ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

3D Design& Gain Analysis of Dipole Antennawith Integrated Frequency Level

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ABSTRACT:This paper examined properties and radiation pattern of Dipole antenna. A brief review is presented here to demonstrate some properties & radiation pattern in 3D.In order to verify the simulation result need to solve some equation. The behaviour of Dipole antenna is analysed through simulation. Its performance investigated by simulation results obtained from -180 degree to +180 degree for rE total and obtained a good gain around 0.3 GHz. Dipole antenna mainly use in order to reduce the effective area of the receiving antenna to receiving microwave power in high electric field regions.It's also Converting electromagnetic radiation in space into electrical currents in conductors or vice-versa, depending on whether it is being used for receiving or for transmitting, respectively. Passive radio telescopes are receiving antennas.

KEYWORDS: Feeder antenna, Omni directional, Near and Far field, Ansys HFSS.

I.INTRODUCTION

Requirements for wider bandwidth capabilities, higher bit rates, and better quality of services are crucial for telecommunication applications. Scientific and engineering community provides a number of novel techniques and methods to meet these requirements. These offer efficient improvements on the throughput of the wireless systems and are usually applied on compatible radiation structures, provided by single or multiple-element antenna architectures. These were further studied in terms of radiation efficiency and performance. Besides, the dipole antenna with integrated balun is an attractive type of radiation element that was studied and investigated in previous literature. This architecture offers small size, easy, and low-cost antenna implementation. It has omnidirectional radiation characteristics, providing narrowband wireless applications. Several techniques have been introduced to improve the efficiency of this radiation element in terms of frequency bandwidth and antenna gain. Furthermore, this antenna is usually combined with various types of reflector structures in order to improve its directivity and performance efficiency. Microwave theory indicates the impact of the reflector presence and introduces essential observations and principles that confirm the corresponding effects. In each case, scattering parameters and radiation patterns are meaningful on antenna design. The corresponding simulated and experimental results provide an interesting amount of measurements that enhance antenna efficiency and performance.

The dipolegetsitsname fromitstwo halves-one oneachsideofitscentre .Adipoleisabalancedantenna, meaningthatthe"poles" aresymmetrical: They're equallengthsandextendinoppose sitedirections fromthefeedpoint. Inits simplestform,adipoleisanantennamade ofwireand fedatitscentre. Dipole antenna consists of two identical conductive elementssuch as metal wires or rods, which are usually symmetrical. The driving current from the transmitter is applied, or for receiving antennas the output signal to the receiver is taken, between the two halves of the antenna. Each side of the feed line to the transmitter or receiver is connected to one of the conductors. This contrasts with a Dipoleantenna, which consists of a single rod or conductor with one side of the feed line connected to it, and the other side connected to some type of ground [1].

The feed point impedance of a dipole antenna is very sensitive to its length. Therefore a dipole will generally only perform optimally over a rather narrow bandwidth, beyond which its impedance will become a poor match for the transmitter or receiver (and transmission line). The real (resistive) and imaginary (reactive) components of that

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impedance, as a function of electrical length. The value of the reactance is highly dependent on the diameter of the conductors with a diameter of .001 wavelengths. Dipoles that are much smaller than the wavelength of the signal are called short dipoles. These have a very low radiationresistance making them inefficient antennas. More of a transmitter's current is dissipated as heat due to the finite resistance of the conductors which is greater than the radiation resistance. However they can nevertheless be practical receiving antennas for longer wavelengths [2].Dipole antennas of lengths approximately equal to any odd multiple of λ/2 are also resonant, presenting a small reactance. However these are rarely used. One size that is more practical though is a dipole with a length of 5/4 wavelengths. Not being close to 3/2 wavelengths, this antenna's impedance has a large (negative) reactance and can only be used with an impedancematching network .It is a desirable length because such an antenna has the highest gain for any dipole which isn't a great deal longer.Ideally, a dipole antenna should be fed using a balanced transmission line matching its typical 65 - 70Ω input impedance. Twin lead with a similar impedance is available but seldom used.

Toberesonantadipolemust beelectricallyahalfwavelengthlongattheoperating frequency. Dipole antenna resonance occursatthelengthatwhichitsimpedance has noreactance-only resistance at a given frequency. As it turns out that resonant compatible with feeding line. Within limits, however, resonance is not necessary for a dipole antenna to be effective.
Thelowestfrequencyatwhichadipole isresonant is known asitsfundamentalresonance. A dipoleworksbestatand aboveitsfundamental resonant [3].

II. TYPES OF DIPOLE ANTENNA

The dipole antenna consists of two conductive elements such as metal wires or rods which are fed by a signal source or feed energy that has been picked up to a receiver. The energy may be transferred to and from the dipole antenna either directly straight into from the electronic instrument, or it may be transferred some distance using a feeder. This leaves considerable room for a variety of different antenna formats.

Although the dipole antenna is often though in its half wave format, there are nevertheless many forms of the antenna that can be used.

- Half wave dipole antenna***:*** The half wave dipole antenna is the one that is most widely used. Being half a wavelength long it is a resonant antenna. A half-wave dipole antenna consists of two quarter-wavelength conductors placed end to end for a total length of approximately $L = \lambda/2$.The magnitude of current in a standing wave along the dipole The current distribution is that of a standing wave, approximately sinusoidal along the length of the dipole, with a node at each end and an antinode (peak current) at the centre (feed point) [4].
- Multiple half wave's dipole antenna***:*** It is possible to utilise a dipole antenna or aerial that is an odd multiple of half wavelengths long.
- Folded dipole antenna***:*** As the name implies this form of the dipole aerial or dipole antenna is folded back on itself. While still retaining the length between the ends of half a wavelength, an additional length of conductor effectively connects the two ends together.
- Short dipole***:*** A short dipole antenna is one where the length is much shorter than that of half a wavelength. Where a dipole antenna is shorter than half a wavelength, the feed impedance starts to rise and its response is less dependent upon frequency changes. Its length also becomes smaller and this has many advantages. It is found that the current profile of the antenna approximately a triangular distribution.
- Non-resonant dipole***:*** A dipole antenna may be operated away from its resonant frequency and fed with a high impedance feeder. This enables it to operate over a much wider bandwidth.

There are also some numerous notable variations of dipole antennas:

- The bow-tie antenna is a dipole with flaring, triangular shaped arms. The shape gives it a much wider bandwidth than an ordinary dipole. It is widely used in UHF television antennas.

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- The G5RV Antenna is a dipole antenna with a symmetric feeder line, which also serves as a 1:1 impedance transformer allowing the transceiver to see the impedance of the antenna (it does not match the antenna to the 50-ohm transceiver. In fact the impedance will be somewhere around 90 ohms at the resonant frequency but significantly different at other frequencies).
- The double Antennais a dipole antenna with a resonant symmetric feeder line.
- The slope antenna is a slanted dipole antenna used for long-range communications or in limited space.
- The AS2259Antennais an inverted-V dipole antenna used for NVIS communications.

III. FEEDING A DIPOLE ANTENNA

Ideally, a half-wave dipole should be fed using a balanced transmission line matching its typical 65 - 70Ω input impedance. Twin leadwith a similar impedance is available but seldom used. Many types of coaxial cable have a characteristic impedance of 75Ω, which would therefore be a good match for a half-wave dipole, however coax is an unbalanced transmission whereas a dipole antenna presents a balanced. When a balanced antenna is fed with a single-ended line, common mode currents can cause the coax line to radiate in addition to the antenna itself [5], distorting the radiation pattern and changing the impedance seen by the line. The dipole can be properly fed, and retain its expected characteristics, by using a balun in between the coaxial feed line and the antenna terminals.

Another solution, especially for receiving antennas, is to use common 300 ohm twin lead in conjunction with a foldeddipole. The folded dipoleis similar to the simple half-wave dipole but with the feed point impedance multiplied by 4, thus closely matching that 300 ohm impedance [6]. This is the most common household antenna for fixed FM broadcast band tuners, which usually include balanced 300 ohm antenna input terminals

IV. MODEL OF DIPOLE ANTENNA

The dipole antenna is often used in planar microwave radiative applications that require an Omni-directional pattern. The model of the dipole is shown in Fig. 1. The dipole arm's width (W) and length (L) will be optimized for 3.0 GHz operation, while the feed gap (g) and the substrate height (h) will be fixed. The model and simulation setup are outlined. The methods used to setup the simulation are outlined. In particular, the following topics are covered:

- Layers Setup
- Model Setup (Parameterization)
- Excitation Setup
- Analysis Setup
- Plotting Results
- Optimization

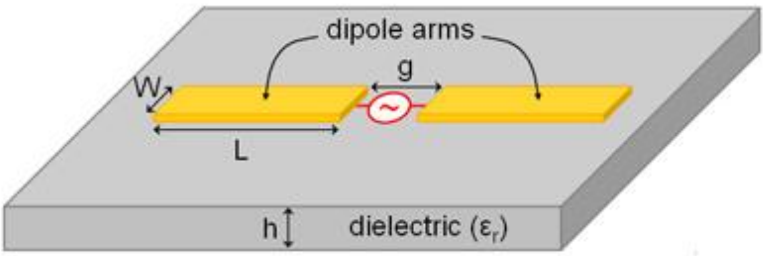

Figure 1. Model of dipole antenna based on differential feeding.

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ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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Vol. 4, Issue 3, March 2015

In figure 1, it shows the basic model of Dipole antenna. FR-4 substrate used in Dipole antenna. FR-4 is a grade designation assigned to glass reinforced epoxy laminate sheets and printed board. Dielectric depends on height of Dipole antenna. Both Dipole arms are same length and same width .Gap between arms depends on its length.

V. EQUATION AND VARIABLES

Rradiation $= (Zo/4\pi)$Cin (2π)=73.1 ohm

Current (I) = $I_m \mathrm{Sin}(\beta (L - |z|))$

Electric Wave (E_θ) = $(60 \times I_m / r) \times [(\mathrm{Cos}(\beta L \mathrm{Cos}\,\theta) - \mathrm{Cos}(\beta L)) / \mathrm{Sin}\,\theta]$

Magnetic Wave (H_Φ) = $(I_m / 2\pi r) \times [(\mathrm{Cos}(\beta L \mathrm{Cos}$ &theta$) - \mathrm{Cos}(\beta L)) / \mathrm{Sin}\,\theta]$

Average radiated power density (P_d) = $(15 \times I_m^2 / \pi r^2) \times [(\mathrm{Cos}(\beta L \mathrm{Cos}\,\theta) - \mathrm{Cos}(\beta L)) / \mathrm{Sin}\theta]^2$

Where, $\beta = 2\pi / \lambda$

λ = Wave Length

I_m = Magnetic Current

L = Half Antenna Length

r = radius

θ = Angle

VI. SIMULATION TOOLS

There are many simulation software for antenna design like CST Studio,AnsysHFSS,Matlabetc.Ansys HFSS used for Dipole Antenna simulation.

ANSYS HFSS software is the industry standard for simulating 3-D full-wave electromagnetic fields. Its gold-standard accuracy, advanced solver and high-performance compute technology have made it an essential tool for engineers doing accurate and rapid design of high-frequency and high-speed electronic components.HFSS offers multiple state-of the-art solver technologies based on finite element, integral equation or advanced hybrid methods to solve a wide range of microwave, RF and high-speed digital applications. The software includes a linear circuit simulator with integrated Optometric for input and matching network design [7].

VII. SIMULATION RESULTS

RadiationPattern:

The antenna radiation pattern is a measure of its power or radiation distribution with respect to a particular type of coordinates. We generally consider spherical coordinates as the ideal antenna is supposed to radiate in a spherically symmetrical pattern. However antennae in practice are not Omni directional but have a radiation maximum along one particular direction. For e.g. Dipole antenna is a broadside antenna wherein the maximum radiation occurs along the axis of the antenna. The radiation pattern of a typical dipole antenna is shown in figure 2

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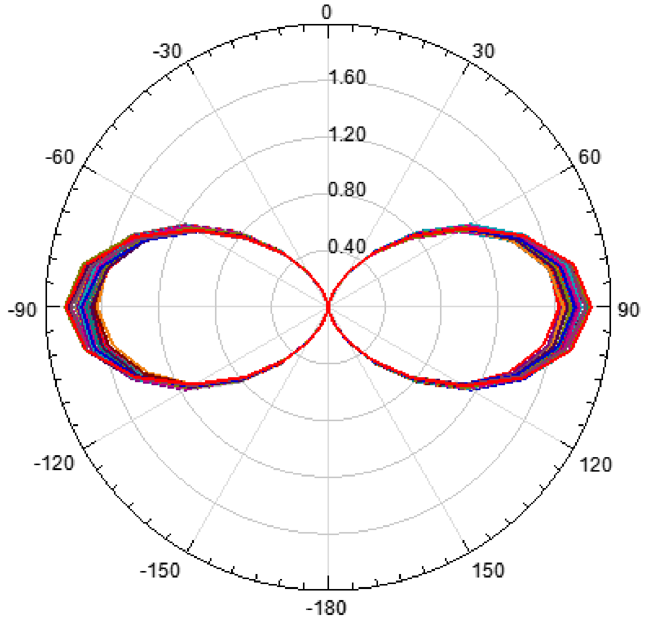

Figure 2: Radiation Pattern of Dipole Antenna (Frequency 0.3 GHz)

In figure 2, it is clearly seen that average frequency is .3 GHz. highest level frequency is up to 0.50 GHZ and lowest on is 0.01 GHz.So the frequency range for radiation pattern of Dipole antenna is (0.01-0.05) GHz. Highest gain for positive pole is 30 degree to 150 degree and for negative pole -30 degree to -150 degree.

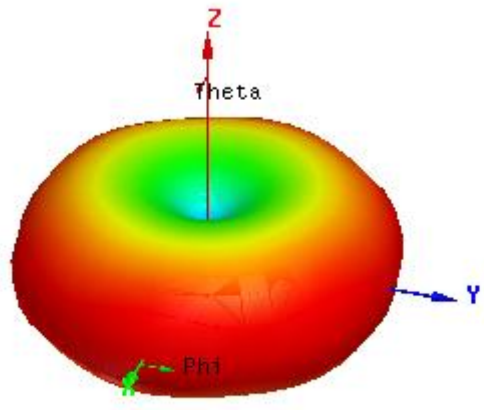

Figure 3: Radiation Pattern 3D

In figure 3, Red colored side shown highest gain part of a radiation pattern. In 3D pattern both positive and negative shown in same axis. Yellow colored describe average gain pattern of Dipole antenna then the next phase is null radiation. In 3D XY, YZ, ZX three axis results are same for radiation pattern of a dipole antenna.

Near-Field and Far-Field Patterns:

The radiation pattern in the region close to the antenna is not exactly the same as the pattern at large distances. The term near-field refers to the field pattern that exists close to the antenna; the term far-field refers to the field pattern at large distances. The far-field is also called the radiation field, and is what is most commonly of interest. The near-field is called the induction field:

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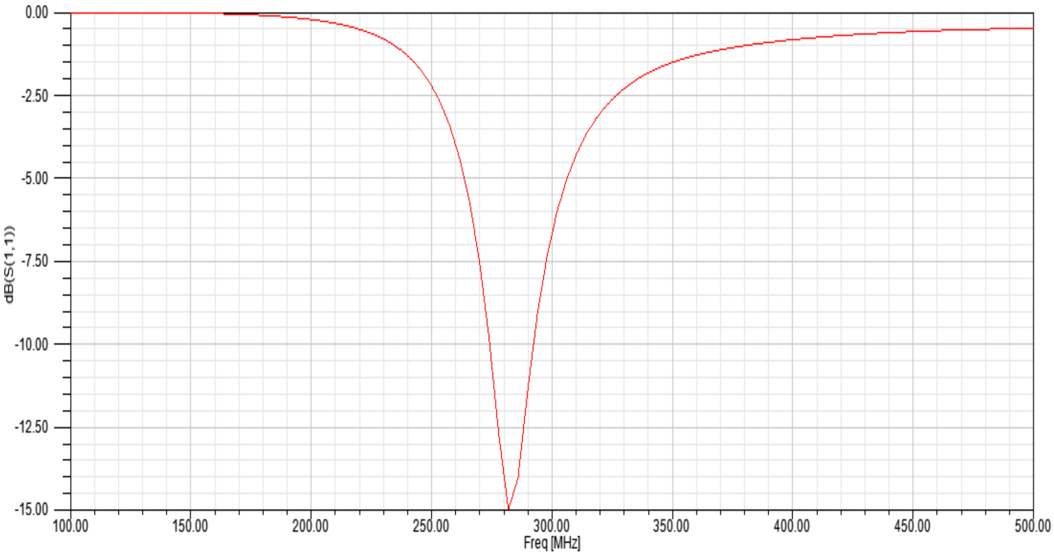

Figure 4: Gain Vs Frequency Graph

In Figure 4, this figure describe a graph of gain vs frequency.it is clearly shown that when frequency is 160 MHz gain is high but when frequency increasing up to 300 MHz gain is in nadir point after a certain time increase frequency gain also increasing.

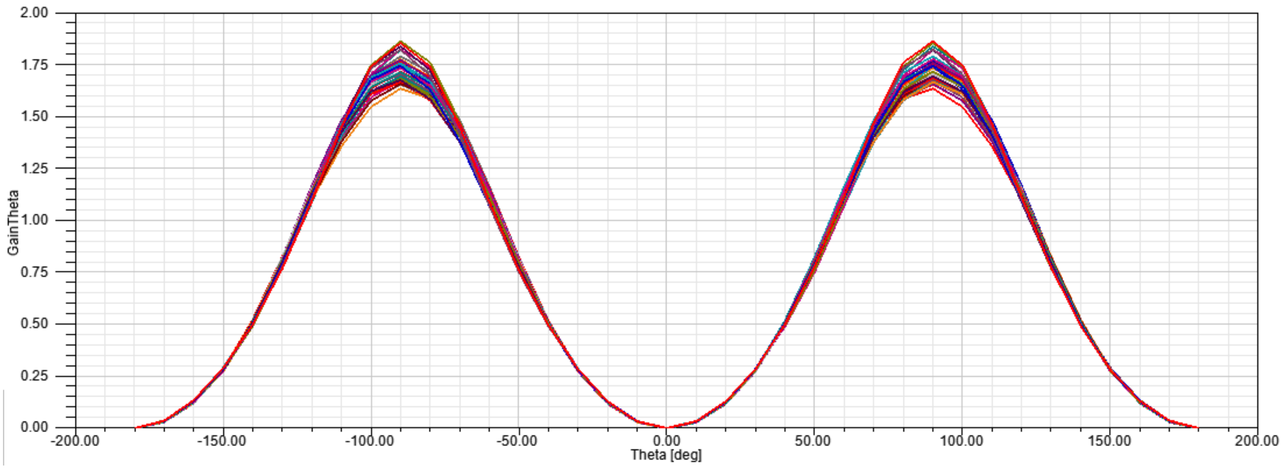

Figure 5: Graphof Gain Vs Angle.

Figure 5 describe graph of gain Vs Angle. Seen that obtain highest gain when the angle is -100 degree or +100 degree. In angle 0 degree gain touch the nadir point. Highest gain obtain from this is around 1.80. After obtained highest gain increasing angle gain will be decreasing.

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ISSN (Online): 2278 – 8875

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(An ISO 3297: 2007 Certified Organization)

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VIII. RESULTS AND DISCUSSION

Data Table for Gain (-180 degree to -10degree):

	Theta [deg]	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='0deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='10deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='20deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='30deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='40deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='50deg'
1	-180.000000	0.000060	0.000060	0.000060	0.000060	0.000060	0.000060
2	-170.000000	0.035626	0.035790	0.035541	0.034960	0.034166	0.033281
3	-160.000000	0.134779	0.133941	0.131990	0.129470	0.126985	0.125025
4	-150.000000	0.288796	0.286416	0.283283	0.279688	0.276391	0.274602
5	-140.000000	0.499944	0.500072	0.502504	0.503668	0.502191	0.500235
6	-130.000000	0.767358	0.774812	0.788413	0.799573	0.804081	0.804063
7	-120.000000	1.092210	1.104690	1.116989	1.126786	1.136519	1.146247
8	-110.000000	1.448640	1.456419	1.441257	1.423697	1.430345	1.458110
9	-100.000000	1.740634	1.732001	1.677362	1.621753	1.620867	1.667864
10	-90.000000	1.853490	1.821980	1.744445	1.674943	1.675625	1.732527
11	-80.000000	1.741337	1.696103	1.628405	1.583232	1.598418	1.650505
12	-70.000000	1.450622	1.413632	1.380765	1.376000	1.405035	1.441767
13	-60.000000	1.089900	1.071716	1.070456	1.089597	1.118393	1.138739
14	-50.000000	0.760006	0.752338	0.759062	0.775703	0.792323	0.801341
15	-40.000000	0.495148	0.490455	0.491390	0.495602	0.499529	0.501714
16	-30.000000	0.285784	0.283644	0.281493	0.279421	0.277441	0.276035
17	-20.000000	0.129718	0.129254	0.127890	0.125957	0.123891	0.122165
18	-10.000000	0.033067	0.033103	0.032858	0.032412	0.031873	0.031356

This is the table for gain -180 degree to -10 degree.in starting gain is around 0 but increasing angle gain increasing This continue up to -90 degree. After -90 degree it decreases with the same ratio of increasing. This cycle run up to touch the next phase.

Data Table for Gain (10 degree to 180 degree):

	Theta [deg]	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='0deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='10deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='20deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='30deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='40deg'	GainTotal Setup1 : LastAdaptive Freq='0.3GHz' Phi='50deg'
20	10.000000	0.034091	0.033653	0.032969	0.032101	0.031138	0.030174
21	20.000000	0.130450	0.129884	0.128470	0.126417	0.124169	0.122201
22	30.000000	0.285126	0.285514	0.284892	0.282979	0.280589	0.279188
23	40.000000	0.501976	0.503901	0.506792	0.508454	0.508985	0.510709
24	50.000000	0.780361	0.782916	0.787657	0.793409	0.800731	0.810838
25	60.000000	1.115131	1.115566	1.108959	1.107343	1.120273	1.144562
26	70.000000	1.473772	1.465108	1.428858	1.403124	1.417168	1.458458
27	80.000000	1.759985	1.734727	1.666431	1.616328	1.632675	1.689241
28	90.000000	1.862702	1.823134	1.745515	1.693627	1.716465	1.777050
29	100.000000	1.745917	1.705027	1.647719	1.618801	1.645693	1.692567
30	110.000000	1.463267	1.435498	1.411752	1.410510	1.433510	1.458185
31	120.000000	1.111075	1.101614	1.103110	1.115266	1.129079	1.137415
32	130.000000	0.772962	0.773739	0.782182	0.792256	0.797495	0.798888
33	140.000000	0.491395	0.491960	0.495458	0.498381	0.498734	0.498435
34	150.000000	0.279198	0.277939	0.276857	0.275441	0.273710	0.272603
35	160.000000	0.131147	0.130379	0.128861	0.126861	0.124718	0.122817
36	170.000000	0.035947	0.035805	0.035277	0.034436	0.033388	0.032251
37	180.000000	0.000060	0.000060	0.000060	0.000060	0.000060	0.000060

This is the table for gain 10 degree to 180 degreeIt is clearly shown that Dipole Antenna gain maintain per 90 degree cycle. Start from nadir point after reach 60 degree it will be in crest then its goes down to nadir point again. Consider -180 degree to +180 for simulation result.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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Vol. 4, Issue 3, March 2015

IX. CONCLUSION

Thisthesisdetailedthe various aspectsassociatedwiththemodellingofDipole antenna. One of the goals was the introductionof HFSS as an effectivetoolforelectromagneticanalysis.Aneffortwasmadetoimpartunderstanding of the design process in HFSS, which would aid the reader in building any simulation in HFSS.A comprehensiveandgraphicdescriptionofeachsteptakenincreatingthesimulationof the Dipole antenna was presented. Achieved Gain is 4 db. Obviously there are some drawbacks of dipole antenna like:

- Low bandwidth
- High Impedance
- Moving space problem
- Size

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BIOGRAPHY

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ApuSamadder has completed B.Sc. from American International University-Bangladesh under the department of Electrical and Electronics Engineering. His core research area is power and energy systems emphasize all aspects of electrical energy, innovation in energy generation and distribution, grid intelligence, renewable resources and efficient devices.

AsaduzzamanImonhas completed B.Sc. from American International University-Bangladesh under the department of Electrical and Electronics Engineering. His main research area is analog and digital VLSI design&Opto Electronics. Also a good knowledge of Microwave.

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