RESEARCH NOTE

TV AND/OR FM TRANSMITTING ANTENNAS DESIGN USING COMPUTER GRAPHIC SYSTEM

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Abstract The purpose of this paper is three fold. First, the major theoretical pattern relationships of TV and/or FM transmitting antennas are dealt with. Secand, the computer calculation method and designing of such patterns using the given relationships. And third, a method in which a computer graphic system can be used to design such antennas for a specific pattern is introduced and its results are presented.

Key Words Antenna, Transmitter, Television

چکیده دراین مقاله روابط اصلی دیاگرام تشعشع نظری آنتن های فرستنده تلویزیونی و یا FM درحالت کلی آورده شده و روش محاسبه و رسم کامپیوتری این دیاگرام به کمک این روابط داده شده است. همچنین روشی که بتوان به کمک یک سیستم گرافیک کامپیوتری، این نوع آنتن ها را برای داشتن دیاگرام معینی طراحی نمود، با ذکر نتایج، معرفی گردیده است.

INTRODUCTION

To evaluate a TV and /or an FM transmitting antenna pattern curve, or an exact design for a precise specific coverage might be tedious, if not impossible. In this paper the principle relations of a TV and /or an FM transmitting antenna as well as a method in which a specific pattern can be designed is presented. The computer programs are not limited to TV or FM antennas, rather they can be used for other antennas by utilizing appropriate formulas. This paper is mainly concerned with the pertinent programs for the TV and /or FM transmitting antennas. These programs are of two types.

The first type deals solely with the calculation of TV and /or FM transmitting antenna patterns; at this stage, different parameters of an antenna such as frenquency of the transmitter, number of panels on each side of the antenna tower, panel specifications, panel angle, etc. are fed into the computer and the antenna pattern is calculated. When the pattern is calculated, it is automatically drawn on the plotter.

The second type is to design a TV and/or an FM transmitting antenna to have a specific horizontal coverage. In this program first the desired coverage is drawn on the computer graphic display screen by light pen. Then the values of the required parameters such as frequency, number of panels on each side, angles, etc. are chosen using the previous experiences on antennas. These data are then stored in the computer. In this case the theoretical coverage of these values is calculated and drawn on the computer graphic display screen. Then the two coverages drawn on the graphic display screen are composed either manually or automatically by the computer, If the two coverages are not similar, the antenna parameters should be modified or changed. This process should be repeated as many times as necessary to get

the desired pattern.

The final stage parameters which are the desired specifications of a suitable antenna design should be transferred to the plotter together with the already calculated antenna pattern curve.

THEORY

Generalities

A TV and/or an FM transmitting antenna is generally located at the top of a high tower having a height of about 200 meters.

The antenna tower can be triangular or rectangular. The antenna under study have consists of some panels placed upon a tower having a square cross-section, (Figure 1). The number of panels on each side varies depending on the energy distribution in different directions. Each panel consists of four dipoles the specificiations of which are generally furnished by the manufacturing factories. In general panels may be angled to the tower surfaces [1].

To calculate the pattern of such antennas, considering the diagram of a $2l$ long dipole, the diagram of the entire dipole and its image with respect to the reflector should be obtained. The radiation of each side of the tower should be calculated with regard to this diagram, as well as the array factor relative to the number of the panel dipoles, and the array factor relative to the number of panels.

The antenna pattern is the vector addition of the resulting diagrams of four sides.

It is clear that the pahse of the panels' phase center should be considered as compared with the origin of the phases.

The following data should be considered for the antenna pattern calculation purposes:

- frequency
- dipole length
- dipole distance from reflector

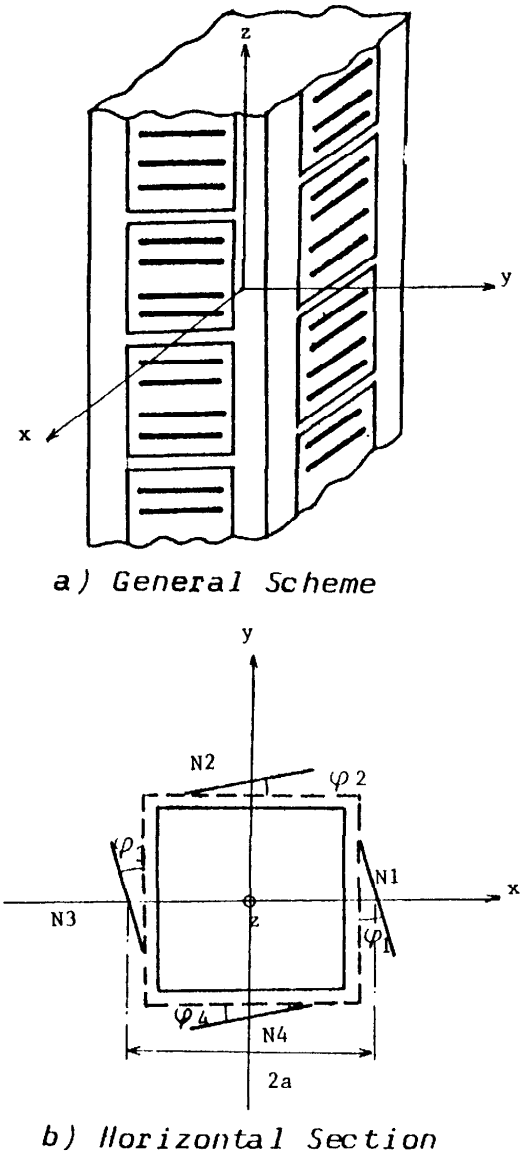

Figure 1. An antenna having a rectangular tower.

- separation of the two dipoles
- Panel rotation angle with respect to tower surfaces
- tower rotation angle in azimuth
- distance of two panels from each other
- number of panels on each side

To simplify the calculations, the dipoles are assumed to be thin with a sinusoidal current distribution while the mutual effect of dipoles on each other is ignored. Moreover, the reflector plate behind the dipoles is assumed perfect conductor having a large dimension (in comparison with λ). Finally the dipoles are assumed to be excited all in phase.

Radiation of A Dipole in Free Space

Consider a dipole of an arbitrary lengh $2l$ which is symmetrically fed at its center. As shown in Figure 2, at a point M with a distance of R from the origin, the Far zone electric field is given by [2].

$$E_D = j\frac{60 I_m e^{-JKR}}{R} \cdot \frac{Cos(Kl\,Cos\,\alpha) - Cos(Kl)}{Sin\,\alpha} \qquad (1)$$

where:

α = Arc Cos $(sin\,\theta\,Sin\,\phi)$; $K = \frac{2\pi}{\lambda}$

and I_m is the current at its maximum point.

Dipoles Near a Reflector

As shown in Figure 3, for a dipole parallel to and a distance ho from a perfect conductor reflector in yoz plane, the radiation diagram can be calculated by multiplying the relative array factor by the E_D [3].

The array factor of ρ_R is as follows:

$$\rho_R = 2\,Sin\,(Kh_0\,Cos\,\beta) \qquad (2)$$

where

β= Arc cos $(Sin\,\theta\,Cos\,\phi)$

Panel Consisting of Four Dipoles

The panels used in UHF and VHF bands TV and /or

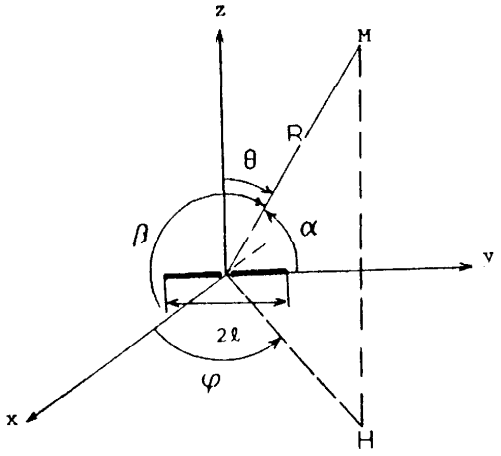

Figure 2. A $2l$ long dipole.

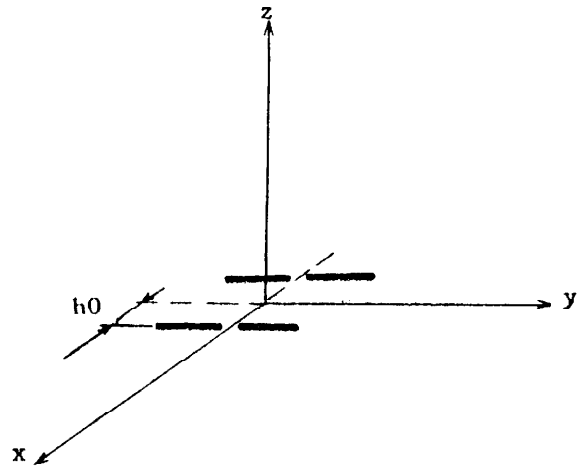

Figure 3. Equivalent scheme of a dipole and a reflector.

FM Transmitting antennas are often equipped with four dipoles. In Figure 4, a panel comprising four dipoles is shown [1]. The radiation diagram of this panel equals the product of panel relative array factor by $\rho_R E_D$. The panel relative array factor is shown as ρ_{PI}, the value of which is obtained by the following equation:

$$\rho_{PI} = 4\,Cos\,(\frac{Kh_1}{2}\,Cos\,\theta).\,Cos\,(\frac{Kh_3}{2}\,Cos\,\theta) \qquad (3)$$

where:

h_1: Separation of the dipoles

h_3: Separation of each pair of dipoles

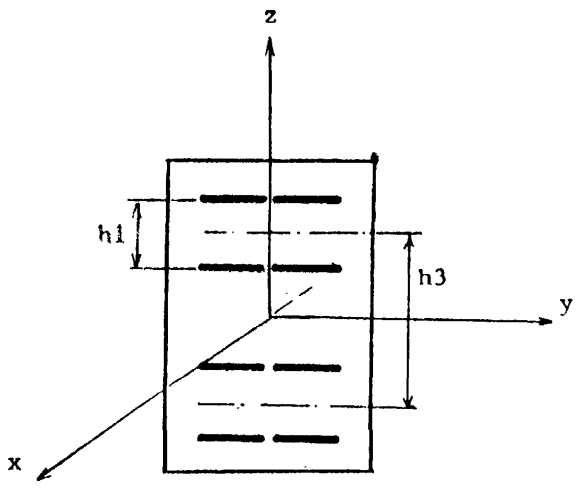

Figure 4. A TV and /or FM Panel.

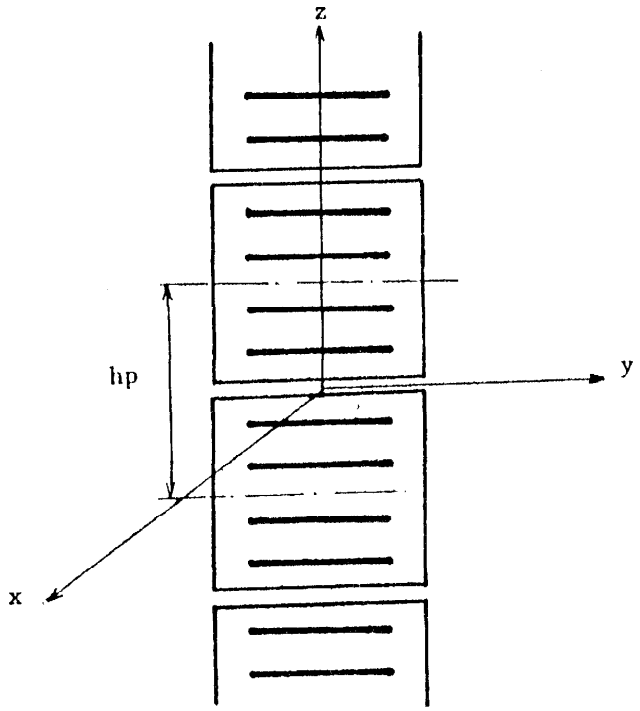

Figure 5. Panels near each other.

Panels Near Each Other

If the number of panels located at one side of the tower equals N (Figure 5) then the relative array factor of this N panel, ρ_{Pn} is given by [4]:

$$\rho_{PN} = \frac{Sin\left(\frac{1}{2} N\, Kh_p Cos\,\theta\right)}{Sin\left(\frac{1}{2} Kh_p Cos\,\theta\right)} \qquad (4)$$

where, h_p is the distance between two panel centers.

Using Equations 1,2,3, and 4, the radiation diagram of several panels for side i which are placed under each other (Figure 5) will be as follows,

$$E_i(\phi, \theta) = \rho_{PNi} \cdot \rho_{Pli} \cdot \rho_{Ki} \cdot E_{Di} \qquad (5)$$

The Radiation Diagram Resulting From the Panel, Placed on the Four Sides of the Tower

In Figure 1, N_i represents the number of panels on side i and the total radiation of the 4 sides will be the vector addition of the fields of the 4 sides of the tower [5] i.e.,

$$E(\phi, \theta) = \sum_{i=1}^{4} E_i(\phi - \phi_i, \theta - \theta_i) e^{j\psi_i} \qquad (6)$$

where,

$$\psi_i = Kd_i\, Cos\,\alpha_i + \phi_i$$

and ϕ_i and θ_i are the polar coordinates of the phase center of all the panels on each side as compared with the phase origin O, and d_i is the distance of panels' center of symmetry of side i from the center O.

COMPUTER PROGRAM

Utilizing Equation 6, a program is developed by means of which an antenna pattern can be calculated and plotted. Computer programs which satisfy the requirements include the 3 following stages:

1- Pattern calculation stage

2- Graphic use stage

3- Plotter use stage

PRESENTATION OF THE RESULTS

The results of the developed program are presented in Figures 6 and 7. The method of drawing the desired pattern by light pen on computer graphic display is also shown. Figure 6 indicates the picture relative to the way of drawing pattern; Figure 7 shows the pattern drawn on the computer graphic display in full. Then the different parameters required for the pattern calculations on the graphic display are loaded by the

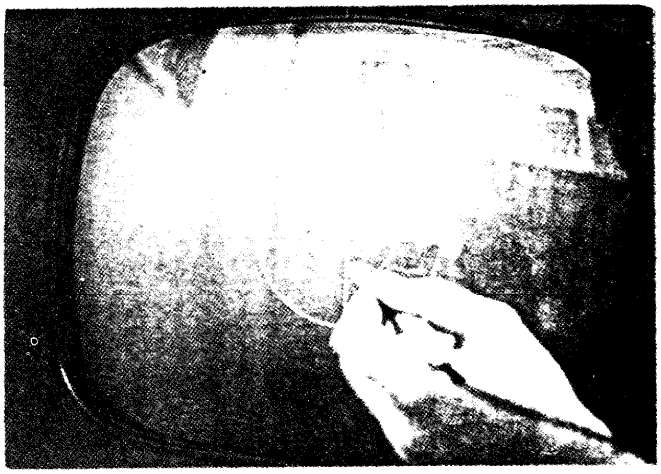

Figure 6. Drawing the intended pattern with light pen.

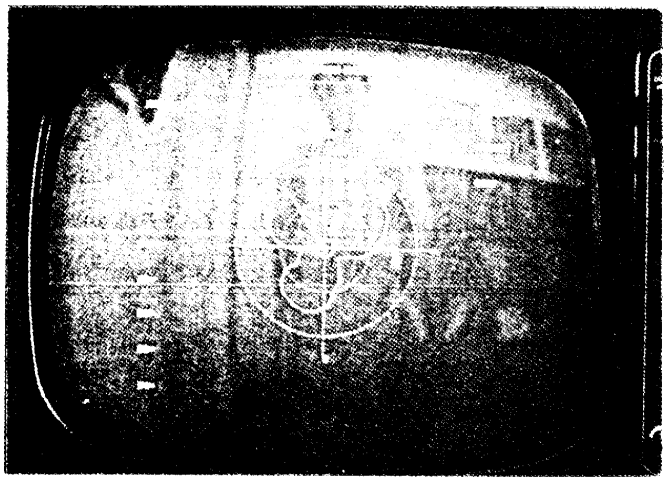

Figure 7. The manually drawn pattern in full.

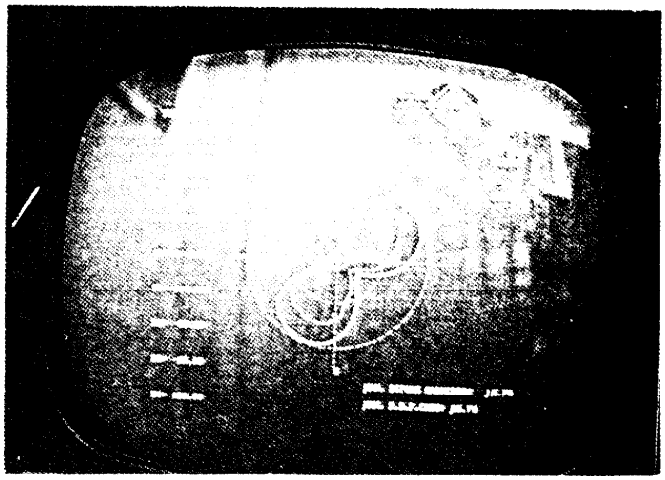

Figure 9. Comparison of the calculated pattern with the manually drawn pattern (Stage 2).

Figure 8. Comparison of the calculated pattern with the manually drawn pattern (Stage 1).

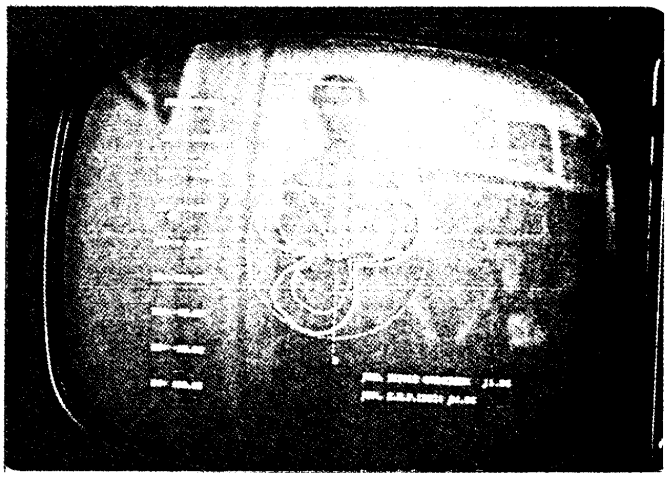

Figure 10. Stage 3.

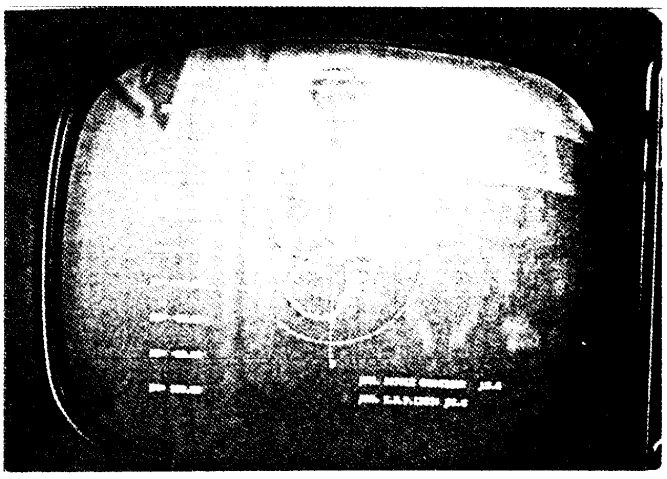

Figure 11. Final Stage.

graphic key board. Upon loading these parameters, the computer calculates the theoretical pattern of the antenna and displays it on the graphic display. Figure. 8 shows the comparison. In case these two patterns do not agree, parameters should be changed repeatedly to obtain the desired coverage, i.e. the coverage which has been drawn manually. These stages are shown in Figures 9, 10, and 11.

Upon obtaining the desired pattern, the results are transferred onto a sheet using a plotter of which sample is shown in Figure 12.

In case we do not aim at designing an antenna and we solely intend to obtain an antenna pattern, there is no need to use the graphic set; the pattern could be calculated by means of loading the computer

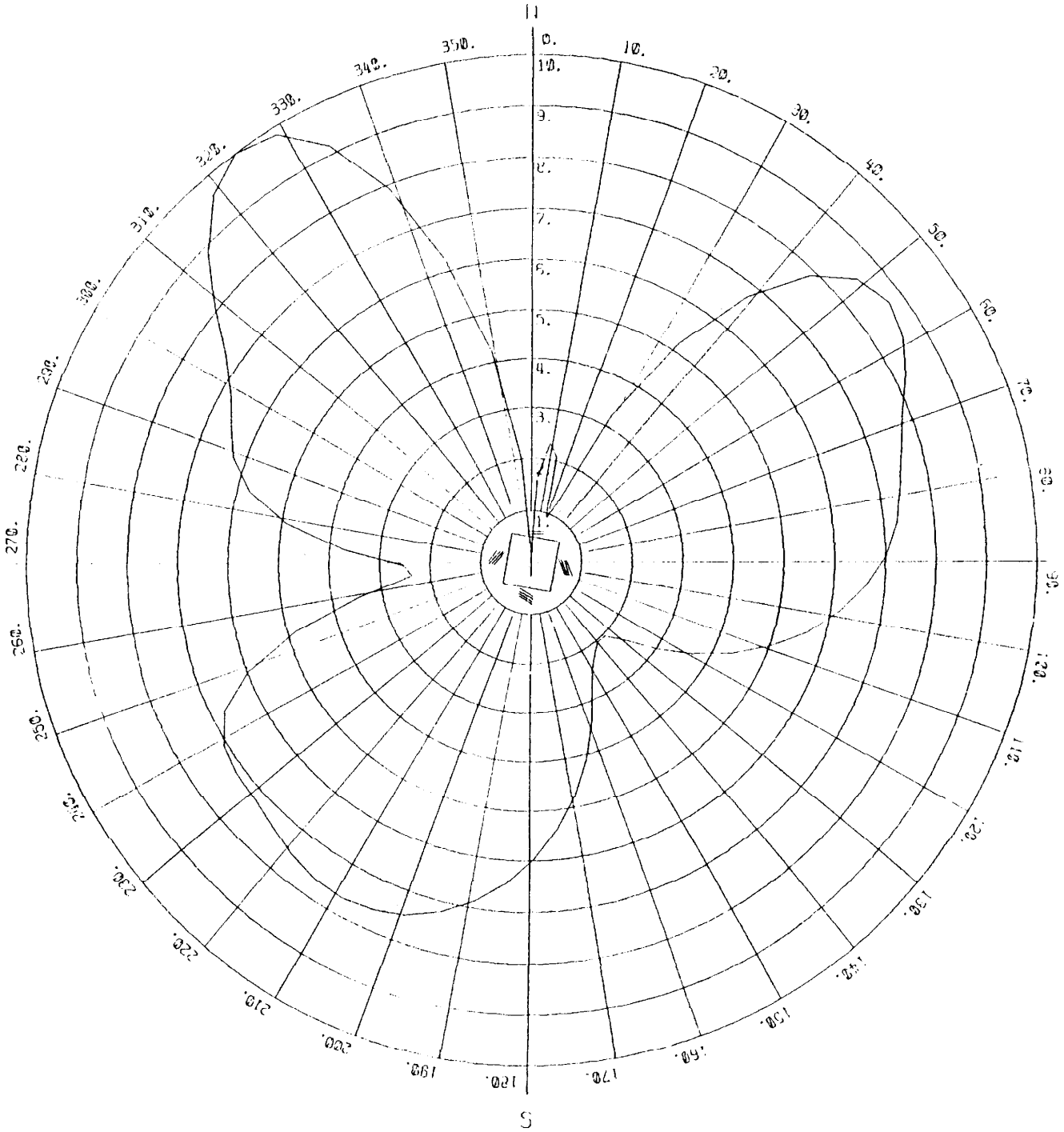

Figure 12. Radiation pattern relative volts.

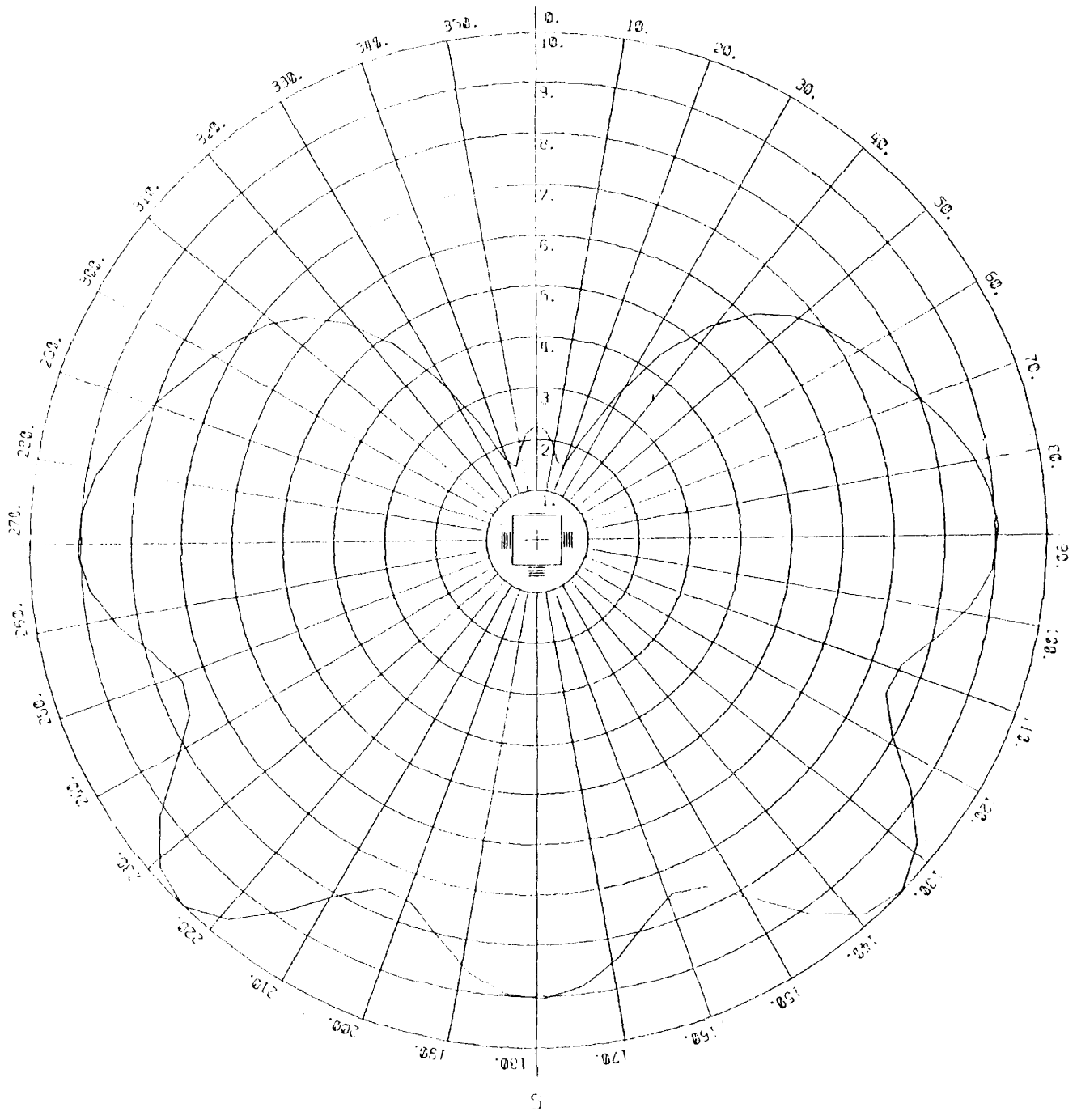

Figure 13. Radiation pattern relation volts.

terminal with different antenna parameters; the result can be directly transferred to the plotter sheet. A sample of such results are provided in Figure 13.

CONCLUSION

The use of a computer graphic system in order to design antennas has been reported. The method empolyed in this paper can be used not only in designing TV & FM transmitting antennas but also in other designs which require complicated calculations.

The results derived from this paper agree with previous ones done in done in some antenna centers (for example LGT and RTF in France). In some cases (such as the generality of the method provided, lack of any need for an experimental panel pattern, and ability to design by computer) the proposed method has even some advantages.

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