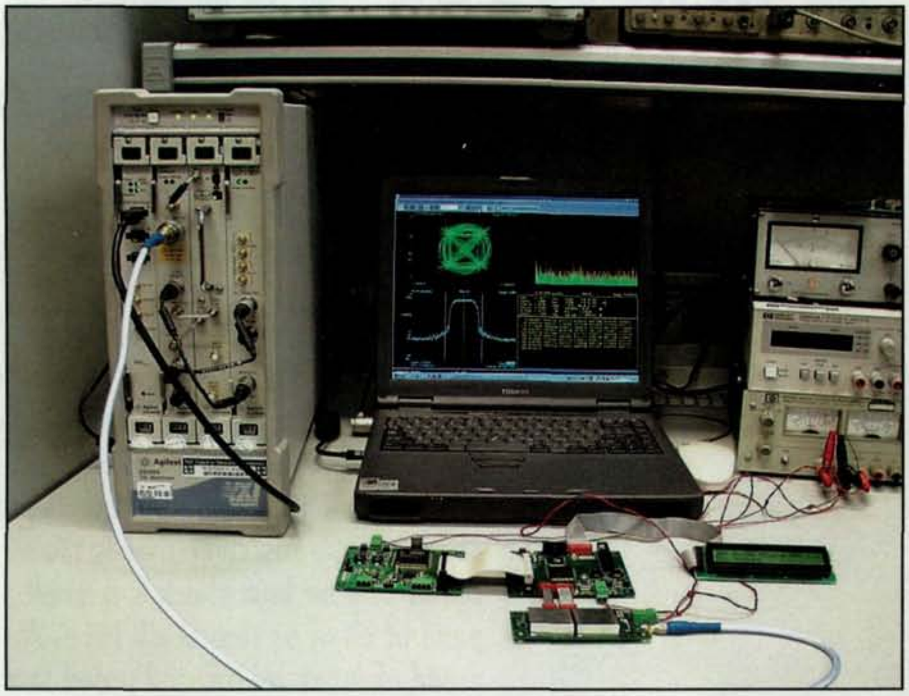

Photo A– The Dutch D-ATV boards under test. In front of the laptop computer are (from left to right) the MPEG-2 encoder, the DVB-S baseband encoder, and (toward the front) the transmitter. Note the LCD display, which is used by the DVB-S encoder to display status. (Photo courtesy of Henk, PE1JOK)

Video Broadcasting (DVB): DVB-C (Cable), DVB-T (Terrestrial), and DVB-S (Satellite). The DVB for Cable expects a very low noise environment, such as would be found on a cable network, and is poorly suited for over-the-air use. The DVB-T standard was created specifically for local terrestrial broadcast, with very strong resistance to multipath distortion, but it requires an ultra-linear signal path, including amplifiers, making the design of a transmitter non-trivial. The DVB-S standard works well with weak signals and places no heavy requirements on the amplifier linearity.

It appeared that the DVB-S standard was the best choice for an ATV system. A major advantage of DVB-S was the wide availability of set-top receivers, operating in the 950–2150 MHz range, that could be had cheap or for free. Testing showed that the weaker multipath performance wasn't really a problem. Thus, with the receivers being freely available, all that was left was the transmitter design. (Note that more recently introduced satellite TV systems prevalent in the United States, such as DISH Network and DIRECTV, use newer Digital Broadcast Satellite [DBS] standards that are incompatible.)

A Grounded Satellite

The transmitter needed to replicate the signal coming from a satellite. After all, that's what the receiver thought it was hearing. Most of the signal processing for a satellite broadcast is done on the ground, with the satellite acting as a repeater. A similar approach to D-ATV was implemented.

Because of the relatively high complexity (and cost) of the transmitter, the D-ATV implementation that made the most sense was to allow users to uplink into the D-ATV repeated site with normal Analog video, and have the repeater transmit in Digital, as shown in fig. 1. The DVB-S system allows for multiple downlink channels on the same signal, so multiple uplinks can be multiplexed onto different digital downlink "channels" at the same time.

Most of the design for a D-ATV system came from off-the-shelf hardware. Certainly, most amateurs already equipped for ATV have what they need to feed video to the repeater site, and set-top boxes, possibly equipped with a frequency converter, are readily available to receive digital signals from the repeater. The receivers for the repeater are commonly available as well, either commercially or built from an old VCR or TV. All that remained was to put a satellite—or at least what looked like one—at the repeater site.

Satellite hardware normally isn't available off the shelf, as you can imagine. Of course, this wasn't really a satellite; not only did it not have to withstand the rigors of space flight, it could be visited and repaired as necessary. On the other hand, quite a bit of signal processing was required, and the requirements were not trivial. Let's have a brief look at the hardware used for a D-ATV repeater.

Although there are at least two implementations of a D-ATV repeater that I am aware of (see sidebar), they both follow the same general architecture. The subject is far too complex to discuss in detail, but this general overview should provide enough information for you to understand what's involved.

Before we start, one point of clarification: These systems, designed and deployed in Europe, use encoders for the PAL standard, which is incompatible with the NTSC standard used in the United States. Although the Dutch website lists an NTSC version as optionally available, I've been unable to find information about one actually being built. Nevertheless, there are only minor technical differences between an NTSC and a PAL implementation.

The D-ATV System

The first piece in the D-ATV chain is the MPEG encoder. MPEG stands for Motion Picture Experts Group, a consortium which developed a number of standards for the (digital) compression of motion pictures and sound. Much like the JPEG standard for still images, MPEG compression can significantly reduce the amount of data required to represent a moving image. There are a few MPEG standards, including ones for audio. For D-ATV, MPEG-2 encoding was chosen.

Essentially, the MPEG-2 encoder is a specialized, real-time digital signal processor (DSP) for video compression. The German implementation uses a Fujitsu MB86390 MPEG-2 encoder along with considerable support circuitry, including a micro-controller and memory. The Dutch implementation doesn't specify the chip set, and you can't tell what it is from the photo, but it looks quite different from the Fujitsu evaluation board. One module is used for each video input stream. The output of this module is a wide, fast digital data stream, to handle the relatively high data rate.

The second piece of the chain is the DVB-S baseband encoder. This piece takes the MPEG-2 compressed video and audio data and converts it to a DVB-S signal at baseband, *feeding it to the* Quadrature (I and Q) transmitter. The German implementation can handle up to four MPEG-2 input data streams, putting each one on a different digital channel. Although we're discussing Digital ATV, the output of this module is analog. After all, the real world, where transmitters live, is still analog.

The last module in the chain is the transmitter. Aside from the wide bandwidth, this is an ordinary I/Q transmitter. In fact, the design of the German version is based on a transmitter designed for high-speed packet. The output power is only a watt or two at 1.2 GHz, and even less at 2.4 GHz, but a decent linear power amplifier is not a problem. With some of the coding gain of DVB-S (about +10 dB) one can expect to use much less power than an FM ATV repeater for the same performance. However, path loss at 23 cm and 13 cm is greater than at 70 cm, and so it might end up an even exchange.

Receivers

The best part of the D-ATV system is that off-the-shelf commercial satellite receivers are used to convert the digital signal to something you can view on your television. Other than a decent antenna, no special equipment is needed to receive D-ATV. This makes for a very popular system. Users transmit their analog video into the digital system on regular ATV frequencies, and then receive their video (and the video of others) on a satellite receiver hooked up to their TV.

The receivers are commonly available in Europe, where much of the D-ATV activity takes place, but suppliers for DVB-S equipment in North America are few. While it's not impossible to find equipment—just search the web for DVB-S receiver—most of the suppliers are in Germany. The few that appear to be in North America seem suspicious to me. Two of them (www.cyberstore.com and www.fta-satellite.com) are especially suspicious, with absolutely no information about the company or location on the site. Places like that make me very nervous, and I do not recommend buying anything from them. Nonetheless, they do offer a range of equipment for DVB-S, so it might be interesting to see what equipment is out there. (If anyone knows anything about any of these North American suppliers, positive or negative, please let me know.)

For example, a PCI card for your computer can be had for under $100, and a stand-alone receiver for under $200. Perhaps one of the dealers in Germany might be willing to ship overseas; just be sure the equipment can output NTSC video. A quick search of eBay (www.ebay.com) found over 100 items, most of them receivers, for under $50. You just need to be sure of what you're buying: a DVB-S receiver (often called a Free To Air satellite receiver) with NTSC video output.

Therefore, the real expense of a Digital ATV system is the digital transmitter system, which I estimate might be built for about $1200. This is a perfect project for an active ATV group, which can convert its existing ATV repeater into a digital system with multi-channel capabilities. Both of the websites listed in the sidebar have general information about the design of their systems, but I'm confident that they would be happy to share their detailed knowledge with you, if you're serious about building a D-ATV system.

Digital Amateur Television is actually being used in Europe, and it won't be long before it makes its way to North America. This kind of project is perfect for an active ATV group to implement, since it requires a bit of money and expertise. The end users will rejoice, since their investment for the upgrade is minimal, and the ATV repeater's capacity will be vastly improved.

Summary

This month we took a look at yet another new digital mode for amateurs to use with their wonderful playground in the aether. The past few columns have looked at digital operating modes, so next time I thought we'd have a look at some hardware: Local Area Networks. Useful for sharing files at home or managing a serious contest effort, this how-to column will explain the nuts and bolts of assembling a computer network. Until then . . . 73, Don N2IRZ

Digital ATV Resources

Dutch D-ATV site, <http://www.xs4all.nl/~pe1jok/>: This English-language site discusses the Dutch D-ATV project, showing test results and performance specifications, along with an in-depth discussion of the rationale for many of the choices made. An excellent starting point.

German AGAF ATV site, <http://www.agaf.de>: This site, mostly in German but with some English translations, offers the most detailed resources and information on D-ATV, including firmware downloads and PC-board patterns. They even note that their first run of 80 D-ATV board sets has just been delivered to those who ordered them. They also offer memberships and subscriptions to their ATV magazine at <http://www.darc.de/distrikte/g/t-agaf/formular.html>, which is a curious mix of German and English. This would be the place to start if you're serious. I would imagine that e-mail contact in English would be okay.

German D-ATV site, <http://www.d-atv.de>: This German-only site is a good source for D-ATV info and photos, albeit a bit old. If German isn't one of your languages, see the next site. You could also try one of the free translation sites available on the web, but technical terms may not be in their dictionaries, and don't expect a good "translation" of grammar and syntax.

SR-systems, <http://www.sr-systems.de/en/index.htm>: Primarily a small consulting company, it lists the D-ATV modules and hints that they are available for sale. Contact Stefan Reimann, DG8FAC, for more info.

Of course, a Google search of Digital Amateur Television will bring up a few dozen additional sites.