DESIGN AND NUMERICAL ANALYSIS OF A SINGLE HALF-WAVE DIPOLE ANTENNA TRANSMITTING AT 235MHz USING METHOD OF MOMENT

Adewumi Adebayo Segun[1], Alade Michael Olasope[2], Rotimi Cornelius Okeowo[3] & Akinleye Abiodun Ismail[4]

[1,2,4]Department of Pure and Applied Physics, Ladoke Akintola University of Technology,
P.M.B 4000, Ogbomoso, Oyo State, Nigeria
[3]Department of Physics, College of Education, P.M.B 750, Ikere-Ekiti, Ekiti State, Nigeria

ABSTRACT

This paper deals with design and numerical analysis of a single Half- wave dipole antenna suitable for transmitting UHF television signals at a frequency of 235MHz using Method of Moment. Two equations, namely the radiating field and the electric field strength equations were used to determine the variations in the electric field strength and free space loss with distance in kilometers. Other parameters such as the power radiated, gain and voltage standing wave ratio of the antenna at this frequency were also evaluated. The radiation patterns obtained shows that the antenna is a good radiator while the variations in electric field strength and free space loss with distance actually show the distance covered and the rate of loss of the signal transmitted at this particular frequency using half –wave dipole antenna.

Keywords: Design, Numerical Analysis, Half-wave dipole Antenna, Method of moment, far field pattern

1. INTRODUCTION

This work was motivated by a desire to improve on the performances of some antennas used for transmitting Television signals in some parts of south west region of Nigeria so as to enhance uniform distribution and higher efficient transmission of Television signals from base stations. The resulting analysis will enhance industry's ability to design antennas that will meet performance specifications and enable Television broadcasting stations to know the importance of design and analysis of antennas before they are employed in transmissions. In today's transmission systems, efficient antennas are required for transmission so as to produce high energy radiating signals that can be transmitted over a long distance for wide coverage before the signal is completely attenuated. An efficient radiating antenna coupled with high power transmitter will reduce the number of repeaters stations and eventually save cost of installations.

Gautama A.K observed and reported that in order to ensure higher power radiation an antenna must have the ability to match the transmission line with the load impedance; it must also have the ability to transfer energy from electrostatic to electromagnetic energy or vice versa.

In this study, the design and numerical analysis of a single short half-wave dipole Antenna suitable for transmitting at the same frequency as that of Nigeria television station NTA Ogbomosho (235MHz) is presented. Half – Wave dipole is chosen because of it wide acceptance in practice and its uses as a reference antenna.

The characteristics of a Half-Wave dipole antenna in literature show that it has distributed capacitance and inductance which make it behave like a resonant circuit with voltage and current out of phase. Half – Wavelength dipole is one of the most commonly used antennas because its radiation resistance is 73 ohms, which is very near the 75-ohm characteristic impedance of some transmission lines, it matching to the line is simplified especially at resonance compare to other antennas. (Kennedy and Davis, 2005; Balanis, 2005).

The diagram figure1 shows the transmitting antenna used for transmitting signal at a frequency of 235MHz in Nigeria Television Authority (NTA) station Ogbomosho, Oyo State, Nigeria. Ogbomosho is located on the latitude 8^0 08' 01'' N and longitude 4^0 14' 48'' E. This station transmits at frequency of 235MHz with a transmitters' power of 5kw but from information gathered from other cities and towns of about 40km away, it has been observed that the signals hardy reach 35km away from the base station before it is completely attenuated. I think this is the main reason why government has to install another Nigerian Television transmitting station in Oyo town which is just 47km away from Ogbomosho which could have been covered by the same base station if efficient antenna properly match with transmission line cable and powered by efficient transmitter is used for transmission. Though the role of free space path loss and other attenuation factors cannot be overlooked yet the importance of a well designed antenna in transmitting systems both at the transmitting and receiving ends cannot be underrated.

Figure.1 Nigeria Television Authority (NTA) Transmitting Antenna Ogbomosho.

However, in this paper a single Half -wave dipole antenna suitable for transmitting at the same frequency (235MHz) as that of NTA Ogbomosho is designed and analyzed numerically to observe its performances and effectiveness over the designed frequency using method of moment.

2. DESIGN ANALYSIS

Step1: The initial condition for the design of the half-wave dipole antenna expected to operate at the design frequency of 235MHz is that the half-wave dipole antenna length dl shown in figure 2 is assumed to be 0.5λ, that is dl is $\lambda/2$ long such that $\lambda = c/f$.

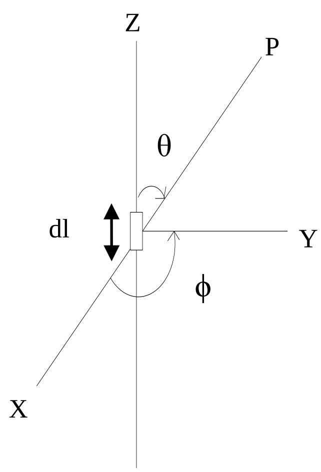


Figure2. Diagram showing the Half- wave dipole antenna located in space.

Since the transmitting half-wave dipole antenna is usually located in free space carrying an oscillating current, it will give rise to two fields $H_{\emptyset}$ (Far field radiation) and E_{θ} (Electric field strength) which can be obtained using the equation (Gautam, 2009).

$$H_{\emptyset} = \frac{I_{odlsin\theta}}{4\pi}[\frac{\omega}{rc}cos\omega\left(t-\frac{r}{c}\right)] \quad 1$$

and

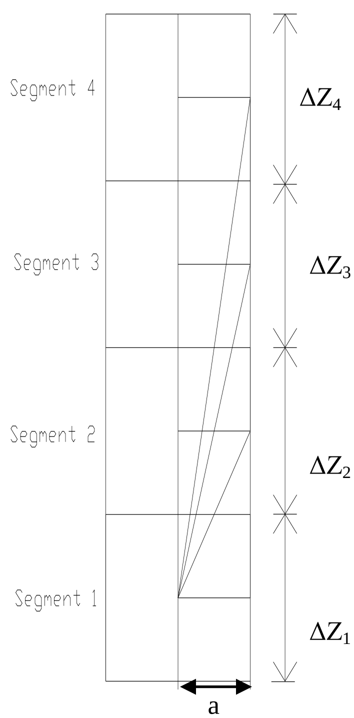
$$E_{\theta} = \frac{I_{odlsin\theta}}{4\pi\epsilon\, c^2 r}[cos\omega(t-\frac{r}{c}] \quad 2$$

where dl is the dipole antenna length (0.5λ), r is the distance of the far field region from the dipole element usually

greater than $2(dl)^2/\lambda$ chosen to be 1.5m.
λ is the wavelength (1.276595745m).
C is the speed of light ($3 \times 10^8 m/s$).
t is the period (1/f)
$\omega = 2\pi f$, f is the frequency (235MHz).
θ is the angle of radiation in degree ($0\text{-}360^0$)
ϵ is the permittivity of free space ($8.85 \times 10^{-12} F/m$)
i_o is the peak value of current.
dl is the length of the dipole antenna.

2.1 Determination of the peak value of the dipole antenna current using method of moment

step2: To determine the peak value of the dipole current i_o using method of moment (circuit equation) technique, the step is as follow: the Half-wave dipole antenna is divided into 4 segments Δz'= 0.125λ long and each assumed to have a uniform current over each segment given by i_1 i_2 i_3 and i_4 as shown in figure 3.



F*igure3. Single Half-wave dipole antenna 0.5λ long divided into 4 segments* $\Delta z_1=\Delta z_2=\Delta z_3=\Delta z_4=0.125\lambda$ *long*

Where the radius a = $r_{11} = r_{22} = r_{33} = r_{44} = 0.001$.

The Half-wave dipole is assumed to be symmetrical so that

$r_{12} = r_{21} = r_{23} = r_{32} = r_{34} = r_{43}$ 3

$r_{13} = r_{31} = r_{24} = r_{42}$ and $r_{14} = r_{41}$ 4

Also

G11=G22=G33=G44, 5

G12=G21=G23=G32=G34=G43, 6

G13=G31=G24=G42and G14=G41. 7

The peak value of the current was determined as follow Using equation 8, 9, 10and 11 (Kraus et al., 2002; John David Jackson, 1998; Balanis, 2005).

$$-E_{z'}(z_m) = \sum_{n=1}^{N} I_n \int_{\Delta z_n'} G(r_{mn})dz' \quad (\mathrm{Vm}^{-1}) \qquad 8$$

Where

$$G(r_{mn}) = -\frac{z_0 \Delta z_\lambda}{8\pi^2 r^3{}_\lambda}\left[\mathrm{e}^{-j2\pi r_\lambda}\left[(1 + j2\pi r_\lambda)\left(2 - 3\left(\frac{a}{r}\right)^2\right) + 4\pi^2 a^2{}_\lambda\right]\right] \quad (\Omega \mathrm{m}^{-2}) \qquad 9$$

$r = r_{mn}$

m=observation point n=source point

Putting

$$G_{mn} = \int_{\Delta z_n'} G(r_{mn})dz' \cong G(r_{mn})\Delta z_n' \quad (\Omega \mathrm{m}^{-1}) \qquad 10$$

Then equation 3 becomes

$$-E_{z'}(z_m) = I_1 G_{m1} + I_2 G_{m2} + \cdots + I_n G_{m3} + \cdots + I_N G_{m4} \quad (\mathrm{V}\lambda^{-1} \text{ or } \mathrm{Vm}^{-1}) \qquad 11$$

Since the short dipole antenna has been divided into 4 segments (m=1, 2, 3, and 4), equation (11) can now be used to obtain a set equation as follow:

$$\begin{aligned} I_1 G_{11} + I_2 G_{12} + I_3 G_{13} + I_4 G_{14} &= -E_{Z'}(Z_1) \\ I_1 G_{21} + I_2 G_{22} + I_3 G_{23} + I_4 G_{24} &= -E_{Z'}(Z_2) \\ I_1 G_{31} + I_2 G_{32} + I_3 G_{33} + I_4 G_{34} &= -E_{Z'}(Z_3) \\ I_1 G_{41} + I_2 G_{42} + I_3 G_{43} + I_4 G_{44} &= -E_{Z'}(Z_4) \end{aligned} \qquad 12$$

This can be expressed in matrix form as:

$$\begin{bmatrix} G_{11} & G_{12} & G_{13} & G_{14} \\ G_{21} & G_{22} & G_{23} & G_{24} \\ G_{31} & G_{32} & G_{33} & G_{34} \\ G_{41} & G_{42} & G_{43} & G_{44} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} -E_{z'}(Z_1) \\ -E_{z'}(Z_2) \\ -E_{z'}(Z_3) \\ -E_{z'}(Z_4) \end{bmatrix} \qquad 13$$

And in compact notation by

$$[G_{mn}]\,[I_n] = -[E_m] \quad (\mathrm{V}\lambda^{-1}\text{or}\mathrm{Vm}^{-1}) \qquad 14$$

Where

m=1, 2,…... , 4

n=1, 2,……., 4

Multiplying both sides of the equation by the distance Δz,

$$\Delta z[G_{mn}]\,[I_n] = -\Delta z[E_m] \quad (\mathrm{V}) \qquad 15$$

This can be written as

$$[z_{mn}]\,[I_n] = -[V_m] \quad (\mathrm{V}) \qquad 16$$

The value of G_{11} to G_{44} can be obtained using the equation (Kraus et al., 2002)

$$G(r_{mn}) = -j\frac{z_0 \Delta z_\lambda}{8\pi^2 r^3{}_\lambda}\left[(\cos 2\pi r_\lambda - j\sin 2\pi r_\lambda)\left[(1 + j2\pi r_\lambda)\left(2 - 3\left(\frac{a}{r}\right)^2\right) + 4\pi^2 a^2{}_\lambda\right]\right] \quad \Omega m^{-1} \qquad 17$$

Where

m = 1, 2, 3, 4.

n = 1, 2, 3, 4.

$\Delta Z_r = 0.125,\ r_\lambda = 0.001 = a$

To determine G_{11} using equation (17)

$$G_{11} = \frac{-j377 \times 0.125}{8\pi^2 (0.0625)^3}(cos2\pi \times 0.0625 - jsin2\pi \times 0.0625) \times \left\{(1 + j2\pi \times 0.0625)\left[2 - 3\left(\frac{0.001}{0.0625}\right)^2\right] + 4\pi^2 \times 0.001^2\right\} = 1872.610248 - j6843.252386 \quad \Omega\ \lambda^{-1} \qquad 18$$

$$G_{12} = \frac{-j377 \times 0.125}{8\pi^2 (0.125)^3}(cos2\pi \times 0.125 - jsin2\pi \times 0.125) \times \left\{(1 + j2\pi \times 0.125)\left[2 - 3\left(\frac{0.001}{0.125}\right)^2\right] + 4\pi^2 \times 0.001^2\right\}$$

$$= 471.5525 - j617.6456351 \quad \Omega\ \lambda^{-1} \qquad 19$$

$$G_{13} = \frac{-j377 \times 0.125}{8\pi^2 (0.25)^3}(cos2\pi \times 0.25 - jsin2\pi \times 0.25) \times \left\{(1 + j2\pi \times 0.25)\left[2 - 3\left(\frac{0.001}{0.25}\right)^2\right] + 4\pi^2 \times 0.001^2\right\}$$

$$= 117.8606799 - j79.65659311\ \Omega\lambda^{-1} \qquad 20$$

$$G_{14} = \frac{-j377 \times 0.125}{8\pi^2 (0.375)^3}(cos2\pi \times 0.375 - jsin2\pi \times 0.375) \times \left\{(1 + j2\pi \times 0.375)\left[2 - 3\left(\frac{0.001}{0.375}\right)^2\right] + 4\pi^2 \times 0.001^2\right\}$$

$$G_{14} = 52.3583196 - j24.80962623 \quad \Omega\ \lambda^{-1} \qquad 21$$

Introducing equation (18), (19), (20), (21) in equation 12 and multiplying by Δz (=0.125), we obtain:

$$I_1(234.076281 - j855.4065483) + I_2(58.94406566 - j77.20570439) + I_3(14.73258499 - j9.957074139) + I_4(6.54478995 + j3.101203279) = -V_1. \qquad 22$$

$$I_1(58.94406566 - j77.20570439) + I_2(234.076281 - j855.4065483) + I_3(58.94406566 - j77.20570439) + I_4(14.73258499 - j9.957074139) = -V_2. \qquad 23$$

$$I_1(14.73258499 - j9.957074139) + I_2(58.94406566 - j77.20570439) + I_3(234.076281 - j855.4065483) + I_4(58.94406566 - j77.20570439) = -V_3. \qquad 24$$

$$I_1(6.54478995 + j3.101203279) + I_2(14.73258499 - j9.957074139) + I_3(58.94406566 - j77.20570439) + I_4(234.076281 - j855.4065483) = -V_4. \qquad 25$$

By symmetry $I_0 = I_3,\ I_2 = I_4$ also for a centre-fed dipole $V_0 = V_3 = 0$ and $V_2 = V_4 = 1$ (Kraus et, al.2002) Equation (22), (23), (24) and (25) was written in matrix form and reduced to 2x2 matrix for simplification using Cramer's rule (Riley et al., 1999).

$$\begin{bmatrix} 248.808866 - j865.3636224 & 65.48885561 - j74.10450111 \\ 117.8881313 - j154.4114088 & 248.808866 - j865.3636324 \end{bmatrix} = \begin{bmatrix} 0 \\ -1 \end{bmatrix} \qquad 26$$

$$I_1 = I_3 = 1.092735368 \times 10^{-3} A. \qquad 27$$

$$I_2 = I_4 = 1.283241794 \times 10^{-4} A. \qquad 28$$

Therefore the peak value of current $I_O = 1.092735368 \times 10^{-3} A$.

Determination of the Corresponding Values $H_\emptyset$ with respect to Angle (θ)

Step3: Introducing the value of I_O and other variables in equation (1) the results is as shown in table 1.

Table 1: Angles and their corresponding far field radiation values

θ (deg)	0	30	60	90	120
H_ϕ	0.0000000000000	0.0000901445127	0.0001561348759	0.0001802890253	0.0001561348759
θ (deg)	150	180	210	240	270
H_ϕ	0.0000901445127	0.0000000000000	-0.0000901445127	-0.0001561348759	-0.0001802890253
θ(deg)	300	330			
H_ϕ	-0.0001561348759	-0.0000901445127.			

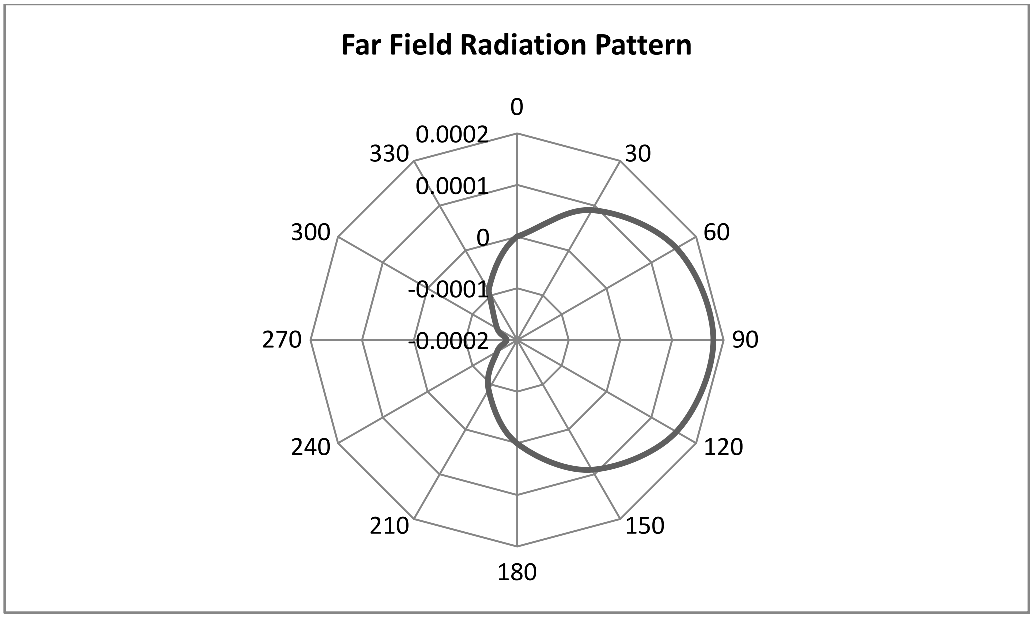


Figure4. Far field radiation pattern of the Half-wave dipole antenna at a frequency of 235MHz.

2.3 Determination of the Corresponding Values (E_θ) with respect to Angle (θ)

Step4: Introducing the value of I_O and other variables in equation (2) the results is as shown in table 2.

Table 2: Angles and their corresponding values of electric field strength

θ (deg)	0	30	60	90	120
E_θ	0.0000000000	0.0342917185	0.05939499874	0.06858343702	0.05939499874
θ (deg)	150	180	210	240	270
E_θ	0.03429171851	0.000000000	-0.03429171851	-0.05939499874	-0.06858343702
θ (deg)	300	330			
E_θ	-0.05939499874	-0.03429171851			

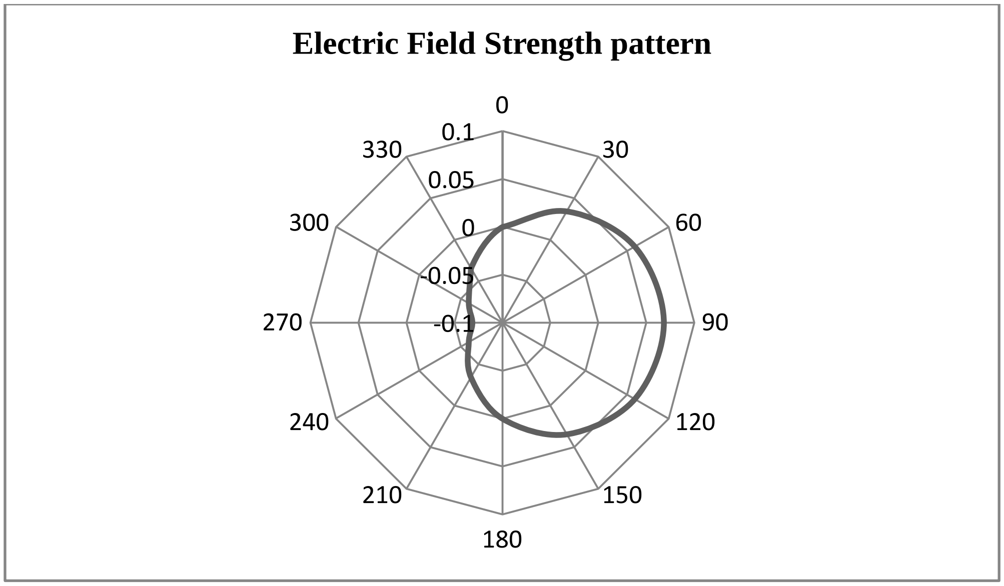


Figure5. Electric field strength pattern of the Half-wave dipole antenna at a frequency of 235MHz

STEP5: The power radiated was determined using the equation (Kraus et al., 2002)

$$P(\theta) = E^2\theta \qquad 29$$

The results is as shown in table3

Table 3: Angles and their corresponding power radiated values

θ (deg)	0	30	60	90	120
$P(\theta)$	0.000000000000	0.001175921958	0.003527765875	0.004703687833	0.003527765875
θ (deg)	150	180	210	240	270
$P(\theta)$	0.001175921958	0.000000000000	0.001175921958	0.003527765875	0.004703687833
θ(deg)	300	330			
$P(\theta)$	0.003527765875	0.001175921958			

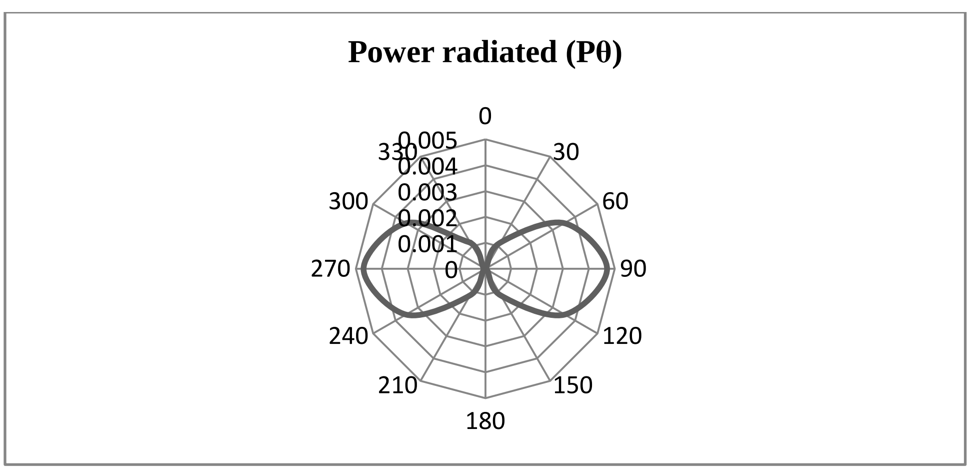


Figure6. Power radiated pattern of the Half-wave dipole antenna at a frequency of 235MHz

STEP6: Normalizing this power with respect to its maximum value yields a normalized power as a function of angle obtained as follow in table 4.

i.e. $pn\theta = p(\theta)/p(\theta)max$ 30

Table 4: Angles and their corresponding normalized radiated power

θ(deg)	0	30	60	90	120	150	180	210	240	270	300	330
(Pnθ)	0.00	0.25	0.75	1.00	0.75	0.25	0.00	0.25	0.75	1.00	0.75	0.25

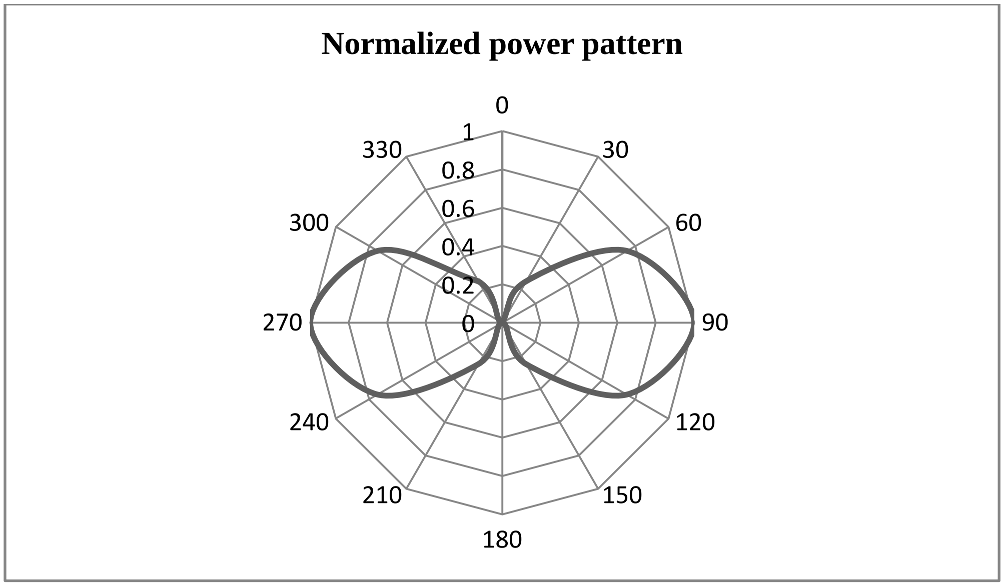


Figure7 Normalized power pattern of the Half- wave dipole at a frequency of 235MHz

STEP7: Normalized power in decibel was obtained from the equation (Kraus et al; 2002)

$dB = 10log_{10}pn(\theta)$ 31

The result is as shown in table 5.

Table5: Angles and their corresponding normalized radiated power.

θ (deg)	0	30	60	90	120
$Pn(\theta)$(dB)	0.00000000	-6.20599983	-1.249387349	0.00000000	-1.249387349
θ (deg)	150	180	210	240	270
$Pn(\theta)$ (dB)	-6.20599983	-0.00000000	-6.20599983	-1.249387349	0.00000000
θ (deg)	300	330			
$Pn(\theta)$ (dB)	-1.249387349	-6.20599983			

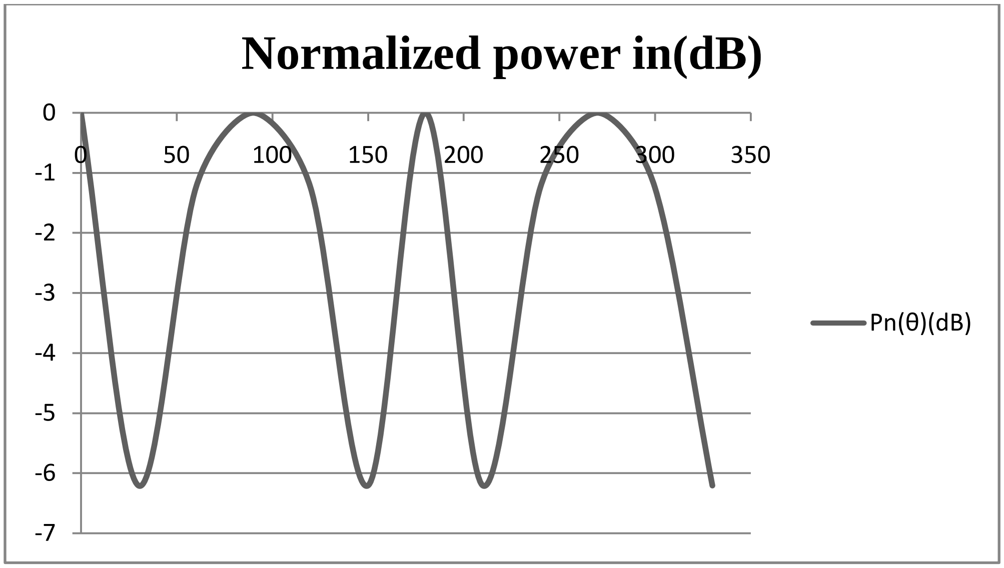


Figure8. Normalized power pattern in decibel of the Half- wave dipole at a frequency of 235MHz

STEP 8: To determine the antenna's directivity, the equation is as follow (Kraus et al; 2002)

$$D = \frac{P(\theta)max}{P(\theta)av} = \frac{0.004703687833}{4.115726854 \times 10^{-3}} = 1.142857143 \text{ Or } 0.57991947\text{dBi} \quad 32$$

Where $P(\theta)max$ is the maximum value of $P(\theta)$and $p(\theta)_{av}$ is the average value of the power radiated

Step9: To determine the gain G of the antenna, the equation is as follow (Kraus et al; 2002)
G=KD
Where K is a constant taken to be 0.61 for half-wave dipole
therefore, $G = 0.61 \times 1.142857143$

Step10: The power is given by the equation (Gautama, 2009)

$$P_{passive} = 320(\frac{1}{\lambda})^2 I^2 rms \text{ Watts} \quad 33$$

$$I_{rms} = \frac{I_O}{\sqrt{2}} = \frac{0.001092735368}{\sqrt{2}} = 0.0007726805972\ (A)$$

$$R_r = 320(\frac{1}{\lambda})^2 = 320(\frac{0.638297872}{1.276595745})^2 = 79.99999\Omega \quad 34$$

Therefore$p = {I_{rms}}^2 \times R_r = 4.776282383 \times 10^{-3}\ Watt$ 35

When this antenna is now fed with the NTA Ogbomosho station transmitter of 5kw the total power radiated will be:

$$T_{Pr} = P_{passive} + pi = (4.776282383 \times 10^{-5} + 5000) watts \quad 36$$

Where (Tpr) is transmitting power radiated by the antenna and (Pi) is the input power or power fed to the transmitter.

$$G = \frac{P_r}{P_i} = \frac{5000.0002985}{5000} = 1.0 \quad 37$$

Step11: The Voltage Standing Wave Ratio (VSWR) is determined using the equation (Kraus et al; 2000)

$$\text{VSWR} = \frac{I_{max} + I_{min}}{I_{max} - I_{min}} = \frac{1.092735368\times10^{-3}+1.283241794\times10^{-4}}{1.092735368\times10^{-3}-1.283241794\times10^{-4}} = 1.3 \quad 38$$

Step12: The variation in electric field intensity relative to distance is obtained from the equation (Gautama, 2009)

$$E_{rms} = \frac{\sqrt{90P_r}}{r} \quad (39)$$

Where E_{rms} is the electric field intensity, r is the distance covered by the signal in kilometers and P_r is the power radiated by the half-wave dipole. The corresponding values of E_{rms} over distance are as shown in table 6.

Table 6: Variation of E_{rms} with distance

Distance (km)	10	20	30	40	50
E_{rms} (V/Km)	67.08204132	33.54102066	22.36068044	16.77051033	13.41640826
Distance (km)	60	70	80	90	100
E_{rms} (V/Km)	11.18034022	9.58314876	8.385255165	7.453560147	6.708204132
Distance (km)	110	120	130	140	150
E_{rms} (V/Km)	6.098367393	5.59017011	5.160157025	4.79157488	4.472136088
Distance (km)	160	170	180	190	200
E_{rms} (V/Km)	4.192627583	3.946002431	3.726780073	3.530633754	3.354102066
Distance (km)	210	220	230	240	250
E_{rms} (V/Km)	3.19438292	3.049183696	2.916610492	2.795085055	2.683281653
Distance (km)	260	270	280	290	300
E_{rms} (V/Km)	2.580078512	2.484520049	2.3958719	2.313173839	2.236068044
Distance (km)	310	320	330	340	350
E_{rms} (V/Km)	2.163936817	2.096313791	2.032789131	1.973001215	1.916629752
Distance (km)	360	370	380	390	400
E_{rms} (V/Km)	1.863390037	1.813028144	1.765316877	1.720052342	1.677051033
Distance (km)	410	420	430	440	450
E_{rms} (V/Km)	1.636147349	1.59719146	1.560047473	1.524591848	1.490712029
Distance (km)	460	470	480	490	500
E_{rms} (V/Km)	1.458305246	1.427277475	1.397542528	1.369021251	1.341640826
Distance (km)	510	520	530	540	550
E_{rms} (V/Km)	1.315334144	1.290039256	1.265698893	1.242260024	1.219673479

Step13: The free space loss of the signal at the design frequency is given by the equation; (Mishra, 2007)

$$L = 32.4 + 20log_{10}(f) + 20log_{10}(d) \quad (40)$$

where f is the frequency in Megahertz and d is the distance in kilometers.
The result is shown in table 7.

Table7: variation of Free space loss with distance

Distance(km)	10	20	30	40	50
Free space loss (dB)	18.28797491	18.65944242	18.86286403	19.00162536	19.10628446
Distance(km)	60	70	80	90	100
Free space loss (dB)	19.18996365	19.25947687	19.31880553	19.37047272	19.41617545
Distance(km)	110	120	130	140	150
Free space loss (dB)	19.45710831	19.49414318	19.52793529	19.55898921	19.58770148
Distance(km)	160	170	180	190	200
Free space loss (dB)	19.61438925	19.63930984	19.66267577	19.68466274	19.70541926
Distance(km)	210	220	230	240	250
Free space loss (dB)	19.72507123	19.74372636	19.76147753	19.77840539	19.79458035
Distance(km)	260	270	280	290	300
Free space loss (dB)	19.81006429	19.82491186	19.83917153	19.85288651	19.86609548
Distance(km)	310	320	330	340	350
Free space loss (dB)	19.87883318	19.89113095	19.90301712	19.91451742	19.92565527
Distance(km)	360	370	380	390	400
Free space loss (dB)	19.93645203	19.94692726	19.95709892	19.9669835	19.9765962
Distance(km)	410	420	430	440	450
Free space loss (dB)	19.98595108	19.99506113	20.00393841	20.0125941	20.02103863
Distance(km)	460	470	480	490	500
Free space loss (dB)	20.02928169	20.03733235	20.04519908	20.05288982	20.06041199
Distance(km)	510	520	530	540	550
Free space loss (dB)	20.06777257	20.07497812	20.08203483	20.08894849	20.0957246

3. RESULTS AND DISCUSSION

Figure 4,5 and 6 show the far field radiation pattern, the electric field strength radiation pattern and the power radiation pattern of the Half-wave dipole antenna at the design frequency of 235MHz using method of moment. The patterns obtained show that the antenna is a good ominidirectional antenna.

Figure 7 and 8 show the normalized pattern in degree and decibel which shows that the antenna has maximum beamwidth or maximum directivity at $\theta = 90^0$ and $\theta = 270^0$. Also figure7 shows that the electric field is left circularly and right circularly polarized with $\delta = \pm 90^0$.

Figure 9 shows the variation in Electric field strength of the Half-wave dipole antenna with respect to distance at the design frequency of 235MHz. It can be observed from fig.8 that the electric field strength decreases with increase in distance. It can be observed from figure8 and table 6 that the electric field strength decreases rapidly within the shortest distance of 20 to 30 km away from the base station. This account for the reason why the signal cannot travel far distance within the same state or region before it is completely attenuated.

Figure10 shows the corresponding free space loss in signal strength as the distance increases. It is obvious from the graph that the loss increases with increase in distance. Also, figure 11 shows the reduction in power density as the distance increases.

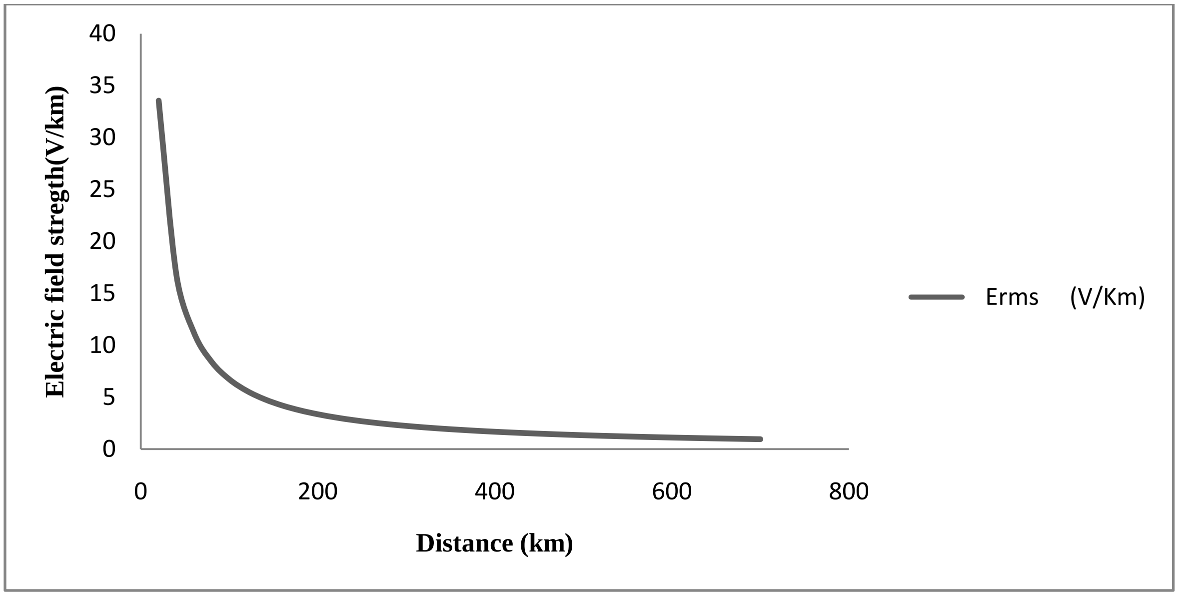


Figure 9 Variation of Electric field with distance.

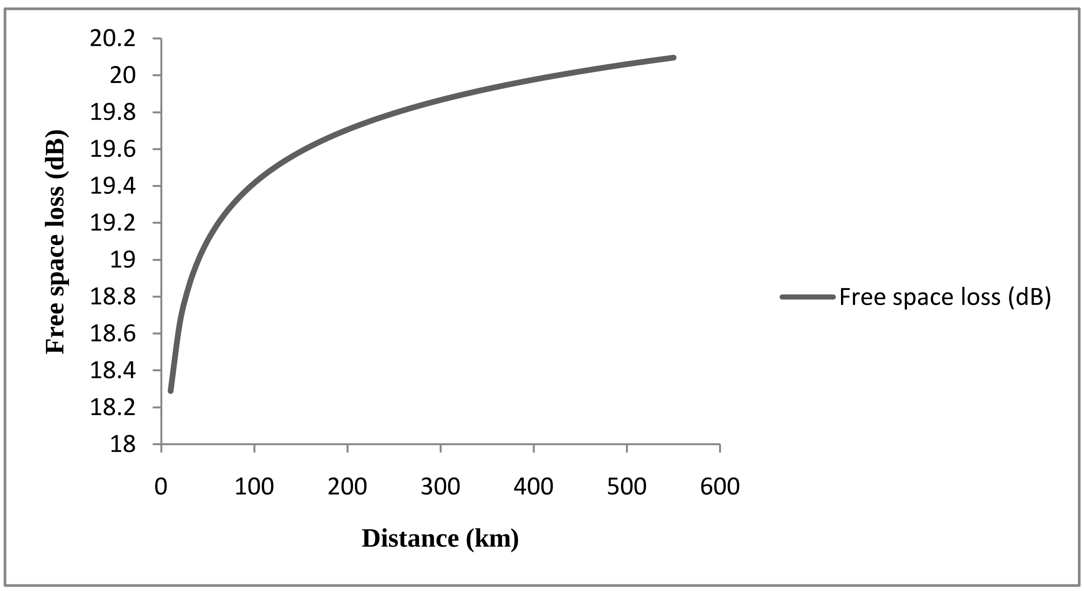


Figure 10 Free space loss per distance

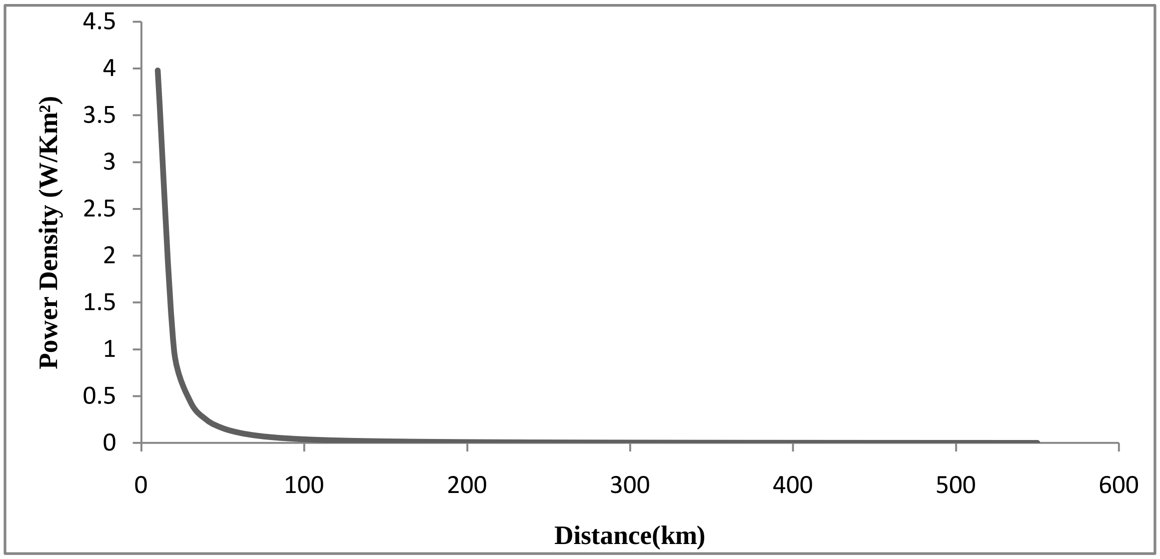


Figure11 Variation of power density with distance.

4. CONCLUSION

The result obtained, in this research, shows that half- wave dipole antenna is not too good for long distance transmission of television signal at the design frequency of 235MHz and that there is need for accurate design and analysis of television station transmitting antennas before implementation so as to minimize the cost of installation and maintenance of multiple transmitting stations within short distance that would have possibly be covered by single transmitting and efficient antenna. Arrays of wide bandwidth antennas coupled with high power transmitters can be employed in television signal transmission for efficient and effective transmission over long distance.

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