Design of a Feed Network for Cosecant Squared Beam based on Suspended Stripline

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***Abstract*-For the cosecant square beam pattern application of an 8-element antenna array, we designed a 8-way non-equal power-divider based on Wilkinson scheme. An improved suspended stripline(SSL) structure is proposed and analyzed here, by using which as planar transmission line, the designed power-divider has good performance in the insertion-loss, and the excitations for output ports agree well with the simulated results.**

I. INTRODUCTION

The cosecant square beam pattern are very significant in some applications (e.g., radars, wireless communications). A cosecant squared beam antenna is required elevation pattern in order for a target approaching at a constant height to be detected with constant power. In order to achieve the pattern, we always need a complex feed network which is made up of some power divided. The Wilkinson power divider is usually used. There are many planar transmission lines applicable for this usage such as microstrip line, air stripline, suspended stripline and so on. But the insertion loss for microstrip line is always large especially for high-frequency applications，and the air stripline has some problem for machining which is not easier assembly than printed transmission lines[1]. The suspended stripline provide a way to reduce the attenuation in a microstrip line at higher frequencies and yet retain some of the features of the microstrip line such as the quasi-TEM nature of the dominant-mode propagation[2], so it can decrease propagation losses and approve the input matching efficiently. Therefore, it is of paramount importance to use SSL on low-loss and highly efficient antenna systems[3-5].

SSL is widely used in filters to ensure quality, but it is rarely applied in power-divide circuits. In this study, we use the suspended stripline as the transmission lines to achieve a non-equal amplitude and non-equal phase feed network. Additionally, by using scheme of Wilkinson power divider and quasi-coaxial structure, high isolation between the outputs is obtained.

II. ANALYSIS AND DESIGN PROCEDURE

Firstly, we give the objective pattern obtained by synthesized algorithm, then the structure of SSL is provided and analyzed, after which, the experiment results are shown and discussed.

A. Target pattern and power divide

We propose to design the input of an 8-element array with cosecant square beam pattern, as shown in Fig. 1. By using the technique for power pattern synthesis proposed by Orchard et al[6], the pattern of cosecant square and the pattern is calculated and the excitation current I_n of each element is shown in the table I.

In order to arrive the excitations of 8 ports, we use the structure as shown in Fig. 2, which is composed of 7 Wilkinson power dividers, and the magnitude of K_i (i=1~7) are depicted in table II.

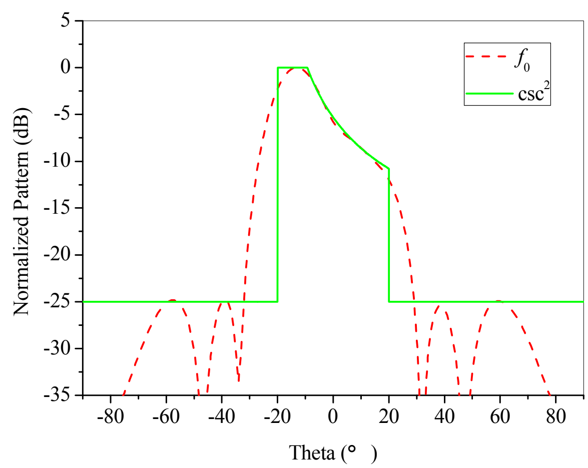


Figure 1. Target Pattern.

TABLE I
EXCITATION CURRENTS

Number	Normalized Amplitude	Phase(°)	Normalized Phase(°)
1	0.3213	129.9121	-45.5094
2	0.4336	175.4215	0
3	0.7539	-144.6394	-320.0609
4	1	-116.9071	-292.3287
5	0.7817	-93.7603	-269.1818
6	0.3201	-60.0165	-235.4381
7	0.3200	55.2841	-120.1375
8	0.3261	89.4477	-85.9738

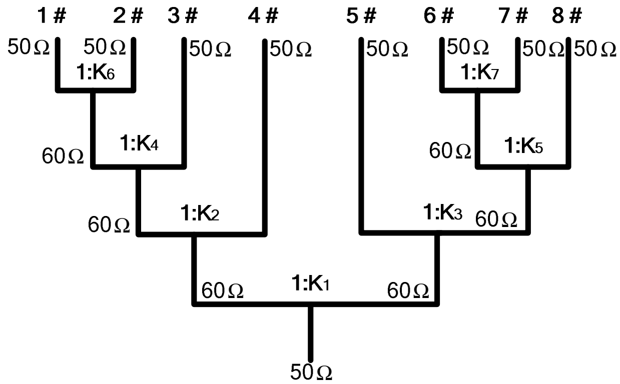


Figure 2. power divided.

TABLE II
POWER DIVIDED PLAN

K_1	K_2	K_3	K_4	K_5	K_6	K_7
0.7042	1.0786	0.7136	1.3969	0.7206	1.3493	0.9998

B. *The structure of suspended stripline*

Structure shown in Fig. 3 are applied for the SSL application, in upper and bottom layer, it is metal for ground of SSL, in medium layer, there is a the substrate with ε_r equal to 2.2, and the thickness is h_0=0.25*mm*, other dimensions are as: h_t=3*mm*, h_d=1.5*mm*, w_{air}=10mm. The width of the center conductor is *w*, which is considered due to different requirements of characteristic impedance.

It should be noted that, two sets of vias are designed in the two sides of the SSL structure, so the microwave energy is focused in the area including the middle substrate and upper and down air gap. Additionally, by observing the field distributions, we can find that the electric field mainly distributed between the center conductor and the outer ground, so the insertion loss for the transmission line can be lower than the traditional microstrip line and stripline.

III. EXPERIMENTAL RESULTS AND DISCUSSION

According to the specifications given in the previous section, the feed network was fabricated as shown in Fig. 4. We compared the normalized amplitude and the phase of 8-element input in Fig. 5, the number on transverse axis means the output port number. From the results, we can conclude that, excellent agreement can be obtained between the measured and simulated results. Besides, the insertion loss for the power divide can reached 0.22dB at the center frequency 5.6 GHz by simulation which have not plus the ports loss.

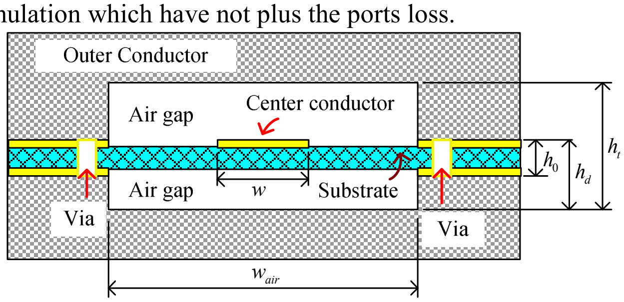


Figure 3. Geometry of the suspended stripline.

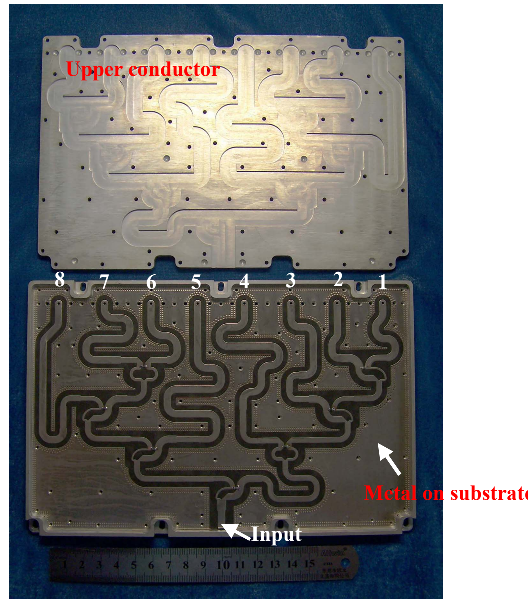
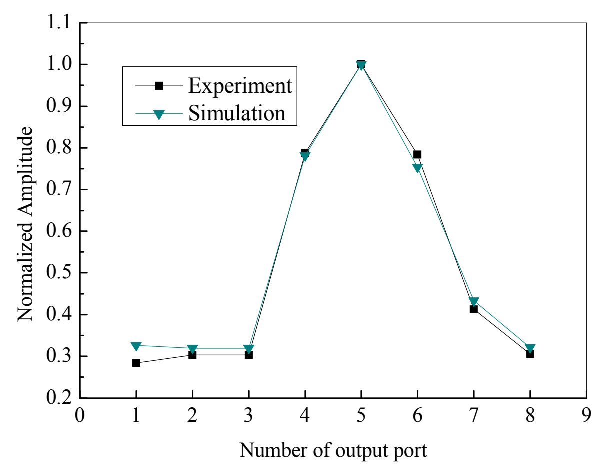
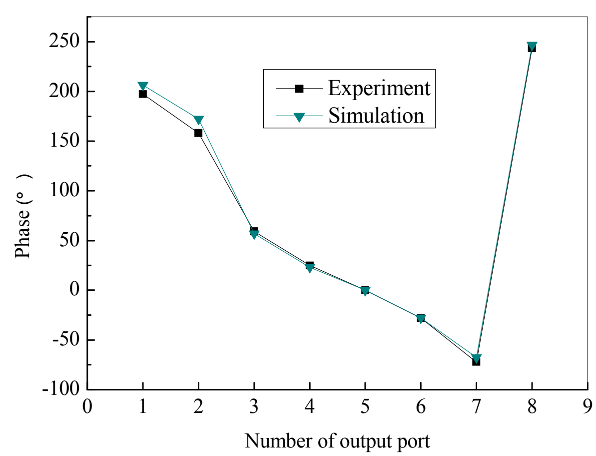


Figure 4. Photograph of the feed network.



(a)



(b)

Figure 5. The compare of the simulation and the experiment.

IV. CONCLUSION

An improved suspended stripline structure is applied in this paper for designing of low-loss non-equal power divider. The power-divider has one input and 8 non-equal output ports, Wilkinson power-divider is applied for each “T” junction, and by using such SSL, low insertion-loss results are obtained. Besides, not any tuning method is considered in this application, while excellent agreement between experiments and simulated results are obtained, which indicates that it is a good choice to design compact and low-loss power-divider based on this structure provided here. But we have not obtain the test insert loss, because the measure of the precision data is difficult and we can reference the simulation data.

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