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E-평면 상호결합에 대한 새로운 모델을 이용한 3단 패치 배열 안테나

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E-plane gap coupled three-patch array antenna using the improved model

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ABSTRACT

An equivalent circuit model of E-plane narrow gap coupled microstrip rectangular patch array is proposed. By use of this model, three-patch array antenna avoiding a conventional feeding network is designed and fabricated. By the analysis of this array antenna using this model and transmission line model, the return loss is calculated and compared with experimental value. The radiation pattern of three-patch array antenna is measured and compared with that of microstrip one patch antenna. The directivity of the fabricated three-patch array antenna is improved by about 4.2dB compared with that of one-patch antenna.

I. INTRODUCTION

M.Maeda formulated the gap capacitance of microstrip transmission line using three dimensional potential Green functions. Here, an equivalent circuit model of the coupling in the gap between the rectangular microstrip patches is described. The return loss is calculated theoretically by use of transmission line model and the improved model on gap-coupling proposed.

II. IMPROVED MODEL AND RETURN LOSS

The antenna configuration is shown in Fig.1. The patch separations S1 and S2 are respectively 0.13, 0.3 times the substrate thickness H. According to this small spacing, the radiators are mutually coupled by E-plane and this allows us to avoid a separate feed.

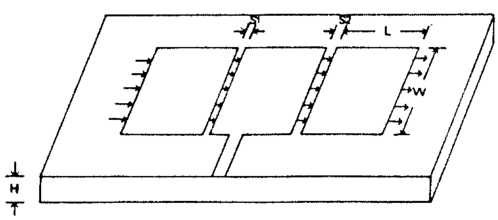

Fig.1. Geometrical structure of three-patch array antenna

The physical gap structure is analyzed using the equivalent π- circuit as shown below. The series capacitance of the π- circuit is shunted by a conductance to account for the radiation loss from the gap.

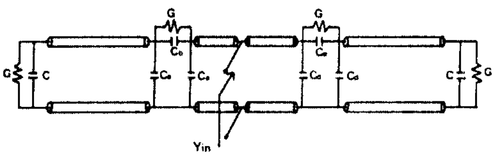

Fig.2. Equivalent circuit for three-patch array antenna

The gap capacitances Ca, Cb, Cd and Ce are calculated using the quasi-static variational method.

To obtain a 50[Ω] match at resonance, the gapwidth S1 at the front end of the central patch radiator is made somewhat smaller than the other gap S2. To find the feed point along the length L, equation (1) is used. A 50Ω-microstrip feed line is attached to the feed point.

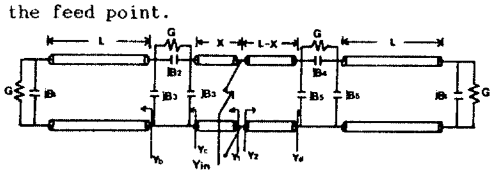

Fig.3. Equivalent circuit for finding the feed point

$$Y_{in} = Y_1 + Y_2$$

$$= Y_o \frac{Y_c + jY_o \tan\beta X}{Y_o + jY_c \tan\beta X} + Y_o \frac{Y_d + jY_o \tan\beta (1 - X)}{Y_o + jY_d \tan\beta (1 - X)} \quad .... (1)$$

here,

$$Y_d = \frac{(G + jB_4)\cdot(Y_b + jB_5)}{(G + jB_4 + Y_b + jB_5)} + jB_5$$

$$Y_c = \frac{(G + jB_2)\cdot(Y_b + jB_3)}{(G + jB_2 + Y_b + jB_3)} + jB_3$$

$$Y_b = Y_o \frac{(G + jB_1) + jY_o \tan\beta l}{Y_o + j(G + jB_1)\tan\beta l}$$

Return loss is calculated theoretically using equation (2).

$$R.L. = 20 \log|\rho| \quad \cdots\cdots (2)$$

here, R.L.: return loss

ρ : reflection coefficient

III. EXPERIMENTAL RESULTS

The length of a radiating patch is obtained by conventional techniques. The length and width of each radiating patch is the same as that of one-patch antenna. The specifications of three-patch array antenna are shown in Table I.

Table I. Specs. of 3 - patch array antenna.

L[mm]	W[mm]	H[mm]	S1[mm]	S2[mm]	Fo[GHz]
30.2	37	1.55	0.2	0.5	3

Fig.4 is the return loss of one-patch microstrip antenna as function of frequency by experiment. The bandwidth of one-patch antenna is 2.2% for a VSWR less than 2. Fig.5 is the return loss of three-patch array antenna as function of frequency obtained theoretically and experimentally.

The experimental values of resonant frequency and return loss for three-patch array antenna are 3.05GHz, -28dB respectively. The bandwidth of three-patch array antenna narrows by 1.2% compared with that of one-patch antenna.

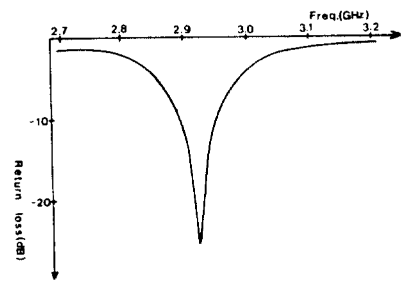

Fig.4. Measured return loss of one-patch antenna

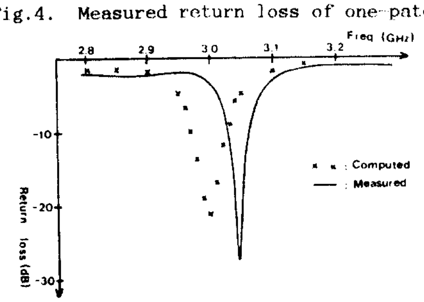

Fig.5. Return loss of three-patch array antenna

Fig.6 is the E-plane radiation pattern for one-patch and three-patch array antenna. Half-power beamwidth of three-patch array antenna and one-patch antenna are 13°, 20° respectively. SLL(side lobe level), a measure of how well the power is concentrated into the main lobe, is -3dB for three-patch array antenna and -2dB for one-patch antenna. Fig.7 is the H-plane radiation pattern for one-patch and three-patch array antenna. There is no eminent difference between one-patch and three-patch array antenna, as far as H-plane radiation pattern is concerned. The directivity of three-patch array antenna is improved by about 4.2dB compared with that of one-patch antenna.

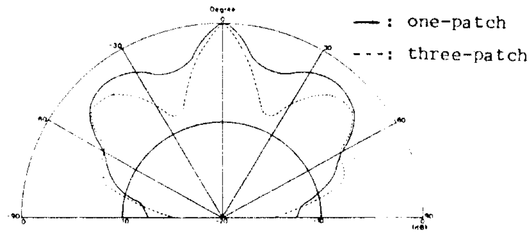

Fig.6. E-plane radiation pattern

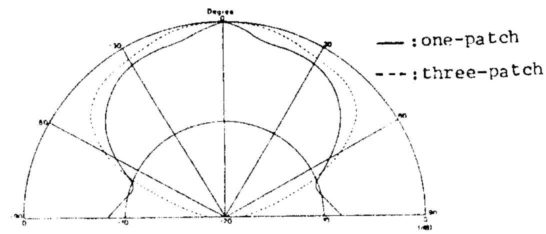

Fig.7. H-plane radiation pattern

Table 2. Aerial details.

	3 patch array antenna	1 - patch antenna
Resonant freq.	3.05 [GHz]	2.92 [GHz]
H.P. beamwidth	13	20
SLL (dB)	-3 dB	-2 dB
Bandwidth	1 %	2.2 %
Directivity	4.2 dB+	

IV. CONCLUSION

The construction of microstrip three-patch array antenna avoiding a conventional feeding network is possible using the model on gap-coupling proposed and transmission line model. As a result of experiment, the deviation of resonant frequency is 1.7% and the return loss is -28dB. In the case of radiation pattern, the half-power beamwidth of three-patch array antenna narrows by about 7° compared with that of one-patch antenna. The directivity of three-patch array antenna is improved by about 4.2dB compared with that of one-patch antenna.

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