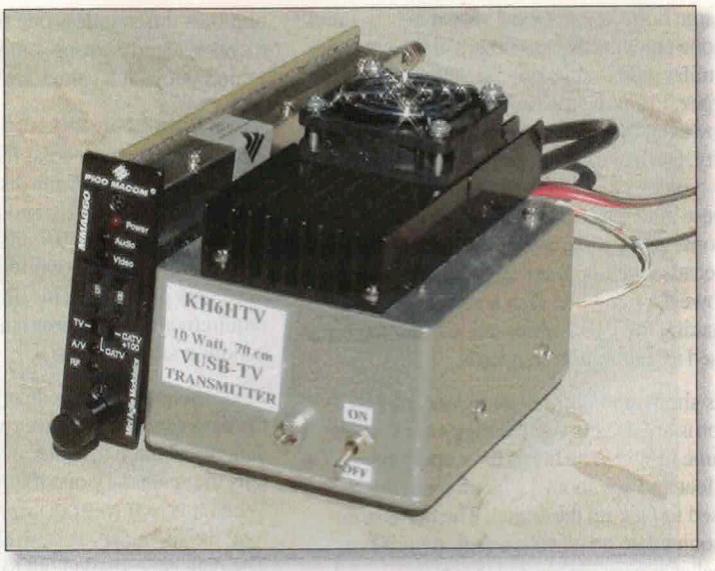
Modern ATV System Design

Amateur television has come a long way — here's an update.



Jim Andrews, KH6HTV

Early ATV had a lot in common with early amateur voice communication — double sideband, full carrier was the mode in use. All of the reasons that made most hams migrate to single sideband, suppressed carrier apply to ATV. In fact, the improvement in efficiency is even more significant because TV receivers mainly receive just one sideband; the other doesn't contribute much to the process.

Why Not Go to SSB?

For hams transmitting video, particularly on the popular 70 centimeter band, a case can be made that we should migrate from DSB AM to the narrower bandwidth, vestigial upper side band (VUSB) modulation to conserve spectrum.

For the transmission of commercial analog, US standard NTSC (National Television Systems Committee), television signals, either via broadcast or cable, the FCC many years ago mandated that VUSB be used within a 6 MHz channel bandwidth. Newer digital TV transmissions must also stay within the same 6 MHz channel bandwidth. Figure 1 shows a typical over the air, commercial broadcast spectrum with 6 MHz TV channels.

The bandwidth of an analog, standard definition (480i), NTSC video signal is 4.2 MHz. For VUSB, the video carrier and the entire 4.2 MHz upper sideband are transmitted along with 750 kHz of the lower sideband. The video carrier is located 1.25 MHz above the lower band edge. The FM audio subcarrier, located 4.5 MHz above the video carrier, is also present in the 6 MHz channel.

Hardware Choices

Current practice among many TV hams is to use low cost, conventional AM-TV transmitters on the 70 centimeter band. This is no doubt because the only 70 centimeter ham TV transmitters that have been offered commercially for sale are AM-TV. Figure 2 shows the typical ham AM-TV spectrum. Compare this to the broadcast spectrum in Figure 1. With this very wide spectrum, it is impossible for other hams to operate on other 70 centimeter TV channels without co-channel interference. The wide spectrum also causes potential interference to hams operating other modes.

Single Channel Sideband Filters

The solution that has been used for many years by spectrum conscious TV hams has been to add a 6 MHz VUSB, band-pass channel filter to the output of their AM-TV transmitters. These filters are available from DCI, Digital Communications (**www.dci.ca**). They have several disadvantages, most significantly that operation is restricted to a single channel, but they also tend to be expensive, large, heavy and have an insertion loss of 1 to 2 dB. Size and weight are definite issues for ARES® or other backpack portable field operations.

Synthesized Single Channel Modulators

Fortunately, there is a modern solution to generating a VUSB ATV signal. We can capitalize on the equipment used by the cable TV (CATV) industry. In the head ends of CATV distribution systems are large banks of VUSB modulators designed to insert video signals onto the cable as RF on individual cable channels. Because every channel is used in a cable system, the RF spectrum coming out of each modulator must be ultra-pure and not extend beyond the allocated 6 MHz channel. This is true whether the modulator is creating an analog channel or a digital channel.

These modulators are synthesized and capable of putting out a TV signal on any CATV channel from 2 to 135. Cable Channels 57 through 61 happen to be in the amateur 70 centimeter band. For example, cable Channel 57 extends from 420 to 426 MHz. The output from these modulators is typically of the order of 0 dBm (1 mW). To create a fully synthesized amateur VUSB-TV transmitter requires just the CATV modulator followed by an ultra-linear power amplifier.

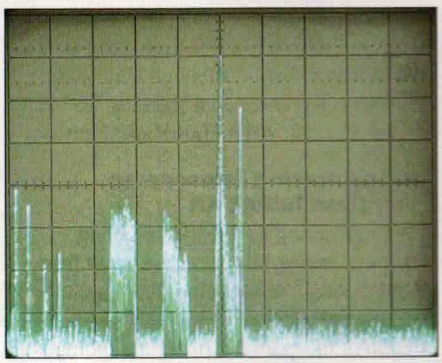


Figure 1 — Typical over the air broadcast spectrum from 150 MHz to 250 MHz. Scale, all plots: vertical axis,10 dB/div; horizontal axis 10 MHz/div. The signal in the center is a channel 11 NTSC analog TV station. Also seen are DTV stations on Channels 7 and 9. The Channel 9 spectrum is distorted due to multi-path.

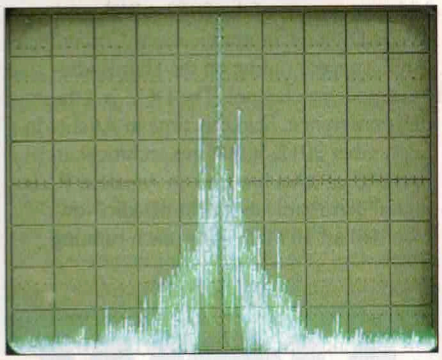


Figure 2 — Spectrum of a typical, commercially available, ham, 70 centimeter, 1 W, AM TV transmitter operating on Channel 60 (439.25 MHz).

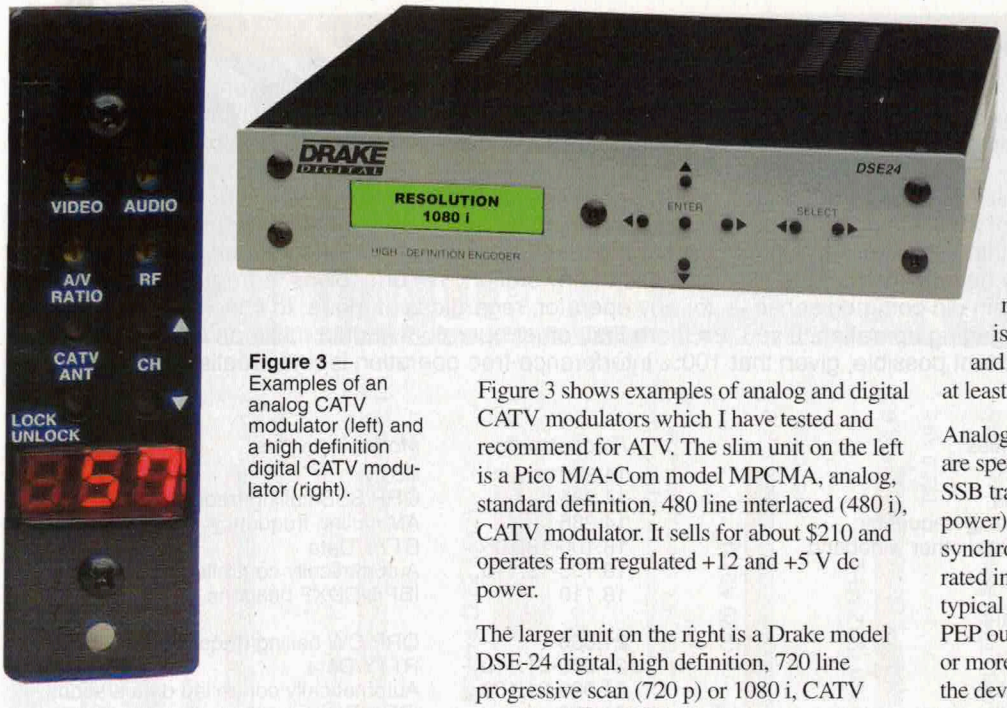


Figure 3 — Examples of an analog CATV modulator (left) and a high definition digital CATV modulator (right).

Figure 3 shows examples of analog and digital CATV modulators which I have tested and recommend for ATV. The slim unit on the left is a Pico M/A-Com model MPCMA, analog, standard definition, 480 line interlaced (480 i), CATV modulator. It sells for about $210 and operates from regulated +12 and +5 V dc power.

The larger unit on the right is a Drake model DSE-24 digital, high definition, 720 line progressive scan (720 p) or 1080 i, CATV modulator. The DSE-24 accepts component, HDMI or computer VGA as video inputs. It puts out an unencrypted digital TV (DTV) signal using QAM-64 modulation. QAM-64 is the modulation scheme used by the cable companies that modern, digital/analog home TV receivers can receive without requiring any cable converter box. Thus, a digital ATV signal from this modulator transmitted on the 70 centimeter band can also be received directly by most current home TV receivers. The DSE-24 sells for about $1200. Both modulators are available from wholesale video dealers such as ATV Research (**www.atvresearch.com**).

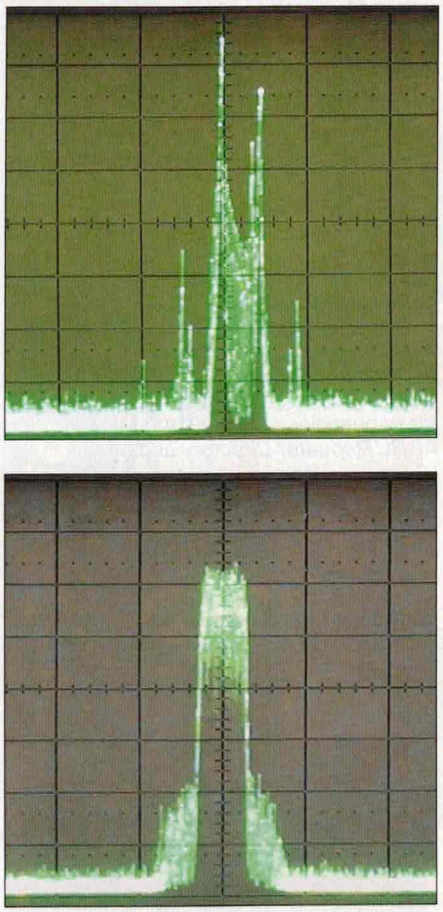


Figure 4 — Typical spectrum analyzer plots for a well adjusted analog, VUSB-TV, ATV transmitter (top) (LSB/USB = –30dB) and a high definition, QAM-64, DTV transmitter (bottom) (MER = –40dB).

Making More Power

The harder problem is to find a suitable linear amplifier. For VUSB, and especially for QAM-64 DTV, the amplifier must be ultra-linear. Any distortion introduced by the amplifier will cause rapid growth of the undesired lower sideband in the VUSB signal and increased error rate in the DTV signal. A key measure of distortion in a DTV signal is the MER (modulation error ratio). It is similar to our more familiar signal to noise ratio, but is appropriate for a digital system. As the MER degrades, noise sidebands start to occur outside the allocated 6 MHz DTV channel.

Linear amplifiers that have been used for AM ATV service in the past are unsatisfactory for VUSB-TV and DTV. The most popular power amplifier modules have been the Toshiba S-AU4 and the SAU83L. Neither is suitable for VUSB-TV or DTV.

After considerable research, I have found the Mitsubishi RAxxH4047 family of RF MOSFET, high power amplifier "brick" modules perform well for VUSB-TV or DTV service. Another excellent brick for a very linear 1 W amplifier is the RFHIC, RFC041. These amplifiers typically require drive levels of around +10 dBm. Since the output of a CATV modulator is typically at 0 dBm or less, an intermediate driver amplifier is also required. A small monolithic microwave integrated circuit (MMIC) is sufficient. It must also be very linear and should have an output power rating of at least +20 dBm.

Analog VUSB-TV transmitter output powers are specified in the same manner as for an SSB transmitter, as PEP (peak envelope power). The peaks occur on the tips of the synchronization pulses. DTV transmitters are rated in terms of their average power. For a typical VUSB-TV transmitter, the maximum PEP output power is typically set to be –3 dB or more below the maximum output power of the device. For a DTV transmitter, the average output power is typically set 10 dB below the maximum output power of the device.

It is extremely important not to overdrive any TV linear amplifier. Doing so will degrade the linearity. The best tool for properly adjusting the drive levels is a spectrum analyzer that can monitor the growth of the undesired lower sideband on a VUSB-TV signal or the out of channel noise sidebands on a DTV signal. Figure 4 shows the spectral plots for well adjusted analog and digital ATV transmitters.

Photos courtesy Jim Andrews, KH6HTV.

Jim Andrews, KH6HTV, is an ARRL member and holds an Amateur Extra class license. He was first licensed in 1965. He has BS, MS and PhD degrees in electrical engineering from the University of Kansas and is a Fellow of the IEEE. Jim is the founder and former president (now retired) of Picosecond Pulse Labs in Boulder, Colorado. He has been active in ATV and ARES since the mid '70s and he is the trustee for the BCARES TV repeater, WØBCR. In retirement, Jim and his wife, Janet, are snowbirds spending their summers in Boulder and the winters in Maui, Hawaii. In Boulder, Jim mainly operates 2 meter FM and UHF and microwave ATV. On Maui, Jim operates strictly on HF voice and PSK31. Jim may be reached at 150 Puukolii Rd, Condo 55, Lahaina, HI 96761 or at **kh6htv@arrl.net**.

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