
Contents

Preface	vii
Introduction	xi
Chapter 1. Transformation Optics Concept: Definition and Tools	1
1.1. State of the art on metamaterials.	1
1.2. Transformation optics	11
1.2.1. Coordinate transformation.	15
1.2.2. Space transformation	23
1.3. Metamaterial engineering	31
1.3.1. Electric resonators	32
1.3.2. Magnetic resonators	32
1.3.3. All-dielectric material	33
1.4. Conclusion	33
Chapter 2. Coordinate Transformation Concept: Transformation of Electromagnetic Sources	35
2.1. Introduction	35
2.2. Isotropic antenna: transforming directive into isotropic pattern	36
2.2.1. Theoretical formulations and numerical simulations.	36
2.2.2. 3D design and implementation using metamaterials.	41

2.2.3. Experimental validation of fabricated isotropic antenna	45
2.3. Miniaturization of electromagnetic sources	47
2.3.1. Theoretical formulations	49
2.3.2. Numerical simulations	54
2.4. Creation of multiple beams	58
2.4.1. Theoretical formulations	59
2.4.2. Numerical validation	62
2.5. Conclusion	64
Chapter 3. Space Transformation Concept: Controlling the Path of Electromagnetic Waves	65
3.1. Introduction	65
3.2. In-phase emission restoring lens	66
3.2.1. Theoretical formulations and numerical simulations	67
3.2.2. 3D design, implementation and full-wave simulations	71
3.2.3. Experimental validation of fabricated in-phase emission restoring lens	76
3.3. Beam steering lens	77
3.3.1. Theoretical formulations and numerical simulations	77
3.3.2. 3D design, implementation and full-wave simulations	81
3.3.3. Experimental validation of fabricated beam steering lens	83
3.4. Conclusion	84
Conclusion	85
Bibliography	89
Index	101