ABSTRACT

Microwave as well as millimeter and sub-millimeter wave nonreciprocal devices like isolators or phase shifters are important in modern communication and radar systems. Although ferrites have traditionally been used in the microwave region, new materials are required to develop devices that operate in the millimeter and sub-millimeter wave regions. One of the possible candidates to develop such devices are high mobility semiconductors where magnetoplasmons can be excited. In this thesis, Drude's model is used to derive a permittivity tensor for a semiconductor material with a DC magnetic bias. Three different methods are then applied to design and analyze waveguides filled with magnetoplasma. The approximate generalized telegraphist's equations are applied and its accuracy is discussed. The second method used here is the Finite element method (FEM) which is a numerical full wave solver of Maxwell's equations. To provide physical insight, an exact analytical method, referred to as the transverse resonance technique, is developed to simulate rectangular waveguide filled with transversely-biased magnetoplasma. By using these methods, isolators and phase shifters are designed using two phenomena, namely, field displacement effect and unidirectional propagation. Different design considerations such as bias, waveguide geometries, etc. are discussed. Finally, the electrostatic wave is studied and analyzed. To further study this phenomena, a quasi-static approximation is applied to analyze different types of waveguides. Analytical as well as a FEM-based computer code are used to find the propagation constants and eigenmodes of various waveguide geometries.