Cavity model is the one of the simplest model to analyze microstrip patch antennas. In this thesis, investigations are carried out to analyze the circular and annular ring microstrip geometries by cavity model. The computed results are compared to the results obtained from IE3D software based on method of moments. Firstly a model for circular antenna based on cavity model is developed and this analysis is further extended to stacked circular disc. The results are compared to simulated results. Good agreement is obtained between the two results. Gain is considerably high in case of stacked elements and radiation efficiency is more than 94% for different cases. From the results it is observed that in this method the cavity model is extended beyond \( h \ll \lambda_0 \) and it is observed that the model is successful for determining various parameters of the stacked antenna.

The ring antenna with coaxial feeding is analyzed with the help of cavity model and circuit theory. The method obtained is quite simple, accurate and can be used to predict the impedance of first few modes. \( \text{TM}_{11} \) is the dominant mode. The computed results are compared to previously published data for \( \text{TM}_{11} \) mode. The result shows that there is disagreement for the real part of impedance with earlier published data and this is possibly due to the method of feeding used. A high degree of agreement is observed between the parameters calculated by this method and IE3D software. The method developed is intuitive and does not demand high computation power.

Continuing with the analysis of similar structures the effect of loading on annular ring antenna is also studied. This is the method to enhance the bandwidth of microstrip antennas. Cavity model is used to find out the resonant frequency of \( \text{TM}_{np} \) mode of loaded annular ring antenna via shorting posts. The posts are thin in diameter with respect to the diameter of ring. For accurate estimation of frequency under loaded condition, the close form expression for the impedance of shunt post as given by Sengupta has been modified to incorporate the empirically generated "Correction Factor". The analysis is extended to the case when posts are loaded randomly (asymmetrically) on an annular ring antenna at \((r_2, \phi)\) where \( r_2 \) is the radial distance of the post from the centre of the patch and \( \phi \) is the angle between the line joining the centre of the patch and the feed probe, and the angular location of the post. This can be shown when we change the angular position of post the resonant frequency is not
altered. For this analysis the resonant frequency does not depend upon the angular location of post. Thus for \( P = 1 \) and \( \phi_i = 0^\circ/180^\circ \), dual resonance is produced at any angular location and for all normal modes except for \( n = 0 \). Hence TM\(_{11}\) is the dominant mode unlike symmetric loading where TM\(_{01}\) is the dominant mode. The variation of resonant frequency is also observed with the radius of posts and it increases as the radius of posts increases. The numerical and simulated results are in complete agreement.

The resonant frequency when the posts are located symmetrically (equi-spaced along the circumference of circle concentric with the patch radiator) is analysed. It is shown that the resonant frequency for each mode depends on the radial distance of the posts from the centre of the patch and radius of post. As the posts move towards the edge of the patch, the resonance frequency of TM\(_{11}\) mode first increases and then drops down. This effect is more pronounced when number of posts \( P \) is large. For the loaded patch, the lowest non-zero mode corresponds to TM\(_{01}\) mode with a resonant frequency less than the dominant TM\(_{11}\) mode of the unloaded patch. Interestingly the use of wall susceptance is not required in the present method. Then the input impedance is calculated for symmetric loading of posts. The resonant resistance decreases as the number of pins increases. Good accuracy is obtained between the measured and simulated results. It is seen that for better impedance matching at both the frequencies a thicker substrate is more useful.

The input impedance of a ring resonator electromagnetically coupled to a microstrip line is calculated by developing a simple model based on cavity model and circuit theory. The line underneath the ring forms a capacitive tap with ring on the top and ground plane below. The capacitance between two conductors is found by two methods. The input impedance is obtained in three main steps. Firstly the impedance of probe fed ring resonator is obtained, secondly the capacitance is calculated and lastly the net impedance is transformed at the line end using classical transmission line transformation. In the first method the capacitance is found by coupling between two cylindrical lines and other is the variational method. The capacitance obtained by both the methods is same. An excellent agreement exists in the resonant resistance of TM\(_{11}\) mode of the loaded ring resonator between theory and simulation with
transmission line loading. It is seen that the ring displays a very high resonant resistance. As proposed in the theory, this can be brought down to 50 Ω by suitable insertion of a transmission line underneath the ring. Normally a ring antenna is used for radiation purposes in the TM_{21} mode, which has a higher resonance frequency. Unlike the conventional use, this proposed structure can be used in its dominant TM_{11} mode giving the advantage of a compact antenna. This simple method of computation is also very useful when an array of rings is to be designed for low side lobes since the amplitude taper can be easily achieved using varying lengths and widths of transmission line.

The investigations carried out in this work have led to the design techniques and characterization of broadband antennas. Using the simple method outlined in this thesis, it is possible to design broadband and dual frequency antennas by stacking and loading of antennas. This analysis can further extended to incorporate switching diodes or varactor diodes. By changing the bias level of varactor diodes, the resonant frequency is tuned. Varactor diodes have also been used for design of polarization agile antenna. The resonant impedance of such loaded antenna is thereby increasing the utility of the design application. It is also fruitful to investigate the effect of an asymmetrically loaded off-centred shorting post in presence of a centred short of finite dimension. The said investigation should lead to computation of resonant frequency, input impedance and radiation pattern of loaded annular ring antennas.