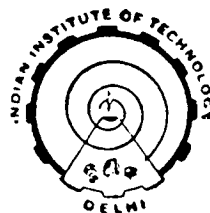


THEORETICAL AND EXPERIMENTAL
INVESTIGATIONS ON
DIELECTRIC RESONATORS

by

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*A thesis submitted to the
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for the award of the degree of*
DOCTOR OF PHILOSOPHY



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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.

CONTENTS

Certificate	(i)
Acknowledgement	(ii)
Abstract	(iii)
List of symbols	(xi)
CHAPTER 1 REVIEW AND SCOPE OF THE THESIS	
1.1 Introduction	1
1.2 Review of Cylindrical Resonators	3
1.3 Review of "Dielectric Waveguide Model" (DWM) Method	4
1.3.1 Isolated Cylindrical Resonator - $TE_{01\delta}$ Mode	4
1.3.2 Cylindrical Resonator on a Dielectric Substrate - $TE_{01\delta}$ Mode	9
1.3.3 Cylindrical Resonator in a Circular Waveguide - $TE_{01\delta}$ Mode	11
1.3.4 Isolated Cylindrical Resonator - $TM_{01\delta}$ Mode	14
1.3.5 Isolated Cylindrical Resonator - Hybrid Modes	17
1.3.6 Results of DWM Method and Comparison with Rigorous Methods	23
1.4 Discussion on DWM Method and Comparison with Rigorous Methods	25
1.5 Rectangular Resonators	33
1.5.1 Okaya's & Barash's Approximation	34
1.5.2 Marcatili's Approximation	39
1.6 Scope and Organization of the Thesis	43
References	49
Appendix 1.A	53
Appendix 1.B	54

CHAPTER 2 ISOLATED CYLINDRICAL AND RING RESONATORS

2.1	Introduction	56
2.2	Method of Analysis - $TE_{01\delta}$ Mode of Cylindrical Resonator	62
2.2.1	Resonant Frequency	66
2.2.2	"Near" Fields outside Resonator	67
2.2.3	Radiation Q-factor	68
2.3	Characteristics of Cylindrical Resonator ($TE_{01\delta}$ Mode) - Theoretical Results	73
2.3.1	Resonant Frequency and Wavenumbers	73
2.3.2	Distribution of Electric Energy	74
2.3.3	Radiation Q-factor	80
2.3.4	Field Distribution	84
2.4	Discussion on the Choice of ' ϵ_{eff} ' and its Range of Validity	92
2.5	Simple Closed Form Expressions	100
2.5.1	Resonator Height	102
2.5.2	Resonant Frequency	102
2.5.3	Radiation Q-factor	103
2.6	Sensitivity Factors	104
2.7	Higher Order Modes	111
2.8	Ring Resonator - $TE_{01\delta}$ Mode	114
2.8.1	Resonant Frequency	116
2.8.2	Radiation Q-factor	117
2.8.3	Numerical Results	118
2.9	Experimental Investigations	119
2.9.1	Experimental Set up	119
2.9.2	Experimental Results	128

2.10	Conclusions	132
	References	136
	Appendix 2.A	139
	Appendix 2.B	141
CHAPTER 3	CYLINDRICAL RESONATOR ON A DIELECTRIC SUBSTRATE BACKED BY A CONDUCTING PLANE	
3.1	Introduction	144
3.2	Effective Dielectric Constant and Resonant Frequency of Dielectric Image Resonator	147
3.3	Effective Dielectric Constant and Resonant Frequency of Resonator on a Dielectric Substrate with Conductive Backing	151
3.4	Radiation from a Dielectric Resonator placed above an Infinite Metallic Plane	153
3.5	Fields, Stored Energy, Conductor loss and Radiated Power	162
3.5.1	" Near " Fields outside the Resonator	162
3.5.2	Stored Energy	164
3.5.3	Conductor Loss	165
3.5.4	Radiated Power	167
3.5.5	Radiation Q-factor	167
3.5.6	Conductor Q-factor	168
3.6	Theoretical Results	168
3.6.1	Resonant Frequency and Radiation Q-factor	168
3.6.2	Radiated Far Fields	180
3.6.3	Effective Dielectric Constant	182
3.6.4	Conductor Q-factor	182
3.7	Experimental Results	184

3.8	Conclusions	188
	References	191
CHAPTER 4 SINGLE AND COUPLED CYLINDRICAL DIELECTRIC RESONATORS		
IN CIRCULAR WAVEGUIDE		
4.1	Introduction	193
4.2	Cylindrical Dielectric Resonator Centred in a Circular Waveguide	195
4.2.1	Determination of Resonant Frequency	195
4.2.2	Numerical Results	199
4.3	Fields Excited by Centred Resonator in a Circular Waveguide	202
4.3.1	Polarization Current Approach	204
4.3.2	Magnetic Dipole Approximation	209
4.3.3	Numerical Results	212
4.4	Fields Excited by Off-Centred Resonator	219
4.4.1	Polarization Current Approximation	219
4.4.2	Numerical Results	223
4.5	Other Resonant Quantities	226
4.5.1	Power Radiated through Waveguide Fields	226
4.5.2	Conductor Q-factor	226
4.5.3	Stored Energy	227
4.5.4	Numerical Results	227
4.6	Coupling between Axially placed Resonators in a Circular Waveguide	229
4.6.1	Distributed Magnetic Dipole Moment Approximation	231
4.6.2	Polarization Current Approach	232
4.6.3	Numerical Results	232

4.7	Resonator in a Cylindrical Cavity	236
4.7.1	Resonant Frequency	236
4.7.2	Numerical Results	238
4.8	Experimental Results	241
4.9	Conclusions	248
	References	251
	Appendix 4.A	252
CHAPTER 5	ISOLATED AND SHIELDED RECTANGULAR DIELECTRIC	
	RESONATORS	
5.1	Introduction	254
5.2	Method of Analysis	255
5.2.1	Rectangular Dielectric Waveguide	256
5.2.2	Isolated Rectangular Dielectric Resonator	262
5.2.3	Shielded Resonator	269
5.3	Theoretical Results	283
5.3.1	Isolated Rectangular Resonator	283
5.3.2	Comparison between Isolated Rectangular and Cylindrical Resonators	289
5.3.3	Shielded Rectangular Resonator	292
5.4	Experimental Results and Comparison with Theory	294
5.4.1	Isolated Resonator	294
5.4.2	Resonator on a Ground Plane	300
5.5	Conclusions	324
	References	328
CHAPTER 6	CONCLUDING SUMMARY AND SCOPE FOR FUTURE WORK	330
	References	337
	List of Publications	338
	Vitae	339