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TANSIENT RADIATION FROM SIMPLE CURRENT DISTRIBUTIONS AND MODEL PARTICLE ANTENNAS

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ABSTRACT

In this paper we've got thought of the transient radiation from two straightforward current of the filamentary current distribution that square measure of accustomed quite sensible antennas as an example the wave component and also the standing dipole. Precise analytical expressions were given for the electrical and magnetic fields of those distributions. Once the excitation was a general operate of your time. These expressions apply in each the close to and also the close to and much zone for associate excitation i.e, Gaussion pulse in time, precise analytical expressions were obtained for the energy effort the filament per unit time per unit length, the overall energy effort the filament per unit length and also the total energy radiated.

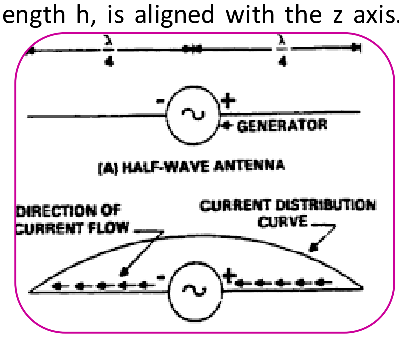
KEYWORDS: *Analytical expressions, current distribution and electromagnetic radiation.*

INTRODUCTION

During the previous few years, variety of articles have appeared within the publications that contend with the radiation from straightforward filamentary current distribution and straightforward wire antennas . the aim of those articles typically is to feature to the physical understanding of the method of radiation, that raise understanding of wherever radiation originates on these structures and also the mechanism by that energy propagates aloof from the structures the way zone. In Associate in Nursing earlier article the author created the radiation from two straightforward filamentary current distributions: traveling-wave and uniform [i-iv]. The radiated of far-zone field of force was computed for and excitation that was a Gaussian pulse in time. Two interpretations for the origin of the radiation were bestowed supported the far-field results. during this article, we have a tendency to continue this investigation; but, the stress is on Associate in Nursing examination of the close to filed and also the connected transport of energy aloof from the present distributions, as a result of these distributors area unit often accustomed model sensible antennas.

ELECTROMAGNETIC FIELDS OF TWO FILAMENTARY CURRENT DISTRIBUTIONS.

The geometry and the associated coordinates for the traveling-wave current distribution, which we call the traveling-wave element, are shown in Fig.-1. The element, of length h, is aligned with the z axis. There is source of currents $I_s(t)$ at the bottom of the element. A traveling wave of current leaves the source and propagates along the element at the speed of light, 'c' unit it reaches the termination, where it is totally absorbed. The distribution for the axial current is



$$I(z,t)=I_s(t-z/c)[U(z)-U(z-h)]\text{.......................................(i)}$$

and from the equation of continuity for electric charge, the change per unit length on the element is
$Q(z,t)=Q_s(t-z/c)[U(z)-U(z-h)]+q_0(t)\delta(z)+q_h(t)\delta(z-h)$...........(ii)

Where,

$Q_s(t)=I_s(t)/c$
$Q_0(t)= -\int_{t`=\infty}^{l} =I_s(t`)/dt`$,
$Q_h(t)= -\int_{t`=\infty}^{l} =I_s(t`-h/c)/dt`$...(iii)

Here, U is the Heaviside unit-step function, and δ is the Dirac delta function. The three terms in Equation (ii) represent a traveling wave of positive charge, Q_x, propagating along the element at the speed of light; a negative charge, q_0 that is left behind at the lower end as the pulse of positive charge leaves the source (the element is electrically neutral): and a positive charge, q_h, that accumulates at the upper and as the pulse enters the termination.

The geometry and the associated coordinates for the standing-wave current distribution, which we call the standing wave dipole, are shown in Fig.-1b. This terminology is used because the distribution becomes the familiar standing wave when the excitation is time harmonic. It is a dipole with the arms (each of length h) aligned with the z axis. There is a source of current, L(t) at the center of the dipole (z=0). The source produces a traveling wave of current (a pulse of positive charge) that propagates at the speed of light up the top up the top arm of the dipole.

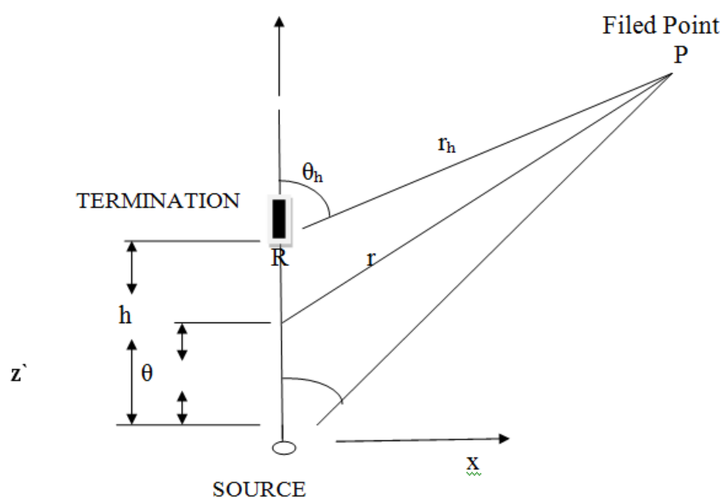


Fig.-1(a) : A schematic drawing showing the traveling- wave element with the coordinates used in evaluating the electromagnetic field.

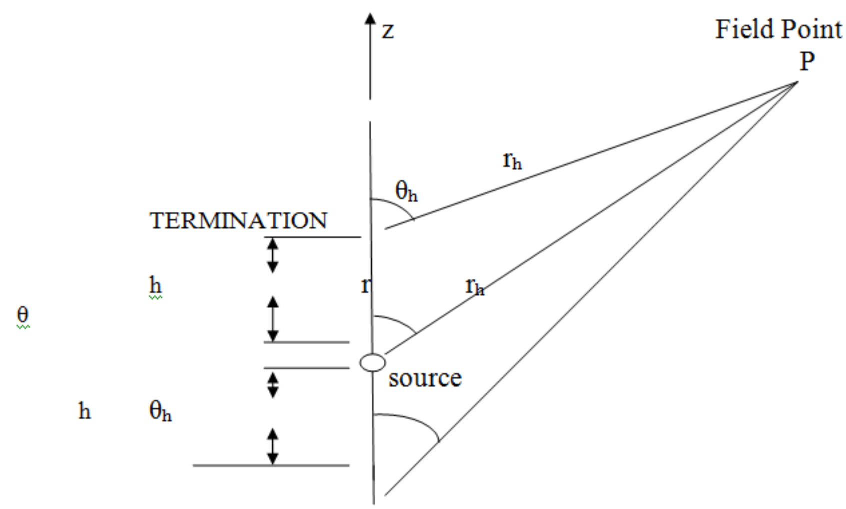


Fig.-1(b) : A schematic drawing showing the standing- wave dipole with the coordinates used in evaluating the electromagnetic field.

A similar traveling wave of current (a pulse of negative charge) propagates down the bottom arm of the dipole. These waves are totally reflected when they reach the open ends of the dipole at time $t=\tau_\alpha=h/c$. This produces traveling waves of current that propagate on the arms from the poen ends toward the source. These waves are totally absorbed when they reach the source at time $t=2\tau_\alpha=2h/c$. The distribution for the axial current is

$I(z,t)=[I_s(t-z/c)-I_s(t+z/c-2h/c][U(z)-U(z-h)]$
$+[I_s(t+z/c)-I_s(t-z/c-2h/c)][U(z+h)-U(z)]$,...........................(iv)
and the charge per unit length on the dipole is
$Q(z,t)=[Q_s(t-z/c)-Q_s(t+z/c-2h/c][U(z)-U(z-h)]$
$+[Q_s(t+z/c)-Q_s(t-z/c-2h/c)][U(z+h)-U(z)]$,.........................(v)

The standing- wave dipole can be viewed as a combination of four basic traveling- wave elements. Two elements are arranged to produce outward- traveling waves on the arms, starting at time t=0 and two elements are arranged to produce inward traveling waves, starting at time $t=\tau_\alpha=h/c$.

This representation is easily understood by comparing the current distributions given in Equations (i) and (iv): Equation (iv) is the sum of four terms, with the same form as Equation (i). Notice from Equation (v) that there is no accumulation of charge at the center of ends of the standing wave dipole as there is for the traveling wave element of Equation (ii). For the standing- wave dipole, equal amounts of positive and negative charge simultaneously leave of enter the source, and the traveling waves of charge are totally reflected at the open ends.

The complete electromagnetic field of these current distributions can be obtained in closed form (vii). The field for the traveling-wave element

$$\bar{\mathbf{M}}(\bar{\mathbf{r}},t) = \frac{1}{4\square\varepsilon_0}\left[\frac{q_0(t-\frac{r}{c})}{r0}\hat{\boldsymbol{r}} + \frac{q_0(t-\frac{r}{c})}{r^2}\hat{\boldsymbol{r}}\right.$$

$+\frac{\cot\left(\frac{\theta}{2}\right)\mathbf{I_s}\,(t-\frac{r}{c})}{cr}\,\widehat{\mathbf{0}}-\frac{\cot\,(\theta_h\,/2)\mathbf{I_s}\,(\mathbf{t-h/c}-r_h/c)}{cr_h}\,\widehat{\boldsymbol{\theta}}_h]$................................(vi)

$\overline{\mathbf{B}}(\bar{\boldsymbol{r}},\mathrm{t}) = \frac{\mu_0}{4\square}\,[+\frac{\cot\,(\theta/2)\mathbf{I_s}\,(\mathbf{t-h/c})}{r} - \frac{\cot\,(\theta_h\,/2)\mathbf{I_s}\,(\mathbf{t-h/c}-r_h/c)}{r_h}\,\widehat{\boldsymbol{\varphi}}$,................(vii)

And the field for the standing-wave dipole is

$\bar{\mathbf{E}}(\bar{\boldsymbol{r}},\mathrm{t}) = \frac{\mu_0 \mathbf{c}}{2\square\,\mathbf{r}\,\sin\theta}\,\{[\mathbf{I_s}(\mathrm{t-r/c})+(\mathbf{I_s}(\mathrm{t-2h/c-r/c})]\widehat{\boldsymbol{\varphi}}$

$-\,\mathbf{I_s}(\mathrm{t-h/c-}\boldsymbol{r_h}/\mathrm{c})]\widehat{\boldsymbol{\theta}}_h - \mathbf{I_s}(\mathrm{t-h/c-}\boldsymbol{r_{-h}}/\mathrm{c})]\vec{\boldsymbol{\theta}}_{-h}\}$,...................................(viii)

$\overline{\mathbf{B}}(\bar{\boldsymbol{r}},\mathrm{t}) = \frac{\mu_0 \mathbf{c}}{2\square\,\mathbf{r}\,\sin\theta}\,\{[\mathbf{I_s}(\mathrm{t-r/c})+(\mathbf{I_s}(\mathrm{t-2h/c-r/c})]$

$-\,\mathbf{I_s}(\mathrm{t-h/c-}\boldsymbol{r_h}/\mathrm{c})] - \mathbf{I_s}(\mathrm{t-h/c-}\boldsymbol{r_h}/\mathrm{c})]\vec{\boldsymbol{\theta}}$,...(ix)

There are three spherical coordinate systems used in the description of these fields. They are shown in Fig.-1(a) for the standing-wave dipole, they are the system r,θ,ϕ with origin at the center of the dipole. They are the system r_h, θ_h, ϕ_h with origin at the top of the dipole and the system r_{-h}, θ_{-h}, ϕ_{-h} with origin at the bottom of the dipole. The azimuthal coordinate is the same in all systems, so

$\hat{\varphi}_h = \hat{\varphi}_{-h} = \hat{\varphi}$,

In the limit as $\underset{\rightarrow}{r}\rightarrow\infty$, Equations (vi) to (ix) simplify to become the radiator far-zone field (vii). For the traveling-wave element the electric field is

$\bar{\mathbf{E}}(\bar{\boldsymbol{r}},\mathrm{t}) = \frac{\mu_0 \mathbf{c}\,\sin\theta}{4\square\,\mathbf{r}\,(1-\cos\theta)}\,\{\mathbf{I_s}(\mathrm{t-r/c}) - \mathbf{I_s}(\mathrm{t-r/c-(h/c)(1-cos\theta)})\}\widehat{\boldsymbol{\theta}}$....................(x)

And for the standing-wave dipole, the electric field is

$\bar{\mathbf{E}}(\bar{\boldsymbol{r}},\mathrm{t}) = \frac{\mu_0 \mathbf{c}}{2\square\,\mathbf{r}\,\sin\theta}\,\{[\mathbf{I_s}(\mathrm{t-r/c})+(\mathbf{I_s}(\mathrm{t-r/c-2h/c})]$

$-\,\mathbf{I_s}(\mathrm{t-r/c-h/c)(1-cos\theta)}] - \mathbf{I_s}(\mathrm{t-r/c-(h/c)(1+cos\theta)})]\}\widehat{\boldsymbol{\theta}}$.......................... (xi)

For both distributions, the radiated magnetic field is simple

$\overline{\mathrm{B}}^{r}(\bar{r},\mathrm{t}) = \frac{1}{c}\,\hat{r}\chi\hat{E}^{r}(\bar{r},\mathrm{t})$..(xii)

Notice that the superscript r is used to indicate the radiated or far zone field. In the calculations that follow, the current of the source is assumed to be a Gaussian pulse of the form

$- I_s(t)] = - I_0 e^{-(t/r)2}$ ....(xiii)

Where τ is the characteristic time for all numerical results, we will use $\tau/\tau_\alpha = 0.076$, then the width of the pulse in space is approximately one fourth of the length of an element (four pulses fit along the length h).

The expressions for the electric and magnetic fields of the current distributions, Equations (vi) to (ix), apply at any point not directly on the filament. Therefore, we can use these expressions to calculate the pointing vector in the space surrounding the filament.

$\vec{s}\,(\vec{r},t) = \frac{1}{\mu_0}\vec{E}\,(\vec{r},t)\chi\vec{B}(\vec{r},t)$...(xiv)

TOTAL ENERGY RADIATED BY THE FILAMENTARY CURRENT DISTRIBUTATION

The total energy radiated by a filament is determined by integrating the normal component of the pointing vector for the radiated field, $\vec{s}^r$ over the surrounding of a large sphere surrounding the filament and over all time.

$U_{rad} = 2\cdot \int_{t=-\infty}^{\infty} \cdot \int_{\theta=0} \hat{r}\ \hat{U}\ \vec{S}^r\ r^2 \sin\theta d\theta dt$

$= \frac{2}{\zeta_0}\int_{t=-\infty}^{\infty} \cdot \int_{\theta \neq 0} \vec{E}^r r^2| \sin\theta dt\theta dt$..(xv)

Where $\zeta_0 = \sqrt{\mu_0/\mu\varepsilon_0}$ is the wave impendence of free space. Surprisingly, this expression can be evaluated in closed form for both current distributions when the source current is the Gaussian pulse of Equation (xiii) for the traveling standing- wave element dipole.

CONCLUSION:-

There are several differences in the descriptions presented above for the energy transport very close to these two structures. Probably the most distinct difference is that energy is continually exchanged between the current filament and the spherical wave- fronts as they travel along the filament, whereas no energy enters or leaves a spherical wave front through the surface of the perfectly conducting monopole.

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