THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON DIELECTRIC RESONATORS

by

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to my family

CERTIFICATE

This is to certify that the dissertation entitled, **"Theoretical and Experimental Investigations on Dielectric Resonators"** which is being submitted by Mr. Rajesh Mongia to the Indian Institute of Technology, Delhi, is a record of the bonafide research work carried out by him under my guidance and supervision.

In my opinion, this dissertation has reached the standard fulfilling the requirements of all the regulations relating to the degree. The results contained in it have not been submitted in part or in full to any other university or institute for the award of any degree or diploma.

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ABSTRACT

The use of dielectric resonators in microwave circuits has increased quite rapidly during the last few years. This has been made possible due to the development of high ε_r, low loss and temperature stable dielectric materials. While cylindrically shaped resonators have been employed in nearly all the applications at microwave frequencies, rectangular shaped resonators offer advantage in terms of ease of fabrication at mm-wave frequencies. Dielectric resonators are also potentially attractive for their use as radiating elements as they are small sized and offer no conductor loss. Both cylindrical and rectangular resonators are the topics of study in this thesis.

The design of circuits using dielectric resonators requires the knowledge of basic quantities such as resonant frequency, radiated far fields and radiation Q-factor (in case resonator is used as a radiating element), conductor Q-factor etc. in the particular configuration in which the resonator is placed. Traditionally, cylindrical resonators have been analysed using "magnetic wall" method and "dielectric waveguide model "(DWM) method. These methods have been used mainly for finding the resonant frequencies only. The accuracy and information available using these methods are quite limited. As a result, a number of rigorous numerical methods have been reported during the last five years or so. Some of these methods are also capable of

providng information such as fields, Q-factors etc. quite accurately. However, all these methods are computationally complex which makes their use in practical application almost prohibitive.

In the present thesis, a simple new technique has been proposed for the analysis of cylindrical resonators in isolated and shielded configurations. Most of the attention is paid to $TE_{01\delta}$ mode of resonance which is the most commonly employed mode of resonance in practical circuits. The technique is analogous to the 'effective dielectric constant' (EDC) method used frequently in the analysis of rectangular dielectric guide structures. Appropriate formulas are presented for 'ε_{eff}' of various resonator structures. The structures considered in this thesis are: isolated cylindrical resonator, isolated ring resonator, dielectric image resonator, resonator on a dielectric substrate backed by a ground plane, and, single and coupled resonators in a circular waveguide. The various resonant characteristics of the resonator such as resonant frequency, radiated fields, radiation and conductor Q-factor, etc. have been studied in detail. In almost all the cases, the results have been compared with those of the rigorous methods reported in the literature. It is shown that the improvement which the present method offers over DWM method is quite significant. The present method can predict various characteristics of the resonator with an accuracy adequate for most of the practical applications. It is thus hoped

that the present method would find wide use in practice. The experimental techniques which were tried for exciting various modes of the resonator are also discussed. Theoretically computed results for the resonant frequency are compared with the experimental results for various structures considered in the thesis.

Finally, the resonant frequencies of various modes of a rectangular resonator are computed using the " dielectric waveguide model" method. Various lower order modes of the resonator are identified. The effect of shielding on various modes of the resonator is also studied. Extensive experiments are conducted to compare the theoretical resonant frequencies with the measured values.

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CHAPTER 2 ISOLATED CYLINDRICAL AND RING RESONATORS