Compact broadband triple-ring five-port reflectometer for microwave brain imaging applications

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ABSTRACT

The broadband five-port reflectometer (FPR) is proposed using a triple-ring based technique. The design introduces a tapering in the inter-ring transmission lines (TLs), which provides additional degrees of freedom for optimization and contributes to increased bandwidth. The miniaturization strategy allows incorporating the third ring without significant size increase. In addition, a method for expressing the effective physical dimension of a planar symmetric FPR is also presented in an easily comprehensible way, which can be implemented for other symmetric planar junctions with more than four ports. The proposed design comprises three concentric rings with phase-shifting arrangements between the inter-ring TLs and outer matching arm sections. Inter-ring TLs are shifted by 36◦ (half factorized value of the inter-port angular distance of 72◦) in three different optimizing steps. Tapered TLs have been used between two consecutive rings to achieve very wide bandwidth of at least 88% in simulations and at least 85% in measurements. Curved matching TLs are used in the final design, yielding a compact size of 0.397λg × 0.377λg with 43% reduction in length and 43% in width compared to its non-compact counterpart. Genetic algorithm and quasiNewton algorithm are used in optimizing the final prototype for operation in the frequency band used for brain microwave imaging. The proposed FPR realized a fractional bandwidth of at least 85% (from 0.96 to 2.38 GHz) with a reflection coefficient below −20 dB and a −6 ± 1 dB transmission coefficient with the required phase shift of ±120◦ between different ports. The measured results agree well with the simulation. Finally, the overall imaging system setup and image construction algorithm are presented and discussed for possible incorporation with this FPR for brain microwave imaging.

KEYWORDS
Five-port reflectometer; Microwave imaging

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