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Research Article

Multifunctional shared aperture antenna for L and S band

Jonny Dhiman[1], Sunil Kumar Khah[1*]

(1) Microwave Antenna Lab, Jaypee University of Information Technology, Himachal Pradesh, India

Abstract

A novel concept of shared aperture to design microstrip patch antenna in the L and S Band. The structure is designed using simulation with FR-4 substrate of dielectric constant 4.3. Sharing of the aperture is used for two antennas using multifunctionality in two different frequencies. One of the designed antennas resonates at 1.945 GHz (for L-Band) and other at 3.255 GHz (for S-Band) with return loss value of -17.56 dB and -34.41 dB respectively. Overall gain obtained are 5.4 dBi and 5.6 dBi for L and S Band respectively with VSWR<2. These antennas can be designed for multiple applications.

Keywords: Microstrip Patch Antenna; Bandwidth; VSWR; Impedance.

1 Introduction

Future need for multiple applications requires sharing of microstrip antennas for multiple frequencies of operation at the same time with some specific scanning requirements. Aperture sharing can be done in different ways such as time multiplexing, partitioning into sub-apertures or entire aperture performing multiple functions simultaneously. Many applications would benefit from a compact shared aperture antenna design. Such as by decreasing the coupling between two antennas or using different designs etc. It would benefit in reducing the overall size, power requirement and cost also. Sharing of the aperture was recently used for the design of various antennas such as for L and C bands [1-3] and for C and X band[4-5] etc depends upon applications.

In the present communication, a new antenna consisting of two dollar shapes is designed, for frequency of operation in L and S Band by doing the multifunctionality of the antennas. Here multifunctionality is done via sharing of aperture for the enhancement of bandwidth as well as reducing overall size. The whole design is analysed by CST (Computer Simulation Technology) -microwave studio using FR-4 as a substrate with dielectric constant of 4.3. Patch and ground surfaces are designed using copper element with dielectric conductivity of 5.96 e^{+007}. The measured results meet the requirement of a frequency of operation in two bands. The S-parameter, bandwidth, VSWR, directivity and far field parameters were calculated for the same and are discussed further.

* Corresponding Author. Email address: sunil_khah@rediffmail.com

2 Antenna Design

The basic design consist of two dollar shapes placed parallel to each other horizontally. The distance between two shapes directly affects the coupling between them, and the appropriate gap is used for minimum coupling. The width for strips of dollar shapes are a and 2.5a mm for small and large shape respectively, and outer circle are a and a+0.5 mm for small and large dollar shapes respectively. The width of the vertical strip used at the center of both design is 0.5 mm and 1.5 mm for small and large designs. The width to length ratio of substrate is of 1:2. Feed location 1 and feed location 2 are as shown in figure 1 for both antennas.

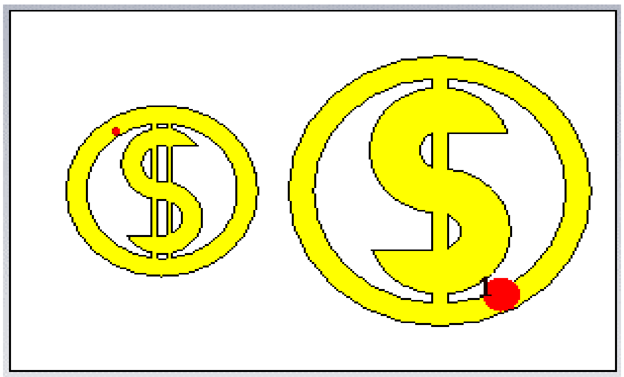

Figure 1: Top view of Basic configuration of patch antenna

The basic design consisting of two shapes is shown in figure 1. Here large sized dollar shape is operating in L-band and small sized is in S-band. Various results as obtained from antenna are shown below.

3 Results and Discussion

3.1. Return Loss

The scattering parameter measured in the form of scattering matrix which shows the return loss of -17.56 dB and -34.41 dB for the frequency of operation of 1.945 GHz (L-band) and 3.255 GHz (S-band) as shown in figure 2 and figure 3. Bandwidth percentage is also calculated for the same. Figure 4 also shows the coupling between two antennas is less than -10 dB. Bandwidth percentage as calculated for L-band is 2.43% and for S-band is 2.422%.

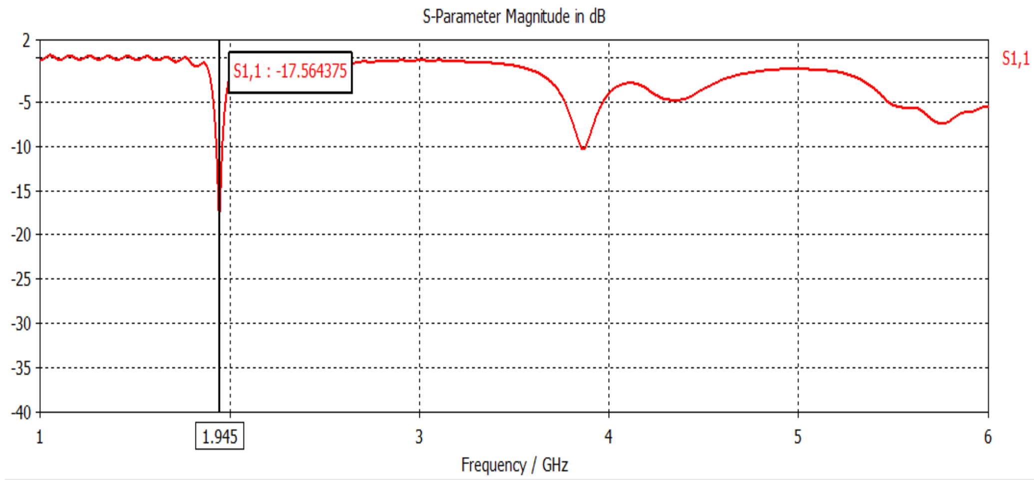

Figure 2: S11 parameter for antenna 1

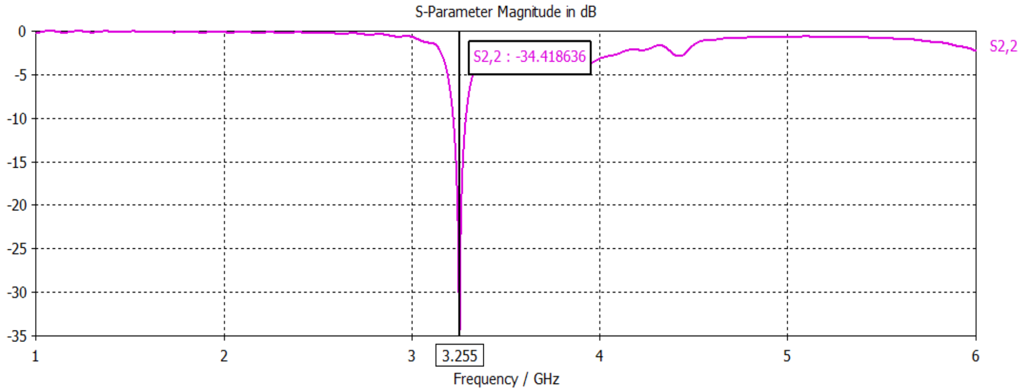

Figure 3: S22 parameter for antenna 2

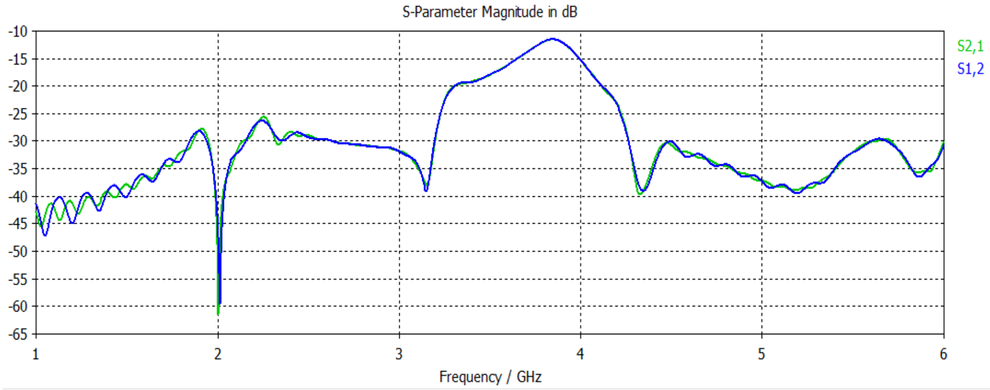

Figure 4: S12 and S21 parameters for two antennas.

Voltage Standing Wave Ratio (VSWR) as obtained from calculated results by using the formula given below, and as obtained from simulated results are shown in table 1.

Table 1: VSWR value for two bands

Band Selected	VSWR	
	Calculated	Simulated
L- Band	1.305:1	1.3051:1
S-Band	1.039:1	1.0387:1

$$VSWR= \frac{1+10^{\frac{-RL}{20}}}{1-10^{\frac{-RL}{20}}} \quad (3.1)$$

$$\text{Also, } RL= -\ 20\log\left[\frac{VSWR-1}{VSWR+1}\right] \quad (3.2)$$

3.2. Z-matrix (Impedance)

The impedance value is also obtained for both ports, the real part for the same are shown in figure 5. Maximum impedance value for the first antenna is around 500 ohm and for 2nd antenna is 230 ohm, while input impedance for feed location 1 is 42.9639 and that of feed location 2 is 48.7732. Also the impedance between two antennas is a maximum of 75 ohm. This is dependent upon the coupling between two antennas.

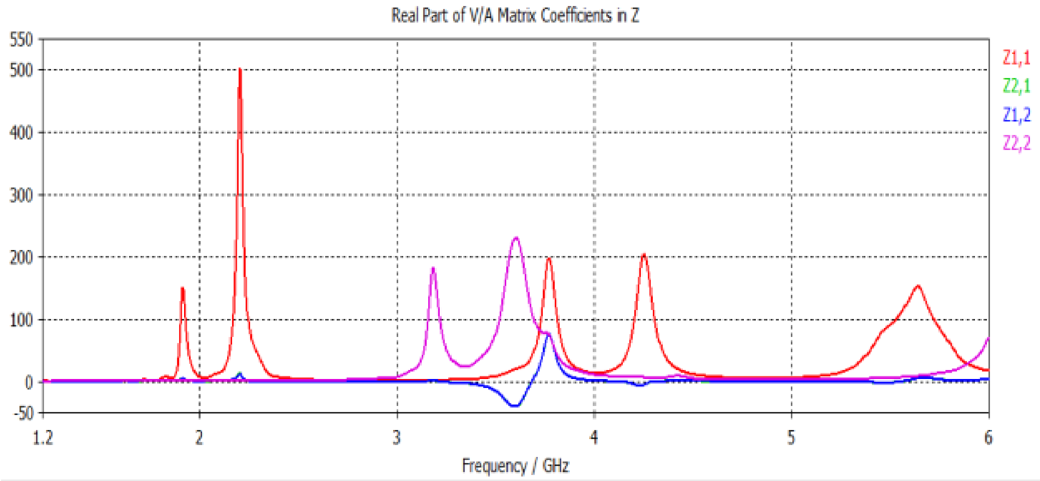

Figure 5: Real part of Z-matrix

3.3. Far field and Gain

The polar plot of the radiation pattern is shown in fig 6 for phi=90 between Theta/degree vs dBi. At resonant frequency of 1.945 GHz (L-band) the antenna directivity as obtained in simulation is 5.4 dBi in the main lobe direction of 3.0 degrees. Also in S-band with resonant frequency of 3.255 GHz simulated directivity is 5.6 dBi with main lobe direction in 0.0 degrees.

3.4. Smith Chart

The VSWR circle is drawn for both ports as shown in figure 8. Various parameters are calculated theortically as well as from smith chart, which are also shown in table 2.

VSWR curve is drwan from normalized load impedance values as calculated using formula given below.

$$z = \frac{Z_L}{Z_0} \tag{3.3}$$

where, Z= normalized load impedance

Z_L= load impedance

Z_0= System impedance (50 ohm)

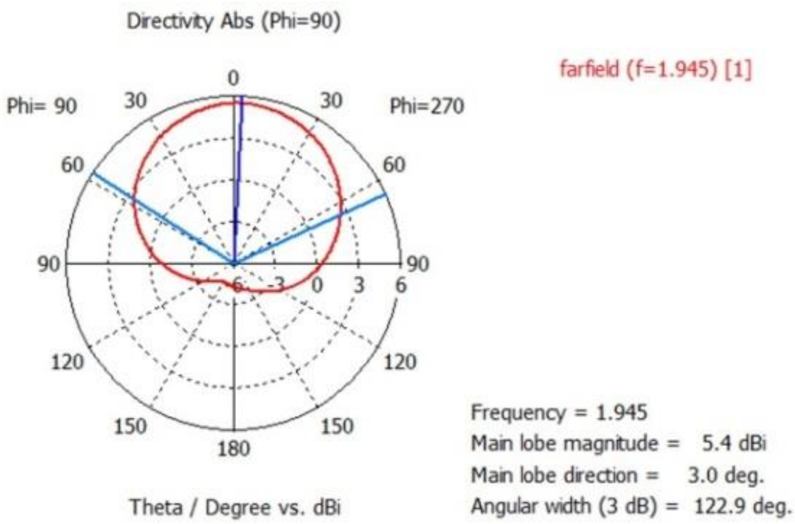

Figure 6: Far field for antenna 1

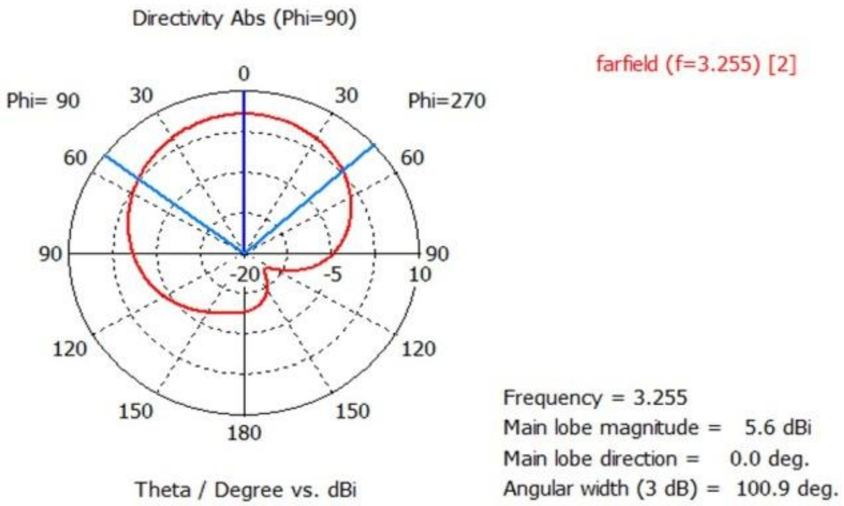

Figure 7: Far field for antenna 2

The normalized input impedance, admittance (calculated from the reverse of impedance), VSWR and return loss values as obtained from figure 8 for antenna 1 and 2 and are shown in table 2. The admittance can also be calculated from smith chart by extending the impedance radius through the center of the VSWR circle until it intersects the circle again. The VSWR value is found by transferring the impedance radius of the VSWR circle to the radial scale as shown in figure 8.

Table 2: paramteres obtained from smith chart.

S.No	Parameter name	Port 1	Port 2
1	Impedance	0.8592-0.204j	0.97546+0.037j
2.	Admittance	1.10177+0.2615j	1.02368-0.389j
3.	VSWR	1.28:1	1.05:1
4.	Return Loss	17 dB	30dB

4 Conclusion

This paper represents the new design consisting of dollar shapes. The designed antenna has been successfully verified for L and S band. The Return Loss,VSWR, input impedance and far field have been succesfully verified for the same. VSWR value obtained from the results is less than 2 and also directivity as obtained from results is above 5dBi. VSWR obatined from simulated results is also equal to the results obtained from calculated as well as smith chart results.

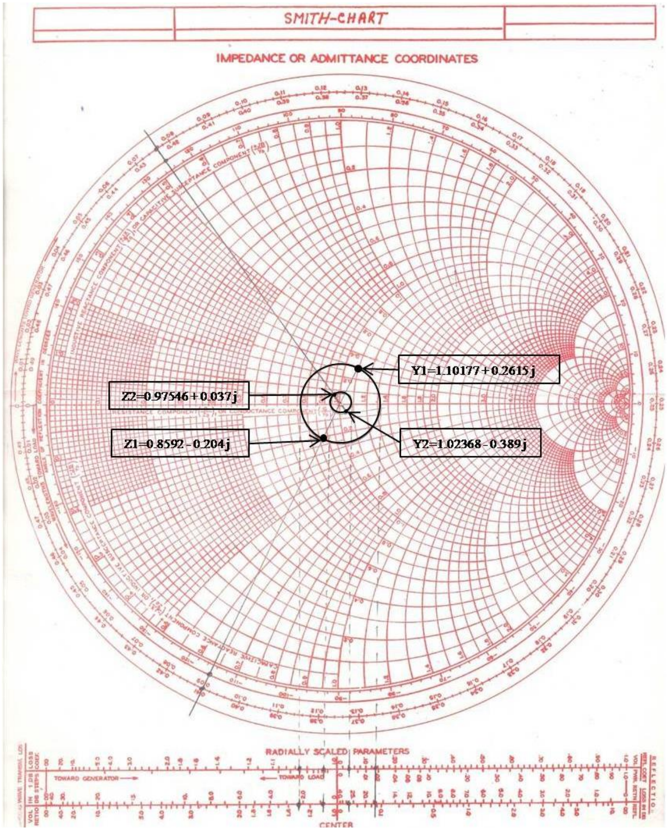

Figure 8: smith chart

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