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EFFECT OF RADIATION ON ELECTROMAGNETIC WAVES

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ABSTRACT: *This project was carried out to know the physics and mechanism behind the effect of radiation on electromagnetic wave. A brief history of electromagnetic wave will be discuss thereby exposing the laws of electric and magnetic field etc, electromagnetic spectrum and the properties of atmosphere with respect to various parts of electromagnetic spectrum. The derivation of the four Maxwell equations both the integral and differential forms and the derivation of electric potential due to electric dipole antenna cause by the effect of radiation and the radiation resistance.*

Keywords: Electromagnetic Wave, Electric Field, Magnetic Field, Radiation.

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INTRODUCTION

Maxwell's equations represent one of the most elegant and concise ways to state the fundamentals of electricity and magnetism. From them one can develop most of the working relationship in the field. Because of their concise statement, they embody a high level of mathematical sophistication and are therefore not generally introduced in an introductory treatment of the subject, except perhaps as summary relationships.

Those basic equations of electricity and magnetism can be used as a starting point for advanced courses, but are usually first encountered as unifying equations after the study of electrical and magnetic phenomenon.

Gauss's Law of Electric Field

Gauss law of electric field states that the total outward flux of the electric field intensity over any close surface at any point in free space is equal to the total charge enclosed by the surface divided by ε_o(permitivity).

Differential Form of Gauss Law of Electric Field

We can now apply the Gauss law to a surface of any given shaped provided it is closed.

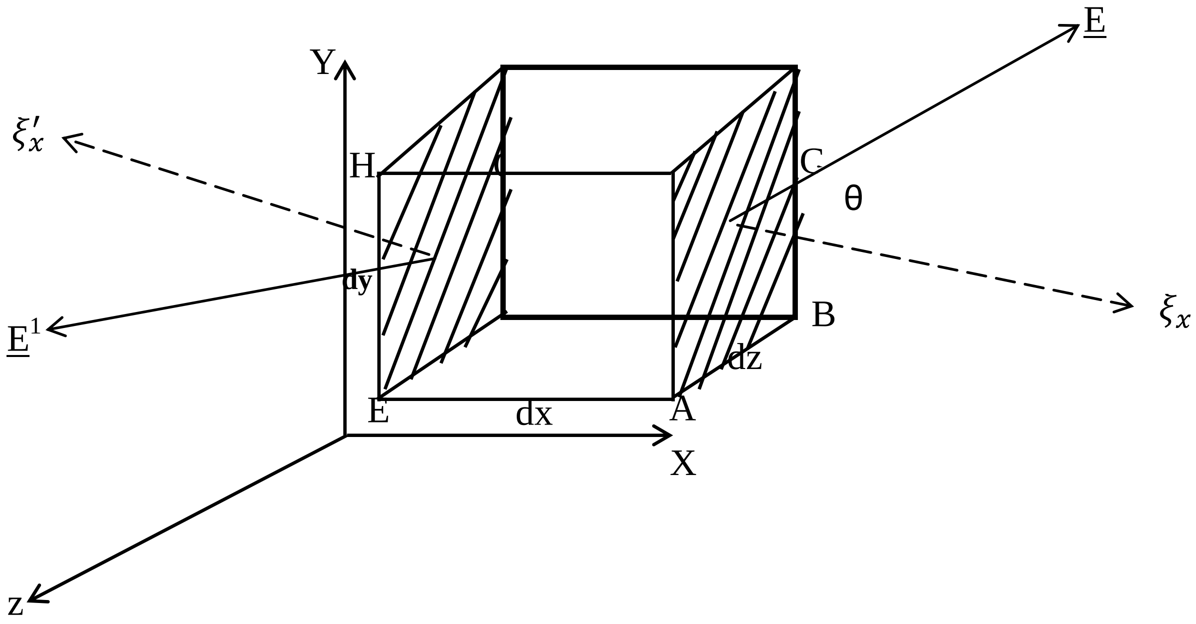

Figure 1.1: Representation of Gauss's Law of Electric Field

The law will now be applied to the diagram by considering the surface of infinitesimal volume. For example edges of the surfaces are parallel to the x, y and z axes as shown in figure 1.1 above and the size of the volume of elements are dx, dy and dz. We first of all take the surface A, B, C and D given by

$ds = dydz$

Now the electric flux through this surface is

$E.ds = |\underline{E}| ds \cos\theta$

$= |\underline{E}| \cos\theta \, dydz$

$= \xi_x dydz \qquad (2.1)$

Where $\xi_x = \underline{E} \cos\theta$

Next we consider the surface E, F, G and H the electric field there is negative.

∴We can write

$\underline{E}'.ds = -\xi_x' dydz \qquad (2.2)$

Therefore, the total flux through the two surfaces is the sum given by

$\xi_x dydz - \xi_x' dydz$
$= (\xi_x - \xi_x') dydz \qquad (2.3)$

The distance between the surfaces $EA = dx$ is very small and therefore

$\xi_x - \xi_x^{\square} \sim 0$ which is the sum of electric field must be small. We can write

$$\xi_x - \xi^{\square}{}_x = \frac{\partial \xi_x^{\square} dx}{\partial x} \qquad (2.4)$$

Now in the x- direction the total flux is given by

$$\frac{\partial \xi_x}{\partial x} dxdydz = \frac{\partial \xi_x}{\partial x} dv \qquad (2.5a)$$

When $dV = dxdydz$ which is the volume element of the box

Also we can obtain the expression for the y- direction and z- direction given

$$\frac{\partial \xi_y}{\partial y} dxdydz = \frac{\partial \xi_y}{dy} dv \qquad (2.5b)$$

$$\frac{\partial \xi_z}{\partial z} dxdydz = \frac{\partial \xi_z}{\partial z} \qquad (2.5c)$$

∴ the total flux through the volume element is given by

$$\square = \frac{\partial \xi_x}{\partial x} dv + \frac{\partial \xi_y}{\partial y} dv + \frac{\partial \xi_z}{\partial z} dv$$

$$= \left[\frac{\partial \xi_x}{\partial x} + \frac{\partial \xi_y}{\partial y} + \frac{\partial \xi_z}{\partial z}\right] dv \qquad (2.6)$$

We now apply Gauss's law so that the total charge will now be given as

$$\square = \frac{dq}{\varepsilon_0} \qquad (2.7)$$

From equation 2.6 and 2.7 we get

$$\left[\frac{\partial \xi_x}{\partial x} + \frac{\partial \xi_y}{\partial y} + \frac{\partial \xi_z}{\partial z}\right] dv = \frac{dq}{\varepsilon_0} \qquad (2.8)$$

In terms of electric charge density ρ

$$dq = \rho dv \qquad (2.9)$$

Substituting equation 2.9 into 2.8 we get

$$\frac{\partial \xi_x}{\partial x} + \frac{\partial \xi_y}{\partial y} + \frac{\partial \xi_z}{\partial z} = \frac{d\rho}{\varepsilon_0} \qquad (2.10)$$

Equation 2.10 is the Gauss's law expressed in differential form.

The hand side expression is refers to as the divergence of electric field vector. It is normally written as:

$$\nabla . \underline{E} = \frac{\rho}{\varepsilon_0} \qquad (2.11)$$

The physical meaning of equation 2.11 is that electric charge and the source of electric field so that the distribution of the charges and their magnitude determine the electric field at each point in space.

Differential Derivation of Faraday's Henry Law

In Cartesian coordinate system, we can consider a general elemental loop by its projection on three coordinate plane. So first we evaluate the equation

$$\oint E \cdot dl = -\frac{\partial \square}{\partial t} \qquad (2.12)$$

For a rectangular loop $(\delta y \times \delta z)$ lying in a plane perpendicular to the axis Ox (figure 2.1 below).

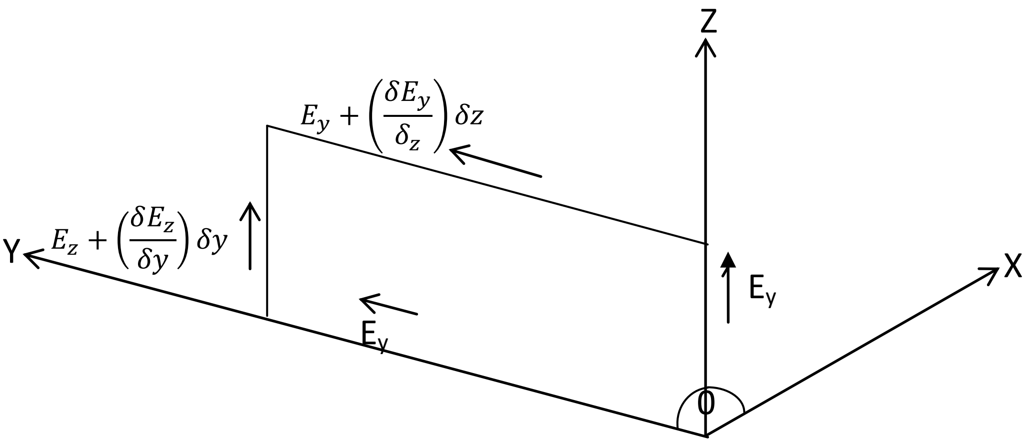

Figure 2.1: Rectangular Loop in the y – z Plane for Evaluating the Line Integral E, dl.

The vat ion of E_y and E_z for the rectangular loop one indicated in figure 2.1 above. So taking the line integral over the closed loop we have.

$$\oint E \cdot dl = E_y \delta y + \left(E_z + \frac{\partial E_z \delta y}{\partial y}\right)\delta z - \left(E_y + \frac{\partial E_y \delta y}{\partial z}\right) - E_z \delta z$$

$$= \left(\frac{\partial E_z}{\partial y}\right) - \left(\frac{\partial E_y}{\partial z}\right)\delta y \delta z \qquad (2.13)$$

Also

$$□ = B_x \delta y \delta z \qquad (2.14)$$

Cancelling $\delta y \delta z$ from the side of equation (2.13) we get.

$$\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z} = -\frac{\partial B_x}{\partial t} \qquad (2.15)$$

By considering two more loops in the z – x and x – y plane, two similar equations for the y and z directions will be obtained.

NB: $\frac{d□}{\delta t}$ = Rate of change of □ with respect to time in a particular circuit.

$\frac{\partial B_x}{\delta t}$ = Time rate of change of B_x which also can vary with position.

The vector whose component in any direction n is the limit of the ratio

$$= \frac{line\ integral\ E\ round\ a\ closed\ loop\ C_n\ normal\ ton}{Area\ of C_n}$$

When C_n is made very small is called the curl symbolically

$$|CurlE| = |\nabla \times E| = \lim_{\delta S_n \to 0} \frac{\oint_{C_n} E \cdot dl}{\delta S_n} \qquad (2.16)$$

Where δS_n is the area of C_n and we have shown above that in Cartesian coordinate

$$CurlE = U_x\left[\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z}\right] + U_y\left[\frac{\partial E_x}{\partial z} - \frac{\partial E_z}{\partial x}\right] + U_z\left[\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y}\right]$$

The three equations 2.14, 2.15, and 2.16 are replaced by a single vector equation i.e.

$$CurlE = \nabla \times E = -\frac{\partial B}{\partial t} \qquad (2.17)$$

Integral Derivative of Faraday' s Henry Law

From the integral form of the law of induction which was experimentally verified by Faraday for the stationary circuit i.e.

$$\oint_C E \cdot dl = -\frac{\partial}{dt}\iint_s B \cdot ds \qquad (2.18)$$

In the generalization, the source current creating the flux may be varying sinusoidal with time, so that B also varies the same way. So B can expressed as

$$B = B(x, y, z, t)$$

i.e. B depends on both the space and the time coordinate we consider a closed contour c which correspond to the left hand side of the above equation (2.16) and left each element dl of C move to a new position C (figure 2.3 below) with a velocity U and V need not be uniform. Then the rate of change of the flux Φ is

$$\frac{d\Phi}{dt} = \frac{d}{dt}\iint_s B \cdot ds$$

$$= \lim_{\Delta t \to 0}\left[\frac{\iint_s B'(t + \Delta t) \cdot ds' - \iint_s Bct) \cdot ds}{\Delta t}\right] \qquad (2.19)$$

Where Δt is the travel – time and $B'(t + \Delta t)$ denotes the flux density across the surface S' at a time $(t + \Delta t)$. The volume swept out by the motion C to C' is bounded by the surface S, S' and by the curved surface joining them.

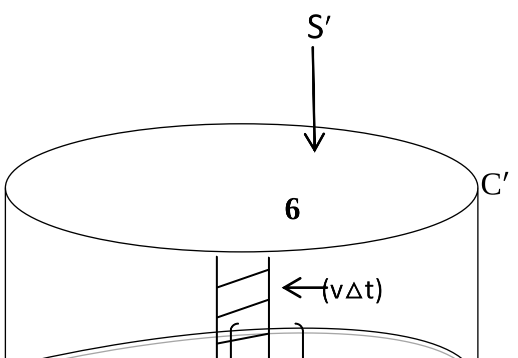

Figure 2.3: The Path of Integration Moves from C to C' in the Time Δt.

Applying the Gauss theorem, we get.

$$\iiint div\, B dv = \iint_S B'(t+\Delta t)\cdot ds' + \int_c B(t+\Delta t)\cdot(dl \times V\Delta t) - \iint_S B(t+\Delta t)\cdot ds \qquad (2.20)$$

Where $dl + V\Delta t$ is the shaded surface element show, the figure above and the negative sign on the last integral indicates that the flux on the lower surface is opposite in sign to that in the upper one. Also, it is to be noted that the instant under consideration is $(t + \Delta t)$.

By Taylors' theorem, the last integral in equation (2.18) is (theorem state that any function satisfying certain condition can be repressed as a Taylor's series.

$$B(t+\Delta t) = B(t) + \frac{\partial B}{\partial t} \qquad (2.21)$$

Applying the stake's theorem which relates surface integrals and line integrals to the second integral on the right – hand side of equation (2.18) we get

$$\int_c B(t+\Delta t)\cdot(dl \times V\Delta t) = \Delta t \int_c V \times B(t+\Delta t)\cdot dl$$

$$= \Delta t \iint_c Curl[V \times B(t+\Delta t)]\cdot dl \qquad 2.22$$

Substituting equation 9 and 10 into equation 8 and using the fact that $V \cdot B = 0$, we get

$$0 = \iint_{s} B'(t+\Delta t) \cdot ds' + \Delta t \iint_{s} Curl[V \times B(t+\Delta t)] \cdot dl - \iint_{s} B(t) \cdot ds + \frac{\partial}{\partial t} \iint_{s} [B(t)ds]\Delta t \qquad (2.23)$$

The superscript on s becomes unnecessary as we calculate $\frac{\Delta\Phi}{\Delta t}$ in the limit. Hence from equation (2.17) we get.

$$\frac{\mathrm{d}\Phi}{\mathrm{d}t} = \frac{\partial}{\partial t} \iint_{s'} B \cdot ds - \iint_{s} Curl(V \times B) \cdot ds \qquad 2.24$$

And the integral form of Faraday's law become

$$\oint_{c} E \cdot dl = -\frac{\partial}{\partial t} \iint_{s'} B \cdot ds - \iint_{s} Curl(V \times B) \cdot ds \qquad (2.25)$$

Or

$$\oint_{c} E \cdot dl = -\frac{d}{dt} \oint_{c} B \cdot ds$$

Differential Form of Ampere's Maxwell Law

Ampere's circuital law (without modification) states that the line integral of the magnetic field H around any closed path or circuit is equal to the current enclosed by the path.
That is

$$\int H \cdot dl = I \qquad (2.26)$$

Let the current is distributed through the surface with a current density J, then

$$I = \int J \cdot ds$$

This implies that

$$\int H \cdot dl = \int J \cdot ds \qquad (2.27)$$

Apply stokes theorem to the L.H.S of equation 2.34 to change line integral to surface integral, that is

$$\int H \cdot dl = \int (\nabla \times v) \cdot ds \qquad (2.28)$$

Substituting equation2.35 into equation 2.34 to get

$$\int (\nabla \times H) \cdot ds = \int S \cdot J \cdot ds \qquad (2.29)$$

As two surface integrals are equal only if their integrands one equal.

Thus,

$$\nabla \times H = J \qquad (2.30)$$

This is the differential form of Ampere's circuital low (without modification) for steady currents.

Taking divergence of equation (2.30)

$$\nabla \cdot (\nabla \times H) = \nabla \cdot J$$

As divergence of the curl of a vector is always zero, therefore

$$\nabla \cdot (\nabla \times H) = 0 \qquad (2.31)$$

It means

$$\nabla . J = 0 \qquad (2.32)$$

Now, this is equation of consistency for steady current but not for time – varying field, as equation of continuity for time varying is

$$\nabla . J = -\frac{dp}{dt} \qquad (2.33)$$

So, there is inconsistency in Ampere's circuital law. This is the reason that led Maxwell to modify;

Ampere's Circuital Law

Maxwell modified Ampere's law by giving the concept of displacement current D and so the concept of displacement current density Jd for time varying fields. He concluded that equation 2.40 for time varying fields should be written as

$$\nabla \times H = J + \mathrm{Jd} \qquad (2.34)$$

By taking divergence of equation (5) we get

$$\nabla \cdot (\nabla \times H) = \nabla . J + \nabla Jd$$

As divergence of the curl of a vector is always zero therefore

$$\nabla . (J + Jd) = 0$$

Or

$$\nabla . J = -\nabla Jd \qquad (2.35)$$

But from equation of continuity for time varying fields,

$$\nabla . J = -\frac{dp}{dt}$$

By comparing above two equation

$$\nabla . Jd = \frac{dp}{dt} \qquad (2.36)$$

Because from Maxwell first equation

$$\nabla . D = P$$

As the divergence of two vectors is equal only if the vectors one equal.

Thus;

$$Jd = \frac{dD}{dt} \qquad (2.37)$$

Substituting equation 2.34 into equation 2.37 we get

$$\nabla \times H = J + \frac{dD}{dt} \qquad (2.38)$$

Here,
$\frac{dD}{dt} = Jd =$ Displacement current density

$J =$ Conduction current density
D = Displacement current

The equation 2.38 is the differential form of Maxwell fourth equation or modified Ampere's circuital law.

Integral Form of Ampere' s Maxwell' s Equation

Taking surface integral of equation 2.45 on both sides we get.

$$\int (\nabla \times H) \cdot ds = \int \left(J + \frac{dD}{dt}\right) \cdot ds \qquad (2.39)$$

Apply Stake's theorem to L.H.S of above equation we get.

$$\int (\nabla \times H) \cdot ds = \int IHdl \qquad (2.40)$$

Comparing the above to equation we get

$$\int H.dl = \int \left(J + \frac{dD}{dt}\right).ds \qquad (2.41)$$

THE ELECTRIC DIPOLE ANTENNA

An electric dipole is a common source of electric field consisting of two equal and opposite point charges +q and –q a short distance d apart. If dis position vector +q with respect to –q the dipole moment is then defined by p= pd. The expression for the potential and field due to an electric dipole simplifies considerably if determined at a distance from the charges which is large compared with d as in the following figure.

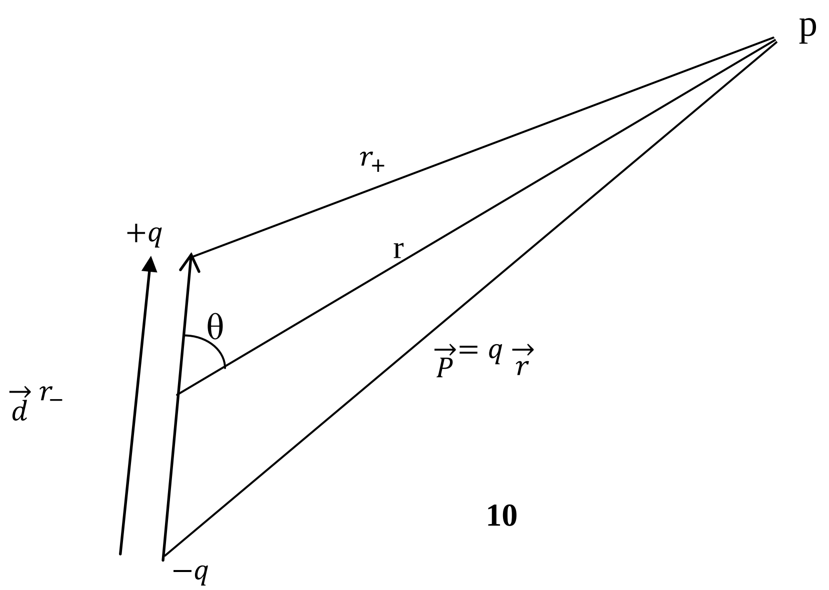

Fig 3.1: Potential Due to an Electric Dipole

Starting with electrostatic scalar potential $V_{(r)}$ as

$$V_r = \int_{ri}^{r} \vec{E} \,.\, dr$$

Or

$$dv = -\vec{E}.dr \qquad (2.42)$$

Now if we take the origin of coordinate system at the dipole center, the electric potential due to the two charges at a point p with position vector $\vec{r}$ may be express by applying the following equation below.

$$V_{(r)} = -\frac{q}{4\pi\varepsilon_0}\int_0^{r_+}\frac{dr}{r_+^2} + \frac{q}{4\pi\varepsilon_0}\int_0^{r_-}\frac{dr}{r_-^2} \qquad (2.43)$$

$$V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r_+} - \frac{1}{r_-}\right) \qquad (2.44)$$

It is convenient to expand r_+ and r_- into power series of the radius $\frac{d}{2r}$ (fig above) as

$$\frac{1}{r_+} = \frac{1}{\sqrt{r^2} + d^2/4 \pm rd\cos\theta} \qquad (2.45)$$

$$\frac{1}{r}\left(1 + \frac{d^2}{4r^2} \pm \frac{d}{r}\cos\theta\right)^{-\frac{1}{2}}$$

$$\frac{1}{r}\left[1 + \frac{d}{dr}\cos\theta + \frac{1}{2}(3cos^2\theta - 1)\left(\frac{d^2}{4r^2}\right) \pm \cdots\right] \qquad (2.46)$$

So the potential is given in terms of dipole moment $\vec{p}$ by

$$V_{(r)} = \frac{qd\cos\theta}{4\pi\varepsilon_0 r^2}$$

$$= \frac{p\cos\theta}{4\pi\varepsilon_0 r^2} = \frac{\vec{p}.\vec{r}}{4\pi\varepsilon_0 r^3} \qquad (2.47)$$

The electrical field to the electrical dipole is obtained by further differentiation since the electric field is minus the gradient of the electrostatic potential

That is

$$\vec{E} = -grad\,V = -\nabla V \qquad (2.48)$$

And also we have

$$\vec{E} = -\nabla\left(\frac{\vec{p}.\vec{r}}{4\pi\varepsilon_0 r^3}\right) = \frac{1}{4\pi\varepsilon_0}\left[\frac{1}{r^3}\nabla(\vec{p}.\vec{r}) + (\vec{p}.\vec{r})\nabla\left(\frac{1}{r^3}\right)\right] \quad (2.49)$$

We can write

$$\nabla\left(\overrightarrow{p.r}\right) = \vec{p} \qquad (2.50)$$

And since

$$\frac{\partial r}{\partial x} = \frac{\partial}{\partial x}(x^2+y^2+z^2)^{\frac{1}{2}} = \frac{x}{r} \qquad (2.50A)$$

$$\frac{\partial r}{\partial y} = \frac{\partial}{\partial y}(x^2+y^2+z^2)^{\frac{1}{2}} = \frac{y}{r} \qquad (2.50B)$$

$$\frac{\partial r}{\partial z} = \frac{\partial}{\partial z}(x^2+y^2+z^2)^{\frac{1}{2}} = \frac{z}{r} \qquad (2.50C)$$

It follows that

$$\nabla\left(\frac{1}{r^3}\right) = -\frac{3}{r^4}\left(\frac{xe_x}{r} + \frac{xe_y}{r} + \frac{xe_z}{r}\right) \qquad (2.51)$$

$$= -\frac{3\vec{r}}{r^5}$$

Thus obtains

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\left[3\frac{(\vec{p}.\vec{r})\vec{r}}{r^5} - \frac{\vec{p}}{r^3}\right] \qquad (2.52)$$

The Half-Wave Antenna

The oscillating dipole discussed so far is useful tool for theoretical wave but it is not a practical antenna. The half wave antenna (fig. 3.2) is simply a straight conductor whose length is half a free-space wavelength. It is feed that the center i.e. a current $(Iocoswt)$is established at the center of the dipole by means of a suitable electronic circuit and a standing wave is formed along the conductor.

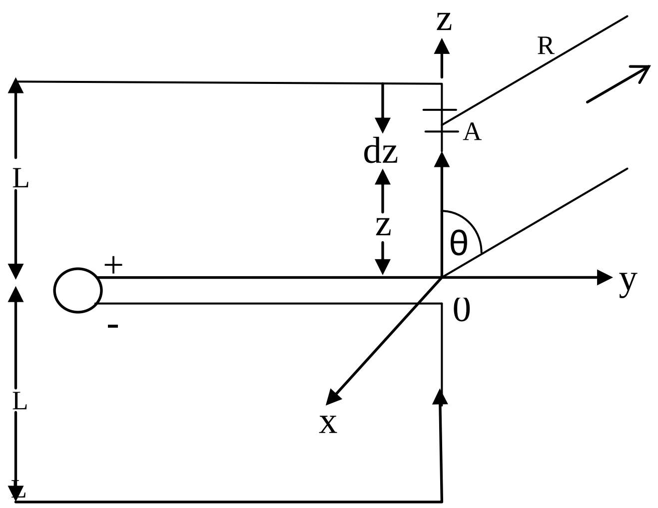

Fig 3.2a: A Linear Dipole Antenna of Length 2L

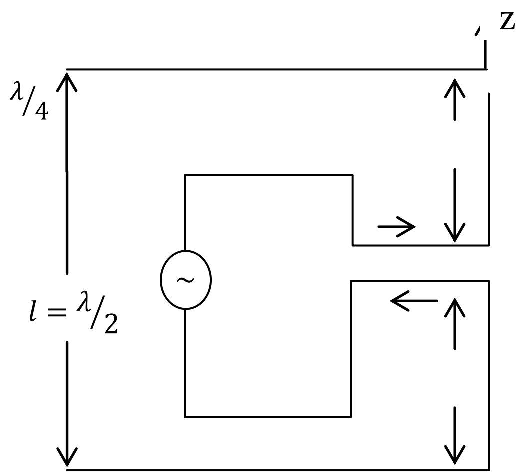

Fig. 3.2b: Center-Fed Half-Wave Antenna

The standing wave of the current on the conductor is

$$I = I_0 exp(j\omega t)\cos(\beta l) \qquad (2.53)$$

Each element (Idl) of the antenna than radicate an electromagnetic wave similar to that of electric dipole and the field at any time in space is the sum of all of these fields.

The vector potential at any point $P(r, \emptyset, \theta)$due to the antenna element Idl at a distance *l* from the center point of the antenna c which is also the origin of our coordinate system is given by;

$$dA_z = \frac{\mu_0 I exp(-j\beta R) dl}{4\pi R} \quad (2.54)$$

Where; R is the distance between the point P and the antenna element (Id*l*).

The total vector potential A_z at P due to all the current element in the antenna is;

$$A_z = \left(\frac{\mu_0}{4\pi}\right) \int_{-\frac{\pi}{4}}^{0} I_0 \cos(\beta l) \exp(-j\beta R) \frac{dl}{R} \ldots$$

$$\left(\frac{\mu_0}{4\pi}\right) \int_{0}^{\frac{\pi}{4}} I_0 \cos(\beta l) \exp(-j\beta R) \frac{dl}{R} \quad (2.55)$$

We can write $R = r - l\cos\theta$

The above expression for A simplifies to

$$A_z = \left(\frac{\mu_0 I_0}{4\pi}\right) exp(-j\beta r) \times \int_{0}^{\frac{\pi}{4}} \cos(\beta l)[\exp(j\beta l \cos\theta) + \exp(-j\beta l \cos\theta)]\, dl \quad (2.56)$$

$$\therefore A_z = \left(\frac{\mu_0}{4\pi r}\right) exp(-j\beta r) \times \int_{0}^{\frac{\pi}{4}} [\cos\{\beta_z(1 + \cos\theta)\} + \cos\{\beta_z(1 - \cos\theta)\}]\, dl$$

$$= \left[\frac{\mu_0 I_0 \exp(-j\beta r)}{2\pi\beta r}\right]\left[cos \frac{\{(\pi/2) cos\, \theta\}}{sin^2\theta}\right] \quad (2.57)$$

Since the current is entirely in the z direction,

$$H_\emptyset = \left(\frac{1}{\mu_0}\right)\left[-\left(\frac{\partial A_z}{\partial r}\right)\sin\theta\right]$$

$$= \left[\frac{jI_0 \exp(-j\beta r)}{2\pi r}\right]\left[\frac{\cos(\pi/2)\cos\theta}{\sin\theta}\right] \quad (2.58)$$

Retaining only $\frac{1}{r}$ term for the large distance considered,

The electric field strength

$$E_\theta = Z_0 H_\emptyset = \left[\frac{j60 I_0 \exp(-j\beta r)}{r}\right]\left[\frac{\cos\{(\pi/2)\cos\theta\}}{\sin\theta\theta}\right] \quad (2.59)$$

The magnitude of the E field for the radiation field of a half wave dipole or a quarter wave monopole is

$$|E_\theta| = \left(\frac{60 I_0}{r}\right)[\cos\{(\pi/2)\cos\theta\}]\frac{v}{m} \quad (2.60)$$

For $\theta = 0$ and $\theta = \pi$ the expression for E_θ and H_ϕ become indeterminate because the trigonometric term become$(0/0)$. To evaluate it, we use L' Hospital's rule

$$\lim_{\theta \to 0\ or\ \pi} \left[\frac{\cos\{(\pi/2)\cos\theta\}}{\sin\theta}\right]$$

$$= \frac{d/_{d\theta}\left[\cos\{(\pi/_2)\cos\theta\}\right]}{d/_{d\theta}(\sin\theta)}\Bigg|_{\theta\to 0\ or\ \pi} \quad (2.61)$$

$$= \frac{\sin\{(\pi/_2)\cos\theta\}(\pi/_2)\sin\theta}{\cos\theta}\Bigg|_{\theta\to 0\ or\ \pi} \quad (2.62)$$

∴The average value in time of the pointing vector $\left(=\frac{1}{2}\ the\ peak\ value\right)$

$$S_{av} = \left(\frac{Z_0 I_0^2}{8\pi^2 r^2}\right)\left[\frac{\cos\theta\{(\pi/_2)\cos\theta\}}{sin^2\theta}\right] \quad (2.63)$$

The total radiated power is obtained by intergrading S_{av} over a sphere of radius r.

$$W = 9.55(I_{rms})^2 \int_0^{2\pi}\int_0^{\pi}\left[\frac{cos^2\{(\pi/_2)\cos\theta\}}{\sin\theta}\right]d\theta \quad (2.64)$$

By replacing I_0 by its rms value I_{rms}. The above integral can be evaluated in a number of ways. One possible way is use substitution.

$$\left(\frac{\pi}{2}\right)\cos\theta = \frac{\alpha}{2} - \frac{\pi}{2}$$

$$\therefore I = \int_0^{\pi}\left[\frac{cos^2\{(\pi/_2)\cos\theta\}}{\sin\theta}\right]d\theta$$

$$= \int_0^{2\pi}\left[\frac{1-\cos\alpha}{\alpha(4\pi - 2\alpha)}\right]d\alpha \quad (2.65)$$

Breaking up the fraction

$$\frac{1}{\alpha(4\pi - 2\alpha)} = \left(\frac{1}{4\pi}\right)\left(\frac{1}{\alpha} + \frac{1}{2\pi - \alpha}\right)$$

$$\therefore I = \left(\frac{\pi}{4\pi}\right)\left[\int_0^{2\pi}\left(\frac{1-\cos\alpha}{\alpha}\right)d\alpha + \int_0^{2\pi}\left(\frac{1-\cos\alpha}{2\pi - \alpha}\right)d\alpha\right] \quad (2.66)$$

$$= \left(\frac{1}{2}\right)\int_0^{2\pi}\left(\frac{1-\cos\alpha}{\alpha}\right)d\alpha \quad (2.67)$$

$$= \left(\frac{1}{2}\right) \times 2.24377$$

By Simpson's rule

$$W = 73.1(I_{rms})^2 watts$$

$$R_{rms} = 73.1$$

Thus the radiation resistance of the half wave antenna is 73.1Ω on the basis of the assumption that the current distribution is sinusoidal which however is no quite correct.

SUMMARY AND CONCLUSION

The system designed for effectively radiating electromagnetive waves are called antenna of which there are many types. Once an antenna creates the electromagnetic wave, the wave travels through the space to its destination where the message contained in the wave has to be extracted. The distance between the transmitting antenna and the receiving point is variable and can be as much as hundreds of thousands of miles. For such large distances, special antennae which receive very narrow beams are used. For receiving purpose, structures similar to transmitting antennae are used. So on this project work, the brief history of electromagnetic wave was done, the deviation of the four (4) Maxwell's equation both the integral and differentiation form was also done and lastly calculation of electric field due to electric dipole antenna and the radiation resistance of a half wave antenna was done.

In this project work, it has come to a conclusion that the sources of any electromagnetic field are electric charges and currents. When these charges are time-varying, they may produce electromagnetic waves propagating away from the sources (and not returning to them). Such a process is known as radiation of electromagnetic waves. Theoretically, any time-varying sources of charges and currents radiate certain amount of energy.

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