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BASIC CHARACTERISTICS OF FOLDED DIPOLE ANTENNAS WITH PARALLEL-WIRE REFLECTOR FOR HF BROADCASTING

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1. INTRODUCTION

The international high-frequency broadcasting service has a world-wide significance for mutual understanding between many countries. The transmitting antenna usually consists of a wideband dipole curtain array with a reflector. The surface of the reflector is frequently made of a mesh or a grid of wires for decreasing wind resistance and reducing system weight[1],[2]. For wide frequency band, the radiating element consists of a wire cage-type dipole or a multi-wire folded dipole with short-bars. Some of such type antennas have been investigated by using the moment method, for examples, in references [3] and [4]. The objective in this paper is to obtain basic reference data for the design of the curtain antenna systems.

This paper presents various characteristics of folded dipole antennas with a parallel-wire reflector calculated by using the method of moment[5]. Firstly, an antenna structure will be shown. Next, some calculated results of the FB ratio, gain, bandwidth, mutual coupling and radiation patterns will be demonstrated.

2. ANTENNA STRUCTURE

A pair of two folded dipoles is a basic unit of the curtain antenna array which will be investigated. Fig.1 shows the geometry of the antenna. It consists of one-pair folded dipoles mounted in front of a parallel-wire reflecting screen. The dimensions of the antenna are shown in Table 1 where [ ] means the typical value for calculations. Two folded dipole elements placed half wavelength apart were connected by two parallel-wire feedlines. The feed point is at the center of the feedlines. For matching, the characteristic impedance Rc of the feedline is set to be the input resistance of the folded dipole element. The E- and H-planes are defined as yz- and xz-planes, respectively.

3. CALCULATED RESULTS

Some characteristics of the antenna have been calculated by using the moment method. Before that, the validity of the calculation was confirmed by some experiments on the mutual couplings measured by image method[6]. The results calculated will be described as follows.

(FB ratio, gain and bandwidth)

An FB ratio (defined as the ratio of the directivity at $\theta = 0°$ to the maximum directivity in $\theta = 120° \sim 180°$) is a very important parameter for such an antenna with a parallel-wire reflector. Fig.2 shows the dependences of the FB ratio and the actual gain on the screen spacing Ss for the approximately fixed Ws. As the spacing Ss became wider, the FB ratio became smaller. The calculted FB ratio was more than 9 dB. For $0.05\lambda o < Ss < 0.15\lambda o$, the variation of the gain calculated was less than 0.5 dB. Next, the FB ratio and actual gain on h for the fixed Ss were shown in Fig.3. The maximum value of the FB ratio was about 13 dB at $h \fallingdotseq 0.25\lambda o$, and that of the actual gain was about 10.4 dBi at $h \fallingdotseq 0.15\lambda o$.

Fig.4 shows the VSWR and actual gain as a function of frequency. The calculated bandwidth (VSWR < 1.5) was about 27%. It was found that wider bandwidth could be achieved by using the two folded dipoles.

(Mutual coupling)

To provide radiation beams in both sides of a parallel-wire reflector, there are some problems such as mutual coupling between the radiators. It is considered that mutual coupling is greatly dependent on the reflector structure, such as the screen spacing and the dipole-to-screen spacing. As shown in Fig.5, two-pair folded dipoles placed in both sides of the parallel-wire reflector will be used to discuss the mutual coupling. Fig.6 shows the dependence of mutual coupling on h for Ss = 0.05, 0.1 and $0.2\lambda o$. For $h > 0.2\lambda o$ and $Ss <= 0.1\lambda o$, the mutual coupling was less than -19 dB.

(Radiation pattern)

For discussing the relation between the radiation pattern and the antenna structure, three different antennas shown in Fig.7 will be used. The model(A) consists of two-pair folded dipoles mounted in front and back of an infinite ground plane. The model(B) and model(C) consist of one-pair folded dipoles in one side and two-pair folded dipoles in both sides of a parallel-wire reflector, respectively. Figs.7 (a) and (b) show the calculated E- and H-plane radiation patterns, respectively. The radiation patterns of the model(A), (B) and (C) are represented by the solid line and broken lines '- -', '---', respectively. Each of the one-pair folded dipoles was excited at the same amplitude and in phase.

The radiation patterns of the model(A) were ideal cases with no mutual coupling between the two-pair folded dipoles. The backlobe level was about -12 dB for the model(B). It was found from the E-plane radiation pattern of the model(C) that the radiation beam became thinner because of the mutual coupling between the two-pair folded dipoles. The radiation levels at $\theta = 90°$ were about -20 dB in the H-plane of the model(C). These results will serve as useful information to design and construct an curtain antenna array.

4. CONCLUSION

Various characteristics of the folded dipole antennas with a parallel-wire reflector have been calculated by using the method of moments and demonstrated. These results could be helpful for the design of the curtain antenna systems. In further research, it is important to develop a wideband folded dipole, a better feeder structure and an antenna array.

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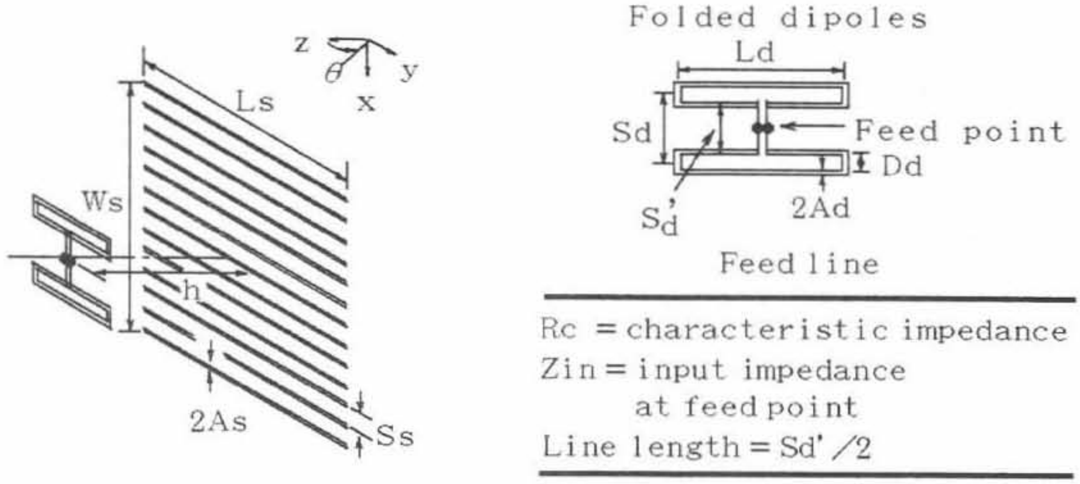


Fig. 1 Geometry of one-pair folded dipole antennas with parallel-wire reflector.

Table 1 Antenna parameters

Ld=[0.478]λo
Dd=[0.045]λo
Sd=[0.5]λo
Ad=[0.0025]λo
h=[0.21]λo

Ls=[1.5]λo
Ws=[1.1]λo
Ss=[0.1]λo
As=[0.001]λo

[ ]:Typical value

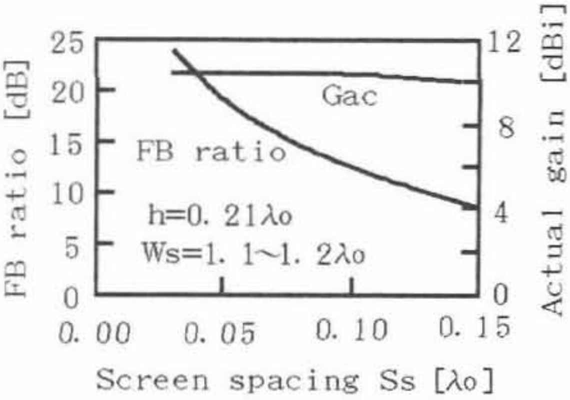


Fig. 2 Dependences of FB ratio and actual gain on Ss.

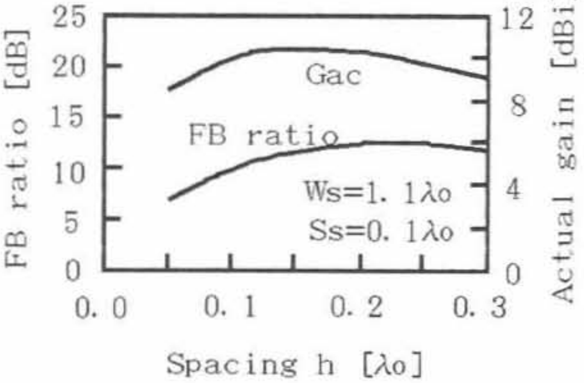


Fig. 3 Dependences of FB ratio and actual gain on h.

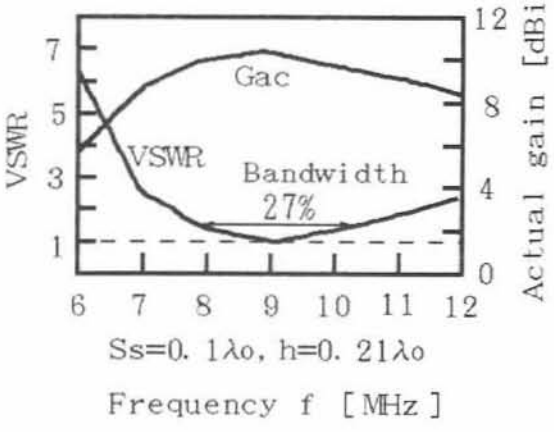


Fig. 4 VSWR and actual gain vs. frequency

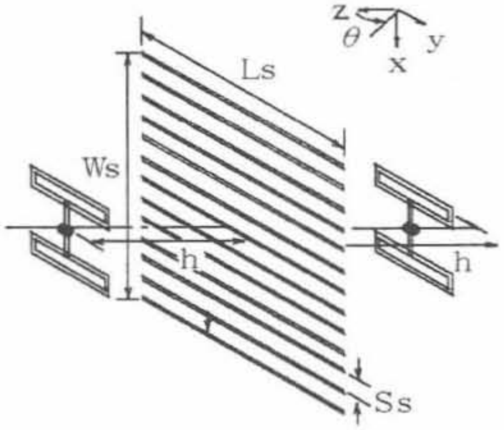


Fig. 5 Two-pair folded dipoles with prallel-wire reflector.

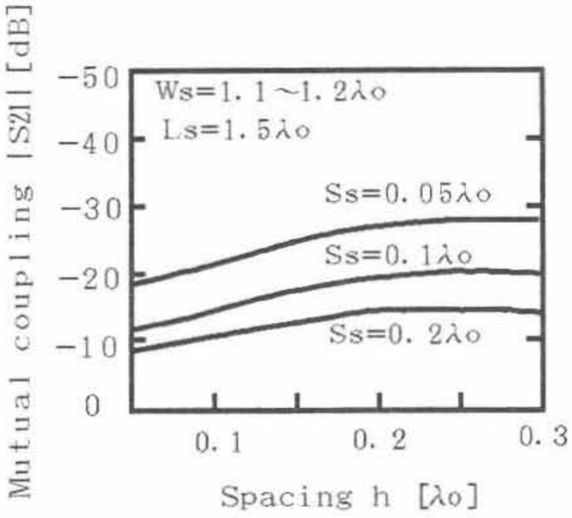
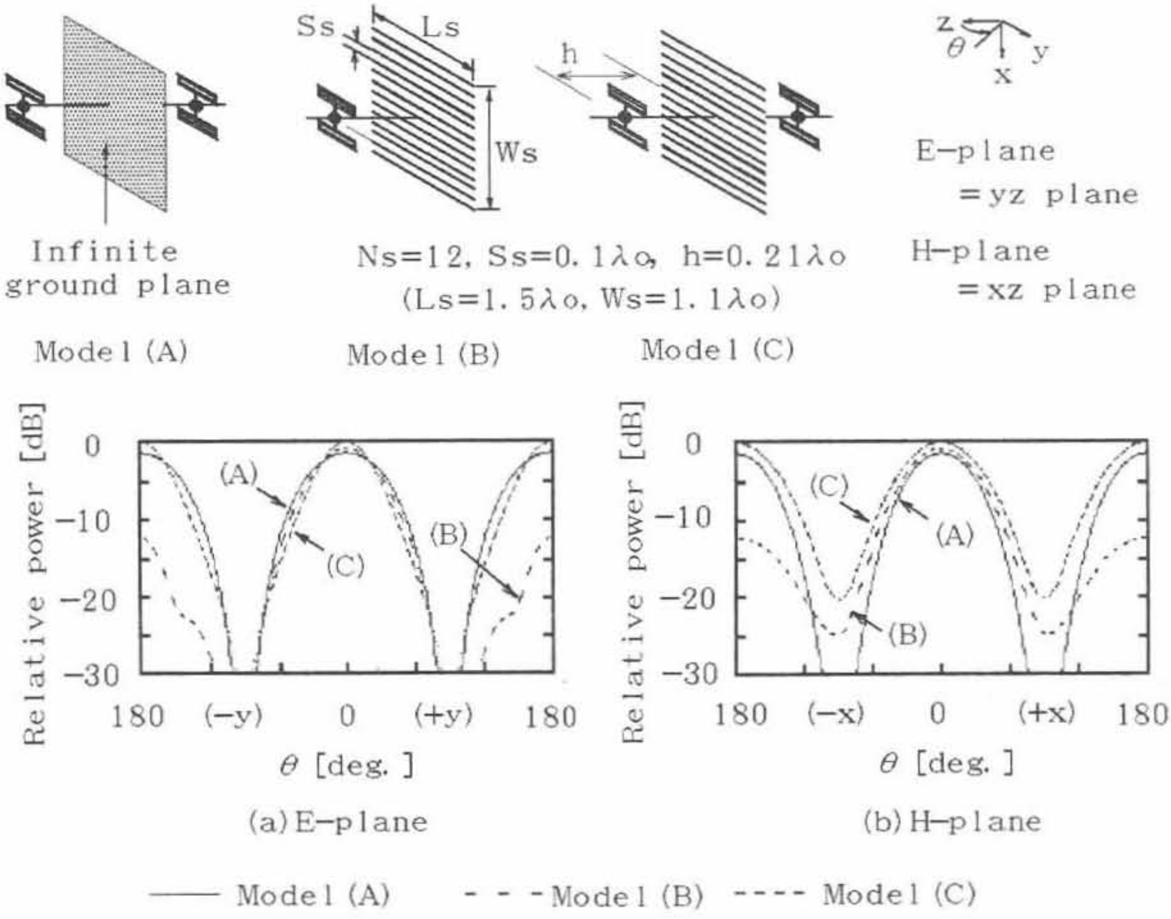


Fig. 6 Dependence of mutual coupling on h.



(a) E-plane

(b) H-plane

Fig. 7 Three different models and radiation patterns.