URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Broadband Phased Array Antenna Utilizing Butler Matrix for S-Band

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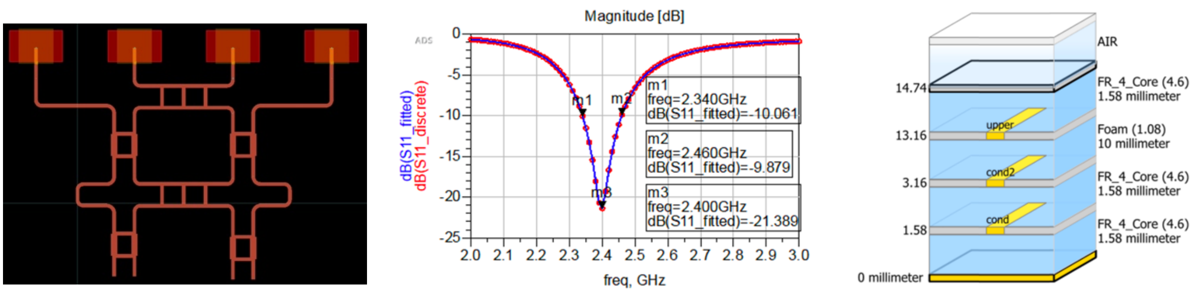
Modern communication systems such as 5G technology require broadband, high gain, beamforming, and low-profile designs. In order to achieve these requirements, planar antennas are commonly used in phased array systems. Microstrip antennas provide low cost, small dimensions, and their ability to be compatible and simply produced on planar surfaces. Although it also has weaknesses such as low bandwidth. There are several ways to increase bandwidth as using slot-shaped, fractal structure, electromagnetic band gap, or multilayer-stacked antennas. On the other hand, phased array antennas are used to increase the directivity, beam scanning of the antenna system, and to perform functions that can be difficult to reach with a single element.

In this study, a broadband passive phased array antenna operating at a frequency of 2.4 GHz is being studied by using effortlessly available and low-cost FR-4 dielectric material. In order to avoid bandwidth constraints multilayer electromagnetic coupled patch antenna structure is utilized [1]. To provide different beam angles, four antennas are fed by using 4x4 Butler Matrix [2] as a beamforming network as shown in Figure 1.



(a) (b) (c)

Figure 1. (a) Butler matrix with antennas, (b) Single element return loss, (c) Substrate layers

Multiple factors are contributing to increasing the bandwidth in multilayer antenna design. Choosing a small dielectric constant plays an important role in increasing the bandwidth. Because the fringing effect on the antenna will be curved and the fringes will reach a further distance. Thus, more radiation will occur. Selecting a material with a low loss tangent will result in increasing the performance of the antenna. As the thickness of the dielectric material increases, the efficiency and bandwidth of the antenna increases.

Taking into account the above considerations, the antenna designed and optimized in the PathWave Keysight ADS program. The feed line and the patch in the middle layer are designed on top of the FR4 material with a dielectric constant of 4.6 and a thickness of 1.58 mm. The width of the feed line is chosen as 2.88 mm and the height is 16.73 mm by optimization. The width and the length of the medium layer are chosen as 27 mm. 10 mm thick foam is placed between the patch in the middle layer and the patch in the upper layer by optimization. The width of the spread on the upper layer is chosen as 41 mm and the length is 24 mm by optimization. As a result of the design simulation, the return loss is 21.389dB and the bandwidth was 120MHz.

References

[1] A. K. Pandey, "Design of a cosecant square-shaped beam pattern SAR antenna array fed with square coaxial feeder network," 2013 European Radar Conference, Nuremberg, 2013, pp. 387-390.

[2] W. Bhowmik, and S. Srivastava, "Optimum Design of a 4x4 Planar Butler Matrix Array for WLAN Application", Journal of Telecommunications, Volume 2, Issue 1, pp. 68-74, April 2010.