REVIEW OF CIRCULATOR TECHNOLOGY

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The ferrite circulator has come a long way from its beginning as a practical application of Faraday rotation some eighteen to twenty years ago.[1] The name, circulator, was coined by A. G. Fox, and in the process of this development, circulators have assumed many forms and an almost equal number of interpretations. Circulators to handle the duplexing function in megawatt systems have utilized differential phase shifters in conjunction with 3 dB power splitters (couplers or tees). A more compact and economical version of the circulator evolved in the use of the turnstile junction.[2] This circulator design also depends on a split of the input power and a phase cancellation of waves due to phase shift introduced in the ferrite loaded turnstile circular guide section. While more compact and potentially cheaper, the turnstile adjustment is somewhat critical and its resulting bandwidth rather limited.

The most widely used circulator today is the Y-junction model.[3] This device is, in fact, the most widely employed ferrite component today, and has largely replaced the traditional resonance isolator as an all purpose nonreciprocal element. Y-junction circulators of both stripline and waveguide designs can be interpreted in terms of a coupling of dielectric resonator modes, and this theory is probably the best developed and most widely accepted at present.[4-6] There is, however, some overlap, particularly in the waveguide designs, with the turnstile theories.[7] Performance parameters of the Y-junction device can be related directly to the intrinsic parameters of the material with good correlation for operation both above and below resonance. Octave bandwidth stripline versions and full guide bandwidth waveguide models are commercially available.

At UHF and low microwave frequencies, the lumped element resonator design has achieved notable success, though the realizable figure of merit is less than that achieved at the higher frequencies.[8-10]

Current efforts in the circulator field focus primarily on reductions in size and cost of components. Microstrip versions have been readily developed by adaptions of stripline designs.[11] A minimization of size through the use of lumped elements at higher frequencies has produced promising results at the expense of some bandwidth.[10]

The advent of digital, latching circulators has led to a number of duplexing and switching devices based on this component.[12] The steady improvement in ferrite materials quality and control and a more thorough understanding of basic loss mechanisms at both low and high rf power levels has aided importantly to a reduction in the cost of development of new models.

Progress in the circulator field has been consistent over virtually the entire eighteen year history and evidence of this sustained growth is found in the papers immediately following.

References

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Notes