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DUAL BAND DIPOLE ANTENNA WITH HARMONIC SUPPRESSION CAPABILITY

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ABSTRACT

This paper presents the design of a dual band dipole antenna with harmonic suppression capability. The proposed antenna consists of a single parasitic element and it operates at frequencies 0.8 GHz, 2.4 GHz, and 4 GHz. The third operating frequency of 4 GHz has been suppressed and this suppression leads to the elimination of noise interference. Thus the final design becomes a dual band (0.8 GHz and 2.4 GHz) dipole antenna which is free from noise interference. The predicted and measured results show that the antenna operates in dual-band with a return loss of -30 dB and -21.3 dB at 0.8 GHz and 2.4GHz respectively. This antenna is fabricated on a FR-4 substrate having 4.3 permittivity and a thickness of 1.6 mm. The simulated and the measured results validate the performance of our proposed antenna and a good agreement is found between the results.

Keywords: dual band dipole, suppression capability, parasitic element.

INTRODUCTION

Nowadays wireless communication systems have become very popular and have been developing rapidly over the last decade. Moreover, high data rates and reduced sized antennas are also in high demand with the advent of new developments. For example; dual-band WLAN systems with IEEE 802.11a/b/g standards have become more attractive. Thus a single antenna with multiple characteristics is highly desirable if it can operate in these bands (Rahman *et al.*, 2013).

Printed monopole antenna (PMA) with microstrip feed line is an important class of broadband antennas. Because of the stripped ground plane on the backside of substrate, these types of antennas provide large bandwidths. The dual band operation can be achieved for these antennas by creating two independent resonating paths in the form of protruding stub in the ground plane and radiating element printed on the top of the substrate. The major challenge in designing these antennas is the tuning of protruding stub in the ground plane with the radiating element of the substrate to provide the dual-band operation in applications such as RFID, WLAN, etc. These antennas are lightweight, have a low profile, are less fragile and can be easily integrated with the handheld devices (Rajib Jana, 2014).

It is also known that the multi-band antennas are often used in satellite systems to reduce the number of on-board and ground antennas. These multi-band antennas can be operated for several applications with the same radiating element. However, the performance of such antenna structures is traditionally limited by the arrangement of their constitutive radiating elements, especially when agility in terms of frequency allocation is required. Moreover, the multiplicity of frequency bands dedicated to radio-navigation or broadcasting applications reveal the need for multiband antennas having flexible and low costfeatures offering the desired performance equivalent to those obtained from mono-application/single-band antennas (Jabbar *et al.*, 2013).

The printed dipole antennas are widely used in commercial and military applications because they bear low profile, small size, light weight, low cost, and are easy to integrate with other electronics (Rao *et al.*, 2013). In all of the commercial and military applications, if dual band operations are desired, separate antennas are designed for each frequency band. However, it is becoming more important to use such systems in one setting, and therefore it is desirable to design a single antenna that covers both the frequency bands (Qian *et al.*, 1998).

On the other hand, the wireless devices that operate in multiband frequencies, with smaller size, are now used by almost everyone. With these wireless devices, the dual-band dipole antennas have been in use vigorously since they are simple, easy to design and fabricate. But the higher order mode (HOM) in these multiband antennas is one of the problems that exist when designing such type of antennas. In microwave and radio-frequency engineering, a stub or a resonant stub is a length of transmission line or waveguide that is connected at one end only. Due to these stubs, some harmonies or higher-order modes appear as return loss. Hence, to overcome the problem of higher order modes, the harmonic suppressed dipole antenna is useful. These stubs reject the undesired frequencies and get only the required frequency. Thus the antenna having stubs has thecapability to suppress the unwanted harmon is or frequencies (Kaneda *et al.*, 2002).

This paper presents the design of a dipole antenna with harmonic suppression capability. By suppressing the harmonic frequency, the noise interference is eliminated, making it a dual-band dipole antenna. There are three sections in the paper. First section discusses the antenna design and section 2 describes its configuration. Section three presents the simulated and measured results. Finally the paper ends with a conclusion.

ANTENNA DESIGN

This section describes the proposed dipole antenna. The antenna is designed with a single parasitic

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element (with and without stubs). Figure-1 shows the geometry of the dual band antenna with the single parasitic element (stubs). As shown in the Figure, the top side of the antenna has a transmission line, single stub, and an arm consisting of parasitic element which is on the center of the arm. Furthermore, the back side of antenna consists of a linear tapered balun and a single stub and the parasitic element is placed on the arm.

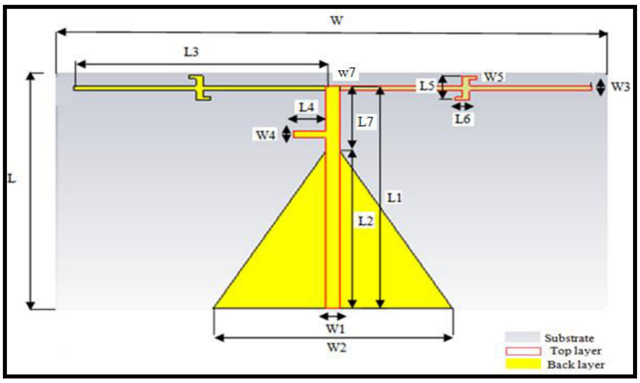

Figure-1. Geometry of a dipole antenna with the single parasitic element (SPE).

The propagation of electromagnetic field is usually considered in free space, where it travels at the speed of light C (3x 〖10〗 ^8m/s). λ, Lambda is the wavelength, expressed in meters (James, 1991) (Sawadi and Amar, 2012). The Formula to determine the width and length of a dipole antenna arms are shown in equations (1) and (2). Ratio for w/d where w, is the width and h (1.6mm)), hence thickness:

$$\frac{W}{h} = \frac{8e^{A}}{e^{2A} - 2} \tag{1}$$

Where A:

$$A = \frac{Z_o}{60}\sqrt{\frac{\varepsilon r+1}{2}} + \frac{\varepsilon r-1}{\varepsilon r+1}\left(0.23 + \frac{0.11}{\varepsilon r}\right)$$

The Effective dielectric, ε(eff):

$$= \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[\frac{1}{\sqrt{1+12[\frac{h}{w}]}}\right]$$

Then

$$\lambda_g = \frac{c}{f\sqrt{\varepsilon eff}}$$

λ = wavelength

C = velocity of light

F = frequency

Then the length is calculated as in equation (2)

$$L = \frac{\lambda_g}{4} \tag{2}$$

Based on the above equations, the calculated parameters are summarized in Table-1.

Table-1. Calculated parameters of dipole antenna.

Name of elements	**Dimensions** (mm)	
Substrate	L	72
	W	152
Transmission line	L1	68
	W1	4
Tapered Balun	L2	26
	W2	26
Arms	L3	69.5
	W3	1.5
Stubs	L4	9
	W4	2
Parasitic element	L5	6
	W5	1
	L6	2
Strip	L7	17
	W7	4

SIMULATED RESULTS

The proposed antenna with and without stubs was simulated in the CST Microwave Studio, and the comparison of the return loss is shown in Figure-2.

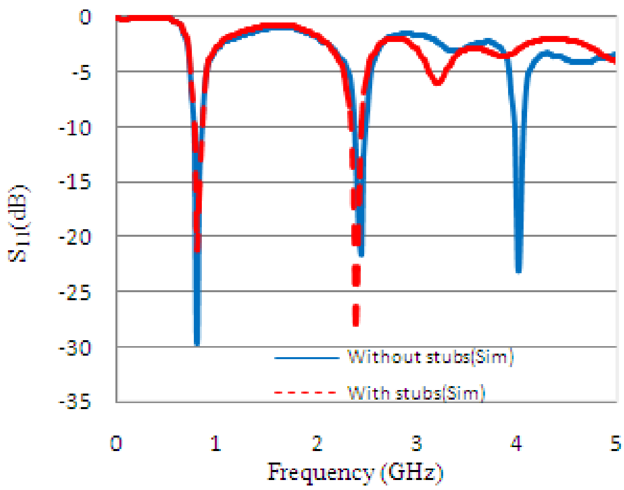

Figure-2. Comparison between the simulated return loss of dipole antenna with and without stubs.

As it can be seen from Figure-2, the antenna has three operating frequency bands without any stubs. For example, the antenna has return loss of -29.506 dB, -20.383 dB and -22.638 dB at 0.8 GHz, 2.4 GHz, and 4 GHz respectively. It can be noticed that a harmonic is appearing (blue color) in the predicted result in Figure-2. Here, the harmonic suppression techniques were

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introduced, and the antenna's operating frequencies reduced to two. As we can see, the antenna has a return loss of -20.984 dB and -27.929 dB at 0.8 GHz and 2.4 GHz respectively. The same analysis was applied to observe the performance of antenna in terms of its gain as shown in Figure-3. It can be noticed that the gain of the antenna without stubs was gradually increasing as the frequency was increased, for example the gain is 1.8 dB at 0.8 GHz which increased to to 2.7 dB at 4 GHz. However, once the stubs are introduced into the design the gain at the higher frequency (4GHz), dropped to -2.4 dB.

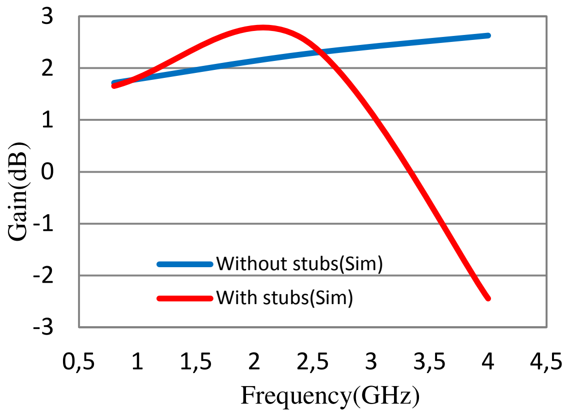
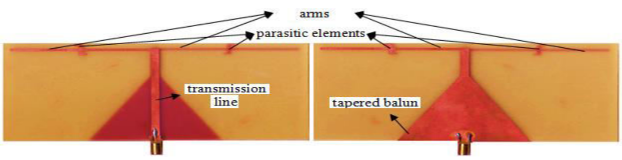


Figure-3. Comparison between the simulated gain of dipole antenna with and without stubs.

FABRICATION AND MEASUREMENT

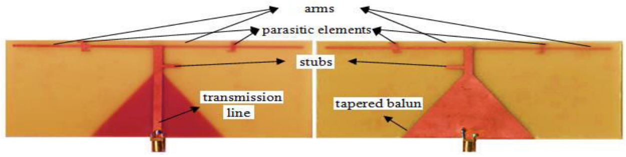
The designed dipole antenna with and without stubs is fabricated using FR-4, which has a permitivity of 4.3 and a thickness of 1.6 mm. The fabrication process is carried out using Photoetching process; in which, the designed dipole antenna is printed on a transparent film and then it is exposed to UV light in order to cover the required region of the substrate. A developer solution was created so as to remove the photo-resist and then the antenna was placed in the etching tank in order to remove the unwanted copper. Finally, the antenna is rinsed and dried. The fabricated antennas without and with stubs are shown in Figure-4 and Figure-5 respectively (Tenopir, 2003).

The scattering parameter measurements were obtained by using a vector network analyzer (VNA) and the radiation pattern dipole antenna were obtained by using a spectrum analyzer and horn antenna (0.5-18 GHz Double Ridge Horn Antenna).



(a) (b)

Figure-4. Fabricated antenna -without stubs (a) Top side –without stubs and (b) back side without stubs.



(a) (b)

Figure-5. Fabricated antenna -with stubs (a) Top side with stubs and (b) back sidewith stubs.

The comparison between the simulated and measured return loss of the dipole antenna with and without stubs is shown in Figure-6. In each case it can be seen that there is a good agreement between the simulated and measured results in terms of the return loss of the proposed dipole antenna.

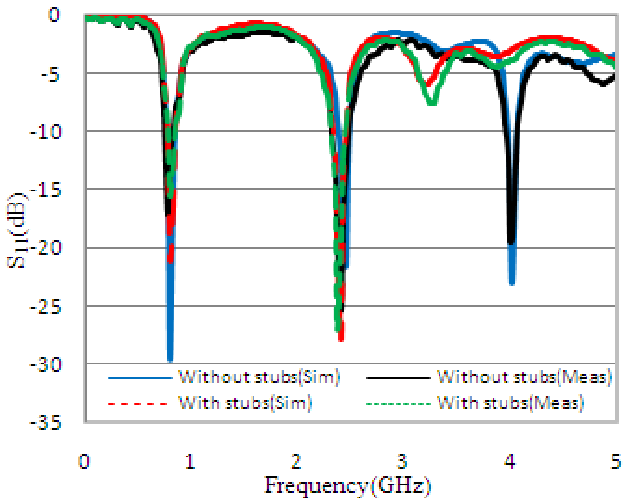


Figure-6. Comparisonbetween simulated and measured return loss of dipole antenna with and without stubs.

Figure-7 shows the bi-directional radiation pattern of the dipole antenna in the E-plane set up. Both simulated and measured results of the pattern of the antenna have shown a good agreement in all the frequency ranges from 0.8 GHz to 2.4 GHz. However, H-plane of pattern analysis of the antenna has shown a pure omnidirectional radiation pattern as shown in Figure-8. The simulated and measured patterns of 0.8 GHz and 2.4 GHz have also shown good agreement.

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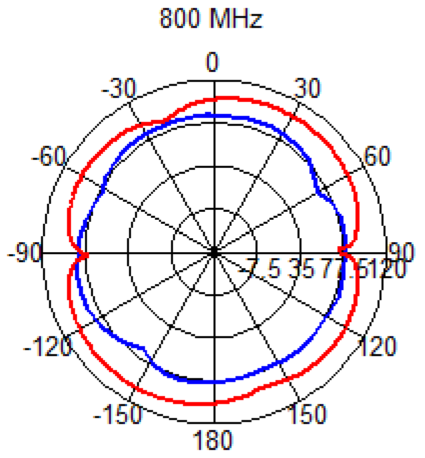
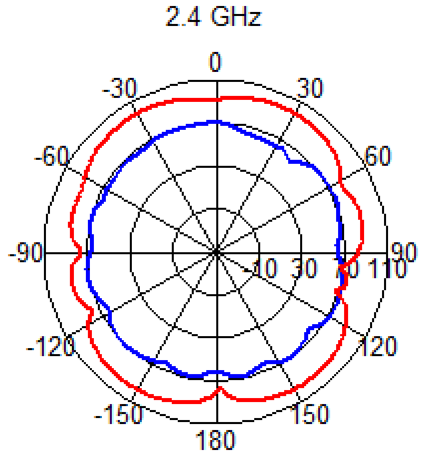


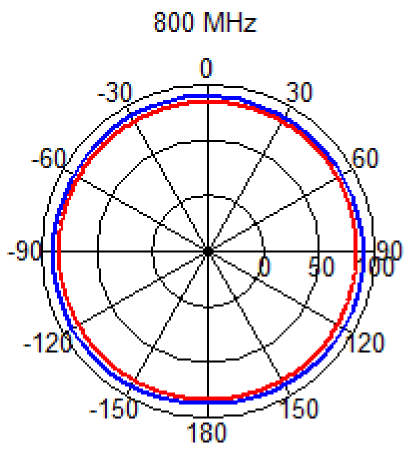
(a)



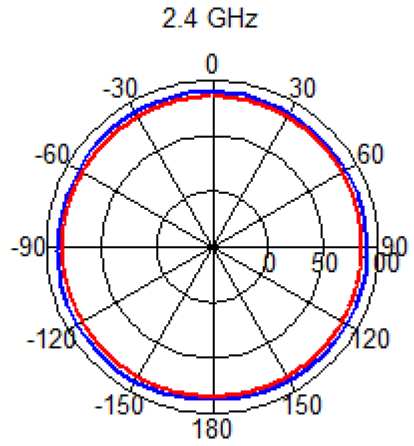
(b)

__ E-plane (Simulated) __ E-plane (Measured)

Figure-7. Comparison of radiation pattern between simulated and measured results of the dipole antenna for E-plane at (a) 0.8 GHz and (b) 2.4 GHz.



(a)



(b)

__ H-plane (Simulated) __ H-plane (Measured)

Figure-8. Comparison of radiation pattern between simulated and measured results of dipole antenna for H-plane at (a) 0.8 GHz and (b) 2.4 GHz.

CONCLUSIONS

A dual band dipole antenna with harmonic suppression was proposed in this work. Firstly, the model of the antenna was designed using CST Microwave studio. The study was conducted initially by starting the design of a transmission line on the top side and a linear tapered balun on the back side with two arms on the top and on the back side., Similarly a single parasitic elements were placed on the arms with same dimensions and same locations (top-side and back-side).By adding two stubs the unwanted harmonics were eliminated and only the desired operating frequencies were obtained. The length, width, and location of the stubs were optimized through a parametric study of the design in order to eliminate the unwanted frequency. The simulated and measured results were compared and found in good agreement with each other. This proposed dual band dipole antenna is a potential candidate in the wireless communication systems as it can operate at dual-bands such as 0.8 GHz and 2.4 GHz.

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REFERENCES

Jabbar S. Hussein Ahmed A. Aouda, Alhussain. 2013. Transmitting Loop Antenna for Efficiency Enhancement. Karbala University College of Engineering.

James W. 1991. Healy, Antenna Here is a Dipole, Assistant Technical Editor.

Kaneda, N., Deal, W. R., Qian, Y., Waterhouse, R. and Itoh, T. 2002. A broadband planar quasi-Yagi antenna. Antennas and Propagation, IEEE Transactions on, 50(8), 1158-1160.

Qian, Y., Deal, W. R., Kaneda, N. and Itoh, T. 1998. Microstrip-fed quasi-Yagi antenna with broadband characteristics. Electronics Letters, 34(23), 2194-2196.

Rahman, T., Zhaowen, Y. and Youcef, H. 2013, August. A dual band monopole microstrip printed antenna for WLAN (2.4/5.2/5.8 GHz) application. In Microwave Technology and Computational Electromagnetics (ICMTCE), 2013 IEEE International Conference on (pp. 204-207). IEEE.

Rajib Jana. 2014. Analysis, Design and Development of Matched Feed for Offset Reflector Antenna Systems. Indian Institute of Technology Guwahati retrieved on 6 October 2014 from http://www.iitg.a.in/ece/phdstud.html.

Rao, S., Shafai, L. and Sharma, S. K. (Eds.). 2013. Handbook of Reflector Antennas and Feed Systems Volume III: Applications of Reflectors. Artech House.

Sawadi, Amar. 2012. An RFID Directional Antenna for Location Positioning". Electronic Theses and Dissertations. Paper 138.

Tenopir, C. 2003. Use and users of electronic library resources: An overview and analysis of recent research studies.