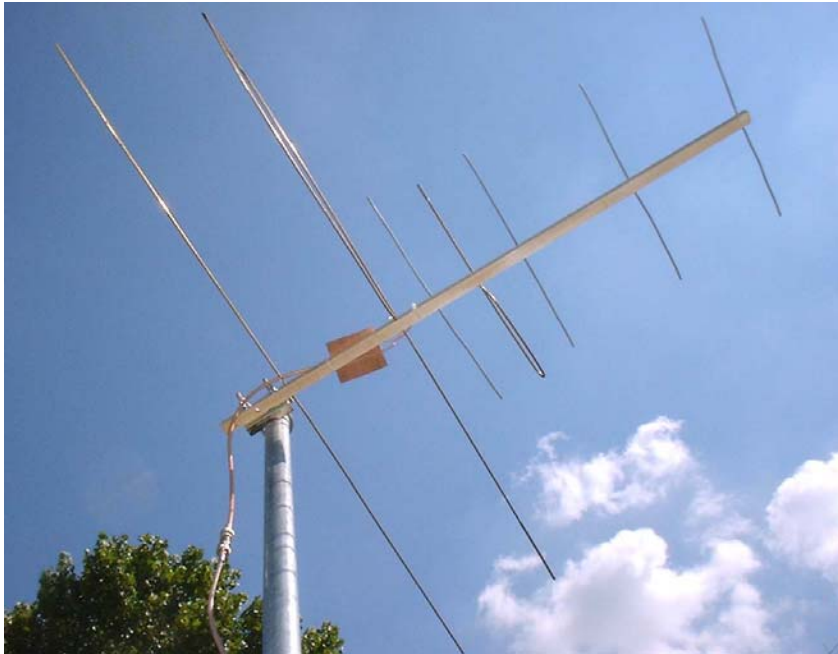


Cheap Antennas for the AMSAT LEO's  
Kent Britain -- WA5VJB



Cheap LEO Antenna



Drew, KO4MA, using the Cheap LEO antenna during a Dayton AMSAT LEO Demonstration

Hand held dual band antennas are popular for QSO's through many of the Low Earth Orbit (LEO) satellites. This article covers several 145 MHz antennas, a larger number of 435 MHz antennas, and how to combine them into one antenna.

Got a **STRONG** arm or plan to use it with a Tripod, then by all means the 4 Element 145 MHz and the 8 element 435 MHz can be used together. Or there is the 2 element 145 and 5 element 435 MHz used in the AMSAT demonstrations. It's is only 32 inches long. Something much lighter for backpacking? How about using a 20 inch long 2 elements on 145 MHz and a 3 elements on 435

MHz. For the 'Arrow' Enthusiasts, this smaller 2 elements on 145 MHz and 3 elements on 435 MHz will actually out perform the standard 'Arrow'. *More on that in a bit.*

One popular commercial antenna mounts the elements 90 degrees to each other. This is a mechanical, not really an electrical, decision. On this antenna the elements can be mounted cross ways, but mounting them flat makes the antenna much easier to lay down in the back of the truck or store in the garage.

#### Construction:

For the boom 5/8 x 5/8" or 3/4 x 3/4" wood works well. If you plan to mount the antenna outside for a long term, a coat of spar varnish, spray enamel, or some of that water proofing stuff you use on wood decks will add years to the life of the antenna.

For the elements I used 1/8" material. The 435 MHz reflector and directors were from a roll of Radio Shack Aluminum Ground Rod wire. RS Stock number 15-035. 40 feet will run you about 5 bucks and make a lot of antenna elements. But #10 bare Copper wire, Bronze Welding Rod, and Hobby tubing have all been used. If you want to use 3/16" diameter elements, cut them 0.2 inches shorter than the dimensions in the tables to compensate for the thicker material. The 2 Meter elements were all made from Bronze or Brass welding rod. I like to use something I can solder the coax to and the Welding Rod solders well.



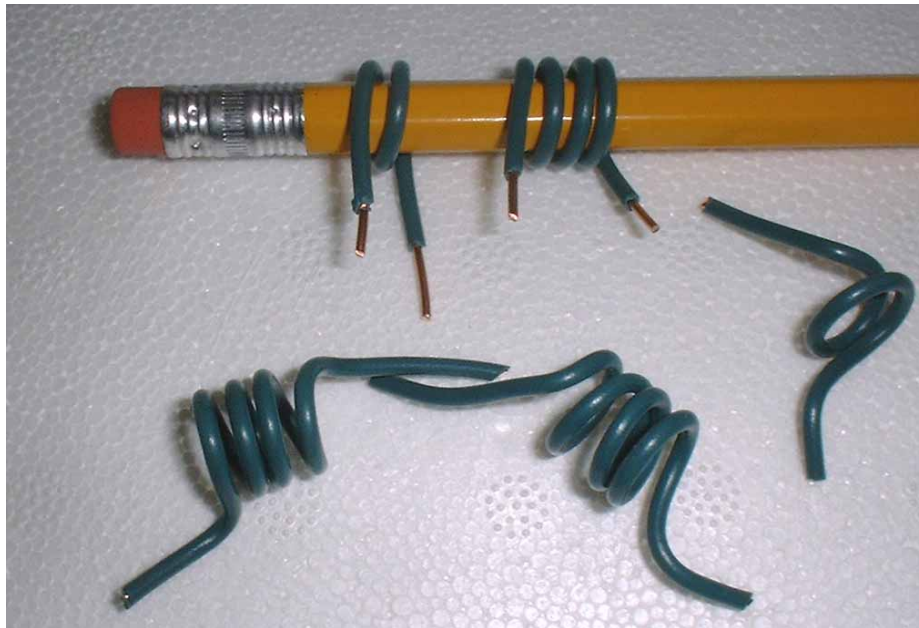
Element Splice

The Welding Rod is only 36" long. A section of 1/8" i.d. Copper or Brass hobby tubing makes a good splice. Just slip it on and solder them together. Save some of that hobby tubing. If you have a habit of "I trimmed the antenna twice, and it's still too short!", then you can solder a piece on the end of the driven element and start over.

I usually hold the elements in place on the boom with a drop of super glue. But Silicon glue and even paint have been used.



The 145/435 MHz Band Splitter



Winding the Band Splitter Coils

#### Splitter:

The band splitter is just a 250 MHz High Pass Filter and a 250 MHz Low Pass Filter connected together. This doesn't have to be very complex, or even very accurate. As long as the filters cut off somewhere between 200 and 400 MHz, they will work fine. So if the coils get squished, just bend them kind of back in shape, and go for it. This one is built cheap, just out in the air on a piece of PC Board. You can build the splitter into a box if you like, with connectors and all, but it's not going to change their performance. And this Band Splitter even makes a good project if you want to use two other 145/435 MHz antennas.

Remember, we are not trying to filter off harmonics, just make the 2 Meter energy go to the 2 Meter antenna, and the 435 MHz signals go to the 435 MHz antenna.

#### Parts list:

Antenna Version	Capacitors	Coils	Wire & Turns
435 MHz High Pass	2 x 4.7 pF Caps	1 Coil	1-1/2 turns #18 or #20 wire on a Pencil
145 MHz Low Pass	1 x 10 pF Cap	2 Coils	3 turns #18 or #20 wire on a Pencil

You're too late, I have already been asked if it needs to be a #2 or a #3 pencil.

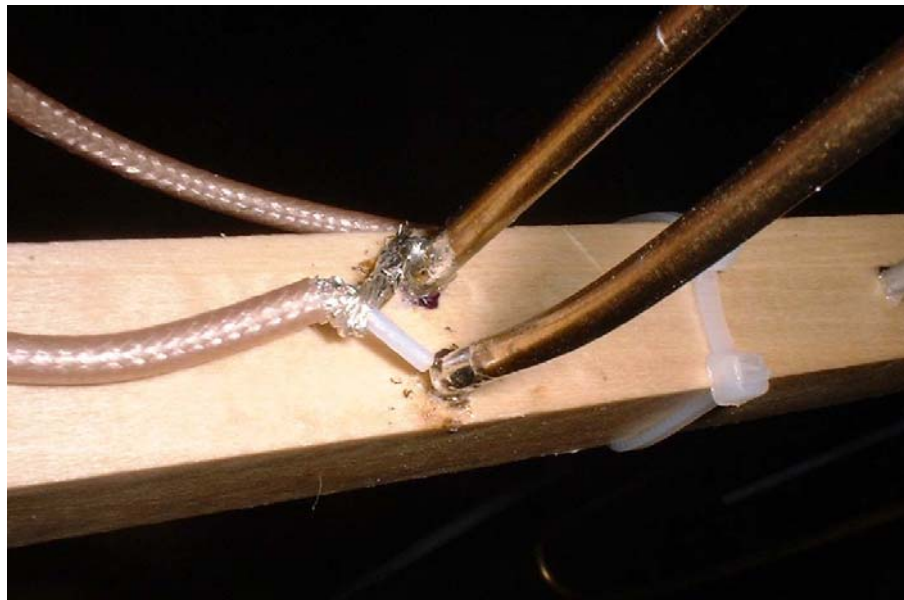
For the record I wound my coils on a Red grading pencil. For those of you with a more mature sense of humor, just about all wood pencils make a 0.3" coil form.

We are frequency spitting the signals, not power dividing, so the length of the coax between the splitter and the antenna is not critical. You want to keep the coax as short a practical, but its exact length is not important. Got a box of 4.7 pF's? You can use 2 of them instead of the 10 pF. Be sure to keep those leads very short. I used Teflon coax on my splitter, it solders so much easier than foam RG-58, but you're free to build it in a box and use connectors if you like, but it's not really necessary.

#### Power Handling

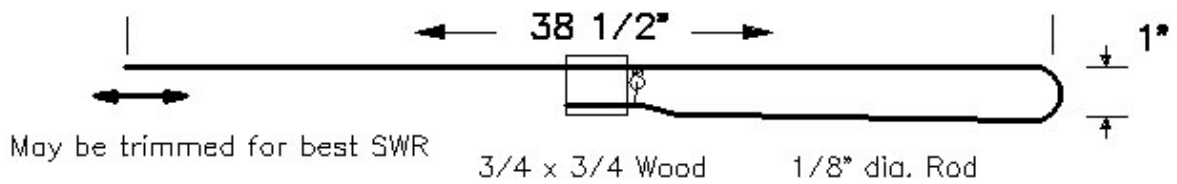
Power handling of this band splitter depends almost entirely on your caps. With 50 volt caps, 20 watts is about your limit. Dig up some 1 kV caps, and the coax will probably melt first as you warm up that 4CX250.

One of my first prototypes tried to use the last 2 Meter director as the 435 MHz reflector. An interesting idea to save weight and make the antenna shorter, but performance suffered too much. So all versions now have a reflector on the 435 MHz portion. The last 145 MHz director and the 435 MHz reflector will interact. If you plan to mount them in the same plane, *what I find easiest*, space them 3 inches apart.



Close Up of Driven Element

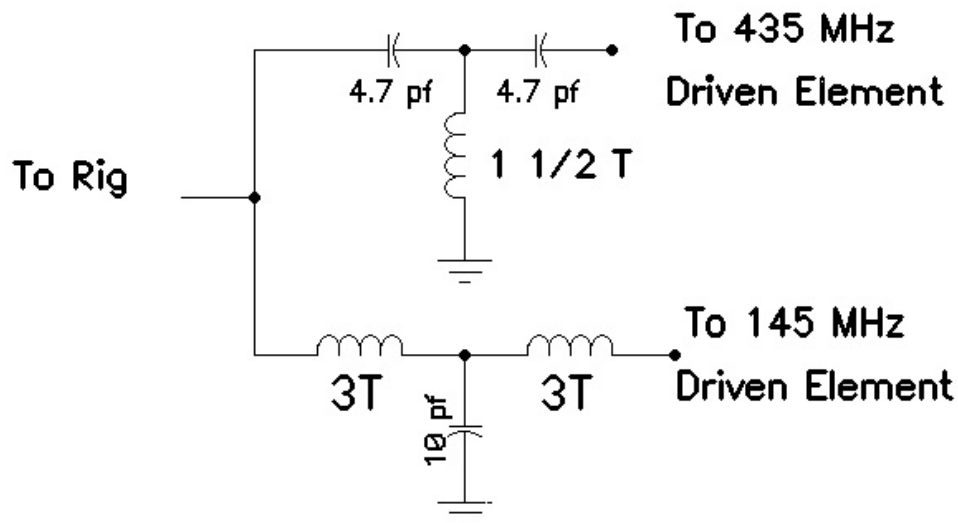
## Two Meter Driven Element



## 435 MHz Driven Element

Figure 1 Dimensions of the Driven Elements

These J driven elements usually bring several comments from people new to "Cheap Yagi's". The shield of the coax goes near the center of the top of the element. This is a voltage null and directly soldering the coax to the driven element has a lot of advantages. The tip of the coax goes to the tip of the J. So you can think of this driven element as 3/4ths of a folded dipole or a gama-match with no capacitor. In free space, the J driven element has about a 150 Ohm impedance. As other elements are added, they load down the impedance of the driven element. If the antenna has relatively wide element spacing, then a direct match to 75 Ohms is possible. Bring in the reflector and directors a little closer, then you have a direct match to 50 Ohms. So the impedance matching is the length and spacing of the other elements. Just build the antenna to the dimensions, solder on the coax, and start talking. No tuning required.



Schematic of the Band Splitter

Tuning it up:

For the ultimate in performance connect a coax to just the 2 Meter portion and trim the free end of the J for best SWR for your favorite LEO uplink frequency. Then connect the coax to just the 435 MHz portion and again trim the free end of the element for best SWR. Now install the band splitter and this time tweak the coil spacing for best SWR at your spot frequencies.

You have now gotten the last 0.1 dB out of the antenna.

For everyone else, just build the antenna to the dimensions and the SWR will be under 2 to 1 on both frequencies. Just build it and talk. The design is pretty Idiot Resistant.

This antenna can be built in 30 combinations of elements and polarization's. One should fit your need. The 2 elements on 145 and 5 elements on 435 MHz version has done great in the field tests. Now you can have fun with the LEO's for less than \$10.

Element Dimensions -- 145 MHz Version				
	Ref	DE	D1	D2
2 element				
Length	40.5	**		
Spacing	0.0	7.0		
3 element				
Length	40.5	**	36.5	
Spacing	0.0	8.5	19.75	
4 element				
Length	40.5	**	37.0	32.5
Spacing	0.0	8.5	19.0	40.0

Element Dimensions -- 435 MHz Version								
	Ref	DE	D1	D2	D3	D4	D5	D6
3 element								
Length	13.5	**	12.2					
Spacing	0.0	2.5	5.5					
4 element								
Length	13.5	**	12.4	11.5				
Spacing	0.0	2.5	5.5	11.5				
5 element								
Length	13.5	**	12.5	12.25	11.75			
Spacing	0.0	2.5	5.25	12.0	18.5			
6 element								
Length	13.4	**	12.4	12.0	12.0	11.0		
Spacing	0.0	2.5	5.5	11.25	17.5	24.0		
8 element								
Length	13.4	**	12.4	12.0	12.0	12.0	12.0	11.1
Spacing	0.0	2.5	5.5	11.25	17.5	24.0	30.5	37.75

\*\* Driven element Dimensions from Figure 1

Ref is the Reflector, DE is the Driven Element, and all spacings are measured from the Reflector element.

My first question was why the 'Arrow' has performed so poorly in the AMSAT demos. Arrows have been on the antenna range at several conferences showing 435 MHz gains as low as 4 dBi. I would like to thank SAM, G4DDK for sending me the detailed dimensions of his Arrow antenna. I built a NEC model of the 435 MHz portion, and the model showed the forward gain peak to be near 457 MHz, not 435 MHz.



Insulated element mounting on the left, direct on the right.

When you change the diameter of an element, you also have to change the length of that element to compensate for the new diameter. Two common ways to mount elements are to make the antenna element part of the boom, or using insulators, electrically isolate the element from the boom. When you make the element part of the boom, you radically change the diameter of the element in that area. Now the length of the element must be changed to allow for this new diameter. This is called the "Boom Correction Factor". I try to avoid correction factors best I can by using thin wood booms with my Cheap Yagi's. I don't know the history of the development of the Arrow antenna, but the model suggests that the dimensions for a 435 MHz Yagi using insulated elements were used for Arrow, but mechanically the elements were made electrically part of boom. It appears no Boom Correction Factor was used.

I have been sent an Arrow to play with on the antenna range, so stand by for another article. It looks like we can squeeze several dB more gain out of the basic Arrow. At the Central States VHF Society Antenna range we measured 7.0 dBd gain out of the 435 MHz section of the Arrow. Several simple mods increased gain 0.3 dB, but I know there are more dB's hiding in there.

For even longer versions of AMSAT Cheap Yagi's visit <http://wa5vjb.com/references.html>