Indian J. Phys. **49**, 488–493 (1975)

Radiation from axial slot on a circular cylinder

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(*Received* 16 *April* 1974, *revised* 11 *March* 1975)

This paper presents some calculations for the radiation from a cylindrical antenna having N slots. The dependence on the slot width and cylinder diameter has also been considered.

1. INTRODUCTION

The basic problem of communicating to and from high speed aircraft has stimulated research work into the theory and application of slotted cylinder antennas (Wait 1959), Silver & Sanders 1950, Bailin 1965). In this paper we have studied the radiation from cylindrical antenna which has several thin slots Such antennas of different diameters corresponding to $D/\lambda = 5, 10, 15, 20$ have been considered and the radiation pattern as a function of the width of the slot has also been studied numerically.

2. FIELD PATTERN OF AXIAL HALF WAVELENGTH SLOT ANTENNA

The type of antenna considered is shown in figures 1 and 2. This is taken to be an infinitely long ideal conductor of diameter D having cylinderical structure.

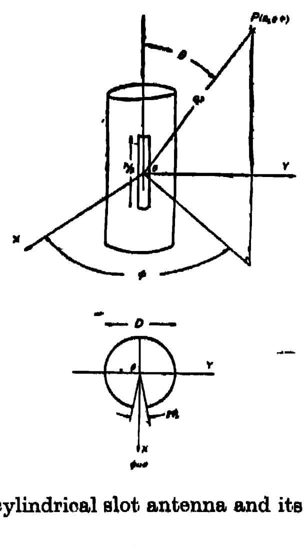

Fig. 1. Coaxial cylindrical slot antenna and its coordinate system.

* This work was done by the author when he was at Tohoku University Sendai Japan during 1973.

The slot is supposed to be of half wavelength in size and axial with the antenna. It is excited with the voltage V at its center. The aperture of the slot is $2\phi_0$

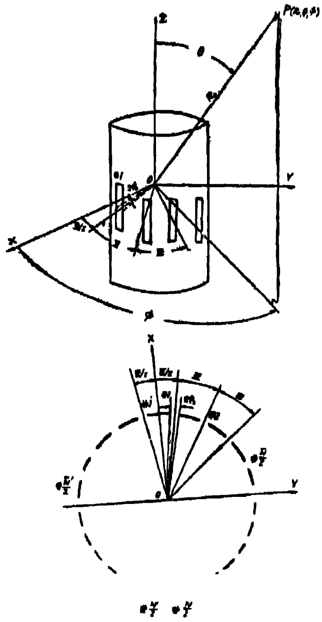

Fig. 2. Cylindrical conductor with many slots and the coordinate system.

and is considered to be relatively narrow. The radiation field of this antenna at far distance point $P(R_0, \theta, \phi)$ is only the ϕ component and θ component is zero. The ϕ component of the electric field may be written as (Wait 1959)

$$E_{\varphi}(\theta, \phi) = \frac{\exp(-j\beta R_0)}{R_0} \cdot \frac{V \cos\left(\frac{\pi}{2} \cos\theta\right)}{\pi^2 \beta \left(\frac{D}{2} \sin^2\theta\right)} \sum_{m=0}^{\infty} \frac{\epsilon_m j^m \cos m\phi . Gm}{H_m^{(2)\prime}\left(\frac{\beta D}{2} \sin\theta\right)}, \quad \ldots (1)$$

where

$$\beta = 2\pi/\lambda, \quad \epsilon = 1 \text{ for } m = 0 \quad \text{and} \quad \epsilon = 2 \quad \text{for } m \neq 0,$$

$$Gm = \frac{\sin m \frac{\phi_2 - \phi_1}{2}}{m . \frac{\phi_2 - \phi_1}{2}}, \quad \ldots (2)$$

$H_m^{(2)\prime}(x)$ is the Bessel function of third kind. If the width of the slot $(2\phi_0)$ is narrow, $G_m \approx 1$ and we get

$$E_{\varphi}(\theta, \phi) = \frac{\exp(-j\beta R_0)}{R_0} \frac{V \cos\left(\frac{\pi}{2} \cos\theta\right)}{\pi^2 \beta . \frac{D}{2} \sin^2\theta} \sum_{m=0}^{\infty} \frac{\epsilon_m j^m \cos m\phi}{H_m^{(2)\prime}\left(\frac{\beta D}{2} \sin\theta\right)}. \quad \ldots (3)$$

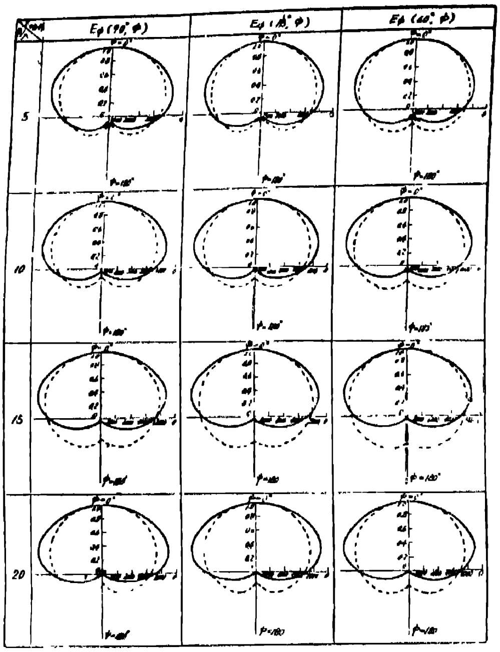

Fig. 3(a) Field pattern, Solid line : Amplitude $E_{\phi}(\theta, \phi)$. Dash line : phase $\angle E_{\phi}(\theta, \phi)$.

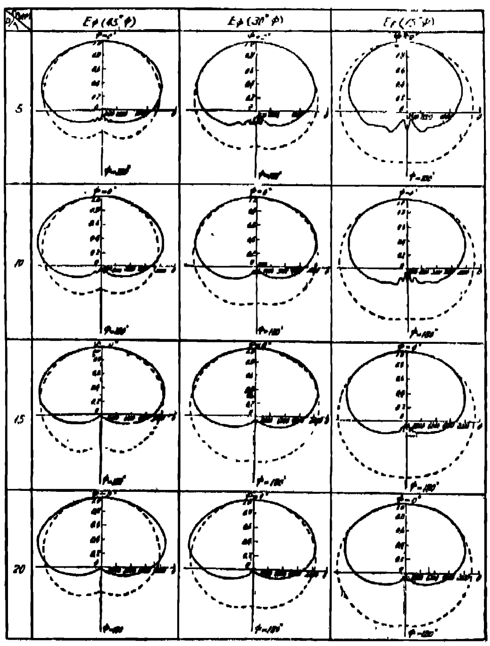

Fig. 3(b) Field pattern, Solid line : Amplitude $E_{\phi}(\theta, \phi)$, Dash line : Phase $\angle E_{\phi}(\theta, \phi)$.

3. Field Pattern of Narrow Slot Antenna

In this section we shall present the results of the calculations of eq. (3) when the slot is narrow. The diameter of the cylinder here considered is 5.0, 10.0, 15.0 and 20.0 wavelength and the angle θ is varied from 90°, 75°, 60°, 45°, 30° and 15° respectively. Using the above parameters the field pattern has been calculated when ϕ varies from 0 to 360°. The results have been shown in figure 3 denoting the field pattern for different θ values as $E_\varphi(90°, \phi)$, $E_\varphi(75°, \phi)$, ..., $E_\varphi(15°, \phi)$ so on. Here solid line indicates the amplitude whereas the dash line indicates the phase. It is found that maximum amplitude of the field is 1 for minimum phase.

4. Influence of the Slotwidth Variation

Here we represent the effect of the variation of the width of the slot on the field pattern. The width of the slot taken into account is supposed to be $2\phi = 0°$, 1°, 2°, 3° and the diameter of the cylindrical antenna is supposed to be varied from $D/\lambda = 5.0$, 10.0, 15.0, 20.0. The results are shown in figure 4 from which it is evident that the field amplitude decreases as the width of the slot is increased.

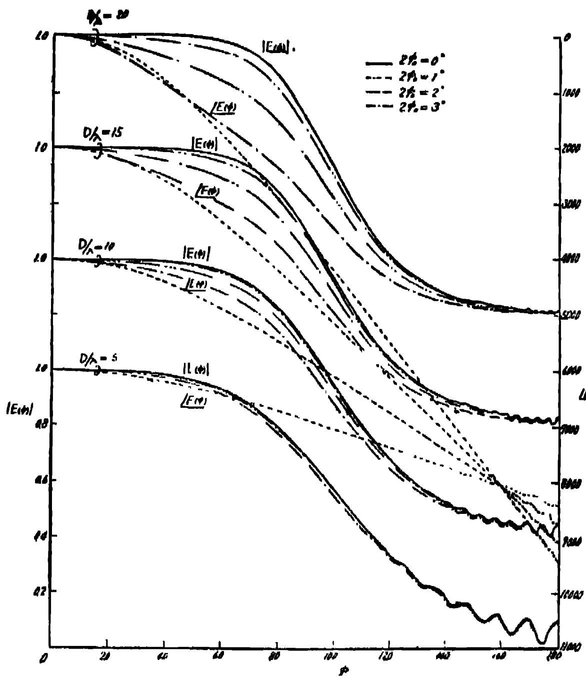

Fig. 4. Field pattern with slot width variation.

5. Horizontal Field Pattern

We represent the horizontal field pattern for the large number of slot antenna along the cylindrical conductors. As shown in figure 2, we arrange N half wave-length slot antennas along the cylindrical conductor at equal angle. Every slot is considered to be fed in a similar way in the positive direction. The horizontal field pattern for different D/λ and N values are shown in figures 5 from which it is evident that number of side lobes increases with the increase in N and the pattern becomes more sharp as we increase the value of D/λ.

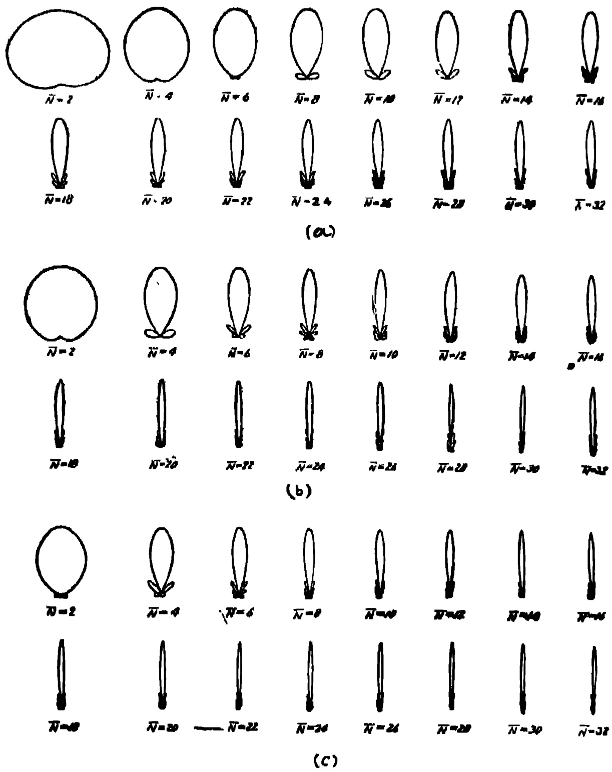

Fig. 5. Horizontal field pattern

(a) $\frac{D}{\lambda} = 5, \quad N = 90$

(b) $\frac{D}{\lambda} = 10, \quad N = 90$

(c) $\frac{D}{\lambda} = 15, \quad N = 90$

6. Summary

In this paper we have calculated the field pattern of half wavelength slot antennas when the diameter of the cylinder is varied from $D/\lambda = 5, 10, 15$ and 20. The variation of the pattern with the slotwidth and number of the slots has also been studied.

Acknowledgment

The author is grateful to Prof. S. Adachi for suggesting the problem and useful discussions on the subject. The financial support from the Tohoku University is also gratefully acknowledged.

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