Preface

The high $T_c$ cuprate superconductors are highly anisotropic, layered type-II superconductors with very short coherence lengths of the order of cell dimensions. This makes it possible for the ceramic superconductors to have a variety of inter- and intra-grain defect structures which form weaklinks in these materials at various levels. The presence of such extrinsic but ubiquitous defects makes the electromagnetic response of these materials very sensitive to the applied field and temperature. Measurement of surface resistance of HTSCs has attracted maximum attention in literature and by and large this is the most thoroughly investigated property at microwave frequencies. This is because $R_s$ is an important parameter as it determines power dissipation. Surface reactance, on the other hand, gives a wealth of information on the penetration depth ($\lambda$) characterising the HTSCs and the magnetic properties.

Magnetically modulated microwave absorption as a function of temperature and low field are two important techniques which can be used to determine the transition temperatures and loss mechanisms, respectively. However, because there is considerable hysteresis in the power absorption and the sample is in a nonequilibrium state during field cycling, the above two techniques, though very sensitive, suffer from a few disadvantages. Direct power absorption is a simple and better tool to study the virgin response of HTSCs. Several authors have used these techniques to study the loss mechanism in these superconductors at microwave frequencies. But to the best of our knowledge, but for a few brief reports, no detailed study has been carried out at radio frequencies.
In the present thesis a detailed study of the high frequency loss mechanisms, penetration depth and the associated novel features such as paramagnetic Meissner effect are presented. The thesis is divided into seven chapters of which chapter 1 consists of a general introduction to HTSCs and high frequency study. It also summarizes the work done in literature relevant to non-resonant microwave absorption. Chapter 2 describes the experimental techniques developed for rf (MHz) measurements. The construction of a rf marginal oscillator for the measurement of change in power absorption and frequency is described.

Chapter 3 consists of a systematic study of rf (11.9 MHz) absorption in sintered BSCCO and GdBCO samples. In the case of BSCCO the results are discussed in the frame work of resistively shunted Josephson junction (RSJ) model. It is also found that the junctions responsible for the absorption are of SIS type. In the case of GdBCO sample the field induced loss is found to be following a combination of RSJ and decoupled junction models. The temperature variation of rf absorption of BSCCO and GdBCO are found to follow the London's two fluid equation.

Chapter 4 describes the results of rf and microwave absorption at high fields obtained on various HTSC, namely, sintered GdBCO and melt textured GdBCO with various percentages of $Re_2BaCO_6(211)$, sintered and press sintered BSCCO samples. The results are explained by invoking flux flow model. It is found that melt textured samples do not show any appreciable microwave and rf absorption at low fields and thus are best suited for bulk device applications at these frequencies. At high fields the increase in the percentage of 211 is found to enhance pinning in these materials.
In chapter 5 the results of field modulated microwave absorption at 9.98 GHz on sintered pellet, powder and melt textured samples of GdBCO are presented. In the case of GdBCO powder, an anomalous zero field maximum followed by minima at ± 0.6 has been observed which has been attributed to the \( \pi \) junctions and the paramagnetic Meissner effect. Various possible origins of \( \pi \) junctions from \( d_{x^2-y^2} \) symmetry consideration and \( Gd^{3+} \) impurity moments are discussed.

In Chapter 6 the results of temperature and field variation of frequency shift of the rf oscillator are reported. Generally, for any superconductor the frequency of oscillator increases as the sample is cooled to below its transition temperature. However, in the case of BSCCO samples an anomalous frequency decrease is observed in the tail region as the sample is cooled. The anomaly is attributed to a change over from intra to inter grain contribution to the penetration depth. In the case of GdBCO sintered pellet an extremely unusual frequency decrease is observed as the sample is cooled which is discussed in relation to the temperature dependent frequency shift of the DyBCO sintered pellet, which also has \( 3^+ \) moments. The possibility of \( Gd^{3+} \) moments interacting with the Josephson currents thus giving rise to such an anomaly is also discussed. Chapter 7 summarizes the results reported in 2,3,4,5 and 6 chapters and gives an overall picture of the rf response in relation to that at microwave frequencies.