

## Microwavelengths

# Microwave Amateur Television

*Amateur microwave bands have a lot of bandwidth, and we only use a small fraction for weak-signal communications. This leaves room for experimentation with wider-bandwidth modes, such as amateur television (ATV).*

*Digital TV requires much less transmitted power for quality pictures, therefore, digital ATV (DATV) has become more popular. For this month's column, I've asked Jim Andrews, KH6HTV, (kh6htv@gmail.com), Editor of the Boulder Amateur Television Club Newsletter, to explain ATV.*

When discussing ATV, most hams think of slow-scan television (SSTV). They're unaware that amateur radio bands can be used for more than voice, CW, digital text modes, or SSTV. However, the FCC allows hams to also operate live broadcast-quality TV on the 70-centimeter band and the higher microwave frequencies. In the US, TV channels are 6 MHz wide. Thus, the 70-centimeter band at 430 MHz is our first higher band with sufficient spectrum available to support TV. It's also close to the UHF TV

broadcast band (470 – 698 MHz) with similar propagation characteristics.

### Digital ATV

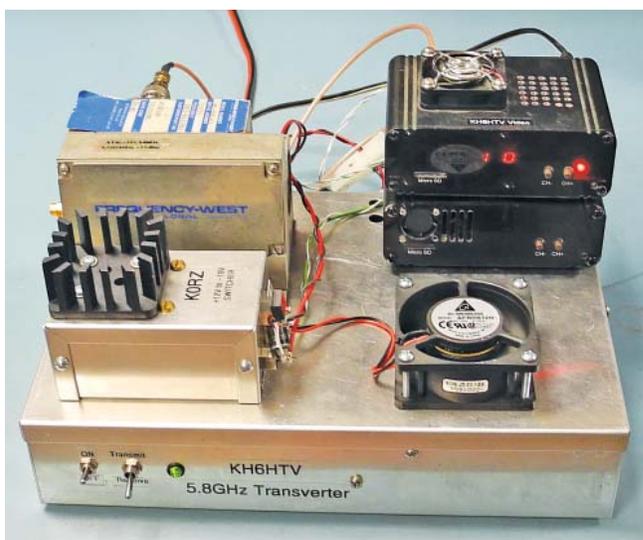
The first ham radio TV two-way contact was made in 1940. Today, broadcast TV has transitioned from the old analog NTSC (National Television Standards Committee) to digital. Many ATV hams now transmit high-definition (1080p) digital video and CD-quality stereo audio, resulting in great pictures and sound. A few US hams are experimenting with the American digital broadcast system called ATSC (Advanced Television Systems Committee), but most are exploring digital TV using the European-based system, DVB-T (Digital Video Broadcasting — Terrestrial). DVB-T uses COFDM modulation with QPSK, 16QAM, or 64QAM and is highly tolerant of severe multipath propagation. In Europe, most ATV hams are using DVB-S (Digital Video Broadcasting — Satellite) and have the QO-100 geostationary satellite to experiment with. This satellite is a transponder for amateur digital TV, with microwave

uplink in the 2.4 GHz band and downlink in the 10 GHz band.

We've found that digital TV outperforms the old analog NTSC TV. Experiments have shown that with identical transmitter powers, antennas, and so on, digital TV provides a perfect image and sound, while a P2-quality analog TV signal provides images that are barely distinguishable.

Due to bandwidth, there's a big difference in TV receiver sensitivity versus SSB or FM voice. It's set by the law of physics and the thermal noise baseline:  $P_n = kTB$ . Boltzmann's constant is  $k$ , the Kelvin temperature is  $T$ , and bandwidth in Hertz is  $B$ . Using this equation for a 6 MHz DATV signal, the noise floor for a receiver will be  $-106$  dBm. For an FM voice radio with 15 kHz bandwidth, it's  $-132$  dBm. For an SSB voice radio with 2.4 kHz bandwidth it's  $-140$  dBm, so a received signal level greater than  $-130$  dBm is needed for a 10 dB signal-to-noise ratio. With DVB-T, using a good low-noise preamplifier on the receiver and 6 MHz bandwidth, QPSK, 1080p resolution, and normal forward error correction (FEC) of 5%, the minimum detectable signal requires an 8 dB signal-to-noise ratio, or about  $-98$  dBm ( $2.8 \mu\text{V}$ ). If we use really aggressive FEC of 1/2, we get another 3 dB in sensitivity. Therefore, a signal of about 30 dB more is needed for DATV compared to SSB.

There's also a difference in how we rate digital transmitter power versus analog. Analog TV is rated the same as an SSB transmitter — by peak envelope power (PEP). The peak is the sync pulse on an analog TV signal. For digital, the waveform has no distinguishing features, but looks like random noise with power peaks 8 – 10 dB above the average root



Jim Andrews', KH6HTV, homebrew 5.8 GHz DVB-T transverter. [Jim Andrews, KH6HTV, photo]



Debbie Goldman, WB2DVT, operating 10 GHz digital ATV during the 2020 ARRL 10 GHz and Up Contest. [Pete Goldman, WB2DVS, photo]

mean square (RMS) power. Therefore, a digital transmitter is rated by its RMS power, which is typically 8 – 10 dB below its maximum power rating. For example, a 10 W RMS DVB-T transmitter amplifier is capable of putting out 50 W PEP in SSB service, and 70 W in FM/CW service.

### DATV Operation

As with 2-meter and 70-centimeter FM voice, ATV hams also use repeaters to enhance their coverage areas. In the US, I know of at least 40 active ATV repeaters (analog, digital, and mixed mode). Most are on the 70- and 23-centimeter bands, but some also include inputs and/or outputs on the higher microwave bands up to 10 GHz. For example, our Boulder, Colorado, W0BTV repeater has inputs on 70 and 23 centimeters, and outputs on the 70- and 5-centimeter bands. Many ATV repeaters also stream their video and audio over the internet. The best place to find many of them is on the British Amateur Television Club's (BATC) website (<https://batc.org.uk/live>). There you'll find almost 60 ATV repeater streams from around the world. The most complex ATV repeater system is that of the Amateur Television Network (ATN), a system of linked ATV

repeaters covering southern California, southern Nevada, and Arizona (Phoenix and Tucson). ATN uses microwave links on the 9- and 5-centimeter bands to tie the various sites together.

Like other microwavers, ATVers like to get out in the field on microwave DXpeditions to see how far they can exchange signals. Boulder ATV hams have worked all bands (70, 33, 23, 13, 9, 5, and 3 centimeters) with digital ATV up to 10 GHz, and have used ATV to send pictures of our club's 2021 Field Day operation around the world. This required an intermediate point-to-point relay hop to get from our mountaintop site to our W0BTV TV repeater, and from there to the internet. We've also participated in the ARRL 10 GHz and Up Contest, but with fewer ATV participants we haven't scored very high. Locally, our current best distances on microwaves are 51 kilometers (5.7 GHz) and 36 kilometers (10 GHz). With our W0BTV DVB-T repeater, we've successfully made two-way contacts with the 70- and 23-centimeter inputs and 70-centimeter output, to 123 kilometers on the Colorado/Wyoming border. The repeater also has an analog FM-TV transmitter on 5.905 GHz, and we've been able to receive that microwave signal out to 112 kilometers.



Don Nelson's, N0YE, DATV picture received from 9.4 miles away, recorded by Jim Andrews, KH6HTV. [Jim Andrews, KH6HTV, photo]

### Equipment

A mixture of commercial and homebrew equipment can be used for digital ATV. HiDes Technologies modulators are popular and cost about \$370. For receivers, we use inexpensive set-top box receivers from Amazon, which only cost \$50. Cheap USB TV tuner dongles for a PC can also be used as receivers. The BATC sells transmitter and receiver kits to its members (they require a computer such as a PC or Raspberry Pi).

Commercial DVB-T modulators and receivers are available for bands up to 13 centimeters (2.4 GHz). Above that, we need to use transverters for digital TV signals. Microwave transverters from Down East Microwave (US) and Kuhne Electronic (Germany) can be easily modified from SSB service to work with digital ATV by using a 70-centimeter DVB-T modulator and receiver for the IF, rather than an SSB transceiver. If you homebrew your digital ATV transverter, the key element is a good local oscillator (LO). For digital TV, absolute frequency accuracy isn't as important as it is for SSB, but low phase noise is crucial in the LO.

### More Information

If you want to learn more about analog and digital ATV, download *Introduction to Amateur Digital Television*, by Jim Andrews, KH6HTV, at [www.arrl.org/atv-fast-scan-amateur-television](http://www.arrl.org/atv-fast-scan-amateur-television).