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ELECTROMAGNETIC WAVE DETECTION BASED ON MULTIBAND ANTENNA DESIGN

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ABSTRACT

Electromagnetic (EM) radiation has been a common concern in most developed and developing countries in terms of the hazard it poses upon human's health and its capabilities of reducing efficiency of electrical and electronic devices in its surrounding. Thus, to overcome this problem, an antenna is playing important role where it should has the function of detecting various hazard of electromagnetic wave. A multi-band microstrip antenna will need to be designed. The antenna design was simulated and the results such as return loss, input impedance, radiation pattern, VSWR, and efficiency were validated and analyzed. Based on the results, it was found that this antenna is able to support modes with resonance of 2.3, 4.5, 4.68 and 5.2 GHz where these resonances are also known as the most high risk EM signal that been exposed by human being in everyday life. The multiband microstrip antenna has been successfully designed by Computer Simulation Technology (CST) microwave studio 2014.

Keywords: electromagnetic, multiband antenna, resonance frequency.

INTRODUCTION

Electromagnetic fields (EMF) are a combination of invisible electric and magnetic fields of force. They are generated by natural phenomena like the Earth's magnetic field but also by human activities, mainly through the use of electricity (Lagorio, 2011).

Exposure to electromagnetic fields is not a new phenomenon. Amid the 20th century, environmental exposure to man-made electromagnetic fields has been consistently expanding as developing electricity request, ever-advancing technologies and changes in social conduct have made more artificial sources (Lagorio, 2011). Recently, with increment of the electronic gadget utilizing electromagnetic wave, the communication disruptions created by the obstruction or the impression of the electromagnetic wave becomes serious issue.

Mobile phones, power lines and computer screens are examples of equipment that generates electromagnetic fields. Mobile telephones are a particular source of EMF that has grown rapidly as people appreciate the many benefits they bring to their lives (Ripin *et al*., 2012). Mobile telephone technology generates EMF in two ways: first from the antenna that are placed around our cities, towns and motorways; and secondly from the telephones themselves which transmit out conversations to the antenna.

The technologies that ultilize today, from our cars, regular appliances, cell phones, discharge EM radiation and electromagnetic radiation that can penetrate and affect us, compromising our health and disturbing our surrounding. Microstrip antennas have turn into a quickly developing region of research (Mythili *et al*., 2009), (Islam, *et al*., 2008) Their applications are boundless, due to their minimized size, simplicity of assembling, and light weight.

Electromagnetic fields are generated by currents running through electric wires. Since they are not powerful and destructive like nuclear or X-ray radiation, they were once thought to be harmless. However, people exposed to them chronically run a higher risk of certain health problems including miscarriages, learning disabilities, and cancer.

In this paper, multiband microstrip antenna for the used of detecting electromagnetic wave is proposed. The antenna is suitable for use in a wireless sensor device to detect high intensity of electromagnetic signal.

MULTIBAND ANTENNA DESIGN

Multiband antenna is located at the receiver side of the whole EM Detection system (Jayasinghe *et al*., 2012) Then, the design is been run by the simulator tool which is Computer Simulation Technology (CST) Microwave Studio software. This software had been utilized for this project design purpose. From the review studied, rectangular shaped antenna with wider ground size will be proposed due to its advantages on ease of designing and producing multiband property.

The design calculation that had been used as shown in equation (1)-(6)

Width of the microstrip patch

$$W = \frac{c}{2f_r \sqrt{\frac{2}{\epsilon_r + 1}}} \qquad (1)$$

Effective dielectric constant

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{\frac{-1}{2}} \qquad (2)$$

The length extension

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$$\Delta L = 0.412h \quad \frac{(\epsilon_r + 0.3)(\frac{w}{h} + 0.264)}{(\epsilon_r - 0.3)(\frac{w}{h} + 0.8)} \qquad (3)$$

The actual length microstrip patch

$$L = \frac{c}{f_r \sqrt{\epsilon_{reff}}} - 2\Delta L \qquad (4)$$

The length and width of the ground plane

$$W_g = 6h + W \qquad (5)$$

$$L_g = 6h + l \qquad (6)$$

Table-1. Design parameters and dimensions of rectangular shaped antenna with wider ground size.

Substrate (FR4)	Dimensions (mm)
Length, Lg	80
Width, Wg	70
Patch (Copper)	Dimensions (mm)
Length, L	30
Width, W	60.32
Feeding	Dimensions (mm)
Quarter Wave Length, qw	2
Width of Feed Line, fd	3.075

Figure-1 shows the layout dimensions of Rectangular Shaped Antenna with wider ground size. Table-1 shows the parameters and dimensions used in proposed multiband microstrip antenna.
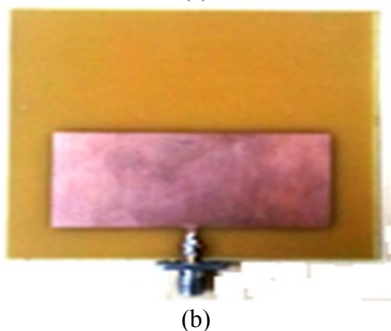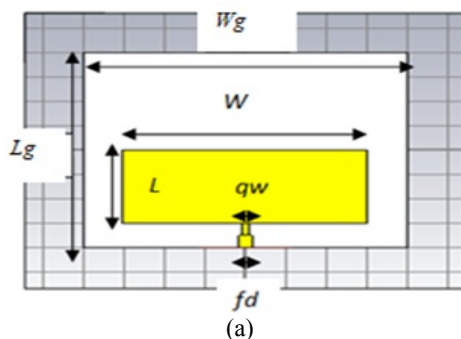

(a)

(b)

Figure-1. Rectangular shaped antenna with wider ground size (a) Simulated design (b) Hardware prototype.

RESULTS AND DISCUSSION
Parametric studies

Two parameters based on the antenna dimension had been undergo parameter studies. There are Length, L and Width, W of rectangular patch. Figure-2 shows the return loss of the antenna with varied length. From the result, it shows that shorter length provided better performance of return loss at resonant frequency of 2.3 GHz and 5.2 GHz. However, the return loss at frequency 4.245 GHz and 4.68 GHz, it shows that longer length had provide better result. Based on the required frequency band, the choice of length ought to be considered for all viewpoints. Length of 30 mm was optimized as the design length for its overall better performance.
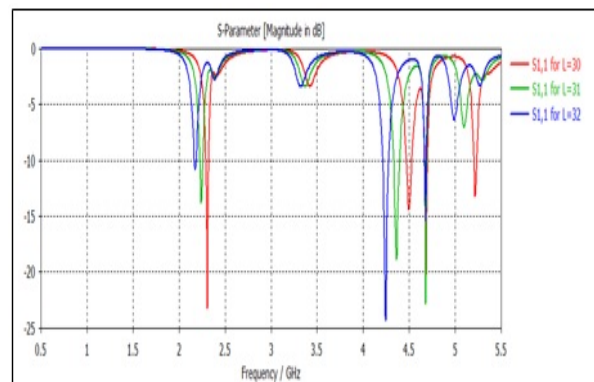

Figure-2. Return loss of the rectangular shaped antenna with different length.

Same goes to the parameter of width, the performance of antenna has proved that return loss will be affected with different width of the patch design. Figure-3 shows the simulation result of the antenna with different width. From the result in Figure-3, it shows that shorter width has provided better return loss result. In this scenario, the width with 60.32 mm has been optimized as the parameter value based on the size and performance considerations.
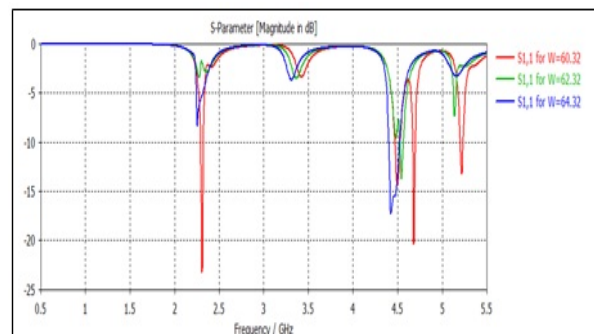

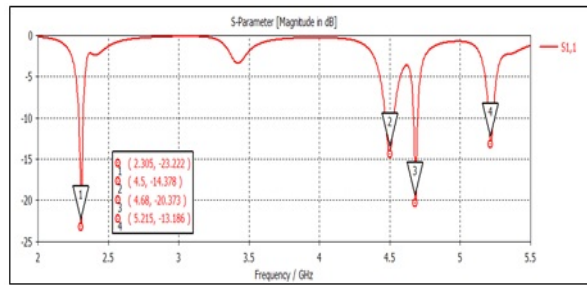**Figure-3.** Return loss of the rectangular shaped antenna with different width.

Figure-4. S-Parameter for rectangular shaped antenna with wider ground size.

Based on the overall antenna size, it is proved that larger size of ground which is 80 x 70 mm that was double the size of the radiating patch is one of the factor to obtain multi frequencies (Jamali *et al*., 2011). In Figure-4, the electromagnetic wave signals produce multiband frequency which shows that the proposed antenna can be used to detect four (4) microwave signals. The signals include 2.3, 4.5, 4.68 and 5.2 GHz. The simulated return loss (S11) shows the antenna's response to be good for the four different bands. The resonant frequency at 2.305 GHz obtain a return loss of -23.222 dB, while in 4.5 GHz is -14.378 dB, 4.68 GHz is -20.373 dB and 5.215 GHz is -13.607 dB. All of the signals are lower than -10dB. The frequency for 4.5GHz and 4.68GHz is mobile network band in US and this antenna also can be used to detect microwave signal in US too.
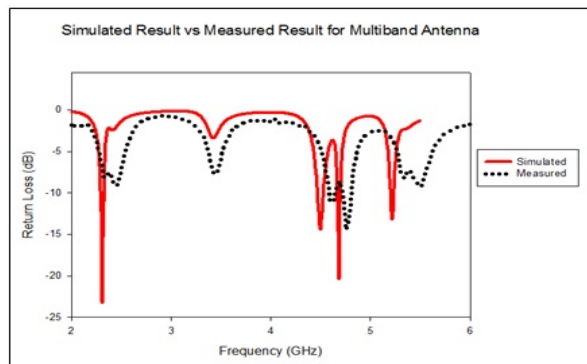

Figure-5. Simulated and measured result.

Figure-5 shows the comparison between the simulated and measured result for the purpose multiband antenna. The return loss value for measurement part is less than -10dB. The result shows on measurement part is not quite good compared to simulation. This condition is due to the multipath fading or interference during the measurement was been done. Overall, the results of both the simulation and measurement are consider to have almost the same characteristic which can be said that the antenna is validated and can be used in real time application.

In electromagnetics, an antenna's power gain is a key performance figure which combines the antenna's

directivity and electrical proficiency (Ranjan *et al*., 2012). Antenna gain is normally characterized as the proportion of the power created by the antenna from a far-handle source on the antenna's beam axis to the power delivered by a speculative lossless isotropic antenna, which is just as delicate to signals from all bearings (Ranjan *et al*., 2012). Directivity is a figure of merit for an antenna. It measures the power density the antenna radiates toward of its strongest emission, compared to the power density radiated by an ideal isotropic radiator radiated the same amount of power (Shah *et al*., 2013). Efficiency is defined as the proportion of the total power radiated by an antenna to the net power acknowledged by the antenna from the associated transmitter. The efficiency that adequate for antenna is over 70% efficiency so that the antenna has a good performance (Lee *et al*., 2008).

Radiation Patterns for as shown in Table-2 are monitored for frequencies of 2.3, 4.5, 4.68 and 5.2 GHz. The antenna has broader 3 dB beam width of 48.6º for 4.5 GHz, 126.9º for 4.68 GHz and 53.3º for 5.2 GHz. The radiation pattern for all frequency behaves directional.

**Table-2.** Radiation pattern for multiband frequencies.

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Table-3. Gain, directivity and efficiency of the propose antenna.

Design	Gain (dB)	Directivity (dBi)	Efficiency (%)
2.3 GHz	3.137	5.124	52.16
4.5 GHz	8.648	10.300	81.70
4.68 GHz	3.484	6.269	54.37
5.2 GHz	4.203	6.709	60.51

Table-3 shows the gain, directivity and efficiency of the propose antenna design. At 2.3 GHz, the gain is 3.137 dB and the directivity is 5.124 dBi while for 4.5 GHz, the gain is 8.648 dB and the directivity is 10.30 dBi. For 4.68 GHz, the gain is 3.484 dB and the directivity is 6.269 dBi. At 5.2GHz, the gain is 4.203 dB and the directivity is 6.709 dBi. Hence, the efficiency for the each of th e resonant frequency mentioned above is 52.16%, 81.70%, 54.37% and 60.13% respectively. The efficiency for 4.5 GHz is better compared with the rest of the resonant frequency.

VSWR is an element of the reflection coefficient which portrays the power reflected from the design (Lee *et al*., 2008). The smaller the VSWR is, the better the antenna that is matched with the transmission line. Thus, more power is transmit than reflect. The standard base of VSWR is 1.0. For this situation, no force is reflected from the proposed antenna, which is actually perfect as can be seen in Figure-6.
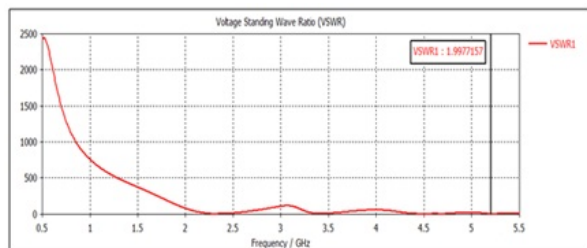
Figure-6. VSWR for 5.2GHz.

CONCLUSIONS

In conclusion, the antenna is simulated and it is found to support for four different bands which are 2.3, 4.5, 4.68 and 5.2 GHz that are used in different applications. In this design, simple feeding technique which is line feed is used and it does not require more than one patch. Here, wider ground rectangular shaped dimensions and the feed position are varied to support multiple bands and to provide impedance matching. The bands are obtained for the resonant frequencies of 2.3, 4.5, 4.68 and 5.2GHz which are also known as one of the hazard EM signals. The simulated return loss, VSWR and radiation patterns for each of the resonant frequencies are plotted. The results shows that the antenna design has return loss below than -10dB while the input impedance equal to 50 Ω and VSWR in range between 1 to 2.

After comparing the simulated and measured results, the simulated is better than in measured result. The simulation process show good results in terms of return loss. The difference results between simulated and measured is due to the imperfection of fabrication.

For future work and recommendation, antenna with slotted properties can be added into the design. The slot can broaden not only the fundamental mode frequency band but also the higher order mode frequency band and it will increase current distribution path and provides capacitive effect. The resonances and bandwidth of the antenna depend on the parameters of the slots cut in the patch which results into controllable bandwidth of the antenna.

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