Multiband Fanned Vertical Antennas

Introduction:

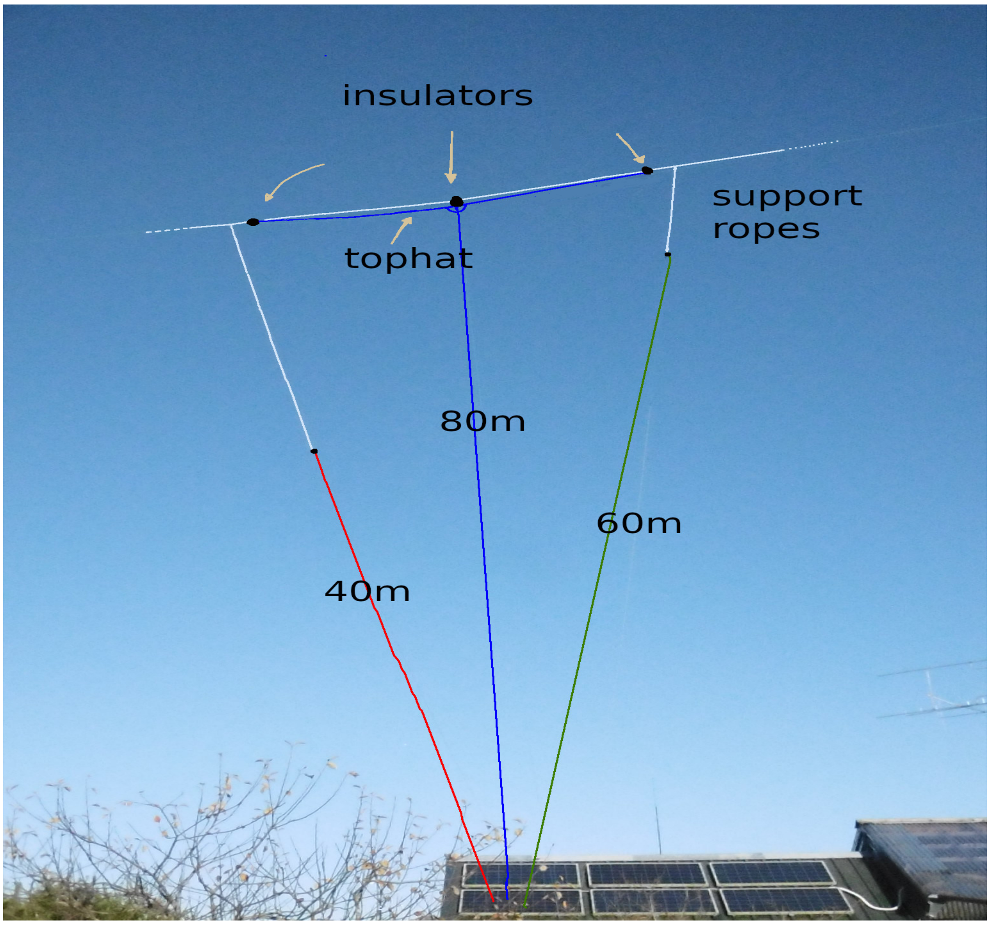
Fanned vertical antennas with several vertical elements sharing a common feedpoint offer a simple solution for operating on two or more bands, without having to retune. This is of particular interest when using digital modes which require automated band changes, e.g. WSPR or connecting to winlink gateways. For reliable long distance point-to-point contacts vertical polarization is advantageous, because a low take-off angle is maintained across all bands. Horizontal multiband antennas have a frequency dependent take-off angle due the relative height above ground and the associated angle of ground reflection for each band.
This article gives an overview of how to build this type of multiband antenna.

The Bottom Half:

As with most vertical monopole antennas a set of elevated resonant radials, a set non-resonant wires buried a few centimeters, or a metal clad roof can be used as a counterpoise. When using elevated radials at least a pair of 1/4 wave radials for each band should be used. A single 50 ohm coax cable will provide a reasonable match to the shared feedpoint, with the coax braid bound to the ground system. An elevated installation may need an insulating 1:1 transformer for the supression of feedline radiation.

How It Works:

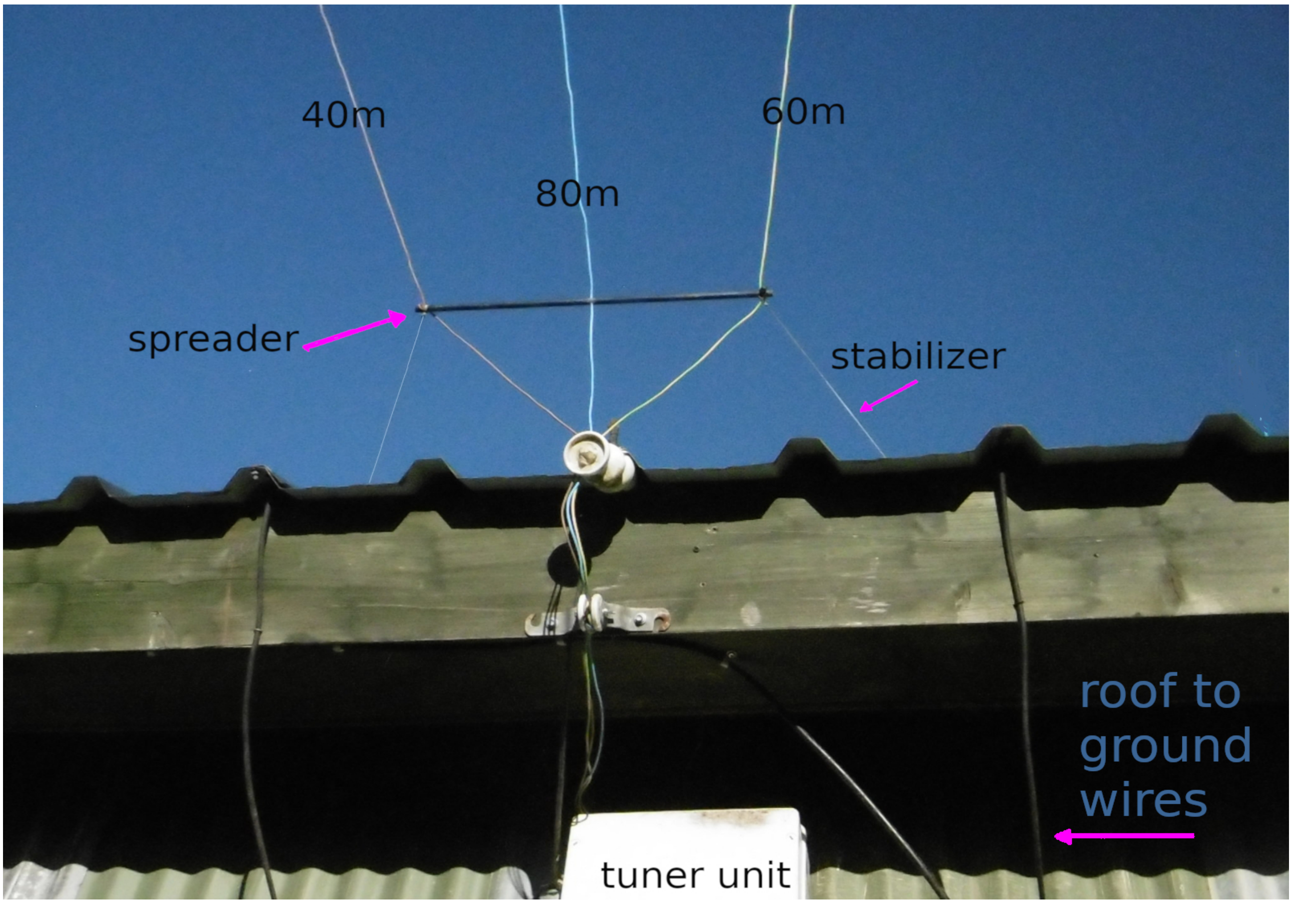
Each radiating element behaves like a single vertical element. Since the neighbouring elements are not resonant they will have little effect on the active element’s radiation pattern. That's it.



Above: A three band vertical, with a T-antenna for the lowest band, held aloft by a rope spanning between other antenna masts, tilted towards the camera by about 15 degrees due to position of the available ‘sky hook’ geometry.

Practical Considerations:

The radiators are spread apart at an angle of no less than 15 degrees. The feedpoint geometry is crucial, mechanical stabilty ensures that the impedance and resonant point of each radiator remains constant. Each radiator is somewhat shorter than the calculated electrical quarter wave, compared to a single element, especially at small spread angles. The mechanical length of a thin wire radiator of a single 1/4 wave vertical is about 97% of the calculated electrical length. A thick metal tube will be even shorter. When combining several elements the capacitive effect between the wires will require additional shortening.
The distance between the radiators close to the feedpoint must be kept as wide as practical, but also as stable as possible.
Changing the length of one of the radiators to achieve resonance at a given frequency will have an effect on the neighbouring radiator(s), more so when the radiators have a small spread angle. This invariably requires repeated adjustments. One should start with no less than about 95% of the calculated electrical length, carefully pruning each radiator in turn while observing all resonance points to avoid overshooting the targets. This is a lengthy process. Keep in mind: the wire can't be cut longer ...
Before cutting an element the end of the wire should be folded back on itself and tightly wrapped until the desired lengths has been found, likely requiring the antenna to be lowered and raised a dozen times. Keep a record of each step and frequently re-measure the actual lengths.



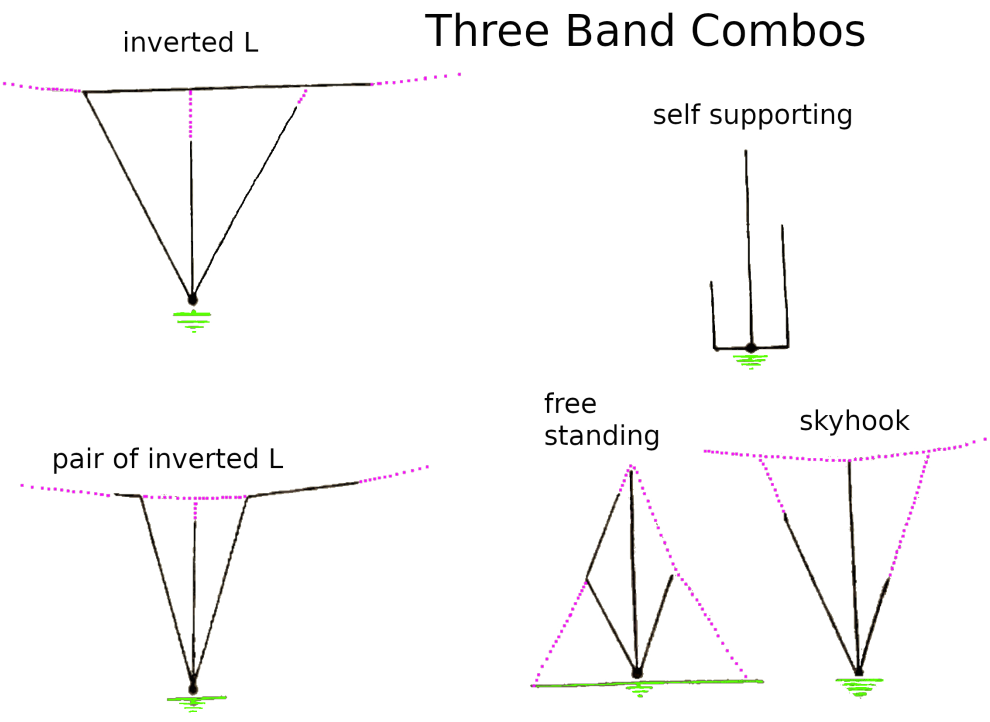
Above: The spreader is made from a piece of fibreglass tent pole, the stabilizers are bits of plastic string. This arrangement keeps the feedpoint stable. The antenna wires are made from a stripped down 20m extension lead. The five top insulators are made from bits of pvc pipe. There are a spark-gap, a neon bulb and a 100 kiloOhm bleeder resistor below the bottom of the ‘tuner unit’, draining static buildup. The relais and capacitors are inside the box.

Fine Tuning - If Needed:

If more fine control is desired, then the radiators are cut for resonance points for each of the CW segments or even below it. The resonance points can then be shifted to the SSB segment by inserting a capacitance in series with the feeder. The capacitor can be of a variable type, or a combination of fix capacitors switched by a bank of relais (the ‘tuner unit’ in the image above). The effect is two-fold: When the antenna is deliberately made too long (= inductive) it can easily be brought back up to resonance with a series capacitor, while also raising the impedance closer to 50 Ohms. That is a desirable side-effect, since a 1/4 wave radiator has an impedance of only around 35 Ohm, equivalent to an SWR of about 1.5 to 1. The losses of the ground system and the loss resistance of the radiator itself have to added to the radiator impedance. For copper radiators this can be ignored, but for stainless steel, galvanized mild steel or aluminum that value can reach a few ohms, resulting in a deceptive near 1:1 SWR. The capacitor itself does not add any noticeable loss - unlike when using loading coils as used in short antennas.
A length of 10% to 20% above the calculated electrical length for the CW segments is a good starting point when using capacitive fine tuning. Even more when the vertical radiator(s) are toploaded, e.g with a capacity hat or as an inverted L. In that configuration the radiator(s) can be up to 3/8 wave long - but tuning becomes quite critical. For ‘shallow’ inverted L or T antennas it may be the only practical way to raise the resistive part of the impedance to 50 Ohm.

Possible Configurations:

20m, 17m and 15m band radiators a easily combined, adding a 12m, and maybe a 10m 'leg' becomes mechanically challenging, but it can be done. A 80m, 60m and 40m combo is probably reaching a mechanical limit. All other combinations are possible, e.g. a pair of 60m and 30m two band fanned monopoles works very well. A good rule of thumb is to not exceed much beyond a 1:2 frequency ratio between the lowest and the highest band in use. Keep in mind that a 160m band inverted L works well on 60m, and a 40m band wire will have a resonance on 15m, but with an unfavourable radiation pattern.



Automatic Tuners:

A tempting method is to simply place a remote automatic tuner at the feedpoint of a single vertical radiator. The manufacturer of the tuner may claim that model ‘xyz’ can tune any frequency between ‘a’ and ‘b’, provided a certain minumum length is used. A good ground system is required in any case. At the lowest frequencies the tuner may struggle to deal with a low impedance, leading to high currents in the switching relais - until they fail. At high frequencies, especially when approaching 1/2 wave resonance the tuner may never find a match, but also suffer from high voltage arcing – another popular way to damage the tuner. Going beyond a length of 5/8 wave the raised main lobe makes it useless for DX, limiting the useful range to one octave at best. But with a set of fanned vertical radiators, rather than just a single radiator, the result is a very capable and efficient antenna. It makes it easy for the automatic tuner to find a match and stay within its safe operating range. If small additional losses caused by standing waves on the coax are acceptable, then an internal tuner will also work very well with this type of multiband antenna.

Conclusion:

Several radiators sharing a common feedpoint allows to build a cheap multiband antenna, avoiding the mechanical and electrical troubles associated with inline ‘traps’ for each band. But patience is required to get it right. There is no point citing exact dimensions, there are too many variables.
The 80-60-40m bands antenna shown above has a height of about 15 meters atop a metal clad shed of 4 meters height, suspended from a pair of 20m masts 60m apart. It takes only a few minutes to lower and raise the antenna.
Finding or creating suitable tie points for a ‘skyhook’ are likely the biggest challenge, unless self-supporting tubes/pipes are used for all radiators. An elegant solution is a free-standing pole with several radiating wires around it, doubling as part of the guy lines.

Sources of inspiration: DJ9UN made a three band version for 160-80-40m,
Rothammel’s Antennenbuch, ARRL Antenna Compendium,
and my need for yet another HF antenna.

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