



List of Figures

1.1	Classification of Some Electroheat Processes in Industry	3
2.1	3 Phase PWM Inverter Circuit for IDH	12
2.2	Eight Inverter Voltage Vectors	13
2.3	Locus of Maximum Linear Control Voltage in Sine PWM and SVPWM . .	14
2.4	The Relationship of abc and Stationary dq Reference Frame	17
2.5	Transitions Between Different Switching States	18
2.6	Optimal Vector Commutation for Sector I	19
2.7	Voltage Space Vector and its Components in (d,q)	23
2.8	Reference Vector as a Combination of Adjacent Vectors at Sector I . . .	25
2.9	Optimal Switching Sequences for Sector I & II	27
2.10	Optimal Switching Sequences for Sector III & IV	28
2.11	Optimal Switching Sequences for Sector V & VI	29
2.12	SVM Generator	31
2.13	Simulation of Inverter Output Line to Line Voltages ($V_{iAB}, V_{iBC}, V_{iCA}$) . .	32
2.14	Simulation Results of Inverter Output Currents (i_{iA}, i_{iB}, i_{iC})	33
2.15	Simulation Results of Load Line to Line Voltages ($V_{LAB}, V_{LBC}, V_{LCA}$) . .	34
2.16	Simulation Results of Load Phase Currents (i_{LA}, i_{LB}, i_{LC})	35
2.17	Simulation Waveforms. (a) Inverter Output Line to Line Voltage (V_{iAB}) (b) Inverter Output Current (i_{iA}) (c) Load Line to Line Voltage (V_{LAB}) (d) Load Phase Current (i_{LA})	36
3.1	Attenuation Constant for Stainless Steel	64
3.2	Phase Constant for Stainless Steel	64
3.3	Propagation Constant for Stainless Steel	65
3.4	Skin Depth for Stainless Steel	65

3.5	Velocity of Propagation for Stainless Steel	66
3.6	Intrinsic Impedance for Stainless Steel	66
3.7	Reactive Component With Intrinsic Impedance for Stainless Steel	67
3.8	Loss Tangent for Stainless Steel	67
3.9	Electric Field Intensity for Stainless Steel	68
3.10	Magnetic Field Intensity for Stainless Steel	68
3.11	Power Density for Stainless Steel	69
3.12	Attenuation Constant for Lemon / Orange	70
3.13	Phase Constant for Lemon / Orange	70
3.14	Propagation Constant for Lemon / Orange	71
3.15	Skin Depth for Lemon / Orange	71
3.16	Velocity of Propagation for Lemon / Orange	72
3.17	Intrinsic Impedance for Lemon / Orange	72
3.18	Reactive Component With Intrinsic Impedance for Lemon / Orange	73
3.19	Loss Tangent for Lemon / Orange	74
3.20	Electric Field Intensity for Lemon / Orange	75
3.21	Magnetic Field Intensity for Lemon / Orange	75
3.22	Power Density for Lemon / Orange	76
3.23	Mesh Analysis for Lemon	76
3.24	Temperature Analysis Using FEM	77
3.25	Skin Depth Analysis Using FEM	78
3.26	Temperature and Skin Depth Analysis With Density Using FEM for Lemon	79
3.27	Displacement Current for Lemon Using FEM at 10 MHz	79
3.28	Displacement Current for Lemon Using FEM at 1KHz	80
3.29	Magnetic Field Density for Lemon Using FEM at 10MHZ	80
3.30	Magnetic Field Density for Lemon Using FEM at 1KHz	80
3.31	Magnetic Field Intensity for Lemon Using FEM at 10MHz	81
3.32	Magnetic Field Intensity for Lemon Using FEM at 1KHz	81
4.1	The Equivalent Circuit of Induction Coil and Work-piece	84
4.2	Practical Representations of IDH Coil	85
4.3	Equivalent Electric Circuit Model of IDH Coil	86
4.4	Structure of The IDH	88

4.5 Three Phase Inverter for IDH	90
4.6 The Region of the Three Phase Inverter Parameters Q and β_s Determine the Starting Process	96
4.7 Circuit of Proposed IDH Equivalent	97
4.8 Simplified Circuit	97
4.9 Power Factor	100
4.10 R Phase Supply Voltage Waveform	101
4.11 Y Phase Supply Voltage Waveform	101
4.12 B Phase Supply Voltage Waveform	101
4.13 Waveform of Primary Output Voltage for V_{ab}	102
4.14 Waveform of Primary Output Voltage for V_{bc}	102
4.15 Waveform of Primary Output Voltage for V_{ca}	102
4.16 Secondary Side Output Voltage V_r	103
4.17 Secondary Side Output Voltage V_y	103
4.18 Secondary Side Output Voltage V_b	103
4.19 Induction Coil Current I_1	104
4.20 Induction Coil Current I_2	104
4.21 Induction Coil Current I_3	104
4.22 FFT of Output Voltage for V_{ab}	105
4.23 FFT of Output Voltage for V_{bc}	105
4.24 FFT of Output Voltage for V_{ca}	106
5.1 The Experimental System of IDH System Control	109
5.2 High Frequency Transformer	110
5.3 Three Phase Induction Coils	111
5.4 Hardware Structure of IDH System Control	112
5.5 Three Phase MOSFET Base Inverter	114
5.6 Encoder 1	117
5.7 Encoder 2	118
5.8 Encoder 3	118
5.9 Gate Pulse for S_1 Using Main Control Unit	119
5.10 Gate Pulse for S_3 Using Main Control Unit	119
5.11 Gate Pulse for S_5 Using Main Control Unit	120

5.12 Gate Pulse for S_4 Using Main Control Unit	120
5.13 Gate Pulse for S_6 Using Main Control Unit	121
5.14 Gate Pulse for S_2 Using Main Control Unit	121
5.15 High Frequency Transformer Input Voltage Waveform (V_{iRY})	122
5.16 High Frequency Transformer Input Voltage Waveform (V_{iYB})	122
5.17 High Frequency Transformer Input Voltage Waveform (V_{iBR})	123
5.18 High Frequency Transformer Output Voltage Waveform (V_{oRY})	123
5.19 High Frequency Transformer Output Voltage Waveform (V_{oYB})	124
5.20 High Frequency Transformer Output Voltage Waveform (V_{oBR})	124
5.21 FFT of Three Phase Inverter Output Voltage Waveform (V_{iRY})	125
5.22 FFT of Three Phase Inverter Output Voltage Waveform (V_{iYB})	125
5.23 FFT of Three Phase Inverter Output Voltage Waveform (V_{iBR})	126
5.24 FFT of Three Phase IDH (V_{oRY})	126
5.25 FFT of Three Phase IDH (V_{oYB})	127
5.26 FFT of Three Phase IDH (V_{oBR})	127
5.27 High Frequency Generator Unit	128
5.28 Gate Pulse for S_1 Using High Frequency Generator Unit	128
5.29 Gate Pulse for S_3 Using High Frequency Generator Unit	129
5.30 Gate Pulse for S_5 Using High Frequency Generator Unit	129
5.31 Gate Pulse for S_4 Using High Frequency Generator Unit	130
5.32 Gate Pulse for S_6 Using High Frequency Generator Unit	130
5.33 Gate Pulse for S_2 Using High Frequency Generator Unit	131
5.34 High Frequency Transformer Input Voltage Waveform (V_{iRY})	131
5.35 High Frequency Transformer Input Voltage Waveform (V_{iYB})	132
5.36 High Frequency Transformer Input Voltage Waveform (V_{iBR})	132
5.37 FFT of Three Phase Inverter Output Voltage Waveform (V_{iRY})	133
5.38 FFT of Three Phase Inverter Output Voltage Waveform (V_{iYB})	133
5.39 FFT of Three Phase Inverter Output Voltage Waveform (V_{iBR})	134
5.40 Sample Result 1	135
5.41 Sample Result 2	136