Liquid Crystal Based Aperture Coupled Series Patch Antenna with Enhanced Beam Coverage for B5G Smartphone

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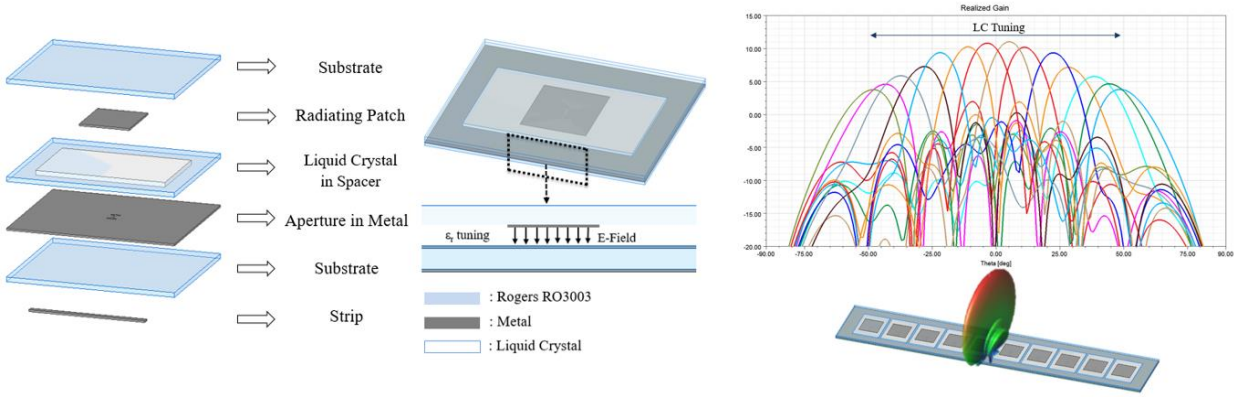
This paper presents a single feed aperture-coupled liquid crystal series patch antenna with enhanced beam steering coverage for B5G smartphone. In the conventional liquid crystal-based array antennas liquid crystal functions in phase shifter where tuned guided wavelength on the feeding path can achieve a tunable range of phase shifter. Beam steering coverage of antenna system employing this-type phase shifter is highly limited due to limited design freedom in the guided structure. In addition, this system topology suffers from a critical disadvantage of high dielectric and ohmic losses caused by lengthy current path leading to bulky and complicated system configurations. This paper proposes a novel design approach to address this problem by extending design freedom up to radiating aperture structure which uses appropriate combinations of the simplified feed structure and adjacent patches closely to the subwavelength level. It is found that this method enables design of series patch antenna with a dramatically improved beam steering coverage as well as antenna miniaturization.

The unit cell of series patch antenna and cross section view are shown in Fig. 1 (a). The unit cell is an aperture coupled patch antenna. The dielectric under the patch is made of LC and this serves as a substrate for the patch antenna. When the dielectric constant of the liquid crystal is changed, the effective wavelength is changed, thereby changing the radiation amplitude and phase at a fixed frequency. The phase tuning range of the unit cell is about one third level of the ideal one. The radiation amplitude decreases as it moves away from the reference value of the dielectric constant and the phase also changes simultaneously.



(a) (b)

Figure 1. (a) Liquid crystal based unit cell structure (b) array antenna and radiation pattern

The spacing between patches of a typical series-fed patch antenna is one guided wavelength. This is to form the main beam in the broadside direction. However, LC based series patch antenna has patch spacing of subwavelength. This is to compensate for the small phase tuning range by varying the phase of the feed wave which excites the patches. The radiation characteristics of an ideal unit cell is the unit radius circle, whose amplitude is kept at max and the phase is tunable in 360°. The available phase range is about one third, so the operating point of ideal unit cell is calculated and approximated to the unit cell circle. Thus, after the operating point of each unit cell to form the main beam in the desired direction is determined in the unit cell circle, the main beam can be formed in the desired Φ_0 by independently controlling the dielectric constant of each cell. Fig. 1 (b) shows the radiation pattern of the 1x10 patch array antenna. Finally, fabricated antenna samples and their measurement results will be presented.