RADIATION PROPERTIES OF A LINEARLY POLARIZED RADIAL-LINE MICROSTRIP ARRAY ANTENNA

Misao HANEISHI,Masahiro SHIBATA, Junya YAMAZAKI, Sakuyosi SAITO
Faculty of Engineering, Saitama University
255 Shimookubo,Urawa 338-8570,Japan
E-mail: haneishi@ees.saitama-u.ac.jp

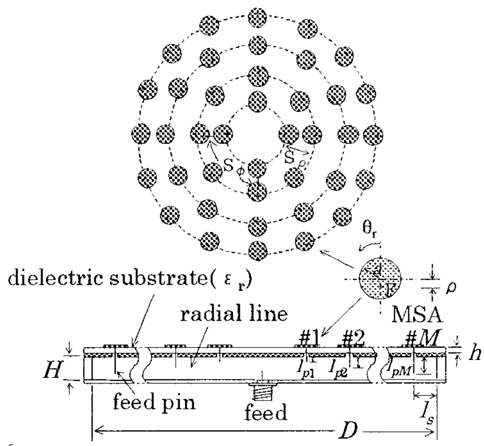
1. Introduction:

In construction of a large-scale planar array, reduction of the feeding loss is important for realization of efficient performance. For this purpose, much attention has recently been paid to an antenna fed by a low-loss radial line [1]-[3]. This paper presents a basic design technique for and the radiation properties of a microstrip array antenna fed by a radial line (RL-MSAA).

First, the radiation properties of an RL-MSAA that has a conical beam radiation pattern are presented. Next, a basic design technique for and the radiation properties of an RL-MSAA composed of newly designed ring-microstrip antenna (R-MSA) elements are presented.

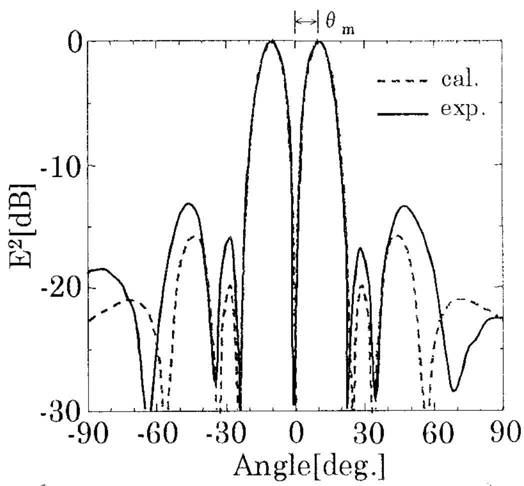
In order to verify the performances of these types of antennas, some planar arrays fed by a low-loss radial line were constructed and tested at the SHF-band.

As a result of experiment, satisfactory performances were achieved in both radiation patterns and input impedance.



(a=4.1, ρ/a=0.3, H=7.5, h=1.2, lp_1=3.1, lp_2=3.7, lp_3=4.1, lp_4=4.3 ,unit[mm], ls=0.16 λ_0.S_ρ=0.5 λ_0)

Fig.1 Basic configuration of a linearly polarized RL-MSAA



(M=4, S_ρ=0.5 λ_0, f_0=11.85[GHz])

Fig.2 Typical conical beam patterns of a test RL-MSAA

2. Radial-line microstrip array antenna (RL-MSAA) having a conical beam and its radiation properties:

(2-1) Basic configuration of the test antenna

As shown in Figure 1, the feeding system of the RL-MSAA is constructed with an one-layered radial line, and the linearly polarized microstrip antenna (LP-MSA) elements are arranged radially on a Teflon fiberglass substrate (ε_r=2.55, tan δ = 0.0018, h=1.2[mm]). Each

LP-MSA element in the array is coupled electromagnetically via a feeding pin to a radial line.

The edge terminal of the radial line is short-circuited, and input power fed by a center coaxial connector is radiated into the free space through the LP-MSA elements. The amplitude distribution of the array is set so it will be uniform by controlling the inserted length of the feeding pin (l_p). In order to obtain a conical beam, the phase distribution of the array is also set so as to be out of phase by controlling the rotational angle (θr) of each LP-MSA element.

(2-2) Radiation properties of the test antenna

A test RL-MSAA having a conical beam (number of rings in the radial direction M=4) was fabricated and tested at the SHF-band.

The geometrical parameters of the test antenna are shown in Figures 1 and 2. An example of the radiation pattern of the test antenna is shown in Figure 2. The conical beam pattern having a tilt angle θ_m of 10 [°] agreed well with the calculated value in the main beam region, as shown in the figure.

Figure 3 shows the input impedance characteristics of the test antenna. As can be seen in the figure, VSWR of the test antenna was below 2.0 over a broadband frequency region.

The relative gain characteristics of the antenna are shown in Figure 4. The variation of relative gain for the test antenna was suppressed to below 0.5 dB over a broadband frequency region. The experimental results showed that the test antenna performed well in terms of both radiation pattern and gain characteristics.

This type of array antenna is, therefore, considered to be a useful model for a conical beam planar array.

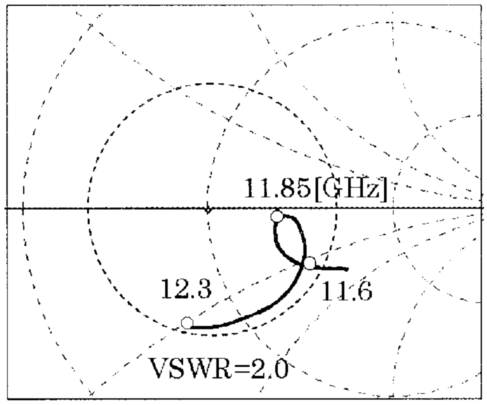


Fig.3 Impedance characteristic of a conical beam RL-MSAA

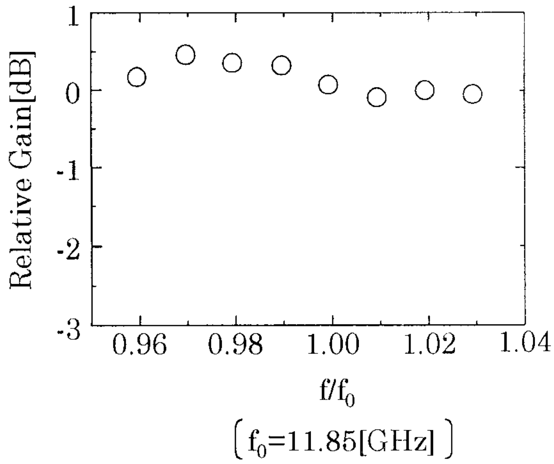
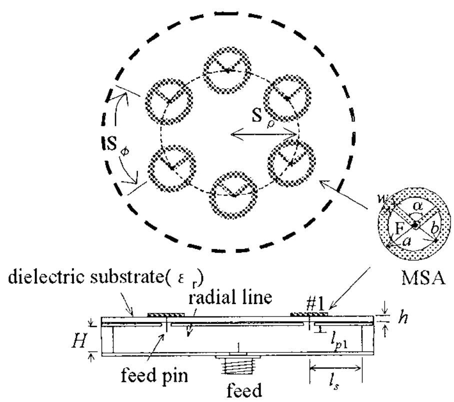


Fig.4 Frequency dependency of a relative gain

3. RL-MSAA composed of ring microstrip antenna (R-MSA) elements:

(3-1) Basic configuration of the test antenna

A ring-microstrip antenna (R-MSA) has been extensively studied due to its many advantages [4]-[6]. For example, it allows the reduction of antenna size.



(H=7.5,h=1.2,l_{p1}=5.5,a=3.5,b=2.13,w=0.6, unit [mm] , α=100° , S_ρ=0.75 λ_0)

Fig.5 Basic configuration of RL-MSAA composed of Ring-MSA elements

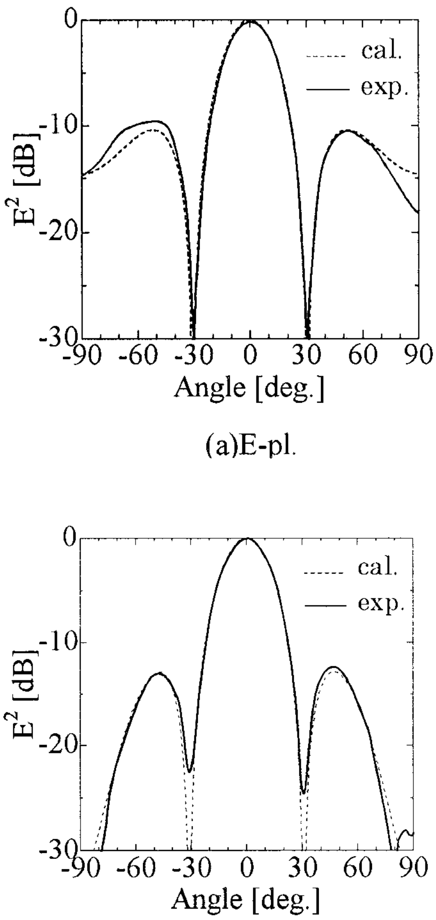
However, an R-MSA element excited by a dominant mode (TM_{110}) has high input impedance characteristics at the feeding point (F). This problem of a linearly polarized R - MSA (LP-R-MSA) element was solved by the introduction of the double-arms feeding technique, as proposed here. The profile of an LP-R-MSA element constructed by using this double-arms feeding technique is shown in Figure 5.

The input impedance of the LP-R-MSA element can be controlled by changing the angle (α) between the double feeding arms. Moreover, by using these double-arms feeding technique, the location of the feeding point (F) for each LP-R-MSA element can be set on the same circumference of a feeding circle, as shown in the figure.

The basic configuration of the test RL - MSAA composed of LP-R-MSA elements having double feeding arms is shown in Figure 5. As shown in this figure, the feeding system of the test antenna is also constructed with a radial line, and the LP - R - MSA elements are arranged on a Teflon fiberglass substrate, as described previously.

The amplitude and phase distributions for this test antenna are set so as to be in phase and uniform in order to obtain usual pencil beam radiation pattern.

The geometrical parameters of the test RL-MSAA are shown in Figures 5 and 6.



(a)E-pl.

(b)H-pl.

($M=1, S_p=0.75\lambda_0, l_{p1}=5.5$[mm]$, f_0=11.85$[GHz])

Fig.6 Radiation patterns of a RL-MSAA with Ring MSA elements

(3-2) Performances of the test antennas

A test RL-MSAA having a pencil beam (number of rings in the radial direction M=1) was fabricated and tested at the SHF-band. The radiation patterns on both E- and H-planes of the test antenna are shown in Figure 6.

Symmetrical radiation patterns were achieved on both E- and H-planes of the antenna. Moreover, the experimental radiation patterns of the antenna agreed well with the computed patterns, as shown in the figure. The gain characteristics of the antenna are also shown in Figure 7 as a function of frequency. As can be seen in this figure, the peak gain of the test antenna was about 14 dBi, and the variation in gain was below 1.0

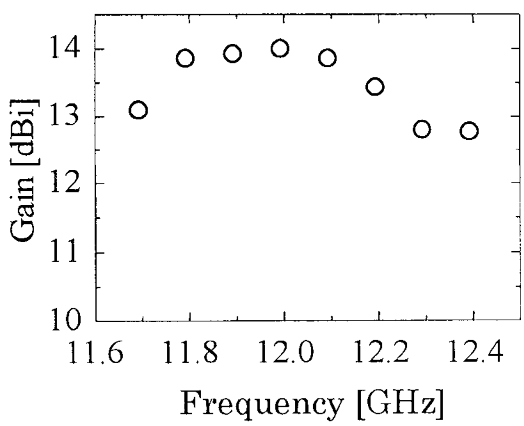


Fig.7 Frequency dependency of a test antenna

dB over a broadband frequency region.

Figure 8 shows the input impedance characteristics of the test antenna. As can be seen in this figure, VSWR of the test antenna was below 2.0 over a broadband frequency region.

4. Conclusion

A new type of linearly polarized microstrip array antenna fed by a radial line (LP- RL-MSAA) was proposed here. First, the radiation properties of this type of RL-MSAA having a conical beam were discussed. Then, the basic design technique for and the radiation properties of an RL-MSAA composed of R-MSA elements were discussed .

Experimental results showed that the test antennas performed well in terms of both radiation pattern and impedance characteristics.

Therefore, this type of RL-MSAA is considered to be a useful model for a conical or pencil beam planar array.

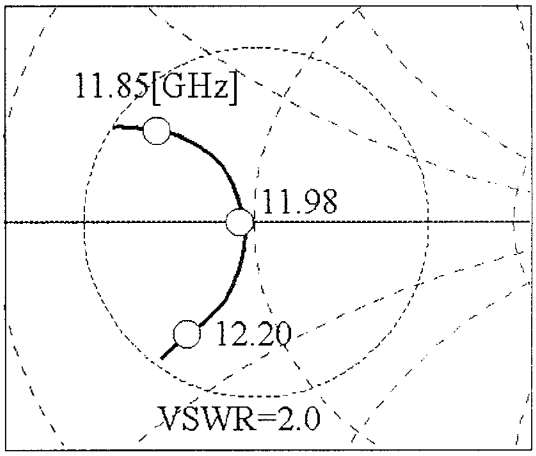


Fig.8 Impedance characteristic of a test antenna

[REFERENCES]

[1] J.Hirokawa, M.Ando and N.Goto:" An analysis of slot radiation on a parallel plate waveguide for radial line slot antenna", IEEE AP-S Symp. Digest, pp.1452-1455, 1989.

[2] H.Nakano and K.Hirose:" Experimental investigation of slot type spiral antenna fed by microstrip line", IEEE AP-S Symp. Digest, pp.1465-1468, 1989.

[3] O,Shibata, S.Saito and M.Haneishi:" Radiation properties of microstrip array antenna fed by radial-line", Electronics and Communications in Japan, Part 1, Vol.76, No.12, pp.93-100, 1993.

[4] W.C.Chew:" A broadband annular-ring microstrip antenna ", IEEE Trans. Antennas and Propagat.,Vol.AP-30, pp.918-922,1982.

[5] T.Tsutumi, S.Tuda and M.Haneishi: "Radiation properties of circularly polarized microstrip ring antenna excited by dominant mode", Proc. of ISAP '92,pp.805-808,1992.

[6] J.R.James ,P.S.Hall and C.Wood:" Microstrip antenna theory and design", IEE Electro-magnetic Wave Series 12, Peter Peregrinus Press, 1981.