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CPW Wideband Microstrip Antenna

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Abstract

One of the vast evolutions of wireless technology is WiMAX technology using Coplanar waveguide feed for Wireless Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX) frequency bands are presented. The proposed antenna is fabricated on Aluminum Nitride Ceramic substrate with dielectric constant 4.6 and thickness of small mm. Antenna is one of the most important components in wireless communication. Due to the presence of two frequency bands of WiMAX used in Indonesia, there is a need to develop an antenna that can operate in both frequencies.

This paper discusses the design of coplanar waveguide (CPW) fed octagon shaped microstrip antenna. From the simulation results, it can be seen that the antenna design proposed by the author has a wide bandwidth that includes frequency band of 2.3 GHz and 3.3 GHz. The antenna gain falls between 1.8 .

Keywords: *Microstrip antenna, CPW i.e. coplanar waveguide, wideband, WiMAX.*

INTRODUCTION

One of the vast evolutions of wireless technology is WiMAX technology. The frequency band used in WiMAX in Indonesia is 2.3 GHz (2.3-2.4 GHz) and 3.3 GHz (3.3-3.4 GHz). The Indonesian government through the Ministry of Communication and Informatics has set several operators to provide WiMAX service. However, to date, not many of those operators provide WiMAX service commercially. The Ministry of Communication and Informatics also set the requirements for Base Transceiver Station (BTS) product, with the minimum local content is 40%, while for the Customer Premises Equipment (CPE), the minimum local content is 30%. Therefore it is vital for education/research/industry institution to conduct research to produce components both for BTS and CPE appliances, to fulfill the local content requirements, and becoming less dependent on import.

One of the crucial components in WiMAX technology is antenna. For its flexible usage, the installed antenna should be able to operate in both 2.3 GHz and 3.3 GHz frequency band.

In addition, for mobile appliances installation such as laptop or tablet, the installed antenna should have a relatively small dimension. Numerous researches on monopole microstrip antenna, including those with octagonal shaped patch and those with coplanar waveguide (CPW) fed, have been conducted [1-4]. However, these antennas have not fulfilled the specification like antenna [1].

Despite its wide bandwidth, the shape is not simple and did not include the 2.3 GHz frequency band. An octagonal shaped antenna has been researched by N. Gunavathi dan S. Raghavan [2], however the operating frequency only operates at 5 GHz upwards. Hence, it cannot be used in WiMAX application in Indonesia. Research on microstrip antenna with octagonal shaped patch was done by Cheng-Hsing Hsu et al. [3] However; its lowest antenna frequency was around 3 GHz without CPW fed. Monopole wideband CPW fed microstrip antenna was studied by K. P. Ray and S. Tiwari [4].

However, the hexagonal shaped patch and its relatively large size is not suitable for mobile appliances usage. This paper will discuss on the design of octagonal CPW fed microstrip antenna which operates at 2.3 GHz and 3.3 GHz frequency band for VSWR < 2. The designed antenna has the largest dimension of 45 mm x 30 mm x 1.6 mm. Recently, design of multiband antenna for wireless communication has become a challenging topic.

Microstrip patch antennas are widely used for designing multiband antenna due to their extraordinary features like low profile, compact size and easily fabricated.

II. ANTENNA DESIGN

Single microstrip patch antenna which contains of single microstrip feeding line along with coplanar ground planes. This antenna contains two L-slots on the patch in order to achieve a peak value of gain so that a dual-band of operation can be obtained simultaneously. The proposed antenna uses an aluminum nitrate ceramic substrate with dielectric constant 8.8 and loss tangent value of zero.

The design of microstrip antenna involves the selection of antenna substrate, antenna patch shape, and determination of shape and CPW slot. Antenna patch is octagon in shape with eight sides. The type of substrate being used is FR4 with1.6 mm thickness and dielectric constant ε = 4.6. This substrate is selected because it is available in local market, reducing the necessity to import, and relatively inexpensive. The CPW configuration used for antenna fed can be seen in Figure 1.

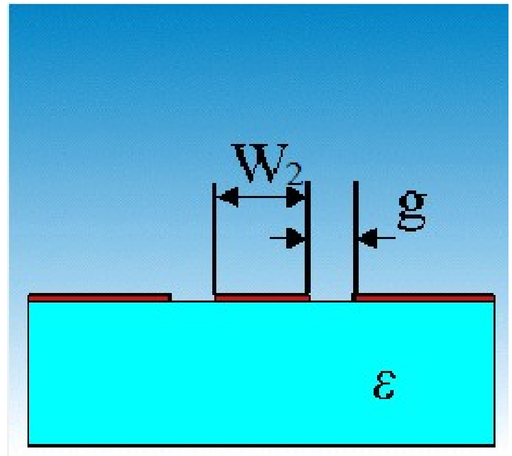

Figure 1 CPW Configuration

The CPW impedance value is determined by the conductor width (W2), gap (g) between conductor and ground plane on the left and right side and dielectric constant (ε). One of the advantages of antenna patch CPW fed is easy for series and parallel circuit usage with active and passive elements that are required to improve gain or to adjust the impedance, and easy integration with monolithic microwave integrated circuit (MMIC).

The initial design is based on [4] whereby the antenna has a hexagonal shape. The dimension of octagonal monopole antennas are estimated, modifying the formula for planar hexagonal monopole antenna [4]. The lower band edge frequency corresponding to VSWR = 2 of this antenna.

From [4], The empirical value of k = 1,15, for FR4substrate with εr = 4.4 and h = 1,59 mm, approximates the lower resonance frequency for VSWR = 2 within 10%. The dimension of proposed antenna is smaller than antenna in [4]. The value of R in antenna [4] is 26 mm, whereas in the proposed antenna the value of R is 13 mm. The details of antenna dimension can be seen in Table 1.

Antenna simulation and optimization were done with the help of 3D electromagnetic simulator software with Finite Integration Technique (FIT) method. The software used in this simulation is able to display several parameters which indicate antennas performance, including return loss, VSWR, impedance, gain, and radiation patterns where those parameters are use.

III. SIMULATION RESULTS AND DISCUSSION

Table: 1 Antenna parameter size

No	Parameter	Size (mm)
1	W	33
2	L	43
3	R	13.2
4	S	2.53
5	L1	15.5
6	W1	13.8
7	W2	2.04
8	g	0.502

In this section, the simulation results of return loss, VSWR, radiation pattern and gain of single patch antenna and double patch antenna array are simulated using Ansoft HFSS and presented. Fig 3 shows simulated return loss of single patch antenna, it is observed that the simulated return loss value for the WiMAX frequency.

The results of antenna simulation and optimization with the above mentioned software. The simulation results presented includes the influence of the number of sides in patch, magnitude of R, S and L1 value towards return loss or antenna S-parameter, return loss and VSWR based on the size of antenna as seen in Figure 2, impedance, gain, and antenna radiation pattern. The antenna's operating frequency is determined by its own dimension. In the context of microstrip patch antenna, the operating frequency depends on the patch dimension. Figure 2 illustrates S-parameters for varying R values. This figure shows that the greater the R value, the further S-parameter shifted to the left, towards the lower frequency. This can be understood as the antenna dimension is proportional to wavelength or inversely related to frequency.

With regard to the antenna impedance created to match 50Ω connector, the created CPW also need to have 50Ω impedance. Hence, the W2 and g parameter are designed so that the value will fall at 50 Ω for the value shown in Table 1.

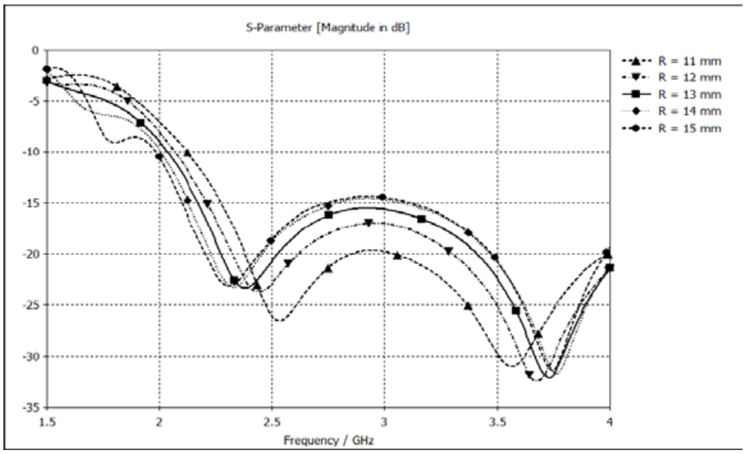

Figure 2 S-Parameter for different R value

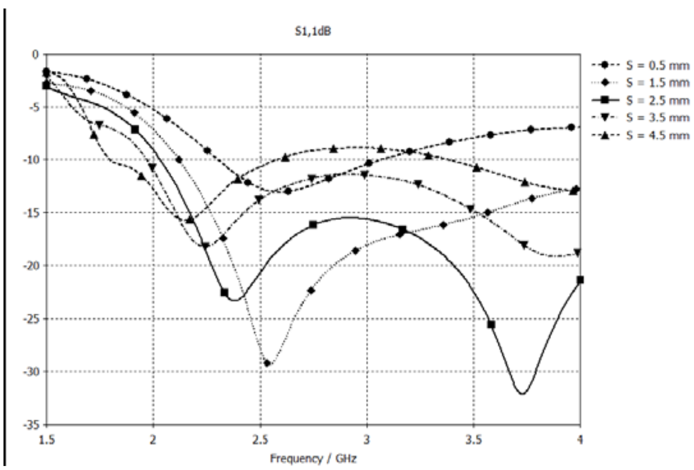

Figure 3. S-Parameter for different S value

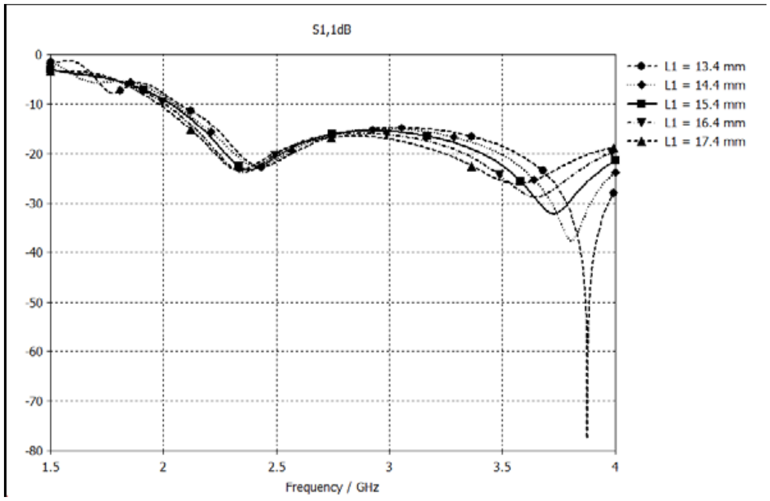

Figure 4 S-Parameter for different L1 value

In order to obtain optimum results, parameter optimization is required for those determining impedance matching. For the purpose of impedance matching, the author did optimization towards S and L1 value. Figure 3 and 4 illustrates S-parameter graphs towards different S and L1 value, where other parameters remain constant.

It can be seen from Figure 3 that there is a high influence of S value towards S-parameter. The most optimal return loss is obtained at S value = 2.5 mm. For S value = 0.5 mm and 4.5 mm, the antenna bandwidth is very narrow, while for S value = 1.5 mm and 3.5 mm, the bandwidth is quite wide, however its return loss is not as good as at S = 2.5 mm. This can be seen in Figure 4.

After several antenna simulations and optimizations, the author found that the optimal antenna dimension is shown in Table 1. The following are the simulation results based on the antenna dimension.

A. Return loss and VSWR the design of proposed antenna is aimed for the WiMAX application which includes frequency band of 2.3 GHz (2.3 – 2.4 GHz) and 3.3 GHz (3.3 – 3.4 GHz). Figure 6 shows that between 2.3 GHz and 3.4 GHz, the antenna return loss is below -10 dB, and even lower than -15 dB. Therefore, this antenna can be implemented in WiMAX application in Indonesia which utilizes frequency band of 2.3 GHz and 3.3 GHz. This is because at 4 GHz, the antenna return loss value is still below -20 dB, as illustrated in Figure 5.

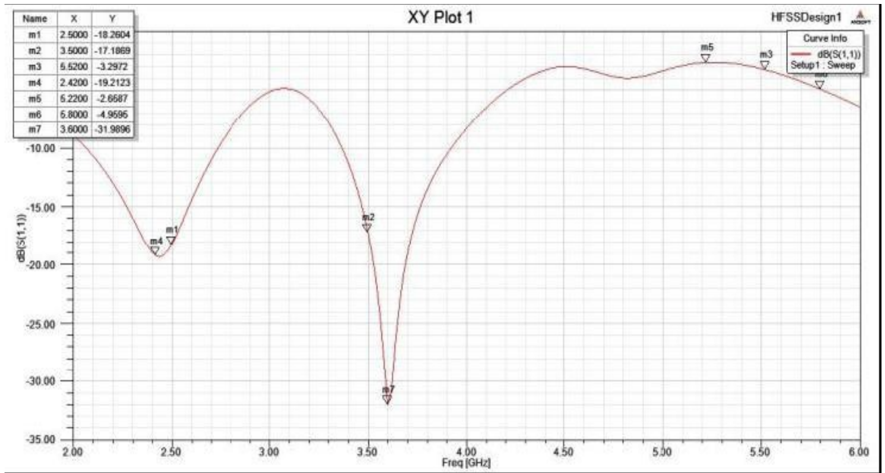

Figure 5: Return Loss

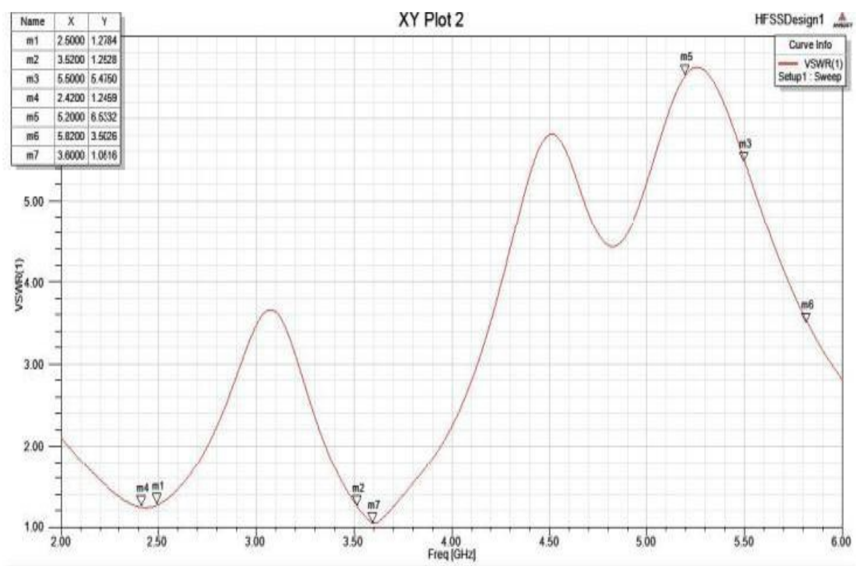

Figure 6: VSWR

Figure 6 shows the proposed antenna VSWR, whereby at frequency range from 2.3 GHz to 3.4 GHz, the VSWR value is less than 1.5. B. Radiation pattern and gain below is the results of simulation of antenna radiation pattern at frequency of 2.35 GHz and 3.35 GHz. Those two frequencies are selected because it is the middle frequency from each frequency band, 2.3 GHz and 3.3 GHz. The antenna radiation pattern for E plane and H plane at frequency 2.35 GHz and 3.35 GHz are illustrated in Figure 8 and 10. On the other hand, the 3D radiation pattern at 2.35 GHz and 3.35 GHz can be

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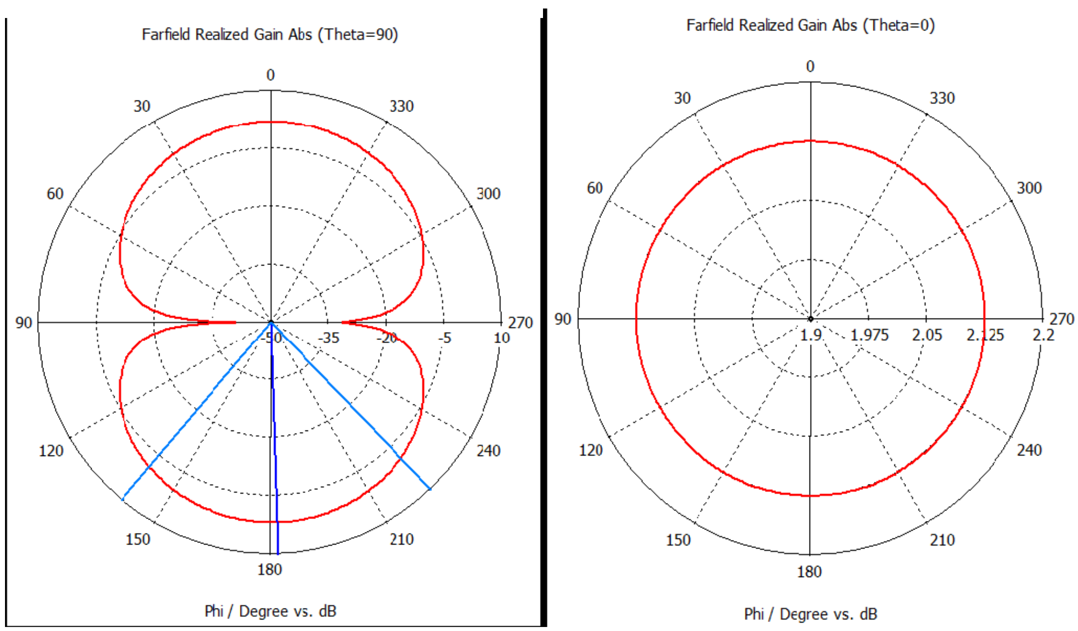
seen in Figure 8 and 10, respectively. Figure 7 to 10 shows the omnidirectional radiation pattern for the proposed antenna. This is according to the characteristics of monopole or dipole antenna in general.



Side E **Side H**

Figure 7: Antenna Radiation Pattern at 2.35 GHz

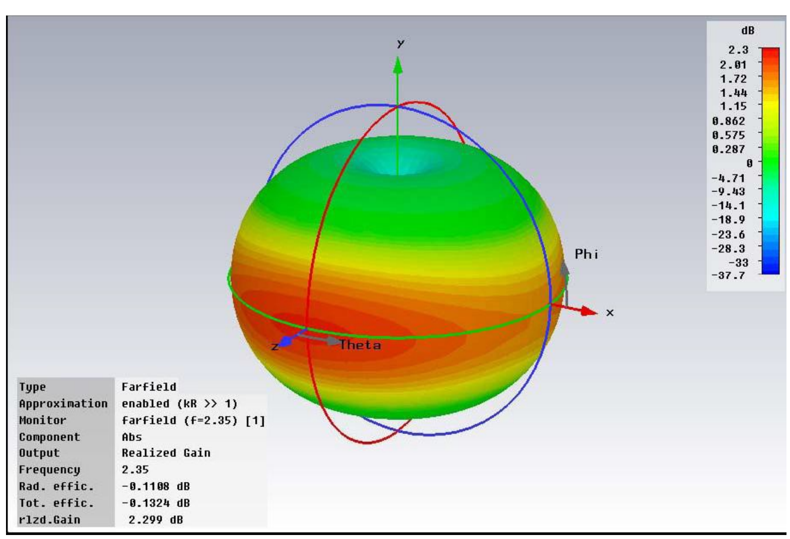
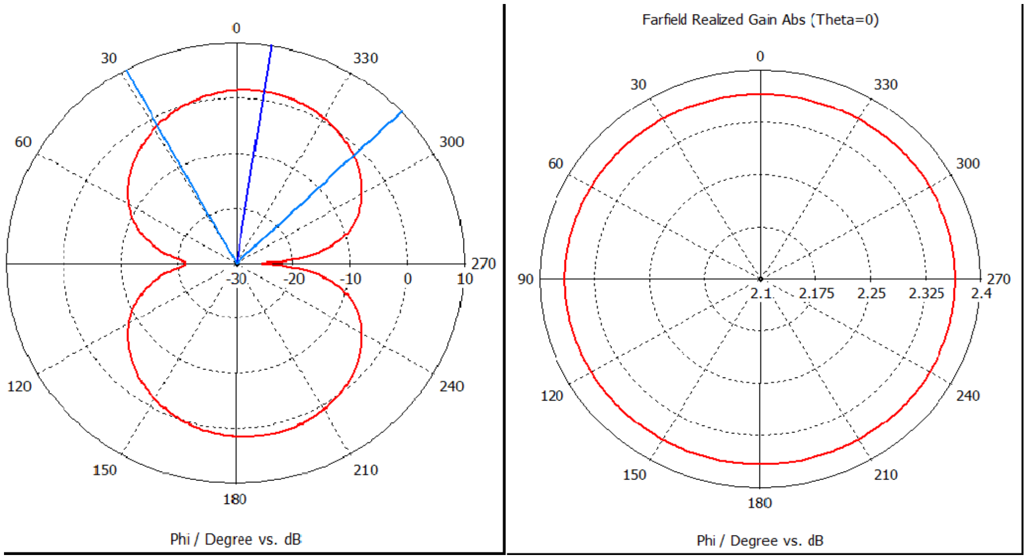


Figure 8 3D antenna radiation pattern at 2.35 GHz frequency



Side E **Side H**

Figure 9: Antenna Radiation pattern at 3.35 GHz

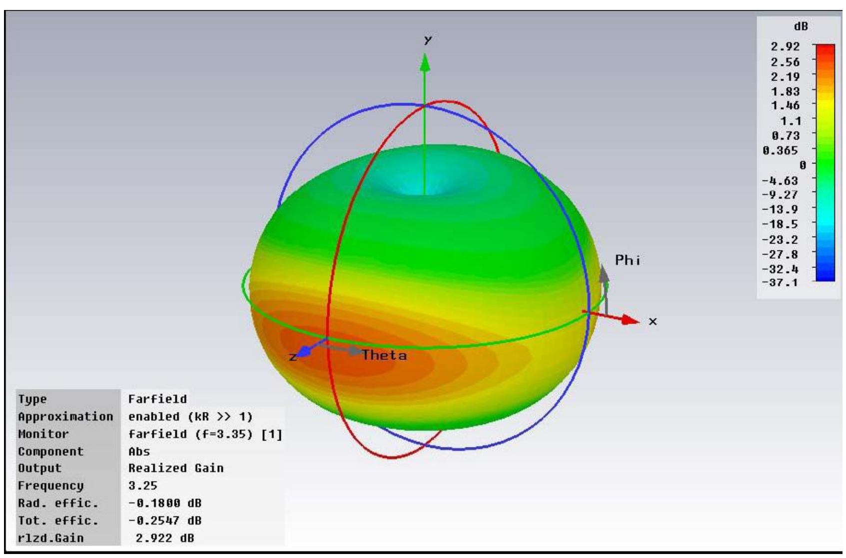


Figure 10 3D antenna radiation pattern at 3.35 GHz frequency

The graph illustrating antenna gain for frequency range between 2.3 GHz and 3.4 GHz is shown in Figure 11. Antenna gain refers to the maximum antenna gain for each frequency. For each frequency, the value of antenna gain may vary according to its direction. As demonstrated in Figure 8 and 10, the antenna gain differs in each direction, presented in different color. Figure 11 shows that antenna gain has the tendency to increase at higher frequency. The value ranges from 2.26 dBi to 3.06 dBi. This can be understood as the higher the frequency, the radiation pattern does not follow omnidirectional pattern completely, as seen in Figure 8 and 10.

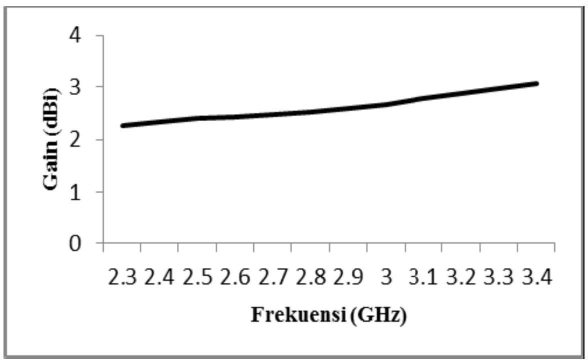


Figure 11: Antenna Gain

IV. CONCLUSION

Design of a microstrip monopole wideband antenna with CPW feed has been discussed. The proposed antenna dimension is 30 mm x 45 mm x 1.6 mm. The substrate antenna uses FR-4 material with dielectric constant of 4.6. The simulation results suggests that the operating frequency ranges between 2.3 GHz and 3.4 GHz for VSWR of less than and bandwidth greater than 2000 MHz for VSWR less than 2. The maximum antenna gain varies from 2.26 dBi to 3.06 dBi with omnidirectional radiation pattern. The operating frequency includes frequency band of 2.3 GHz and 3.3 GHz, hence this antenna can be implemented for WiMAX applications.

REFERENCES

I. L. Zhu, K. L. Melde, "On-wafer measurement of microstrip-based circuits with a broadband via less transition", IEEE Trans. Adv. Packag., vol. 29, no. 3, pp. 654-659, Aug. 2006.

II. G. Kompa, Practical Microstrip Design and Applications, MA, Norwood: Artech House, pp. 175-181, 2005.

III. Chu, Qing-Xin and Liang-Hua Ye, Design of Compact Dual-Wideband Antenna with Assembled Monopoles, 2010, IEEE Transactions On Antennas And Propagation, Vol. 58, No. 12, Page(s): 4063 – 4066.

IV. Gunavathi, N. and S. Raghavan, 2010, A CPW- fed Octagon Shaped Antenna for 5GHz WLAN and Higher Band UWB Applications, IEEE 2010 International Conference on Computing Communication and Networking Technologies (ICCCNT).

V. Hsu, Cheng-Hsing, et al., 2012, Planar Octagon Monopole Antenna for UWB Applications, IEEE 2012 Sixth International Conference on Electromagnetic Field Problems and Applications (ICEF).

VI. Ray, K. P. and S. Tiwari, 2008, Vertex Fed Printed Hexagonal Monopole Antenna, IEEE.

VII. T. Yuasa, T. Nishino, H. Oh-Hashi, "Simple design formula for parallel plate mode suppression by ground via-holes", 2004 IEEE MTT-S Int. Microwave Symp. Dig., vol. 2, pp. 641-644, 2004-Jun.-611.

