Optimization of the Directivity of Sum and Shaped Patterns using Circular Taylor and Ludwig Distributions

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The use of Taylor and Ludwig circular distributions are two useful approaches to the synthesis of sum and shaped patterns using planar arrays with circular boundaries. The excitations of the discrete arrays are determined by conventional sampling of these continuous distributions. These two techniques use a transition parameter ($\bar{n}$) that controls the number of nulls manipulated in order to afford a specific side lobe level for the $\bar{n}$-1 innermost lobes whereas the remaining lobes decay as $u^{-3/2}$ for Taylor and $u^{-5/2}$ for Ludwig.

Elliott in Table 6.8 of his book (R.S. Elliott, *Antenna Theory and Design*, Revised Edition, John Wiley & Sons, 2003) listed the optimal values of the $\bar{n}$ parameter in circular Taylor distributions for sum patterns that afford a maximum directivity versus different values of side lobe level (SLL). The herein proposed work shows that these values obtained by Elliott represent the necessary number of the controlled near-in side lobes that guarantees the far-out side lobes fits very well with the side lobe topography of the $J_1(\pi u)/\pi u$ function. For non-optimal values of $\bar{n}$ parameter only share with this function the property of decaying as $u^{-3/2}$. In addition, following the aforementioned procedure of Elliott, a determination of the optimal values of the $\bar{n}$ parameter for different values of SLL is also developed. The novelty of this presentation lies in the introduction of another two scenarios for this problem:

1. Sum patterns based on a circular Ludwig distributions in which, as also it happens in Taylor distributions, all the roots of their patterns are real, so the side lobes are interspersed by deep nulls.

2. Shaped patterns based on an extension of both Taylor and Ludwig distributions in which some roots are complex in order to obtain a pattern with properly filled nulls in the shaped region.

The obtained results show that in the case of Ludwig distributions the optimal $\bar{n}$ parameter is larger than in the case of Taylor distributions.

Once these optimal values are established, it can be carried out a comparison between the two types of distributions (Taylor and Ludwig) in terms of their directivities through the integration of their patterns and in terms of their Q value (ratio of the reactive power to the power radiated).

In conclusion, it can be said that by using Ludwig distributions it can be achieved much lower Q factors values than with Taylor distributions, but, in return, Ludwig distributions present a slightly smaller directivity than in the case of Taylor.