PERFORMANCE COMPARISON OF FEEDING TECHNIQUES OF MICROSTRIP ANTENNA

Ch.Gayathri, I.Sumanth, K.Siva Ganesh, R.Vijaya Durga

(ECE, Lendi Institute of Engineering And Technology, India, Email:gayathri.chadalawada@gmail.com)

Abstract- In this paper we are comparing the performance of direct coupled feed antenna and parasitically coupled antenna. In direct feed antenna a four element microstrip antenna is directly fed through a collective feed network using T-junctions and quarter wave transformers while in a parasitic feed antenna the size of the feeding network constricts which results in a smaller size for the array. This paper also includes the radiation characteristics of the two different feeding techniques simulated using Ansoft HFSS 13.0 software. Both the feeding techniques radiate in broadside with same bandwidth characteristics and same gain. The return loss of parasitic feed antenna also decreases by the use simple feed network.

Keywords- Direct feed array, Microstrip antenna, Mutual coupling, Parasitic feed array, Return loss, Quarter wave transformers

INTRODUCTION

Microstrip antennas have a conducting patch printed on a microwave substrate, and have the features of low profile, light weight, easy fabrication. However, microstrip antennas naturally have a narrow bandwidth and bandwidth enhancement necessary for practical applications. These antennas have wide range of applications in wireless communications. To distribute the power from the transmitter a power network must be used. In this study, the direct feed approach uses multi-layer structure of feeding the antenna array. The use of quarter wave transformers and T-junctions delivers complexity to direct feed network which in turn increases the fabrication cost. Also the performance of the antenna may be affected by the air gap between the layers. So we go for the study of single-layer structure which is parasitically fed.

DESIGN AND OPTIMIZATION OF DIRECT FEED ANTENNA

In this study the direct feed antenna radiating in broadside direction measures 72.9mm× 93.4mm designed using Teflon substrate which is 1.57mm thick with a dielectric constant of 2.2. In direct feed array the elements at the top of the array are fed in opposite direction to the elements at the bottom with a phase delay at the center to compensate the difference. The l_6 should be extremely small so that the coupling between the lines is eliminated. The antenna is optimized to operate between 5.2GHz to 5.5GHz. This antenna's feed network occupies more space compared with the size of radiating elements. The ohmic losses corresponding to the feed network can be minimized if the feed network is eliminated.

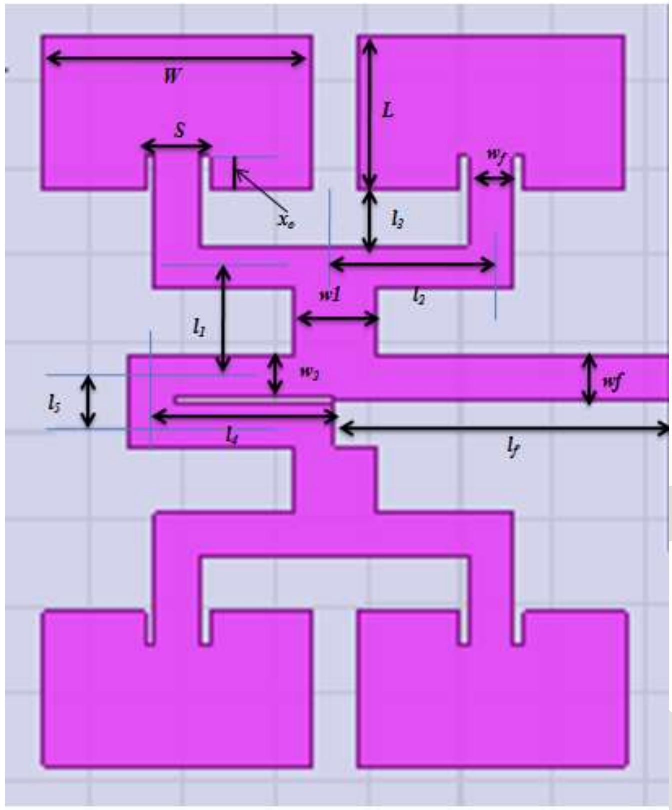

Fig.1 A four element direct feed array radiating in broadside direction.

Parameter	Value
w_f	4.87mm
l_f	25.0mm
x_o	3.86mm
S	7.01mm
W	29.02mm
L	17.60mm
l_1	12.39mm
l_2	17.06mm
l_3	6.47mm
l_4	9.84mm
l_5	20.86mm
l_6	10.00mm
w_1	8.7mm
w_2	7.39mm

Table1**:** Dimensions of four element direct feed array.

To avoid this complex feed network and to simplify the design and fabrication we go for parasitically coupled antenna The patch elements in this design are not attached to the microstrip feed but are excited through a capacitive gap. Here, for the parasitically coupled array we indicatively consider radiation in the broadside direction. The former goal is to inspect if this new design has any potential to compare its performance with that of direct feed antenna.

PERFORMANCE OF THE PARASITICALLY FED ANTENNA

A technique for improving the performance of the antenna using a single layer parasitic feed is shown. With respect to the mentioned antenna in fig.2, a parasitically fed array is optimized for the design frequency band of 3 to 7Ghz. The dimensional parameters of parasitically feed antenna are given in Table2 which measures about 71.0mm X 55.3 mm.

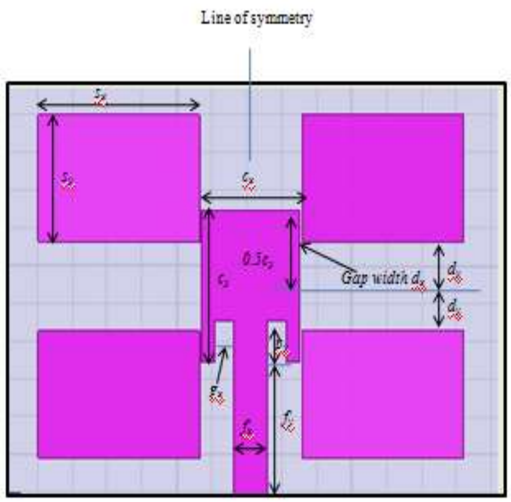

Fig.2. Parasitically fed array configuration.

Parameter	Value	Parameter	Value
c_x	14.14mm	s_x	23.11mm
c_y	20.01mm	s_y	16.93mm
f_x	4.89mm	d_x	0.25mm
p_y	17.50mm	d_y	5.86mm
p_y	5.50mm	d_z	2.64mm

Table2: Dimensions of parasitic feed array

COMPARISON OF DIRECT FEED AND PARASITIC FEED ARRAY ANTENNA

In this section, the performance of the parasitically fed array is compared with that of direct feed antenna array. The antenna is characterized by antenna gain, impedance matching, radiation pattern and efficiency. The return losses, VSWR, radiation patterns, are shown in Figs. 3.1(b), 3.2(b), 3.3(b), respectively. In majority of the bandwidths the efficiency of parasitically fed antenna slightly better than that of direct feed antenna.

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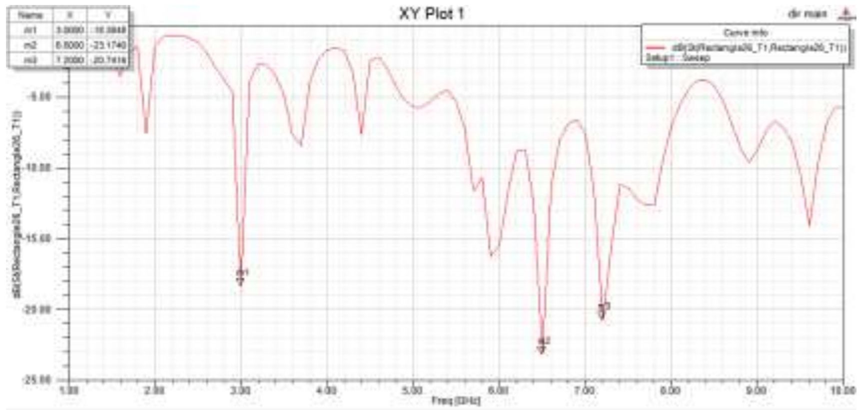

Fig. 3.1(a) reflection coefficient versus frequency of direct feed antenna

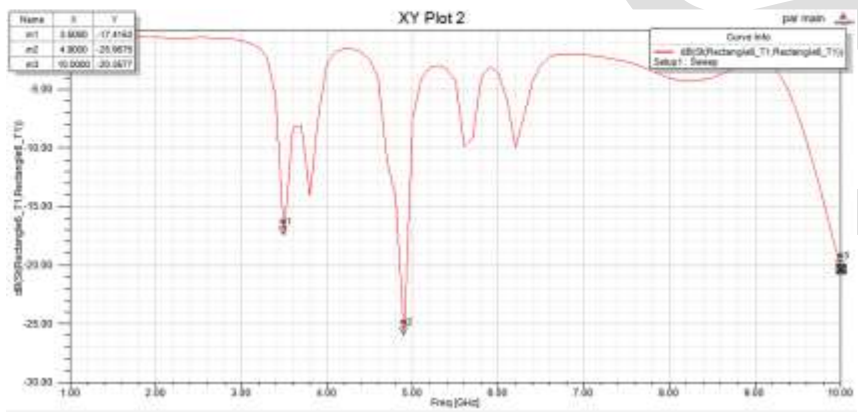

Fig. 3.1(b) reflection coefficient versus frequency of parasitic feed antenna

In parasitic feed antenna the amount of waves reflecting back to the source decreases which in turn increases the overall gain of the antenna

$$\text{Return loss} = -20\log\frac{Za-Zo}{Za+Zo}$$

Where *Za* is the antenna input impedance and *Zo* is the measurement characteristic impedance.

The VSWR, which can derive from the level of reflected and incident waves, is also an indication of how closely or efficiently anantenna terminal input impedance is matched to the characteristic impedance of the transmission line. Most wireless system operates at 50 Ohm impedance. A VSWR of 1 indicates an antenna impedance of exactly 50 ohms.

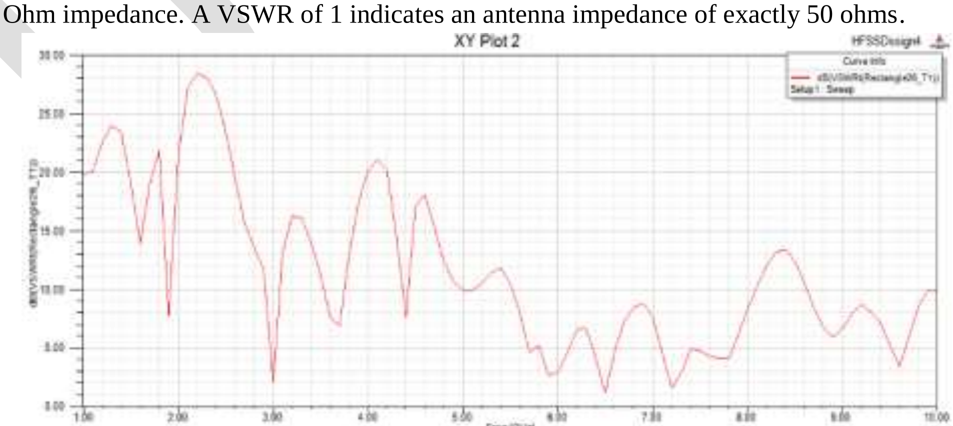

Fig. 3.2(a) VSWR of direct feed antenna

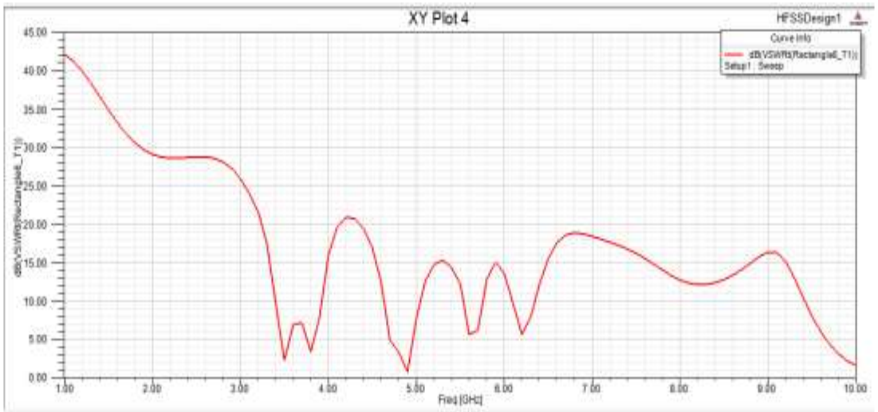

Fig. 3.2(b) VSWR of parasitic feed antenna

The radiation pattern of both the antennas that are compared is shown below. That is, the antenna's pattern describes how the antenna radiates energy out into space (or how it receives energy).

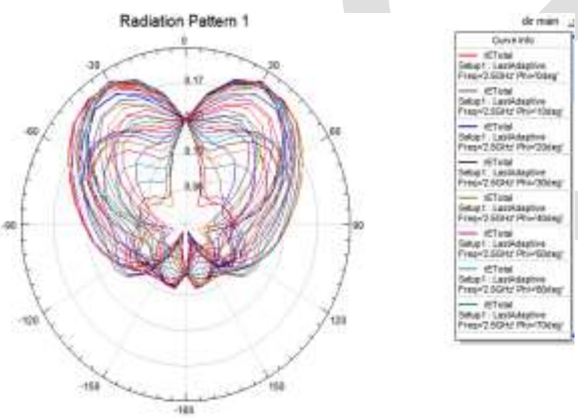

Fig. 3.3(a) radiation pattern of direct feed antenna

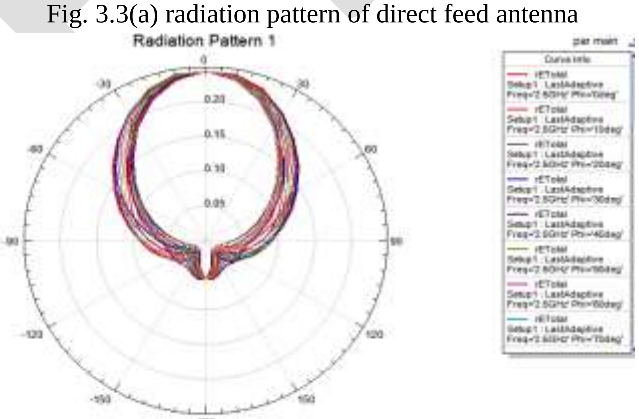

Fig. 3.3(b) radiation pattern of parasitic feed antenna

An antenna radiates energy in all directions, at least to some extent, so the antenna pattern is actually three-dimensional. The antenna patterns (azimuth and elevation plane patterns) are frequently shown as plots in polar coordinates. This gives the viewer the ability to easily visualize how the antenna radiates in all directions

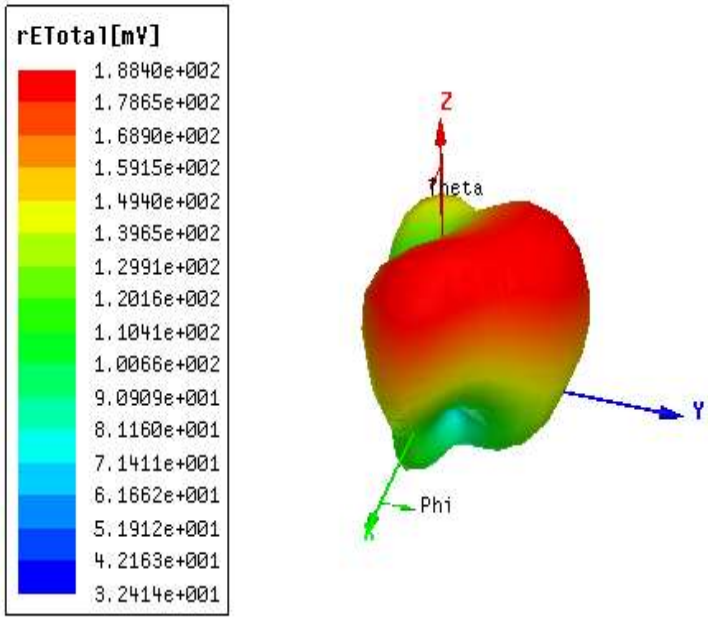

Fig.3.4(a). 3D Gain of direct feed antenna

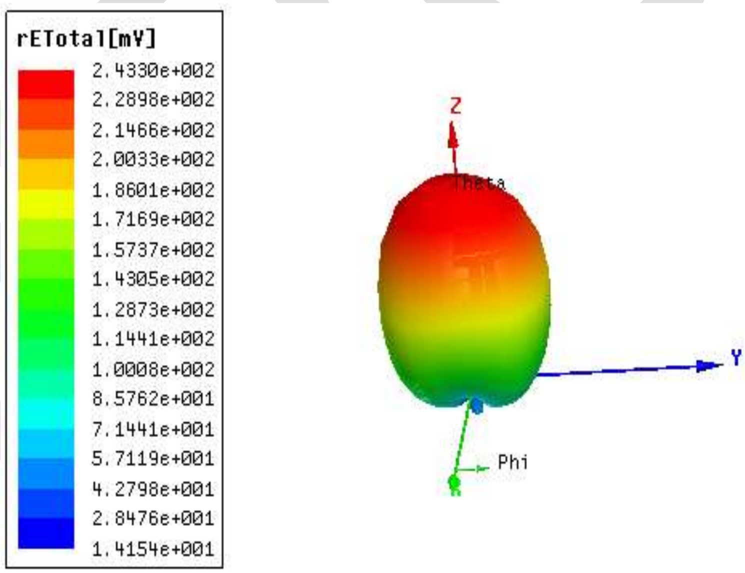

Fig.3.4(b) 3D Gain of parasitic feed antenna

The bandwidth, efficiency and broadside gain of parasitic feed antenna in general are similar to those of the direct fed antenna array. The performance of the antenna is summarized in Table3. The efficiency of parasitic feed antenna is slightly better than that of the direct fed array.

Parameter	Frequency (GHz)	Return loss (dB)	VSWR
Direct feed	3	-16.5	1.352
	6.5	-23.1	1.151
	7.2	-21	1.196
Parasitic feed	3.5	-17.5	1.308
	4.9	-26	1.106
	10	-20	1.222

Table3: Comparison of feeding techniques

OTHER COMPARISONS

As the feeding techniques are different further comparisons should be performed to justify the parasitic feeding approach.

COMPARISION BASED ON PATCH SIZEAND SEPERATION

In this subsection, the radiation pattern of parasitic feeding antenna is compared with that of the direct feeding approach using the same element size and spacing. The feeding network feeds the elements in the same phase for broadside radiation, as well as for impedance matching. The patch size and element spacing of direct feed antenna is the same as those of parasitic feed.

A LIST OF COMPARISIONS

In this subsection comparison of bandwidth, gain, efficiency of single layer and multi layered structure antennas are compared. A list of comparisons is given in Table.3.The bandwidth, efficiency and broadside gain of parasitic antenna are similar to those of the direct feed antenna array. However the size and substrate of both the antennas is different. Recent research [2]–[4] has used multi-layer structures in constructing broadside arrays that result in a smaller size or higher gain, but the approach causes an increase in complexity in terms of both production and in the integration of other circuit components on the same printed circuit board. On Teflon substrate the gain of the multi-layer array (11.1 dBi) [3] is similar to that of single layer arrays, but the efficiency of the multilayer is (>91%) is higher than that of the single layer. Whereas, the multi-layer array on the LTCC substrate [4] has a smaller gain (7.17dBi) with a total of eight elements as this array is made for 10mm^2 MMIC chip. In this illustration, the parasitic feeding techniques can be used to simplify the feeding network, resulting in smaller size and similar performance while the structure is maintained as a single layer.

CONCLUSION

The comparison of two feeding techniques to a four element microstrip single layer patch array is done in this study. The first approach was a directly fed array with T-junctions and quarter waveforms and the second was a parasitically fed array. As a result of simple feeding system, the size of parasitically fed array decreases and the maximum obtained efficiency is higher. The other characteristics of the parasitically fed array such as
impedance, bandwidth and maximum broadside gain, are similar to those of the direct fed array.

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