The investigation and realization of novel types of microwave mode transducers have been presented in this thesis. Circular waveguide discontinuities which occur in a multi-frequency mode transducer have been modeled and analyzed. A common ortho-mode transducer operating at widely separated frequency bands has been conceptualized, designed and developed. The design is based on modal analysis approach to give optimum performance of return loss, mode purity, inter-port isolation and insertion loss at all the frequency bands. Dominant mode purity of circular waveguide is obtained in the outermost section of OMT at each frequency band which ensures desired radiation patterns of a corrugated horn antenna fed by the OMT. Power has been estimated in the higher-order modes and the electromagnetic modeling of the rectangular to circular waveguide transitions has been done to arrive at the optimum design of OMT. This concept has been utilized also to develop a mode transducer operating at three widely separated frequency bands centered at frequencies higher than the center frequencies of the four frequency OMT. The simulated and measured results of the mode transducers are presented.

Hybrid mode transducers in the form of corrugated horns have been designed and developed yielding optimum radiation performance at all the frequency bands. The design has been done using the technique of harmonic operation of corrugation depth to operate at all the four frequency bands. The horn geometry is optimized to get proper power ratio in the various modes at the horn aperture in order to yield symmetric far field co-polar patterns and low level of cross-polar radiations at all the frequency bands. The horn has been tested with the developed 8-port OMT. The measured performance of OMT and horn are in close agreement with the simulated results. A multi-mode corrugated horn has also been developed at three widely separated frequency bands to be fed by a common three frequency mode transducer.

Multi-mode transducers in the form of elliptical and circular multi-mode feeds have been designed and developed at Ku-band yielding sector shape primary radiation patterns in order to achieve high gain beams of the reflector antenna. Measured and simulated performance of multi-mode feeds are presented.

New type of mode transducers supporting circularly symmetric TE_{01} and TM_{01} modes of a circular waveguide have been designed to develop a compact dual-channel rotary joint at Ku-band using modal analysis approach. The simulated and measured results of the rotary joints are presented for return loss, insertion loss, isolation between channels, mode coupling behavior, variation of return loss and insertion loss with 360 degree rotation.