Abstract

In approximation of the given current distribution it has been suggested a solution considering the influence of the circular loop antenna curvature and elementary radiator curvature upon their directional characteristics. On the basis of potential Hertz technique the expressions for calculating all the components of electromagnetic radiation fields of wire loop antennas, stimulated by the running wave of the current, and curved dipole in Spherical and Decart coordinate systems in the near-field zone have been derived. It has been shown that wave processes near by the examined radiators are distinguished by great gradients of amplitudes of the electromagnetic fields.

Keywords: curved dipole, circular loop antenna, near-field zone, electromagnetic waves

I. INTRODUCTION

As is known [1-3], the Bonch-Bruevich orientation rule of diagram’s multiplication in the radiation theory is true only if elementary radiators are identical all over the aerial. In case of a curvilinear emitter the elementary radiators differ in each point on the aerial surface, but the antenna’s pattern according to the Fresnel principle is defined by the fields summation of elementary radiators radiation.

The aim of this report is to study the near-field effects of curved dipole and consider the account of conductor curvature upon their directional characteristics in the far-field and near-field zones of observation.

II. MAIN PART

To find the directional characteristics of curved dipole in the near-field zone, let us dispose them perpendicularly to radius of curvature $\rho$ (Fig. 1).

To find $\vec{E}$ and $\vec{H}$ we write:

$$\vec{E} = \nabla \times \vec{A} + \kappa^2 \vec{A},$$

$$\vec{H} = \omega \times \vec{A}.$$ 

Also take into account:

$$\nabla \times j \varphi dl = \int_{L} \nabla \cdot (\vec{I}, \nabla \varphi) dl,$$

$$\begin{align*}
  x^0 &= R^0 \sin \theta \cos \varphi + \varphi^0 \cos \theta \cos \varphi - \varphi^0 \sin \theta \\
  y^0 &= R^0 \sin \varphi \cos \theta \sin \varphi + \varphi^0 \cos \theta \cos \varphi + \varphi^0 \cos \varphi \\
  z^0 &= R^0 \cos \theta - \varphi^0 \sin \theta
\end{align*}$$

and

$$i\omega \nabla \times \vec{A} =$$

$$= \frac{1}{4\pi} \int_{S} \left( \frac{1}{R \sin \theta} \left( \frac{\partial}{\partial \theta} (j_0 \varphi \sin \theta) - \frac{\partial}{\partial \varphi} (j_0 \psi) \right) \hat{R}^0 + \frac{1}{R} \left( \frac{\partial}{\partial \theta} (j_0 \psi) - \frac{\partial}{\partial \varphi} (R j_0 \varphi) \right) \hat{\theta} + \frac{1}{R} \left( \frac{\partial}{\partial R} (R j_0 \varphi) - \frac{\partial}{\partial \theta} (j_0 \psi) \right) \hat{\phi} \right) dS.$$ 

Due to $\frac{\rho}{\lambda} \ll 1$ the expression for $\vec{j}$ can bee written as: $\vec{j} = \vec{l}^0 j_0$, where $\vec{l}^0 = -\vec{x}^0 \sin \varphi' + \vec{y}^0 \cos \varphi'$. and $\vec{l}^0$ - unit tangent vector, $l$ - length element. Total length of dipole is $l = 2\rho \Delta \varphi$.

On the basis of the Hertz potentials technique the expressions for calculating all the components of...
Curved Radiators in the Near-Field and Far-Field Zones of Observation

Electromagnetic radiation fields of the curved dipole have been derived:

in Spherical coordinate system (for $\varphi = 0$) –

$$E_R = \frac{j_0}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \left\{ (q\varphi(g - f^2)(R - \rho\sin\theta\cos(\varphi')) + $$

$$+ \psi f \sin\theta\sin(\varphi'))\rho d\varphi' +$$

$$- \frac{j_0 k^2 \sin\theta}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi \sin(\varphi')\rho d\varphi' +$$

$$E_\theta = \frac{j_0 \cos\theta}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \left\{ (q\varphi(g - f^2)\rho\cos(\varphi')) -$$

$$- \psi f \sin(\varphi')\rho d\varphi' -$$

$$- \frac{j_0 k^2 \cos\theta}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi \sin(\varphi')\rho d\varphi' +$$

$$E_\varphi = -\psi f \cos(\varphi')\rho d\varphi' + \frac{j_0 k^2 \cos\theta}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi \cos(\varphi')\rho d\varphi'$$

$$H_R = \frac{i_0 \rho\cos\theta}{4\pi} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi f \rho d\varphi' ,$$

$$H_\theta = \frac{j_0 i_k \rho}{4\pi} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi f (R - \rho\sin\theta)\cos\varphi'\rho d\varphi' ,$$

$$H_\varphi = -\psi f \sin\varphi'\rho d\varphi' ,$$

where:

$$\psi = \exp(-ikr) ,$$

$$r = \sqrt{(R^2 + \rho^2 - 2\rho R \sin\theta\cos(\varphi - \varphi'))} ,$$

$$f = \frac{ik}{r} + \frac{1}{r^3} ,$$

$$g = \frac{-ik}{r^3} + \frac{2}{r^5} ,$$

$$q = -R\sin\theta\sin(\varphi - \varphi') ;$$

in Decart coordinate system –

$$E_x = \frac{1}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \left\{ (q\varphi(x - x_a))(g - f^2) +$$

$$+ \psi f \sin\varphi'\rho d\varphi' - \frac{k^2 j_0}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \sin\varphi'\psi\rho d\varphi' ,$$

$$E_y = \frac{\rho}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \left\{ (q\varphi(y - y_a))(g - f^2) -$$

$$- \psi f \cos\varphi'\rho d\varphi' + \frac{j_0 k^2 \rho}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi \cos\varphi'\rho d\varphi'$$

The radiated fields of circular loop antenna in the far-field zone can be written as:

$$E_z = \frac{1}{4\pi iwe} \int_{-\Delta\varphi'}^{\Delta\varphi'} q\varphi(z - f^2)\rho d\varphi' ,$$

$$H_z = \frac{j_0 \rho^2}{4\pi} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi f \cos\varphi'\rho d\varphi' ,$$

$$H_y = \frac{j_0 \rho^2}{4\pi} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi f \sin\varphi'\rho d\varphi' ,$$

$$H_x = \frac{j_0 \rho^2}{4\pi} \int_{-\Delta\varphi'}^{\Delta\varphi'} \psi f (x - x_a)\cos\varphi'\rho d\varphi'$$

where:

$$q = i_0\left(\sin\varphi'(x - x_a) - \cos\varphi'(y - y_a)\right) ,$$

$$g = \frac{-ik}{r} + \frac{2}{r^5} ,$$

$$x_a = \rho\cos\varphi' , y_a = \rho\sin\varphi' , dl = \rho d\varphi' .$$

This solution considers the influence of the conductor curvature upon their directional characteristics in the near-field zone. Wave processes near the curved dipole are distinguished by great gradients of the electromagnetic fields amplitudes.

In approximation of the given current distribution a solution considering the influence of the circular loop antennas curvature upon their directional characteristics has been suggested(Fig.2). In the decision various orientations of elementary radiators in space were considered.

Fig. 2. Loop antenna in Spherical coordinate system.
The approach of the given current was used. The influence of conductor curvature upon its directional characteristics in the far- and near-field zones are significant.

$$E_\theta = \frac{j\rho(R)k^2\rho\Delta\varphi}{2\pi\omega e} \cos \theta$$

$$\cdot \int_0^{2\pi} \sin \varphi' e^{-\frac{j2\pi\rho}{\lambda} \rho\sin \theta \cos \varphi'} d\varphi'$$

$$E_\varphi = \frac{j\rho(R)k^2\rho\Delta\varphi}{2\pi\omega e}$$

$$\cdot \int_0^{2\pi} \cos \varphi' e^{-\frac{j2\pi\rho}{\lambda} \rho\sin \theta \cos \varphi'} d\varphi'$$

The more relative sizes of the circular loop the less these differences.

### III. Conclusion

The account of conductor curvature upon their directional characteristics in the far-field and near-field zones are considered.

## References

