The 2D – 3D – 2D' Method for Communication System Research

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Abstract – **This paper contains a description of the proposed 2D – 3D – 2D' method, which allows transition from the existing two-dimensional dependences to the ancillary three-dimensional dependences and follows to the required two-dimensional dependences. It helps to simplify the research**

Keywords – **antennas, modulation, MATLAB**

I. Essence of the Proposed Method

During the analysis of communication systems and individual functional units the output function y is mostly defined from the partial components x_1, x_2, ... x_n.

$$y=f(x_1, x_2,.. x_n) \quad (1)$$

It is often important to have only a two-dimensional dependences (2D') in the researches, for example, $x_1 = f_1 (x_2)$ with y = constant, which cannot be obtained in explicit form from the relationship (1). At the same time it is possible just to get another two-dimensional (2D) dependence $y = f (x_1)$ when x_2, ... x_n – constant. It is necessary to plot a family of two-dimensional (2D) dependences on the basis of which it would be obtained the required two-dimensional (2D') dependence. But this approach requires significant expenditures for research. At the same time it can be relatively easy to get a graphic three-dimensional (3D) dependence $y = f (x_1, x_2)$ when x_3, ... x_n – const. The resulting spatial dependence can be crossed by the plane at the desired value y = const. Projection of the resulting cross-section on the plane (x_1, x_2) represents the objective two-dimensional (2D') dependence.

Thus, the proposed method [3] allows to get the required two-dimensional (2D') graphic dependence simply. Further, if it is necessary, it is possible to get an analytic dependence by the properly approximation of the plot. This method can be applied in the study of various functional units for communication systems. It is shown in the example of the modulation and antennas research.

II. Research of the Dependence Between Signal to Noise Ratio and Bit Error Rate for Different Modulation Schemes

Dependence of the bit errors probability P_b for MPSK (M-Phase Shift Keying) is defined as follows [1]:

$$P_b = \frac{2}{k} Q\left(\sqrt{2k\left(\frac{E_b}{N_o}\right)}\right) \sin\left(\frac{\pi}{M}\right) \quad (2)$$

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where E_b/N_o – signal to noise ratio; k- bit's number per symbol; $M=2^k$.

Fig.1 shows the typical energy effectiveness characteristics for the MPSK (2).

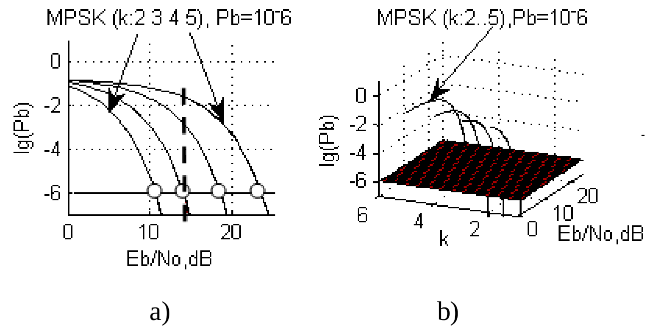

Fig.1.MPSK energy effectiveness: (a) – 2D characteristics; (б) – 3D characteristics

In Fig. 1, it is shown 2D characteristics "separated" on axis k and resulting generated 3D characteristics. Then the resulting characteristics intersects by the plane that corresponds to a given value of $P_b = 10^{-6}$.

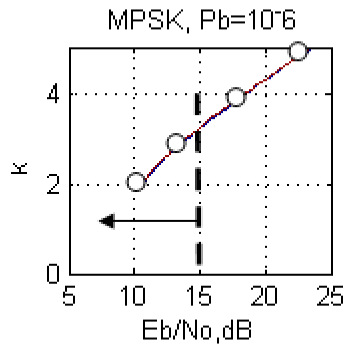

Fig.2. 2D' characteristic for BPSK ($P_b=10^{-6}$)

As a result of the 3D characteristics projection on the plane (k, Eb / No), the required 2D' characteristic is obtained, which shows the dependence of Eb/No (k) at Pb = 10^{-6}.

Thus, it is obtained the graphical representation of the unknown 2D' characteristics, which can be approximated, if necessary. This step gives an analytical dependence.

III. Definition of the Dependence for the Antenna Main Lobe Width

The antennas main lobe width (MLW) refers to one of the most important and widely used parameters of antennas. But in most cases there is any opportunity to determine its dependence on the parameters of antennas in an explicit form. Therefore it is necessary to plot a family of directional patterns to select the desired option. You can easily obtain the analytical dependence for MLW using the method of 2D-3D-2D'. That approch simlifies the further analysis of communication systems. MLW determination is shown on the example of a symmetric dipol.

Normalized directional pattern (DP) for symmetrical dipole (SD), located along the axis OZ, is the follows[1]:

$$F(v)=\frac{\cos(2\pi L_n\cos\theta)-\cos(2\pi L_n)}{(1-\cos(2\pi L_n))\sin\theta}\ \text{– (at } 2l<\frac{5\lambda}{4}\text{)} \qquad (3)$$

where Ln=L/λ – is the normalized reach of SD; □=v – is an angle of the spherical coordinate system.

There is the way to determine MLW on the basis of DP on-plane use.

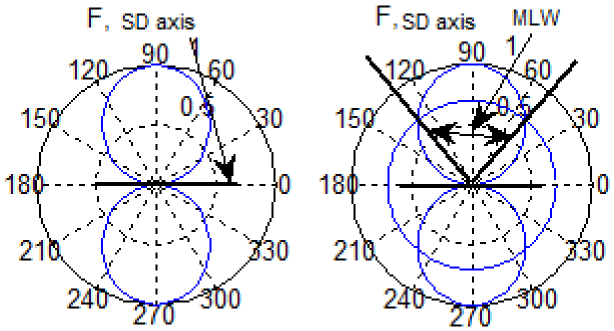

Fig.3. DP of SD (L_n =0.25) in the polar coordinate system and MLW determination

For this purpose it is ploted an auxiliary circle with the radius equals to 0.7 through the DP for field intensity. The points of DP intersection with this circle indicate the amount of MLW (2□$_{0.5}$ – for power). Similarly, we can determine the MLW using DP in a rectangular coordinate system.

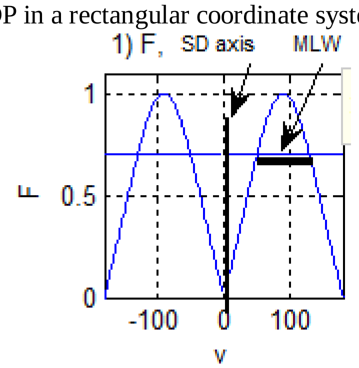

Fig.4. DP of SD (L_n =0.25) in the rectangular coordinate system and MLW determination

In this case, a subsidiary straight line is ploted at 0.7. The intercepts of this straight line with DP indicate the amount of MLW.

Thus, to determine the required two-dimensional dependence 2D' (2□$_{0.5}$(Ln)) it is necessary to build a set of DP (dependences 2D, Figure 3), because of on the basis of eq. 3 we can not determine the 2D'dependence in explicit form.

Lets plot an auxiliary spatial 3D dependence based on the set of 2D dependences to solve this problem. On that curve one of the axes marks with Ln value and it is shown a supporting plane for which the normalized DP is 0.7 (F = 0.7).

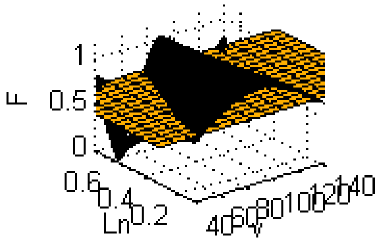

Fig.5. Anscillary spatial dependence for DP of SD

The projection of auxiliary (3D) spatial DP on a plane (Ln, v) represents the required two-dimensional 2D'dependence.

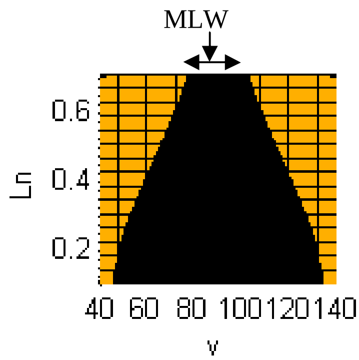

Fig.6. Dependence of the MLW from Ln for SD

It is relatively easy to obtain an analytical expression for the desired dependence on the basis of the dependence 2□$_{0.5}$ (Ln), shown in fig. 6.

CONCLUSION

The proposed method is the powerful mean for required two-dimensional dependences determination. It is recommended to utilize it for the case when analytic methods are too much complex to use or there is no way to define these dependences in the analytic form.

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