Digital & Analog TV Repeater
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The purpose of this application note is to document the new Boulder, Colorado Television Repeater. Boulder has had an analog, NTSC, VUSB-TV repeater since 1991 [1 & 2]. It was designed, built, modified, and maintained since it's origin by Jim Andrews, KH6HTV (formerly WA0NHD). The most recent analog design dates from 1997 with some modifications / upgrades in 2006. The repeater has been in almost continuous service since 1991. It's only failures have been faulty small signal relays. This most
current revision is a major upgrade adding digital television (DTV) capability to the repeater, both for receive and transmit.

The major features of this new repeater are:
1. dual-band receive capability (23cm & 70cm)
2. two analog receive modes (23cm FM-TV & 70cm VUSB-TV)
3. DVB-T receive mode on both bands
4. 70cm transmit in either analog (NTSC, VUSB-TV) or digital (DVB-T) modes
5. Beacon mode

The selection of the operating mode is done by a control operator using DTMF (touchtones) on a separate RF control channel. The repeater's receive frequencies are: DTV = 1243MHz & 441MHz, ATV Receive = 1247MHz (FM) & 439.25MHz (VUSB). The transmit frequencies are: DTV = 423MHz (DVB-T) & ATV = 421.25MHz (VUSB). The control frequency is un-published and kept confidential.

**BLOCK DIAGRAM:** The block diagram of the DTV / ATV repeater is shown in Fig. 2 on the next page. A detailed study of this diagram will reveal the key, important details of the overall system design and it's parameters. Key elements are: 1. four separate TV receivers, 2. dual-mode transmitter, 3. Arduino micro-computer for repeater control and 4. Raspberry-Pi micro-computer for generating hi-def (1080P) video for ID and Beacon purposes.

Elements of the original ATV repeater were retained and reused in this new repeater. They included: antennas and coax feed-lines, tri-plexer, 70cm band-pass filters, 70cm & 23cm preamps, 70cm VUSB receiver, 70cm VUSB modulator, 2m FM control receiver, DTMF tone decoder, analog A/V switch, 15kHz horizontal sync detector, audio squelch, A/V line drivers (VDAs) and 13.8Vdc power supply.

New items added included: KH6HTV Video 23cm FM-TV receiver, Hi-Des DVB-T receivers, Hi-Des DVB-T modulator, KH6HTV Video 70cm RF Linear Power Amplifier, HDMI Switch Matrix, Arduino micro-computer and Raspberry-Pi micro-computer. Plus many 100s of hours of design and labor by both Jim Andrews, KH6HTV, and Don Nelson, N0YE.

The detailed schematic diagrams for the various modules in the repeater are found in the appendix at the rear of this application note. They are for: TV Transmitter, TV Receivers, HDMI Switch Matrix, Controller, Horiz. Sync detector & VDA, and audio squelch & line amps. These various modules are described in more detail in the sections following.
Fig. 2  Block Diagram of DTV / ATV Repeater
**TV RECEIVERS:** For the detailed schematic diagram of the TV receiver panel, see the page 3 schematic in the appendix. Fig. 3 above is a photo of the 19" panel holding all of the receivers, except for the control FM receiver which sits separately on an open shelf also holding the 13.8Vdc power supply. The receive antenna is connected to the Diamond triplexer for dividing the incoming rf signals to either the 23cm receiver, 70cm receivers or the 2m control FM receiver. Next are band-pass filters. The large copper colored item in the photo is the 438-444MHz, Ch 60, inter-digital, band-pass filter (BPF). Mounted on top of it (upper center of photo) is the 23cm BPF. This was a special, custom, 1.5GHz filter supplied by Don, NOYE. Don found it in some surplus microwave gear and he modified it for our purposes. It is a combo band-pass, notch filter. We have a major problem here in Colorado with a new, powerful FAA RADAR at the Denver airport operating on 1265 & 1267MHz, smack in the middle of the 23cm ham band. Don's filter put >60dB notches on these frequencies. Without Don's filter, the 23cm band would have been unusable for us.

There are low-noise preamplifiers following the band-pass filters. Their outputs are then split two ways with 3dB power splitters to feed the various receivers. The DVB-T model HV-120A receivers are from Hi-Des in Taiwan ([www.hides.com.tw](http://www.hides.com.tw)). See reference [3] for a full technical evaluation of the HV-120A. They are the two, black, modules in the lower center of the photo with the white labels. One is for 70cm (441MHz, 6MHz BW) and the other is for 23cm (1243MHz, 6MHz BW). The HDMI outputs are used with the resolution set to 1080P. Each Hi-Des HV-120A receiver was modified to put out a logic signal indicating a Valid DVB-T signal was present. This was done by pulling off a signal from the Red/Green receiver status LED. For details, see reference [4]. The circuit used is also shown on the schematic. It is a slight variation of the one described in [4] for the older HV-110 due to different on/off voltages found on the pc board. A 100uF capacitor, C1, was added to the original circuit to smooth out on/off fluctuations when the incoming rf signal was just at digital threshold. The Valid RF Signal logic outputs come from open collector transistors, Q1. They go directly to the Arduino system controller.
The 23cm FM-TV receiver consists of a model 23-7 23cm Down-Converter and a model 23-5 70MHz IF & FM-TV Demodulator from KH6HTV Video. It is the black modules on the far right side of the photo. Detailed specifications for them can be found on the web site: www.kh6htv.com The 23-5's output is standard definition (480i), NTSC, composite video and line level audio.

The 70cm VUSB-TV receiver is a model MPCD from Pico-Macom. It is the silver colored module on the far left side in the photo. These are excellent receivers as they were originally designed for use in the head-ends of cable TV companies. It is fully synthesized and operates on any standard USA broadcast or cable TV channel. It is set to operate on cable channel 60 (439.25MHz). It's output is standard definition (480i), NTSC, composite video and line level mono audio.

Linear voltage regulators, U1-U4, are used to provide proper operating dc voltages for the various receivers. The Macom MPCD receiver requires well regulated +12Vdc and +5Vdc. The Hi-Des HV-120A requires +12Vdc. Having both the ATV and DTV receivers activated at the same time was found to cause "de-sense" of the active receiver in use. Thus a dc power relay circuit was added to turn off the opposite receiver when it was not being used. This was controlled by the DTMF command 3, R-AD.

![Fig. 4](image-url)  
Fig. 4 S21 swept frequency response of the 23cm RF circuit from antenna input to the output of the -3dB power divider. 1250MHz center frequency, 200MHz span, 5dB/div & 20MHz/div
Fig. 5 S21 swept frequency response of the 70cm RF circuit from antenna input to the output of the -3dB power divider. 441MHz center frequency, 20MHz span, 5dB/div & 2MHz/div

Figs. 4 & 5 above show the S21 swept frequency responses of the 23cm and 70cm RF circuits. In both cases, the effective gain is about 10dB ahead of the various ATV & DTV receivers. The filter responses are dramatically different due to the different requirements on each band. On 70cm band, the filter bandwidth needed to be very narrow at 6MHz with very steep skirts, especially on the lower sideband. This was to reject the very strong signal from the TV repeater's transmitter which was only 18MHz lower in frequency. On the 23cm band, interference from the repeater transmitter was not an issue. What was an issue was the strong interference from the FAA radar at DIA. The region of interest for receiving our TV signals on 23cm was only from 1240-1254MHz and over this region the response was relatively flat.

The repeater receiver's noise figures are mainly determined by the input band-pass filters. Good, pre-amplifiers with low noise figures under 1dB are used. However, the overall noise figure is degraded by the insertion loss of the BPFs ahead of the pre-amps. Thus the resultant sensitivities do not match those measured previously for the DTV receivers with pre-amps [5].

Tests were run to determine the actual receiver sensitivities of the repeater. For details on how to perform these tests, see reference [5]. For the DTV receivers, this is the digital threshold at which the receiver turns on it's video and also keys the repeater. The DVB-T sensitivity is: -94dBm (23cm) and -92dBm (70cm) for a typical QPSK signal. For 16-QAM, they were: -89dBm (23cm) and -87dBm (70cm). For 64-QAM, they were: -80dBm (23cm) and -77dBm (70cm). Some additional improvement could be obtained if more aggressive FEC coding is used by the repeater user [5].
For the ATV receivers, the sensitivity measured was the level at which the horiz. sync detector keyed up the TV repeater. For 23cm FM-TV, the sensitivity is -100dBm. For 70cm VUSB-TV, the sensitivity is -91dBm. At repeater key up threshold the quality of an ATV signal as viewed on an NTSC studio monitor was P1 (FM) or P2+ (VUSB).

P ratings mean in quick summary: P1 = horrible, all snow, sync present, P2 = unuseable picture, but can see large features in a snow storm, P3 = useable picture with lots of colored snow, P4 = good picture with some minor defects and P5 = perfect picture. For a good picture (P4), an rf signal to noise ratio, s/n, of 24dB is required for VUSB-TV and 13dB for FM-TV. Perfect P5 pictures require >40dB and >20dB respectively. For a further description of the meaning of a TV signal "P" rating, see reference [6].

For the TV repeater, actual measurements gave the following P results.
70cm VUSB-TV:   P3 = -90dBm, P4 = -83dBm & P5 = -65dBm
23cm FM-TV:   P1 = -100dBm, P2 = -97dBm, P3 = -92dBm, P4 = -87dBm & P5 = -75dBm

The superiority of FM vs VUSB is obvious from the above measurements!

Picture quality is always P5 (perfect) for DTV. Only at digital threshold is some pixelization or frame freezing seen. The digital threshold "cliff" is typically only about 1dB wide. Thus, we now understand the technical superiority in receiver sensitivity of DVB-T over the older analog systems. For a P5 picture, the repeater requires -93dBm (DVB-T, QPSK) vs. -75dBm (FM-TV), vs. -65dBm (VUSB-TV). Very dramatic differences indeed!

Fig. 6  TV Repeater, 70cm, Transmitter -- mounted on 19" rack panel, rear view
ATV / DTV -- TV TRANSMITTER: For the detailed schematic diagram of the TV receiver panel, see the page 2 schematic in the appendix. Fig. 6 above is a photo of the 19" panel holding all the transmitter components. The transmitter basically consists of two modulators feeding a 3dB power combiner and then an RF linear power amplifier, followed by a band-pass channel filter. The selection of either operating as an analog (ATV) or digital (DTV) transmitter is determined simply by powering up the appropriate modulator. This is done via the logic control line labeled "TX-AD" which comes from the system controller. This turns on/off the appropriate voltage regulator, U1&U2 or U3. A Pico-Macom, model MPCMA, is used as the analog, VUSB-TV, modulator. It is the silver colored module in the left center of the above photo. Again, like the Macom receiver (demodulator), this is an excellent unit designed originally for use in cable TV company head-end offices. The input to this modulator is composite video and line level audio. It produces extremely pure VUSB-TV modulation with no out of channel energy. The digital modulator is a Hi-Des model HV-100EH producing DVB-T modulation.

The input to this modulator is high-definition, 1080P, video and stereo audio via HDMI from the HDMI Switch Matrix. The HV-100EH modulator is programmed to transmit 1080P, H.264, QPSK, 6MHz BW, 8K FFT, 3/4 FEC Code, 1/16 Guard, 5.25Mbps code rate. These settings were selected as a compromise between wanting to definitely transmit 1080P video, but at a lower bit rate with more forward error correction to extend the coverage range of the repeater. The sacrifice was made in ability to track fast moving video. For most typical ham TV video, that is not an issue.

The output powers from the two modulators are quite weak at less than 1 milli-watt (0dBm). They must be amplified to useful power levels in the watt range. To preserve the spectral purity of the modulator signals, the amplifier used must be extremely linear. Any non-linearity will result in the growth of undesired sideband out of the assigned, 6 MHz (420-426MHz) channel. The amplifier used is a KH6HTV Video model 70-12C. The amplifier is the black module with the cooling fins and fan in the lower right side of the photo. Detailed specs. can be found on the web site: www.kh6htv.com Key specs. are 53dB gain, +42dBm pep (ATV) or +38dBm avg (DTV). It operates on +13.8Vdc and draws about 5 Amps. The amplifier comes with a built-in PTT (Push-To-Transmit) circuit. Grounding the PTT line turns on the amplifier. The amplifier's on/off ratio is 113dB. PTT logic control for the amplifier comes from the system controller.
Fig. 7 Spectrum of DVB-T Transmitter. Center freq. is 423MHz, 10dB/div & 2MHz/div. Pout = +36dBm avg. (4 Watts), out of channel shoulder break-point is -32dB.

Fig. 8 Spectrum of VUSB-TV Transmitter. Center freq. is 421.25MHz, 10dB/div & 2MHz/div. Pout = +40dBm PEP (10 Watts) Lower sideband energy was unmeasurable and below the spectrum analyzer's noise floor. The test signal was color bars. Dominant peaks seen left to right are video carrier, color sub-carrier (+3.58MHz) and audio sub-carrier (+4.5MHz).
While the output spectrum from the power amplifier is quite clean, we use an extra, inter-
digital, band-pass filter to further reduce the out of channel emissions. This 6MHz
bandwidth, BPF is the large copper plate seen in the photo. Both modulators are
mounted to this BPF. This BPF introduces -2dB of insertion loss. The resultant output
power to the antenna is digital, +36dBm rms average (4 Watts) for DVB-T or analog,
+40dBm PEP (peak envelope power) (10 Watts) for VUSB-TV. Figs. 7 & 8 above show
the resultant DTV & ATV spectrums presented to the DB-411 transmit antenna.

![HDMI SWITCH MATRIX](image)

**HDMI SWITCH MATRIX:** A key component required for a digital TV
repeater which uses more than a single video source is a means of switching between
various HDMI sources. A simple DTV repeater was discussed in reference [4]. Don,
N0YE, has built such a DTV repeater and it was extremely simple to build. One simply
took the HDMI output from a Hi-Des receiver and plugged it into the HDMI input of a
Hi-Des modulator. The Red/Green receiver status LED was used to key the PTT line of
the rf power amplifier and "voila" you have a functioning DTV repeater. To add other
video sources, such as additional receivers, local camera, video ID generator, computer,
etc. really complicates the issue because a means now must be found to remotely switch
among these various HDMI sources. I studied this problem and came up with a low
cost, working solution. It is shown above in Fig. 9. The detailed schematic diagram is
found in the appendix, page 4. Additional details are found in AN-30, reference [7].
For operating the repeater as an ATV transmitter, analog, composite video & audio was
required. Thus, for the various hi-def, HDMI, digital sources, HDMI to Composite
converter modules were included in the HDMI Switch Matrix design. Likewise for
retransmitting incoming analog video & audio as digital, a Composite to HDMI converter
module was included, (see SW3 in schematic).

**VIDEO ID GENERATOR:** To meet FCC identification requirements,
and also to have a source of video for operation in the BEACON mode, some form of
video ID was required. The original 1991 ATV repeater used a simple ID generator,
model VDG-1, from Elktronics. It produced a composite video of four selectable, simple
test patterns with call sign super-imposed on the image. This old ID generator was
removed and replaced with a much improved video ID generator in this new repeater. The original idea was to use a high-definition (1080P), Blu-Ray, DVD player as the source of ID video. An auto-play, auto-repeat disc would be used to provide a continuous stream of HDMI video. The disc would have the repeater's call sign superimposed on each frame of video. A Samsung model BD-F5700 was found that performed suitably, including always starting up properly and running after a power failure. Some other Blu-Ray players failed this test.

I prepared a hi-def (1080P), ID video slide show of about 30 photos and power point slides that gave detailed information about the TV repeater and showed photos of the repeater and it's site. I put the repeater's call sign, W0BCR, on each and every video frame. I prepared the video on my Apple MacBook Pro computer using i-Movie. The video was in H.264 format and stored as a .mp4 file. I then burned a Blu-Ray disc using Toast Titanium program. It performed flawlessly in the Samsung player.

Midway through the new repeater project, Don, N0YE, convinced me to instead use a Raspberry-Pi microcomputer instead of the Blu-Ray DVD player. He felt that in the long term, it would be more reliable and it would eliminate a mechanical device from the system. The Raspberry-Pi is an amazingly powerful computer for only $40. It provides an HDMI output for driving a display monitor. Don and Ken Rawlings, KV5Y, came up with a R-Pi program that would read from a USB flash drive, memory stick an .mp4 file and then play it continuously. "Voila" it worked! I thus elected to use it instead of the Blu-Ray player. The Raspberry Pi was installed in the HDMI switch matrix enclosure.

**HORIZ. SYNC DETECTOR:** For incoming ATV signals, a means was needed to determine when a valid rf TV signal was present. I used the existing circuitry from my original 1997 design. The schematic is found in the appendix, page 6. The circuit basically looks for the presence of horizontal sync pulses at 15.7kHz to determine when a valid TV signal is present. It consists of a buffer amp (Q18), sync stripper (Q19-20), an active 15kHz band-pass filter (U3) and a 567 tone decoder (U4). The logic output from Q24, called "ATV-OK", goes to the Arduino system controller. It works very reliably. Also included on the same board was a 1 in, 3 out VDA (Q14-17).

**AUDIO SQUELCH:** For incoming ATV signals, a means was also needed to squelch out extremely noisy audio from very weak signals. Again, I used the existing circuitry from my 1997 design. The schematic is found in the appendix, page 7. The squelch concept is to look for the presence of an abnormal amount of high frequency noise as an indicator of a "noisy" audio signal. The circuit consists of an input buffer (U5), followed by an 11kHz band-pass filter, a 10X amp, then diode detector to provide a dc voltage proportional to the amount of HF audio noise. With a noisy signal, the dc voltage is high enough that relay K9 interrupts the audio signal path. With normal audio, minus HF noise, the dc voltage drops and relay K9 closes. The squelch sensitivity is set via the front panel, level adjust pot, R55. Also included in the existing circuits was a 1 X summing amplifier to inject Morse code audio from an ID generator. This Morse generator was deleted from the new repeater design. With the new Raspberry-Pi video ID generator, it was felt that Morse code ID was redundant and unnecessary. FCC
regulations only require IDing in either audio or video, but not both. Finally there were three audio line drivers (U10-12) along with a monitor speaker audio amp (U7).

REPEATER CONTROLLER: The heart of the new TV repeater is it's Controller, Fig. 10 above. The detailed schematic is found in the appendix, page 5. I reused my original 1997, WA0NHD-TV repeater controller rack mount enclosure and many of it's circuits. The Elktronics video ID generator board and the Circuit Specialists Morse code ID generator boards were removed. The DTMF decoder and the analog
circuitry perfboard were retained. New items added include 12V, A/V relays and an Arduino micro-computer and a handful of transistors, etc. All of the analog and digital inputs and outputs to the Controller are on the rear panel and are via RCA jacks. A bank of LEDs are provided on the front panel to indicate the status of the repeater. They display the DTMF decoder states along with indicators of valid input rf tv signals and the PTT status. The Arduino is the small, blue, pc board in the lower right of the photo. The DTMF decoder is the green, pc board in the lower left of the photo.

The only reliability issue with the original 1997 design was the use of Radio Shack small signal relays. None of the old relays were reused, but were left in place. I elected to use new 12V relays identical to those used on the reliable DTMF-8 decoder board. They were OMRON model G5V-1 DC12. The string of relays, K1 - K8, are all new and they perform the analog switching in and out of the various composite video sources and line level audio sources. The selected A/V signal then goes on to the horiz. sync detector, audio squelch, VDA and audio line amps previously described which are on the hand-wired perf board.

**ARDUINO:** A $25 Arduino - UNO (www.arduino.cc) micro-computer was used as the system controller. It reads the state of the DTMF decoder to set the receive and transmit configuration of the repeater. It then sets the HDMI Switch Matrix switches accordingly. It senses when a Valid TV signal is present and then keys the transmitter via the PTT line. If the BEACON mode is set, it turns on the transmitter continuously with the ID generator video being broadcast. In normal repeat mode, it turns on the ID generator for a brief interval at the termination of an incoming rf-tv signal. To meet FCC requirements, it also has a 10 minute ID timer. Table I in the appendix lists the various Arduino pins and functions. The computer code for the Arduino was written by Don Nelson, N0YE. It contains about 600 lines of code, including comments.
REPEATER SITE: The Boulder TV Repeater is located in Chautauqua park, Fig. 11, about 800 ft. above the city on the side of Green mountain. Full details are given in reference [2]. It's GPS coordinates are: 39° 59' 41" N x 105° 16' 46"W at an elevation of 5,875 ft. It is housed in a repeater shack, Fig. 12, along with repeaters for the Boulder police, sheriff and fire departments.

Fig. 11 Google Earth view of TV Repeater site, Boulder, Colorado

Fig. 12 TV Repeater shack in Chautauqua Park. The antennas are at 40ft.
OPERATION: The repeater is simple to use. It is an "open" repeater. The only requirement to key it up is to have a valid TV signal. For analog TV, this means simply the presence of 15.7kHz horizontal sync pulses. For DTV, the signal must be in the DVB-T format, on the correct center frequency (1243 or 441MHz) and have a bandwidth of 6MHz. After an incoming TV signal drops, the repeater transmitter has a long ID interval as a trailer. The video slide show is played during this trailer. The trailer is 3 minutes duration for DTV and 30 seconds for ATV. The trailer can be useful to determine if you are in fact able to key up the repeater.

The repeater has several modes in which it can operate. The normal mode is: input = 23cm DTV, output = DTV. For selecting other modes, a control operator needs to send the appropriate DTMF commands to the repeater on the control frequency. The codes are listed below in the table. The control frequency and the password are confidential and are only given to authorized control operators.

<table>
<thead>
<tr>
<th>Control Code</th>
<th>FUNCTION</th>
<th>( * )</th>
<th>( # )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BEACON - continuous playing slide show video with ID on each slide</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>2</td>
<td>Receiver Band Switch</td>
<td>70cm</td>
<td>23cm</td>
</tr>
<tr>
<td>3</td>
<td>Receiver Mode</td>
<td>ATV</td>
<td>DTV</td>
</tr>
<tr>
<td>4</td>
<td>Transmitter Mode</td>
<td>ATV</td>
<td>DTV</td>
</tr>
<tr>
<td>7</td>
<td>Transmitter Disable</td>
<td>OFF</td>
<td>Enabled</td>
</tr>
<tr>
<td>8</td>
<td>System Master Reset - also reboots the DTV modulator (note: 35 second time delay)</td>
<td>Reset to # State</td>
<td></td>
</tr>
</tbody>
</table>

Control Sequence: Password + Function Code + either a * or #
Example: To turn on the Beacon, key in xxx 1 *

RE-BOOTING: Many modern day digital devices occasionally "hick-up" and go stupid. For most, the simple solution is to do a power cycle "Re-Boot". The Hi-Des equipment is no different. Thus, the user might sometimes find the repeater system is acting "funky". In this case, a re-booting is suggested. To re-boot the DTV receivers, simply cycle back and forth the DTMF receiver mode (3). To re-boot the DTV modulator, simply cycle back and forth the DTMF transmitter mode (4). A system master reset command (8) also re-boots the modulator. Re-booting is not available (at this time) for either the Arduino nor the Raspberry-Pi micro-computers. All equipment reboots and returns to the default state (#) upon a power failure and reactivation of the AC power line. There is no DC battery back-up to the TV repeater.
COVERAGE AREA: The Boulder TV repeater gives good coverage over the eastern half of Boulder County. It does not penetrate into the mountains in the western half of the county. Its signal reaches out at least 35 miles to the south-east to the Denver international airport. Fig. 13 above shows the predicted coverage area for ATV transmissions. This map was generated using the Longley-Rice computer program [8]. For additional reading on 70cm DTV propagation, see reference [9]. The confidence
level, time availability and location availability were all set to 50%. A key assumption made in the program was for a simple 1/4 \( \lambda \) monopole vertical, whip receive antenna at a height of 1.5 meters. This is the equivalent of having a mobile receiver in an automobile. Obviously, using better and higher antennas will enhance this coverage area. The results shown in Fig. 13 have been confirmed by mobile receiving field trials.

The DTV transmitter coverage of the repeater has yet to be determined. It is anticipated that it will be the same as for the ATV transmitter, except that all of the colored areas in the above map, Fig. 13, will get perfect, P5, digital pictures. Computer simulations and mobile field trials will be performed in the fall of 2016. The results will be reported in a future application note.

REFERENCES:

2. www.qrz.com enter call sign W0BCR, KH6HTV is the trustee

Note: KH6HTV Video application notes are available to be down-loaded as .pdf files from the web site: www.kh6htv.com

APPENDIX: The following pages are supplemental information. They contain the detailed schematic diagrams and the Arduino pin assignments and functions. The Arduino computer program is not included.
# TABLE I  --  ARDUINO -- LOGIC INPUTS & OUTPUTS
## PIN ASSIGNMENTS and FUNCTIONS

Revision 3.1 (8/29/16, kh6htv)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>In/Out</th>
<th>NAME</th>
<th>SOURCE/DESTINATION</th>
<th>DESCRIPTION</th>
<th>LOGIC STATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>IN</td>
<td>BEACON</td>
<td>DTMF-8 # = Off</td>
<td>BEACON with R-Pi player continuous playing slide show</td>
<td>HI = Beacon OFF = 5V LO = Beacon ON = 0V from DTMF-8 latching relay #1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* = On</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>IN</td>
<td>R-BAND</td>
<td>DTMF-8 # = 23cm</td>
<td>Receiver Band Switch</td>
<td>HI = 70cm, LO = 23cm from Q1, open collector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* = 70cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>IN</td>
<td>R-AD</td>
<td>DTMF-8 # = DTV</td>
<td>Receiver Mode</td>
<td>HI = ATV, LO = DTV from Q2, open collector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* = ATV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>IN</td>
<td>TX-AD</td>
<td>DTMF-8 # = DTV</td>
<td>Transmitter Mode</td>
<td>HI = DTV, LO = ATV from Q3, open collector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* = ATV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>IN</td>
<td>RESET</td>
<td>from U2, 10 sec reset pulse stretcher</td>
<td>Command to reset to # states and also re-boot the DTV modulator</td>
<td>normal = LOW Reset = HI, 10 second pulse</td>
</tr>
<tr>
<td>7</td>
<td>IN</td>
<td>W23cmOK</td>
<td>HV-120A (23cm)</td>
<td>Red/Green LED detector of Valid 23cm DTV signal</td>
<td>HI = Red, no signal present LO = Green, Valid signal open collector transistor</td>
</tr>
<tr>
<td>8</td>
<td>IN</td>
<td>W70cmOK</td>
<td>HV-120A (70cm)</td>
<td>Red/Green LED detector of Valid 70cm DTV signal</td>
<td>HI = Red, no signal present LO = Green, Valid signal open collector transistor</td>
</tr>
<tr>
<td>9</td>
<td>IN</td>
<td>ATV-OK</td>
<td>ATV Switch, horiz sync detector ckt.</td>
<td>Horiz Sync Detector of valid NTSC ATV signal, either 23cm FM or 70cm VUSB</td>
<td>HI = No ATV signal present LO = Valid ATV Signal open collector transistor</td>
</tr>
<tr>
<td>10</td>
<td>OUT</td>
<td>PTT</td>
<td>Transmitter 19&quot; panel, via DTMF-8 relay #7 &amp; Q7</td>
<td>PTT = &quot;Push-To-Transmit&quot;, DTMF-8 relay #7 is for Disabling Transmitter</td>
<td>HI = transmitter ON LO = transmitter OFF</td>
</tr>
<tr>
<td>11</td>
<td>OUT</td>
<td>SW1</td>
<td>HDMI Switch via Q8</td>
<td>select 23cm DTV rcvr</td>
<td>HI = ON, LO = OFF</td>
</tr>
<tr>
<td>12</td>
<td>OUT</td>
<td>SW2</td>
<td>HDMI Switch via Q9</td>
<td>select 70cm DTV rcvr</td>
<td>HI = ON, LO = OFF</td>
</tr>
<tr>
<td>A0</td>
<td>OUT</td>
<td>SW3</td>
<td>HDMI Switch via Q10</td>
<td>select ATV A/V, 70cm VUSB or 23cm FM</td>
<td>HI = ON, LO = OFF</td>
</tr>
<tr>
<td>A1</td>
<td>OUT</td>
<td>SW4</td>
<td>HDMI Switch via Q11</td>
<td>select R-Pi ID slides</td>
<td>HI = ON, LO = OFF</td>
</tr>
<tr>
<td>A2</td>
<td>OUT</td>
<td>ATV-ID</td>
<td>ATV Switch, relays K7-8 via Q13</td>
<td>inject ID video to ATV A/V output</td>
<td>HI = ON, LO = OFF</td>
</tr>
<tr>
<td>A3</td>
<td>OUT</td>
<td>HDMI-Pwr</td>
<td>HDMI Sw Matrix</td>
<td>dc power cycle HDMI switches 1-5</td>
<td>HI = ON, LO = OFF</td>
</tr>
</tbody>
</table>