Simulating a microstrip vibrator emitter

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Abstract. There has been a shift from omnidirectional antennas in the azimuth plane to active phased antenna arrays with wide-angle scanning in ground communication systems. The report presents models of such antenna arrays and demonstrates the possibility of increasing the energy potential by using spatial schemes for constructing such antennas. To practically implement spatial antenna arrays, omnidirectional emitters in the azimuthal plane are used: balanced and unbalanced unipoles. It is advisable to manufacture vibrators using printed technology. The report presents the design of a micro-strip vibrator emitter for a cylindrical or concentric cylindrical antenna array. The results of numerical electrodynamic modeling are presented. The parameters and main characteristics of the emitter in the antenna array are determined.

1. Introduction

These days, the omnidirectional antennas in the azimuth plane are used in ground communication systems. Replacing such antennas with active phased array antenna (APAA) with wide-angle scanning can significantly increase the energy potential of the communication system. Wide-angle scanning antennas can be implemented in the form of conformal or spatial APAA [1-7]. Moreover, spatial antenna arrays have better energy and cost characteristics than conformal ones [8,9]. In the spatial APAA, all emitters are excited with a phase distribution corresponding to the formation of the radiation maximum in a given direction in the azimuthal plane. Figure 1 shows an example of constructing a concentric cylindrical antenna array and demonstrates a spatial radiation pattern.

Figure 2 shows an example of constructing a cylindrical antenna array and demonstrates a spatial radiation pattern.

However, non-directional emitters in the azimuthal plane are required in order to construct spatial antenna arrays with wide-angle scanning. As a rule, vibrator emitters are considered as elements of such antennas. In addition, printed antennas have been increasingly used these days [10].

The report shows the results of simulating micro-strip vibrator emitters that provide an acceptable change in directivity and matching characteristics in a 9% band. Their frequency characteristics have been determined by agreement.

The object of the work lies in simulation and parametric optimization of the directivity characteristics of micro-strip vibrator emitters as part of a cylindrical antenna array.
2. Micro-strip vibrator emitter simulation

Non-directive emitters in the azimuthal plane are required to construct spatial antenna arrays with wide-angle scanning. As a rule, vibrator emitters are considered as elements of such antennas. It is necessary that the spacing of the emitters in the equivalent aperture is less than the wavelength. With switching scanning in an eight-element scheme, there will be no deviation of the radiation pattern, because the equivalent transmitting aperture will be the same at any position of the element projection beam. Nevertheless, the distance between the elements is equal to half the wavelength. Such a construction scheme can be implemented on elements in the microstrip structure. To increase the gain ratio, it is advisable to place the elements on two floors.

Figure 3 shows a microstrip vibrator emitter with coaxial excitation.

The emitter model is calculated considering the parameters of the base material RO4003C, the parameters of which are given in Table 1. The emitter is excited by the coaxial cable SF-085/086-FEP.
Figure 3. General view of the microstrip vibrator emitter.

Table 1. The parameters of the base material RO4003C.

| Parameter                                | Value       |
|------------------------------------------|-------------|
| Dielectric Constant, $\varepsilon_r$     | 3.38 ± 0.05 |
| Dissipation Factor, $\delta$             | 0.0027      |
| Thermal Coefficient of $\varepsilon_r$, ppm/°C | +40         |
| Density, gm/cm$^3$                       | 1.79        |

Figure 4 shows the radiation patterns of a microstrip vibrator emitter.

Figure 4. The radiation pattern of the microstrip vibrator emitter.

Figure 5 shows the radiation patterns of two vibrator emitters.

To construct a cylindrical antenna array of eight emitters, it is necessary to consider the influence of the fastening elements on the radiation characteristics and matching of individual emitters. Figure 6 shows a general view of the emitters in the frame. Figure 7 shows the radiation pattern. The 15 mm frame does not significantly affect the directivity characteristics, and the antenna gain is reduced by about 1 dB. However, the frame leads to a mismatch between the emitters and the transmission lines. Figure 8 shows the dependencies of the standing wave ratio (SWR) for each of the emitters on the frequency.
Figure 5. The radiation pattern of two vibrators.

Figure 6. General view of emitters with horizontal polarization in a frame.

Figure 7. Radiation pattern.
Figure 8. SWR dependencies for each of the emitters on the frequency.

The developed element can be used to construct spatial antenna arrays. However, with a small size of the equivalent aperture, the difference in the gain of the conformal and spatial antenna arrays turns out to be insignificant, which is shown in Figure 9.

Figure 10 shows a model of the antenna array, which includes fastening elements and a screen.

Figure 11 shows the radiation pattern of the cylindrical antenna array. The interaction of elements in the antenna array changes both directional characteristics and matching characteristics. Figure 12 shows the dependence of the SWR on the frequency of one element in the antenna array.

Figure 9. Gain ratio dependency on the frequency of concentric cylindrical and cylindrical antenna arrays.
Figure 10. General view of the cylindrical antenna array.

Figure 11. Radiation pattern of the cylindrical antenna array.
Figure 12. SWR dependency on frequency for one element in the antenna array.

3. Conclusion
Thus, a micro-strip vibrator emitter has been developed providing operation in a 9% band as part of the cylindrical antenna array. The report shows the possibility of using this emitter as an element of a spatial antenna array with the size of the equivalent aperture slightly exceeding the wavelength of about 1.5 wavelength. The dependencies of the gain on the frequency for concentric cylindrical and cylindrical antenna arrays are shown, illustrating the possibility of increasing the energy potential using the spatial arrangement of elements. Radiation patterns and frequency characteristics of micro-strip vibrator emitters, as well as antenna arrays of two elements, are provided, and calculated taking into account the influence of the fastening elements on the directivity and matching characteristics.

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