Multi-Function Dielectric Resonator Array for Beam Scanning and Practical Bandpass Filters with High Selectivity

Milad Sharifi Sorkherizi*, and Ahmed A. Kishk
ECE Department, Concordia University, Montreal, Quebec, Canada,
www.ece.concordia.ca

The idea of using a dielectric resonator for dual purposes as a radiating element and a resonator cavity filter has been introduced in 2008. In all the published papers both antenna and filter are kept at a minimalistic level of complexity in such a way that the filtering characteristic is not practical, since the selectivity and the equi-ripple bandwidth don't match today's requirements of communication systems. Also the antenna was kept as simple as possible, which is only a single radiating element. In this paper we will introduce a state of the art design based on dual application of dielectric resonators for a beam scanning antenna array and a practical bandpass filter with acceptable selectivity and bandwidth.

The possibility of using unmetallized dielectric objects as cavity resonators was first introduced in 1939, but practical usage of them in microwave devices had to wait until 1960s, due to high loss effect of them in microwave frequencies and unstable material characteristic vs temperature. Then many novel designs have been introduced which enabled the implementation of complex filtering functions in a compact size with a very small insertion loss, which comes from high unloaded quality factor of the dielectric resonators. Also, low loss dielectric resonators with high permittivity have been used in antennas since 1980s, in order to have a compact, lightweight and low cost device, which also benefits from high radiation efficiency and flexible feed arrangement.

In this paper we propose a novel design technique that uses multiple resonator cavities to design an antenna array. One of the resonators is excited in $HEM_{11\delta}$ mode using a printed microstrip line. Other elements of the array are working as parasitic elements, which are connected to lumped capacitive loads. By using proper capacitances, the radiation beam can be controlled effectively. Same resonators are excited in $TE_{01\delta}$ mode using proximity coupled microstrip lines, which are orthogonal to the antenna feed lines. This mode is used as the filtering function to implement a narrow bandpass filter with Chebyshev response. Two microstrip resonators also are used to increase the order of the filter to achieve better selectivity. No metallic enclosure is used in the design. Only metallic discs are placed over the resonators to improve the quality factor of $TE_{01\delta}$ mode with minimum effect on the radiating mode. We used coupling matrix to design and tune the filter. An analytic method is used to extract the coupling matrix from simulated response of the filter in order to optimize the filter efficiently. Due to unwanted cross-coupling between the resonators, filter response shows a transmission zero in lower side of the passband that enhances the selectivity of the filter.