Modelling Microwave Devices with Liquid Crystal Substrates

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Liquid crystals are attractive as a medium for communications equipment in the millimetre-wave band leading to compact and reconfigurable devices with low power consumption. Designing filters, resonators and couplers for this purpose is not straightforward. Often simplifying assumptions are made when evaluating the behaviour of the microwave fields. For example, the liquid crystal may be considered to act as a uniform dielectric. This process is further complicated by the fact that few liquid crystals have been characterised in this band.

In this paper accurate modelling is applied to the design of microwave devices with liquid crystal substrates. The modelling takes into account the full permittivity tensor calculated from the minimisation of the free energy of the liquid crystal when calculating the microwave fields [1, 2]. Interesting configurations to consider include a ring resonator positioned between two parallel strip lines, with a common substrate and ground plane. In this configuration, the device can act as a directional coupler, a notch or a bandpass filter or a narrow band switch. Another possible structure is a filter made up of resonator patches. Different voltages may be applied to each patch so as to control the resonant frequency and bandwidth. Material properties of the liquid crystal have been estimated by fitting experimental to modelled results for a simpler stripline structure. A number of possible device designs and alignments are evaluated and reconfigurability is demonstrated.

[1] R. James, E. Willman, F.A. Fernández, S.E. Day, *IEEE Trans. Electron Devices*, **2006**, 53(7), 1575-1582.
[2] L. Zhang and S. Xu, *International Journal of Infrared and Millimeter Waves*, **1995,** 16(8), 1351-1360.