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RADIATION PATTERN OF A HELICAL YAGI ANTENNA

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INTRODUCTION

A Yagi antenna with its conventional constituent dipoles replaced by short normal mode helices has been analyzed using the concepts of 1) periodically loaded line theory, and 2) travelling wave antennas.

MATHEMATICAL ANALYSIS

Sengupta[1] has derived an expression for the phase velocity along the infinite Yagi structure consisting of conventional parasitic dipoles as

$$\frac{v}{c} = 1 - z\lambda/4\pi \, dx \qquad \ldots(1)$$

where v/c = the ratio of phase velocity along the structure to the free space velocity, z = characteristic impedance of the transmission line, d = loading interval, and x = reactance offered by the loading dipoles.

Recently, it has been shown[2] that if normal mode helices with proper choice of parameters are made to replace the conventional dipoles of the Yagi antenna, then the so called helical Yagi structure also acts as a slow wave structure. In this case Eqn.(1) will be modified to[2]

$$\frac{v}{c} = 1 - z\lambda/4\pi d(X_c - X_L) \quad \ldots(2)$$

where X_c is the capacitative reactance of short dipoles, and X_L is the inductive reactance of the Loops. Fig.(1) represents the helical Yagi antenna and its equivalent circuit.

Considering the uniform long helical Yagi antenna of length L equivalent to a line source of length L excited by a travelling wave the expression for the radiation pattern may be written as

$$F(\theta) = \int_{-L/2}^{L/2} e^{-j(\beta - k\cos\theta)} \, dz \qquad \ldots(3)$$

Solving the integral and simplifying, we have

$$F(\theta) = L\left(\frac{\sin A}{A}\right)$$

where

$k = 2\pi/\lambda$

$A = \pi L/\lambda \cdot (\beta/k - \cos\theta)$,

θ = angle measured from the axis of the antenna,

$$\beta = \omega/C \left(1 - \frac{Z\,A}{4\pi d(X_c - X_L)}\right)$$

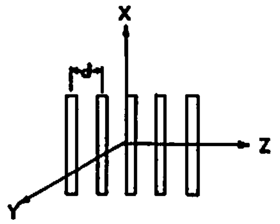
Calculations were made for the helical Yagi structure with following parameters:

Z_o = 300 ohm, 600 ohms,

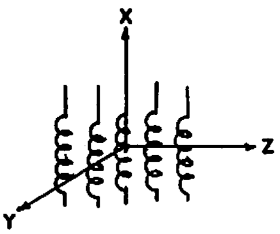
$C = 3\times10^8$ m/sec

X_c = 2200 ohm for one short dipole of length .05 λ

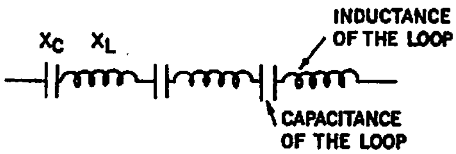
FIG. I



(A) CONVENTIONAL YAGI STRUCTURE

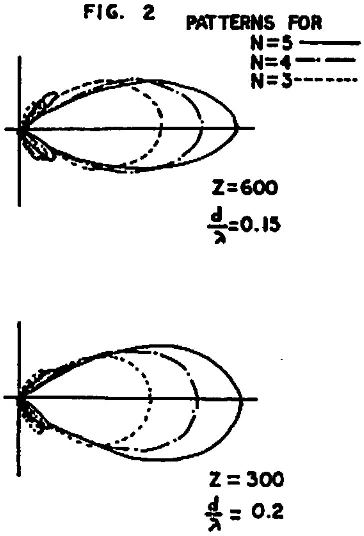


(B) PROPOSED YAGI STRUCTURE



(C) EQUIVALENT CIRCUIT OF PROPOSED STRUCTURE

FIG. 2



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X_L = 941 ohm for one loop of diameter .1λ, S = .05 λ radius of the wire = .0001λ

d/λ = .15, .2

f = $1x10^6$ Hz

CONCLUSIONS

From this analysis it is found that an unidirectional pattern with good side lobe ratio can be obtained from the proposed helical Yagi structure. The obvious advantages of the structure are:

(1) Transverse dimensions are reduced.

(2) Circular polarization can be achieved by suitable choice of helix parameters.

REFERENCES

1. Sengupta, D.L., "Phase velocity of wave propagation along an infinite Yagi structure", IRE Trans. on Antenna and Prop., Vol.AP7, pp. 234-239, July, 1959.

2. Bhatnagar, P.S.; Kosta, S.P., and Chaudhuri, M. "Helical infinite structure" - To be published in Proc. IEEE (U.S.A.).