P. C. Electronics 2522 Paxson Lane Arcadia CA 91007-8537 USA (c) 2006
Tom (W6ORG) & Mary Ann (WB6YSS) Tel: **(626) 447-4565** m-th 8am-5pm pst (UTC - 8)
24 hr FAX order line (626) 447-0489 Email: Tom6org@hamtv.com
Web site: www.hamtv.com

THINKING ABOUT PUTTING UP AN ATV REPEATER?

By Tom O'Hara, W6ORG © 2005

HERE ARE SOME THINGS TO THINK ABOUT BEFORE SPENDING ANY MONEY

There is no denying the ego boost of being able to say that you put together a repeater, are the owner, or that it carries your call. And sure you will get a lot of verbal encouragement from the local ATVers for you to do it.

Most repeater owners or builders I have talked with over the years have told me their club or group at first was all for it with promises of money and help. But when it came down to it that help disappeared or each had different ideas about how it would be configured or placed. It usually ends up with one or two people doing all the work.

So the first thing I suggest is to plan it all out and then have everyone that is going to be involved have their part, whether it is building something, buying a part or just giving funds, defined on paper. Discuss it all and select a systems manager to see that everything comes together in a timely manner, and a technical manager who makes sure the right components are selected and go together properly. Have each person initial or sign for his part of the project so that there is no miss-understanding months later as to who was supposed to do what and when.

Things will change over the course of the project, and as they do the system manager can up date thetasks and keep everybody informed as to progress and what is needed.

When you nail people down like this you quickly separate the talkers from the doers.

THE SITE

The most important decision after you have all the players is to select the repeater site. Chances are that the highest and best coverage spot already has repeaters on it by other amateurs, business, government, etc. A meeting with the site manager or owner should be set up with only the system manager and technical manager to find out the rental costs, are there U.S. Forestry or BLM permits required, what are the frequencies and power output of other systems that might be of interference potential, site access restrictions, technical requirements, antenna type and placement, coax or hardline length, rack space, etc.

Decide if you are going inband or crossband repeat and horizontal or vertical antenna polarization. Have a meeting with your areas frequency coordination council and discuss the alternatives with them. Coordination is done by site and it's area of coverage which has the most effect on interference probabilities. Keep it friendly and technical. It may take more than one meeting and some testing.

An inband will be the hardest to coordinate due to taking up so much spectrum. See page six for info about the different considerations in the 420-450 MHz band plan. Take it with you to the meeting. Remember you will need at least 12 MHz frequency separation in order for the VSB filters to do their job. I suggest 421.25 output and either 434.0 or 439.25 input.

Crossband has the benefits of taking only one channel on 70cm for an input, and leaving the other for simplex and DX. Low in and high out gives the most performance and least cost to your users because it is very easy to put a preamp at the antenna to save the higher feed line loss with frequency than a transmitter and amp. Most existing ATVers will have a 70cm transmitter for simplex and DX and will just have to add a downconverter and antenna which is much less cost than a whole new transmitter and hard line. Transmitting equipment costs go up greatly with frequency.

The other benefits are users being able to see their own video coming back for more accurate video gain, lighting, and focus adjustments and other testing when no one else is around. It is also easier to sell to the frequency coordinators. The optimum frequencies as far as harmonic relationship and other economic and coordination considerations is 426.25 in and 923.25 or 1253.25 out.

As you can see there are a lot of details to be worked and planned out before the first piece of equipment is bought. I generally tell people to plan on about $3000 on the average before they have a good working machine, and not to just try to get by with what is in the junk box or could be thrown together especially if it is at a shared electronic site - see pages 9 and 10.

The biggest cost will be for the hard line, antennas, and vestigial sideband filters. These items will be of most interest to the site owner as far as physical placement and any technical requirements. The transmitter, receiver, power supply, VOR and ID are actually the easiest to place and take up the least room.

W6ATN OAT Mountain CA 434.0 & 2442 in / 923.25 out ATV Repeater Site

CHECK IT OUT

The next step is to make tests at the planned site to see what the coverage and interference patterns might be. I suggest two trips.

The first time to do it is when the other site transmitters are on the air, and the second when convenient to get most of the ATVers in the area on the air. I know of people who thought they had a nice quiet site when they went up to the hill top on a nice Sunday afternoon with their ATV transceiver and had no problems, but were wiped out by intermods from pagers and RCC transmitters during normal business hours. Or the one ATVer who was your best supporter has a multipath ghost or building blocking the path.

So make your tests over a long enough period of time during the peak use segments of the day that the other transmitters are operating. Get the word out to the local gang about the test hours, day, ATV frequency and 2 meter coordination talk back channel in plenty of time.

Each case of interference is unique and the cure can be equally unique such that it would be a large application note on its own. But most often the cause is insufficient filtering and shielding both by the ATV system and other systems at the same site or within a few miles.

You may find some interference from other mode users quite a distance away will appear with the antenna now quite a bit higher in the air than you have at home. While frequency coordinators may give you a frequency, it is difficult to accurately predict if a distant link or repeater could be seen at your site.

Assuming the site checks out good and your potential users and supporters are happy with the signal strength from your test transmissions at the site, you are ready to start building the machine.

FILTERS AND CABLE

The longest lead item is usually the VSB filters and should be ordered first. I suggest two good sources: TX RX Systems for inband duplexers, or individual filters, and DCI for good low (1 dB) insertion loss and low cost VSB filters. These filters are absolutely necessary in the antenna lines of both the transmitter and the receiver. A low pass filter is necessary in the receive line since VSB filters pass the 3rd harmonic - Mini-Circuits Lab NLP-550.

Next is feed line. All coax needs to have 100% shielding both down from the antenna as well as all interconnects. RG55 double shielded 50 Ohm coax is good for interconnects - While mandatory between the filters and the transmitter and receiver antenna ports, it includes short video, audio, control and DC power lines.

With the antenna line you have performance verses cost considerations. The best line to the antenna would be 1" copper hard line down to Belden 9913 depending on the length you need to run. Up to 100 ft, 9913 at 2.7 dB loss per hundred feet is not too bad. Over 100 feet on 70 cm or on 33 and 23 cm, the largest copper hardline you can afford to keep the loss down to 2-3 dB is the way to go.

Use one continuous run and type N connectors to minimize moisture contamination or connector losses. I do not suggest aluminum hard line as the shield often oxidizes and loosens at the connectors from moisture and wind vibration (job security for many cable company maintenance personnel).

Route the cable separated from other cables as much as possible, especially the receive, to minimize cross talk. After you verify all is well with a power meter check at both the transmitter and load ends of the cable, weather proof all outside connectors with coax seal or 2 layers of vinyl electrical tape. Secure the cable up the tower at different distances to minimize mechanical resonances that can occur in high wind conditions.

ANTENNAS

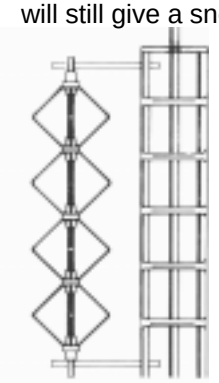
Most all repeater antennas are intended to be omni directional. They will probably only be omni if your antenna is the one in the clear on top. But at any shared electronic site yours will be one out of many at the antenna farm. You may not have many mounting options that would not greatly affect the antenna omni pattern.

All you can do is to try to stick it out 2 or more wavelengths from any other metal supports or antennas on an arm. This is another reason to know what frequency your neighbors are on so you can have the most vertical separation from those closest to your frequency.

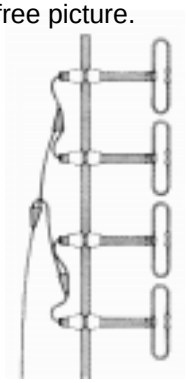
Think of the worst storm in your area you can remember, add many pounds of ice, and then solidly mount your antenna to the structure with that in mind....plus keep your fingers crossed! Support the antenna with a cross arm not only at the bottom, but an insulated one at the top.

When the repeater antenna and coax is installed it is not a bad idea to check out the coverage again, just to see if the mounting didn't happen to put a null right toward the meanest most vocal ATVer in the area. Moving the mounting a few inches can often change the pattern to a new set of conditions.

With all omni antennas, vertical or horizontally polarized, the higher the gain, the narrower the vertical beam width. This could be a problem for those close to the repeater if the site is 500 ft or more above the average terrain. The cure would be a down tilt antenna (usually the resonant length is just above the transmitting frequency for the down tilt) or a lower gain and therefore broader beamwidth antenna. Antenna placement again could be the cause by putting a null right at the wrong guy (another one of Murphies laws). You generally want the highest gain at the horizon in the vertical lobe for DX. The signal is usually still quite strong close in such that the vertical lobe gain roll off at large angles below the horizon will still give a snow free picture.

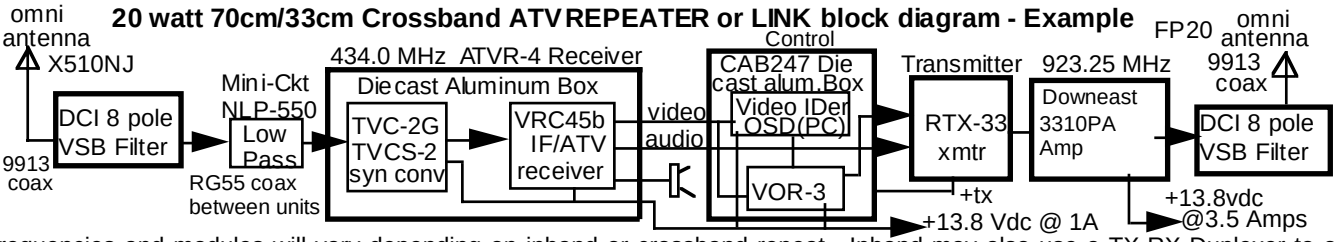


TZU - Zig-Zag horizontal omni (side mounted)



Exposed Dipole broad band vertical omni

Commercial sites may require more rugged commercial antennas than the usual amateur types. Telewave ANT450D6-9, DB Products DB420 and others make 70cm 6 to 10 dBd broadband exposed dipole type vertical omnis for single antenna & duplexer systems. Diamond has a 9.3 dBd vertical stick (F-718) with 3 models to cover 10 MHz segments of the 70 cm band at a relatively low price. These are good for 2 antenna inband systems. Lindsay makes the TZU zig zag horizontal omni for 70 or 23 cm with 4.5 dBd gain and they also have a 8 bay 70cm version with 9 dBd. Olde Antenna Lab quad Big Wheels and HERD Rib-Cage slot horizontal ominis get 6 dBd. The Comet FP20 33cm has10 dBd vertical gain. The F1230 has 11 dBd on 23 cm.



Frequencies and modules will vary depending on inband or crossband repeat. Inband may also use a TX-RX Duplexer to one broadband antenna instead of two. TheVideo Operated Relay is put in its own CAB247 box with an Intuitive Circuits OSD-ID(PC) video ID board, not in the receiver or transmitter box. The high current power amp must have its own separate power supply. See more repeater examples and priced out parts lists on pages 9 and 10.

OK, you have checked out the site, coordinated the frequencies, gotten the antenna(s), feedline and filters, now for the fun part, the repeater itself.

Repeaters tend to evolve and change over a few years so a modular approach makes much more sense than putting it all in one chassis or enclosure. It also allows changes and additions to be made easily without having to make many trips to the hill top to bring the system down to the bench for major surgery. One trip to the hill to sub or plug in a small module also saves the wrath of the flock that have no patience for down time.

To start, there are 3 basic active modules: The transmitter, the receiver and the control/ID units. See the block diagram. Each should be mounted in it's own completely shielded box with appropriate coaxial connectors for inter-connection. They can be bolted to 19" panels if they are to be put into a rack at the repeater site.

RTX series Transmitter

I like the LMB CU247 diecast aluminum boxes, but there are others that have complete contact along all seams. The shielding is absolutely necessary to keep your transmitter, and any others near by, from desensing the receiver. You would be surprised how RF can get through cracks in chassis and less than 100% shields in coax.

It is possible to shield and filter effectively. I had interference free weak signal video at my 434 MHz input repeater sharing the same building and antenna structure with five 70 cm FM repeaters and links. Some ATV repeaters share a site with megawatt UHF broadcast TV stations.

DC lines can be fed thru the chassis with 500 to 1000 pF feedthru caps. Audio and video lines should be coaxial connectors with bypass caps mounted right at the connector with as short of lead length as possible. I use 100 pF for audio lines and video lines. Do not use beads on video lines.

I suggest double shielded or aluminum foil + braid coax for all interconnections. Any lead that is not 100% shielded and bypassed at the connector is likely to become a poor but significant antenna to conduct unwanted RF into the box.

TRANSMITTER

Careful attention must be made to all internal RF connections and connector assemblies. Any VSWR in the transmitter that makes the reflected energy travel on the outside of the the coax and over every nook and cranny of the box can reach the receiver.

Many do not realize that a good VSWR reading outside of the transmitter box does not mean the interconnecting coax from the transmitter board to the chassis connector is good. Coaxial integrity in the receiver is also important to keep unwanted ground currents from sneaking inside.

So keep the RF inside the coax as much as possible with very short center conductor and shield leads. It does not make much sense to pay the bux for a good quality VSB filter to have it bypassed by poor shielding and construction practices.

Run RG-58, 55, 6 or 8 coax for the leads to the power supply to minimize pickup or radiationto or from the transmitter. You can use the same supply as the receiver if the transmitter draws 1 Amp or less, but all power leads must connect directly at the power supply terminals, not to a junctionstrip on leads away from the supply.

Make sure that all composite video inputs are resistively terminated in 75 Ohms, and that all output waveforms are 1 Volt peak to peak with the proper bandpass and setup levels at each module. Do not attempt to compensate for a shortcoming in one module by adjusting another, as it will all change as other video sources are added such as the ID, TVRO Shuttle video, links, etc.

The RTX transmitters are available along with companion amplifiers for 70, 33 and 23 cm depending on the band you want to output on. The block diagram example shows a crossband repeater starting with a 923.25 MHz RTX-33 transmitter driving a Downeast amplifier, but you could substitute a RTX-70 driving a 50 or 100 watt amp or a RTX-23 driving the Downeast amp for crossband output or link.

AMPLIFIERS

Closer attention must be paid to driving amplifiers within their linear region with repeaters than the home station. Any non-linearities, intermods, incorrect setups by the users stations will be multiplied by those present through the repeater. Another factor is the possibility of 100% duty cycle and continuous unattended operation.

For reliability reasons the amplifiers are purposely run at 90% of the peak power capability for best linearity. The repeater version of many amplifers are constructed as a 19" rack panel that is all heat sink and or have a fan.

But more important, the sync tip is set to not exceed 90% so that the sound subcarrier riding on the sync at -15 dBc has the head room to swing just up to but not exceed the 100% power level. If the sound gets squashed on the sync tip there might be some audio buzz added. Likewise, the video gain must be set not to exceed 10% power swing on the white areas.

Intermod generation goes up at higher power swings which raises the sideband noise and video modulation products such that the VSB filters will not

be able to reject them enough to keep them out of the repeater receiver.

Also it is desirable to run the color burst down at a level that does not get too far into the amplifiers compression level. If each amplifier starting at the users transmitter and amp up through the repeaters receiver and amp compresses or rolls off the color burst a little it will add up to loss of color on all but the strongest stations.

So it is better to underdrive a repeater amp than over drive it for many reasons. If need be in the case of overdrive, the insertion loss of an additional bandpass filter, fixed coax attenuator or long length of double shielded coax can be used at the lowest level to insure linearity.

The RTX transmitters 1.5 Watts pep will properly drive the recommended amplifiers without attenuation and near peak power capability. But if the TXA5-70d/PA5 20 Watt module system is used to drive a Mirage D1010ATVN-R, follow the final amp p.e.p. output and pedestal setup proceedure to drop the power down to the linear range. The adjustments are on the TXA5-70d board. An additional VSB filter is required between the duplexer and D1010NR for a single antenna inband repeater system for additional desense prevention.

Air should be blown across any repeater amplifiers fins even if rated for 100% duty cycle to insure that heat does not build-up especially in a cabinet.

The Mirage repeater amplifiers do not have any filtering on the 13.8 Vdc power leads. They can act as antennas to pick up stray radiation inside the amp shield and re-radiate it outside to cause reseiver desense. You can wrap foil around the leads to help minimize radiation, or better yet is to mount a SO239 connector on the chassis after punching the the red lead hole out to 5/8" dia. and drilling 4 holes for the flange mounting screws. Sand paper the anodize around the holes for good ground contact. Run the red and black wires internally to the SO-239 connector and add some 100 pF bypass caps with short leads from the center red lead pin to the ground lug under one of the connector mounting screws that has the black wire soldered to it. Run RG-213 with a PL-259 plug to the power supply. Any amp drawing more than 5 Amps should have its own power supply and the leads as large and short as possible.

RECEIVER

All ATV repeater receivers should be crystal controlled. Even a temperature stabilized free running oscillator will slowly change frequency with age, dust accumulation, oxidation, etc. Once the machine is up and operating well, you probably will not want to make several trips to the hill top to just tweek the LO back on center frequency.

ATVR-4 complete ready to go ATV repeater receiver

Outputs from the receiver module should be one or two composite video and one line level audio. The receiver composite video output standard is 1 V peak to peak into 75 Ohms just like it is for cameras and other video devices. It is handy to have one video output to go to the transmitter, and another one to go to a local monitor to aid monitoring and adjustment while at the site. It could also go to a crossband repeat or link transmitter.

The line audio is also about 1 volt peak to peak but operates into a 10K high impedance or 600 Ohm load. Another nice feature is to have the audio squelched to keep the audio noise down with the weaker video signals that can key up the horizontal sync operated relay but are not strong enough to quiet the sound. A local speaker amp is also of benefit for monitoring at the site. The ATVR series of receivers have all these features.

Especially for an inband repeater, a separate power supply from the one used by the transmittermust be used if the transmitter draws more than 1 Amp. There could be some conducted interference on the common power supply lines, and the final amp varying load with video modulation could set up a feedback path through the receiver. Run RG-58 coax for the power lead directly to the power supply terminals.

I recommend single frequency conversion directly to the standard 45.75 MHz TV IF as in the ATVR receiver rather than to a channel 3 TV receiver. A channel 3 receiver has a free running LO that can drift, and also more possible system mix and image products from strong near-by transmitters.

The 45.75 MHz TV IF SAW filters are made to favor the lower vestigial sideband. To properly receive the standard upper VSB, the local oscillator in TV tuners is above the receiver input frequency to invert the VSB. So if you have a downconverter for channel 3, it is not just a simple matter of moving the local oscillator up 15.5 MHz to output on 45.75 MHz instead of 61.25 MHz. It actually has to be moved up to 107 MHz.

Many new repeater receiver systems start out having way too much system gain which ends up being swamped by the stronger ATV stations and makes it more susceptible to intermodsand desense cycling.

Total receiver gain should be just enough to start the video AGC voltage to move on noise. Any more gain does not improve sensitivity, it just pumps up the AGC with the amplified noise floor. Adding preamps ahead of a good preamp in the downconverter most often does not improve sensitivity but rather gives more intermod interference produced in the overloaded first mixer or following stages.

To check your system just measure the video IF AGC dc Voltage, not the RF or delayed AGC, with the downconverter turned off and then see if it changes much when turned back on. Ideally the voltage change should be slight assuming no signal input and properly terminated.

The noise floor in most TV receivers is no better than 10 microvolts due to the noise power floor with the 3 MHz 3 dB bandwidth of the video luminence amplifiers to minimize intermod with the 3.58 MHz color amplifiers. The preamp stage should have the best noise figure device possible to get as close to the 1 uV as you can. But you may have to dump some gain with resistive attenuation between the downconverter and the receiver to also have wide dynamic range.

You want to get the weakest signals but at the same time be able to

accommodate that guy 2 miles away who won't turn off his 100 Watt afterburner and wonders why the repeater picture is rolling and distorted from clipping. The RF or delayed AGC which controls the preamp gainis set to start between 150 and 200 microvolts. This level is considered snow free, or P5, for ATV.

ID AND CONTROL

FM voice repeaters key by means of a carrier operated relay from limiter current or squelch, or by sub-audible tone (CTCSS) decoder. The same can be done with ATV, but with the wide band nature of video and all the other modes that can get into the passband, a video operated relay is more commonly used.

A video operated relay (VOR) looks for valid horizontal sync out of a sync separator. The probability of false keying from radar, voice or digital modes is low since the signals must first go through a sync separator and then a tone decoder at 15734 Hz. To further protect from unwanted signal capture, a time delay of a second or so of valid horizontal sync can be designed in before keying the actual relay that applies the voltage to the transmitter exciter. DC power to the final amplifier is left on at all times.

The PC Electronics VOR-3 or ATVC-4 board have an exciter B+ relay, timers and another relay for switching between the received video and a video ID or to key a MCW ID (Comm. Spec. ID-8) to meet legal requirements. You must identify with legible letters in the video or by audio within every 10 minutes of continuous and at the end of a transmission (97.119). The OSD-ID board will generate an ID video and/or the ATVC-4 controller board has a MCW ID.

While the FCC rules used to say that a repeater must turn off within 5 seconds, it was a common practice before as is now to keep the video ID and repeater transmitter on for 5 to 30 seconds after some one dropped their transmitter in order to have some video signal to tune their receivers or align their beams to.

Some illegally have video ID or other locally generated video turned on by anyones two meter tones. FCC rules forbid primary control below 220.5 MHz. One possible way around that is to also repeat the 2 meter audio on the sound subcarrier in which case it is a crossband repeater in the same mode and the video secondary.

Turning on the ATV repeater transmitter with video ID by a timer with no one inputting to the machine (beacon mode) is also illegalbelow 902 MHz. These are grey areas that are usually not challenged but, you as a repeater owner should be aware.

SOME WHISTLES AND BELLS

Once the basic machine is up and running, the real fun begins by adding some additional functions.

Mixing in the local 2 meter ATV calling frequency at about half the incoming ATV sound level helps everybody hear those that are on opposite sides of the hilltop or too far away for normal 2 meter simplex communications or for repeaters that are not co-located. The Intuitive Circuits ATVC-4 can mix 4 audios plus the remote control audio, scan or select up to 4 video inputs - Space Shuttle, weather radar, links from other ATV repeaters, video S-meter from the OSD-SSM board, remote camera, - do the ID timing and switch in the on board MCW ID or external video ID. Both the VOR-3 and the ATVC-4 have a beacon mode where you can transmit the video ID every 10 minutes for testing or DX purposes.

The OSD series of video overlay boards canboth ID as well as give other text info about the repeater.

The DTMF-8 Controller Board has 8 relay outputs which should be more than enough to switch relays for various video and audio sources and even special modes for camera pan and tilt. You can parallel as many DTMF-8's as you want with their own access codes.

I suggest the decoder be connected to the incoming sound subcarrier to make it easy for ATV transmitting stations to use. A timer can be added to limit the on time if the users video goes away and they forget to return it to normal repeat mode.

TWO ANTENNAS VS DUPLEXER

This question is asked a lot by those about to put up an inband 70 cm repeater. A crossband repeater has such freguency separation that simpler single bandpass filters in each antenna line may be good enough, but an inband ATV repeater has much tougher requirements.

The broadband noise out of an amp with just carrier is probably no better than 70 dB. Add to that the video source noise at 40 dB additionally rolled off by the video modulator, amp intermod and sideband harmonics and you have a lot of energy next door waiting to go into your 1 to 2 microvolt receiver.

If you have a 100 Watt amp, the peak power is 157 dB above a microvolt. Depending on what the actual transmitter noise and video sideband harmonic level are from all causes at the receiver passband, the VSB filter on the transmit antenna line has to knockall that noise and sidebands down to below one microvolt.

Also the receiver VSB filter has to knock the transmitter carrier as well as sideband power down to at least 1/10 milliwatt (70 dB below 100 Watts) so as not to overload or intermod with the downconverter preamp or mixer.

This is a tall order for a filter with low insertion loss and a flat 6 MHz bandpass. A good quality VSB filter has 80 to 100 dB of rejection 12 MHz away. It also means no leakage from poor shielding or coax around the filters. The TX-RX Systems 26-66-01A Duplexer or the individual DCI 8 or 10 pole VSB filters do a good job with less than 1.2 dB insertion loss. But we still need at least 50 dB more attenuation to prevent overload or desense.

With a two antenna system you need vertical separation. Regardless of polarization, an omni will have a minimum field above and below it. The higher the gain the greater the isolation at the same distance, since the vertical lobe is narrowed. For the old Phelps Dodge 10 dB stick Station Masters, 20 ft end to end gave about 50 dB at 450.

If your antenna is less than 10 dBd, but you don't have much room on the tower to get added separation, try finding a magic null point. Fix the transmitting antenna at its location on the tower and transmit. Connect a spectrum analyzer or other calibrated signal strength device to the receiver coax without the VSB filter. Have someone slowly move the receive antenna up and down on the tower to

find a minimum point and lock it in place.

With the TX-RX 70 cm duplexer to a single broadband antenna, another VSB filter from DCI or SI can be put in the line between the duplexer and amp to get the added rejection. If you have excess drive you can try putting the filter between the transmitter and amplifier, but the amplifier IM products may exceed the 50 dB requirement. In either case do not over drive or over modulate, or else the sideband harmonics may capture your receiver and make it cycle between the video ID and noise.

70 CM ATV FREQUENCY SELECTION CONSIDERATIONS

Here are some pros and cons to consider when determining the ATV bandplan for your area. Only 2 frequencies can be used for ATV without a high probability of mutual interference as well asto leave plenty of space for other modes. The choice must also be made between an inband repeater with simplex shared on the repeater input or output, or a repeater input with crossband output and a separate simplex channel.

421.25 MHz

This is most used output for repeaters and requires a VSB filter in the antenna line of every transmitter to keep sidebands and final generated intermods from interfering outside the amateur band below 420 MHz. The channel occupies 420 to 426.0 MHz and corresponds to cable channel 57. It is listed in ARRL bandplan for ATV repeater or simplex, but shared with control links and experimental. I recommend it for repeater outputs only, since the VSB filter requirement for each user is impractical.

FM or packet links, control, etc. can then use 426.0 to 431.0 with 3 MHz channel splits. This gives 80 duplex 25 kHz channels and 40 simplex channels or less combinations with some multiple adjacent channels used for higher baud rate or voice fidelity. Packet can use 431.0 to 431.6.

426.25

This is the most popular simplex or secondary channel. Half of all our transmitters sold to date have had this frequency requested. There has been least interference noted on this channel in the lightly populated areas. Most used by state and local government amateur radio emergency groups, R/C modelers, robots, and special purpose video links.

426.25 MHz is uggested as a good crossband repeater input, however other mode users at the bottom of the band should be high in low out near the same site to prevent overload.

Sometimes 426.25 is used as a repeater input for crossband or when 439.25 is used as an output in active 440 FM areas.

The channel bandwidth is 425.0 to 431.0 MHz. Other modeswould occuply 420 to 425 MHz. Channels at 421.75 and 422.67 +/- 200 kHz (32 NBFM channels out of the 120 possible) should be assigned last when all others have been filled, and only at which time VSB filtering would be required of those having enough LSB color or sound subcarrier power to actually cause interference.

427.25 MHz

Used in a few areas instead of 426.25 because it corresponds to cable channel 58. Listed in ARRL band plan solely for ATV simplex, not shared. However, 426.25 was preferred to minimize possibility of the 427.25 sound subcarrier at 431.75 from overloading any near by 432.0 weak signal or EME receivers. Today modern narrowband weak signal receivers generally have enough dynamic range and rejection. Occupied bandwidth is 426.0 to 432.0.

This channel would give 40 more 25 kHz channels (total of 120 from 420-426 MHz) for FM Voice links with 422.75 and 423.67 +/- 200 kHz to be skipped.

434.0 MHz

It's the most popular input frequency to switch to when local FM repeaters fill in below 444.0 or use high in/low out in areas using 439.25 ATV. This frees up to 200 FM voice repeater channels from 440 to 450 MHz. 433.25 MHz, cable channel 59, would have been the logical choice, but weak signal users were concerned about sideband energy at 432.0. While this frequency uses 432.75 to 438.75. Experiments showed most energy down ≥40 dB and random at any one spot frequency 1 MHz from the video carrier. This is below the FCC bandwidth definition of bandwidth (-26 dB) so technically does not violate the repeater prohibition in the 435-438 satellite segment. Vertical polarization also minimizes energy to 432 MHz DXers who are horizontal.

FMinks would be located between 438.7 and 440.0 MHz instead of 433 to 435 MHz. Simplex packet would be at 431.0 to 431.6 MHz.

Experiments with satellite users showed no interference between 435 to 438 MHz except for one person within a mile with beams pointed right at each other. However satellite uplink stations greatly interfere with video down to -40 dBc. Since satellites are not in view for very long, the convention is when the video gets hit with uplink signals, wait for 15 minutes, and come back later when the pass is over.

Alternately if the video is important, like a public service event, etc., known 2 meter calling frequencies are used to work out a temporary schedule on a gentlemanly basis. In Southern California the Satellite users are on 144.144 USB, weak signal operators on 144.170 USB, and ATVers 146.43 FM.

Likewise if there is a UHF contest we give up ATV for that weekend, and in fact we get on and give the contesters some points.....helps change their attitude about sharing the band. They stay off during the Rose Parade and some of the other public service events the local ATVers do.

439.25 MHz

Occupied bandwidthis 438 to 444.0 MHz and corresponds to cable channel 60. It's the most popular frequency east of the Rockies for repeater input or DX simplex where UHF FM repeaters have not filled up the 40 25 kHz channels from 444.0 to 445.0 or are high in/low out. Some use 439.25 for repeater output and 426.25 as an input if UHF FM repeaters give too much interference and 434.0 is not available.

It is the only frequency available to those in Canada or above the A line per the ARRL band plan. Some have used 434.6 DSB or 434.0 VSB or without sound subcarrier in Canada. Also some repeater inputs have favored the lower VSB instead of the upper, when unable to get FM repeaters to stay above 444.0.

439.25 is listed as an ATV repeater input in the ARRL Repeater Directory

70 cm band plan. However 442-445 is also shown as FM repeater inputs or outputs. This is incompatible as FM will tear up a video signal if below 444 and a video signal will interfere with FM if on 442.83 or 433.75 +/- 200 kHz, the color and sound subcarrier frequencies. But this is what you get when ATVers do not take an active and technical part in the band planning and spectrum management.

Optimum FM repeater offset would be low in and high out to keep any nearby or at the same site FM transmitters from overloading the ATV repeater receiver, even with a good VSB filter. Since there is likely to be so few ATV repeaters in any given area, those FM repeaters closest or at the site should be placed as high in the band as possible. Use of CTCSS by all FM repeaters is recommended.

CROSSBAND REPEATER

The 33 cm band (902-928 MHz)DX is roughly half that of the the distances listed on the 70 cm table. While this makes an inband 70 cm machine look more desirable, the 6 dB difference can be compensated for with the smaller, higher gain antennas and antenna mounted preamp by the users.

A crossband repeater with its output on 33 or 23 cm, although having more path loss than 70 cm, may still be well within the antenna height RF horizons for snow free pictures within your coverage area. The benefit of freeing up the other 70 cm ATV channel for simplex and users being able to see their own video coming back is well worth serious consideration.

23 cm(1240-1300 MHz) is suggested over 33 cm in the more populated areas since amateurs share this band with many other services that have priority such as vehicle location.

Cross-banding makes it easier to link into adjacent repeater areas. If your area outputs on 33 cm and the adjacent one on 23 cm, than all that is necessary to link is a receiver on the others frequency. The video can be selected via tone control to repeat the 70 cm receiver or the adjacent areas repeater outputs receiver.

Another selectable crossband receiver can also be used for special purpose links to bring in Space Shuttle video from someone's TVRO, weather radar video, or other public service event that needs to be keyed in for long periods without chance of some one accidently coming up on the normal repeater input.

The 70cm 420-450 MHz distance miles are in the order of 1.5/20/50/100 Watts.

TRANSMIT	0 dBd Dipole	9 dBd Diamond F718L	16 dBd DSFO-25 beam
RECEIVE			
DIPOLE 0 dBd	.9/3.4/5.5/7.7	2.4/8.5/14/20	6/21/34/48
5L-70cm 8dBd	2.3/8/13/19	6/22/36/50	14/53/84/120
DSFO-25 16dBd	6/21/34/48	15/56*/88/126	37/133/210/300

33cm 902-928 MHz band will be half the 70cm distances, and 23cm 1/3.

Distances are line fo sight, P5 snow free pictures. For P4 pictures multiply the distances by 2, P3 by 4, etc.

ATV REPEATER DX

While it is almost impossible to predict actual ATV DX due to different terrain and conditions, the line of sight snow free picture distance can be calculated given all the controllable factors. We must know the transmitter peak envelope power (p.e.p. - sync tip), coax loss, and antenna gain over a dipole. At the receive end, we must also know the system noise figure and bandwidth. The chart assumes no antenna obstructions between them, TVC-4G GaAsfet downconverter, or TC70 Transceiver connected to a good TV set with 3 MHz IF bandwidth, 3 dB loss in coax at both ends, and snow free defined as a carrier to noise ratio of 40 dB (about 200 microvolts).

The distances in miles are shown in the order of 1/20/50/100 Watts which is the RTX70-1 by itself, RTC-70S (20W), RTX70-1 driving a Mirage D26N (50 Watt) or Mirage D100ATVNR (100 Watt) linear amp. To find the possible DX under line of sight conditions find your antenna model or equivalent gain across the top. Then go down to the receive ends antenna or gain. Now read the miles that corresponds to your transmit power.

The purpose of the DX chart is to enable you to better figure what is needed in your system to have the best chance of getting good pictures where you want them. This is especially important to repeater owners or those setting up for a public service event to figure the expected area of coverage.

The Diamond F-718 antenna used on two antenna in-band machines is an example of a popular high gain broadband omni vertical that is used for inband repeaters with a duplexer or at base stations. The DB Products DB420 exposed multiple dipole array is close enough in gain also for comparison. If a repeater is running 50 Watts to a DB420 or F718 omni, it could be snowfree to a station 56* miles away using a 5L-70cm beam. Distance will double or half with each 6 dB change.

There is no accurate way to figure non line of sight conditions due to obstructions or terrain. Different structures and foliage have different attenuations at different frequencies. I have measured 20 dB of change dropping just 5 ft below the top of a Walnut tree 50 ft from the antenna. I could still see the repeater through the leaves and branches.

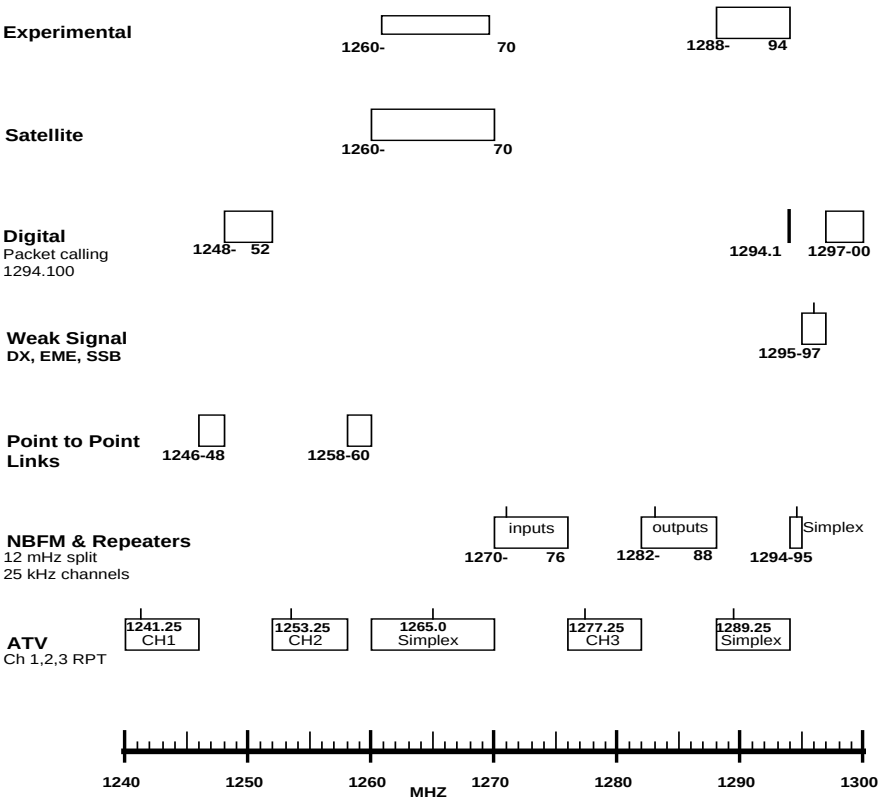
Normal RF horizon if the land were perfectly flat is only 10 miles from the top of a 50 ft tower. If raised to 100 ft it goes to 14.1 miles. If you are lucky enough to have a 5000 ft above average terrain mountain top to put your machine on, the horizon is now 100 miles. The distance in miles equals the square root of twice the height in feet. For more info see the 1986-94ARRL Handbook chapter 22 or 94-02 books pg 21.20.

This means that the line of sight calculations are valid, assuming no obstructions, if the sum of the repeaters RF horizon and the users RF horizon are equal to or less than the distances shown on the table.

Temperature inversion ducting can make UHF signals skip almost like HF ones giving DX many hundreds of miles. However if the repeater antenna is on a hill top that is above the inversion layer, it can act as a lossy barrier. Best time for inversions is around sunset in early summer, but conditions vary in all parts of the country.

23CM BAND PLAN & USAGE

May vary in different areas, checkwith your local Frequency Coordination Council



Weak Signal: CW, SSB, SSTV, FAX, ACSB, & narrow band experimental. No FM. 1296.1 SSB Calling.
FM Simplex Calling: 1294.500.
Novice SSB Calling: 1294.900 (1294 .8-1295.0).
Packet Calling: 1294.100 (1294.0-1 294.2).
Remote base simplex calling: 1294.700.

23cm Snow free line of sight Miles per 1/18/35/100 Watts

		omni	beam
XMIT.	0 dBd	10 dBd	16.3 dBd
	Dipole	Diamond F1230	2424LYRM
REC.			
Dipole	.4/1.6/2.5/4	1/4/6/10	2/8/11/20
Diamond F1230	1/4/6/10	2.3/10/14/24	5/20/28/50
2424LYRM	2/8/11/20	5/20/*28/50	10/42/59/100

Similar to the 70 cm example, the snow free line of sight DX of a 1253.25 MHz crossband repeater output running 35 Watts from a RTX-23 driving a Downeast amp to a 10 dB omni will get *28 miles snow free P5 pictures to someone using the 24 element, 6 ft long loop Yagi. The RF horizons would just make it if the two towers were at 100 ft each or more likely the repeater at or above 200 ft and the user at 50 ft.

If you still had line of sight past 28 miles to the repeater, you cound get P4 pictures up to twice that distance. 8 of the Southern California repeaters are crossband to 23cm with good pictures over 100 miles. The 6000' mountain range with all the repeater sites on the tops really help.

Some of the 23 cm Southern California ATV repeaters are linked to their adjacent 33 cm neighbors via 2.4 GHz FM ATV. ATN links Las Vegas Nevada, Los Angeles, San Diego and Santa Barbara California ATV repeaters together. Plans are to link with Phoenix AZ and Tucson next.

The 23 cm band has 5 AM ATV channels which can be used for combinations of repeaters, links and simplex. If FM ATV is desired, it will take up two of the AM channels at the bottom of the band below 1260 MHz. You will have to work out shifting of the other mode users with your local coordinator. We suggest 1252 MHz. With 4 MHz video deviation and 5.5 MHz sound, the occupied bandwidth is 19 MHz. 2442 MHz FM ATV is also used for repeat or link using low cost converted part 15 license free gear with line of sight DX up to 25 miles running 100 mW.

EQUIPMENT SOURCES

ATV Research - remote cameras
Box 620, Dakota City NE 68731
(800) 39203922

CMC- Sinclair - 70 cm antennas
7020 Hayvenhurst Ave #E
Van Nuys CA 91406
(818) 994-4455

DB Products - antennas
POB 569610, Dallas TX 75356
(214) 631-0310

DCI - 70, 33, 23 and 13 cm VSB filters
PC Electronics (626) 447-4565 or
Box 293, 29 Hummingbird Bay
White City, SK, Canada S0G 5B0
(800) 563-5351 dci@dci.ca

HERD Elect. Rib-Cage Slot Horz. omni
2596 Church Rd, York PA 17404
(717) 764-4805

HI-Spec - 100W 33 & 23cm ampsPOB
387, Jupiter FL 33468
(407) 746-5031

Intuitive Circuits DTMF-8 Decoder, OSD-ID(PC) video IDer, OSD-SSM video S-meter and ATVC-4 ATV repeater controller
P. C. Electronics (626) 447-4565

Lindsay antennas - TZU antenna
50 Mary St.
Lindsay Ontario Canada K9V 4S7
(705) 324-2196

Mini-Circuits Lab - NLP-550 low pass
(417) 335-5935

Mouser Electronics - die cast boxes, big catalogue of electronic parts.
(800) 346-6873 www.mouser.com

Olde Antenna Lab - Horiz. Big Wheels
41541 Dublin Dr, Parker CO 80138
(303) 841-1735 W6OAL@aol.com

P.C. Electronics - xmtr, rcvr, ant, etc.
2522 Paxson Ln, Arcadia CA 91007
(626) 447-4565, fax (626) 447-0489
tomsmb@aol.com www.hamtv.com

Telewave - 70 cm antennas
1155 Terra Bella
Mountain View CA 94043
(415) 968-4400

TX-RX Systems - VSB duplexers
8625 Industrial Parkway
Angola NY 14006
(716) 5494700

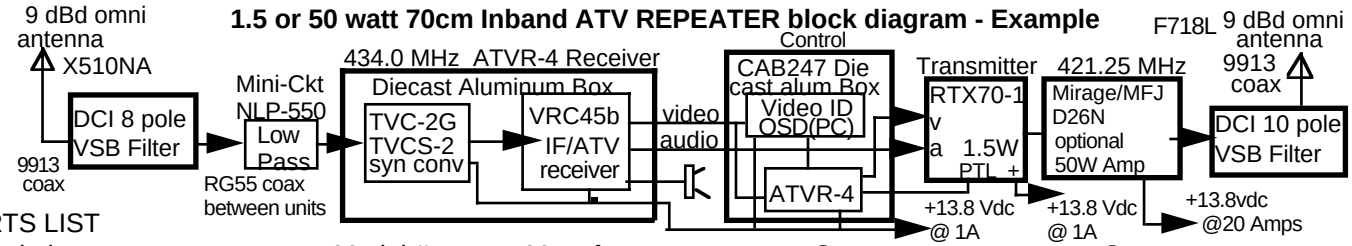
P. C. Electronics 2522 Paxson Lane Arcadia CA 91007-8537 USA

Tel: **(626) 447-4565** m-th 8am-5:30pm pst (UTC - 8) Tom (W6ORG) & Mary Ann (WB6YSS)

24 hr FAX order line (626) 447-0489 Email: Tom6org@hamtv.com
Web site: www.hamtv.com

ATV Repeater Cost Examples

1.5 or 50 watt 70cm Inband ATV REPEATER block diagram - Example

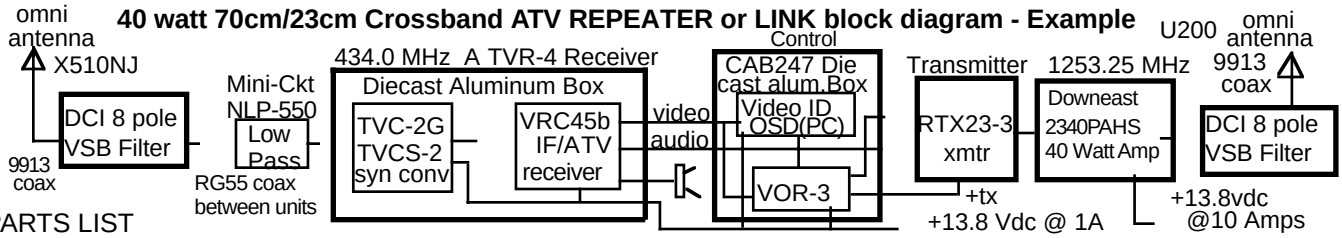


PARTS LIST

Description	Model #	Manufacturer	Source	Cost
Antenna 430-440 MHz	X510NJ	Diamond	P. C. Electronics	$209
Antenna 420-430 MHz	F718L	Diamond	P. C. Electronics	$238
ATV Receiver 70cm	ATVR-4	P. C. Electronics	P. C. Electronics	$299
ATV Transmitter 70cm	RTX70-1	P. C. Electronics	P. C. Electronics	$289
Video Operated Control board	VOR-3	P. C. Electronics	P. C. Electronics	$79
50W (60 w pep) Linear Amp	D26N	MFJ/Mirage	AES	$259.99
70cm VSB filter 421.25 MHz	DCI-421.25-8C	DCI	P. C. Electronics	$449
70cm VSB filter 434.0 MHz	DCI-434.0-6C	DCI	P. C. Electronics	$399
Die Cast Aluminum box	1590D	Hammond	Mouser Electronics	$24
Low Pass inline filter	NLP-550	MiniCircuit Lab	MiniCircuit Lab	$40
Power Supply 13.8 Vdc @ 2.5A	RS 22-504	Radio Shack	Radio Shack	$39.99
Power Supply 13.8 Vdc @ 20A	RS-20M	Astron	AES	$119.95
50 Ohm Coax Cable, 250 ft roll	9913	Belden	AES	$129.95
Video Identifier	OSD-ID(PC)	Intuitive Circuits	P. C. Electronics	$139 (optional)
			Total	$2714.88

Add about $200 for misc. cables, connectors, hardware etc, and mabe a DTMF decoder/relay board to remotely control the system on or off. An Intuitive Circuits ATVC-4 Plus ($349) four input controller can be substituted for the VOR-3 and an old camera for the video IDer. You could substitute a Mirage D100ATVR in place of the D26N for 100 watts out . A fan must be added to the D26N to blow air over the heatsink fins.

40 watt 70cm/23cm Crossband ATV REPEATER or LINK block diagram - Example



PARTS LIST

Description	Model #	Manufacturer	Source	Cost
Antenna 430-440 MHz	X510NJ	Diamond	P. C. Electronics	$209
Antenna1240-1300 MHz	GP21	Comet	P. C. Electronics	$169
ATV Receiver 70cm	ATVR-4	P. C. Electronics	P. C. Electronics	$299
ATV Transmitter 23cm	RTX23-3	P. C. Electronics	P. C. Electronics	$399
Video Operated Control board	VOR-3	P. C. Electronics	P. C. Electronics	$79
40W 23cm Linear Amp	2340PAHS	Downeast Micro.	Downeast Microwave	$400
70cm VSB filter 434.0 MHz	DCI-434.0-6C	DCI	P. C. Electronics	$399
33cm VSB filter 1253.25 MHz	DCI-1253.25-6C	DCI	P. C. Electronics	$399
Die Cast Aluminum box	1590D	Hammond	Mouser Electronics	$24
Low Pass inline filter	NLP-550	MiniCircuit Lab	MiniCircuit Lab	$40
Power Supply 13.8 Vdc @ 2.5A	RS 22-504	Radio Shack	Radio Shack	$39.99
Power Supply 13.8 Vdc @ 10A	RS-12A	Astron	AES	$79.99
50 Ohm Coax Cable, 250 ft roll	9913	Belden	AES	$129.95
Video Identifier	OSD-ID(PC)	Intuitive Circuits	P. C. Electronics	$139 (optional)
			Total	$2,805.93

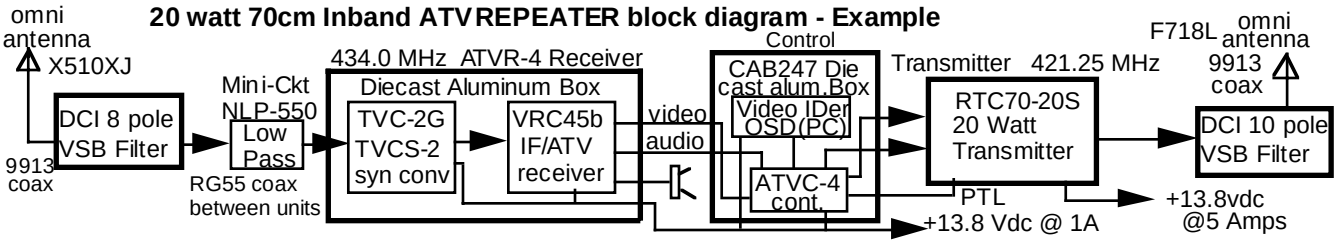
AM or FM Transmitters, antennas and filters may be substituted for higher bands.

P. C. Electronics 2522 Paxson Lane Arcadia CA 91007-8537 USA

Tel: **(626) 447-4565** m-th 8am-5:30pm pst (UTC - 8) Tom (W6ORG) & Mary Ann (WB6YSS)

24 hr FAX order line (626) 447-0489 Email: Tom6org@hamtv.com
Web site: www.hamtv.com

Inband 420-450 MHz ATV Repeater Cost Examples cont.



PARTS LIST

Description	Model #	Manufacturer	Source	Cost
Antenna 430-440 MHz	X510NJ	Diamond	P. C. Electronics	$209
Antenna 420-430 MHz	F718L	Diamond	P. C. Electronics	$238
ATV Receiver 70cm	ATVR-4	P. C. Electronics	P. C. Electronics	$299
ATV Transmitter 70cm	RTC-70-20Sa	P. C. Electronics	P. C. Electronics	$589
Video Operated Control board	ATVC-4 Plus	Intuitive Circuits	P. C. Electronics	$349
70cm VSB filter 421.25 MHz	DCI-421.25-8C	DCI	P. C. Electronics	$449
70cm VSB filter 434.0 MHz	DCI-434.0-6C	DCI	P. C. Electronics	$399
Die Cast Aluminum box	1590D	Hammond	Mouser Electronics	$24
Low Pass inline filter	NLP-550	MiniCircuit Lab	MiniCircuit Lab	$40
Power Supply 13.8 Vdc @ 1A	22-504	Radio Shack	Radio Shack	39.99
Power Supply 13.8 Vdc @ 5A	RS-7A	Astron	AES	$59.99
50 Ohm Coax Cable, 250 ft roll	9913	Belden	AES	$129.95
Video Identifier	OSD-ID(PC)	Intuitive Circuits	P. C. Electronics	$139 (optional)
			Total	$2964.93

See Source list on page 8 for phone numbers.

Remote Tower Mounted Pan and Tilt Camera

A camera at the repeater site can show the sky line, local weather conditions, approaching storms, site intruders, broken antennas and cables, etc. The camera pan and tilt can be controlled by an Intuitive Circuits DTMF-8 decoder from a receiver audio line - be it the repeater receivers sound subcarrier or control receiver. Most pan and tilts run off of 24VAC and can be controlled by the DTMF decoder through relays. If the decoder is mounted in the weather proof enclosure with the camera all you need to run up the tower is an audio tone control line, camera video coax and 24VAC. 12 VDC for the camera and decoder can be recified and filtered from the 24 VAC. Some run the camera video through a OSD-ID(SA) video IDer and use the tower video as the repeater ID source. Otherwise another DTMF-8 decoder or ATVC-4 four input ATV repeater controller must be used to switch the video sources to the transmitter.

ATV Research has the Pelco line of outdoor pan and tilt systems and weather proof camera housings. For their catalogue of these items and cameras call 1-800-392-3922 or see their web site www.atvresearch.com