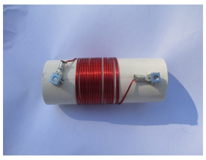
Low Cost Antenna Traps

September 2014



Mouse-over any image to see it larger!

Let’s work through the design of a simple-to-construct low-cost antenna ‘trap’ - like the one pictured above - for the 40 metre band, i.e. the 7 MHz or 40 meter (USA) band. It is used to make up a dual-band 80m/40m dipole where previously only a 40m dipole existed and there is room to add extra wire on each side to make it work on the 80m band too.

The typical issue when building L-C trapped antennas is where to find a capacitor that will withstand the voltages associated with high power transmitters exciting the antenna, not to mention the currents flowing through the trap coil when the bands lower than the trap frequency are being used. Even if you do find one physically suitable, it’s capacitance value is probably far too high anyway.

The concept behind trapped antennas will be taken in a simplistic view only, the trap at the end of each segment acts as a parallel resonant circuit at the “switching frequency” thus producing a high impedance at that frequency and thereby isolating one segment from the next. Secondly, the trap acts as a series inductance at frequencies lower than its parallel resonant frequency thus shortening the effective physical dipole length of the subsequent legs.

Be aware that trapped antennas exhibit a narrower SWR response curve than a full-size dipole at the same frequency. For example a standard dipole on 80m might exhibit a bandwidth of 170-180KHz at the 2.5:1 SWR points while a trapped one may only have 40-60KHz between the same SWR values. For instance, the Diamond W-8010 multiband antenna has a nominal bandwidth of just 12KHz at 1.5:1 SWR on 80m. The main advantage of a trapped antenna is less wire is required, only two end mounting points are needed (in lieu of two *for each dipole leg* in a ray dipole assembly) and results in a slightly more compact arrangement. You can also mount either form in an inverted-V format but expect that the lengths of the wire legs will be slightly shorter due to the increased capacitance-to-ground effects.

I have also become a fan of using “tails” to do the fine tuning of antennas to frequency and this becomes much more important when working with multiband antennas, whether trapped or full size. What is a 'tail' you may well ask? Put simply, the last part of the dipole length is made variable by placing the mechanical termination back some 100 to 300mm from the proper dipole length and then the tail is adjusted in length to obtain the tuning point to the desired frequency. If that mechanical point is an antenna trap, the physical length of the segment remains unchanged thus allowing the next segment length to be independently tuned to its desired frequency, and so on..See Trap-style Inverted-V Antenna for 3.5, 7, 14, 21 & 28 MHz (/~vk4adc/web/index.php/hf-projects/45-hf-antennas/104-gridlocw) or Diamond W8010 & WARC Band Mods (/~vk4adc/web/index.php/hf-projects/45-hf-antennas/99-caveat-emptor-radiomart-v2) for some ideas about tails but note that the dipole lengths will be different because this style of LC trap has a larger series inductance on the lower bands than a coaxial trap with the same design frequency.

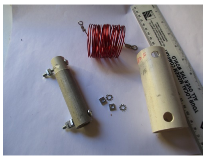
The approach being taken here to manufacture an antenna trap is to use electrical conduit as the dielectric between two aluminium tube cylinders and create a physical capacitor that way. The resulting capacitor is then mounted centrally inside the coil former tube to make a physically neat - while strong - arrangement.

The hardest part is to find the aluminium tubing lengths with the correct dimensions to provide a snug fit both inside and outside the rigid conduit tube.

The following material details and dimensions are for ONE TRAP only, so double the quantities to have enough to make the second one.

- Electrical conduit 20mm OD (rigid style UPVC material), 16mm ID, 100mm long, 3/16” / 5mm hole right through the tube 10mm in from each end.
  (e.g. Bunnings: DETA 20mm Heavy duty rigid conduit (orange) F/L 4330850 or DETA 20mm Medium duty rigid conduit (light grey/white) F/L 4330846)
- Aluminium tube 22mm OD, 20mm ID, 75mm long, 3/16” / 5mm hole 10mm in from one end through both sides. (ID dimension is critical, and should be a snug fit over the 20mm conduit)

- Aluminium tube 16mm OD, 12.5mm ID, 75mm long, 3/16” / 5mm hole 10mm in from one end through both sides. (ID dimension is critical, and should be a snug fit inside the 20mm conduit)
- Plumbing PVC pressure pipe, white, rigid style PVC material, 40 mm nominal bore (which is actually 42mm OD), 100mm long, two 3/16” / 5mm holes at 10mm in from each end through both sides (i.e. 80mm apart), one side hole then re-drilled out to 10mm dia. If you plan to use PVC end caps, make this tube about 40mm longer but still with the same 80mm hole-to-hole spacing dimension.
(e.g. Bunnings: Holman 40mm 1m Press PVC Pipe Class 9 Pvp409-1, F/L 4750049)
- Enamelled copper wire, 1.25mm diameter (e.g. use a 10 metre roll).
- Two solder lugs to suit 1.25mm wire and a 3/16” / 5mm bolt.
- Two 40mm long screws of 3/16” or 5mm plus 8 nuts to suit, 6 spring washers to suit.



The parts used to make up the 'trap'.

Given the above dimensions for the aluminium tubes, there is an overlap of 50mm of the two metal cylinders when assembled. That calculates as a working surface area of the cylinders as a capacitor plate at 2915 sqmm.

Why the extra holes through the 'inner' tube?
So I could vary the capacitance during the experimentation phase....
The outermost hole was the one used in the final trap design.

From my experiments, the dielectric constant (K) of the UPVC tube that I used is about 2.2 at 7MHz, but other manufacturer's materials may differ slightly. There isn’t a published value available from the web for used of this style of conduit at RF but indicative values found are 3.9 at 50Hz and 3.3 at 100Hz. I haven’t determined the dielectric constant at other amateur frequencies but it probably is in the same ballpark.

One factor that is not either available from the web or from my experimentation is the dielectric loss at RF. One of the nominal tests for suitability of a material has been to place a length of it plus a cup of water, separated, in a microwave oven and heat it at full power for one minute. If the material under test was hot, it was considered lossy at 2.4GHz and not really suitable but here we are operating at HF and it is a whole different ballgame. The validity of the tests at microwave may not compare properly.

By the way, the breakdown voltage of this style of conduit is typically 14-20KV/mm so a 2mm dielectric thickness gives a value greater than 20KV. The other air gaps are around 8mm in air so typically better than 100KV breakdown.

The assembled capacitor illustrated against a ruler to display dimensions, 100m over length with 25mm of PVC tube exposed on the LHS.
Note one screw (RHS) acts as the connection to the outside sleeve while the one on the other end (LHS) seems only to pass through the PVC tube.
Check the actual end detail in later photos.

From the standard capacitance formula for two-plate capacitor:

C= K*Eo*A/D, where Eo= 8.854x10-12

where:
K is the dielectric constant of the material,
A is the overlapping surface area of the plates, (in sq mm)
d is the distance between the plates, (in mm) and
C is capacitance in pF

Effective capacitance calculates out at 28pF.

Now we have a fixed known capacitance value, the parallel inductance required to resonate it at our desired trap frequency can be calculated via the formula:

2*pi*F= 1/sqrt(L*C) giving F= 1/(2*pi*sqrt(L*C)) etc..

[sqrt = square root]

For a design frequency of 7.1MHz, the required inductance is around 17.5uH.

What coil dimensions do we need?

The following formula calculates the inductance of a single layer air cored inductor:

L= (d^2 * n^2)/(18d+40l)

where:

Lis inductance in micro Henrys,
d is coil diameter in inches,
l is coil length in inches, and
n is number of turns.

There are a number of web-based calculators to make this part easy but I use a MS-Excel based version that makes manipulation of the variables quicker.

Since we are using 42mm OD conduit as the coil former, that gives us a value for D at 1.65 inches.

For the moment let's use the same value for the coil length L…, 42mm or 1.65 inches.

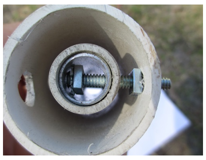
The calculator shows that we will need around 25 turns to obtain 17.5uH.

On the 42mm PVC former, that equates to 25 turns over a 42mm length.

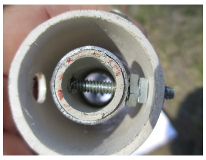
The wire I want to use is 1.25mm diameter enamelled so 25 turns x 1.25 diameter = 37.5mm long - so it will fit within our 42mm coil length dimension. In fact we can stretch the coil out a bit on the 42mm former to make it resonate at our desired frequency.

Also those dimensions work out that about 3.3 metres of enamelled wire is required per trap.

There is no step-by-step assembly instruction, just make it look like the photos. You may have to do it a couple of times to get it right simply because the screw lengths are longer than the internal diameter of the coil former tube and you can't just push it in fully assembled. Consider it a variant of a Rubik's Cube puzzle to get the assembly order correct. Here's a tip: see the 10mm diameter hole on the LHS, the screw head will fit through it - as will a screwdriver to tighten it up during assembly. Longnose pliers plus the screwdriver are all that is needed to complete the assembly of the capacitor.

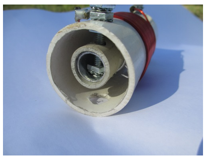


The inner tube end showing the spring washer plus internal nut.
The additional nut inside the outer tube (RHS) acts as a spacer to keep the capacitor assembly mechanically stable.



The outer tube end showing the spring washer plus external nut.
The additional nut inside the outer tube (RHS) acts as a spacer/standoff to keep the capacitor assembly mechanically stable.

There is just enough thread protruding to attach a couple of heavy solder lugs for the incoming and outgoing wires but if you are finding them just a trifle too short, substitute 50mm long screws during the assembly process.



Finally use a “grid-dip” style meter, antenna analyser or something similar, to fine-tune the traps so that they tune to the same frequency +/- 20KHz then seal the coil onto the former with electrical tape. Recheck the frequency then coat it with a marine varnish etc to ensure that it doesn’t weather, unwrap or allow the coil to deform over time.

If you can’t waterproof the assembly properly, consider not waterproofing it at all so that any moisture can evaporate. Ideally attaching the matching 40mm PVC end caps to each end and allowing the 10mm screwdriver access holes to act as drain holes will solve the moisture issues anyway. The main consideration is to keep the capacitor area dry. You can also use an expoxy glue to hold the aluminium tubes in place and to provide a measure of moisture exclusion into the dielectric area.

An alternative is to place the whole coil/capacitor assembly into a much larger diameter PVC pipe complete with end caps and just let the bolts protrude through.. The drawback with this latter option is the extra weight added.

My original unit came up at 6.92MHz with the coil’s turns close spaced. It quickly moved up to 7.1MHz by spreading the turns slightly at one end of the coil. Job done.

Ok, where are the overall antenna dimensions?? Not here ! This article is about an idea for low-cost antenna traps and not building the whole antenna…… Apart from which, the leg lengths of a dipole vary with height above ground, wire diameter, insulated versus uninsulated wire, etc.. Try checking out the page at Adjusting HF Antenna Lengths (/~vk4adc/web/index.php/hf-projects/45-hf-antennas/98-caveat-emptor-radiomart-v3) but consider using a correction factor of 0.98 (or so) for most installations.

Q&A

Can I make similar traps for other bands??? Yes, adjust the length dimensions of the aluminium tubes plus the separating dielectric sleeve to obtain a different capacitance, design a different coil to resonate at the desired frequency. A problem may be getting suitable inductor and capacitor values to create traps at considerably higher frequencies, yes - 14MHz is considerably higher with a former 42mm in diameter…. Making a trap at 3.6MHz to allow the addition of 160 metres coverage onto an existing 80metre dipole (or a 80m/40m) is quite feasible though.

Could I make the capacitor tube longer?? Yes, but to maintain a capacitance around 28pF, the overlap between the two tubes must still be about 50mm. For an overall capacitor length of 125mm, the 20mm dielectric tube dimension is 125mm, the 16mm and 22mm metal tubes are both 100mm long

Can I use other dimension sizes for the tubes for the capacitor?? Yes, provided they are a snug fit so that the capacitance created doesn’t vary with vibration in the wind etc.

There are a number of suitable and useful electronics calculators at http://www.daycounter.com/ (http://www.daycounter.com/) as at September 2014...