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INPUT IMPEDANCE AND THE GAIN OF THE LOG PERIODIC DIPOLE ANTENNA

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In this communication Kosta's[1] theory of log periodic dipole (LPD) antenna is further extended to determine the radiation resistance, input impedance and the gain of the LPD antenna with $\gamma \neq 0^\circ$.

Radiation Resistance : Using the concept of the Poynting's vector, following Kraus[2] and using the expression[1] for $E(\theta,\phi)$ the power radiated W is given by

$$W = \frac{60 I_m^2}{\pi} \int_0^{2\pi} \int_0^{\pi} |f(\theta,\phi)|^2 \sin\theta \, d\theta \, d\phi \qquad ...(1)$$

where

$$|E(\theta,\phi)| = \frac{120 I_m}{r_o} |f(\theta,\phi)|$$

Equating this to $I_m^2 R_o/2$ the radiation resistance is given by

$$R_o = \frac{120}{\pi} \int_0^{2\pi} \int_0^{\pi} |f(\theta,\phi)|^2 \sin\theta \, d\theta \, d\phi \qquad ...(2)$$

Substituting $\alpha = 35^\circ$, $\tau = 0.888$, $N = 3$, $\lambda = 30$ cms and $\gamma = 10^\circ$, 20°, 30° and 40° the values of radiation resistance were calculated and are given in Table 1.

Input Impedance : To a first order of approximation the LPD antenna with $\gamma \neq 0^\circ$ (for smaller values of γ) can be considered equivalent to a periodically loaded transmission line as shown in Fig. (1). As is given in literature[3], the characteristic impedance of this loaded line is given by

$$Z_e = \frac{Z_o}{(1 + Z_o/kx\,d)} \qquad ...(3)$$

where $Z_o = 276 \log (D/r)$.
Taking average feed point displacement between the first two dipoles $D = (R_1 + R_2) \sin (\gamma/2)$ and period $d = (R_2 - R_1) \cos (\gamma/2)$ calculations were made for the input impedance of the LPD with parameters $\alpha = 35^\circ$, $\tau = 0.888$, $\lambda = 30$ cms, $R_1 = 7.534$ cms, $R_2 = 8.559$ cms, average dipole length of two short dipoles = 2.55 cms, radius of the dipole $a = 0.05$ cm, radius of the feeder line $r = 0.3$ cm and various values of $\gamma = 10^\circ$, 20°, 30°, 40° and 50°. The value of x for the average length of the first two dipoles was found from the curves given in Jordan[4]. From the calculations it is found that the input impedance falls from the value of 178 ohms to 116 ohms as γ is decreased from 50° to 10° (Table 1).

Power Gain : Using the approximate formula

$$G = 10 \log \left(\frac{41253}{\theta_{E_\theta} \, \theta_{E_\phi}} \right) \qquad ..(4)$$

with symbols having usual meanings the value of G was calculated using the expression for E_θ and E_ϕ given in the literature for the parameters[1] given above. It is found that the power gain G varies from 11 dB to 9 dB as the value of ψ is decreased from 40° to 10° (Table 1).

TABLE 1

ψ	R_o	Z_o	G
10°	27.71	116.1	9.13 dB
20°	24.56	148.3	9.68 dB
30°	20.46	163.7	10.18 dB
40°	16.54	172.6	11.05 dB
50°	13.56	178.1	--

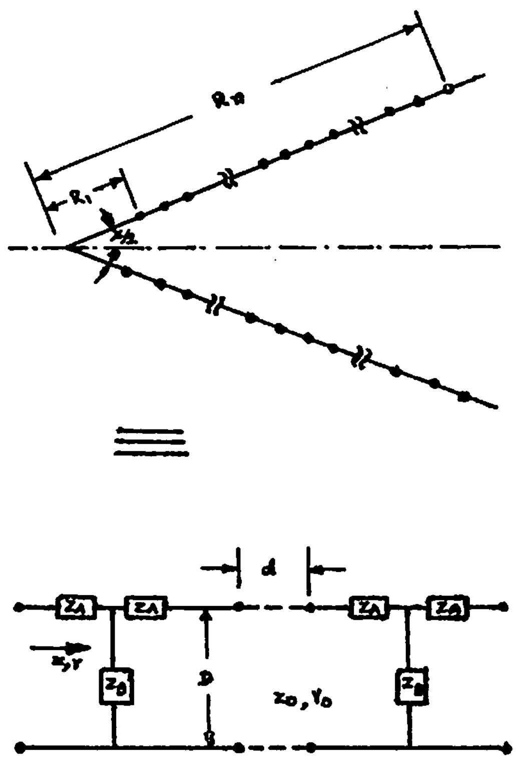

FIG. 1 LPD ANTENNA AND ITS EQUIVALENT CIRCUIT

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1. Kosta, S.P. et al, 'A note on the theory of log-periodic dipole antenna', scheduled to appear in IEEE Transactions on Antenna and Propagation (U.S.A.), Sept. 1970 issue.
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4. Jordan, E.C., 'Electromagnetic waves and radiating systems', (New Delhi: Prentice Hall of India, Pvt.Ltd.), 1969, p.548.