1.1. Introduction:

Electronic oscillators convert direct current power to alternating power without the aid of an external source of controlling voltage. These oscillators can operate at frequencies from a few cycles per second to several hundreds of megacycles per second and may produce at the output power of several hundreds of kilowatts. The oscillators hence find extensive application in many fields of electrical engineering; e.g., in radio and television receivers and transmitters, in frequency standards, in frequency multiplication and division, in the generation of test signals in the laboratory, in induction and dielectric heating. One very important application of high power oscillators is in the nuclear particle accelerators as in cyclotrons and synchrocyclotrons. The different oscillators used in these various fields are based on some common oscillator circuits like tuned grid, tuned anode, Hartley, Colpitts and similar circuits. The linear analysis of these oscillators are very well discussed in standard text books.

Usually the active element in these oscillators which is very often a vacuum tube introduce nonlinearities. The nonlinearity leads to many interesting phenomena e.g. limit cycles, entrainment of frequency, multimode oscillations, hysteresis and jump in amplitudes due to the variation of oscillator parameters etc. Such phenomenon have also been investigated for the commonly used oscillators since the days of van der Pol. However, in spite of many detailed studies that have been made on
oscillators there still originate problems in some practical application of these oscillators which require further investigation.

The author has been engaged for the last five years in the design and construction of R.F. oscillators for cyclic particle accelerators. In connection with this work he came across certain problems associated with the grounded grid oscillator as applied in cyclotron and synchrocyclotron which required to be studied in details. There also arose along with the study the requirement of investigating an oscillator with delayed feedback and a simple tuned anode oscillator using a tube of high transconductances. These investigations have led to quite a few important results. These studies along with the results form the subject-matter of the present dissertation. The scope of the thesis is outlined below.

1.2. Scope of the Thesis:

In Chapter II of the thesis a brief review of the design of the radio frequency system of the cyclotron and the synchrocyclotron is given. This includes the design of the dee system as well as the design of the different circuit components of the grounded grid oscillator used for cyclotron and synchrocyclotron for optimum operation of the respective oscillator at the desired dee frequency. Excitation of the unwanted modes of oscillation is also discussed.

In Chapter III of the thesis a linear analysis of a grounded grid oscillator considering the effects of all important circuit elements is presented. It is shown that the oscillator may execute oscillations at one of the cyclotron dee resonant frequencies and/or at one of the coupling
transmission line frequencies. The conditions of excitation of these oscillations are derived. Experimental evidence obtained from a model oscillator verifying the theoretically derived results are also given.

In Chapter IV of the thesis an analysis of a grounded grid synchrocyclotron oscillator is presented using a lumped equivalent circuit. It is shown that for some circuit adjustments of the oscillator, oscillations may be excited at the dee resonant frequency, at the anode to dee coupling transmission line frequency or simultaneously at both the frequencies. The excitation of simultaneous oscillations is explained by considering the tube nonlinearities. Experimental results obtained from a model oscillator, generally confirming the analytical results are also presented.

In order to understand the effect of the tube nonlinearity on the modes of oscillation in a multi-mode oscillator to which class cyclotron and synchrocyclotron oscillators belong, a detailed study of the characteristics of a simplified oscillator, i.e. a tuned anode oscillator with a tuned load using the same oscillator tube, has also been done. The results of these studies are described in Chapter V. Two new phenomena were observed in these studies. One of the phenomena is simultaneous oscillations at two non-harmonically related frequencies as was observed in the cyclotron and synchrocyclotron oscillators; the other phenomenon is automatic switching from one frequency to the other.

As mentioned earlier a cyclotron or a synchrocyclotron oscillator has essentially multimode properties which arise from the dee resonant
circuit and the tube to dee coupling circuits. In the analysis presented in Chapter III and IV, the dee to tube coupling circuit has been replaced by lumped equivalent circuits. However, the dee to plate coupling circuits are distributed in nature since the coupling line lengths may be of the order of a quarter wavelength. To investigate the effect of the distributed nature of the coupling line a general study has been made of a oscillator in which the plate to grid feedback is provided by a delay line. Results of these studies are presented in Chapter VI. Also the delay line oscillators form a class by themselves and have many interesting properties which remain yet unexplored. The author has investigated some of these properties e.g. free oscillations, harmonic generation, synchronisation and switching. These studies are also presented in Chapter VI.