A–10–3 EXPONENTIAL LOG-PERIODIC ANTENNAS

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Log-periodic antennas have proven their usefulness in the range from HF to UHF and microwaves. Radiation pattern and gain are practically constant in the design frequency band and VSWR does not exceed a specified maximum ; at HF usually 2 : 1 or 2.5 : 1.

Fig. 1 shows schematically a log-periodic dipole antenna (LPDA) which is very popular for HF communications. Cf. Ref. [1] , p.613. Its design is characterized by two equations,

$$L_{k+1} = \tau L_k \qquad (1)$$

and

$$S_k = 2\sigma L_k \qquad (2)$$

where L_k is the length of dipole number k, and S_k is the spacing between this and the shorter adjacent dipole. The scaling factor τ and the spacing factor σ are constants which determine gain and radiation pattern of the antenna. The number of dipoles, n, depends on these factors, but also very much on the required bandwidth. The example, Fig. 1, shows a LPDA comprising n = 30 dipoles.

HF communication circuits have to use generally lower frequencies of the design band for shorter communication distances, and higher frequencies for longer distances. Very welcome would be an antenna with gain increasing with frequency which is accompanied by a second favourable feature, namely decreasing radiation angle.

An antenna which offers these properties is the exponential log-periodic dipole antenna (ELPDA), shown schematically in Fig. 2. Cf. Ref. [2] . The difference between an ELPDA and a standard LPDA is the tapering of the factors τ and σ . They increase smoothly from dipole to dipole so that gain increases with frequency. Cf. Ref. [3] , Fig. 11. The design of an ELPDA is defined by the following equations for the length of dipoles:

$$L_2 = \tau_1 L_1, L_3 = \tau_2 L_2, L_4 = \tau_3 L_3, \ldots\ldots L_n = \tau_{n-1} L_{n-1} \qquad (3)$$

whereby

$$\tau_1 < \tau_2 < \tau_3 < \ldots\ldots < \tau_{n-1} \qquad (4)$$

The spacing between adjacent dipoles is defined by following equations

$$S_1 = 2\sigma_1 L_1 , S_2 = 2\sigma_2 L_2 , \ldots\ldots S_{n-1} = 2\sigma_{n-1} L_{n-1} \qquad (5)$$

whereby

$$\sigma_1 < \sigma_2 < \sigma_3 < \ldots\ldots < \sigma_{n-1} \qquad (6)$$

A very satisfactory performance of a tapered LPDA is obtained when the tapering is defined by an exponential function, e.g.

$$\tau_k = t^{k-1} \tau \qquad (7)$$

The coefficient $t > 1$, so that (4) is satisfied.

Similarly the spacing factors are defined by

$$\sigma_k = s^{k-1}\,\sigma. \tag{8}$$

The coefficient $s > 1$, so that (6) is satisfied. A special design is feasible with $s = 1$.

The designer of an ELPDA selects the scaling and spacing factors for the lowest and the highest frequency of the specified frequency band. These factors may be marked by subscripts L and H, respectively:

$$\tau_L = \tau, \qquad \tau_H = t^{n-2}\,\tau \tag{9}$$

$$\sigma_L = \sigma, \qquad \sigma_H = s^{n-2}\,\sigma \tag{10}$$

The taper coefficient t and s can be obtained from (9) and (10):

$$t = (\tau_H / \tau_L)^{1/(n-2)} \tag{11}$$

$$s = (\sigma_H / \sigma_L)^{1/(n-2)} \tag{12}$$

For example, an ELPDA, Fig.2, may be designed with n = 30 dipoles, and factors

$$\tau_L = 0{\cdot}85, \quad \sigma_L = 0{\cdot}05,$$

$$\tau_H = 0{\cdot}98, \quad \sigma_H = 0{\cdot}16,$$

to obtain a gain of about 7.7 dBi at the lowest design frequency, and 12 dBi at the highest frequency. Cf. Ref. [3], Fig. 11. The taper coefficients are then from (11) and (12), $t = 1{\cdot}0051$, $s = 1{\cdot}0424$.

Model tests have indicated that the ELPDA, Fig.2, has similar properties as experienced in the LPDA, Fig.1.

The ELPDA design requires less real estate than the LPDA, if gain required at the highest design frequency is specified.

There are some other exponential functions available which differ from (7) and (8). Exponential taper can be used also in other types of log-periodic and in frequency-independent antennas.

References.

[1] E.C. Jordan, and K.G. Balmain, Electromagnetic Waves and Radiating Systems. 2nd edition, 1968, Prentice Hall.

[2] Australian Patent Application PD No. 2042, lodged 13.10.77.

[3] R.L. Carrel, "The Design of Log-Periodic Dipole Antennas." 1961 IRE International Convention Record, p. 61-75.

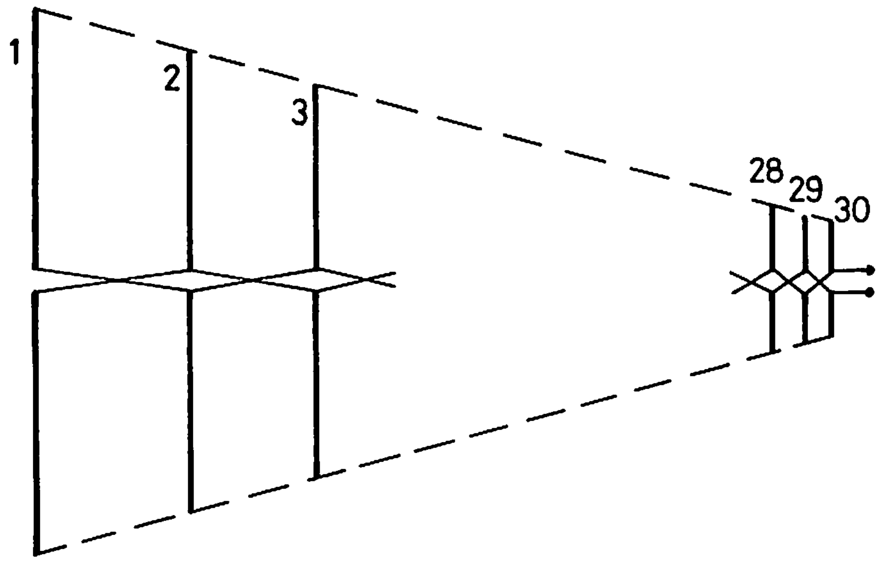

Fig.1 - Log-Periodic dipole antenna (LPDA)

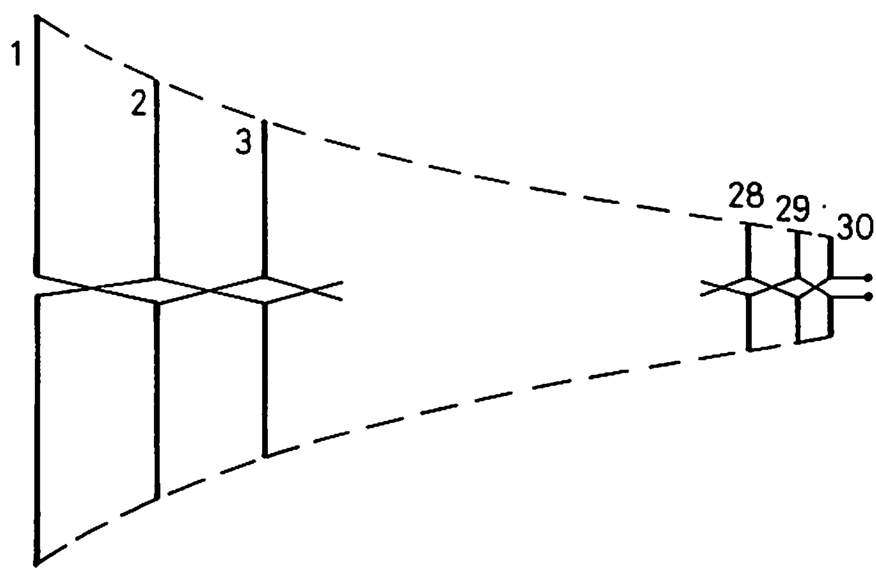

Fig.2 - Exponential log-periodic dipole antenna (ELPDA).