Inverted L vs. Vertical T antennas

At the search of the best Tx antenna for a low-latitude location

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After having learnt which are the effects of the Earth's magnetic field on 160 m. propagation at low latitudes, it came out that the best antenna for my future QTH near Quito, Ecuador should be two:

- A vertical T with 60 ¼ wave radials for best low angle DX coverage, which is very effective towards North America, Europe, Japan and southern South America, but with high losses in the East and West directions
- A reasonably high dipole (or inverted V) hanging North-South to cover East and West directions

Of course this is not possible in a residential lot without tall trees around, and thus my only possible solution is an "Inverted L".

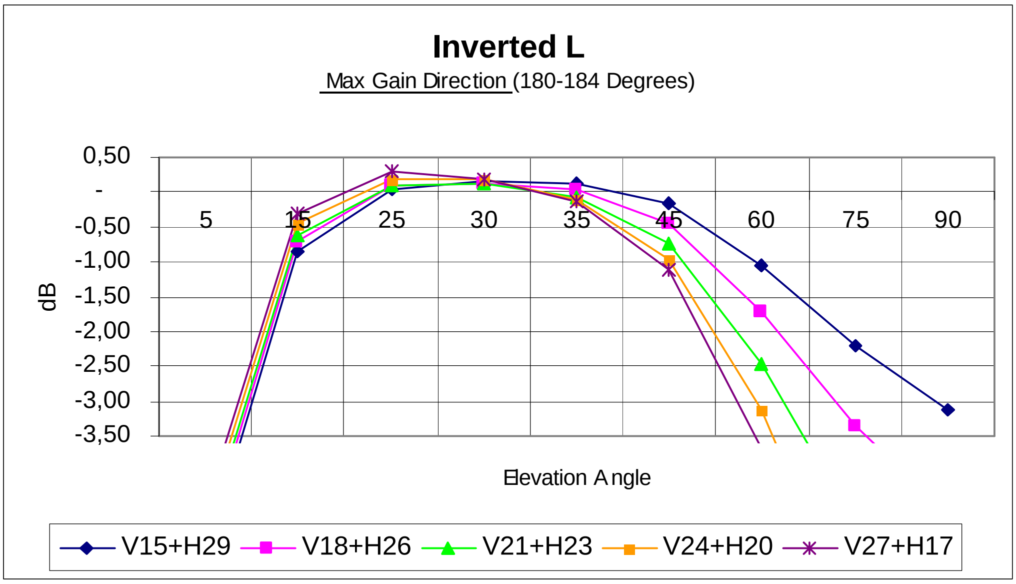
I ran several models on EZNEC 5+ at the search of the best one to be installed in my 1.896 sq.m. lot. I can install a vertical aluminium tube at about 30 meters distance from the house and from there lay out an horizontal wire reaching a support at 13 m. height on the roof. These are going to be my constraints, while the ¼ wave radials have to be cut towards the house but can be laid outside two sides of my terrain.

Inverted L models

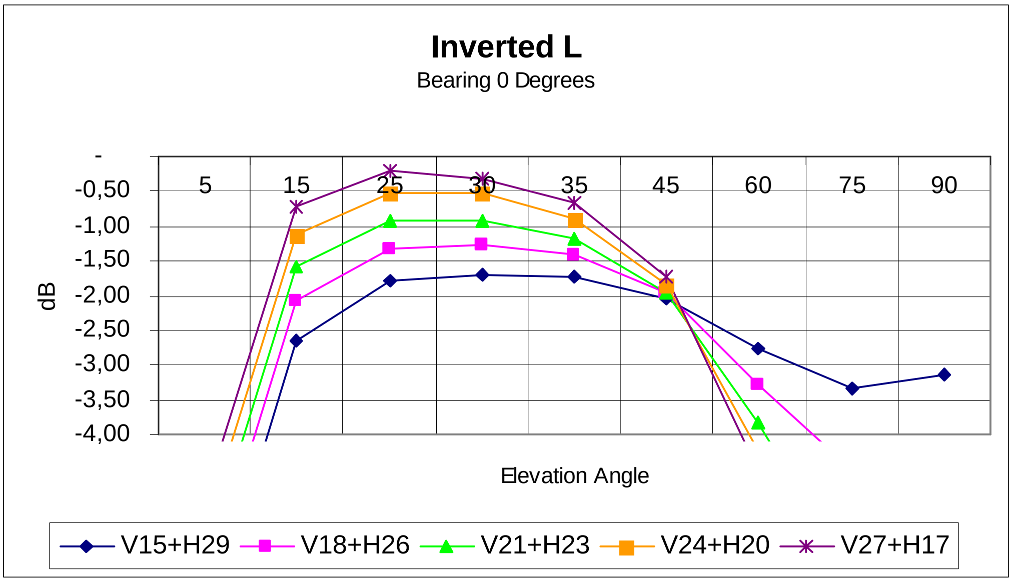
In this session I modelled five Inv.L configurations, starting from 27m vertical and decreasing it until 15m., keeping the total length at 44 meters, with the horizontal wire hanging on the same support point at 30m.distance and 13m. high; thus the sloping angle varies step by step. I used a real Minimec ground with a 10 ohms load resistor to simulate losses. The following graphs refer to:

- V27+H17: 27m. vertical + 17m. horizontal (source impedance = 33,96 –j1,86 ohms)
- V24+H20: 24m. vertical + 20m. horizontal (source impedance = 30,26 –j3,07 ohms)
- V21+H23: 21m. vertical + 23m. horizontal (source impedance = 26,97 +j1,63 ohms)
- V18+H26: 18m. vertical + 26m. horizontal (source impedance = 24,03 +3,37 ohms)
- V15+H29: 15m. vertical + 29m. horizontal (source impedance = 21,87 +9,24 ohms).

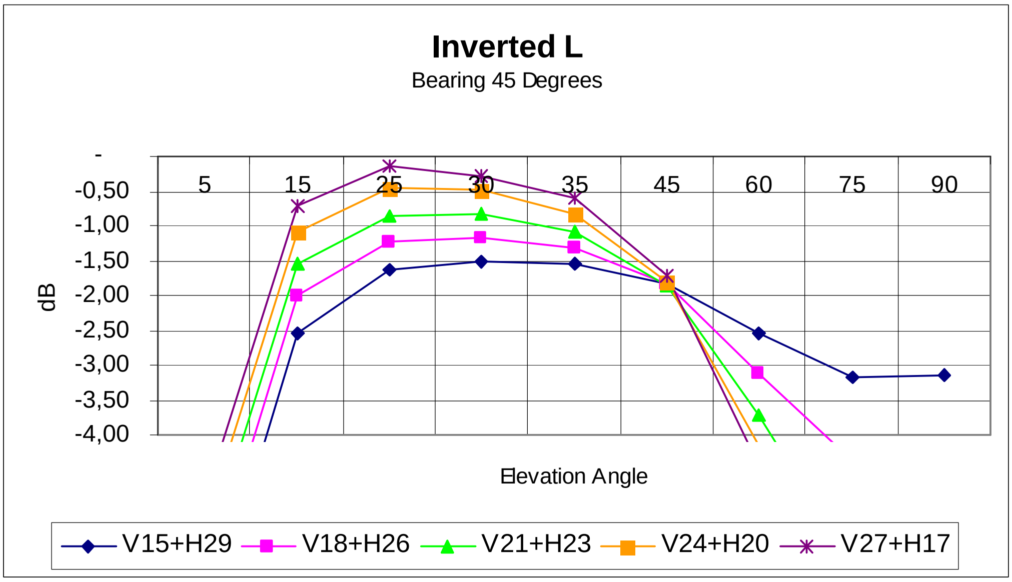
I ran them at several take off angles, from 5 to 90 degrees for four azimuth directions: about 180 degrees – at the maximum gain, at 0 degrees – NA direction; at 45 degrees – Europe, and at 90 degrees – broadside East-West direction.



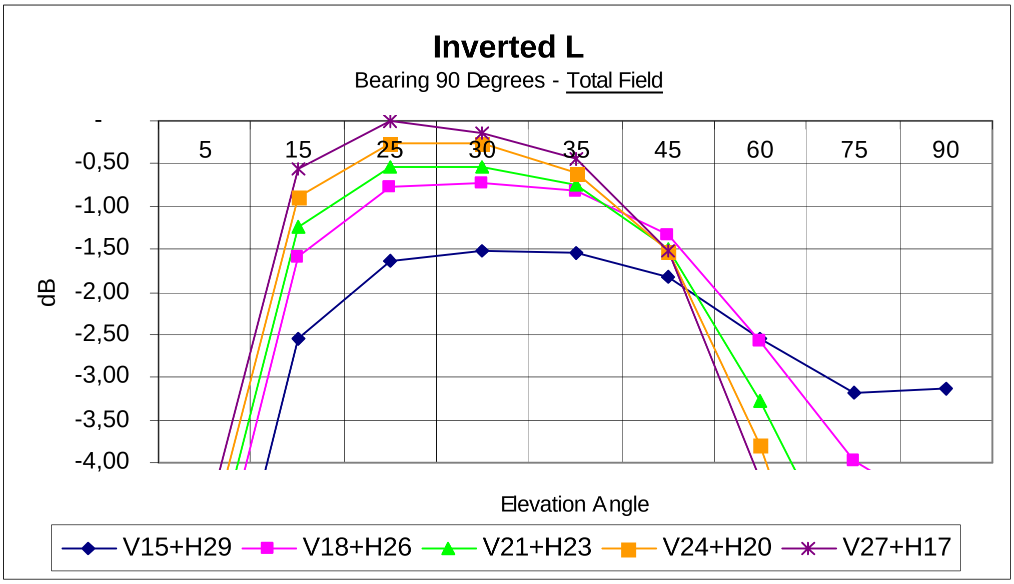
In this graph – the direction of the horizontal wire – we see a small gain of the higher antenna at low angles, no difference at 30 degrees, and a much more high angle radiation by the low antennas.



In this graph – the direction opposed to the horizontal wire – we see about 2 dB lower gain of the lower antenna compared to the highest one, until 45 degrees of radiation angle, where the situation is reversed.

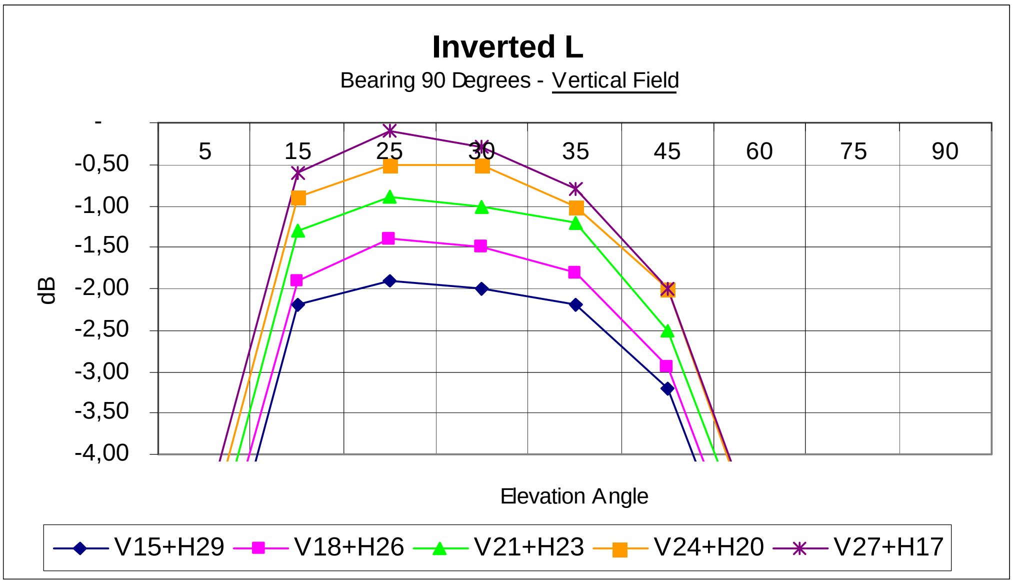


Here – towards Europe – looks like the same as above, i.e. the lobe is quite broad.

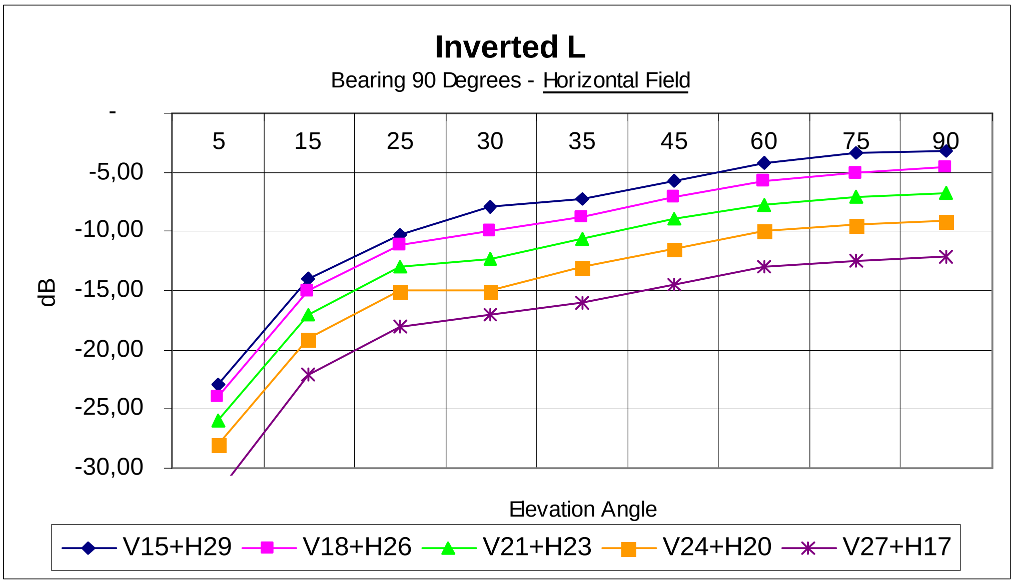


This is broadside to the horizontal wire, and the four higher antennas show about half dB better.

Now let's look separately at the two field components; in the previous azimuths there was no trace of the horizontal field, but at 90 degrees – broadside to the wire – it becomes relevant.

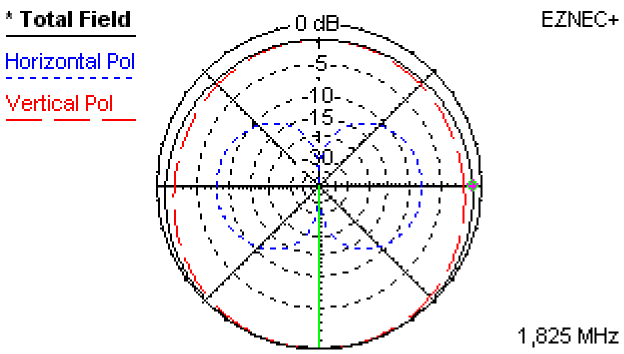


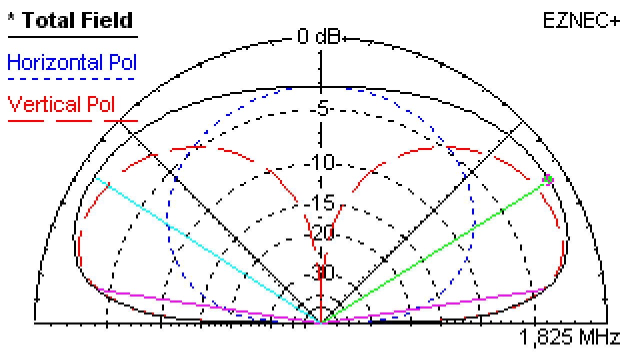
The vertical field holds up at low angles, but it's about half dB lower than the total field, meaning that there is also a small contribute from the horizontal component.



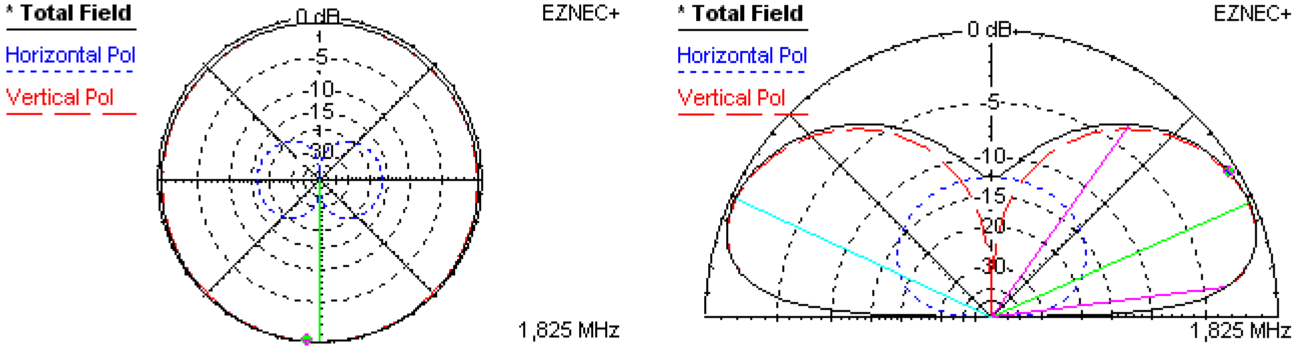
This is the horizontal field which, at low elevation angles, is more than 10 dB down, but at high angles becomes relevant, especially for the longer horizontal wire antennas.

These are a couple of EZNEC plots to better show the two fields behaviour:





Azimuth and elevation plots for the lowest Inverted L (V15+H29) – bearing 90 degrees

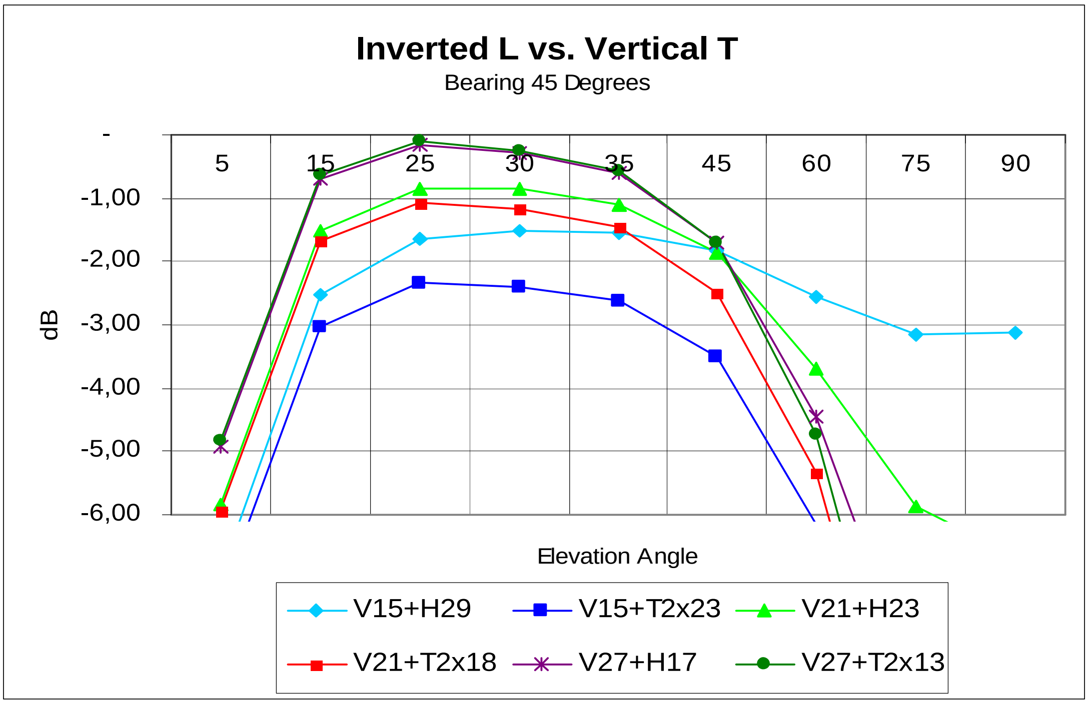


Azimuth and elevation plots for the highest Inverted L (V27+H17) – bearing 90 degrees

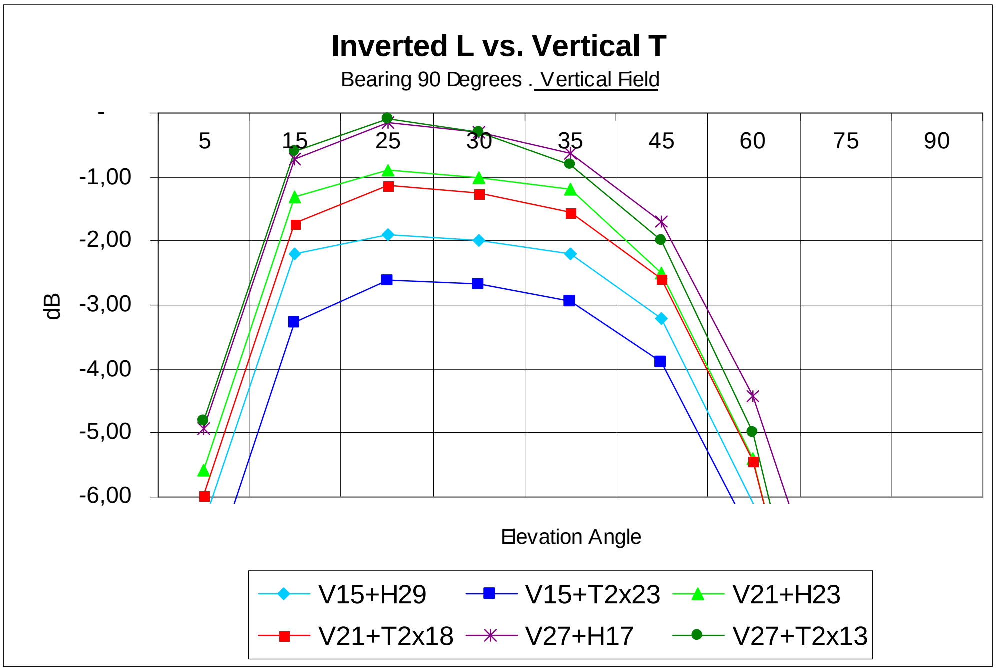
<u>Inverted L vs. Vertical T models</u>

Than I compared three of the inverted L models with the corresponding vertical Tees, with the sloping wires hanging to 6m. high at a fixed distance. The length of these loading wires has been roughly adjusted to get resonance:

- V27+2x13: 27m.vert.+two 13m sloping wires (source impedance 31,89 +j1,69 ohms)
- V21+2x18: 21m.vert.+two 18m sloping wires (source impedance 22,04 +j1,02 ohms)
- V15+2x23: 15m.vert.+two 23m sloping wires (source impedance 16,30 +j0,55 ohms)

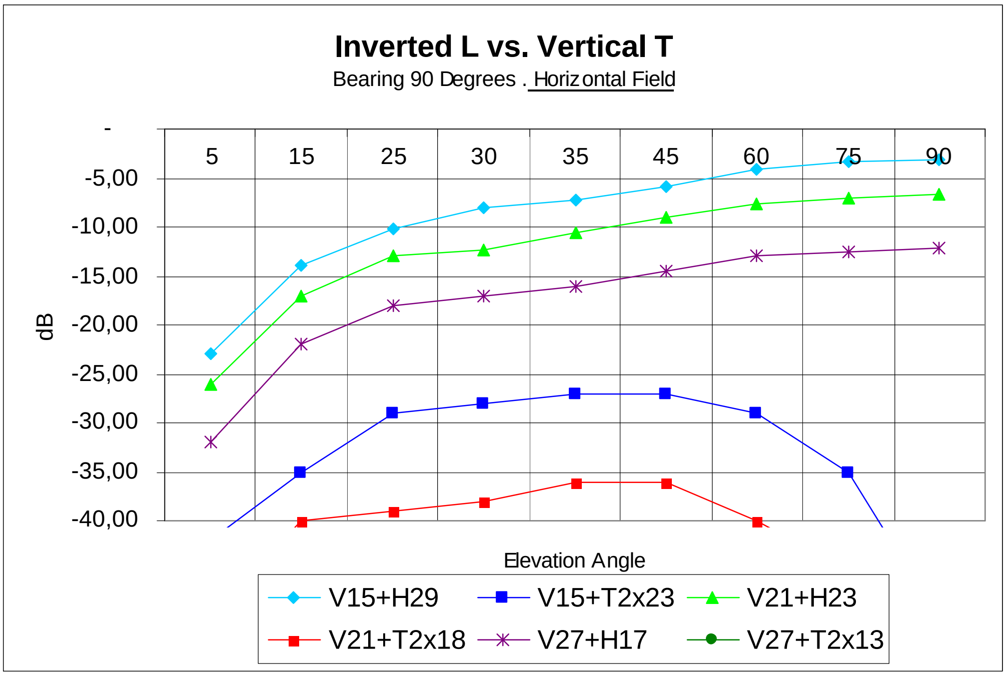


Bearing to Europe: at 27m. height there is no difference between Inverted L and Vertical T;
at 21m. the inverted L seems better.
The 15m vertical T loses even on high angles, but the inverted L has too much high angle radiation



The vertical field at 90 degrees bearing is almost the same from both antennas 27m. high; there is a small difference at 21m., while lowering at 15m. it's better the inverted L than the vertical T.

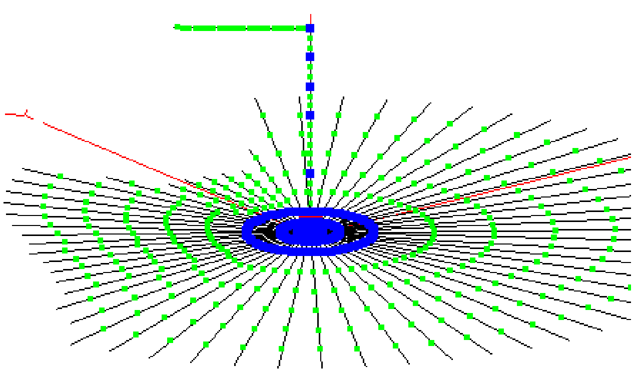
But magneto-ionic propagation theory says that, <u>at a low-latitude QTH</u>, I need some horizontal polarization in the East-West direction, so the following is the leading graph:



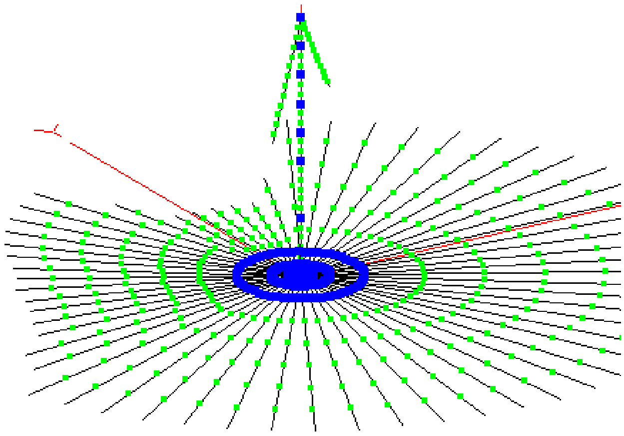
The best antenna on this graph appears to be the lowest one (with longest horizontal wire), but we saw above that it wastes too much energy on higher angles.
T verticals are at least 25dB down or out of picture.

<u>The two selected models over 60 ground radials an matching L networks</u>

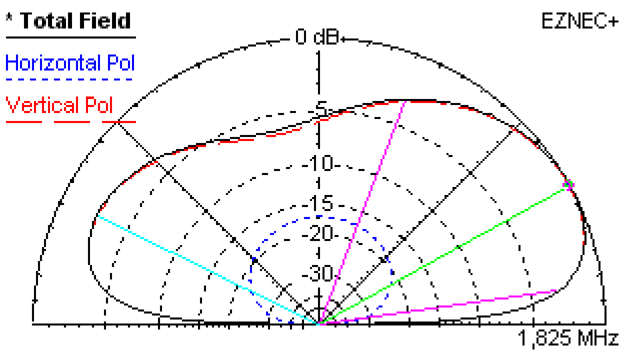
At this point my choice will be on the Inverted L 21m high and I model it on a real high accuracy ground with 60 ¼ wave radials, some of them cut as necessary for my real lot requirements. The following are the "View antenna" Eznec images and the resulting elevation plots:

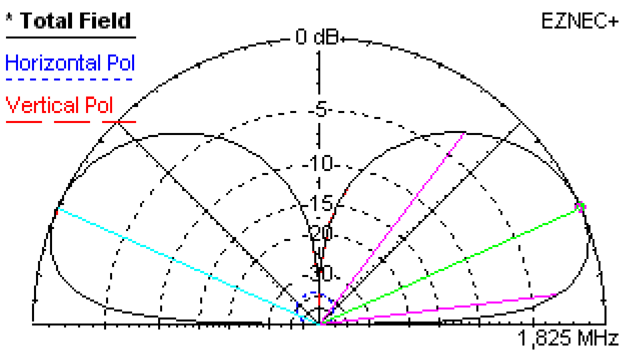


Inverted L (21m. vert. + 23m. horizontal)

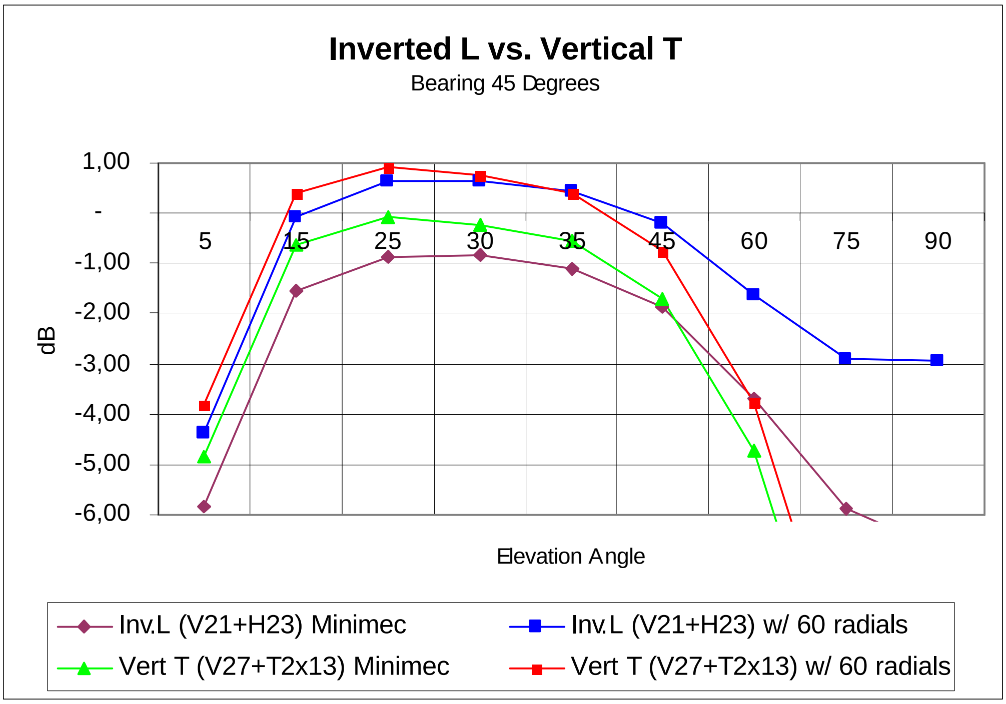


Vertical T (27m. high + 2 x13 loading wires)



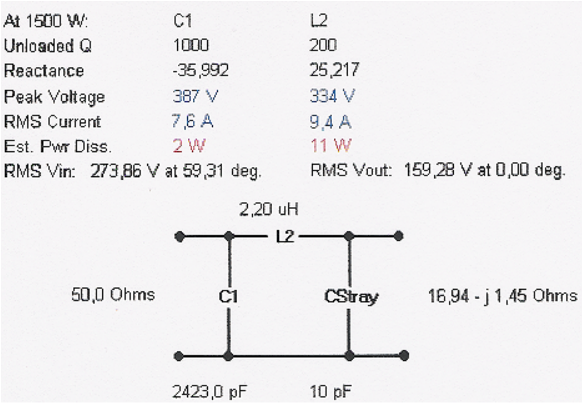


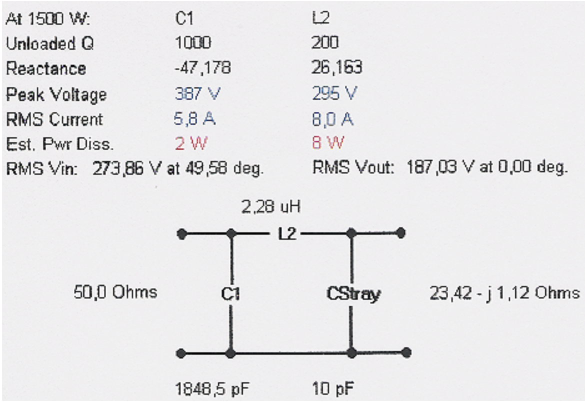
The next graph compare them with the two different Eznec ground types: Minimec with a loading resistor and real accuracy with 60 radials.



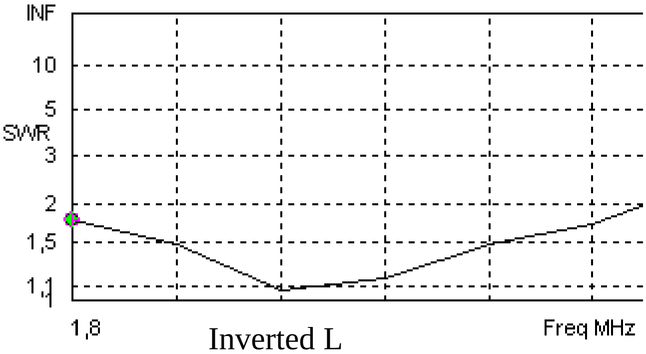
They look quite well also with the real ground and this graph definitely confirms that the Vertical T is better for DXing at our mid-latitudes and high-latitudes, but for low-latitudes, where higher radiation angles and horizontal polarization are needed, this inverted L should be used.

So I proceeded to calculate the L network with TLW (a free program with the ARRL Antenna Book):

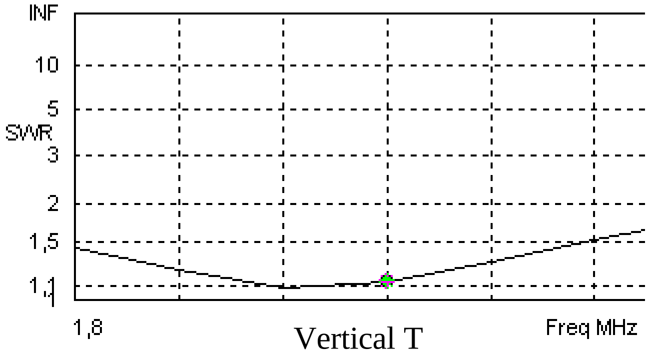




After adding the resulting above values as an L Network in EZNEC we get the following SWR plots:



Inverted L

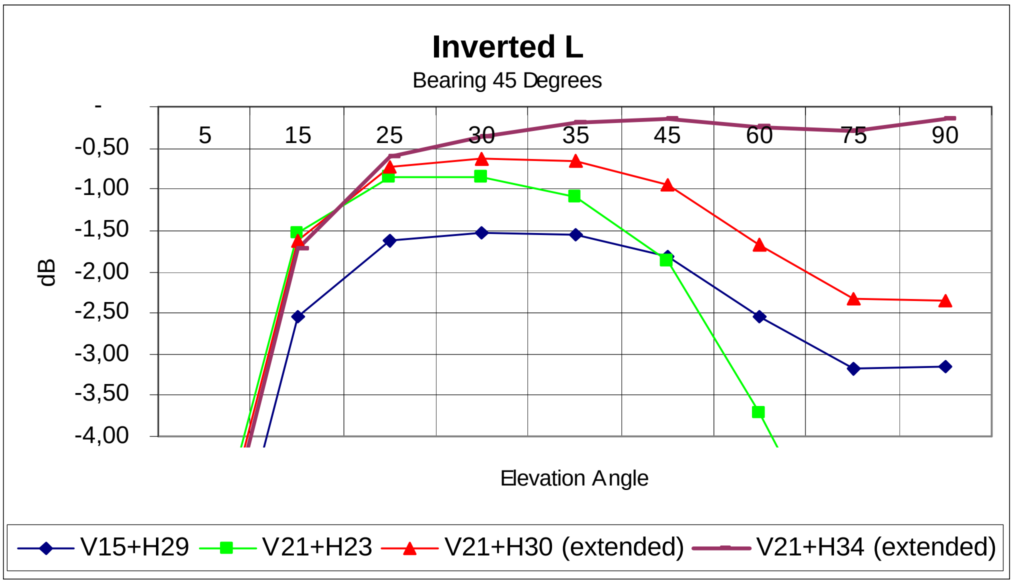


Vertical T

As expected, the vertical T is little broader the inverted L, but both are perfectly matched to the 50 ohms feeding line by means of easily manageable components with low losses.

Inverted L extended beyond ¼ wave resonance

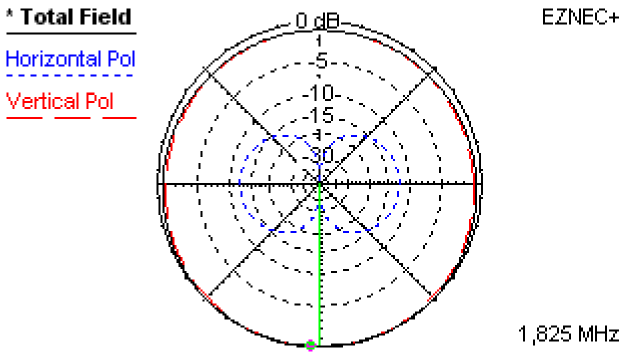
At last I wanted to see what happens by lengthening the horizontal wire from 23 to 30 (51m.) and than to 34 meters (total 55m long).



The 51m. antenna looks like the lower Inverted L, about 1 dB better, while the longest one is definitely a cloud warmer.

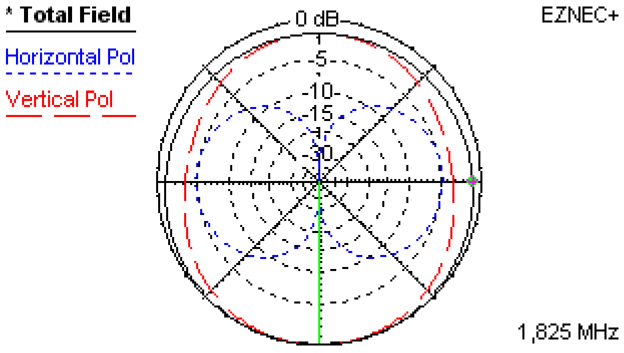
Obviously the horizontal field is increased, as shown in these azimuth plots taken at the best elevation angle:

Inverted L 44m. V21+H23



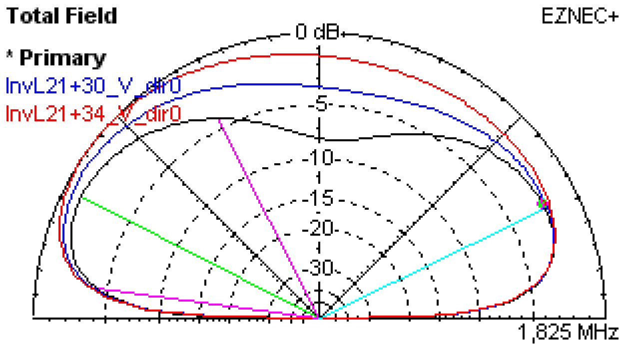
Max take off angle 27 degrees

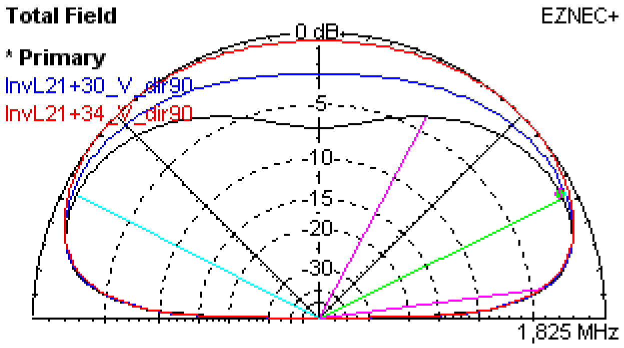
Inverted L 55m V21+H34



Max take off angle 38 degrees

But in the following vertical plots, where the extended traces are added to the primary one, (black, which is the resonant 44m. inverted L), it seems that too much energy is wasted to warm up the sky!





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Luis IV3PRK …planning to move to HC1