DUAL BAND MICROSTRIP PATCH ANTENNA

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Abstract - **This paper concentrates on designing a dual band microstrip patch antenna. The study involves two different frequencies which are 1.2GHz and 2.4GHz for Global Positioning System (GPS) and Wireless Local Area Network (WLAN) Industrial, Scientific and Medical (ISM) band applications that standardized by Global Navigation Satellite Systems (GNSS) and IEEE 802.11b. The size of the antenna is 130mm x 131mm and simulated using Computer Simulation Technology (CST) software. Then the designed antenna is fabricated on a RT Duroid 5870 substrate with dielectric constant, ε_r = 2.33, loss tangent, *tan* δ = 0.0012 and thickness, *h*=0.787 mm. The results of return loss (S_{11}), Voltage Standing Wave Ratio (VSWR) and input impedance of the designed antenna are compared between simulation and measurement. The measurement is done by using Vector Network Analyzer (VNA). From the simulation results, a good return loss and VSWR was obtained for both frequencies although there are some relative errors for 1.2GHz that is 16.96% and for 2.4GHz it is 1.08%. Meanwhile, in the measurement, the operating frequencies were same as in the simulation.**

Keywords- **Dual-frequency antenna; stripline fed antenna; Global Positioning System (GPS); Wireless Local Area Network (WLAN) Industrial, Scientific and Medical (ISM)**

I. INTRODUCTION

An antenna may be defined as a metallic device used for radiating or receiving electromagnetic waves which acts as the transition region between free space and guiding structure like a transmission line in order to communicate even in a longer distance [1].

The design of an antenna system is very important in a transmitting station. The antenna must be able to radiate efficiently so the power supplied by the transmitter is not wasted. An efficient transmitting antenna must have exact dimensions, determined by the frequency being transmitted. The dimensions of the receiving antenna are not critical for relatively low frequencies, but their importance increases drastically as the transmitted frequency increases [2, 3].

Patch antennas are popular for their well-known attractive features, such as a low profile, light weight and compatibility with monolithic microwave integrated circuits (MMICs) [4-6]. Their main disadvantage is an intrinsic limitation in bandwidth, which is due to the resonant nature of the patch structure. On the other hand, modern communication systems, such as those for satellite links (GPS, vehicular, etc.), as well as emerging applications, such as wireless local area network (WLAN), often require antenna with compactness and low cost, thus rendering planar technology useful and sometimes unavoidable [7].

In applications in which the increased bandwidth is needed for operating at two sub-bands, a valid alternative to the broadening of total bandwidth is represented by dual-frequency patch antennas. Dual-frequency antennas exhibit a dual-resonant behavior in a single radiating structure which also known as dual band antenna [8, 9]. In many urban areas, the base stations of antennas of different mobile systems are often installed on the same building. It is desirable to have different frequency antenna to be used by two different radio mobile systems but using the same antenna [10].

Hence, in this research, a dual band microstrip patch antenna will be design for operating at two different frequencies which are 1.2GHz and 2.4GHz. Then, the performance of dual band antenna will be compared between simulation and measurement.

II. METHODOLOGY

Figure 1 shows the flowchart of the procedure throughout the project in designing the proposed antenna. Literature review about the dual band was studied. The antenna was designed and simulated by using the CST software. After the analysis of antenna characteristic, the antenna was fabricated on the RT Duroid 5870 printed circuit board (PCB) with overall size of 130mm x 131mm and dielectric substrate ε_r = 2.33. The fabrication antenna design verified using Vector Network Analyzer (VNA). Report and documentation was written after the fabrication antenna results meet the requirement.

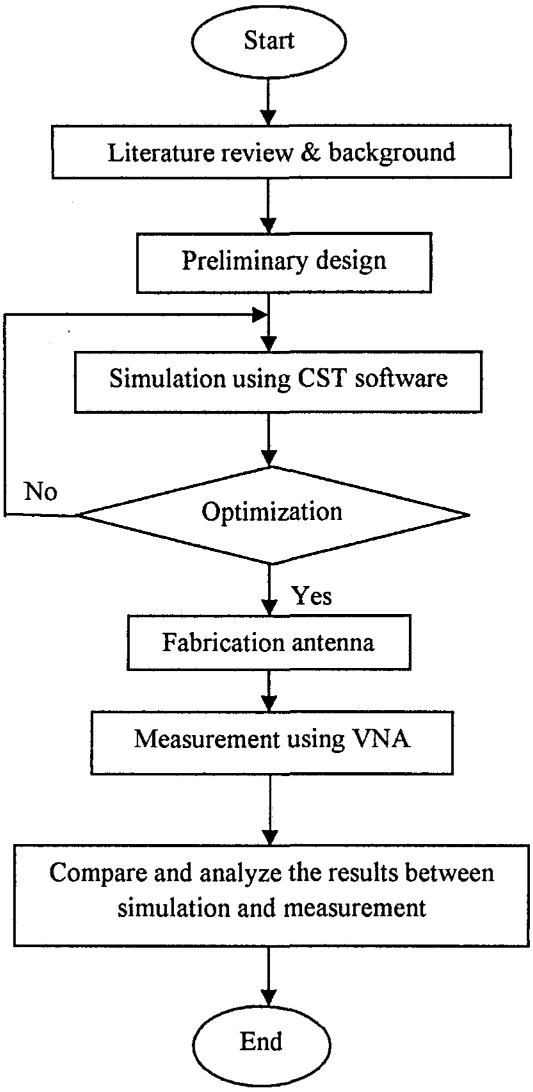

Figure 1: The flowchart of the procedure throughout the project

III. ANTENNA DESIGN

There are many types of substrate in the market nowadays. Before stick with one substrate, researched have been made by simulation using CST software. The relative permittivities that have been used are 2.2, 2.33, 2.94, 4.9, 6.15 and 10.2. By using different ε_r, the sizes are compared between them to get the good dual frequency as desired.

Hence, the original design antenna consists of printed rectangular patch antenna that has been chosen is RT Duroid 5870 substrate with thickness, h= 0.787mm and relative permittivity, ε_r= 2.33. The width and length of the patch is depending on the calculation with W= 86.87mm and L= 81.60mm. For the feed line, the length is quarter wavelength, l= 40.95mm while the width, w= 2.3041mm.

To get the good performance while obtained the frequencies required, some adjustment has been made to the patch which make the width and length become W= 121.286mm and L= 87.05mm. In order to eliminate the unnecessary frequencies, shapes are extruded in the radiating patch. First, the left side of the patch was extruding with triangle shape. As it is still not operate at the needed frequency, the bottom right side was also extruding with triangle shape. Figure 2 shows the extruded patch antenna. The reducing area is about 23.94% that make the patch become 8030.2mm^2. Figure 3 shows the fabricated antenna.

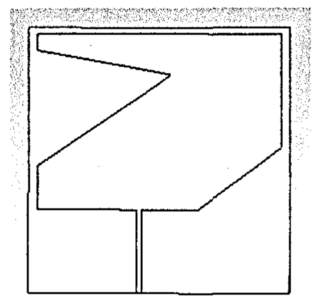

Figure 2: The extruded patch antenna

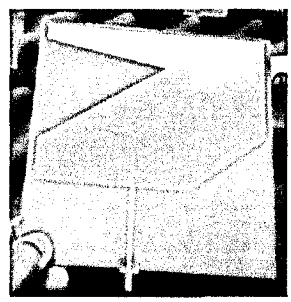

Figure 3: The fabricated antenna

IV. RESULTS AND DISCUSSION

The performance of antenna such as return loss, voltage standing wave ratio (VSWR) and input impedance will be read out and examined. The result will be compared between simulation and measurement.

There is an additional experiment has been done in the measurement session. Another technique has been added to the fed which is stripline feeding technique where the same substrate is used. It has been etched only on one side and the length is same as the length of fed while the width same as the ground plane width. Figure 8 shows the stripline feeding technique. The results from the different techniques have been compared.

A. Return Loss, S_{11}

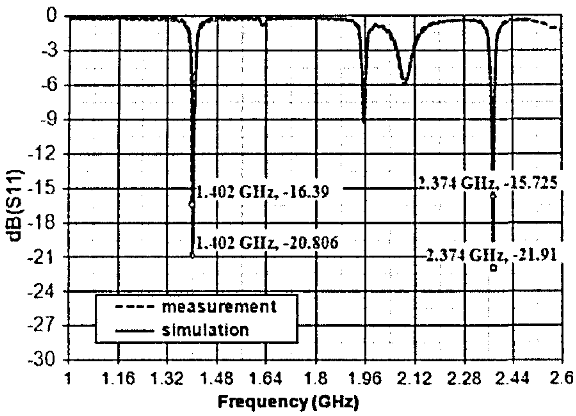

Figure 4: Simulation and Measurement of Return Loss S_{11}

Figure 4 shows the result of return loss. From the graph, shown that the different is only with the return loss as the frequencies drop are same for simulation and measurement. For 1.402GHz, the return loss for simulation is -16.39dB while for measurement is -20.806dB. For 2.374GHz, the return loss for simulation is -21.91dB and for measurement is -15.725dB.

For both simulation and measurement, the bandwidth is calculated refer to return loss at -10dB. From the simulation, the bandwidth for 1.402GHz is 0.57% and the bandwidth for measurement is same. For 2.374GHz, the bandwidth is 0.35% for simulation and also measurement.

B. Voltage Standing Wave Ratio (VSWR)

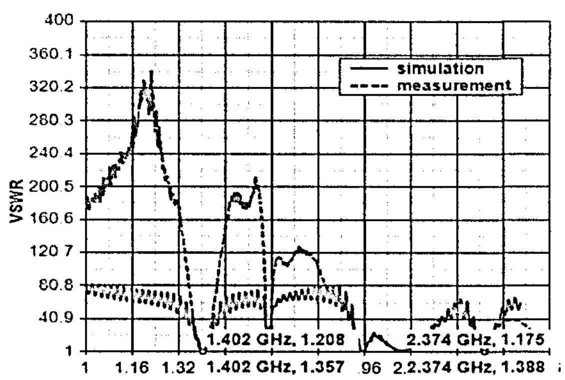

Figure 5: VSWR for simulation and measurement

Result for VSWR between simulation and measurement is shows in figure 5. For 1.402GHz, the VSWR for simulation is 1.357 and for measurement is 1.208. For 2.374GHz, the VSWR for simulation is 1.175 and for measurement is 1.388.

The input impedance of the antenna is 50Ω. As the patch is cut to make it obtain dual band, the value for input impedance also changed. For 1.402GHz, the simulation is 60.72Ω and the measurement is 55.642Ω while for 2.374GHz, the simulation is 50.113Ω and the measurement is 42.719Ω.

C. Radiation Pattern

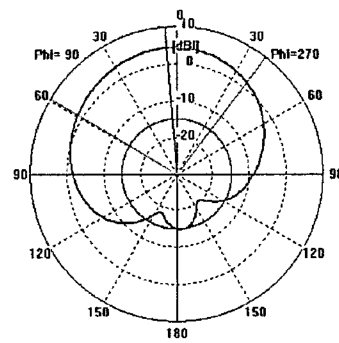

Figure 6: Radiation Pattern for 1.2GHz

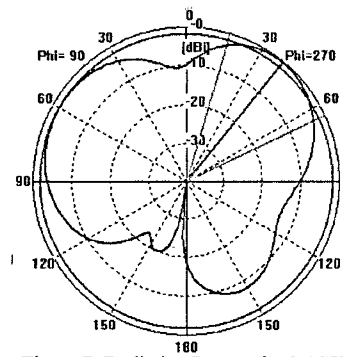

Figure 7: Radiation Pattern for 2.4GHz

Radiation pattern is another performance of an antenna that is being studied is this research. The result of radiation patterns are being showed in figure 6 for 1.2GHz and figure 7 for 2.4GHz. From the figures, we can see that for 1.2GHz, the angular width is 96.6° and side lobe level is -19.4dB. While for 2.4GHz, the angular width is 47.8° and the side lobe level is -1.3dB.

The effect of the performance such as the return loss, input impedance and VSWR of the antenna were examined in this design. From the experiment, it can be said that the feed or port location and the distance between the extruded patch and the radiating edge were really affected to the overall antenna parameters. From the simulation results, a good return loss and VSWR was obtained for both frequencies although there are some relative errors for 1.2GHz that is 16.96% and for 2.4GHz it is 1.08%. Meanwhile, in the measurement, the operating frequencies were same as in the simulation.

Table 1 shows all the parameters different between simulation and measurement for microstrip fed antenna. Table 2 shows the result for stripline fed antenna. There is no much different between microstrip fed and stripline fed. For microstrip fed, the results between the two frequencies are equal. But for stripline fed, the results at 1.2GHz are better than 2.4GHz.

Parameter	Simulation		Measurement	
Frequency (GHz)	1.402	2.374	1.402	2.374
Return Loss(dB)	-16.39	-21.91	-20.806	-15.725
VSWR	1.357	1.175	1.208	1.388
Input Impedance (Ω)	60.72	50.113	55.624	42.719
Bandwidth (%)	0.57	0.35	0.57	0.35

Table 1: Parameter different between simulation and measurement for microstrip fed antenna

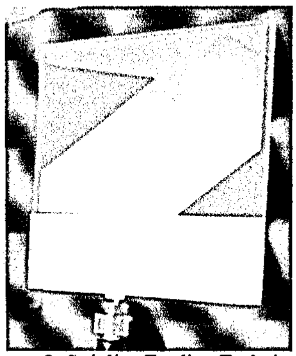

Figure 8: Stripline Feeding Technique

Parameter	Measurement	
Frequency (GHz)	1.404	2.374
Return Loss (dB)	-26.780	-11.323
VSWR	1.101	1.739
Input Impedance (Ω)	55.194	44.56
Bandwidth (%)	0.61	0.17

Table 2: Parameter for stripline fed antenna

V. CONCLUSION

The antenna design to operate at 1.2GHz and 2.4GHz (a GPS and IEEE 802.11b frequency band) is presented in this paper. There are five parameters that can give effect for the resonance frequencies. They are the area of the port, the area of the patch, location of the fed, location of the patch extruded and area of the substrate. From this project, it can be concluded that the single patch antenna designed can be used for dual band as it can perform at two different frequencies.

From the simulation, it is proved that, the bigger the ε_r and the size of the patch, the smaller the frequency can be. That means, if we want the size of the patch and the frequency is small, we can use the bigger ε_r.

VI. ACKNOWLEDGEMENT

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