TRIPLE BAND DIPOLE ANTENNA WITH HARMONIC SUPPRESSION CAPABILITY

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For my beloved mother and father

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ABSTRACT

The wireless communication system has become very popular and has been developed rapidly over last one and a half decade. Wireless devices that operate in multiband frequencies, with smaller size, are now used by almost everyone. In this work, multiband dipole antenna with harmonic suppression capability has been designed. The Triple-band dipole antenna has been vigorous since it is simple, easy to be designed and fabricated. However, higher order modes (HOM) in these multiband antennas gives problems when designing such type of antennas. The proposed antenna consists of two designs; the first design is triple band dipole antenna with harmonic suppression capability which generate four frequency bands 0.8 GHz/2.4 GHz/ 4 GHz/ 5.8 GHz; The unwanted frequency of 4 GHz have been suppressed by adding single stub. The second design is dual band dipole antenna with two stubs to eliminate the unwanted frequency. Design two is repeated of three different scenarios 0.8/ 2.4 GHz, 0.8/ 5.8 GHz, and 2.4/ 5.8 GHz. The proposed concept has been investigated through simulation in CST Microwave studio and actual experimental works. The simulation and experimental results confirm the validity of the proposed antenna. There have been matching agreements between both simulation and measurements results.

ABSTRAK

Sistem komunikasi tanpa wayar menjadi semakin popular dan berkembang dengan pesat sejak satu setengah dekad yang lalu. Peranti tanpa wayar yang beroperasi pada pelbagai jalur frekuensi, bersaiz kecil, kini digunakan oleh hampir semua orang. Dalam kerja ini, antena dwikutub pelbagai jalur dengan keupayaan menindas harmonik telah direkabentuk. Antena dwikutub tiga jalur telah di pilih kerana ia ringkas, mudah direkabentuk dan difabrikasi. Walaubagaimanapun, mod tertib tinggi (HOM) menjadi masalah pada antena pelbagai jalur apabila antenna jenis ini direka bentuk. Antena yang dicadangkan mempunyai dua rekabentuk; reka bentuk pertama mempunyai tiga parasit elemen di mana ia menghasilkan 0.8 GHz, 2.4 GHz, 4 GHz dan 5.8 GHz frekuensi; manakala rekabentuk kedua dihasilkan dengan menambah dua puntung rekabentuk dengan frekuensi yang sama dengan rekabentuk pertama dimana ia menghapuskan frekuensi yang lain. Frekuensi yang tidak diingini telah ditindas dengan menambah puntung. Reka bentuk pertama berjaya menghapuskan frekuensi pada 4 GHz manakala reka bentuk kedua menindas frekuensi pada 4 GHz dan satu daripada tiga frekuensi. Penindasan menjurus kepada menghapuskan kebarangkalian gangguan bunyi dengan mengeluarkan frekuensi yang tidak diingini. Reka bentuk kedua diulang tiga senario yang berbeza 0.8/ 2.4 GHz, 0.8/ 5.8 GHz, and 2.4/ 5.8 GHz. Konsep yang dicadangkan telah dikaji melalui simulasi pada CST Microwave studio dan kerja-kerja eksperimen yang sebenar. Hasil simulasi dan eksperimen mengesahkan reka bentuk yang di dicadangkan. Terdapat kesepadanan diantara hasil simulasi dan pengukuran.

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LIST OF ABBREVIATIONS

PMA	-	Printed monopole antenna
WLAN	-	Wireless local area network
MHZ	-	Mega hertz
GHZ	-	Giga hertz
2-D	-	Two dimension
3-D	-	Three dimension
BW	-	Bandwidth
VNA	-	Vector network analyzer
GSM	-	Global system for mobile communication
mm	-	Millimeter
ISM	-	Industrial, scientific and medical
HOM	-	Higher order mode
HSA	-	Harmonic suppressed antenna
EBG	-	Electromagnetic bandgap
DGS	-	Defeated ground Structure
PBG	-	Photonic bandgap
E-Plane	-	Electric plane

H-Place	-	Magnetic plane
HPBW	-	Half-power beam width
VSWR	-	Voltage standing wave ratio
SPE	-	Single parasitic element
TPE	-	Three parasitic elements
RL	-	Return loss
CST	-	Computer simulation technology
%BW	-	Percentage bandwidt

CHAPTER 1

INTRODUCTION

1.0 Background

The increased growth of Wi-Fi communication, the urgency to design cheaper amount, portable, lower profile planar settings and wideband multiple-frequency planar antennas turn out to be highly interesting. The popularity in the cellphone technologies have been significantly degreased the size and weight. Antenna with higher acquire efficiency are definitely the needed a few of the apps in conversation. Contemporary portable Wi-Fi methods are already needed to run at multiple frequency rings allowing a variety of communication services. Furthermore, as increasing numbers of communication alternatives are integrated into just one product, multiband antennas turn out to be a little bit more appealing for the decline in actual manufacturing and estate expenses. Different posts have mentioned various designs and techniques for multiband antennas [1-14].

Generally speaking, the key of multiband antennas are discovered by developing resonators of a number of unique resonant lengths and multiple resonances included in the antenna design. On the other hand, numerous resonating patches are set up in portable configurations. Dipole antennas always have difficulty in complying with such requirement because the bandwidths of the printed dipole antennas are generally narrow and are often insufficient for many applications hoverer. There are many papers dealing with the best way to develop known simple antenna structures to multi-band features for instance like, inverted F or inverted L antennas [15], embedded folded dipoles [16] or PIFA's with folded feeding structures [17]. Harmonic suppression which attributes additional placement decrease, the standard thought implementation of antenna with harmonic suppression is to steer clear of spurious radiation that very easily generated at higher purchase resonant frequencies of antenna from your circuits. Wireless Local Area Network (WLAN) provides the data networking needs of public wireless service subscribers. High gain antenna is critical to WLAN system.

This project will introduce a triple band dipole antenna and investigate the characterization of antenna design with harmonic suppression for wireless communication.

2.1 Problem Statement

Wireless devices that operate at multiband frequencies with smaller physical sizes have now been used in many applications. The triple-band dipole antennas have been used vigorously, since they are simple, easy to be designed and fabricated. The higher order mode (HOM) frequencies in these multiband antennas is one of the problems which has many undesired frequencies and noises that exist when designing such type of triple band dipole antennas.

To overcome the undesired higher order modes, a triple band dipole antenna with harmonic suppression capability is proposed, to eliminate the undesired frequencies.

1.2 Project Objectives

This project provides an investigation on the performance optimization of triple band dipole antenna with harmonic suppression. The objectives of this project are:

- To design a triple-band dipole antenna
- To design and develop a triple band dipole antenna with harmonic suppression capability
- To simulate and fabricate and test the triple-band dipole antenna with harmonic suppression

2.1 Scope of the Project

The scopes of this project are:

- Triple band dipole antenna operates at the following frequency

Operating frequency	System application
800 MHz	GSM 900 MHz
2.4 GHz	ISM Band/ WLAN
5.8 GHz	ISM Band/ WLAN

- Employing stub to suppress higher order mode (HOM).
- The Triple band dipole antenna will be analyzed through simulation using CST and then experimented by using network analyzer, and farfield measurement.

CHAPTER 2

LITERATURE REVIEW

2.1 Review of Harmonic Suppression Antenna

Harmonic suppression antennas (HSAs) suppress power radiation at harmonic wavelengths from active integrated antennas (AIA). An antenna that presents impedance match fundamental design frequency (fo) and maximized reflection at harmonic wavelengths is stated harmonic suppression antenna. AIAs popular, suffer undesired harmonics which must be removed or hidden. The undesirable harmonics are critical degrade the antenna performance. Within the conventional AIAs, harmonic suppression filters were employed which create additional insertion loss while antenna size. Additionally, the input impedance HSA design minimized resistance in the harmonic wavelengths largely reactive. The wireless power transfer system must operate efficiently and also the deficits of one's during receiving and conversion of signal processes minimized by suppressing the undesirable signal, however, the interface antenna nonlinear circuit component diode [19-26].

In addition, the productive included antenna continues to be eye-catching section of investigation more recently, because of their small dimension, affordable, and multiple capabilities. The AIA may be regarded as a dynamic microwave circuit where the input or output 5arbor is free of charge place. The main uses of lively built-in antenna are wi-fi communication methods in military and civilian purposes. The design and fabrication of such elements could require a number of steps and ways, dependant upon the region of software and modern technology and materials characterization. In every case, the antenna is totally or carefully incorporated with the productive system produce a subsystem on a single board and might offer distinct circuit functions such as resonating, duplexing filtering as well as radiating that explain its unique part.

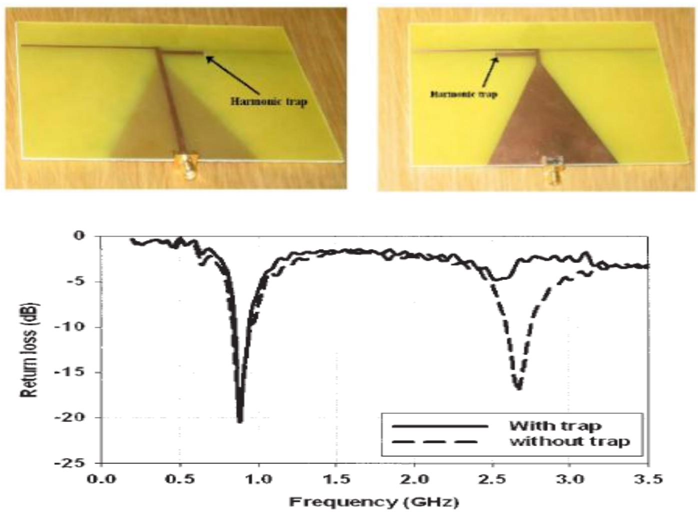
A number of techniques are actually suggested to handle harmonics for example photonic band-gap (PBG), electromagnetic band gap structures (EBG), meta- materials, defected ground structure (DGS) and stubs. As a result, in radio-frequency engineering and microwave, a stub is actually a transmission line which links one end to another. In addition to, stubs are generally employed in frequency selective filters, antenna impedance matching circuits, and resonant circuits for UHF electronic oscillators and RF amplifiers [29]. In this particular thesis, stubs used to get rid of the undesirable frequencies which improves the antenna radiation functionality.

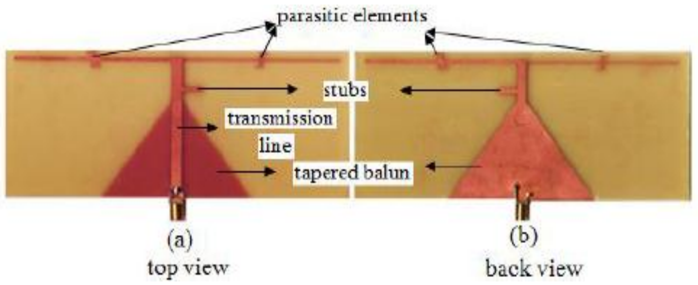
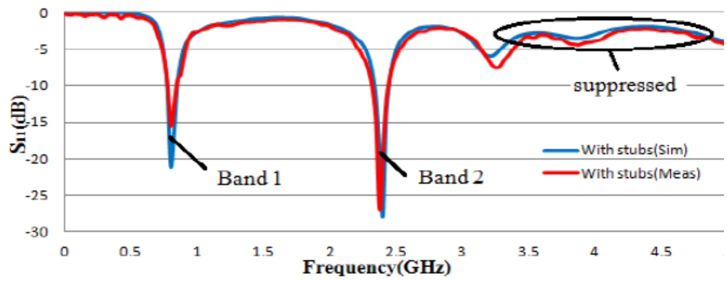
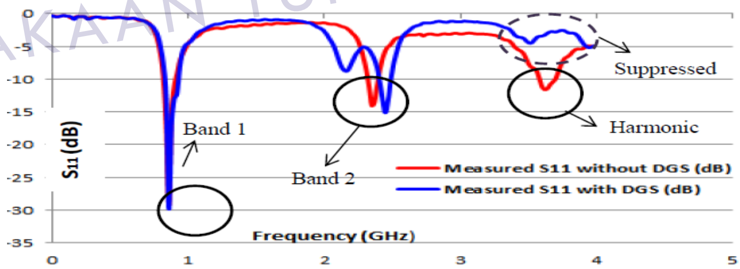
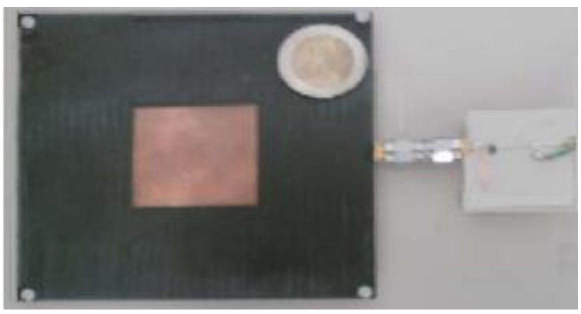
In microwave and radio-frequency engineering, a stub or resonant stub is a length of transmission line or waveguide that is connected at one end only. The other end of the stub is both left open-circuit or as short-circuited. Ignoring transmission line losses, the input impedance of a stub is strictly reactive; capacitive or inductive, dependent upon the electric powered entire stub, and on whether it be open or short circuit. Stub may possibly therefore function as capacitors, inductors and resonant circuits at radio frequencies [37].

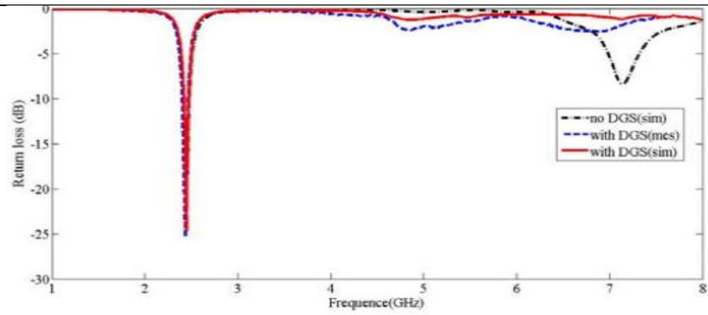
Several research works conducted recently as recorded featuring important of antenna design at 2.45GHz(ISM Band) application[31], which not only act as radiator but also able to suppress the unwanted harmonic at high order frequency several studies have been conducted on antenna harmonic rejection technique in order to proposed new design with improvement in order to proposed new design with important in overall system performance in terms of its good return loss, voltage standing wave ratio, radiation pattern, directivity and gain.

The best technique will be applied on the basic structure of radiating element to control the distribution of current flow on the patch antenna like slit, stub, defective ground structure or else. In turn, the performance of the overall system will be improved since the technique used will maximized power at the fundamental frequency and suppressed the radiated power at harmonic frequencies to achieve harmonic rejection characteristic. However, antenna harmonic suppression will have maximum power transfer at its design frequency if input impedance of antenna is 50 ohm and perfectly matched with the characteristic impedance of transmission line in order to obtain maximum energy transfer between transmission feed line and an antenna.

Table 2.1: Various research work associated harmonic rejection

Ref	Suppression Technique	Antenna structure and results
[35]	Stubs are used to eliminate 2.7GHz.	

[45]	Stubs are used to eliminate 4 GHz	 
[49]	DGS is used to suppress 3.6 GHz	 
[43]	Eliminated 7 GHz by DGS f_o = 2.45 GHz	

2.2 Review of Multiband Antenna

Antenna made to operate on many different band. These antennas usually applied designs exactly where one section of the antenna is active for one band, and another part is active for any distinct band. A multiband antenna might have less than average gain or can be actually bigger in compensation.

One of the standard ways of obtaining multiband operations would be to utilize from higher order resonances. This theory is revealed in Figure 2.1. That the monopole antenna is usually used with a length of $\lambda/4$ Figure 2.1(a). For this particular scenario, the antenna resonates at f_o with electric field minimum at the supply. A similar condition of the minimum electric field at the feed also exists when same antenna's length corresponds to $3\lambda/4$, Figure 2.1(b). As a result, the monopole antenna may also resonate at $3f_o$. Other higher resonances also really exist at increased frequencies for example $5f_o$. Higher order resonances are employed in various types of antennas including patches, helices, dipoles and slots. The antenna provides the resonances at frequencies f_o and $2.6f_o$ that higher order resonances theory virtually holds for this particular situation [38].

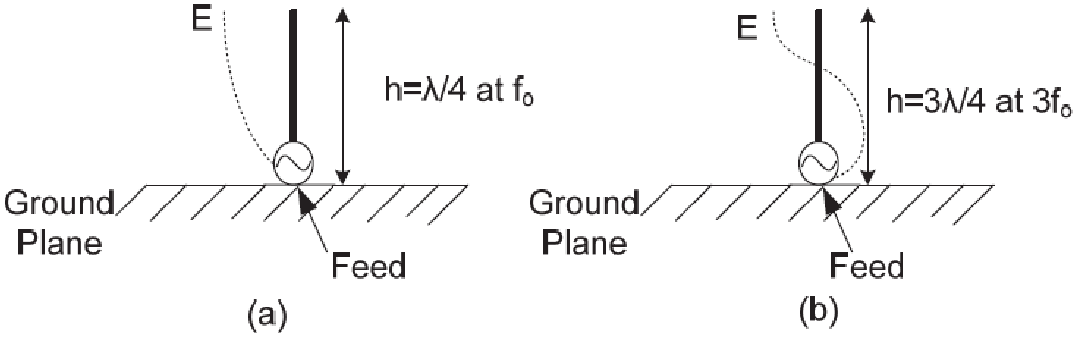


Figure 2.1: (a) An antenna resonating at *fo* (b) Same antenna resonating at 3*fo* (E is the electric field magnitude) [38]

Multiple resonant structures is considered the most preferred technique for obtaining multiband antenna method is the utilization of multiple resonant structures. A couple of resonant structures, which are closely situated in space or even co-situated by using a single feed. The multiple resonant structure method is also commonly used in cellular communication systems to attain multiband mobile antennas.

Parasitic resonators is yet another technique to get multiband features is definitely the implementation of parasitic resonators to the antenna system. This element is not directly fed, although in this technique, an extra parasitic element is added to the fed antenna for the operation at a different frequency. It really is parasitically combined from in close proximity to field of the antenna and resonates at an additional volume. In Figure 2.2 the antenna at first functions at GSM 900 and 1800 frequency bands without having a parasitic component. With the addition of the parasitic element, a triple band antenna for GSM 1900, 900 and 1800 frequency bands is optained [38].

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