Antenna Considerations and Range Expectations
ATV Transmitters

The results you obtain with the ATV Transmitters depend on several things. These are as follows, in order of importance:

- Antennas and height thereof
- Expected Picture quality
- Path of propagation of signals
- Geographical Location and Terrain
- Presence of interference
- Receiver Sensitivity
- Transmitter Power

We are frequently asked *by* amateurs, R/C hobbyists, and surveillance users about how much range a given transmitter and receiver setup will have. While it is theoretically possible to predict this in free space, environ- mental factors present on this planet will affect this prediction in an unfortunately negative manner. Like the weather for next year, this is very difficult to predict and impossible to guarantee. It has manufacturer or kinds of circuits. To demonstrate what is involved, we will nothing to do with compare an ATV system to a radio system using a 2 watt handle talkie, such as used by hams, police, or security personnel, etc. These have ranges varying from 1/4 mile in bad locations to 10 or more miles from a good location such as a hilltop. No repeaters will be assumed, just simplex operation to another HT or base setup. Typically, these units have receivers with 0.2 microvolt sensitivity at threshold and small whip antennas with zero gain or less. Bandwidth is typically 13 KHZ for two way narrowband FM.

Remember that ordinary TV broadcast (and most ATV) NTSC format signals need 3 to 5 MHz bandwidth depending on resolution and whether B/W or color the receiver must have this bandwidth Since thermal noise and is directly proportional to bandwidth, a TV receiver will have a much larger background noise level. Assuming the TV receiver and the HT have similar noise figures (3to 6 dB is typical) then the ratio of background noise power is:

$$\frac{\text{Noise of TV receiver} \quad 5\text{ MHz} \quad 5000000}{\text{Noise of HT receiver} \quad 13\text{ KHz} \quad 13000} = 384.61 \text{ or } 385 \text{ times}$$

The TV receiver must contend with 385 times as much noise power as the radio receiver. Also, consider the fact that an 8 08 signal to noise power ratio gives adequate copy on the radio, 8 dB is useless for any picture. Some receivers need at least 10 to 15 08 just to hold sync. You would not watch a TV picture with a 20 DB S/N as it would be very snowy. And 30 DB would still be somewhat snowy. Therefore another 22 DB more signal is needed at the TV set at the minimum. 22 03 is 158 times more received signal power. For a good cable quality picture 45 to 50 DB is the minimum. For ham use the 30 dB figure might be adequate. This means then, 385 X 158 or 60,830 times the signal power is needed at the TV receiver. This is a ratio of *48* DB.

However, this is not as bleak as it may sound. A good amateur installation would use directional Yagi antennas at both receiver and transmitter sites, having 15 08 to even 20 dB gain, low(< 308 NF) noise down converters, and possibly 100 to 200 watt linear amplifiers. This could increase system gain by 15+15+3 or 33 DO, and if a 100 watt linear amplifier is used another 17 DB (assuming a 2 watt ATV transmitter as an exciter). This is 50 dB and even more if 20 DB gain antennas are used, and also higher power up to 1 KW for a total of 70 08 possible. A station like this would have an effective radiated power of 1 to 100 kilowatts. The latter figure is typical of a UHF broadcast station.

A relatively low power transmitter with an effective antenna will tar outperform a higher power transmitter with a mediocre antenna. An average receiver with a good antenna will likewise far outperform a more sensitive receiver with a simple whip or loop antenna. Remember that at UHF propagation is generally restricted to line of sight. If both receiver and transmitter sites have good antennas (10-15 element Yagi or better) and there is a relatively unobstructed path between the sites, ranges of 30 to as much as 100 miles can be obtained. On the other extreme, if simple antennas such as six inch whip antennas are used in rough or hilly terrain, ½ mile would be doing well. In cities with concrete and steel structures this might be reduce, to as little as 100 yards. Therefore the antenna system is the single most important factor in regard to range obtained. At 915 and 1260 MHz simple whip antennas are nearly useless for significant range. And there are no cure-all circuits to improve this. For many years a lot of research has gone into small antennas and there seems no way to get around this. You have to radiate the transmitter power efficiently and at the receiving sue capture as much as possible. It has nothing to do with the kind of transmitter or receiver being used. There simply are no magic tricks. Poor antenna give poor results. Miniature antennas yield miniature results. Theoretically, a small antenna can be efficient but in practice the very low radiation resistances encountered are difficult to match without high losses in required matching networks. Also, bandwidth can be a problem and NTSC television needs 4 MHz for good definition. Some antenna may be a problem in this regard, as for example, long yogis with gamma match feed. On the other hand, big antennas will generally give big results if properly tuned and matched. ATV operation, unlike 2 M FM or HF SS8 operation, is not a “plug together and play” business if you want best results. To get good results, all peripheral equipment must be compatible, properly interfaced, video levels must be correct, and you must make some effort and do your homework on your antenna system.

All antennas have a gain factor expressed in dec[i]bels. Usually this is relative to an isotropic radiator. An isotropic radiator radiates uniformly in all directions, as does appoint source of light. All the power that the transmitter produces ideally is radiated by the antenna. However this is not generally true in practice since there are losses in both the antenna and its associated feedline. The transmitted power is effectively multiplied by the antenna system gain, which is the sum of the line losses and the antenna gain (or loss for many small simple antennas). The gain in Decibels (dB) directly add and may be expressed as a numerical factor. The transmitter power and the antenna gain when multiplied equal the effective radiated power.

Directional gain antennas such as yagi arrays and log periodics increase range and reduce interference and ghosting. Do all possible at receiver before attempting improvements at transmitter end of path. This is the best practice, less expensive, environmentally sound, and good engineering practice, and will reduce RF pollution for other users of the spectrum. Next, install a good directional transmitting antenna and a low loss feedline. Use only low loss coax and if more than 40-50 feet use hard-line, as line losses are very high at 440 MHz and still higher at 915 and 1260 MHz. Also remember that obstructions such as buildings, hills, foliage, and large metal structures can cause shadows in the propagation path, limiting coverage in these areas. This effect becomes more pronounced at higher frequencies. Also, while some “fill” occurs in these shadow areas due to reflections, diffraction, and scattering, multiple paths and reflections can cause ghosting problems. A good directional antenna can help to reduce these effects. The most ineffective way from a cost standpoint is to use more transmitter power. You will be disappointed if this is the way you try to increase range. Good antennas are far more effective than brute force and increased power is ALWAYS the LAST resort.

Some typical figures are as follows. By the way, antenna gain also counts at the receiver in the same way. Always use the better antenna at the receiving site if at all possible.

TYPE ANTENNA	GAIN DB-			IMPROVEMENT FACTOR			ERP WITH 2W XMTR		
Makeshift, no or poor ground	-30	to	-10	0-001	to	0-1	0.002	to	0 2 Watts
Rubber Duckie	-20	to	-2	0 0 1	to	0 7	0 0 2	to	1.4 Watts
1/4 wave whip (poor ground)	-20	to	-6	0.01	to	0.25	0.02	to	0.5 Watts
1/4 wave whip ./ground plane	-2	to	0	0.64	to	1-0	1.3	to	2 Watts
D-cone	-6	to	0	0.25	to	1-0	0.5	to	2 Watts
5/8 wave whip	0	to	+3	1	to	2	2	to	4 watts
1/2 Wave dipole	0	to	+3	1	to	2	2	to	4 watts
vertical collinear	+3	to	+6	2	to	4	4	to	8 Watts
3 element Yagi	+3	to	+8	2	to	6	4	to	12 watts
Log Periodic array	+5	to	+9	5	to	6	10	to	16 watts
Corner Reflector	+6	to	+10	4	to	10	8	to	20 watts
Helical Antenna	+8	to	+13	6	to	20	12	to	40 Watts
10 element Yagi	+10	to	+12	10	to	16	20	to	32 watts
15 element Yagi	+14	to	+15	25	to	32	50	to	64 Watts
4 stacked Yogis, 15 el or larger	+17	to	+20	50	to	100	100	to	200 Watts
Oish, Parabolic	+15	to	+25	32	to	316	64	to	732 Watts

(Practical at 915 & 1260 MHz)

- *GAINS ARE PRACTICALLY OBSERVED IN ACTUAL USE, NOT THEORETICAL FIGURES.*

You can see the dramatic difference in using good antennas. To increase range do the following, in order of priority:

1) Use a better receiving antenna with 8 DB or higher gain_
2) Use a low noise downconverter and/or a low noise preamp.
3) *Increase height of receive antenna_*
4)Make sure to use low loss feedlines, as short as possible.
5) *Increase height of transmitting antenna.*
6) Use a better transmitting antenna if possible.
7) *If possible use B/W instead of color video.*
8) If audio is unnecessary, disable sound subcarrier - reduces bandwidth. 8) Increase transmitter power only as a LAST RESORT.

For more antenna information consult a good text on antennas or the ARRL Handbook or ARRL Antenna Handbook, as well as manufacturers literature.

SIMPLE ATV ANTENNAS YOU CAN HAKE

A good antenna is important for good results, but a few simple design, that can be easily built out of readily available materials will be presented. Thesewill be a 1/4 wave ground plane, a 3 element yagi, and a 5 element yagi No detailed mechanical construction details will be given as one can easily
see what needs to be done from the figures. Element material can be 3/32'
brass welding or brazing rod, which takes solder very easily and is easy to work with hand tools. Booms for yagi antennas can be 1/2" tubing of a nonconducting material such as PVC pipe, fiberglass, oe even wood dowel stock that is dry and sealed against moisture. Metal can be used.but element lengths will need adjustment. Holes can be drilled thru the 1/2*: tubing and elements force fitted through the holes. Baluns can be made of short lengths of teflon (RG-188 or RG-316 types) or PVC coaxial cable (RG-174 type)- If you can get some, .141 semirigid is ideal for this purpose_ This can usually be found at hamfests, or surplus dealers, or scrounged from junked equipment.In a pinch you can use RG-58 but it is rather large. The balun should be an electrical half wave at the antenna frequency (440 MHz), and this is typically 05 to 0.7 times the free space (physical) half wavelength_ This will be in the vicinity of 4 inches for 440 MHz_ The balun acts as a 4:1 impedance transformer and provides a balanced feed fron an unbalanced coax feeder, to feed
the driven element, which is a folded dipole. The antenna should be carefully made to the given dimensions, then checked for VSWR. 1.5:1 or less is ideal. Checkat several frequencies a few MHz above and below your intended operating frequency and adjust element lengths for least VSWR. You will find that the ground plane is broad but the yagi antennas are somewhat 'sharper"- Even a 3 element yagi has 7 to 8 06 gain and is still small. Using 3 element yagi antennas at both transmitter and receiver will increase your system gain 14 to 16 OB (up to 25-40 times) over just using simple 1/4 wave ground planes. For an equivalent received picture this means a 5 to 7 times range increase. Even more can be had with larger yagis. Try these simple antennas and see for yourself what better antennas can do.

The following tables apply to the figures herein, for 439.25 MHz_

ANTENNA Lengths (inches):	REF	DE	D1	D2	D3	GAIN(approx)
1/4 wave Groundplane	Radiator 639" Radials 6-71"					0 dB
3 Element Yagi	13.77	13.12	12.59	--	--	7-8dB
5 Element Yagi	13.49	12.85	12.33	11.84	11.36	9-10 dB

For frequencies other than 439.25 MHz simply scale inversely:

Modified Element Length = 439.25/(F desired) * (dimensions as shown) (or spacing)

Some adjustment may be necessary for optimum results. See figures for details of construction. Antennas can be fun to experiment with so feel free to do so. They are by far the determining factor in system effectiveness and will give more results