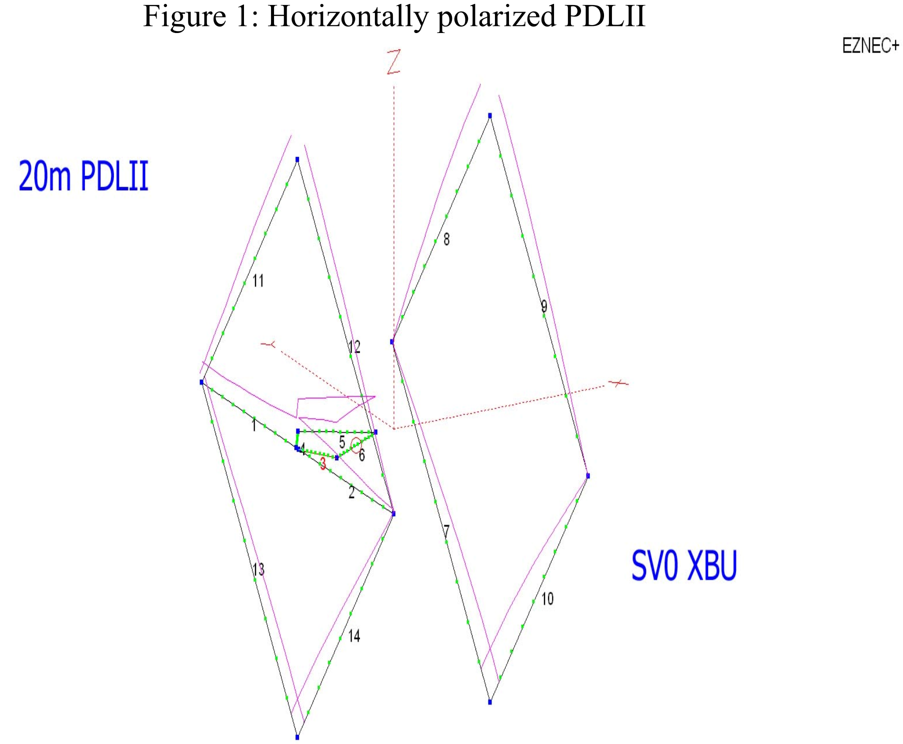
Avanti PDLII – Long boom version (Updated: July 26 2014)

During the 1980s, Avanti developed and brought to the CB (Citizens Band) market a Phase Diversity Loop (PDLII) antenna for the 11m band. This was a two element 'quad' loop excited via a half-wave dipole. The PDLII featured both horizontal and vertical polarizations with a claimed front to back of 32 dBi, and gain figures of 12 dBi with low takeoff angle (TOA). Inherent within the design of this antenna was excellent isolation between vertical and horizontal antenna currents at the correct phase. My goal was to model then secondly, alter my existing 11m PDLII for a target frequency of 28.45 MHz. In modelling this antenna, I optimized it for maximum 180 degrees front to back ratio and accepted whatever gain and input impedance the PDLII produced. In reality, you can only optimise for one of the three parameters, gain, VSWR (voltage standing wave ratio) or F/B (front to back ratio).

The basic setup of the antenna employs a half-wave dipole to excite a full wave loop of wire (in the shape of a diamond) to generate RF currents in correct phase(s) for either horizontal or vertical polarization.

For simplicity, Figure 1 illustrates the basic setup, (horizontal polarization only) for a 20m PDLII with the red trace depicting current distribution. The gamma rod source point is on wire 6 of the matching section.

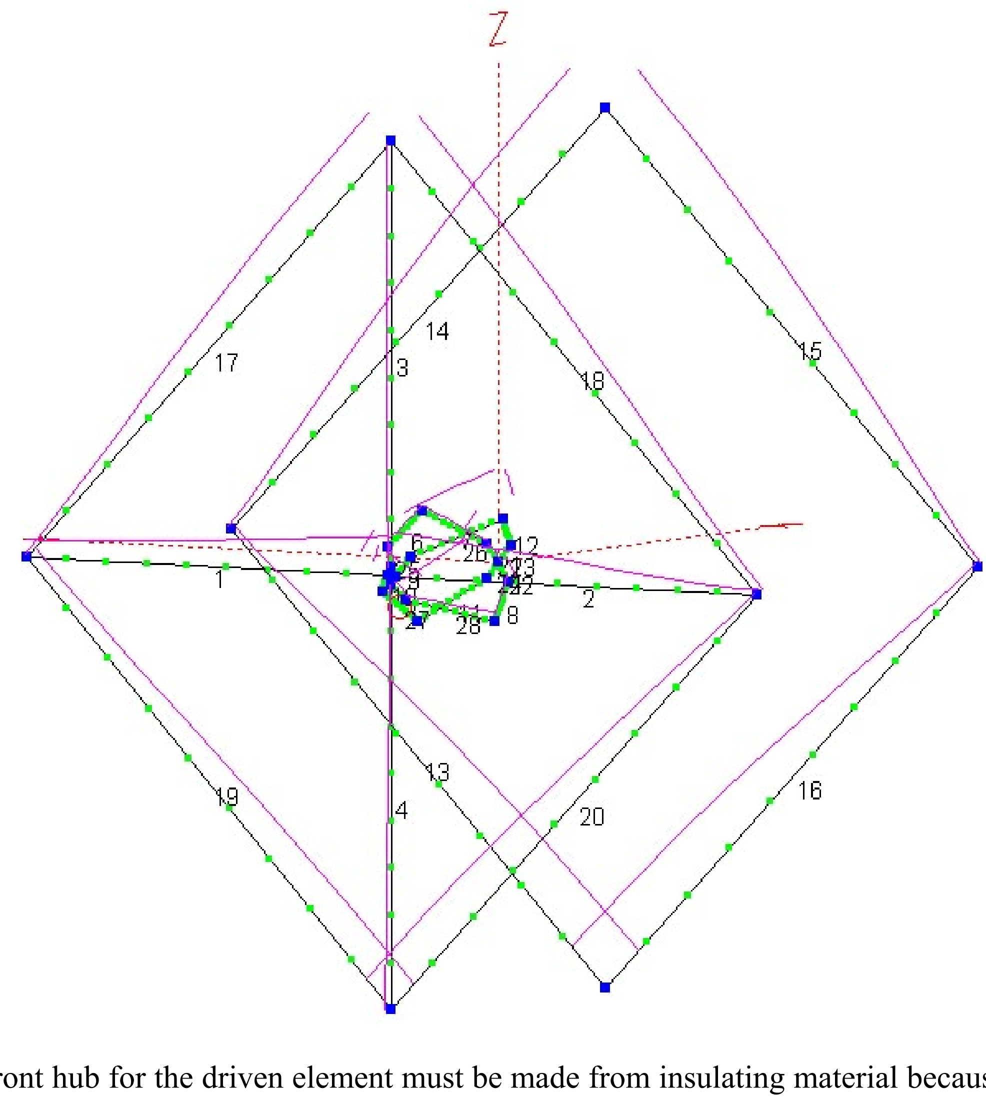
Figure 1: Horizontally polarized PDLII



Wires 1, 2, 3, 4, 5 and 6 comprise a folded halfwave dipole. Note, wires 1, 4 and 5 form one side of the dipole whilst wires 2, 3 and 6 form the other side of the dipole. Wire ends 1 and 2 physically connect to the diamond-shaped loop and are part of the folded dipole. Wires 7, 8, 9 and 10 form the parasitic reflector.

Figure 2 illustrates wires for both vertical and horizontal elements. The PDLII manual gives an overview on the vertical and horizontal driven element configuration and the patent gives an overview on the theory behind the hybrid feedpoint or excitation points generated from the folded dipole to the quad shaped loop.

Figure 2: PDLII horizontal and vertical polarisation



The front hub for the driven element must be made from insulating material because each spreader element and matching section per polarisation comprise either the vertical or horizontal parts of the folded dipole. One end of the vertical and horizontal folded dipole ground onto the boom and the reflector of course, is isolated from the boom using solid glass fibre rods.

I'm a bit of a newbie in terms of modelling but initial questions I asked of EZNEC 5+ were (a) is EZNEC able to model this unusual antenna and (b) what confidence do I place on model outputs because I was unable to find any EZNEC simulations of this particular type of antenna anywhere?

Normally, you would model one antenna against another, (normally a dipole) and then try and explain similarities and differences between the two. In this situation I decided to email Rod Llewellyn the developer of EZNEC and ask him if its possible to model this co-inductive feed antenna to which he said yes. I then decided to model my PDLII based on original information from the Avanti blurb which states:

12 dBi gain, 2 kW rated, DC ground construction, F/B 32 dBi and finally, polarity isolation, vertical to horizontal is 23 dBi.

To ensure I was in the right ball-park I also looked at the radiation patterns from the Avanti PDLII patent. I also assumed that the RF engineers at Avanti had access to an antenna range because they state gain, F/B data etc in their patent.

Model caveats and F/B optimisation decisions.

I used EZNEC 5+ with real ground, high accuracy. I did not use element diameter taper corrections. Due to the nature of the feed of this antenna I modeled the horizontal and vertical polarizations separately. I'm not sure how to model two sources with separate coax on one antenna feedpoint with one active and one dormant polarisation.

In order to derive element length, matching section and ball-park gamma rod dimensions for the folded dipole, I used two very handy programs written by VE3SQB called 'dipole driven quad' and 'gamma'. Both programs are available from his website.

The original matching section for my PDLII was long lost so I used these programs to 'brew' my own matching section and gamma rod. The new matching section necessitated a longer boom length so that I could physically fit the gamma rod and optimize F/B. I also used a slightly larger loop size for my reflector. To improve F/B I incrementally moved the distance of the reflector relative to the driven element. I then played around with various wire size diameters and loop lengths to achieve maximum F/B. What is really interesting about this antenna are, gain, lowish VSWR and maximum F/B are not even closely related in terms of one frequency. The feedpoint impedance of my modeled PDLII was approximately 200 Ω plus or minus 15 for much of the band of interest. These values confirmed that the model was indeed measuring an impedance expected of a folded dipole.

Average Gain Test (AGT) for both polarizations was approximately 1.15 which may suggest I might be pushing at the limits of the model. I also carried out a segment convergence test on one parameter e.g. F/B and model outputs held up well at low numbers of segments for both polarisations.

The following Figures detail the radiation pattern and gain figures from EZNEC compared to data from the Avanti patent (also see Table 1 below).

Figure 3a: Horizontal pattern from EZNEC

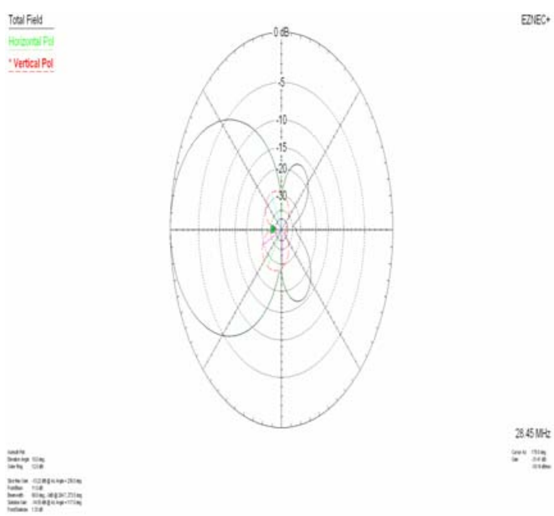


Figure 3b: Avanti horizontal pattern from patent

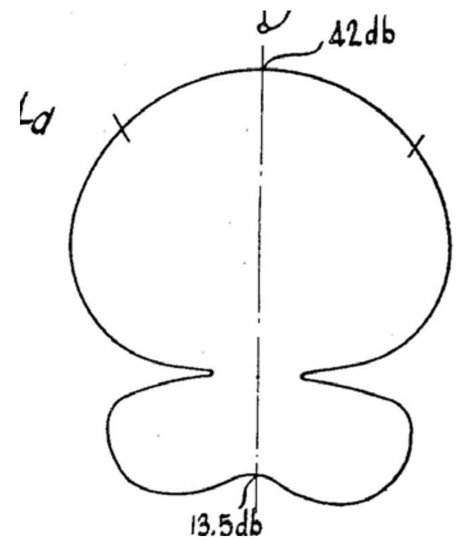
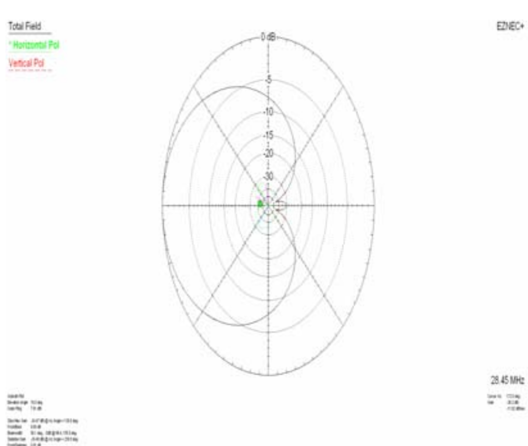
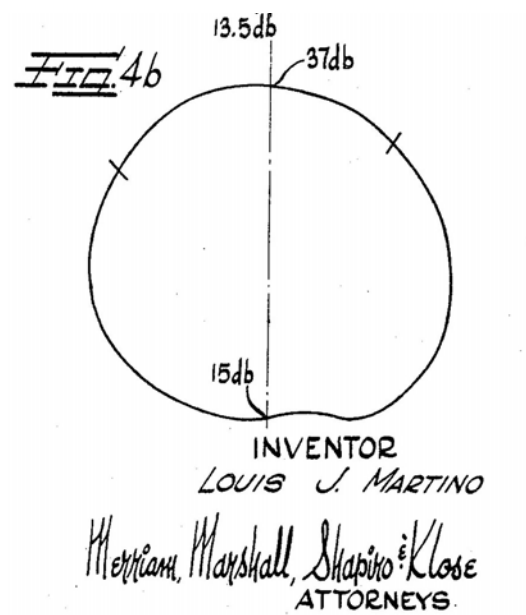


Fig 4b: Avanti vertical pattern from patent

Figure 4a: Vertical pattern from EZNEC





Reassuringly, both the horizontal and vertical azimuth radiation patterns and performance data are fairly similar. Table 1 details performance data from 3a and 4a for a target frequency of 28.45 MHz

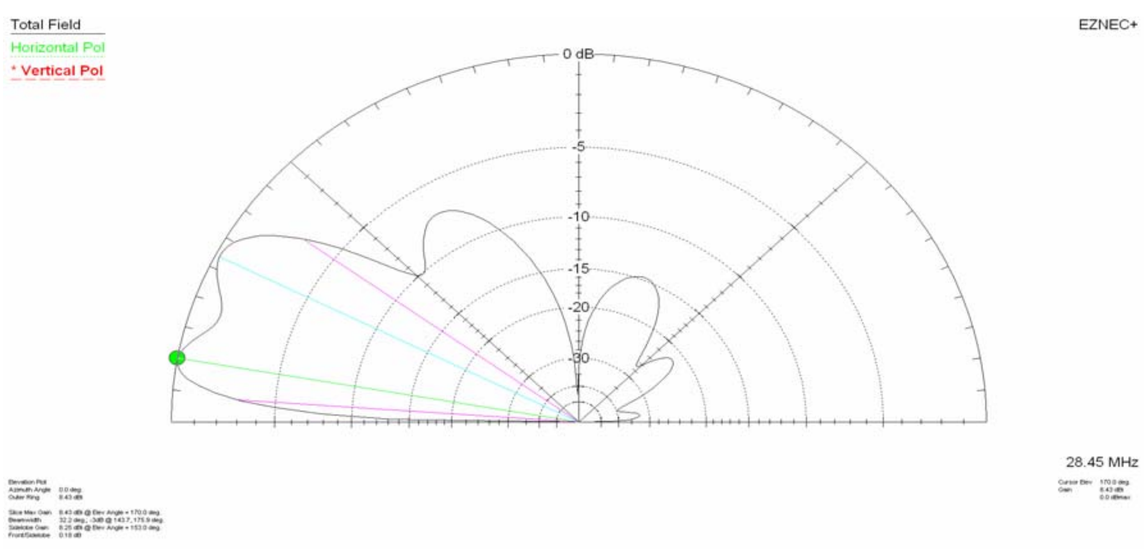
Table 1: Modelled performance data from long boom PDLII

PDLII Long Boom	Horizontal polarisation	Vertical polarisation
F/B (dB)	32.64	30.94
Gain (dBi)	12.5	7.15
Isolation between polarisations	11	9.85

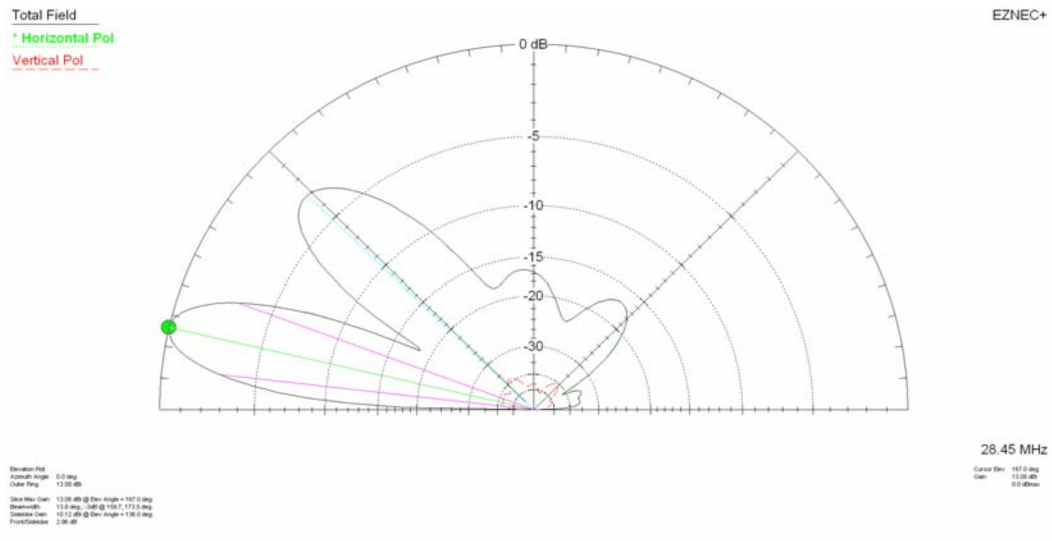
When the antenna is switched for horizontal, there will also be a smaller vertical field and vice-versa. From Table 1 above, the horizontal F/B is 32.64 dB and the isolation value is 11 dB. Simply subtract 11 from 32.64 to derive 21 dB which is the exact value quoted in the Avanti patent. Roughly the same value is obtained when you work out the strength of the horizontal field in relation to the vertical field (30.94 – 9.85 = 21.1 dB). These data gave me confidence that EZNEC is able to model a PDLII reasonably well.

The following Figures illustrate elevation or take-off angles for the modeled PDLII.

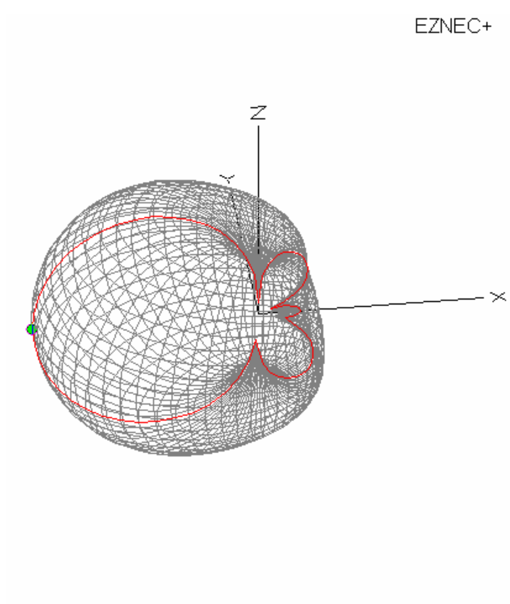
Vertical elevation plot



Horizontal elevation plot



Maximum radiation patterns for both polarizations are low with TOAs of 10 degrees and 13 degrees respectively for the vertical and horizontal polarizations. There are however, several significant lobes at different angles which may or may not contribute to the DX signal you are trying for. Below is a 3D plot of the vertical component of the PDLII which makes it a little easier to visualize what might be going on.



Conclusions:

Does it work and how well does it work? It has been up in the air about two weeks and I've listened but not transmitted. The first day of putting it up I was tuning across the band and heard a DL station chatting to a station in the South Atlantic (ZD7FT) on

28.490 MHz. He was based in Saint Helena Island some 4000 miles from where I live, (Athens Greece). ZD7FT was 5/2 and when I swung the PDLII towards him he came up to between 5/5 and 5/7 on voice peaks. The band conditions at the time were relatively flat with ‘quiet’ atmospheric conditions. Conditions since that first day has been even more quiet with little band activity. I can only say the antenna works but need more time to evaluate.

Incidentally, I checked the VSWR on my FT-2000 bandscope and the VSWR pattern was fairly consistent with EZNEC’s impedance model prediction. The only difference I could see was the VSWR within my setup was consistently lower than predicted and this was probably due to losses, both ground and coax in my antenna system.

EZNEC also has a ‘re-size’ option which instantly allows you to re-scale your model for different bands. I re-scaled the model for 20m and 2m with similar performance characteristics. For such a small boom length on 20m, the performance data looks really useful if you are tight on space or using ‘lightish’ spec antenna rotators. This design of antenna will really shine on 2m because of its inherent gain, high F/B, easy matching requirements via a gamma rod and of course, it has both horizontal and vertical polarization. EZNEC works really well although I experienced several problems (a) how the model deals with dis-similar materials e.g. copper and aluminium in terms of overall losses, (b) it is difficult to ensure segment 1 feeds into segment 2 of its adjoining wire (effectively I attempted to model 2 separate antennas, a folded dipole and loop of wire and (c) the angle and closeness of wire connections was a big problem which meant that the physical build of my long boom PDLII is slightly different to how I modeled it. The other unknowns are the direction and magnitude of the currents. I’ve spent much head-scratching over this and I won’t solve it till someone tells me whether I’ve modeled it correctly.

The biggest headache was the actual tuning of the antenna and you can make it less painful if you have access to an antenna analyzer or failing that, a field strength meter with SWR meter. I used an MFJ259B to find resonance (using the advanced function) by finding the ‘sweet spot’ on the matching section at the modeled frequency and then balancing low resonance with a VSWR of about 1.5. The procedure to do this is in the Avanti manual. The precise location of the gamma rod on the matching section will depend on your target frequency, the materials you use, the dimensions of the gamma rod itself and the height above ground you tune the antenna. My 10m tune was fairly similar to the 11m tune but if you are building for 20m or 2m, the VE3SQB ‘gamma’ program will definitely be a big help.

The biggest single problem in playing with these types of antennas is finding original Avanti front, back and middle hub sets or alternatively, brewing your own!!

Any comments/criticisms, tips or hints welcome. I hope to tweak my antenna system more as I gain more experience in modelling and in the use of this type of antenna.