Design of Superstrate for Wide-Angle Impedance Matching in Microstrip Phased Array

Zeeshan Qamar[1,2], Nafati Aboserwal[1,2], Jorge L. Salazar-Cerreno[1,2]
[1]School of Electrical and Computer Engineering,
[2]Advanced Radar Research Center (ARRC),
The University of Oklahoma, Norman, OK, USA 73019
{zeeshan.qamar, nafati, salazar}@ou.edu

Abstract

Active phased arrays are widely used for radar and satellite communication applications due to their flexibility in shaping and electronically steering the radiation beam. On current mobile platforms, active phased arrays with large angular coverage are required i.e. $\geq \pm 70°$. This is important not only for the operational scanning characteristics of phased arrays, but also for compensating any misalignment due to the movements of the mounting platforms. The scanning range of typical phased arrays are limited to $\pm 45°$ and often resort to multi-aperture solutions, where different angular sectors are covered by different antenna panels. Even in these cases, the phased array having $\pm 70°$ are required in all scanning planes. For these large covering range phased array antennas, the well known problem of scan losses becomes an important issue. Various research work to mitigate this issue have been investigated. There are two main cause of scanning limitations in the phased array. First is the reduction of the antenna's effective area [1]. Second is the dependence of the active/scan impedance of array element from the scanning angle [2], [3]. This is due to the mutual coupling variation between the elements when the array beam is pointing at oblique angles. This clearly results in a mismatch between the antennas for large scanning angles. In order to increase the impedance matching, an additional dielectric layers above the phased arrays can be used [2], [4]. This solution does not require a complex design and, more important, can be applied without modifying an existing phased array design. However, the scanning range of $\pm 60°$ has been achieved using the a dielectric sheet. The impedance matching can also be increased by using the meta-material based superstrate [5], [6].

In this paper, an-isotropic superstrate is proposed for wide angle impedance matching (WAIM) that provide the desired scanning range of $\pm 70°$ when combined with the phased array antenna. At first, the proposed structure is characterized in order to observe the electromagnetic transparency at oblique angles using three probe RF scanner. Then integrated with the phased array antenna to obtain the desired beam patterns.

References

[1] P. Hannan, D. Lerner, and G. Knittel, "Impedance matching a phased-array antenna over wide scan angles by connecting circuits," *IEEE Transactions on Antennas and Propagation*, vol. 13, no. 1, pp. 28–34, 1965.

[2] E. Magill and H. Wheeler, "Wide-angle impedance matching of a planar array antenna by a dielectric sheet," *IEEE Transactions on Antennas and Propagation*, vol. 14, no. 1, pp. 49–53, 1966.

[3] R. C. Hansen, *Phased array antennas*. John Wiley & Sons, 2009, vol. 213.

[4] G. Yang, Q. Chen, J. Li, S. Zhou, and Z. Xing, "Improving wide-angle scanning performance of phased array antenna by dielectric sheet," *IEEE Access*, 2019.

[5] M. Ebrahimpouri, L. Herran, and O. Quevedo-Teruel, "Wide-angle impedance matching using glide-symmetric metasurfaces," *IEEE Microwave and Wireless Components Letters*, 2019.

[6] F.-L. Jin, X. Ding, Y.-F. Cheng, B.-Z. Wang, and W. Shao, "Impedance matching design of a low-profile wide-angle scanning phased array," *IEEE Transactions on Antennas and Propagation*, vol. 67, no. 10, pp. 6401–6409, 2019.