Build the Slim JIM Antenna

A Unique VHF Antenna with gain over a J-Pole

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Way back in 1987, I was at the Zurich Airport, Switzerland, waiting for my plane ride back to the Philippines after attending our yearly conference. I arrived at the airport too early and was blaming myself for not using the extra time for another tour of the city museum. Besides, I have pre-checked-in my luggage via the Euro-rail in Basle. Now, I needed something to read to pass the time. From the corner of my eye, I noticed a small bookshop a little further. I decided to look around for something to read. As a Ham, one can surmise what I want to read! Ham Radio and Electronics of course!

I was browsing the magazines but all are in German or Swiss edition. Later, the old man in the counter came near me. He said something I couldn't understand but I realized that he was asking what I want. I immediately blurted to him .. "Electronics!" the man gazed at me puzzled. Then I said "Ham Radio?" he was even more puzzled. Finally, I moved up my right arm to just below my right ear and said loudly " Hello Hello! … Baker one to Baker two … over!". Ahhh! he said, pointing to me over a bunch of booklets in the far corner of the store. He guided me to the site blabbering and smiling. He turned his head towards me and asked the usual question…..Asian???. Philipinen! I answered. He nodded while dipping his fingers to retrieve a booklet. There it was! He handed to me this booklet printed in English…*"Two-meter Antenna Handbook"*, a 1980 edition. I bought it!

Back to my seat, I browsed the contents like an eagle looking for a prey. It was an antenna project booklet written by F.C. Judd (G2BCX), an English Ham. I was particularly interested with the unique antenna which the author called "Slim JIM". It was the first time that I have encountered this design and drove me with great interest to continue reading. I finished the section before I boarded the plane.

Now, many years later, I have to build a VHF antenna for my second QTH in Calamba City. One that meets the strict structure requirements of the subdivision … No transmitting towers, no guy wires and other offensive antenna structures. I remembered the Slim JIM and so I went back to the bookshelf in my shack at Los Baños. The pages are now turning khaki yellow but the design does not change in performance, I mused.

The Slim JIM Design

From the book, the slim JIM was developed based on the basic J-Pole design, see Fig.1. Both are omni-directional. The J-Pole antenna became so popular in the VHF band because of its simplicity in design and construction. The MARS'..ians mass produced this antenna during the VHF frenzy in the mid-80's. It is a vertically polarized half-wavelength radiator and fed with a quarter-wave stub to shock excite it. This antenna is fed with a balance line but numerous hams preferred to feed it simply with an unbalanced coax transmission line and neglecting the degradation of the radiation pattern because it filled the purpose of portability and functionality. Impedance matching is achieved by sliding the feed point above the shorted end of the quarter-wave stub. The J-Pole, when properly fed and mounted, exhibits a vertical radiation angle about 30 degrees from horizontal. This pattern is the focus of the Slim JIM design. Rather than launching the signal for the birds, the addition of a parallel element beside the half-wave radiator forces the radiation angle to dip towards the horizon, where it is really needed.

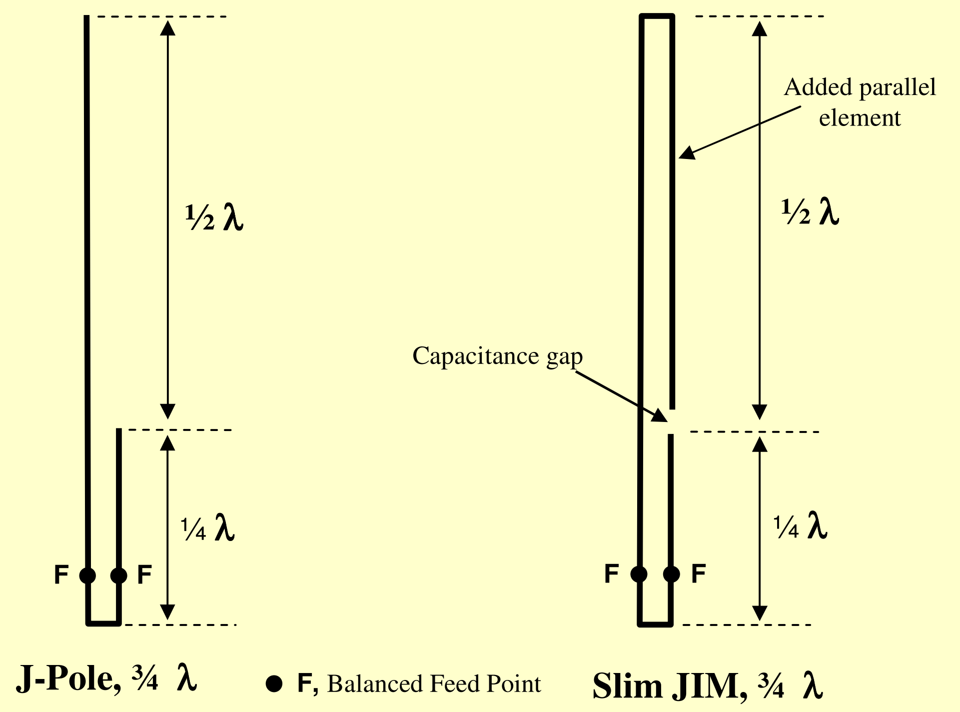


Fig.1. The development of the Slim JIM Antenna. Note the added parallel element beside the main radiator.

The reduced vertical radiation angle (about 8-10 degrees from horizontal) of the Slim JIM results to an apparent gain over the J-Pole. Measurements and signal tests reported by users of this antenna confirms the claim of the original designer, G2BCX.

The gain is attributed to the addition of the element, looped from the top of the radiator and back to the matching stub below it but leaving a capacitance gap. The resulting electromagnetic field of the fed signal is in-phase with the main radiator by virtue of induction where both elements are shock-excited by the feed stub. The resulting wave shape is shown in Fig. 2.

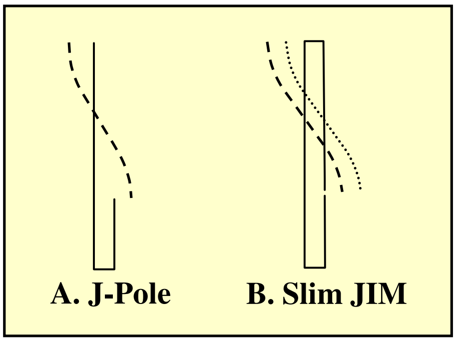


Fig. 2. Signal wave shape of a J-pole (A) and the Slim JIM (B)

The double wave and in-phase signal pulls the angle of the radiation pattern downwards towards the horizon with a slight elongation, hence the claimed horizontal gain of 6dB over the J-Pole. The vertical radiation pattern of the Slim JIM compared to the J-Pole is shown in Fig. 3.

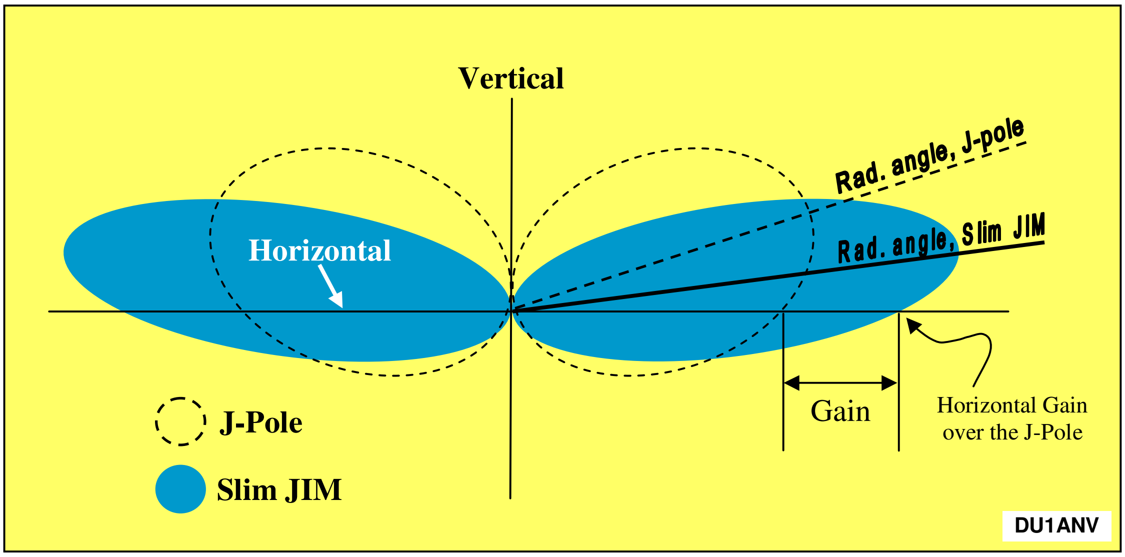


Fig. 3. The vertical angle of radiation and pattern of the J-Pole and Slim JIM antenna

The name Slim JIM was derived from the J-Pole but improved by the developer of the antenna. It was called **"Slim"** because the antenna does not need a radial to throw signals. And **"JIM"**, because of the quarter wave stub matching technique called "**J** Integrated Match", hence the Slim JIM as named by the original designer. I selected this as a weekend project for my QTH in Calamba City because when mounted, it looks like a simple pole, unobtrusive and fools the eye of inspectors looking for structural eye soars in the subdivision. I mounted the finished product without attracting the auditors hi!

Constructing the Slim JIM

According to references, this antenna can be constructed from anything such as; twin lead 300 ohm TV antenna lead-in, copper and aluminum tubing and solid copper wire. I opted for the first for my experiments and finally choose the solid copper wire for the final construction project. The solid copper wire was chosen due to its stiffness and rigidity when the Slim JIM is mounted inside a blue PVC plastic water pipe for weather proofing when the completed project is mounted outside the home QTH.

List of Materials:

	Material	Description	Source
1.	Plastic tubing	PVC Blue – 1 x 8 ft. (Diameter= 32 mm)	Hardware store
2.	Plastic tubing	PVC Blue - 1 x 8 ft. (Diameter = 40 mm)	Hardware store
3.	Plastic end cap	PVC Blue – 1 pc. (Diameter = 32 mm)	Hardware store
4.	Plastic reducer/coupling	PVC Blue – 1 pc. (40 mm x 32 mm)	Hardware store
5.	Electrical copper wire	3 meters of No. 12 gauge insulated.	Hardware & Elec. store
6.	Plastic discs	Circular disc separators (see text) – 6 pieces	Your junk box
7.	Nylon fishing line	1 meter of 1-2 mm thick nylon line	Hardware store

Tools required: Antenna analyzer or SWR meter, Soldering iron, hand drill with set of small bits, soldering lead, hack saw and miscellaneous hobby station hardware.

Construction steps and assembly:

1. Remove all the insulation of the solid electrical wire by using a pocket knife.
2. Draw tension the bare wire by mounting one end of the wire in a vise or post, then with a plier at the other end, pull the wire tout several times (2-3 jerks will do) until it is straight with no kinks.
3. Layout the wire in a flat surface or on the floor and follow the illustration in Fig. 4 to make the loop of the Slim Jim and with the dimensions as shown (A ½ inch diameter drill bit was used as a jig to make the rounded corners when looping the wire):

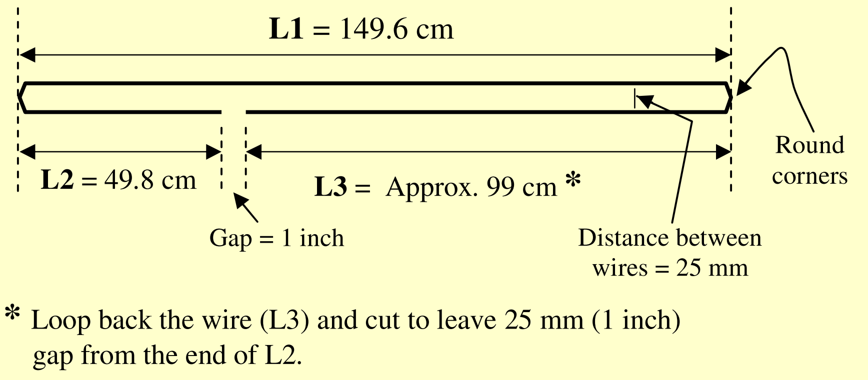


Fig. 4. The dimensions for a center operating frequency of 145 MHz

4. Once completed, hang the loop vertically and set aside meanwhile.
5. Now, fabricate the circular insulator disc separators. These discs will fix the parallel elements together and at the same time will serve as stiffeners to fix the capacitance gap in place. The same will fix the elements centered in the PVC tube enclosure after assembly to ensure that the elements will not touch the PVC sidewall. Make 6 of these discs. In this project, the discs were fabricated from empty plastic boxes about 1-2 mm thick. I used empty KODAK color slide plastic boxes. Measure the inside diameter of the PVC tubing and then with a drawing compass, make circles that have slightly less diameter than the inside diameter of the PVC tubing. Cut these discs with a knife or a shear scissor. Each disc will be drilled with two holes to insert the wire element. These holes must be drilled with smaller diameter holes so that the element wires will fit snugly once inserted but can slide with slight hand pressure. The completed discs will look like the one shown in Fig. 5.

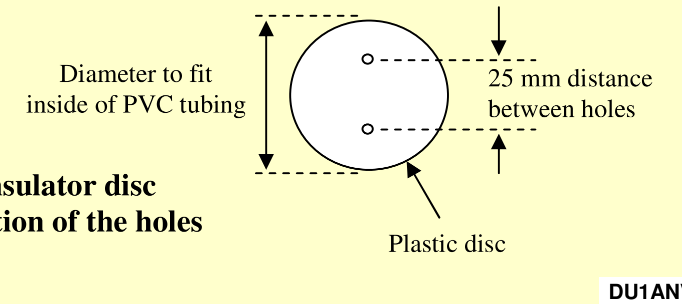


Fig. 5. A single insulator disc showing the position of the holes

6. Retrieve the Slim JIM loop and begin inserting the disc separators. Insert the element at one hole at a time at the top of L2 then slide it onto L1 until the second hole aligns with the tip of L3. Insert this wire into the second hole and continue pushing to the top of the element. Do the same with the others. Of course, the last 2 discs will re-enter the top of L2. The assembled element with the discs installed will look like the illustration shown in Fig. 6.

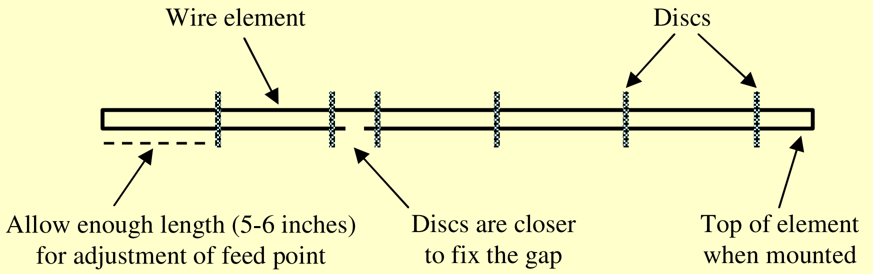


Fig. 6. The Slim JIM element showing the position of the disc insulators

7. Align the elements and discs so that the wires are in perfect parallel. You are now ready to tune and adjust the feed-point of the coax transmission line at the bottom of the "**J**".

Adjustments and Tune up

1. Hang the Slim JIM with a piece of nylon string with its top side up, away from physical objects (Humans, plants and other magnetic materials etc…) within one wavelength or further. This antenna, like the J-Pole, is temperamental! It does not like solid objects around it. This is because the active element is an open space radiator. Any material near it will throw the VSWR crazy. The feed-point (or bottom of the "**J**") must be about one-half wavelength above ground when the whole element is hanged.
2. Splice the RG 58 to bring out the shield/braid and center conductor clear. The lengths of which should be enough to be soldered to the feed-point (Marked "**F**"). Solder the shield/braid to the open leg of the "**J**" exactly 3 inches from the bottom. Likewise, solder the center conductor of the cable to L1, also 3 inches from the bottom of the other leg of the "**J**" as shown in Fig. 7.

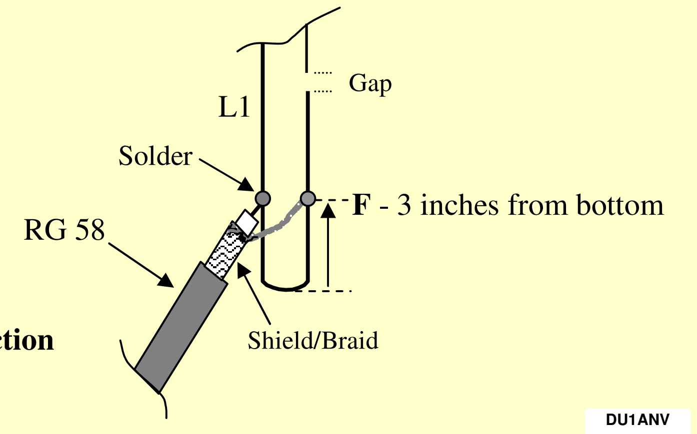
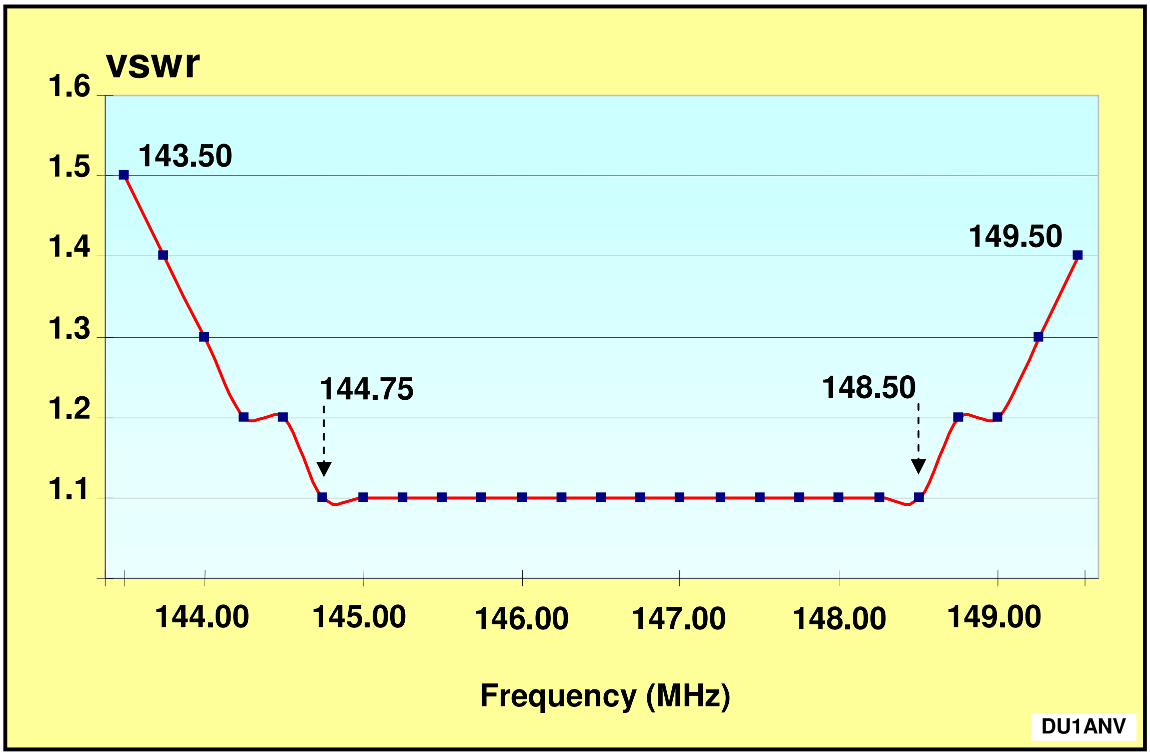


Fig. 7. Feed point connection in the matching stub.

3. **Checking the bandwidth and resonant frequency:** Before installing the assembled antenna into its PVC tube enclosure, you must recheck its VSWR curve to ensure that the antenna resonance and bandwidth is close to the design frequency. Use an antenna analyzer for this purpose. In case an antenna analyzer is not available, you can use your normal SWR meter and radio transceiver to check the bandwidth and VSWR curve. The graph shown in Fig.8 is the VSWR curve of my Slim JIM project in open air with the dimensions shown in Fig. 4.



Trace of VSWR vs Freq. Bare Slim Jim antenna in open air space

■ Test points

Fig. 8. The polynomial trace of the bandwidth based on the voltage standing wave ratios at various frequencies measured by an MFJ -259B antenna analyzer.

If your measurements are within the boundaries as those shown in Fig. 8 or thereabout, you are lucky. If the VSWR you found is high, you must unsolder the coax at the feed-point and try to find a position (Slide the coax up or down in increments of 0.5 cm each time) where you can achieve the lowest swr reading and solder the connection at this point. If the resonant frequency (lowest swr reading) is way below 144.0 MHz, it means that the lengths of the radiator (L1 and L3) are too long. You must adjust by shortening the element beginning at the top of L1. How? … get a round jig (1/2 inch diameter drill bit or a wooden dowel) and place this inside the "U" to serve as stopper held by your left hand. Then pull the open end of L3 with a plier. You can extract 1/2 inch at a time by this technique. Cut this extracted length so that the 1 inch gap from the open end of L2 is maintained. Finally, re-align the elements and discs and measure again the swr. Repeat this procedure until the resonant point is within the figures shown in the graph of Fig 8.

Remember!.... *The resonant frequency will shift lower when installed inside a PVC tube. The project described in this article shifted to a center frequency of 145 when finally installed inside a blue PVC water pipe. Also, the VSWR will change depending on the type of disc insulators you use.*

Final assembly

When everything is in order, you are ready to place the Slim JIM inside the PVC pipe for its final enclosure. Follow the assembly guideline below:

1. Make sure the coax cable is securely soldered at the final feed point.
2. Check the alignment of the parallel wire elements and discs.
3. Get some glue (I used instant super Glue made by Pioneer) and put a dab of glue in each entry point of the wire through the plastic discs. This is to ensure that the discs will not move or slide down when the antenna is finally mounted in vertical position.
4. Now, get the 32 mm diameter PVC pipe and lay it horizontal in a table. Insert the antenna (top of L1 & L3) inside the tube and carefully push the entire element until this top end appears at the opposite end of the tube and stop.
5. Get the PVC end cap. Drill the top center of this end cap with a small diameter bit where the nylon string will pass through.
6. Loop the nylon string at the top of the element and tie a strong knot (make sure it will not unravel). Push the other end of this string through the hole of the PVC end cap and leave about 3-5 inches free before tying a knot at the top of the end cap. Plug the cap to the end of the tube.

When finally assembled, the Slim JIM will look like the cut-away illustration shown in Fig 9.

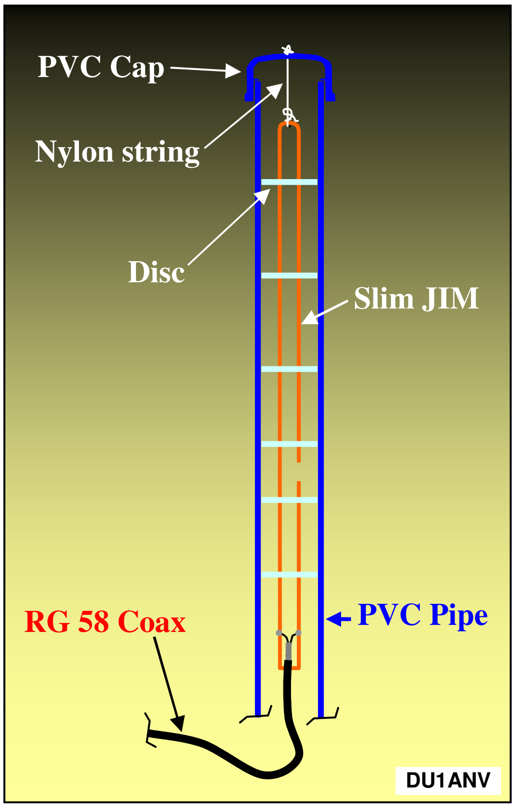


Fig. 9. The Slim JIM Mounted in the PVC enclosure.

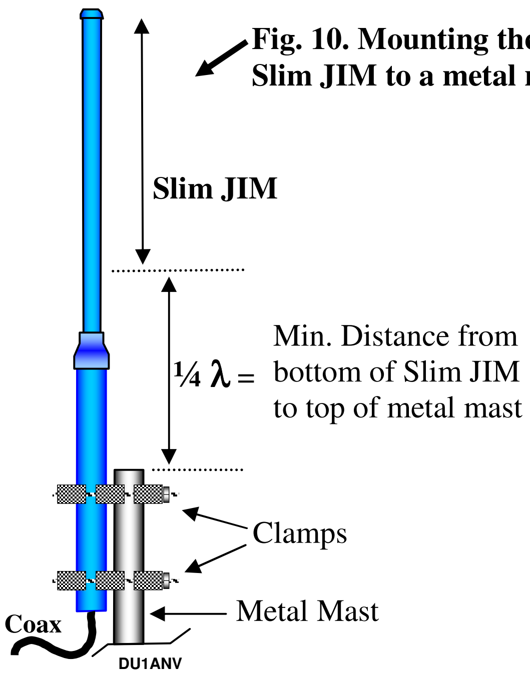


Fig. 10. Mounting the Slim JIM to a metal mast

7. Stand the PVC tube housing and pull the coax lightly downwards to tension the nylon string on top. Finally, put a dab of water sealant (Vulca Seal) or anything to keep moisture from sipping through the nylon knot on top of the end cap. **Note:** For servicing purposes, do not cement the end cap to the tube.
8. That's it! You are ready to mount your Slim JIM into a mast.

Recommended mounting scheme

The Slim JIM is an open space antenna. It is recommended that the antenna must be mounted in a free and open area, away from tree branches to enjoy the benefit of the horizontal gain. I installed mine using the mounting scheme shown in Fig.10. If a metal mast will be used, the bottom of the slim JIM must be at least a minimum of a quarter-wavelength (19 to 20 inches) above the top of the metal mast to avoid interaction. Wider stacking distance way above the top of the metal mast is recommended.

Considering the frequent typhoons occurring in the Philippines, I decided to cut the PVC enclosure to just below the bottom of the "**J**" match (about 20 cm) and used a PVC tube reducer to join the upper PVC enclosure to a larger diameter tube (see Parts list), the length of which depends on your preference for mounting purposes (see Fig 10). Use a PVC cement to join the upper and lower tube at the reducer coupling point. The whole purpose is to reduce wind resistance and strengthening of the lower tube for mounting with the use of metal clamps and U-bolts.

I installed my antenna using a regular 1 ½ inch diameter metal water pipe and the whole was mounted against the cement fence wall beside the Home QTH. The Builder should use his/her own discretion according to preference in mounting the whole antenna setup. The diameter of the steel mast does not really require the use of guy wires.

Performance test

After erecting the antenna, I connected my portable VHF radio (Icom 02AT) to the 15 meters of RG 58 coax and gave a shout to my compadre, Estoy/DU1FLA via the DX1MK repeater in Los Baños using low power (500 milliwatts). He responded immediately and gave me an evaluation of my signal reaching the repeater, which is about 15 km away from my home QTH in Calamba city. I was coming to the repeater with full quieting signal. Compared to the J-Pole at the same location, I used to go high power (3.5 Watts) using the same radio to barely access the repeater above noise. Estoy went to simplex in the uplink and he gave me a signal report of just below squelch level but Q-5 with my 500 mW. At 3.5 watts, he gave me a signal report of S2-S3 with his J-Pole receive antenna. Recalling again the performance of my former J-Pole, I can reach Estoy via simplex for just barely above noise level only when I transmitted 3.5 watts from the same location. This simple test satisfied my curiosity to the Slim JIM. Using this antenna to access the DX1MK repeater, I can now transmit at 500 milliwatts and trigger the repeater at "full quieting". This is a significant improvement compared to my old reliable J-Pole. Another station, DW1NSM/Cesar, gave me a signal report of S-3 (at 500 mW) and S-7 to 8 (at 3.5 W). Cesar did not mention his receiving antenna but his home QTH is 3 Km East of Estoy's QTH in Los Baños, Laguna. These two stations are not in "line of sight" from my location in Calamba. To reach these two stations, my signal will have to skim through two solid mountain sides at the foot of mount Mt. Maria Makiling before reaching these two fixed ham stations, beyond and below the second mountain side mass.

Adding to my curiosity, I decided to calculate the effective RF power reaching the feed point of the Slim JIM. From my earlier records, the same coax transmission line has a 10.2 dB coax loss at 145 MHZ as measured by my MFJ 259B analyzer, just 3 days before. Using the same loss figure, I roughly calculated the remaining RF power driving the antenna. Thus;

500 mW – 3 dB = 250 mW lost
250 mW – 3 dB = 125 mW lost
125 mW – 3 dB = 62.5 mW lost
62.5 mW – 3 dB = 31.25 mW lost
Total loss: -12 dB = 468.75 milliwatts lost
Balance = 31.25 milliwatts reaching the feed-point of the Slim Jim (if -12 dB loss).

The -3dB point is in fact half power of input each time a 3 db loss was added from the former. For quick and rough calculations, the -12 dB loss was used for calculation then extrapolated up to the -10.2 dB point. Considering the RG 58 as a lossy transmission line, I was probably transmitting an effective RF power reaching the feed-point of the Slim JIM antenna in the range of 45-50 milliwatts (actually 47.75 mW, calculated) at low power. I said to myself, WOW! I am reaching the DX1MK repeater with approximately 50 milliwatts driving the antenna!

From the above signal reports, the better performance of the Slim JIM over my J-Pole can only be explained by the following scenario:

1. The Slim JIM exhibits a vertical radiation angle of between 8-10 degrees from the Horizontal plane compared to the J-Pole which is 30 degrees from horizontal.
2. The power gain of the Slim JIM in the horizontal plane is 6 db (as claimed) over the J-pole (see Fig. 3)

Therefore, the apparent power gain of the Slim JIM in the horizontal plane can be calculated to show its better performance in reaching and receiving DX stations. Thus:

Reference antenna : J-pole (see pattern in Fig. 3). Designated as 0 dB point when **47.75 mW** of RF power is driving it as per above calculations.

Since the Slim JIM has a 6 dB horizontal gain, the total available RF energy where the precious microvolts are focused in the horizontal plane is:

47.75 mW +3 dB = 95.49 mW
47.75 mW +3 dB = 95.49 mW
Total power gain = +6 dB = **190.98 Milliwatts**

Each +3 dB point doubles the power. To check:

Power ratio = **antilog** (6 db / 10) = 4.00 (rounded)
(P1 /47.75} = 4.00 P1 = **191 Milliwatts**

dB_{power} gain = 10 $\mathbf{log_{10}}$ [191/47.75] = **6.02 dB**

Conclusion: The relative power gain of the Slim JIM is 4 times over the J-pole in the horizontal plane.

The performance of the Slim JIM was impressive. Like the J-Pole, the Slim JIM exhibited a wide bandwidth. The VSWR was 1:1.4 at 143 MHz, was 1.1 flat from 144.00 to 148.75 MHz, and 1:1.4 at 149.75 MHz. as measured when erected in the selected location.

I decided to install permanently the Slim JIM using that old unbalanced Coax cable at my Calamba QTH.

For the perfectionist Hams, they may replace the RG 58 with a less lossy cable to significantly improve the performance. Further, they can add a choke coil made of 5-6 turns of the same transmission line forming a diameter of 5 inches located near the feed-point. This is to circumvent the inherently unbalanced coaxial line (This is a simple BALUN). Wrap the coil tightly with electrical tape. Of course, the coax must be brought out from within the PVC tube just below the feed-point to fix the BALUN outside (see Fig. 11). This is an ugly eye soar but the omni-directional pattern will remain less altered and preventing the flow of RF energy back into the coax shield of the transmission line. This addition will certainly improve further the performance of the Slim JIM but I did not bother to add this BALUN for the reason described earlier.

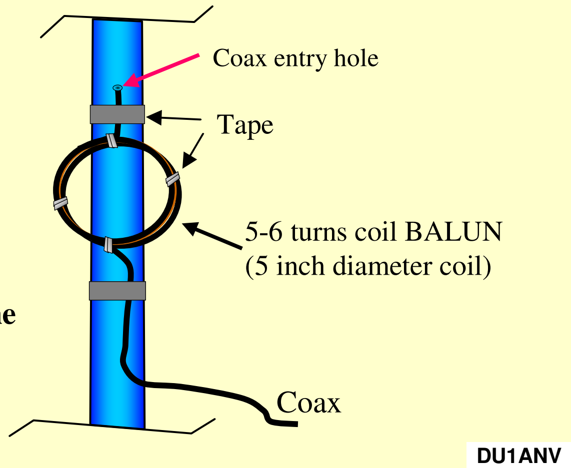


Fig. 11. Installation of the coil BALUN if added.

Constructing the Slim JIM for other frequencies

For other working frequencies, calculate the new dimensions by following the formula shown below:

$$L1\ (cm) = \frac{217 \times 100}{\text{New operating Freq (MHz)}}$$

$$L2\ (cm) = \frac{L1\ (cm)}{3}$$

The constant 217 was derived after including the velocity factor when the antenna is enclosed inside a blue PVC tube. It should be used to calculate the length of L1 when using a No. 12 gauge solid copper wire. This formula may not apply to other materials used for the radiating element and the type of enclosure.

The Physico-Chemical properties of the material used for each type of enclosure is innate and hence, the specific velocity factor. When doing antenna projects in the VHF and UHF region, a good construction practice is to add 2-3 percent more to the calculated length and then trim the length down during the adjustments to center the desired frequency. It is better to cut a long element than adding extra length to a short element. Finally, it is imperative that a resonance check must be performed when the radiating element is installed in the selected enclosure.

Incidentally, the slim JIM antenna design is usable up to the UHF region by following the same construction technique.

That's all folks!...... Happy home brewing!!

“A low reading of voltage standing wave ratio (VSWR) always indicates resonance”

Fact? or Fallacy?.......... Joe/DU1ANV