Simple Half-Wave Dipole Antenna Analysis for Wireless Applications by CST Microwave Studio

Mohammad Tareq*
Asst. Professor,
Dept. of EETE,
Dhaka International University (DIU),
66-Green Road,
Dhaka-1205, Bangladesh

Dewan Ashraful Alam
Programmer, Election Commission Secretariat,
Sher-E-Bangla Nagar,
Dhaka-1207,
Bangladesh

Mazidul Islam
Lecturer, Dept. of EETE,
Dhaka International University (DIU),
66, Green Road, Dhaka-1205, Bangladesh

Razin Ahmed
Lecturer, Dept. of EEE,
International University of Business Agriculture and Technology (IUBAT),
Dhaka-1230,
Bangladesh

ABSTRACT
In this paper, a simple half-wave dipole antenna has been designed and analyzed for wireless applications. Resonant frequency for the dipole antenna was 5 GHz and as a simulation tool CST Microwave Studio (MWS) has been used. After that the return loss curve, the VSWR and the far-field radiation patterns of the half-wave dipole antenna have been observed.

Keywords
Dipole Antenna, CST MWS, Far-field radiation

1. INTRODUCTION
Dipole antenna is very common practical wire antenna [1]. There are several types of dipole antennas such as hartzian dipole, half-wave dipole, small dipole [2] etc.

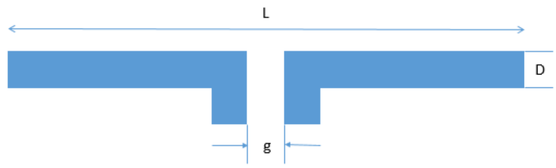

Fig. 1: Half-Wave Dipole Antenna

A general construction of a half-wave dipole antenna [3] has been shown in the Fig.1. There is a gap between two arms of half-wave dipole antenna for feeding purpose. Here L is the total length of the antenna, D is the thickness of antenna arm and g is the feeding gap. Radiation resistance of the half-wave dipole is 73 Ohm which matched with the line impedance [4].

2. DESIGN PARAMETERS
Dimension of an antenna changes based on the resonant frequency. As a resonant frequency 5GHz has been chosen. By taking this into consideration several antenna dimension have been calculated [5].

Resonant frequency, $f_r = 5$ GHz

Wavelength,

$$\lambda = \frac{c}{f} = (3 \times 10^{11}) \div (5 \times 10^{9}) = 60\ mm \ldots \ldots (1)$$

Length of half-wave dipole antenna,

$$L = \frac{143}{f} = 28.6\ mm \ldots \ldots (2)$$

Feeding gap of the antenna,

$$g = \frac{L}{200} = \frac{28.6}{200} = 0.143\ mm \ldots \ldots (3)$$

Radius of the wire,

$$R = \frac{\lambda}{1000} = \frac{60}{1000} = 0.06\ mm \ldots \ldots (4)$$

From the first equation, wavelength has been calculated based on which length of the dipole antenna has been found from the second equation. Feeding gap and radius of the wire have been calculated from the equation no.3 and 4 respectively.

All dimensions of the antenna are given in the Table 1.

Table 1: Design Parameters of the Antenna

Parameter	Value	Unit
Resonant Frequency (f_r)	5	GHz
Wavelength (λ)	60	mm
Impedance	73	Ohm
Length of the dipole (L)	28.6	mm
Radius of the dipole (R)	0.06	mm

3. SIMULATIONS AND RESULTS
3.1. Simulations
According to the design parameters a half-wave dipole antenna has been designed in CST MWS. In the Fig. 2 designed half-wave dipole antenna has been shown.

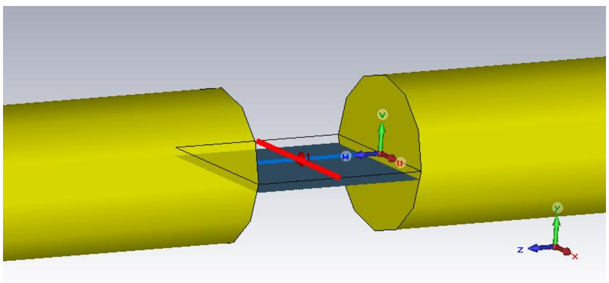

Fig. 2: Designed Half-Wave Dipole Antenna

For the simulation purpose the ranges of frequencies have been chosen from 4 GHz to 6 GHz.

For making the simulation fast and more accurate global mesh properties have been optimized. As antenna copper (annealed) has been used and between the two antenna arms a sheet has been selected.

3.2. Results

After the simulation return loss has been observed. Return loss curve has been shown in the Fig.3.

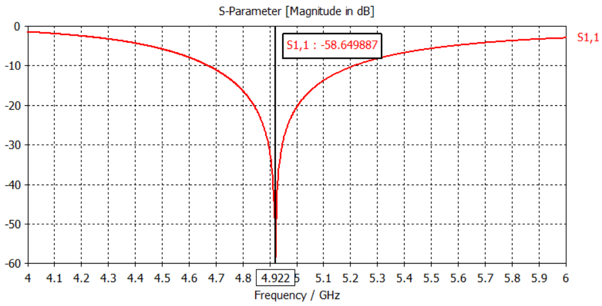

Fig. 3: Return Loss Curve for the designed Half-Wave Dipole Antenna

From the Fig. 2 authors have found that the antenna is resonating at 4.992 GHz. Moreover, the value of return loss has been found as -58.65 dB (approx.).

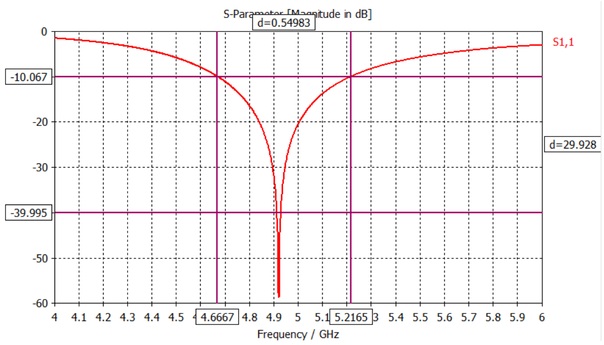

Fig. 4: Bandwidth Curve for the designed Half-Wave Dipole Antenna

Bandwidth of the antenna has shown in the Fig. 4. Bandwidth of the designed antenna has found as 0.54983 GHz. Ranges of frequency at -10 dB are 4.6667 GHz and 5.2165 GHz.

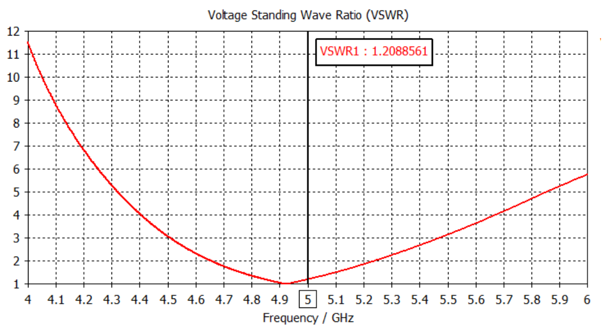

Fig. 5: VSWR Plot of the designed Half-Wave Dipole Antenna

VSWR curve has shown in the Fig. 5. Authors have found it was 1.2 at the resonant frequency 5GHz.

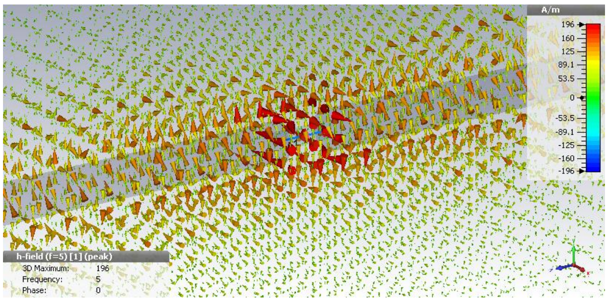

Fig. 6: H-field Distribution of the designed Half-Wave Dipole Antenna

Magnetic field density has shown in the Fig. 6.

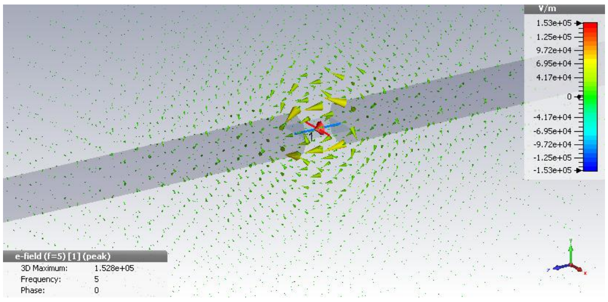

Fig. 7: E-field Distribution of the designed Half-Wave Dipole Antenna

Electric field distribution has shown in the Fig. 7.

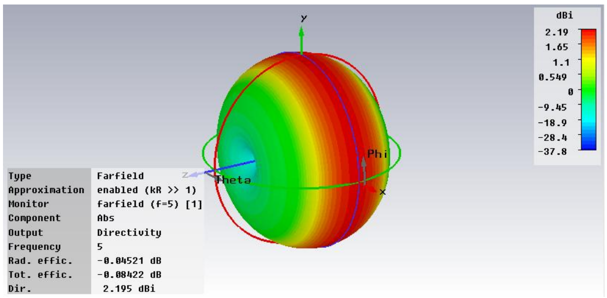

Fig. 8: 3-D Far-Field Radiation Pattern for Directivity of Designed Half-Wave Dipole Antenna

Far-field radiation [6] pattern has been shown in the Fig. 8. Directivity has found as 2.195 dBi. Obtained directivity was almost identical to the theoretical ones [7]. Red color shows the maximum radiation.

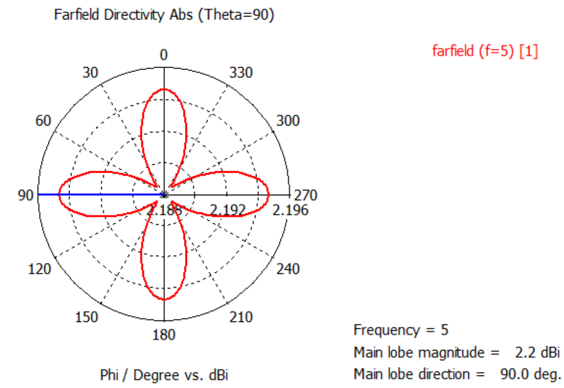

Fig. 9: Polar Plot for Azimuthal Angle of the Designed Half-Wave Dipole Antenna

Polar plot for azimuthal angle has shown in the Fig. 9.

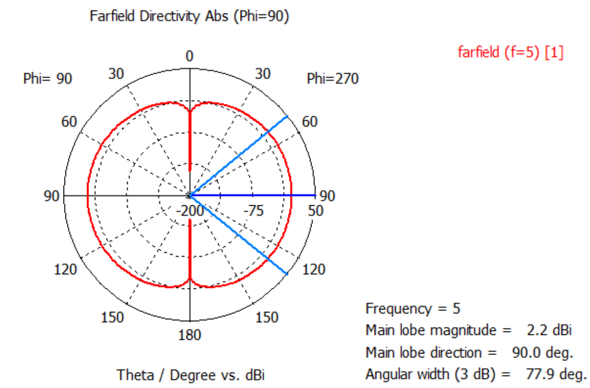

Fig. 9: Polar Plot for Elevation Angle of the Designed Half-Wave Dipole Antenna

Polar plot for elevation angle has shown in the Fig. 9.

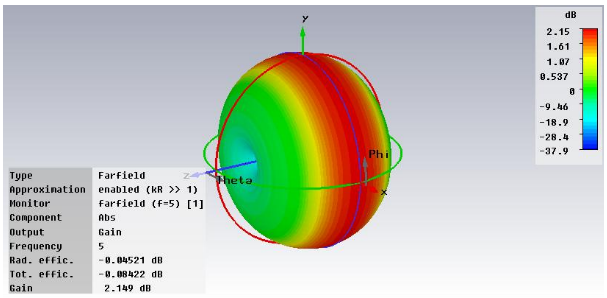

Fig. 10: Far-field Radiation Pattern for Gain of the Designed Half-Wave Dipole Antenna

Gain has found as 2.149 dB from the simulation which has shown in the Fig. 10.

Summary of the simulated results are given in the Table 2.

Table 2: Simulated Results of the Designed Antenna

Parameter	Value	Unit
Resonant Frequency (f_r)	4.922	GHz
Bandwidth	0.54983	GHz
Directivity	2.195	dBi
Gain	2.149	dB
Return Loss	-58.6498	dB

4. CONCLUSIONS

Main objective of this paper was to observe the several antenna characteristics for popular wire antenna. As a popular practical antenna half-wave dipole antenna was selected. Obtained results were acceptable for practical implementation of this types of antennas. As a simulation tool CST Microwave Studio was used which ease the simulation. Obtained resonant frequency (4.992 GHz) was lesser than target frequency (5 GHz) which is acceptable. Return loss obtained as -58.6498 dB which shows the characteristic of reflection coefficient. Bandwidth was observed as almost 550 MHz which is good enough to cover various wireless applications. There are few scopes to improve the results by optimizing several parameters which might be fruitful for researchers. Author would like to work on these in future.

5. REFERENCES

[1] Balanis, Constantine A., "Antenna Theory Analysis and Design", John Wiley & Sons, 3rd Edition, USA (2005), pg.151

[2] Ramo, Simon, Whinnery, John R., Duzer, Theodore Van, "Fields and Waves in Communication Electronics", , John Wiley & Sons, 3rd Edition, Canada (1994)

[3] Saunders, Simon R., Zavala, Alezandro Aragon, "Antennas and Propagation for Wireless Communication Systems", John Wiley & Sons, 2nd Edition, England (2007), pg. 73

[4] Balanis, Constantine A., "Antenna Theory Analysis and Design", John Wiley & Sons, 3rd Edition, USA (2005), pg. 182

[5] Parminder Singh, Ankita Sharma, Neha Uniyal,Richa Kala, "Half-Wave Dipole Antenna for GSM Applications", International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970), Volume-2 Number-4 Issue-6 December-2012

[6] Balanis, Constantine A., "Antenna Theory Analysis and Design", John Wiley & Sons, 3rd Edition, USA (2005), pg. 34-35

[7] Saunders, Simon R., Zavala, Alezandro Aragon, "Antennas and Propagation for Wireless Communication Systems", John Wiley & Sons, 2nd Edition, England (2007), pg. 77