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Simulation of Bradband Rectangular Monopole Antenna

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Abstract: *To design an antenna, especially broadband monopole planar rectangular antenna that was printed on printed circuit board (PCB) consists of a rectangular patch and a ground plane. Beside of mathematical procedure, this design step needs a simulation to get more accurate hypothesis. At this paper, the simulation software that used by author is Ansoft-HFSS that can be used for designing and simulating the antenna with more detail and more accurate result. The result of this software will be compared with measurement result. Even though the simulation result and measurement result of presented antenna has differences, both of them (the simulated antenna and presented antenna) can work at frequency range 1.5 GHz until 2.7 GHz that means can be used for commercial communication technology such as HSDPA, Wimax, Bluetooth and wifi.This suggest that once the antenna is a broadband antenna that has very large bandwidth.*
Keywords: *Rectangular monopole antenna, Printed circuit board, Ansoft-HFSS*

I. Introduction

The use of a single wideband antenna which covers a wide range of frequencies is very desirable for many applications including wireless and high data rate communication, position and tracking, sensing and imaging, and radar. Planar plate monopole antenna is a candidate of the antenna. They are interesting to be simulated due to their broad impedance bandwidth, linearly polarized unidirectional radiation pattern and low cost construction.,where a thin planar metal element can be used instead of the traditional wire element of a monopole antenna. Antennas with small size are generally constructed in microstrip concept with various forms. Basically, a microstrip antenna has a narrow bandwidth due to the high quality Q factor reaches the value of 100 (Balanis, 2005:822), but research results have shown that the microstrip antenna with very wide field of frequency bands has been generated (Mazinani and Hassani, 2009, Ahmad and Jar'alla, 2008, Azari and Rowhani, 2008, and Promburt, 2009). According to study of Mazinani and Hassani, 2009, Ahmad and Jar'alla, 2008, Azari and Rowhani, 2008, and Promburt, 2009, rectangular patch and ground of antenna are built on printed circuit board and other material such as alumina. For microstrip structure, a high quality dielectric materials such as FR4 or Roger 4003 is usually the chosen printed circuit board. Researches of antennas relate to frequency of mobile communication have been conducted and reported but a broad band planar antenna that works in the range from 1.5 to 2.7 GHz is still a bit done. The reported researches such as from Ray and Rangga (Ray and Rangga, 2006: 1693-1696), Faraz, Imran, Syed, and Abid (Faraz, Imran, Syed and Abid, 2011:8-11) and Kshetrimayun (Kshetrimayun, 2008:474-480) usually use commercial simulator software to simulate their design such as Advanced Design System (ADS software), and IE3D so that the researchers can estimate the results of their work. However, a software such as Ansoft-HFSS is rarely used to simulate the designed antenna because it is complicated and the limitation of the Ansoft-HFSS itself.UsingAnsoft-HFSS for designing and simulating the antenna is to get more detail and accurate antenna size and simulated result after realization of designed antenna.Based on the reasons stated above, the authors are eager to study, simulate broadband planar rectangular monopole antenna (Alkurbo, Pramono And Santoso 2012) using Ansoft-HFSS.

II. Design and Simulation

The headings and subheadings The dimensions of antenna were estimated using formulation given for planar disc monopole antenna. The lower frequency for VSWR =2 is given as (Kumar and Ray,2003):

$$2\pi r L = WL \quad (1)$$

Which gives

$$r = \frac{W}{2\pi} \quad (2)$$

The input impedance of a ¼ monopole antenna is half of that of the ½ dipole antenna. Thus, the input impedance of an infinitesimally thin monopole antenna is 36.5 + j 21.25 Ω, which is inductive. The real input impedance is obtained when a slightly smaller length of the monopole is used as given by (Kumar and Ray , 2003):

$$L = 0.24l\ \lambda\ F \quad (3)$$

Where

$F = \frac{L/r}{1+L/r} = \frac{L}{L+r}$ so that the wavelength λ is obtained as : λ=(L + r)/0.24 ,Therefore, the lower frequency f L is given by:

f L = c/λ = (30 x 0.24) / (L + r) = 7.2/(L + r) GHz (4)

where, L is the length of the monopole, r is the effective radius of an equivalent cylindrical monopole antenna and p is the length of the feed line in cm.

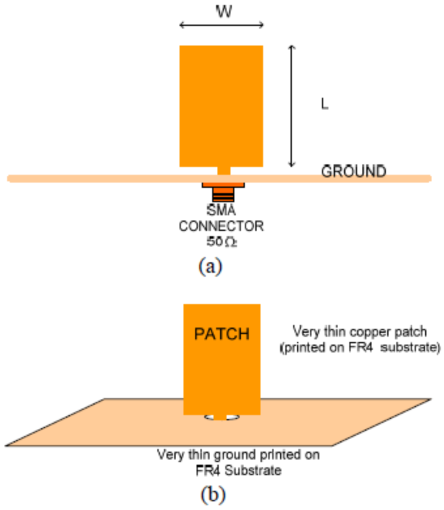

Figure1: Printed Rectangular Monopole Antenna (a) front view (b) actual shape

However, unlike the planar disc monopole antenna, this configuration has dielectric layer on one side of a printed monopole.This dielectric material increase the effective dimensions of the monopole leading to reduction in the lower frequency. This is also confirmed by simulation studies. Hence, appropriate equation for the lower frequency is given as (KP Ray and Ranagga, 2006):

f L = 7.2/(L + r + p) GHz (5)

For lower frequency side of 1.5 GHz, and p and r are assumed to 0.4 cm and 0.1 cm respectively, so that the length (L) of radiator is 43 mm. The width of radiator can be calculated by W= 2πr so that W = 25.1 mm. A printed rectangular patch on a printed circuit board can be treated as thin plate so that the presented antenna can be assumed as rectangular planar monopole. The reason is as follows, the skin depth of current on copper that has resistivity 1.724.10-8 ohm per meter can be calculated by skin depth (Hund,1989) , (m)= $\sqrt{\frac{r}{\pi f \mu}}$ where r is resistivity in ohm per meter, f is frequency in Hz, and μ is permeability in Henry per meter. At frequency of 1.5 GHz, the value of skin depth is 1.7μm, so that the thickness printed copper on PCB of 25 μm is much greater than requirement. From the calculation result it can be concluded that the printed radiator can be treated as a thin plate. The length of ground should be greater than 2x ¼ λλ (Balanis, 2005:511), so that the size of ground plane of 6 cm x 10.5 cm is adequate to fulfill the ground criteria.

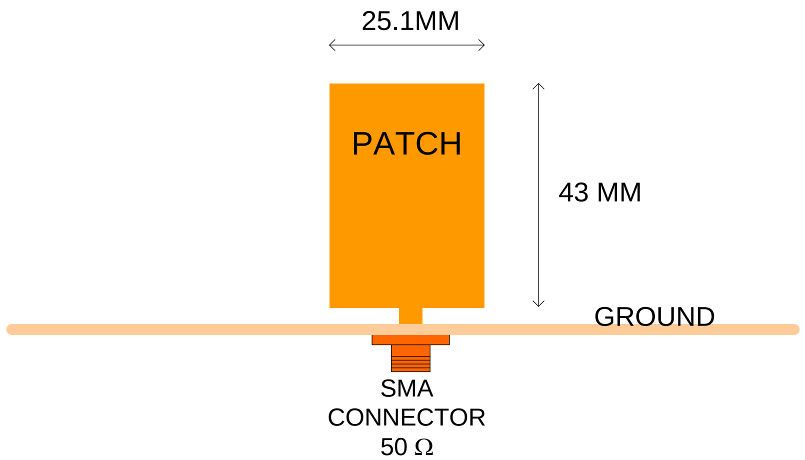

Figure (2): Dimension of presented Antenna

III. Simulation

The aim of simulation is to get predicted characteristic of presented antenna using Ansoft-HFSS software. By applying that software researcher can design and simulate the antenna easily. The following chart explains several steps to design and simulate the presented antenna

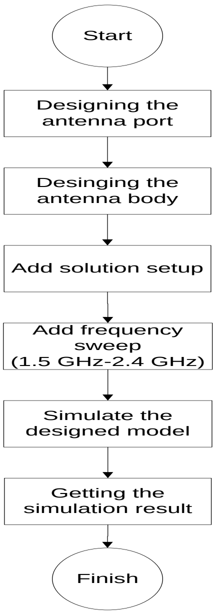

Figure3: Flowcharts of antenna design and simulation

1. Designing the Antenna Port

To design an antenna with Ansoft-HFSS, researcher must design antenna port at first. The antenna port that will be used for realized antenna is SMA connector. Port model must be same as real port including the shape of port, material of port, and port size. Port designing can be done with following steps as below

1. Draw the box with coordinate position 0, 0, 0; x size 12 mm; y size 12 mm; and z size 2 mm
2. Draw the cylinder with coordinate position 6,6,0; radius 2.75 mm; and height 2 mm
3. Subtract the box with cylinder
4. Assign the subtracted box material as copper
5. Draw the cylinder with coordinate position 6,6,-2; radius 3 mm ; height 7.5 mm
6. Draw the cylinder with coordinate position 6,6,-2; radius 2.75 mm; height 7.5 mm
7. Subtract the cylinder on number 5 with cylinder on number 6
8. Assign the subtracted cylinder material as copper
9. Draw the cylinder with coordinate position 6,6,2; radius 2.75 mm; height 11.5 mm
10. Draw the cylinder with coordinate position 6,6,2; radius 0.635 mm; height 11.5 mm
11. Subtract the cylinder on number 9 with cylinder on number 10
12. Assign subtracted cylinder material with Teflon
13. Draw cylinder with coordinate position 6,6,2; radius 6.35 mm; height 11.5 mm
14. Assign the cylinder material with copper

After those steps, the result as shown below

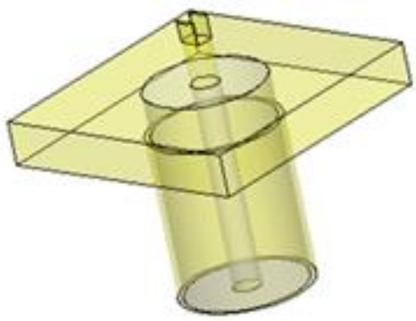

Figure4: The port model

2. Designing the Antenna Body and Ground Plane

After design the antenna port, researcher must design antenna and ground plane. The size of antenna and ground plane model must be same as antenna size that will be realized.teh size of antenna and ground plane is defined by mathematical calculation at section 4.1. The following steps to design ground plane and antenna body as shown below

1. Draw the box with coordinate position -30 ,-52.5 ,0; x size 60 mm; y size 105 mm; z size 2 mm
2. Draw the cylinder with position 0,0,2; radius 2.75 mm; height 2 mm
3. Subtract the box with the cylinder
4. Assign subtracted box with aluminum
5. shift point of view into YZ axis
6. draw the box with coordinate position -0.418 ,-12.55 ,2; x size 0.836 mm; y size 25.1 mm; z size 47mm
7. assign the box material with FR4-Epoxy
8. draw rectangle with coordinate position 0.418 ,-12.55 ,49; axis x; y size 25.1 mm; z size 43 mm
9. draw rectangle with coordinate position 0.418 ,0.5 ,2; axis x; y size 1 mm; z size 4 mm
10. unite rectangle at number 8 and rectangle number 9

The result of modeling an antenna shown below

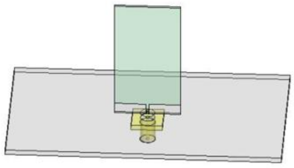

Figure5: The antenna model.

3. Add Solution Setup

Before start simulate, researcher must add solution setup for antenna model. Solution setup consists solution frequency and adaptive solution to make sure software can simulate the model. The figure of add solution setup shown below

Figure 6: Solution setup

4. Add Frequency sweep

Frequency sweep consist of range of frequencies that will be used for simulation with value can be changed by researcher. The figure of add frequency sweep can be shown below

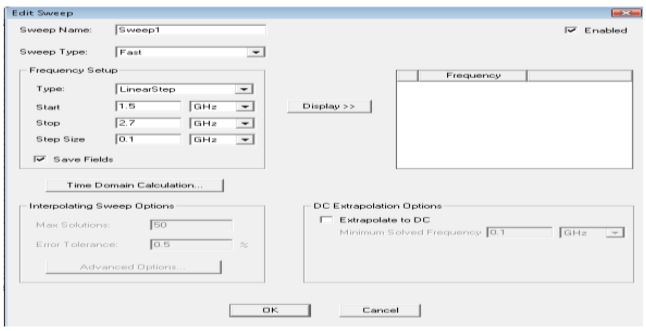

Figure7: Frequency sweep

5. Simulate the Designed Model

If the solution setup and frequency sweep has been set, only click the analyze icon ( ) simulation will be started.

IV. Getting the Result and Discussion

After simulation has been done, researcher can get the simulation data result. Researcher only with click menu HFFS then click result, the simulation result that consist of antenna parameter can be shown

Simulation Result

1. VSWR and S11 Result

Simulation using Ansoft-HFSS results VSWR, S-Parameter, radiation pattern, and gain displays. The VSWR and S-parameter figure a basic parameter of an antenna because it represents power of antenna that can be transmitted and reflected.

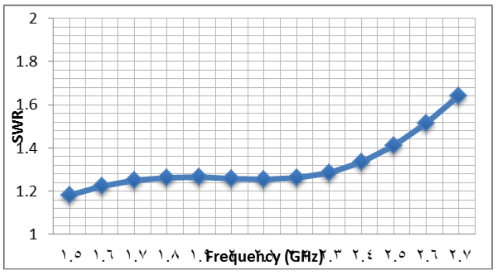

Figure 8: VSWR versus frequency from simulation result

Simulation result of the VSWR shows that the value of VSWR is different from one frequency to another. The value of frequency increases from nearly 1.2 at 1.5 GHz and 1.3 at 2.3 GHz. The data shows that the SWR level of the antenna is less than 2. It means that SWR tends to close with how much mismatched at propagation media and antenna losses. The best condition when VSWR=1. It means ideally matched. However ideally matched condition cannot be reached, hence VSWR can be tolerated 1<VSWR<2 2 (Punit,2004:19)..

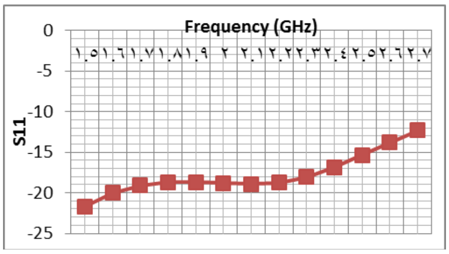

Figure 9: S-Parameter versus frequency from simulation result

Figure 9 shows the level of S-parameter at difference frequencies. Negative value means that the losses of antenna are decreased. While the energy transmitted is increased. It also means that the mismatched propagation line is decreased. According from theory, the good antenna must have S-Parameter value below -9.54 dB or that means 10% of energy is reflected and 90% of energy is absorbed and transmitted/received (Punit, 2004:9).There are differences between measurement and simulation results. Some reasons can be considered, first, the construction is not absolutely the same especially at feeder point. Feeder at simulation did not represent as SMA connector that has impedance of 50 ohms. Second, the distance between patch and ground of the both antenna is not exactly the same.

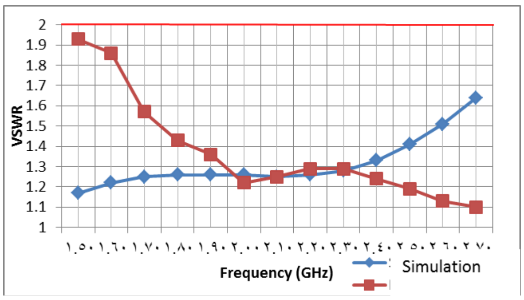

Figure10: VSWR versus frequency from simulation and measurement

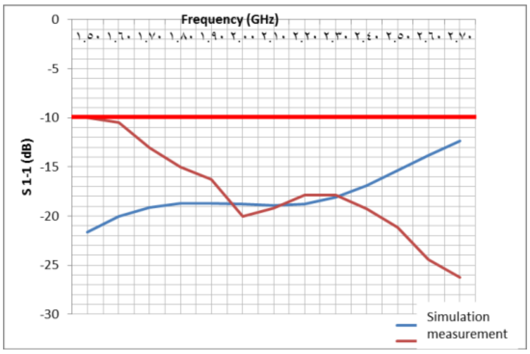

Figure11: S11 versus frequency from simulation and measurement

Researcher compares VSWR and S-parameter from simulation and measurement as shown at Figure 10 for VSWR, and Figure 11 for S-Parameter (S11). At simulation result, researcher get that the lowest VSWR level at 1.5 GHz is at 1.19 and s11 level is at 23 dB and the highest is at frequency 2.7 GHz with VSWR level at 1.66 and s-parameter at -14 dB. But it was very different if we look the result from measurement. At the result, the lowest VSWR level was at frequency 2.7 GHz with the VSWR level at 1.1 and s-parameter level is at -26.2 dB. However, in generally, VSWR and S- Parameter, both at simulation and measurement result obtained of value below 2 for VSWR for all frequencies and below -10 dB for S-Parameter for all frequencies.
The percentage of differentiation can be obtained from
Diff (%)=((simulation result-measurement result))/(simulation result)×100%

Simulation result is used for divider because the value from simulation result is the hypothesis value and it is used for reference value. 2 for VSWR, the smallest difference is 0 % at 2.1 GHz. It means that both of simulation and measurement shows same result at frequency 2.1 GHz. Besides that, the biggest difference is 64.96% at 1.5 GHz. It means that simulation result and measurement result is totally different. 3 for S-Parameter, the smallest difference is 1.16% at 2.1 it means between simulation and measurement result is relatively close. For the biggest difference is 112.66% at 2.7 GHz.The result from simulation and measurement can be different. The simulation result is given by mathematic expression, with ideal condition or that means no losses especially unidentified losses which calculated. At measurement result, it is given from real condition when researcher measure the antenna, such as researcher can get losses at measurement process or researcher can make failure at measurement process.

2. Radiation Pattern Result

Radiation pattern of simulated antenna in Figure 10 shows that the energy radiated at azimuth plane is nearly same at all direction.

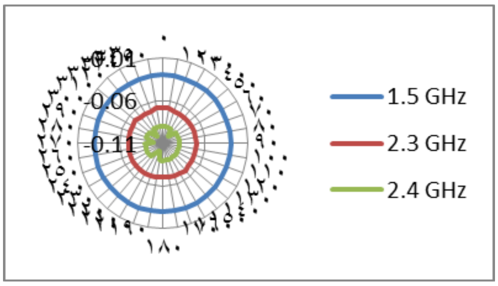

Figure12: Radiation pattern on azimuth plane from simulation result

According to the simulation, the antenna can be radiated maximally at most of azimuth. It also shows that the antenna is Omni directional and this is match with geometry of antenna (monopole antenna). At ideal condition radiation pattern has same size at all direction or usually called isotropic. However, at reality, isotropic condition cannot be applied, only can be approached with Omni directional antenna, such as monopole antenna (Balanis, 2005:33). If comparing the radiation pattern from simulation result and measurement result are totally different. In simulation result, the radiation pattern is almost nearly perfect. Nearly perfect means, that each value of radiation pattern is nearly same from each other. Thus, it can be looked nearly perfect but it is not perfect. Then, when look at measurement result, it can be shown clearly. The radiation pattern from each azimuth is looked different each other.

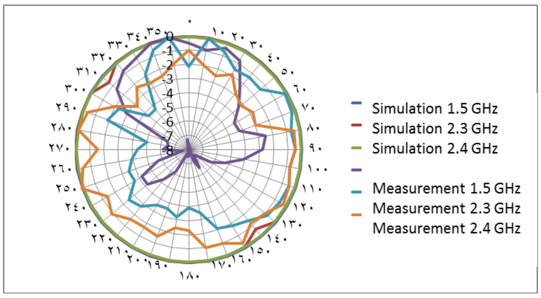

Figure13: Radiation power from simulation and measurement

According figure 13, especially at measurement result, shows that radiation pattern is almost perfect in every direction and every measured frequency. It means that the monopole antenna is Omni directional.The differences between measurement and simulation result is caused by the condition when measurement process, such as losses from propagation media, interference signal, losses transmission line (mismatched) or from measurement device.

3. Gain Result

Another parameter displayed by the simulator of the antenna is its gain refers to energy radiated by antenna at certain direction when compared to a reference antenna at the same distance and the same input energy. The reference antenna chosen is dipole antenna or isotropic antenna.

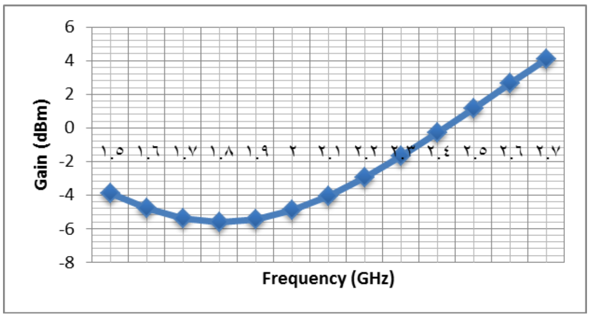

Figure14: Gain versus frequency from simulation result

Gain of an antenna (in a given direction) is defined as "the ratio of the intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically (Balanis, 2005:66). Figure 14 shows that the gain antenna depends on the frequency. The minimum gain of -5 dBm occurs at frequency 1.8 GHz and maximum gain (4 dBm) occurs at frequency of 2.7 GHz

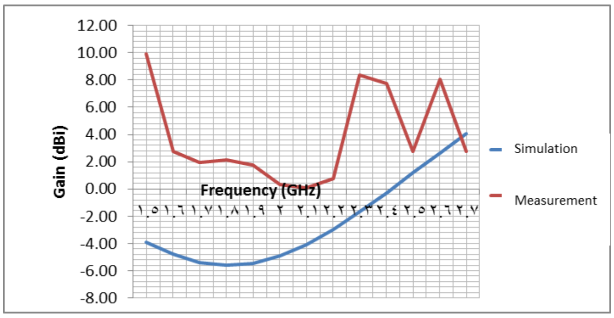

Figure 15 Antenna gain from simulation and measurement

There are many differences if comparing the result at simulation and measurement. The simulation result shows that it has negative value at 1.5 GHz until 2.4 GHz. It means that the gain of the antenna is not good according the simulation result but at measurement result shows that the gain of antenna only have positive value or it can categorized into quiet high.Gain with minus value means that the signal power which is transmitted/ received will be decreased and otherwise. It can be approved by according to Effective Isotropic Radiated Power (EIRP) equation. (Young, 2004:3).

EIRP= antenna gain (dBi) + transmitted/received power (dBm)

According the Figure 13, especially from measurement result, obtained gain value with more than 0 dB. It means that according EIRP, the radiated power can be increased at each frequency. Differences of gain result from simulation and measurement is caused at simulation gets the data with ideal condition and at measurement several problems can take effect of the result, such as losses at propagation line and failure at measurement procedure.

V. Conclusion

There were differences of parameter between simulation and measurement, result of simulation showed that from 1.5 GHz until 2.7 GHz, VSWR level was increased from 1.18 until 1.74 but at measurement showed that at same frequency range VSWR was decreased from 1.5 until 1.1. It was also happened in another antenna parameter, the simulation result showed that gain of antenna had positive value only at frequency range 2.3 GHz until 2.7 GHz, but in measurement the positive gain was happened at all range frequency (1.5 GHz-2.7 GHz). Other parameters showed also the same, radiation pattern at simulation shows nearly the same for all azimuths, but in measurement showed that the radiation pattern had various level at each azimuth and the result of polarization, in the simulation showed that polarization nearly same for all azimuths but in measurement it was in minimum level of polarization at azimuth 90 degrees and maximum level polarization was at 0 degree.

Acknowledgements

An The differences of parameter between simulation and measurements were caused of several factors, such as mismatched at transmission line, losses at propagation media, or losses of component at measure device.

References

[1] Ahmad and Jar'alla, "Design and Simulation of Broadband Rectangular Microstrip Antenna". Eng. Tech Vol. 26 No.1, 2008s.

[2] *Azari. A and Rowhani. J, "Ultra Wideband Fractal Microstrip Antenna Design" , Electromagnetic Reseach C , Vol 2,2008, P. 7-12*

[3] *Azim, Tariqul and Misran, "Compact Planar Antenna for UWB Applications", International Review of Electrical Engineering 5 (4) pp. 1848-1852, 2010.*

[4] *Balanis, C.A, "Antenna Theory: Analysis and Design", John Wiley and Son, New Jersey, 2005.*

[5] *Dubost&Zizter, "Antennas a Large Band", Masson, Paris, 1976, P. 128-129*

[6] *Faraz, Imran, Syed and Abid," Design of an Ultra Wideband Monopole Antenna for Handheld Devices", ASIAN JOURNAL OF ENGINEERING, SCIENCES & TECHNOLOGY VOL. 1 ISSUE 1, 2011, P. 8-11*

[7] *Huang and Boyle, "Antennas from Theory to Practice", Wiley, UK, 2008.*

[8] *IEEE, "IEEE Standard Test Procedures for Antennas", IEEE Standard Board, New York, USA, 1979.*

[9] *Kshetrmayun, 2008, "Printed Monopole Antennas for Multiband Applications", International Journal of Microstrip and Optical Technology, Vol 3. No.4, 2008, P. 474-480*

[10] *Kumar and Ray, "Broadband Microstrip Antennas", Artech House, UK, 2008.*

[11] *Lu Wong, "Compact and Broadband Microstrip Antenna", John Wiley, UK, 2002.*

[12] *Mazinani and Hassani, "Novel Omnidirectional Broadband Planar Monopole Antenna With Various Loading Plate Shapes", Progress in Electromagnetic Research, PIER 97, 2009, P.241-257*

[13] *Meinke, H and Gundlach, F.W, 1968, Taschenbuch der Hochfrequenztechnik, Springer-Verlag, Berlin, New York, 1968, pp. 531-535.*

[14] *Milligan, "Modern Antenna Design", Wiley-Interscience, Hokoben, New Jersey, 2005.*

[15] *Nakar, PunitShantilal, "Design of a compact Microstrip Patch Antenna for use in Wireless/Cellular Devices", http://diginole.lib.fsu.edu/etd/2790, Florida, USA, 2004. (Accessed at December 21st 2012)*

[16] *Nalbantoglu and Yanik, "A Multiband Rectangular Patch Antenna For Wireless Communication", Research Paper , Subanci University, 2004, P.4-16*

[17] *Pillalamari, Bhusana and Kumar, 2010. "Novel Printed Rectangular Patch Monopole*

[18] *Antenna with Slit Ground Plane for UWB Application". The NEHU Journal Vol.VIII. No. 1. January 2010. P. 79-87*

[19] *Prombutr.PKirawanic and P Akkaraekthalin, "Bandwidth Enhancement of UWB Microstrip Antenna with a Modified Ground Plane", HindawiPublising Corporation, internationajJournal of Microwave Science and Technology Volume 2009 artical ID 8215115.*

[20] *Rashid A and Saeed, "Design of Microstrip Antennas for WLAN", Journal of Applied Science 5(1), 2005, P.47-51*

[21] *Ray, K.P.; Ranga, Y.; , "Printed rectangular monopole antennas," Antennas and Propagation Society International Symposium 2006, IEEE , vol., no., pp.1693-1696, 9-14 July 2006*

[22] *Schaubert, Daniel and Pozar, David, "Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays", Wiley, USA, 1995, P. 158*

[23] *Sinnema, W," Electronic Trasmission Technology", Prentice Hall, New Jersey, USA, 1988, p 15 – 17 Young, "Understanding Decibels and Their Use in Radio System", YDI Wireless, USA, 2004, p 3 Alkurbo,Pramono, Santoso"Design and Construct of Broadband Printed Rectangular Monoplee Antenna" Journal of Electroniccs and communication Enginering volum2, Issue 4 (Sep.-Oct. 2012), PP 20-24.*