1. SUMMARY:

Microwave and millimeter-wave analog phase shifters are essential components in phased-array antennas for telecommunications and radar applications and are mainly based on ferrite material. But extremely high cost and frequency limitation of ferrite material has limited the use of the array antennas to military applications and made them impractical for mobile satellite communication devices. In this study, novel semiconductor phase shifters will be studied as potentially low-cost and miniaturized phasers, which can be used in the phased array antennas.

In the 1st part of this report, the gyroelectric properties responsible for phase shift action in semiconductor material are examined. The Drude-Zener model is adopted in the analysis to derive the permittivity tensor of magnetized semiconductor, dual to that of permeability tensor of magnetized ferrites. The constraints imposed by the model and the limitations of this approach are discussed. Based on these constraints and limitations a suitable semiconductor, Indium Antimonide (InSb), is chosen to implement the phase shift section where phase shift is achieved by changing the applied DC bias field. Closed for techniques are used to analyze the modal behavior of the magnetized InSb rod in terms of applied bias field and signal frequency. In the second part of the project this technique will be extended to compute the phase shift properties of the InSb rod.

In the 2nd part of the report, the phase shift requirements for microstrip patch array were analyzed and calculated using using genetic algorithm.

5. CONCLUSION:

In this report, a brief introduction to gaseous plasma in which its unique characteristics together with the criteria for its existence are discussed. Comparison between magnetizes semiconductor and gaseous plasma is carried out. The gyroelectric properties of magnetized semiconductor are considered and the Drude-Zener model of the semiconductor is employed for the derivation of the permittivity tensor. Losses due to the electron collisions in the semiconductor are modeled by inclusion of the electron collision frequency into the analysis. After surveying the properties of some important semiconductor materials, it is concluded that indium antimonide (InSb) is the most suitable candidate for our purposes mainly because of its low electron collision frequency. At liquid nitrogen temperature, $\boldsymbol{v_c}$ of the InSb is 10 times lower than its corresponding value at the ambient temperature.

The modal analysis of InSb rod, suitable for constructing phase shifters, is carried in terms of experimental variables, Bias field and Signal frequency. This closed form analysis, although rigorous, illustrated lossy resonance regions and continuous modal behavior with different regions of magnetic bias. This data will help us to determine the biasing conditions to continually vary the phase shift of the InSb rod and operate within low-loss regions. The changes in modal behavior of the InSb rod with changing external (radius) and internal parameters (carrier concentration, dielectric properties, effective mass) are also calculated and plotted for optimization purposes. The phase shift produced by the InSb rod is under investigation and will be presented in the next report.

In the 2nd part of the report, the phase shift requirements are investigated. The required phase shift function was calculated for different scan angles.These results will be later used to design a linear microstrip array antenna, where the mutual coupling will be taken in consideration.