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Correction of Measurements in Circular Polarized Antennas

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Abstract: *The great expansion of the communications in recent times has forced the development of more sophisticated techniques in order to make the equipment compatible with the new constraints imposed. In this context, occupying the radiating system device a role of fundamental importance, we sought to achieve a high standard of quality in the design of such devices. To meet this goal and in order to obtain greater reliability, new processes have been established to determine the electrical characteristics of antennas. However, though widely reported, these new methods are not always directly applicable to any type of antenna, with the need for greater care in the use of these methods to a given purpose. This paper discusses one of these cases where the actual characteristics of the antenna may be incompatible with the results of measurements.*

Keywords: *Antennas, Polarization, Gain, Axial Relation*

I. Introduction

The determination of the electrical characteristics of an antenna is a job that requires a lot of care, being as important as the design of the device. Processes not consistent with the type of antenna to be analyzed could lead to unacceptable errors that will be reflected in the final output of the intended system. In this article, we will show the error introduced in the usual determination processes of radiation pattern and gain of circular polarized antennas, with particular emphasis on the helical antennas. After this introduction, item II describes the common methods for evaluation of radiation pattern and gain of antennas; item III presents the expressions for the radiation fields produced by an helical antenna; item IV analyzes the behavior of the Axial Ratio parameter and item V presents the conclusions for this article.

II. Radiation Pattern and Gain Measurements

The classical method for the determination of the radiation pattern of an antenna assumes the use of a field testing where there are two towers: in one is placed a transmitting antenna and in the other is placed the antenna under test. It is provided a turn of 360^0 from the test antenna and the levels of the received signal are evaluated as a function of the angular variation. For linearly polarized antennas, if the antennas are in vertical polarization (transmitter and test) it is obtained the vertical diagram, whereas if the polarization of the antennas is horizontal, it determines the horizontal radiation pattern.

The gain of an antenna can be obtained by various methods. The simplest and more reliable method is called "absolute gain process". In this method, two identical test antennas are situated on the towers of the field testing and oriented in the direction of maximum radiation (one facing the other). The received signal is compared with the one received by a cable interconnecting the antennas. Knowing the free space attenuation and the attenuation of the cables and connectors, the gain of an antenna test is determined.

It is becoming more widespread the so called "integration method of radiation patterns" for calculation of gain. This fact is primarily due to two factors: the impossibility of getting a connection cable between the transmitter and receiver antennas and the fact that the modern equipment to evaluate the radiation pattern already possess an attached integrator, thus facilitating the service. This method is a direct application of the gain definition. Where there are no integrator, the process is manually developed, according to the following expressions [1]:

$$g_H = \frac{2n}{\pi \sum_{1}^{n} s_H(\phi)\sin(\phi)} \tag{1}$$

$$g_V = \frac{2n}{\pi \sum_{1}^{n} s_V(\theta)\sin(\theta)} \tag{2}$$

$$\frac{1}{g} = \frac{1}{g_H} + \frac{1}{g_V} \tag{3}$$

$$G = 10\log_{10} g \tag{4}$$

where:

n → number of points considered in the radiation pattern;
$s_H(\phi)$ → Power density in the ϕ direction of the horizontal pattern;
$s_V(\theta)$ → Power density in the θ direction of the vertical pattern;
G → Antenna gain in dB;

This method provides reliable values for linearly polarized antennas having spatial diagrams with a reasonably circular symmetry.

For circular polarized antennas, however, these methods for measuring radiation pattern, and principally gain, may lead to unacceptable errors. This is basically due to the fact that these antennas present circular polarization characteristics only in the direction of the axis of the structure. Outside this direction, the polarization can be elliptical or else linear. Figure 1 clarifies the commentary.

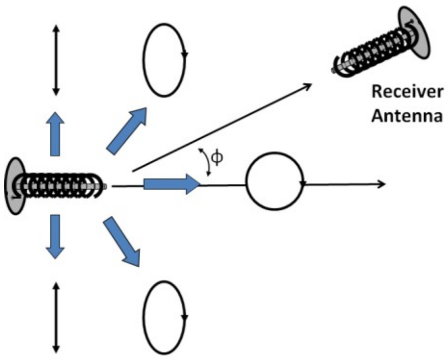

Figure 1: Types of Polarization Radiated by the Helical Antenna

It can be shown that the elliptical polarized wave can be decomposed into two waves of opposite circular directions and different intensities. In the case of linear polarization, we have the decomposition formed by two circular waves in opposite directions and with equal magnitudes. Then, from Figure 1 it is easy to conclude that the receiving antenna, turning around the transmitting antenna, will only receive the circular component of the radiation field (coherent with the direction of winding of its helix). This will result in a radiaton pattern with distortions, not representative of the real case. If the integration method of radiation pattern is used, the gain also will change [2].

III. Equations for the Helical Antenna

For a quantitative analysis of the effect described in the previous section, it will be used as a mathematical model the helical antenna, since it is of great use for transmission in circular polarization. Figure 2 shows the geometry of the problem [3, 4].

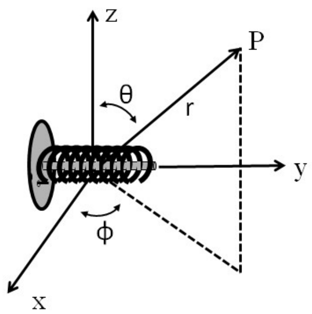

Figure 2: Geometry for the Problem

According to the reference [5, 6], the radiated fields of the helical antenna can be approximated by:

$$E_\theta = j\frac{30\pi I e^{-j\beta r}}{r}\left[J_2(\sin\phi) - J_0(\sin\phi)\frac{\sin(N\Psi/2)}{\Psi/2}\right] \quad (5)$$

$$E_\phi = j\frac{30\pi I e^{-j\beta r}}{r}\left[J_2\left(\sin\phi\right)+J_0\left(\sin\phi\right)\right]\cos\phi\frac{\sin\left(N\psi/2\right)}{\Psi/2} \quad (6)$$

$$\Psi = \beta\left(S\cos\phi - L/P\right) \quad (7)$$

where:
N → number of turns of the helix;
P → phase velocity of the current wave propagating in the helix;
L → lenght of one turn of the helix;
S → separation between adjacent turns;
I → current in the antenna input;
J_0 and J_2 → Bessel functions of orders 0 and 2, respectively;
β → phase constant (=2π/λ);

It was considered the case of an helical antenna with C=λ (C → helix circunference) and $\theta = 0^0$.

IV. Axial Ratio

The axial ratio is defined as the ratio between the major and minor axes of the ellipse of polarization. This amount ranges from 1 (the case of circular polarization) to infinity (the case of linear polarization). According to the general expressions of the radiated fields of the helical antenna (expressions (5), (6) and (7)), the axial ratio is given by:

$$AR = \frac{|E_\theta|}{|E_\phi|} = \left|\frac{J_2\left(\sin\phi\right)-J_0\left(\sin\phi\right)}{\left[J_2\left(\sin\phi\right)+J_0\left(\sin\phi\right)\right]\cos\phi}\right| \quad (8)$$

Based on equation (8), Figure 3 shows the variation of the axial ratio parameter. It is observed that, as one would expect, the polarization is absolutely circular for $\phi = 0^0$, becoming progressively elliptical and linear for $\phi = 90^0$. We have the same situation for ϕ greater than 90^0, and it must be noted that the electric field undergoes a reversal of the polarization direction. This is consistent with the real case because in this situation, the helix is presented with the winding on the contrary of the previous case.

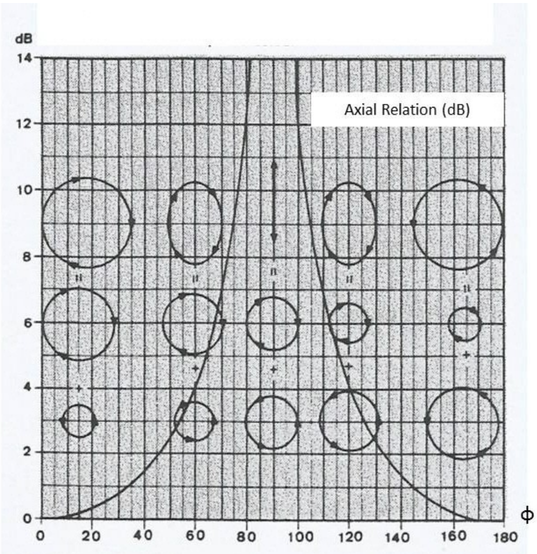

Figure 3: Axial Ratio

Also, Figure 3 shows drawings of the decomposition of an elliptically polarized wave into a sum of two circularly polarized waves in opposite directions. Thus, assuming that the receiving antenna of Figure 1 has the spirals of the helix wound right, it only takes cognizance of the circular polarization component in the same sense and, in accordance with the drawing of Figure 3, one can expect a large discrepancy between actual and measured radiation pattern for ϕ greater than 90^0,approximately. Consequently, considering that the measurement of gain based on the integration of the radiation pattern depends on the accuracy of this figure, one can also conclude that, in the case of circular polarization antennas, if no further precautions are taken, we have the risk of obtaining gain measures that are not in accordance with actual values [7].

V. Conclusions

This article has sought to show that the methods usually employed for experimental determination of radiation patterns and gain of antennas usually do not apply in the case of circular polarization antennas. In fact, one can even say that the use of the traditional methods applied to circular polarization antennas will result in obtaining values indicatives of a superior performance, compared to the actual antenna case.

Thus, the technique analysis presented here assumes that, when measuring the radiation pattern of an antenna for circular polarization, using applicable methods developed for linear polarization antennas, the result will be getting a "better behaved" diagram compared with that the real case, due to the lower levels of lateral lobes and a better front-to-back ratio.

In the case of determining the gain by the process of radiation patterns integration, considering that they are better than the real case, it can be expected that (unrealistic) higher gains will be obtained.

In a future work the authors will be developing some practical cases in order to provide a quantitative analysis of the theory here presented.

References

[1]. R. F. Harrington, Time Harmonic Electromagnetic Fields (New York: Mc Graw Hill, 1961).
[2]. Kraus and Carver, Electromagnetics (New York: Mc Graw Hill, 1965).
[3]. J. D. Kraus, Characteristics of Helical Antennas Radiating in the Axial Mode, Journal of Applied Physics, v19, jan 1947, 87-96.
[4]. J. D. Kraus, The Helical Antenna, Proceedings of the IRE, March 1949, 263-272.
[5]. I. Inagaki and Sekiguchi, An Investigation of the Array of Circular-Loop Antennas, IEEE Transactions on Antennas and Propagation, AP-19, nº4, July 1971.
[6]. Lindsay and J. E. Junior, A Circular Loop Antenna with Nonuniform Current Distribution, IRE Transactions on Antennas and Propagation, July 1960, 439-441.
[7]. E. R. Vale, Characteristics of Circular Polarized Antennas, Revista Telebrás, dez 1980, 50-56.