Tunable Dual Frequency Microstrip Antenna using Adjustable Stub-Loading for Wireless Communication

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I. Introduction

Recently, many dual frequency microstrip antenna designs have been excited by using slot-loading technique [1] – [3]. These antennas configurations, however, are difficult to be tuned once the antenna has been fabricated. In several applications, there might be requirement to tune the operating frequency of the antenna once it is fabricated. Another technique to achieve the excitation dual frequency microstrip antenna operation is by embedding a stub-loading to the microstrip antenna element [4].

In this paper, therefore, a novel technique to excite dual frequency microstrip antenna utilizing the embedded an adjustable stub-loading is proposed. Using this antenna configuration it is possible to design a tunable dual frequency microstrip antenna though the antenna has been fabricated. The stub-loading is placed at the other side of feeding line. The tunable dual frequency is then can easily be tuned by sliding length of the stub-loading. To obtain the operating frequencies of interest several dimensions of the stub-loading were simulated using Microwave Office™ where the Method of Moment (MoM) is used for computation.

The antenna is designed to be operated at the L and S-band as this frequency range is used in many wireless communication systems.

II. Antenna Design

The top view of the proposed antenna configuration is shown in Fig. 1. The antenna system was designed using a single layer dielectric substrate in which use GML 1032 substrate having relative dielectric permittivity of ε_r = 3.2, loss tangent of $tan\delta$ = 0.0025 and dielectric substrate thickness of h = 1.52 mm. The antenna was designed to operate at the dominant frequency mode of 2.4 GHz. The antenna dimension was calculated using the cavity model [5], where the length of antenna is 3.39 cm and the width is 4.30 cm.

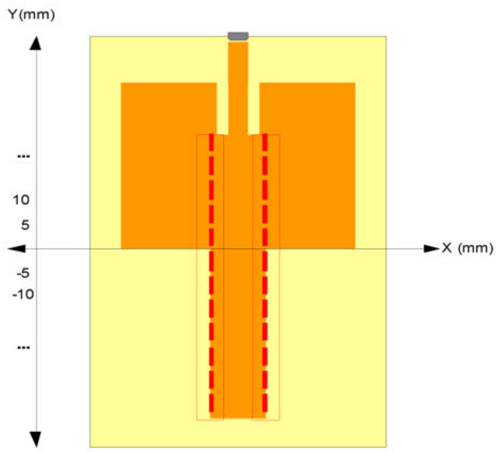

Fig. 1. The top view of the dual frequency microstrip antenna configuration.

The second operating frequency was determined by embedding stub-loading which is placed at the opposite site of feeding line. Various stub-loading dimensions have been simulated in which their dimensions are chosen from ($0.5\lambda_d$ x 4) mm to ($0.5\lambda_d$ x 12) mm. The return loss of each stub-loading was characterized by placing the edge of stub-loading -3 mm from the edge of antenna element, making

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gap, and then slide the stub-loading up in the +*y* direction up to + 23 mm.

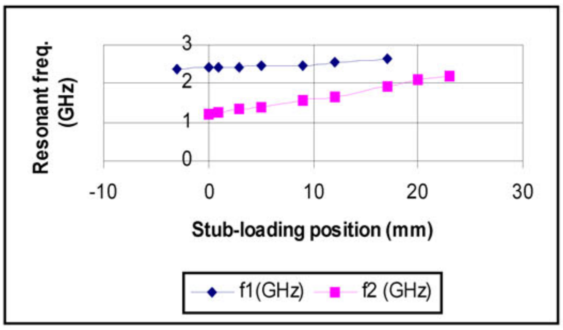
To obtain impedance matching of the antenna system with measurement equipment, a 50 Ω input impedance matching of the antenna is determined by putting inset line as already well known. The length of the inset line is 1.05 cm and the gap width is 0.2 cm.

III. Results and Discussion

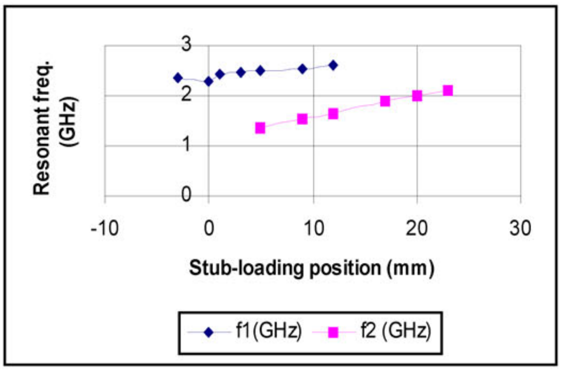
The simulation has been carried out using various stub-loading dimensions as aforementioned. It was revealed from the simulation that the optimum one is the stub -loading having the dimension of ($0.5\lambda_d$ x 4) mm. Using this stub-loading, the dual frequencies can be excited from 2.47 GHz to 2.86 GHz as the first resonant frequencies, f_1, and from 1.22 GHz to 2.11 GHz as the second resonant frequencies, f_2. Those frequencies have been generated by varying stub-loading position. The generated frequencies as a function of stub line loading positions are depicted in Fig. 2 (a).

For comparison, other two stub-loading dimensions such as ($0.5\lambda_d$ x 8) mm and ($0.5\lambda_d$ x 12) mm are also displayed in Fig. 2 (b) and Fig. 2 (c), respectively. It is observed from the figures that the dual frequency excited only in the short stub length position.

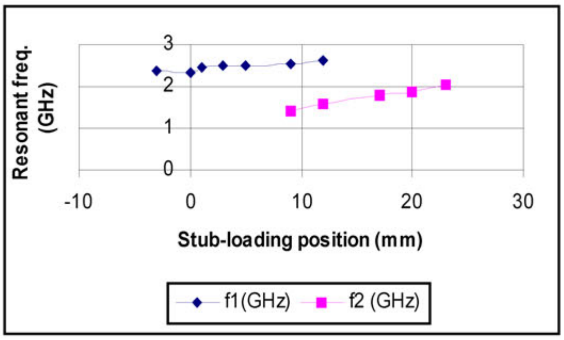
Furthermore, the antenna system was fabricated and measured to confirm with the simulation one. From the experimental results it is shown that the excited dual frequencies were in excellent agreements with the simulation one. The comparison between simulation and experiment values of the ratio of the dual frequencies is given in Fig. 3, for stub loading with dimension of ($0.5\lambda_d$ x 4) mm.



(a)



(b)



(c)

Fig. 2. Resonant frequencies as a function of load position for various stub loading dimensions: (a) ($0.5\lambda_d$ x 4) mm, (b) ($0.5\lambda_d$ x 8) mm, (c) ($0.5\lambda_d$ x 12) mm.

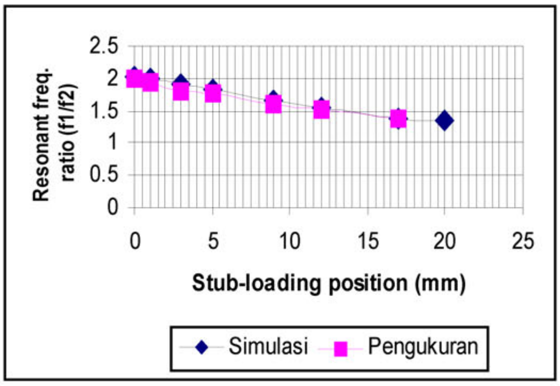


Fig. 3. Comparison between simulation and measurement results of resonant frequency ratio for stub loading ($0,5\lambda_d$ x 4) mm.

The return loss characteristics of the antenna system have also been measured as depicted in Fig. 4. In this figure, it is shown the resonant frequency for stub-loading ($0.5\lambda_d$ x 4) mm with position 3 mm. The return loss of -20.6 dB and -20.4 dB were achieved for resonant frequencies of 2.44 GHz and 1.35 GHz, respectively.

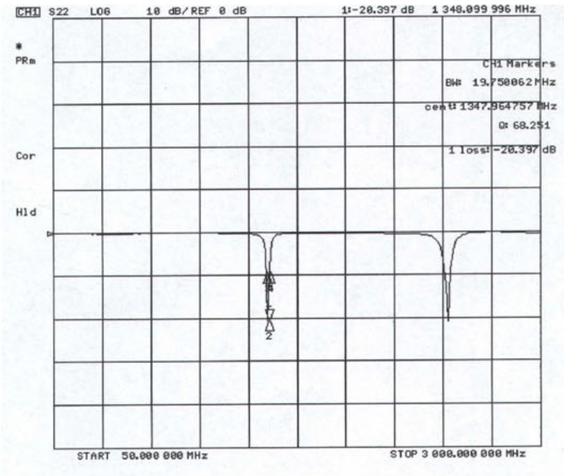
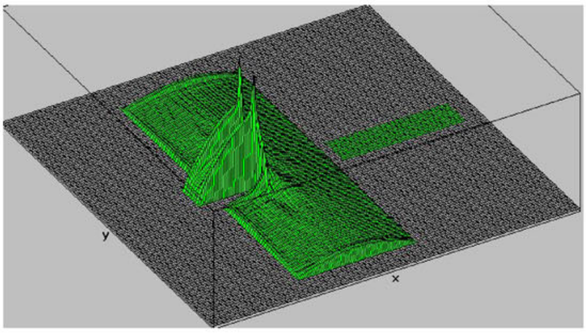


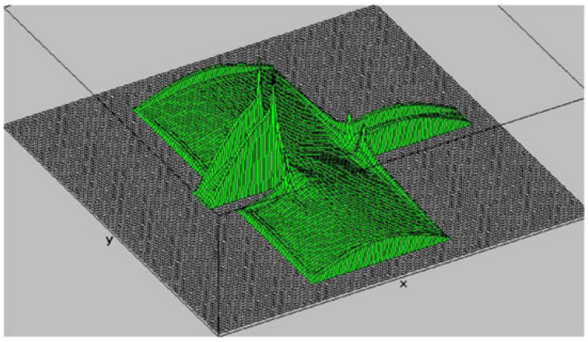
Fig. 4. Return loss characteristic of dual frequency microstrip antenna for stub loading dimension ($0.5\lambda_d$ x 4) mm at a position of 3 mm.

From simulation study it is shown that the dual frequency is not generated for stub-loading which is capacitively coupled or at the position –3 mm, as shown in Fig. 5 (a). It is shown that the dominant mode is excited but there is no second resonant frequency excited. However the dual frequency can be generated as the position of stub loading is slide up as shown in Fig. 5 (b). The dominant mode is excited at the antenna patch while the second frequency is excited at the stub-loading. These current distributions were generated using Mstrip40 [6] where this software is based on Method of Moment.

The radiation pattern of the dual frequency microstrip antenna has also been carried out in this study. The measurement results of the radiation pattern are shown in Fig. 6 for the dual frequency microstrip antenna using stub-loading with the dimension of ($0.5\lambda_d$ x 4) mm at position of 9 mm. It is observed that the E-plane pattern is in broadside direction for both frequencies.



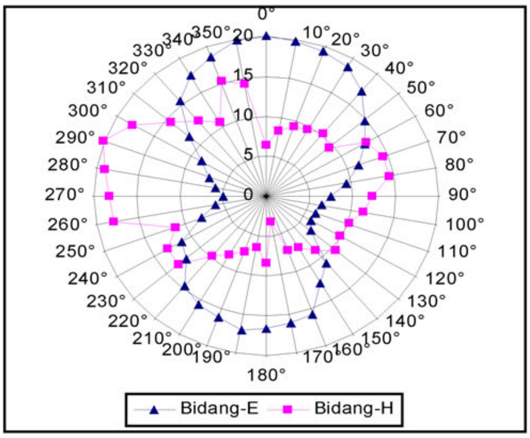
(a)



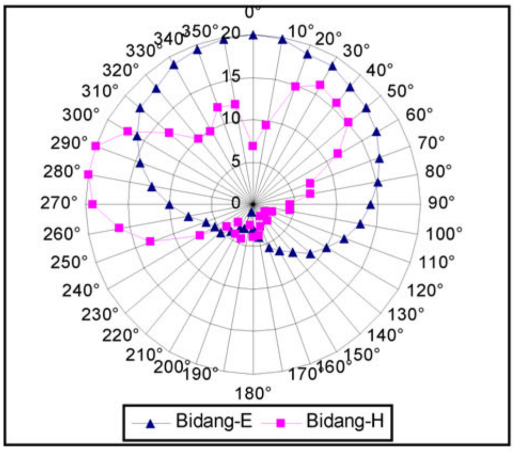
(b)

Fig. 5. Current distribution of the proposed dual frequency microstrip antenna. Using stub loading with the dimension of ($0.5\lambda_d$ x 4) mm at position: (a) -3 mm (offline), (b) 9 mm

Furthermore, we also measured the antenna gain which is showed 4.49 dB and 4.48 dB at both frequencies of 2.44 GHz and 1.35 GHz, respectively. The frequency ratio between the two frequencies is 2 for the lowest frequency and 1.4 for the highest frequency.



(a)



(b)

Fig. 6. Radiation pattern of the dual frequency microstrip antenna using stub loading with the dimension of ($0.5\lambda_d$ x 4) mm at position of 9 mm: (a) frequency 2.44 GHz, (b) frequency 1.35 GHz.

IV. Conclusion

The dual frequency microstrip antenna using adjustable stub-loading have been studied both for simulation and experimentation. It is shown that their radiation characteristics are well behaved. In addition, by sliding the stub-loading, the dual frequency can easily be varied in the design frequency range. Therefore the proposed antenna will be useful to be implemented in practice.

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