CRLH-TL Multi-Band Microstrip Patch Antenna

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Multi-band microstrip patch antennas have been recently implemented with a composite right/left-handed metamaterial transmission line (CRLH-TL). A method to model the CRLH-TL unit-cell has been investigated (Itoh et.al. *Dual-Mode Compact Microstrip Antenna Based on Fundamental Backward wave*, Volume 4, 2005) for a microstrip patch antenna in the Sievenpiper mushroom configuration. In the present work, a design methodology that leads to an easier implementation has been developed, for multi-band microstrip patch antenna using a CRLH unit cell consisting of series and shunt stubs. (Fig.1b)

The equivalent circuit model shown in Fig 1(a) consists of a CRLH unit-cell with a LH series capacitance (C_L), and RH series inductance (L_R), LH shunt inductance (L_L), and RH shunt capacitance (C_R). By cascading multiple CRLH unit-cells each of length p, a CRLH-TL of length N*p can be realized. By applying the periodic boundary conditions (PBCs) related to the Bloch-Floquet theorem to the CRLH unit cell (Itoh et.al. *Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications*. Wiley, 2004), the dispersion relation (eq. 1) is obtained.

$$\beta(\omega)\rho = \pm\sqrt{L_R C_R \omega^2 + \frac{1}{\omega^2 C_L L_L} - \left(\frac{L_R}{L_L} + \frac{C_R}{C_L}\right)} \qquad (1)$$

The design methodology for a dual band microstrip antenna is as follows. For a desired transition frequency, assuming a value for the series inductor or shunt inductor, the rest of the circuit elements for the unit cell are obtained. The dispersion graph, Fig 2, obtained from eq.1 shows that for a given value of β there are two frequencies propagating simultaneously, corresponding to the LH and RH regions. The microstrip patch antenna can now be designed with series and shunt stubs (fig. 1b). The above method has been applied for a transition frequency of 20 GHz from which a RH frequency of 36 GHz and a LH frequency of 10 GHz have been selected. Fig 3 shows the return loss at these two frequencies establishing dual band operation. This method has been extended to multiband performance for more than two LH resonant frequencies by using multiple unit cells. The work under progress is validation by measurement.

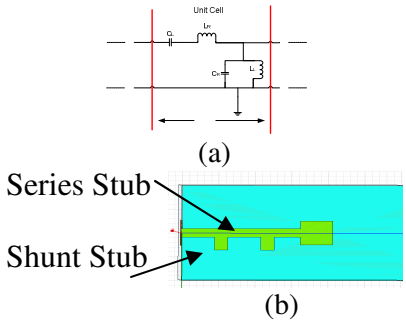

Fig 1: Equivalent Circuit Model and CRLH-TL Multi-Band Microstrip Patch Antenna

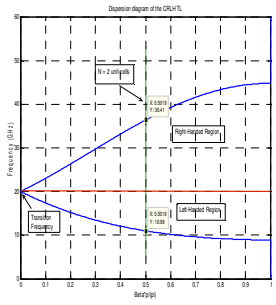

Fig 2: The dispersion diagram of the CRLH-TL

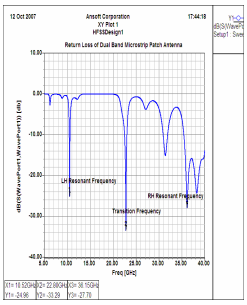

Fig 3: Return loss of dual band microstrip patch antenna

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Prof. Steven C. Reising
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Dear Professor Reising,

With reference to the paper titled "CRLH-TL Multi-Band Microstrip Patch Antenna" submitted by my graduate student Zebo Qiu, this is to verify that Zebo has worked independently and that my role has been as an advisor.

He has entered his paper for the student competition. Please contact me if you require any further information. Thank you.

Regards

Jayanti Venkataraman, Professor

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