

CONTENTS

TOPICS	Page No.
List of Figures	i - xviii
List of Tables	xix - xxv
List of Abbreviations and Symbols	xxvi
Preface	xxvii - xxxiii
Chapter 1: ZnO based Varistor Ceramics-An Introduction	1
1.1. ZnO based Varistor	1
1.2. Background	2
1.3. Varistor Microstructure	3
1.4. Conduction Mechanism	6
1.5. Effect of Additives Oxides	9
1.6. Electrical Measurements	10
1.7. Selection Procedure	12
1.7.1. Overvoltage types and sources	12
1.7.2. Principle of protection and characteristic impedance	13
1.8. Evolution of Overvoltage Protection Practice	14
1.8.1. Simple spark gaps	14
1.8.2. Valve-type arresters	15
1.8.3. Surge arresters with active gaps	15
1.8.4. Metal oxide surge arresters	16
1.9. Application of ZnO Varistor	17
1.9.1. Zinc-Oxide (ZnO) Varistor as Surge Arresters for Protection of Series Compensation (SC) Stations.	17
1.9.2. Surge Arresters for Protection of High Voltage Direct Current Stations (HVDC).	19
1.9.3. Effect of Static Fault Current Limiter uses along with Zinc-Oxide (ZnO) Varistor on Distribution Power Quality.	21
1.9.4. Wide Areas of Application for Varistors.	23

Chapter 2: Literature Review: Zinc Oxide, Doping process, ZnO-Bi₂O₃ based varistor, ZnO-V₂O₅-based Varistor, Impedance spectroscopy studies.	24
2.1. Zinc Oxide (ZnO): An Overview	24
2.1.1. Crystal Structure of Zinc Oxide	25
2.1.2. Application of Zinc Oxide	26
2.2. Doping process in Zinc Oxide	26
2.2.1. Doping in Zinc Oxide: Intrinsic Defects	27
2.2.2. Doping in Zinc Oxide: Extrinsic Defects	28
2.3. Classical ZnO-Bi ₂ O ₃ based Varistor	29
2.4. ZnO-V ₂ O ₅ based Varistor Ceramics	31
2.4.1. ZnO-V ₂ O ₅ Varistor system	31
2.4.2. ZnO-V ₂ O ₅ -Cr ₂ O ₃ Varistor system	40
2.5. Impedance Spectroscopy Studies of Grain Boundary Phenomena in the Zinc Oxide based Varistors	41
Chapter 3: Aims and Objectives of Present Investigations	48
Chapter 4: Synthesis and Characterization Methods	51
4.1 Synthesis of Specimens	51
4.1.1 Materials Used	51
4.1.2 Weighing and Milling	52
4.1.3 Compaction	53
4.1.4 Sintering	53
4.1.5 Lapping and Electroding	54
4.2 Characterization Techniques	56
4.2.1 X-ray Diffraction (XRD)	56
4.2.2 Scanning Electron Microscopy (SEM) and Energy-dispersive X-ray spectroscopy (EDS)	58
4.2.3 Density	62
4.2.4 Complex plane impedance analysis	63
4.2.5 Dielectric characteristics	70
4.2.6 Electric Field-Current Density (E-J) Characteristics	70

Chapter 5: Electrical and Structural Characterization of Nb₂O₅ Doped ZnO - V₂O₅ Varistor Ceramics Sintered at Different Temperatures.	71
5.1 Synthesis and Structural Behavior of Nb ₂ O ₅ Doped ZnO -V ₂ O ₅ Varistor.	73
5.1.1 X-Ray Diffraction (XRD)	75
5.1.2 Scanning Electron Microscopy (SEM)	81
5.1.3. Energy-dispersive X-ray spectroscopy (EDS)	87
5.1.4. Percentage Theoretical Density	97
5.2 Electrical Behaviour of Nb ₂ O ₅ Doped ZnO-V ₂ O ₅ varistor.	99
5.2.1 Non-Linear Properties	99
5.2.2 Dielectric Spectroscopy	104
5.2.3. Impedance Spectroscopy	109
Chapter 6: Electrical and Structural Characterization of MnO Doped ZnO - V₂O₅ - Nb₂O₅ Varistor Ceramics Sintered at Different Temperatures.	136
6.1 Synthesis and Structural Behavior of MnO Doped ZnO - V ₂ O ₅ - Nb ₂ O ₅ Varistor ceramics.	138
6.1.1 X-Ray Diffraction (XRD)	140
6.1.2 Scanning Electron Microscopy (SEM)	147
6.1.3. Energy-Dispersive X-Ray Spectroscopy (EDS)	152
6.1.4. Percentage Theoretical Density	162
6.2 Electrical Behaviour of MnO Doped ZnO - V ₂ O ₅ - Nb ₂ O ₅ Varistor.	164
6.2.1 Non-Linear Properties	164
6.2.2 Dielectric Spectroscopy	170
6.2.3 Impedance Spectroscopy	174
Chapter 7: Electrical and Structural Characterization of ZrO₂ doped ZnO - V₂O₅ - Cr₂O₃ Varistor Ceramics Sintered at Different Temperatures.	200
7.1 Synthesis and Structural Behavior of ZrO ₂ Doped ZnO-V ₂ O ₅ -Cr ₂ O ₃ Varistor Ceramics.	201
7.1.1 X-Ray Diffraction (XRD)	203
7.1.2 Scanning Electron Microscopy (SEM)	210

7.1.3	Energy-Dispersive X-Ray Spectroscopy (EDS)	216
7.1.4	Percentage Theoretical Density	225
7.2	Electrical Behaviour of ZrO_2 Doped $\text{ZnO-V}_2\text{O}_5\text{-Cr}_2\text{O}_3$ Varistor	226
7.2.1	Non-Linear Properties	226
7.2.2	Dielectric Spectroscopy	233
7.2.3	Impedance Spectroscopy	237
Chapter 8: Conclusions and Scope for Future Work		262
8.1	Conclusions	262
8.2	Scope for Future Work	265
References		266
Outcomes of the Present Thesis		278
(a)	List of Publications in International Journals	278
(b)	List of Research Papers in International and National Conferences	278