Using Antenna Traps

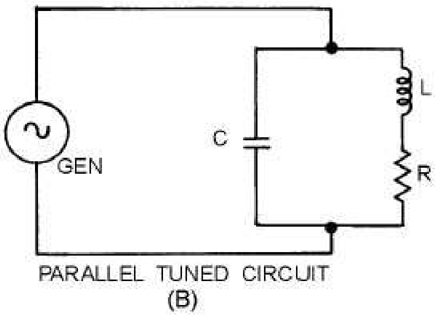
Trapped antennas have a long and not always illustrious history in amateur radio use. In this article I will look in some detail at traps and finally make some suggestions about how they might be used.

What is an Antenna Trap?

A trap is a parallel tuned circuit (a capacitor in parallel with an inductor). Parallel tuned circuits (PTC) are used in all sorts of radio applications as they are selective: in this context a PTC has a resonant frequency at which it has a high impedance [1]. At frequencies below the resonant frequency the reactance of the parallel tuned circuit will be inductive; above the resonant frequency the reactance will be capacitive [2].

Modelling Traps

Traps are modelled in antenna software with a model that assumes a perfect capacitor and an inductor with a small series resistance which takes into account the resistance of the conductor and core losses.

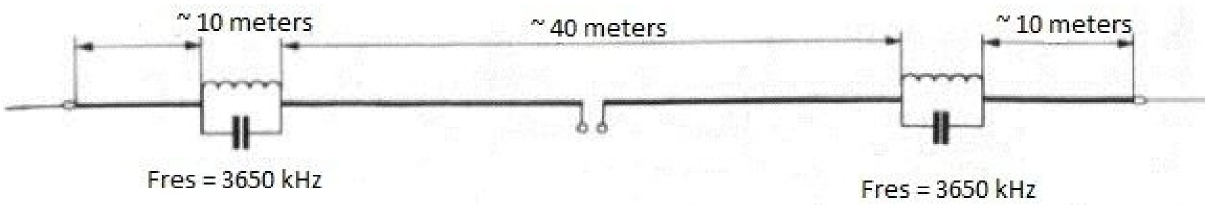


http://electriciantraining.tpub.com/14181/css/14181_14.htm

Using Traps

When used in an antenna system, a trap can be used to isolate one part of the antenna from another. This is the simplest application of traps. Conventional wisdom [3] is to resonant the trap at the lower band edge of the higher frequency band (I have not seen any explanation as to why this approach is adopted).

The following diagram shows how a trap is used in a two band dipole system the trap is resonant at the higher of the two frequency bands and isolates that part of the antenna on that band. On the lower band the trap appears like an inductor, this means that on the lower frequency the antenna is a bit shorter that it would be without the trap. This shortening can be controlled by selecting a suitable LC ratio. The use of a trap also tends to reduce the usable bandwidth on the antenna at the lower frequency.



http://www.pa1m.nl/pa1m/80-160-antenna-for-the-small-garden/

This is the most common way of using traps and in many ways it's the easiest. Adjusting a trapped antenna is easy –provided you follow one simple rule: always start the adjustment with the section of the antenna closest to the feed point (the highest frequency section). Once that is adjusted, the lower frequency section can be adjusted without any affect on the higher frequency section.

Our example uses two traps, one in each leg of the dipole to give two bands. The idea can be extended to give three bands by having two traps in each leg of the dipole. Beyond three bands the bandwidth of the antenna on the lowest band and the matching usually become problematic.

This method of using traps, while being the simplest, is also the most lossy way to use traps. It is the potential loss associated with traps that has given rise to their poor reputation. This poor reputation, I believe, arose due to problems associated with some makes of trapped beam antennas in widespread use in the 1970s and 80s. The traps used in these antennas suffered from reliability problems, possibly due to water ingress. This, when coupled with a rather over optimistic manufacturers power rating caused the traps to burn out.

Another factor that may have tarnished the name of traps is the use of traps made solely from co-axial cable [4][5]. These are undoubtedly a very clever idea but are relatively lossy and often heavy compared to lumped-element traps (ones made with inductors and capacitors). The inherent losses are often acceptable when traded against convenience and ease of manufacture, remembering of course that all antennas have losses. The other disadvantage of co-ax traps is that the designer has no control over the LC ratio. This can be a problem in the design of reduced-size antennas. For a detailed look at trap losses, I recommend Tom W8JI's article [6].

The off-resonance characteristics of PTCs can be used in another way to make multiband antennas. By using a trap resonant between the two bands, losses due to the traps are further reduced [2] and the bandwidth of the antenna on the lower band is increased. It is debateable whether "trap" is the right term to describe a PTC used in this way.

There are downsides to this approach however:

1. Adjusting antennas with off-frequency traps can be difficult because the two sections of the antenna are not isolated from each other and thus they interact. This means that there is no single

“correct length” for each section. Many happy hours can be spent discovering that there are numerous potential solutions depending on where the “trap” is located.

2. The overall antenna length is longer than for a conventional trap dipole.

Yardley [7] suggests that the PTC resonant frequency for off-frequency “traps” should be the geometric mean of the two bands. I don’t believe that it is very critical.

While traps are most often used in making multiband dipole antennas or as part of Yagi antennas, they are equally useful for making multi-band end-fed half-wave antennas.

Making Traps

Here we look at how traps for use in wire antennas can be made. Traps for use in Yagi systems are mechanically different to account for their different application: electrically, they are identical.

Traps for wire antennas are relatively simple to make if you have the right test equipment. For lumped-element traps, a good starting point is to choose a value of capacitance (one that you have in your junk box is a good start) and then work out the corresponding value of inductance for your desired resonant frequency [1]. As a start I would choose a capacitance of between 30 and 50pF for traps between 14 and 30 MHz. Use a capacitor that will be suitable for RF and reasonably temperature-stable such as a silvered mica type.

The inductor will need to be made. You can wind a coil on a former or use a toroidal core. A coil wound on a former will have a higher Q (less loss) but will be more bulky than a coil wound on a toroid. The bulk of the coil can be a consideration if the traps are to be used as part of a portable antenna. Bulky could tend to get snagged on branches. There are lots of software applications available that will help you design your coil e.g.[8]. Wire up the capacitor and inductor in parallel.

Co-axial traps can be designed using Tony Field’s excellent software [9]. You may also wish to read G4HFQ’s article on co-axial traps [10].

To adjust your trap, the best tool to use is a calibrated network analyser. The turns of wire on your toroid or former can be moved apart or closer together to achieve the correct resonant frequency. This adjustment process is often easier with toroidal cores. VK4ADC shows several methods for adjusting traps [11]. If your traps are to be used as pairs (in a dipole for example), their resonant frequencies should be close to each other to preserve the balanced nature of the antenna.

Other ways to use Traps

Traps can also be used as part of a more complex design. An example is the multiband trap antenna designed by Bob J. Van Donselaar [12]. Here one pair of traps is cleverly used to implement a five band antenna, albeit one that requires an antenna tuner to be used.

Retrofitting Traps

If you have a dipole antenna, you can often add additional higher frequency bands by inserting traps. A dipole will need traps in each leg of the antenna. Using the usual dipole formula and calculate the length of the dipole on the higher band. Add a few percent to the length and cut your dipole. Insert the trap and adjust the higher frequency part of the dipole for resonance. Once this is done, adjust the lower frequency part for resonance. Because of the loading effect of the traps, the overall length will be a little shorter than before.

References

[1] http://www.allaboutcircuits.com/vol_2/chpt_6/2.html

[2] http://arcarc.xmission.com/PDF_Electronics/RLC%20circuits%20&%20Resonance.pdf

[3] To Trap or not to Trap, Antennex, LB Cebik

[4] Build a space efficient dipole antenna for 40, 80 and 160 meters, Al Buxton, QST July 1992

[5] Two New Multiband Trap Dipoles, Al Buxton, QST August 1994

[6] http://www.w8ji.com/traps.htm

[7] Designing Trap Antennas: a new approach, Yardley B., Ham Radio, Aug 1987

[8] http://www.dl5swb.de/html/mini_ring_core_calculator.htm

[9] http://www.qsl.net/ve6yp/CoaxTrap.html

[10] www.g4hfq.co.uk/g2hcg/traps.doc

[11] http://www.vk4adc.com/web/index.php/hf-projects/46-antenna-traps/105-tuning-hf-coax-traps.html

[12] http://sharon.esrac.ele.tue.nl/~on9cvd/E-Multiband%20trap%20antenne.htm

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