DVB-T Television Repeater
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The FCC allows licensed amateur radio operators to transmit wide bandwidth, fast-scan, video on the 70 cm (420-450MHz) band and all higher microwave bands. On the 70 cm band, the ARRL national band plan [1] calls for TV repeater inputs to be on Ch 60 (438-444MHz) and outputs to be on Ch 57 (420-426MHz) with TV simplex operations on Ch 58 (426-432MHz). Note: These channel number designations are those used by the USA cable TV industry. Cable channels 57 through 61 land directly on the amateur 70 cm band.

To build an in-band, 70 cm, Television Repeater, Fig. 1, very high selectivity, band-pass filters (BPF) are mandatory on both the transmitter and receiver. On the 70 cm band, 6 MHz channels are used and the typical spacing between the input and output is only 18 MHz. The purpose for the BPF on the receiver input is to prevent fundamental overload of the receiver's front end by the extremely strong, near-field signal from the transmitter. The purpose of the BPF on the transmitters' output is to prevent any out of band spurious spectrum from polluting the RF environment of adjacent channels and especially the receiver's channel. The BPFs used are typically of the Inter-Digital BPF design, Fig. 2. Fig. 3 shows a typical swept frequency insertion loss (S21) of a BPF as used for amateur TV service. Amateurs with some ordinary machine tools, such as a drill press, etc. can roll their own such filters. Application Note, AN-22b [reference 2] gives details.
Fig. 2 Typical, 70 cm, Inter-Digital Band-Pass Filter. Shown with top cover removed.

Fig. 3 Swept frequency insertion loss response ($S_{21}$) of a typical 6 MHz, band-pass filter used for amateur TV service. center frequency = Ch 57 (423 MHz), 10 dB/div & 2 MHz/div.

Most 2 m and 70 cm, FM voice repeaters with 25 kHz channels typically use a single antenna for both transmit and receive. A duplexer is typically used between the antenna and the transmitter and receiver. On 2 meters, the frequency separation typically used is 600 kHz, or a ratio of 600/25 = 24:1. On 70 cm, the frequency separation typically used is 5 MHz, or an even higher ratio of 5000/25 = 200:1. For TV signals with channel
bandwidths of 6 MHz, the ratio of transmit/receive separation to bandwidth is only 18 MHz / 6 MHz = 3:1. With this close separation of only 3:1, it is very difficult to build an effective duplexer for TV repeater service. Thus, usually amateur TV repeaters do not use a single common antenna for both transmit and receive, but two separate antennas as shown in Fig. 1. If omni directional antennas are used, they should be positioned on the same supporting mast, directly one above the other so that they are sitting in the null position of each other's antenna pattern to achieve the maximum isolation. For portable repeaters using directional, yagi antennas, there is definitely a right and a wrong way to position your antennas! See Fig. 4 below.

![Diagram](https://via.placeholder.com/150)

Fig. 4 Portable TV Repeater using Yagi Antennas. The secret to a repeater is high isolation between the transmitter and the receiver.

**CROSS-BAND TV REPEATERS:** Repeater can also be built as "Cross-Band", meaning the input and output frequencies are not on the same bands. Oftentimes, assembling a cross-band repeater is much simpler than building an in-band repeater because of the extreme separation in input/output frequencies. In some cases, the special band-pass filters can even be eliminated. Then it is a simple matter of patching the output of the receiver into the input of the transmitter and you are on the air repeating. Especially easy is when the input frequency is on a band lower than the output frequency. If the output frequency is however on the lower band, then much more care is required. One must first consider the selection of frequencies. One should especially avoid choosing frequencies where the receive frequency is on one of the harmonics of the transmitter frequency. If this is unavoidable, then extra low-pass filtering will be required on the transmitter's output.

**DVB-T REPEATER:** It is a very straight forward matter to assemble a DVB-T repeater, especially when one uses the modulators and receivers from Hi-Des Technologies in Taiwan [3]. Several possible receivers are recommended. For a 70 cm
in-band repeater use the Hi-Des model HV-110 or the newer HV-120A. For a cross-band DTV repeater with a 23 cm input, the Hi-Des model HV-120A is the recommended receiver. However, it's 23 cm sensitivity [4] is poor and a good, low noise, 23 cm preamp, such as the KH6HTV Video model 23-4LNA, should always be used with the HV-120A. The recommended DVB-T modulator is either the Hi-Des model HV-100EH, or HV-320E. RF linear power amplifiers are available from KH6HTV Video for the 70cm, 33cm and 23cm bands.

For automatic operation of a repeater, one only wants it to be transmitting when it is receiving a valid incoming signal. At all other times the transmitter needs to be disabled. Disabling is easily accomplished using the PTT (Push-To-Talk) line on the RF power amplifier. The PTT line is keyed using a logic "Valid Signal" from the receiver. KH6HTV VIDEO RF Linear Power Amplifiers are all equipped with the ability to use a PTT control line. They typically have PTT On/Off ratios of >90dB. Low PTT = RF ON, High PTT = RF Off.

![Fig. 5](image)

**Fig. 5** Simple circuit modification to obtain "Valid Signal" from HV-110 receiver.

![Fig. 6](image)

**Fig. 6** View of underside of HV-110 pc board showing location of Green LED tap.

It is a very simple matter to obtain a "Valid Signal" logic signal from the Hi-Des model HV-110 receiver. The receiver has a front panel bi-color LED which indicates the status. When it is red, no signal is being received. When it is green, a valid signal is present. Thus, connecting a wire to the green LED provides the necessary "Valid Signal". A simple buffer circuit is shown in Fig. 5 to convert this signal into a suitable open collector transistor switch to drive a PTT line. The capacitor, C1, is used as a low-pass filter to
remove the rapid fluctuations which occur for a very weak signal at digital threshold. It adds some turn-on delay but improves the overall performance. Fig. 6 shows where to find the green LED tap point. Fig. 7 shows the installation of the "Valid Signal" circuit.

Fig. 7 View of topside of HV-110 pc board showing installation of "Valid Signal" circuit modification.

A similar modification can also be added to the HV-120A, however the dc voltage levels are a bit different and an additional series diode is required.

**FCC ID & Control:** The FCC requires that all amateur radio transmissions be identified at least once every ten minutes. Using a Hi-Des DVB-T modulator, identification is automatic and we never have to do it manually or with extra circuitry. In the original design of the DVB-T system, identification of the "Service Name" was included in the outgoing DVB-T digital data stream header. By programming your own call sign (such as KH6HTV) as the Service Name, your transmissions are continuously identified automatically. They will appear on the screen of a receiving station.

The FCC also requires that a control operator maintain positive control over a repeater in the event of malfunction, or malicious usage. For a repeater in one's own home, or a manned portable repeater on an ARES operation, this is a simple matter of the operator turning off the master power switch. For an unmanned, remote base repeater, control must be maintained either via a land-line or radio link on a separate control frequency. This will necessitate the installation of an additional control radio receiver and DTMF decoder with a relay to interrupt the Valid Signal logic signal on the transmitter's PTT line.

**Other Features:** Obviously, repeaters can grow to have much more exotic capabilities than the simple one shown in Fig. 1. A repeater might have multiple receiver inputs, both multiple bands, and multiple modes such as VUSB-TV, FM-TV, DVB-S, DVB-T, local TV cameras, etc. A repeater might also have multiple transmitters on multiple bands with multiple modes. A good example of such a complex ATV repeater is the ATCO (Amateur TV in Central Ohio) repeater in Columbus, Ohio (www.atco.tv). Another is the ATN (Amateur Television Network) of eleven, microwave linked, TV repeaters in southern California, Nevada and Arizona (www.atn-tv.org).
A nice feature to have on a repeater is a "Beacon" mode. This allows a user to activate the repeater transmitter to be turned on without requiring an incoming signal. This is very useful to allow users to optimize their home receiving stations with a known signal from the TV repeater. In the Beacon mode, the video source would be generated locally at the repeater site. It could be a tower mounted TV camera. Another useful source is to have a DVD player at the repeater site playing a continuous loop slide show of information about the repeater, the sponsoring club, etc. Each slide should carry the repeater's call sign for identification.

A REAL DTV REPEATER: Fig. 8 is a photo of an actual, basic, 70cm, DVB-T repeater built according to the block diagram of Fig. 1. This repeater was built in the summer of 2019 by KH6HTV for the Pueblo, Colorado amateur radio club (W0PHC). More details about this TV repeater are found in ref. [5].

REFERENCES: