Wire Log-Periodic Dipole Array – or the Beam in Your Suitcase

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How it all began:

In 2003 I did two holiday-type DXpeditions: in January from HI using a commercial 7ele log-periodic and in April from 6W using a "holiday-brewed" dipole. The difference apart of the obvious better performance of the log:

- In Senegal I had to shorten / lengthen the dipole each time I wanted to change the band.
- The wire for the dipole found easily its place in the suitcase – the log-periodic, mast and antenna rotor luckily were already installed in the Dominican Republic.

Back in France our radio club F6KOP started preparations for our March 2004 DXpedition to Togo – 5V7C. When it came to the question what antennas to bring along by aircraft (without paying for any excess luggage), I mentioned that I was considering building a wire 11-ele log-periodic dipole array (LPDA) for the 10,12,15,17,20m band.

A bit of theory:

The basic theory of log-periodic dipole antennas had been described first in 1961. The LPDA consists of several dipoles with different length and spacing. All dipoles are fed through a common feeder-line whereby from element to element the connections are crossed out. The LPDA is typically fed through a 1:4 or 1:6 balun onto the shortest element. Feed line input impedance calculations depending on wire diameter and spacing are given in [1] and [2].

On each frequency within the operating bandwidth of the LPDA, 3 to 5 elements are contributing to its performance.

The most important parameters of the antenna design are the design constant τ and the relative spacing constant σ. For each τ, an associated optimum σ_{opt} exists where the maximum gain is achieved. Of course the gain is greater when the apex angle α of the antenna is decreased: While covering the same bandwidth the antenna needs more elements and gets longer.

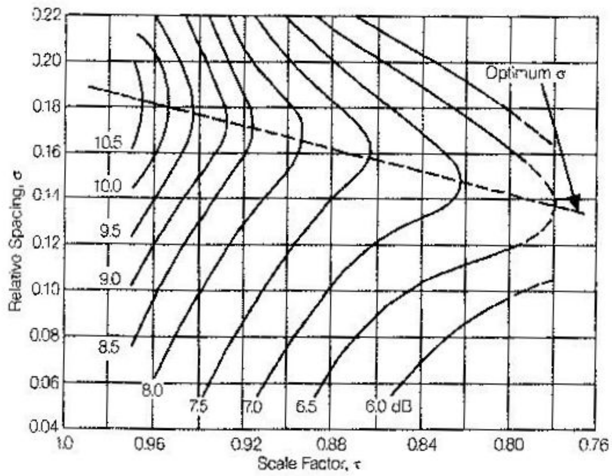

Figure 1: Gain as a function of σ and τ

The design typically starts with values of required bandwidth $B=\lambda_{max}/\lambda_{min}$ and chosen σ and τ parameters that allow a reasonable boom length A. Further calculation leads to the number of required elements N and element length l_n and element spacing s_n.

Typical realistic gains of LPDA with reasonable boom length are in the range of 4 to 6 dBd. By sloping the elements forward additional gains have been calculated in some studies. Front to back ratios are typically in the range of 15 to 25 dB.

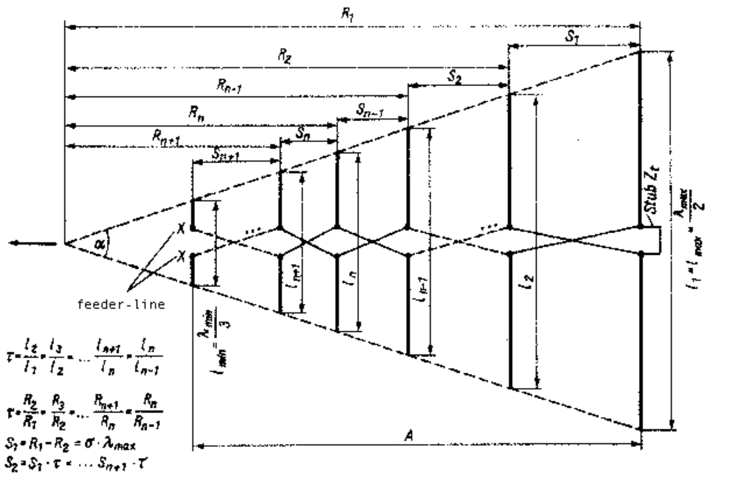

Figure 2: Design parameters of LPDA

Let's build one:

The straightforward example in [2] was followed and can be summarized as follows.
In order to cover the frequency range of 13.3 to 30 MHz with a sufficiently short boom, $\tau = 0.9$ and $\sigma = 0.05$ are chosen. This leads to a calculated gain of 4.6 dBd and an apex angle $\alpha = 53°$. Furthermore required boom length A=7.3m and associated number of elements N=11.25 are calculated. 11 elements are chosen and yields to the following design parameters element length l_n and element spacing s_n for the construction (in meters):

l_1	L_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
11.25	10.13	9.11	8.20	7.38	6.64	5.98	5.38	4.84	4.36	3.92

s_1	S_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
1.125	1.012	0.911	0.820	0.738	0.664	0.598	0.538	0.484	0.436

Table 1: 11-ele LPDA 14 to 30 MHz, element lengths and element spacings

The mechanical layout given in Figure 3 allows a common feeder line with equal spacing. Every even element is used to cross the wires. The impedance of such a set-up can be easily calculated. I used a spacing of about 30mm and wire with a diameter of 2 mm. A lot of practical hints of building wire antennas can be found in [1].
I constructed just two different types of pieces of 5mm strong Plexiglas (any other isolating material is also okay): one is used for the rear attachment of the feeder line, the other 9 identical ones for the spacers of the twin line. The front attachment was replaced by the balun.

Figure 3: Construction detail

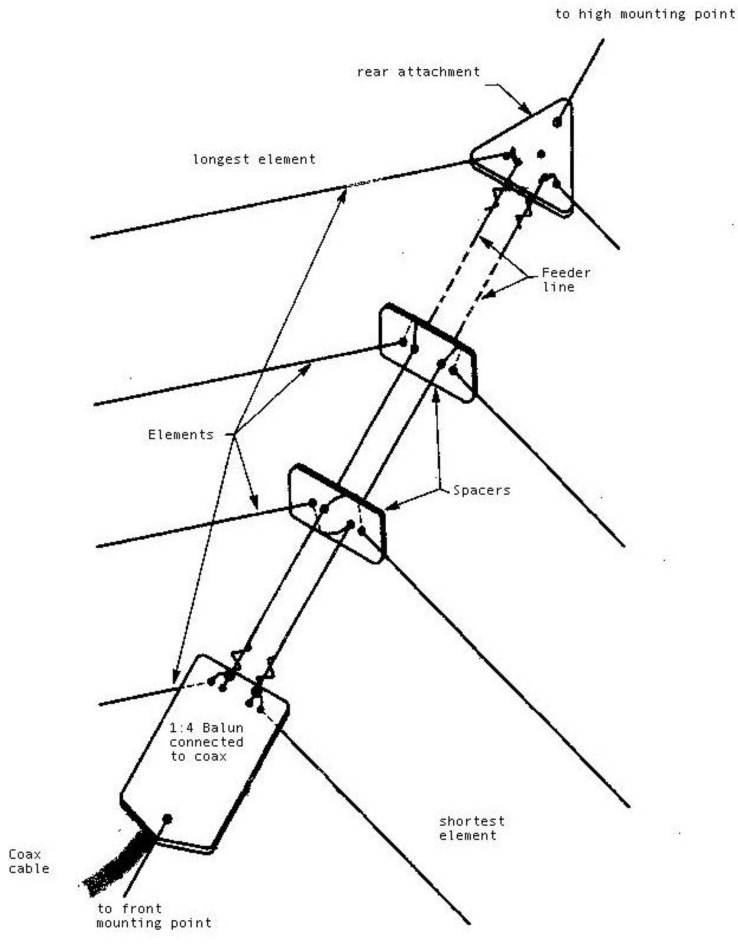

Figure 4: Details of feeder line connection to elements

The elements were made of antenna copper wire, the feed line of copper coated steel wire. All elements are terminated with small isolators. Once you have laid out the antenna, uncoiled all elements and all spaced correctly to each other, you can start tightening all isolators with nylon rope. It is quite simple but with all the wire – its close to 100m in total - you can easily end up with a mess.

Next one has to fix the required ropes to the different anchor points: The rear attachment as well as the balun shall be attached to long, strong nylon rope (yachting type). There is quite some force on the boom once the antenna is hanging in the air. Next there are the other anchor points, two ropes from both ends of the longest element and two from the ends of the shortest element. If you extend the two nylon strings used for fixing the element isolators all the way to the forward balun rope you will need only 4 ropes in total. Usually I mount the antenna feeder line forward sloping and the elements in a slight inverted V configuration. This is the easiest way because it needs only one high point for mounting.

Figure 5: „Don't tell me that this bunch of cables shall be a full-size multi-band beam.."

Some experience:

So far the 11-ele LPDA had been used at four different locations, including the DXpeditions to Togo in March 2004 (5V7C) and to French Guyana, Salut Islands, in March 2005 (TO7C).
In Togo we managed to fix the antenna boom and the two ends of the longest element via ropes onto the roof of the hotel. Considering the height of about 15m above ground we needed to pull a very long rope for the sloping set-up to a small tree in the backyard to achieve an angle of about 30 degrees. That way the antenna was pointing to North America, which gave us excellent reports for running barefoot. Being in Togo had the convenient side effect that the beam heading for long-path Pacific was exactly the same than US. Timed, selective calls (good preparatory work is key) allowed us to get many stations from this difficult path into our log.

When preparing the DXpedition to French Guyana in 2005, the 11-ele LPDA was right from the beginning on our packing list. Since the goal of our activity was also a focus on lower bands, the construction of a 4 –ele LPDA for 40m was quickly agreed upon. Of course the full-size elements of this array are quite long on 40m but the boom stays sufficiently short with about 7m in length. At the qth in Salut Islands we managed to mount both logs at about 10m high in the palm trees at the highest place of the island. During our activity we changed them twice in direction (US, Japan and Europe). Due to the rather wide apex angle of about 60° the change in direction was only relevant for Japan. However such we were able to get more than 500 JAs into the TO7C log.
Compared to our three commercial verticals for the higher bands, signals were not just much better, but also fading was much less important. The 4-ele LPDA for the 40m-band produced loud signals in Europe even at advanced local times during the morning when hams did not expect any more DX-signals from South America.

Figure 6: LPDA set-up at TO7C operation

Conclusion:

If you feel like doing some radioactivity from some remote place and you do not want to spend any extra money for excess luggage you might as well consider this antenna. Not only it covers all bands from 10m to 20m (even 6m works well – 3rd harmonics), but it also does not need any tuner with an excellent SWR over the whole range. Being on some remote place you might have just one preferred beam heading, i.e. to your home continent, hi. Anyhow, all you really need is at least one high mounting point (a palm tree would perfectly do) and some place around. The required storage room for the transport of the antenna is limited to a small plastic bag – like going for shopping. The overall weight of the 11-ele LPDA including about 100m of nylon ropes is about 3.5kg! Moreover you will notice that this set-up has sufficient gain to compensate for an amplifier of about 500W - not to mention the extra 20kg of the amp. Last you profit of the same gain in receive mode – something best amplifiers cannot provide.
I hope to encourage some of you to consider wire antennas as a valid option. LPDAs are extremely easy to build and provide high value for little money. Looking forward to working you soon from some remote place, barefoot, with wire antennas, of course.

Notes:

[1] More Wire Antenna Classics Volume 2, ARRL, 1999
[2] Rothammels Antennenbuch, Volume 12, DARC, 2001