Application Note
AN-67
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Comparison Tests of Various 70 & 23 cm, Antennas for ATV

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Table of Contents:

INTRODUCTION:

We hope this will be viewed as a Consumer Reports on ATV Antennas. Our objective was to evaluate as many as possible commercial 70 cm antennas for use with Amateur Television (ATV). While doing so, we also evaluated some home-brew antennas. The key word for such antennas is -- **"BROAD-BAND"**. Our TV signals are broad, 6 MHz typically, plus when we transmit on several TV channels, we need to be able to cover the entire band. Our two most popular bands for ATV are #1 - 70cm & #2 - 23cm. The required antenna band-widths are thus at least 30 MHz (420-450) and 60 MHz (1240-1300). Hopefully our results will help other ATV hams to find suitable antennas for their stations.

In years past we have run a couple of major testing sessions to evaluate antennas for ATV service. The first was in 2011 and was documented in KH6HTV application note AN-4, "Antennas for Ham TV". The second was in 2017 and documented in KH6HTV app. note AN-40, "70 cm Antennas for ATV". Now once again, here in 2023-24, we have done some more antenna testing. In none of the tests are the results totally accurate. They were never performed on high quality antenna ranges nor using the rigorous methods employed by organizations such as Georgia Tech University, FCC or NIST. So, gain figures from our tests are really not absolute, but in reality comparisons between various antennas of their performance on our particular test ranges. For each of these tests (2011, 2017 & 2023-24), the reference antenna used was a 2.2dBi, 1/4 wave, ground plane.

We break the antennas tested into four different catagories. They are 1. Directional, high gain Yagi antennas, 2. Omni-directional, high gain base station antennas, 3. Small, whip antennas such as might be used on hand-held radios and 4. Mobile antennas. We did an e-mail solicitation to lots of Boulder hams to donate antennas to be tested. While we would have preferred to have a much larger data base, particularly of commercial antennas, what is reported here are the antennas actually provided by various hams. We also included in our tests a few home-brew antennas which some hams wanted us to test. The test results for the home-brew antennas are not included here, but were reported to the builders.

Polarization: ATV hams in Boulder, Colorado all use Vertical Polarization for both 70 cm & 23 cm bands. Why? It was a historical decision dating back to the early 1990s. To support in the field ARES operations, both back-pack portable and mobile, vertical antennas were deemed the most suitable. Thus, all of our testing was done using vertical polarization.

Test Frequencies: We performed all of our tests using live, 6 MHz BW, digital DVB-T signals. We tested all of the antennas on all five 70 cm, 6 MHz, ATV channels. They were: Ch 57 (423 MHz), Ch 58 (429 MHz), Ch 59 (435 MHz), Ch 60 (441 MHz) & Ch 61 (447 MHz). The top end at 447 is not normally used for ATV due to it's dedicated use for FM voice repeaters. We have included it to show the performance of the antennas for use there for other purposes. On the 23cm band, there are ten available, 6 MHz, ATV channels. We tested on five of them spaced 12 MHz apart. They were: 1243, 1255, 1267, 1279, 1291 MHz.

I present here first in Tables 1 - 4 our actual test results for both Gain and Return Loss of each antenna. Tables 1 & 2 are for the 70cm band and Table 3 & 4 for the 23cm band. Next is my recommendation of the best antennas to use for ATV service. This is followed with the details of our test setup and procedures. Several appendixes are included with supplemental material. Appendix #1 gives the details about the reference antenna we used. Appendix #2 gives the details of the antenna mounting bracket used for testing HT style whip antennas. Appendix #3 is a supplemental document, AN-66 RL, with the actual plots of Return Loss vs. Frequency for each antenna. Appendix #4 is also a supplemental document, AN-66 Notes, with additional data and comments about each of the antennas tested

Table 1: 70 cm Antennas Tested for ATV Service

Antenna Gains (in dBi) vs. DATV 6 MHz Channels' Center Frequency (in MHz)

ANTENNA	Mfgr's Gain Spec	Ch 57 423 MHz	Ch 58 429 MHz	Ch 59 435 MHz	Ch 60 441 MHz	Ch 61 447 MHz
YAGI ANTENNAS						
M-Squared 420-50-11 (11 elements, 60" boom, rear mt)	+13.4dBi	+12.9	+12.1	+12.3	+12.1	+12.4
M-Squared 440-6SS (6 elements, 36" boom, rear mt)	+11dBi	+10.5	+9.7	+9.4	+9.0	+9.0
Diamond A430S10 *** (10 elements, 47" boom, center mt)	+13dBi	+10.5	+10.7	+10.4	+9.9	+8.2
Cushcraft A449-11 (11 elements, 53" boom, center mt)	+13.2dBi	+3.6	+7.3	+9.4	+9.0	+9.7
Antennas-Amplifiers 70cm23cm11WB (70/23cm, 4 elements, 20" boom, rear mt)	+8.1dBi	+8.8	+7.9	+7.2	+7.2	+7.6
KLM (obsolete, now M^2) (6 elements, 28" boom, rear mt)	+11 ??	+8.6	+9.0	+9.1	+8.7	+9.6
BASE STATION - OMNI						
Diamond X50NA (2m/70cm, 67" tall)	+7.2dBi	+5.4	+5.5	+6.5	+6.8	+7.6
Diamond X6000A (2m/70cm/23cm, 126" tall)	+9.0dBi	***-5.6***	***-2.4***	+1.9	+6.1	+9.2
Cushcraft ELR270 (2m/70cm, 46" tall)	+5.5dBi	+0.6	***-1.1***	***-2.1***	***-3.6***	***-3.5***
HAND-HELD ANTENNAS						
Diamond SRH999 (6m/2m/70cm/23cm,SMA, 19.5")	4dBR?	+1.5	+1.9	+1.9	+1.7	+1.4
Bingfu BFN00606 (2m/70cm, SMA, 15" tall)	+3dBi	+3.0	+1.6	+1.4	+1.4	+0.9
Nagoya/TID NA771 (2m/70cm, SMA, 15" tall)	+3dBi	+0.1	+0.3	+0.4	-0.5	-0.7
Baofeng std. HT whip (2m/70cm, SMA, 6.5" tall)	none	***-9.0***	***-7.5***	***-4.6***	***-4.3***	***-3.4***

KH6HTV Reference 1/4 λ Ground Plane (10.5" tall)	+2.1dBi	+2.1	+2.1	+2.1	+2.1	+2.1
MOBILE ANTENNAS						
Diamond NR2000NA (2m/70cm/23cm, N, 41" tall)	+6.3dBi	+4.9	+6.6	+5.3	+3.6	+4.4
Diamond MR77 (2m/70cm, PL-259, 20" tall)	+3.4dBi	***-0.3***	+1.2	***-0.4***	***-2.2***	***-4.2***
Vmuksan 770R (2m/70cm, PL-259, 39" tall)	5.5dB?	+4.9	+6.1	+3.6	+2.1	+2.5
Browning BR-1713-B-S (70cm, NMO, 34" tall)	5.5dBd	+2.7	+3.5	+2.5	+1.5	+2.5
NMO 1/4 wave	none	***-2.5***	***-3.6***	***-2.7***	***-2.4***	***-1.6***
Diamond SRH999 (6m/2m/70cm/23cm, 19.5" tall) (HT whip on mag. mt.)	4dBR?	+0.3	+0.6	+0.6	+0.4	+0.7
Bingfu BFN00606 (2m/70cm, 15" tall) (HT whip on mag. mt.)	+3dBi	+1.1	+1.3	***-0.8***	***-3.4***	***-5.3***

*** Note: Per the Diamond instructions, their yagi antennas are not supposed to be mounted on metal. For this test, it was mounted on a PVC mast

Table 2: Antenna Return Loss (in dB) on the 70cm Band

note: -14dB RL => 1.5:1 vswr, -10dB RL => 2.0:1 vswr

ANTENNA	fo (MHz)	RL(fo)	> 14 dB RL	> 10 dB RL
YAGI ANTENNAS				
M-Squared 420-50-11	439	-24dB	418-446	416-457
M-Squared 440-6SS	435	-25dB	412-451	409-454
Diamond A430S10 ***	438	-40dB	433-441	<410-442
Cushcraft A449-11	437	-31dB	433-442	427-447
Antennas-Amplifiers 70cm23cm11WB	432	-39dB	417-437	411-455
KLM (obsolete, now M^2)	445	-40dB	434->460	<410->460
BASE STATION - OMNI				
Diamond X50NA	448	-35dB	436-453	426-455
Diamond X6000A	447	-40dB	434-452	423-455
Cushcraft ELR270	432	-31dB	433-442	423-448
HAND-HELD ANTENNAS				
Diamond SRH999	444	-19dB	438-449	432-455
Bingfu BFN00606	438	-14dB	NA	425-452
Nagoya/TID NA771	445	-8dB	NA	NA
Baofeng std. HT whip	458	-21dB	448- >460	439- >460
KH6HTV Reference 1/4 λ GP	440	-28dB	423-454	413- >460
MOBILE ANTENNAS				
Diamond NR2000NA	441	-32dB	443-450	439-452
Diamond MR77	426	-20dB	420-437	410-443
Vmuksan 770R	434	-19dB	420-438	416-441
Browning BR-1713-B-S	443	-47dB	>20dB 425-451	NA
NMO 1/4 wave	422	-32dB	<410-455	NA
Diamond SRH999	443	-28dB	439-446	425-448
Bingfu BFN00606	420	-36dB	416-436	414-438

Table 3: 23 cm Antennas Tested for ATV Service

Antenna Gains (in dBi) vs. DATV 6 MHz Channels' Center Frequency (in MHz)

ANTENNA	Mfgr's Gain Spec.	1243 MHz	1255 MHz	1267 MHz	1279 MHz	1291 MHz
YAGI ANTENNAS						
Directive Systems DSE2414LYRMK (loop, 14 element, 36" boom, rear mt)	15dBi	14.5	16.2	16.9	16.6	15.5
Antennas-Amplfiers 70cm23cm11WB (7 element, 20" boom, rear mt)	11.4dBi	10.7	11.8	12.1	12.2	11.0
BASE STATION - OMNI						
Diamond X6000A (2m/70cm/23cm, 126" tall)	10dBi	8.2	7.1	6.6	6.0	4.0
HAND-HELD ANTENNAS						
Diamond SRH999 (6m/2m/70cm/23cm, SMA,19.5")	4dBR?	3.2	4.2	3.7	3.2	2.8
KH6HTV Reference 1/4 Wave Ground Plane	2.2dBi	2.2	2.2	2.2	2.2	2.2
MOBILE ANTENNA						
Diamond NR2000NA (2m/70cm/23cm, N, 41" tall)	9.7dBi	+9.2	+9.4	+7.9	+7.2	+6.9
Diamond NR124 (23cm, N, 29" tall)	8.4dBi	+9.9	+9.0	+6.9	+4.8	+4.1
Diamond SRH999 (HT whip on mag. mt.)	4dBR?	0.0	+0.9	+1.0	+1.8	+2.6

Table 4: Antenna Return Loss (in dB) on the 23cm Band

note: -14dB RL => 1.5:1 vswr, -10dB RL => 2.0:1 vswr

ANTENNA	fo	RL(fo)	> 14dB	> 10dB
YAGI ANTENNAS				
Directive Systems DSE2414LYRMK	1275	-33dB	1250-1290	1246-1298
Antennas-Amplfiers 70cm23cm11WB	1281	-35dB	1220-1317	<1220->1320
BASE STATION - OMNI				
Diamond X6000A	1295	-18dB	1285-1310	1264-1320
HAND-HELD ANTENNAS				
Diamond SRH999	1283	-22dB	1266-1295	1239-1303
KH6HTV Reference 1/4 λ GP	1261	-14dB	NA	1231-1284
MOBILE ANTENNA				
Diamond NR2000N	1295	-30dB	1290-1298	1253-1300
Diamond NR124	1267	-31dB	1260-1272	1255-1274

RECOMMENDED ANTENNAS for ATV Service:

Yagi Antennas: M-Squared, model 440-6SS (70 cm, 10 dBi)
Directive Systems, model DSE2414LYRMK (23 cm, 15 dBi)
Antennas-Amplfiers, model 70cm23cm11WB (70cm, 8dBi & 23cm, 11dBi)

Base Station: Diamond, model X50NA (70 cm, 6 dBi)
Diamond, model X6000A (23 cm only, 7 dBi do not use on 70 cm)

HT Antenna: Diamond, model SRH999 (70 cm, +1.5 dBi & 23 cm, +3.5 dBi)
Bingfu, model BFN00606 (70 cm, +1.5 dBi)

Mobile Antenna: Diamond, model NR2000N (70 cm, 5 dBi & 23 cm, 7.5 dBi)

TEST SITES: We tested antennas on several different occasions and from several different test sites. But we encountered issues with most of them. The sites used were:

1. Lowell Blvd. & 152ed St. -- Westminster --in parking area with open space to west 39º 58' 25"N x 105º 2' 5"W
2. Legionaire's Hill -- city of Boulder -- in parking area unobstructed view to west to WA0TQG, 40º 0' 58"N x 105º 11' 22"W
3. Boulder County EOC / 911 Center -- city of Boulder -- parking lot, unobstructed view to the south to N0YE
4. Viele Lake -- city of Boulder -- rec. center parking lot, near to N0YE's QTH
5. KH6HTV home QTH --- east of Lafayette -- receive site setup 100 yards to west in open space 39º 59' 2"N x 105º 3' 4"W
6. Spanish Hills -- KH6HTV former QTH, now a vacant lot -- south-east of Boulder --- receive site setup 100 yards to north-east - -- unobstructed view over flat ground 39º 58' 43"N x 105º 10' 53"W (Final & Best Site, used for final data)

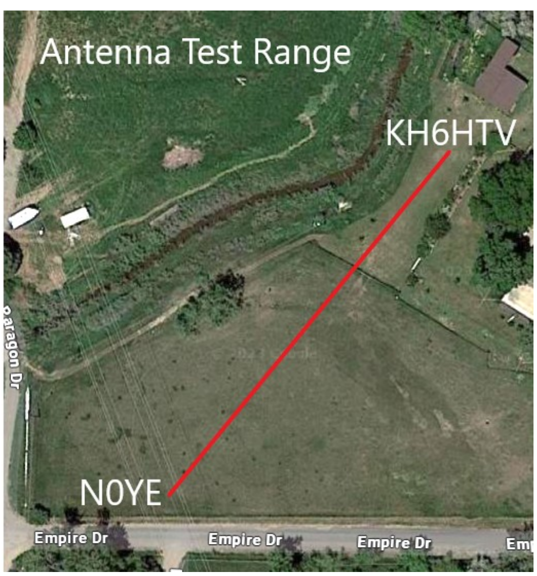
View from Lowell Blvd. test site towards W0BTV repeater The line-of-sight distance to the repeater was about 13 miles. The repeater's rf signal level to our reference antenna was about -71dBm.

The first site on Lowell Blvd. was simply to check out and confirm the test procedures. The tests were only performed on 423 MHz using the W0BTV's DVB-T beacon signal. We had an unobstructed, clear line-of-sight path of 20.4 km to the W0BTV repeater from Lowell Blvd. We used a pre-amp and 3dB power splitter to feed the signal to two receivers. One was a Hi-Des HV-110, DVB-T receiver with a video monitor. The other was a TinySA-Ultra spectrum analyzer. The measurements of rf power from both instruments correlated quite closely.

Legionaire's Hill Test Site -- east side of city of Boulder

The next site tried was Legionaire's Hill using WA0TQG as a signal source, 18 km to the west on Sugar Loaf mountain. We had some RFI, equipment failure, and then high winds, so got no usable results from this site. The third site tested was the EOC/911 center using N0YE as a signal source, 7.4 km to the south on the other side of the city of Boulder. Again we had RFI and equipment failures, so still no good test results.

The last two sites were related to KH6HTV. Site 5 was from his back deck with his home station antennas as the test source radiating to the west towards the W0BTV ATV repeater. His deck faced open space with no obstructions. There was still RFI at this site due to it's relatively high hill top location being exposed to RF & broadcast TV signals from the Denver metro area. Plus, it was not possible to do a mobile antenna test on a vehicle there.



Spanish Hills Test Site

View from receive site to transmitter site

The final site, and the one which worked the best was KH6HTV's former QTH in the Spanish Hills residential area to the south-east of the city of Boulder. This at present is a vacant lot of 2 1/4 acres of flat ground. Jim's new home was being constructed on the site, but as yet was simply a basement. As it turned out this site was the most RFI free site for our testing. Being down the slope 180 ft. below the top of Davidson Mesa, it was shielded from a lot of RF signals from the Denver metro area. It has a great view however to the west to the city of Boulder and the Rocky Mountains. Our test range consisted of N0YE and KH6HTV parking their automobiles as shown in this aerial photo, about 100 yards apart.

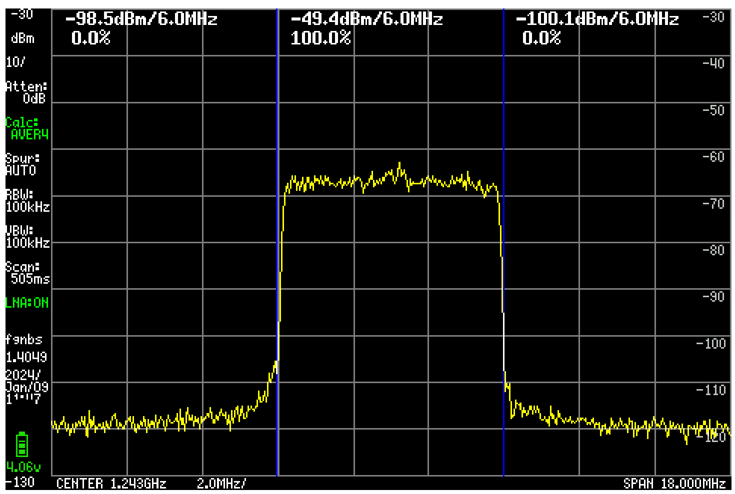
Another advantage of having a shorter test range was the ability to fine tune the RF field strength. When we used signal sources which were anywhere from 4 to 13 miles distant the test signal level was lower and comparable to other RFI signals. With a much shorter range, we were able to generate a considerably stronger rf field which dominated over any potential RFI signals. As it turned out, starting out with a 3 watt transmitter, our fields were actually too strong for our test receivers so we inserted fixed SMA attenuators between the DVB-T modulator and rf power amplifier to be able to fine tune our test signal field strength. For the 70 cm test we ended up using +15dBm.

Test Source: Our live video source was a pre-recorded home video movie playing continuously on a Media Player with HDMI output. For the 70cm tests, we used a Hi-Des HV-320E DVB-T Modulator driving a KH6HTV model 70-7B rf linear power amplifier (3 W, +35dBm) into an M-Squared 440-6SS, 6 element Yagi antenna mounted on an antenna mast at about 6 ft. We then adjusted rf radiated power to give the proper level at receive site. We ended up using a 20dB attenuator between modulator and amplifier. Resultant RF power output was thus +15dBm. Don operated the transmitter and switched channels upon request. We used all five, standard, 6 MHz wide, 70cm ATV channels of 57 (423), 58 (429), 59 (435), 60 (441) & 61 (447 MHz center frequency).

For the 23cm tests, the equipment was similar. HV-320E modulator driving a KH6HTV model 23-12 amplifier (2 W, +33dBm) into a Directive Systems loop yagi antenna. Again the rf radiated power was then lowered by 20dB to +13dBm. We tested on five, alternating 6 MHz ATV channels starting at 1243 and ending at 1291 MHz.

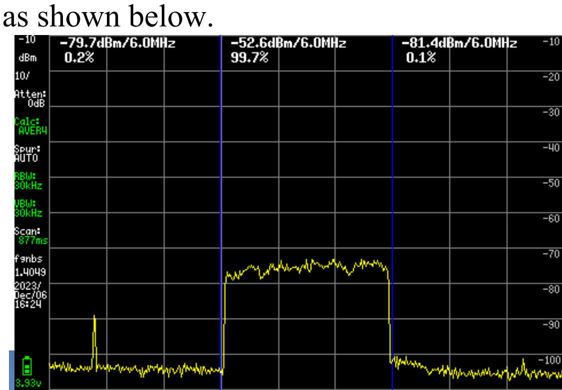
Receive Site Details: Jim set up his Volvo SUV 100 yards to the north-east of Don's Mercedes SUV. All of the antennas tested were at a height of approximately 6 ft. A standard roof mount antenna tripod with a 5 ft. metal mast was used to support the yagi and base station antennas. A special anchor for the tripod was constructed of 1x6 wood planks and held in place by the front tire of the vehicle. (*Note: for the Diamond yagi antenna, it was necessary to substitute a PVC pipe for the normal metal mast. A metal mast dramatically detunes the Diamond yagis and lowers their gains. Diamond in their specs. also warn against mounting their yagis directly against a metal mast.*) Mag. mount mobile antennas were placed on the center of the SUV's roof top. Most of the mobile antennas were tested using a Diamond DPK-4NM-N mobile magnetic mount with a type N connector and low loss coax cable. An NMO mag. mount was used for NMO antennas. Some mag. mount antennas had their own built-in magnet and they were used as is. To test the HT whip antennas, a video camera tripod was used. A special antenna bracket was built which mounted between the video camera and the base plate. The bracket had an SMA connector on it to attach the antenna under test. The tripod height was adjusted to place this SMA connector also at about 6 ft above ground. Details about this antenna bracket are in Appendix 2.

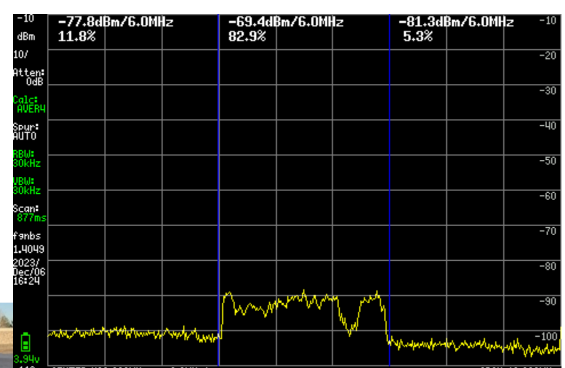
The received field strength was measured using a TinySA-Ultra Spectrum Analyzer. The TinySA was set up to measure the total channel power in the 6 MHz wide TV channel. It gave a resolution down to 0.1dB with an accurate read-out in dBm. To avoid overloading the spectrum analyzer, we adjusted downward the source transmitter power. We ended up using a 70 cm transmitter source of +15dBm. This gave us signal strengths from the various antennas ranging from a low of -60dBm to a high of +25dBm. The typical receive signal strength from our 1/4 wave reference antenna was of the order of -45dBm.



1243MHz signal received by Reference Antenna

Using a spectrum analyzer, we were able to observe the quality of the DVB-T 6 MHz wide spectrum coming from the antennas under test. In most cases, the observed spectrums looked like perfect raised rectangles of white noise with no ripple. Some antennas which did not have perfectly flat frequency responses showed some slope on the top of the rectangle. Some antennas tested showed severe suck-outs on some channels as shown below.





B

(the Bad & Ugly !)
owell Blvd. Site
on camera tripod

Reference 1/4 wave ground planeon Diamond mag. mount on camera tripod
antenna.

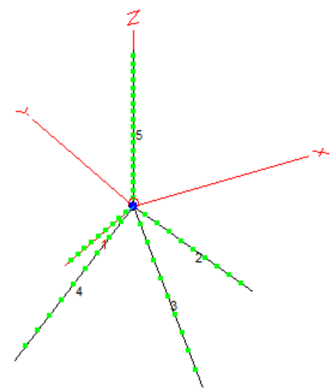
Data Processing: Our reference antenna was a 1/4 wave λ, ground plane with four drooping (45º) 1/4 λ radials. It's EZNEC computed gain was +2.1dBi. Details about this antenna are in Appendix 1. Before each class of antenna was measured, this reference antenna was first placed at the same location as the antennas to be tested. The above photos show the placement of the reference antenna. For mobile testing, the antenna was mounted on a 6" piece of semi-rigid coax to position it above the mag. mount. Signal strengths from the reference antenna were then measured on each of the five TV channels (57-61). These values were then subtracted from the values measured for the antenna under test. This gave a gain of dBr, i.e. relative to a reference. Then the gain of the reference, +2.1dBi, was added to this value to give the resultant antenna gain in dBi. The results are tabulated in Tables 1 & 3. The same test cable was used for each antenna tested. The exception was for the mobile antennas. They had their own coax cables attached to their mag. mounts. These cables were of various types and lengths. The data for each mobile antenna was thus corrected for the calculated cable loss. The gain values reported for mobile antennas are for the base of the antenna, not at the far end of the coax cable.

APPENDIX 1:

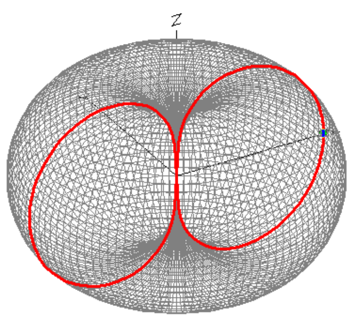
REFERENCE GAIN -- 1/4 λ Ground Plane Antenna

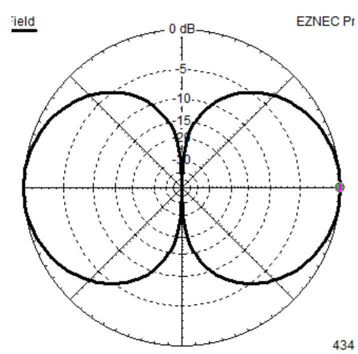
Jim, KH6HTV

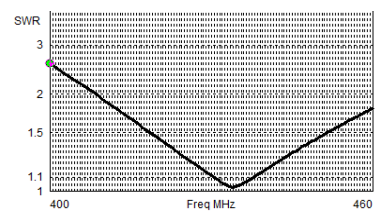
We could just simply do comparison tests between various antennas and rate them accordingly. However, it would really be nice if we could assign an absolute gain value in dBi. To do this, we need to have some reference antenna to compare our other antennas to. For microwaves, we typically use a standard gain, flared waveguide horn antenna. For HF & VHF measurements, the classical 1/2 wave (λ) dipole antenna is typically used. For vertical polarization on VHF/UHF, we typically use a 1/4 λ ground plane antenna. It consists of a single 1/4 λ vertical radiator rod plus four, 1/4 λ radials drooping down at a 45° angle.



Using the EZNEC antenna modeling program, it is straight forward to determine this antenna's predicted performance. I designed on EZNEC such an antenna for the 70 cm band. It was designed for a center frequency of 434 MHz and used #14 gauge, solid copper wires for the elements. The lengths of both the vertical radiator and the four radials were optimized on EZNEC. The final design was with a vertical radiator of 6.2". The four radials were 6.7".







EZNEC calculations: Free Space Gain = 2.1dBi flat across 70 cm band. Omni directional performance in the azimuth (X-Y) plane. min. VSWR = 1.03:1 at 434 MHz, 1.5:1 vswr limits (-14 dB return loss) = 418 & 452 MHz

An actual antenna was then built using a bulkhead mount, type N (f) connector. This antenna is shown on the previous page mounted on the camera/antenna bracket. For eye safety, I looped the ends of all the 14 ga. copper wires back on themselves and soldered the loop to the wire. The lengths were then measured and cut to the tips of these loops. I then measured the vswr with a Nano-VNA. The results were: min. vswr = 1.05:1 at 430 MHz, < 1.5:1 (417-463), < 2:1 (409-470) & < 3:1 (396-481 MHz) This antenna is thus a very good match to 50 Ω over the entire 70 cm amateur band.

23cm Ref. Antenna: A similar 1/4 λ GP reference antenna was also designed and built for 23cm band. 14 ga. copper wire was also used. The vertical radiator was 2.04" and the four drooping radials were 2.30" The computed gain was +2.2 dBi. The min. VSWR was 1.02:1 at 1272 MHz. The computed 1.5:1 vswr limits were 1214 to 1340 MHz. Constructing this antenna on a type N connector was a bit more "iffy" as the connector base made up a larger portion of the radials. Measurements showed the resultant antenna had it's min. vswr of ?? at ??. The 1.5:1 limits were ?? to ?? MHz.

So, can we use the calculated **Gain of +2.1 dBi** as our reference antenna ? Well yes and no. It is a starting place. It is the theoretical gain for the antenna out in free space with nothing else to perturbate the EM fields. With EZNEC, we can then start to add disturbances and see their effects on both the far field patterns and the gain on the horizon. First off, we have the coax cable feed line, plus the support mast dropping down vertically. A metal rod of various lengths can be tried with EZNEC to simulate these. It causes some dimpling in the pattern. It remains omni-directional, but now adds some uncertainty of ±1 dB or so to the +2.1 dBi gain figure. A major disturbance is to then simulate in EZNEC the effects of using the antenna over real earth. We now have ground reflections to deal with. They can get to be much more serious in distorting the far field pattern and cause greater variations in the gain.

But, being real "amateurs", not true antenna scientists, I guess for lack of better tools, we might as well go ahead and use the +2.1 dBi figure for our inter-comparisons of our various ATV antennas.

Note: If you don't agree with my measurement technique and the use of my "Reference" antenna, then you can still use these data tables. First subtract 2.1dB from the values in the table given in dBi. Now your new table is simply a table of Relative Gain instead. So now call the gains expressed as "dBR" where R was our 1/4 λ ground plane.

APPENDIX - 2:

Inexpensive Antenna Mount for Camera Tripod

Jim, KH6HTV

Ten years ago, I published my app. note, AN-15, "Simple Camera Tripod Antenna Bracket". I think it is worth while to again bring it to the attention of you ATVers. It is extremely simple to build and very low cost.

The antenna bracket is fabricated from a piece of 1 3/8", 14 gauge, perforated, steel flat bar. The steel bar is pre-drilled with 3/8" holes. These bars are readily available from your hardware or home improvement store. The thickness of the bar is ideal to fit between the camera tripod mounting plate and the camcorder. Only one or two holes need to be through one of the pre-drilled 3/8" holes. An extra small, #12 (0.189") hole is drilled next to an existing large hole to accommodate the base plate alignment pin. The camera mounting screw is typically either a 1/4"-20 (small consumer cameras) or 3/8"-16 (large professional cameras). Either screw will go through one of the pre-drilled 3/8" holes. To mount the antenna, I use either a BNC or SMA jack/jack (f/f) bulkhead adapter. For a BNC another existing hole on the top of the bracket is enlarged to 1/2" for mounting the BNC bulkhead adapter. The bracket is then bent in two locations as seen in the photo. The exact length of the bar and location of these bends depends upon the size of the camera used and the desired antenna height above the camera. A 50 Ω, coax cable is used to attach the antenna to the TV transmitter.