



**Application Note**  
**AN-13**  
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## **High Definition 64QAM Digital TV Transmitter**

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**Note:** The original AN-13 was written in 2012 and the cable TV modulation method of 64-QAM was used. Since then, the author has discovered the European Digital Video Broadcast - Terrestrial, DVB-T, modulation scheme. It has been found to be far superior for over-the-air transmissions than CATV 64-QAM, particularly in terms of receiver sensitivity and tolerance of multi-path. The reader of this app. note is also encouraged to read about DVB-T in application note, AN-17.

The purpose of this application note is to show how to build your own High Definition Digital TV (DTV) transmitter. Finally, it is now a simple matter for a ham to assemble his own Hi-Def, DTV transmitter at a reasonable investment comparable to buying an HF transceiver.

Several years ago, when the FCC first declared that the TV broadcast industry would need to transition from the old analog, NTSC, TV system to using DTV, I became excited about the possibility of also doing DTV on the ham bands. I immediately started doing internet web searches for possible DTV exciters. The first "hits" were only for exciters from the broadcast industry suppliers, such as the Harris Corp. They offered an ATSC, 8-VSB, 1 mW, exciter for only \$80,000 !!! Ouch ! Way beyond the typical ham budget. I next started searching for ICs to roll my own. No luck. They seemed to be tightly guarded, in-house, trade secrets. Every six months or so, I would again do an exhaustive internet, Goggle search. After a few years, the price for DTV exciters finally started to drop a bit. I found some for about \$10,000. Still way beyond the normal ham budget. Finally, last year (June, 2011), my Goggle DTV search finally paid off. The old ham radio company, R.L. Drake, was offering a DTV exciter for only \$1,200. ([www.rldrake.com](http://www.rldrake.com)) This was finally a price comparable to a good HF transceiver. I immediately bought one and was able to build a ham DTV transmitter. By the end of the summer of 2011, I was the first ham in Boulder to transmit high definition (1080i), beautiful digital TV pictures.

Drake is an old line ham radio manufacturer dating back to 1943. Drake no longer makes ham radio equipment, but is now a supplier of cable TV (CATV) equipment and closed-circuit TV gear. In the early days of satellite TV, Drake made satellite TV receivers. More recently they have been supplying analog, NTSC, standard-definition CATV modulators and de-modulators and other equipment for use in the head-ends of CATV

systems. With the digital transition, most CATV systems are now converting their systems from analog to digital. Thus, to remain competitive, Drake needed to also offer DTV equipment.



**DTV EXCITER** --- The Drake Model DSE-24 is a DTV encoder and RF exciter. It accepts as video inputs, the typical consumer types of HDMI (unencrypted), hi-def component [ Y (green), Cr (red) & Cb (blue) ], hi-def computer VGA and standard definition (480i) composite. The computer VGA is looped-thru so it can also be displayed on a monitor. The DSE-24 accepts and encodes video resolutions of 1080i, 720p, 480p and 480i. The DSE-24 accepts as audio inputs, HDMI, optical S/PDIF and stereo analog (line level - RCA). The DSE-24 then encodes the video to MPEG2 and the audio to MPEG1 formats. It next creates an RF signal using QAM-64 or QAM-256 modulation. The digital RF signals are not the same as found on broadcast TV. They are a different, digital, modulation scheme called Quadrature Amplitude Modulation (QAM). This is the same modulation scheme used by the CATV industry and can be received directly on any modern analog/digital TV receiver without requiring an external converter box. The RF output can be on any CATV channel from 8 MHz to 1 GHz. It thus covers both the 70 cm and 33 cm ham bands. The channel spacing is 6 MHz. The output power is adjustable over a 15 dB range with -4 dBm maximum. Thus, to be useful as a ham DTV transmitter, an RF amplifier is required.

**RF AMPLIFIERS** --- It turned out that adding an RF amplifier to the DTV exciter was not a simple matter. My previous 70 cm, analog TV transmitter designs had been built using "brick" module RF power amplifiers. The favorite module used by many hams for many years has been the Toshiba S-AU4. The S-AU4 was capable of 20 Watts saturated output power. In VUSB-TV service, it was typically pushed to give 10 Watts PEP max. on the sync tips. At this level, it just started to compress the sync tips. The lower sideband suppression was -20 dB. When I tried to drive the S-AU4 with the Drake DTV exciter, I found that my digital TV receiver refused to decode the signal. Why? It turned out that DTV requires extremely linear amplifiers. The S-AU4 was linear, but not ultra-linear.

I thus spent the rest of the summer of 2011 researching the issue of DTV and amplifier linearity. I discovered the critical parameter called MER, or Modulation Error Ratio. This is a measure of the amount of distortion present in the DTV signal. If the MER is worse than -27 dB for 64-QAM or -31 dB for 256-QAM, then the digital TV receiver can not decode the signal, regardless of the signal strength. With the S-AU4, the MER was worse than -20 dB, even at low drive levels. I eventually found several brick, linear

amplifiers that were suitable for DTV service. If I operated them in class A or AB mode and restricted the drive level to keep the average output power well below the max. saturated power rating, I was able to achieve MERs of > 40 dB. A MER of 40 dB is the CATV industry standard for their DTV signals. The result of this R&D effort was a line of ultra-linear, 70 cm, RF amplifiers with DTV output powers of 1/4 W, 1 W, 2 W and 5 Watts (models 70-5 thru 70-10). Each amplifier (except the 70-8) has sufficient gain to be driven directly by the low -4 dBm signal from the Drake DSE-24 exciter.



**ASSEMBLE YOUR OWN** ---- To assemble your own DTV transmitter is a simple matter of purchasing a few items, interconnecting them, then add your Hi-Def camcorder or Blu-Ray DVD player, an antenna and 12 Vdc power supply and you are on the air with High-Definition video.

1. Purchase the Drake DSE-24 from ATV Research ( [www.atvresearch.com](http://www.atvresearch.com) ). \$1,185.
2. The Drake DSE-24 operates from +5 Vdc at 1.5 Amps. It includes a 120 Vac, wall-wart, switching 5 V power supply. If you plan to operate mobile or portable DTV, then you will need a 12 Vdc to 5 Vdc switcher. We recommend the Power Stream Technology model DCZ0503. ( [www.powerstream.com](http://www.powerstream.com) ). \$48. It puts out 5.2 Vdc, 3 Amp max. from an input of 8 to 28 Vdc.
3. Purchase a linear amplifier from KH6HTV Video ( [www.kh6htv.com](http://www.kh6htv.com) ). The most popular is the highest power, model 70-8A amplifier, shown in the photo above. \$450. It does not have sufficient power gain to be driven directly by the low -4 dBm from the DSE-24. You also need to purchase the model 70-4B, 18 dB gain, driver amplifier for \$100. The 70-8A instruction manual gives details on the connections and proper output level setting for the DSE-24. With this combo, you will be transmitting a 5 Watt (avg) (+37 dBm) DTV signal. The best DX to date with this DTV transmitter has been 75 miles from Cheyenne, Wyoming to Boulder, Colorado.
4. Another popular option is to purchase the KH6HTV Video model 70-10 TV transmitter. This is a complete, analog VUSB-TV transmitter with adjustable power levels of 10 W, 3 W or 1 W (pep). SMA jacks are found on the rear panel with the

VUSB exciter output and input to the RF amplifier. In normal operation, a short SMA jumper connects these jacks. For DTV use, disconnect the SMA jumper and attach the RF output from the DSE-24 to the amplifier SMA input jack. In DTV service, the RF output power is also selectable at 2 Watts max.

**Additional Reading** --- To learn more about digital TV, I suggest that you read my other application notes. They are available on my web site: [www.kh6htv.com](http://www.kh6htv.com) Those most relevant to DTV include: AN-2 "Digital TV -- the Good, the Bad & the Ugly", AN-3 "Field Trials Comparing VUSB, FM, DVB-S & 64QAM Television", AN-6 "MER -- What is it ?", AN-8 "Linear Amplifiers -- Buyer Beware", AN-11 "Digital TV DX Record for Colorado" and AN-12 "Reception of Ham TV"