Application Note
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70 cm & Microwave Amateur TV Frequencies

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Licensed amateur radio operators in the USA are permitted by the FCC to transmit, live, fast-scan, color television pictures with audio in the 70 cm (420-450 MHz) band and all higher frequency amateur radio bands (33 cm, 23 cm, 13 cm, etc.). Where possible, hams in the USA have tried to adhere to the commercial broadcast and cable TV standard channels with 6 MHz channel spacing. For the 70 cm band, this means using cable TV channels 57 through 61. For the 33 cm (902-928 MHz) band, this means using cable TV channels 143, 144, and 145.

Commercial broadcast and cable TV, NTSC, analog TV transmissions used Vestigial Upper Side Band (VUSB) modulation of the video signal with the video carrier 1.25 MHz above the lower channel edge. 25 kHz deviation FM modulation was used for the audio signal with the audio carrier 4.5 MHz above the video carrier (i.e. 5.75 MHz above the lower channel edge). All of the emitted spectrum was to be contained within the FCC authorized 6 MHz channel. Analog TV transmitter power was specified the same as for a SSB transmitter, i.e. peak-envelope power (PEP) with the peak occurring on the sync tips. Broadcast TV channel widths vary around the world. While the USA uses 6 MHz, many other countries use either 7 or 8 MHz.

With the transition of commercial TV broadcast from analog to digital, the 6 MHz channel widths and spacing were retained. The same frequencies and channel numbers were also retained for digital TV. For digital TV, it is identified by the center frequency of the channel. In the USA, commercial broadcast digital TV (DTV) uses the 8VSB-ATSC modulation method to convey both the video and audio signals.

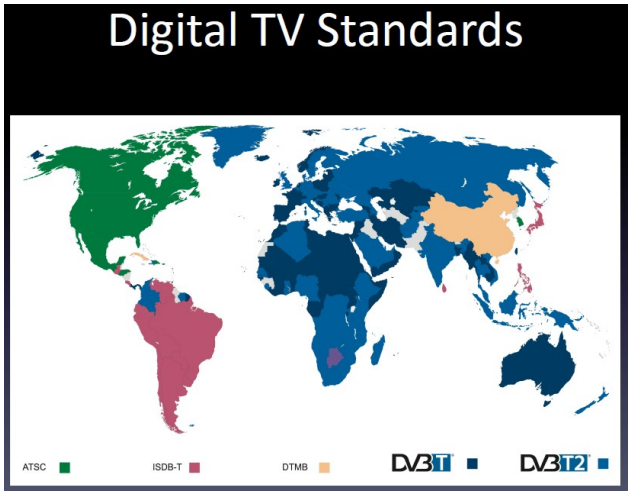

Fig. 1 DTV Stds

On the cable TV systems, Quadrature Amplitude Modulation (QAM) is used with typically either 64 or 256 level. (i.e. 64-QAM or 256-QAM). Again, all of the emitted spectrum is required to be contained within the authorized 6 MHz channel.

USA TV Amateurs are now also transitioning to digital TV. Most USA, DATV hams are using the European Digital Video Broadcasting - Terrestrial, DVB-T, digital TV modulation technique on the ham bands. For DVB-T in the USA, they are adhering to maximum bandwidths of 6 MHz. Some ATV repeater groups, especially in large metro areas, are using narrower DVB-T bandwidths down to 2 MHz.

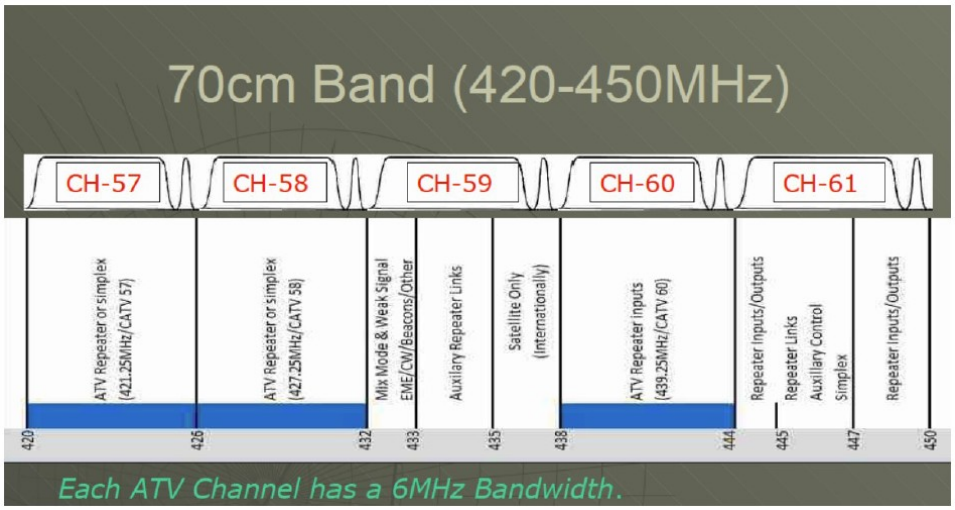

Fig. 2 70 cm Band ATV Channels

70 cm Ham TV Frequencies --- The 70 cm band has 30 MHz available and could thus accommodate up to five, 6 MHz TV channels. The cable TV channels 57 - 61 span the 70 cm ham band. Thus, many hams opted to use these same channels and frequencies for the ease in reception of the old analog, NTSC TV using ordinary, off-the-shelf, TV receivers. However, in certain portions of the USA, the local conventions established many years ago dictated the use of other, non-standard frequencies. The most commonly used were 426.25 MHz and 434 MHz for AM or VUSB.. Also in some areas, inverted sideband, VLSB, was used. For these non-standard operations, often times separate, specialized down converters and receivers were required.

The ARRL has band plans with recommendations for sub-dividing each amateur band. They can be found at: ***http://www.arrl.org/band-plan*** For the 70 cm band, the ARRL recommends that Ch 57 (420-426) be used as an ATV repeater output with Ch 60 (438-444) as repeater input. They recommend Ch 58 (426-432 MHz) be used for Simplex.

At the high end of the band, Ch 61 (444-450) should be completely avoided due to the heavy usage there by FM voice repeaters. Ch 59 (432-438) is sometimes used by ARES groups for intermittent TV operations, but normally should be used only as a last resort due to it's use for SSB/CW weak signals and ham satellites.

33 cm Ham TV Frequencies ---- The 33 cm band covers from 902 to 928 MHz and with 26 MHz has space for a maximum of four, 6 MHz TV channels. Three CATV channels land completely within the band. The ARRL recommends three TV channels on 33 cm at 909-915, 915-921 & 921-927 MHz. It should be noted that the 33 cm band is also an unlicensed ISM band and operations are subject to severe RFI from these other unlicensed ISM users and devices. In general, due to the high background RFI noise level from all these unlicensed ISM users, the 33 cm band is typically avoided for ATV use.

23 cm Ham TV Frequencies ---- The 23 cm band is the second most popular band for ATV after the 70 cm band. The 23 cm band covers from 1240 to 1300 MHz and with 60 MHz has space for a maximum of ten, 6 MHz TV channels. The cable channel designators do not extend above 1 GHz. The L-band, IF frequencies of broadcast TV satellites do straddle the 23 cm band and hams are using satellite TV receivers for this band for DVB-S ATV. Analog ham TV activity on 23 cm is either 12+MHz wide, AM-TV or 20 MHz wide, FM-TV, typically with 4 MHz deviation and 6 MHz sound sub-carrier(s). In the USA, most digital ATV uses DVB-T. In the 23 cm band, 6 MHz bandwidth DVB-T is common using the standard analog channels. In Europe, most of the ham digital TV (DTV) activity is located on this band using narrower band, DVB-S modulation and low cost, satellite "Free-to-Air" (FTA) receivers.

The ARRL band plan for the 23 cm band recommends three, 6 MHz TV channels. They are 23-1 (1240-1246), 23-2 (1252-1258) & 23-3 (1276-1282 MHz). They also recommend that FM-ATV use 1240-1260 MHz. The most commonly used frequency for FM-TV and DTV is 1255 MHz. In general, the 23 cm band is much quieter and less occupied then either the 70 cm or 33 cm bands. It should be noted that the FAA has recently installed new, radars in the 23 cm band which will limit amateur use of certain frequencies in the vicinity of these radars. This is particularly a problem in major metro areas.

13 cm Ham TV Frequencies ---- The 13 cm band is split into two amateur segments from 2300 to 2310 MHz and 2390 to 2450 MHz. The ARRL band plan discourages wide-band signals, such as TV in the lower 2300-2310 MHz portion. The ARRL band plan wants all broadband modes, such as ATV, to use the 2410 to 2450 MHz region.

It should be noted that the frequencies from 2400 to 2450 MHz, in the 13 cm band are also an unlicensed ISM band and operations are subject to severe RFI from these other unlicensed ISM users and devices. In particular, there is extremely wide spread use of this band for Wi-Fi routers. The only clear region for relatively RFI free TV operation is the 10 MHz portion from 2390 to 2400 MHz. Clearly then 2.39 to 2.40 GHz should be our first choice for any TV operations at 13 cm. I suggest that the bottom portion should be our sole, 13 cm, 6 MHz ATV channel (2390 - 2396 MHz) to stay as far away as possible from Wi-Fi RFI.

9 cm Ham TV Frequencies ---- The 9 cm band covers from 3.3 to 3.45 GHz. The ARRL band plan encourages wide-band modes (> 1 MHz), such as TV, in the 20 MHz

segment of 3.31 to 3.30 GHz. They encourage TV to use the 20 MHz segment 3.36 to 3.38 GHz. Three, 6 MHz TV channels would fit in this segment, or one wide-band FM-TV channel.

5 cm Ham TV Frequencies ---- The 5 cm band covers from 5.650 to 5.925 GHz. The ARRL band plan encourages wide-band modes (> 1 MHz), including ATV, in two, 75 MHz, segments: 5.675 to5.750 GHz and 5.850 to 5.925 GHz. The ARRL has not specified any specific slots for ATV.

It should be noted that this is another band shared with unlicensed, ISM transmitters. The ISM band is from 5.725 to 5.875 GHz. It too is being used now for Wi-Fi. To avoid 5.8 GHz Wi-Fi, we should probably put our TV operations in the 50 MHz segments below of 5.675 to 5.725 GHz and above at 5.875 to 5.925 GHz.

Inexpensive, analog, FM-TV transmitters for the 5.8 GHz band are available. They are designed and intended for the drone market. They presently are the most affordable way to do analog ATV. They typically come pre-programmed for 40 TV channels. Fortunately, some of these channels do lie in the the 5.675-5.725 and 5.875-5.925 GHz slots.

3 cm Ham TV Frequencies ---- The 3 cm band covers from 10.0 to 10.5 GHz. The ARRL band plan encourages wide-band modes (> 1 MHz), including ATV in two segments: 10.125 to 10.200 GHz, and 10.375 to 10.45 GHz. The ARRL has not specified any specific slots for ATV.

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Boulder, Colorado ATV Frequencies:

In Boulder, all ATV activity is currently using digital DVB-T with 6 MHz TV channels on all bands 70 cm thru 3 cm. Analog FM-TV is currently confined to the 5 cm band. Most ATV activity is on the 70 cm and 23 cm bands.

70 cm Band: Boulder's W0BTV, TV repeater follows the ARRL band plan with input on Ch 60 (441 MHz) and output on Ch 57 (423 MHz). The Boulder ARES group, BCARES, will use up to four TV channels for emergency operations. They are channels 57, 58, 59 & 60. (423, 429, 435 & 441 MHz).

33 cm Band: Not typically used. Considered a "Junk Band" due to high levels of RFI.

23cm Band: Boulder's W0BTV, TV repeater uses the ARRL band plan channel 23-1 1243 MHz (1240 - 1246 MHz) as the primary input frequency. Secondary usage is channel 23-2 1255 MHz (1252 - 1258 MHz).

13 cm Band: Simplex ATV uses 2.393 GHz (2.390 - 2.396 MHz)

9 cm Band: Simplex ATV uses 3.370 GHz (3.367 - 3.373 MHz)

5 cm Band: For simplex DVB-T, we use 5.678 GHz (5.675 - 5.681 GHz) For simplex FM-TV, we use Ch 3-2, 5.685 GHz. Boulder's W0BTV, TV repeater has a secondary, 5 cm, FM-TV transmitter on Ch 3-6, 5.905 GHz. It runs 24/7 as a microwave beacon.

3 cm Band: Simplex ATV uses 10.380 GHz (10.377 - 10.383 GHz).