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ANALYSIS OF A THIN WIRE PARABOLIC ANTENNA

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§1 INTRODUCTION

In this paper, the characteristics of a thin wire parabolic antenna(P.A) which varies from the shape of cylindrical antenna to that of parallel transmission line are discussed, mainly on the effect of the variation of the parabola's shape and the location of the feed point.

§2 REPRESENTATION OF ELECTRIC FIELD

In this analysis, parabolic-cylinder coordinates is used. As shown in Fig.1, ξ=const., η=const. are intersecting parabolic cylinders which are parallel to the Z axis. ξ,η,ζ are called parabolic-cylinder coordinates and related to rectangular coordinates by the following equations,

$$x=\frac{1}{2}(\eta^2-\xi^2)\quad y=\xi\eta\quad z=-\zeta \tag{1}$$

The P.A. is putted on the coordinates(ξ,ζ=const.) and the various shapes of the P.A. are shown in Fig.2.

A point(ξ,η,ζ) is the origin and a point(ξ',η',ζ') is the observed point and the current is treated as filament source with assumption that the radius of the antenna wire is very small.

Using this coordinates, η' component of the electric field of the P.A. is given by

$$E_{\eta'}(\xi',\eta',\zeta')=\frac{1}{j4\pi\omega\varepsilon}\int_{-\ell}^{\ell} I(\eta)\,K(\xi,\eta,z,\xi',\eta',z')\,d\eta \tag{2}$$

where

$$K(\xi,\eta,z,\xi',\eta',z')=\left\{\frac{4\pi^2}{\lambda^2}(\xi\xi'+\eta\eta')-\frac{\partial}{\partial\eta}\frac{\partial}{\partial\eta'}\right\}\frac{e^{-j\frac{2\pi}{\lambda}r}}{r}$$

λ is wavelength and ω is angular-frequency and ε is dielectric const. and r is distance between the origin and the observed point, and $I(\eta)$ is the current along the wire.

§3 CURRENT DISTRIBUTION

$I(\eta)$ is expanded to a Fourier series as follows,

$$I(\eta)=\sum_{\ell=0}^{\infty}\left[A_\ell\cos\left\{(\ell+\tfrac{1}{2})\pi\frac{s(\eta)}{L}\right\}+B_\ell\sin\left\{(\ell+1)\pi\frac{s(\eta)}{L}\right\}\right] \tag{3}$$

And η' component of the electric field on the surface of the antenna which is given by impressed voltage is expanded to a Fourier series as follows,

$$E(\eta')=\sum_{m=0}^{\infty}\left[C_m\cos\left\{(m+\tfrac{1}{2})\pi\frac{s(\eta')}{L}\right\}+D_m\sin\left\{(m+1)\pi\frac{s(\eta')}{L}\right\}\right] \tag{4}$$

where

A_ℓ, B_ℓ, C_m, D_m are the coefficients of a Fourier series.

2L is antenna length and $s(\eta)$ is length function on the η axis which is given by

$$s(\eta)=\int_0^{\eta}\sqrt{\xi^2+\eta^2}\,d\eta\ ,\quad s(\ell)=L$$

Considering the continuity of the electric field on the surface to Eqs (2),(3) and (4), the current distribution is determined.

§4 CHARACTERISTICS

The current distributions are shown in Fig.3,4 and 5. In those figures, the absolute value $|I|$ is normalized by the maximum value.

The input impedance is shown in Fig. 6.

The field patterns are shown in Fig. 7 and 8. In Fig.7, symbols × are the experimental values for ξ=0.2, 2L=0.5λ, d=L/400.

§5 REFERENCE

T.Shiokawa and R.Sato,
The Journal of the Institute of Television Engineering, in press.

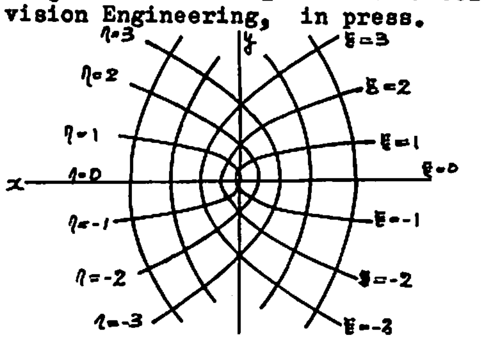

Fig.1 Parabolic-Cylinder Coordinates

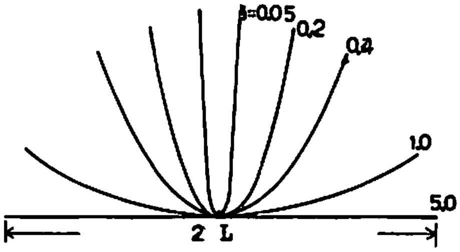

Fig.2 Various shapes of P.A.

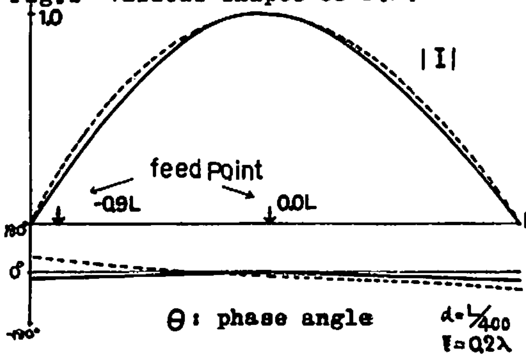

Fig.3 Current Distribution for 2L=0.5λ
feed point -------- =-0.9L
——— = 0.0L

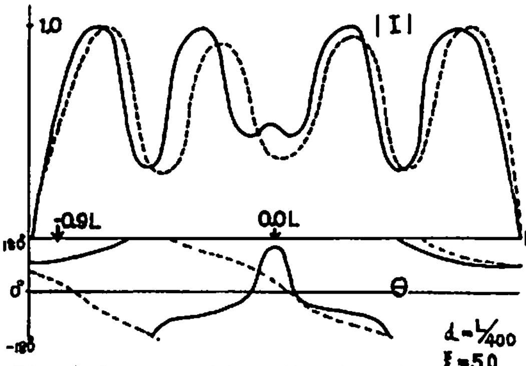

Fig.4 Current Distribution for 2L=2λ

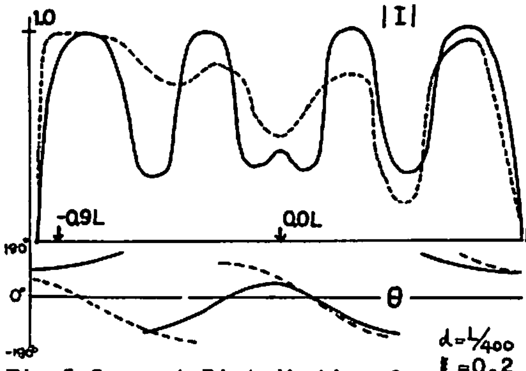

Fig.5 Current Distribution for ξ=0.2 2L=2λ

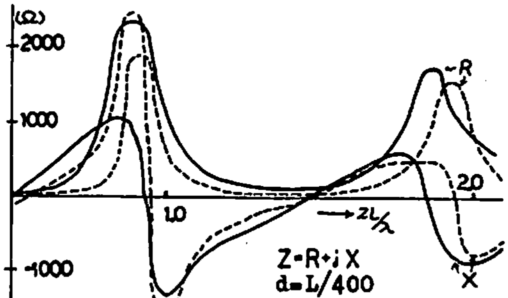

Fig.6 Input Impedance of P.A.
feed point 0.0L -------- ξ=0.2
——— ξ=5.0

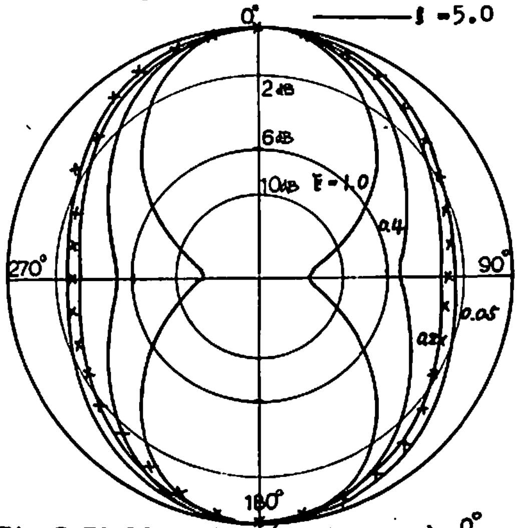

Fig.7 Field pattern(Horizontal)
2L=0.5λ d=L/400

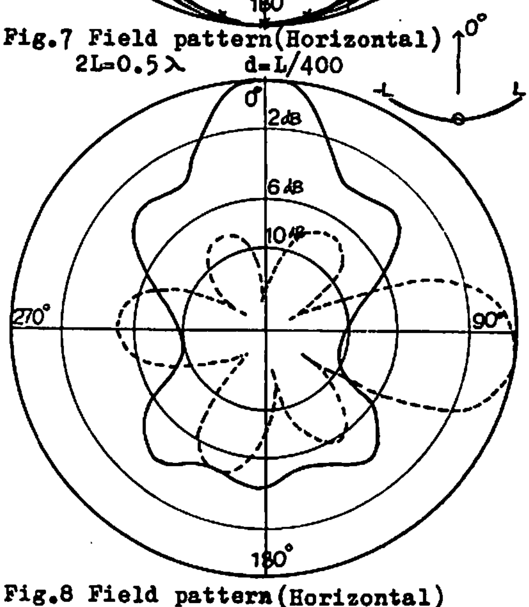

Fig.8 Field pattern(Horizontal)
2L=2λ, d=L/400 feed point —— 0.0
ξ=0.4 ------ -0.9L