

Dual Frequency Microstrip Antenna Fed by Electromagnetic Coupling For Satellite Application

Indra Surjati, Yuli Kurnia Ningsih, and Benny Reinmart

Electrical Engineering Department
Faculty of Industrial Technology Universitas Trisakti
Jl. Kyai Tapa No.1 Grogol, Jakarta 11440, Indonesia

Abstrak

Teknik yang paling banyak digunakan untuk menghasilkan dua frekuensi yang berbeda adalah dengan menambahkan beban pada patch antena mikrostrip. Pada makalah ini dilakukan penelitian untuk mendisain suatu patch antena mikrostrip yang bekerja pada dua frekuensi yang berbeda tanpa menambahkan beban pada patch antena. Patch antena mikrostrip tersebut dicatu menggunakan saluran mikrostrip dan ke dua frekuensi tersebut dapat dibangkitkan dengan mengontrol panjang dari patch antena dan juga mengatur posisi dan panjang dari saluran pencatu mikrostrip. Antena ini di disain untuk satelit yang bekerja pada frekuensi 3,702 GHz sampai 4,198 GHz untuk downlink dan frekuensi 5,927 GHz sampai 6,423 GHz untuk uplink. Dari hasil penelitian, frekuensi pertama dari satelit bekerja pada 3,9 GHz dengan return loss -27,84 dB, VSWR 1,085 dengan bandwidth sebesar 416 MHz atau sekitar 83,8%. Sedangkan frekuensi kedua dari satelit bekerja pada 6 GHz dengan return loss -18,43 dB, VSWR 1,272 dan bandwidth sebesar 385 MHz atau sekitar 77,6%.

Kata kunci: Dua frekuensi, antena mikrostrip bentuk segiempat, elektromagnetik kopling, satelit.

Abstract

Recently, the most popular technique for obtaining dual frequency operation is by introducing a reactive loading to a single patch antenna. This paper proposed a design of dual frequency operation microstrip antenna without using a reactive loading to a single patch antenna. The proposed antenna fed by microstrip feed line and the two resonant frequencies can be generated by controlling the length of the patch antenna and also by adjusting the position and the length of the microstrip feed line. The proposed antenna was designed to be able to work on two different frequencies for Satellite application which is at 3.702 GHz up to 4.198 GHz for downlink frequency and at 5.927 GHz up to 6.423 GHz for uplink frequency. The results shown that the first frequency is at 3.9 GHz with return loss of -27.84 dB, VSWR 1.085 and impedance bandwidth 416 MHz or about 83.8%. The second frequency is at 6 GHz with return loss of -18.43 dB, VSWR 1.272 and impedance bandwidth 385 MHz or about 77.6%.

Keywords: Dual frequency, rectangular microstrip antenna, electromagnetic coupling, satellite.

1. Introduction

Modern communication system such as Satellite, Radar and Global Position System (GPS) often require dual frequency operation. When the system require at two frequencies too far apart, dual frequency patch antenna may avoid the use of two different antennas.

Basically, dual frequency patch antenna will be divided as orthogonal mode dual frequency patch antenna, multi patch dual frequency antenna, and reactively loaded dual frequency patch antenna [1]. For the orthogonal mode dual frequency patch antenna, an interesting features of these antenna is their capability of simultaneous matching of the input impedance at two frequencies with single feed structure. At multi patch dual frequency antenna, the dual frequency behavior is obtained by means of multiple radiating elements. And for obtaining dual frequency using reactively loaded patch antenna is to introduce a reactive loading to a single patch. Recently, the most popular technique for obtaining dual frequency is by introducing a reactive loading to a single patch [2][3][4][5].

Feeding system can be divided into two types such as probe feed or direct coupling and electromagnetic coupling. Microstrip line and coplanar waveguide are two types of transmission line usually used as a feeding line for the electromagnetic coupling [6]. The use of electromagnetically coupled is to avoid the disadvantages of probe mechanism [6].

This paper therefore proposed a new design for achieving dual frequency operation with out adding a reactive loading to a single patch. The dual frequency operation can be generated by controlling the patch lengt and adjusted the microstrip line postion and also the length of microstrip line. Details of the proposed antenna design and experimental results of the obtained dual frequency performances are presented.

2. Antenna Design

Geometry of the proposed antenna feed by microstrip line can be shown in Figure 1 (a) and (b). The proposed antenna is constructed on two layers with the same dielectric substrate. The patch antenna is fabricated on Taconic TLY 5 and the substrate having a relative permittivity (ϵ_r) = 2.20, substrate of thickness (h) = 1.58 mm and loss tangent ($\tan\delta$) = 0.0009.

The proposed antenna works at frequency 5.1 GHz. The length (L) and width (W) of the proposed antenna are given by :

$$(1) \quad L_{\text{eff}} = \frac{c}{2f_0\sqrt{\epsilon_r}}$$

$$W = \frac{c}{2f_0\sqrt{\frac{\epsilon_r+1}{2}}} \quad (2)$$

From (1) and (2), the length of the antenna (L) is 20 mm and the width (W) is 23 mm. The transmission line width (w) is given by :

$$B = \frac{60\pi^2}{Z_0\sqrt{\epsilon_r}} \quad (3)$$

$$w = \frac{2h}{\pi} \left\{ B - 1 - \ln(2B - 1) + \frac{\epsilon_r - 1}{2\epsilon_r} \left[\ln(B - 1) + 0,39 - \frac{0,61}{\epsilon_r} \right] \right\} \quad (4)$$

From (3) and (4), the width of the transmission line is 4.8 mm. The patch antenna is fabricated on the first layer and the microstrip feed line is realized on the second layer. Therefore the microstrip line feeding system is electromagnetically coupled to the patch.

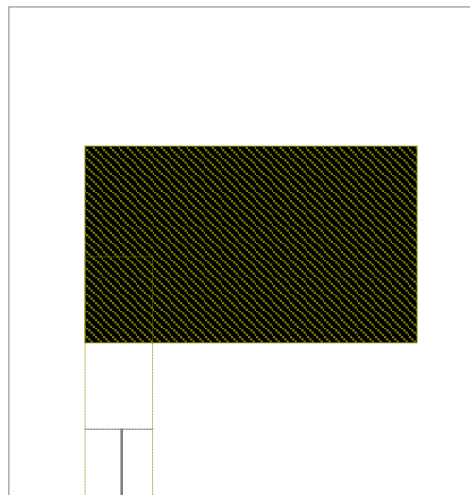


Figure 1(a) Top view of the proposed antenna

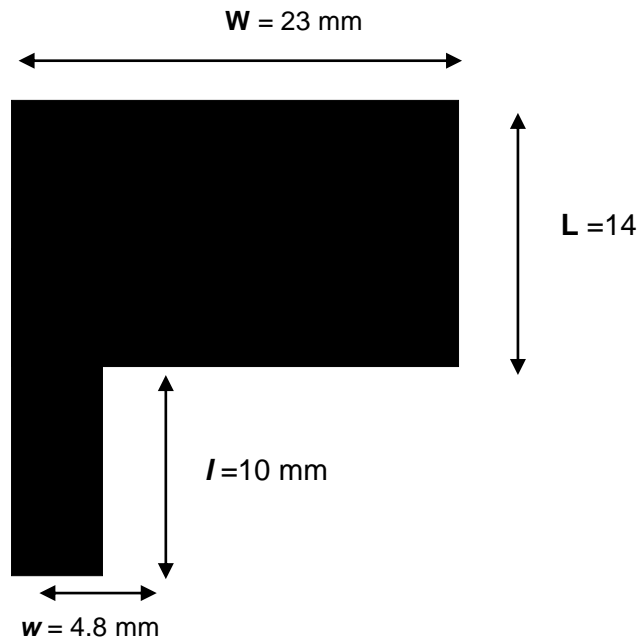


Figure 1(b) Dimension of the proposed antenna

3. Experimental Results

The proposed antenna was designed for Palapa C2 Satellite that can be worked at two different frequencies at 3.702 GHz up to 4.198 GHz for downlink frequency and at 5.927 GHz up to 6.423 GHz for uplink frequency.

The transmission line is at the center of the width of the patch antenna as seen in Figure 2. With the dimension of the proposed antenna and the length of transmission line at 15.2 mm, return loss of -8.832 dB and VSWR 2.229 can be achieved as seen in Figure 3 (a) and (b).

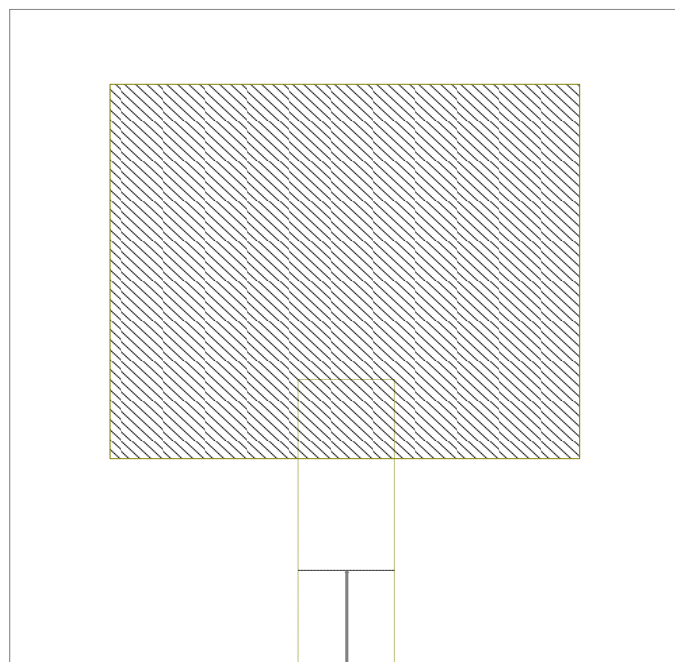


Figure 2 The proposed antenna with the length of the transmission line at 15.2 mm

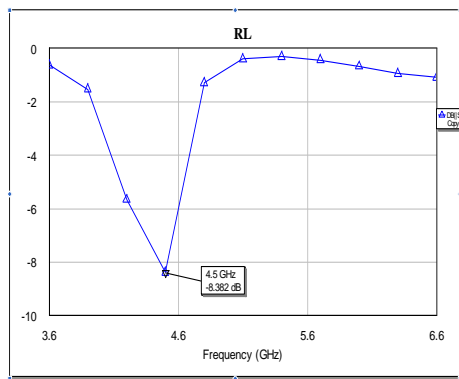


Figure3 (a) The proposed antenna with antenna

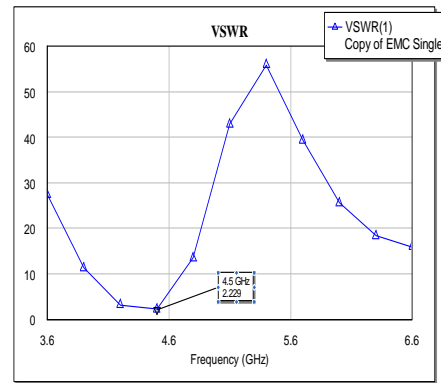


Figure3 (b) The proposed

return loss of -8.832 dB

with VSWR 2.229

From Figure 3 (a) and (b), the standard minimum of return loss and VSWR from the proposed antenna to create dual frequency operation cannot be reached and the antenna cannot work at frequency 5.1 GHz. After the length of the proposed antenna reduced to 17 mm, a shifted frequency will be occurred and the antenna can be able to work at frequency 5.1 GHz. Return loss of -17.68 dB and VSWR 1.303 can be achieved as seen in Figure 4 (a) and (b).

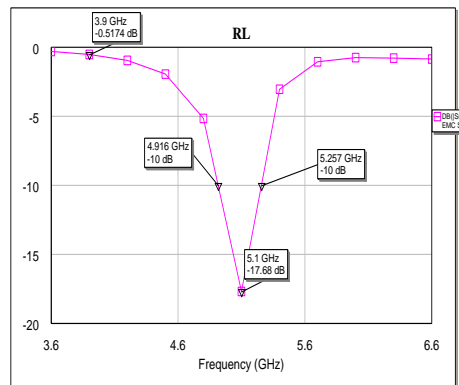


Figure 4 (a) Proposed antenna at frequency 5.1 GHz with return loss -17.68 dB

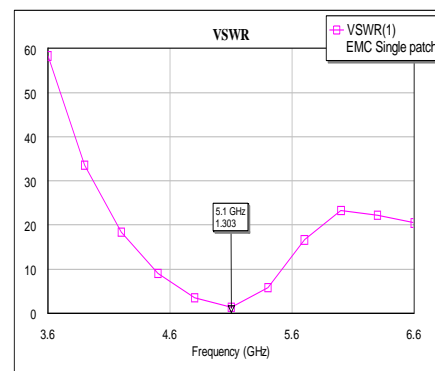


Figure 4 (b) Proposed antenna at 5.1 GHz with VSWR 1.303

According to the results at Figure 4 (a) and (b), with this position we can use it as a reference to the next iteration.

To create dual frequency operation for the proposed antenna is by setting the length of the feeding line as seen in Table 1 and Figure 5 (a) and (b) and then adjusting the feed line position of the proposed antenna. Return loss of -15.56 dB and VSWR 1.4 at frequency 3.9 GHz and return loss of -25.76 dB with VSWR 1.108 at frequency 5.1 GHz can be achieved as seen in Table 2 and Figure 6 (a) and (b).

Table 1 Return loss and VSWR after adjusting the length of the feeding line

Length of the feeding line (mm)	3.9 GHz		5.1 GHz	
	Return loss (dB)	VSWR	Return loss (dB)	VSWR
15.8	-11.37	1.717	-23.39	1.061
16.6	-13.76	1.717	-30.6	1.061
17.2	-15.56	1.717	-25.76	1.061

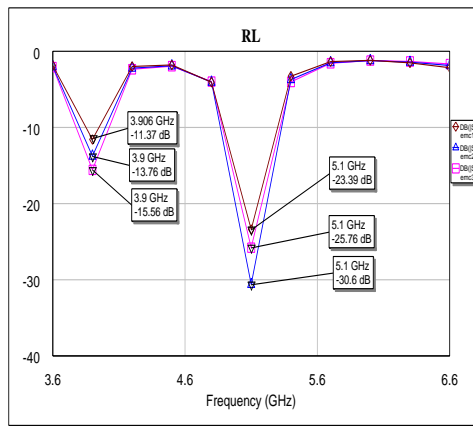


Figure 5 (a)
Return loss after adjusting the length of the feeding line

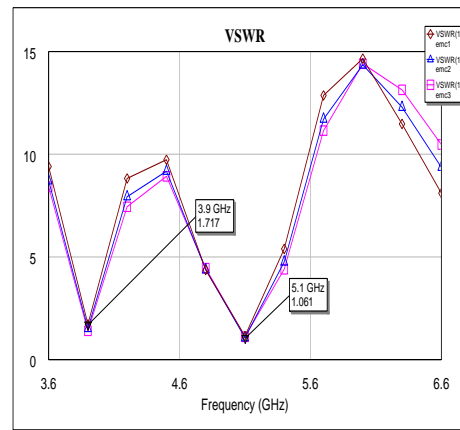


Figure 5 (b) VSWR after adjusting the length of the feeding line

Table 2 Return loss value after adjusting the feed line position

Parameter	Feed position shifted as far as 3.2 mm		Feed position shifted as far as 6.4 mm		Feed position shifted as far as 9.4mm	
Return Loss (dB)	-2.61	-18.64	-7.719	-21.31	-15.56	-25.76
VSWR	-	1.265	2.397	1.188	1.4	1.108
Bandwidth (MHz)	NR	358	NR	393	250	435
Center Frequency (GHz)	3.9	5.1	3.9	5.1	3.9	5.1

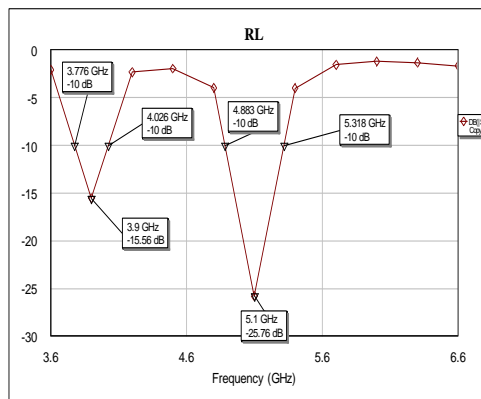


Figure 6 (a)
Return loss against frequency after adjusting the feed position

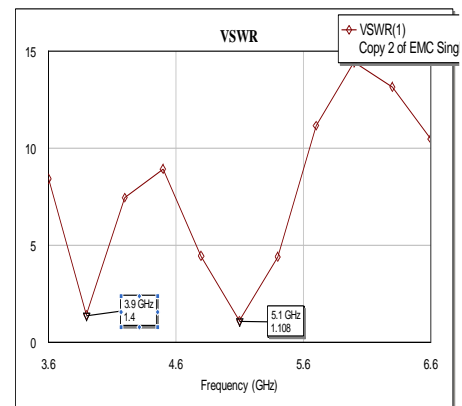


Figure 6 (b) VSWR against frequency after adjusting the feed position

After adjusting the feed line position and the length of the feeding line, the proposed antenna already working at two different frequencies. But the upper frequency did not meet the specified frequency of the proposed antenna. By controlling the length of patch antenna, we can fulfill the needed frequency at 6 GHz as seen in Table 3 and Figure 7 (a) and (b).

Table 3 Return loss value after controlling the length of the patch antenna

Parameter	Reduced length patch antenna 1 mm		Reduced length patch antenna 2 mm		Reduced length patch antenna 3 mm	
Return Loss (dB)	-17.16	-30.47	-20.69	- 25.6	-27.84	-18.43
VSWR	1.322	1.06	1.204	1.111	1.085	1.272
Bandwidth (MHz)	286	471	345	449	416	385
Center Frequency (GHz)	3.9	5.4	3.9	5.7	3.9	6
Bandwidth Expected (MHz)	496	496	496	496	496	496

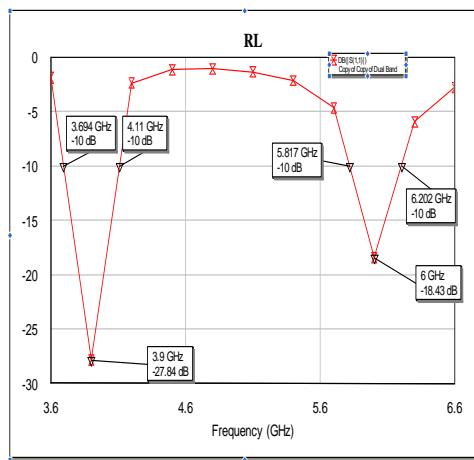


Figure 7 (a)
Return loss against frequency after controlling the length patch antenna

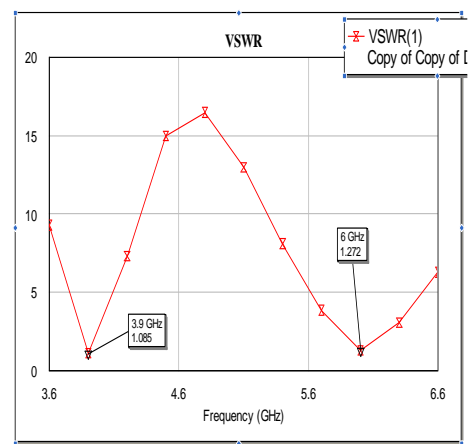


Figure 7 (b) VSWR against frequency after controlling the length patch antenna

This paper shown that to create dual frequency operation can be done without using a reactive loading to a single patch. The proposed antenna can be generated by adjusting the feed position and controlling the length patch of the antenna and the results parameters can be seen in Table 4.

Table 4 Parameters result of the proposed antenna

Parameter	First Design	Characterization feed point		Characterization length patch antenna	
Center Frequency (GHz)	5.1	3.9	5.1	3.9	6
Return Loss (dB)	-17.68	-15.56	-25.76	-27.84	- 18.43
VSWR	1.303	1.4	1.108	1.085	1.272
Bandwidth (MHz)	-	250	435	416	385

The proposed antenna cannot be able to require the range frequency in amount of 496 GHz as expected from the frequency range of the uplink at 3.702 GHz up to 4.198 GHz and downlink at 5.927 GHz up to 6.423 GHz. Table 4 shown that impedance bandwidth for the first frequency is 416 MHz or about 83.8% and the second frequency is 385 MHz or about 77.6%.

Figure 8 shown the input impedance and Figure 9 shown the broadside radiation pattern of the proposed antenna.

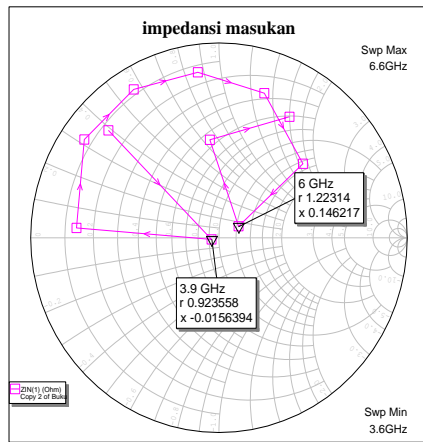


Figure 8
Input impedance of the proposed
Antenna

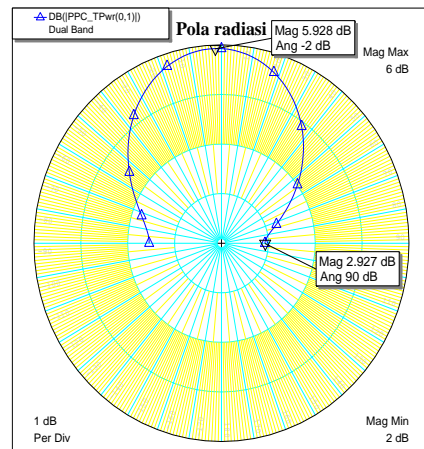


Figure 9 Radiation pattern of the proposed
antenna

4. Conclusion

A novel configuration to excite dual frequency operation for Satellite application using microstrip line has been experimentally studied. It is shown that the two frequencies can be easily controlled by varying the length patch antenna and adjusting the feed position and also the length of the microstrip feed line. It is observed that return loss of -27.84 dB with VSWR 1.085 can be achieved for the first frequency at 3.9 GHz and the impedance bandwidth is about 416 MHz or 83.8%. For the second frequency is at 6 GHz with return loss of -18.43 dB and VSWR 1.272 has the impedance bandwidth of 385 MHz or 77.6%. Therefore the proposed antenna is applicable as a new candidate for dual frequency antenna microstrip for Satellite application.

References

- [1] Maci, S and G.B.Gentili, "Dual Frequency Patch Antennas", *IEEE Antennas and Propagation Magazine*, Vol.39, No.6, December 1997
- [2] Surjati, Indra, "Dual Frequency Operation Triangular Microstrip Antenna Using A Pair Of Slit", *11th Asia Pasific Conference on Communications*, Perth, Western Austarlia, Oktober 2005
- [3] Surjati, I, Yuli KN and Bramantyo S, "Dual Band Microstrip Antenna Using Slot Fed by Electromagnetic Coupling", *Proceeding Quality of Reaserch*, University of Indonesia, August, 2009
- [4] Roy,J.S, et al, "New Dual Frequency Microstrip Antenna for Wireless Communication", *Romanian Journal of Information Science and Technology*, Volume 10, Number 1, 2007
- [5] El-Tager, A.M, et al, "A Circularly Polarized Dual Frequency Square Patch Antenna for TT&C Satellite Application", *Progress in Electromagnetic Reaserch Symposium*, Beijing, China, March, 2009
- [6] Rahardjo,E.T, "Studies On The Microstrip Antennas Fed By Electromagnetic Coupling", Doctoral Thesis, Saitama University, 1996