List of Figures

Figure No.	Caption of Figures	Page No.
Figure 1.1:	(a) SISO system, (b) SIMO system, (c) MISO system, and (d) MIMO system	5
Figure 1.2:	Schematic and front view of the PIFA	7
Figure 1.3:	(a) Electric field distribution along patch resonant length and (b) Quarter wave patch, shorted at one end	11
Figure 1.4:	Planar monopole antenna inside portable devices	13
Figure 1.5:	(a) Quarter wave monopole antenna and (b) Equivalent half wave dipole antenna	13
Figure 1.6:	Different DGS geometries: (a) Dumbbell-shaped, (b) Spiral-shaped, (c) H-shaped, (d) U-shaped, (e) Arrow head dumbbell, (f) Concentric ring shaped, (g) Split ring resonators, (h) Meander line, (i) Cross-shaped, (j) Circular head dumbbell, (k) Square heads connected with U-slots, (l) Open loop dumbbell, (m) Fractal, (n) Half-circle, and (o) V-shaped	17
Figure 1.7:	Neutralization line between multi antenna systems	18
Figure 1.8:	EBG structure between MIMO antenna elements	19
Figure 1.9:	Loading of dielectric wall between MIMO antenna for isolation	19
Figure 1.10:	External feed network for isolation improvement (a) Decoupling network, and (b) Branchline decoupling feed network	20
Figure 2.1:	A typical Rayleigh fading envelope	42
Figure 2.2:	Spherical coordinates in mobile radio environments	43
Figure 2.3:	Incident radio wave arriving at the receiving antenna in multipath environment	47
Figure 2.4:	Gaussian distribution model of incident waves	74

Figure 2.5:	Probability for different number of branches of an M - port antenna system and diversity gain definition for M	F1
	= 2	51
Figure 2.6:	The illustration of SPLSR	56
Figure 2.7:	Total power radiated from antenna	57
Figure 3.1:	Proposed antenna (a) without folded shorting strip, and (b) with folded shorting strip	61
Figure 3.2:	(a) 3-D view of single antenna element, (b) Unfolded planar structure of single antenna element, and (c) Optimized dimensions of (b) in mm	61
Figure 3.3:	(a) Effect of different configurations on reflection coefficient, and (b) Effect of folded shorting strip on S-parameters	63
Figure 3.4:	Variation of S-parameters with (a) slot length (l_s) , (b) slot width (w_s) , (c) side arm length (l_a) , and (d) folded shorting strip length (l)	65
Figure 3.5:	(a) Prototype of proposed antenna (size compared with Samsung Galaxy S GT I9000), and (b) Simulated and measured <i>S</i> -parameters of proposed structure	66
Figure 3.6:	Far field radiation patterns (a) Simulated 3D at 2.45 GHz and 5.5 GHz, and (b) Measured 2D at 2.45 GHz and 5.5 GHz.	67
Figure 3.7:	Variation of measured peak realized gain and calculated total antenna efficiency	69
Figure 3.8:	(a) Surface current distribution at 2.45 GHz, (b) Surface current distribution at 5.5 GHz, (c) Vector surface current flow on folded shorting strip at 2.45 GHz, and (d) Vector surface current flow on folded shorting strip at 5.5 GHz.	69
Figure 3.9:	Variation of ECC with frequency	70
Figure 3.10:	Configuration of mobile environment with MIMO antenna	73

Figure 3.11: Effect of mobile environment on S-parameters of 73

MIMO antenna.....

Figure 3.12:	Distribution of energy over human head phantom, (a) Average SAR over 1g and (b) Average SAR over 10g	75
Figure 4.1:	(a) Antenna configuration with zoomed structure of single antenna element and fabricated antenna, (b) Unfolded planar structure of single antenna element, and (c) Optimized dimensions of (b) (unit in mm)	80
Figure 4.2:	Effect of different configurations on reflection coefficient	81
Figure 4.3:	Effect of slot length (S_l) on S-parameters	83
Figure 4.4:	Effect of slot width (S_w) on <i>S</i> -parameters	83
Figure 4.5:	Effect of length of the side arm 1 (L_{s1}) on S-parameters	84
Figure 4.6:	Effect of width of the side arms (W_{s1}) on S-parameters	84
Figure 4.7:	Simulated and measured results of <i>S</i> -parameters in Free Space	84
Figure 4.8:	Configuration of the mobile phone with user proximity	86
Figure 4.9:	Variation of S-parameters without folded shorting strip in different environment, (a) S_{11} and (b) S_{21}	86
Figure 4.10:	Variation of S-parameters of the proposed antenna in different environment	87
Figure 4.11:	Surface current distribution (with and without folded shorting strip) when Ant. 1 is excited while Ant. 2 is matched terminated with 50Ω load	88
Figure 4.12:	(a) Simulated 3D far field radiation patterns at different resonance frequencies and (b) Measured 2D far field radiation patterns at different resonance frequencies	90
Figure 4.13:	(a) Variation of measured peak realized gain and (b) Total antenna efficiency with frequency	91
Figure 4.14:	Variation of ECC and EDG with frequency	92
Figure 4.15:	SAR simulation setup according to CTIA	94
Figure 4.16:	Distribution of energy over human tissue, (a) Average SAR over 1g and (b) Average SAR over 10g	94

Figure 5.1:	Configuration of proposed antenna with fabricated prototype	102
Figure 5.2:	(a) 3-D view of the single antenna element, (b) Detailed dimension of proposed patch unfolded into a planar structure, and (c) Detailed dimension of added resonating arm.	102
Figure 5.3:	Evolution of antenna element and respective reflection coefficient.	103
Figure 5.4:	Surface current distribution on the antenna at 5.25 GHz.	103
Figure 5.5:	Variation of S-parameters with slot shape parameters, (a) x_1 , (b) y_1 , and (c) W_s	105
Figure 5.6:	Variation of <i>S</i> -parameters with antenna shape parameters, (a) G_a , (b) L_a , and (c) W_{a1}	106
Figure 5.7:	Variation of S-parameters with antenna shape parameters, (a) W_{a2} and (b) W_{sh}	107
Figure 5.8:	S-parameters of the proposed MIMO antenna	108
Figure 5.9:	(a) Simulated 3D far field radiation patterns for the MIMO antenna at 1.575 GHz, 2.62 GHz, 3.35 GHz, and 5.25 GHz and (b) Measured 2D far field radiation patterns at 1.575 GHz, 2.62 GHz, 3.35 GHz, and 5.25 GHz.	110
Figure 5.10:	Variation of measured peak realized gain and total efficiency with frequency	111
Figure 5.11:	Variation of ECC and EDG with frequency	111
Figure 5.12:	Mobile phone configuration with antenna elements	114
Figure 5.13:	Model of antenna elements locations of (a) SAM Head and PDA Hand (Talk mode), (b) PDA Hand (Data mode), and (c) Dual Hand (Read mode)	115
Figure 5.14:	Variation of S-parameters in mobile environment	116
Figure 5.15:	Variation of S-parameters of PIFA in the presence of user proximity (a) Talk mode, (b) Data mode, and (c) Read mode	117
Figure 5.16:	(a) Total efficiency, (b) ECC, and (c) multiplexing Efficiency of the SAM Head and PDA Hand (Talk	

	mode) for PIFA	119
Figure 5.17:	(a) Total efficiency, (b) ECC, and (c) Multiplexing efficiency of the PDA Hand (Data mode) for PIFA	121
Figure 5.18:	(a) Total efficiency, (b) ECC, and (c) Multiplexing efficiency of the Dual Hand (Read mode) for PIFA	121
Figure 5.19:	Variation of power loss in user proximity at different frequencies for PIFA, (a) 1.575 GHz, (b) 2.62 GHz, (c) 3.35 GHz, and (d) 5.25 GHz	124
Figure 5.20:	SAR simulation setup according to CTIA	125
Figure 6.1:	(a) Front and rear view of the proposed antenna, (b) Detail dimensions of the single antenna element, and (c) Fabricated prototype	133
Figure 6.2:	(a) Effect of different configurations on reflection coefficient, (b) Surface current distribution for different cases	135
Figure 6.3:	Variation of reflection coefficient with various shape parameters (a) l_2 (b) w_1 , and (c) w_2	137
Figure 6.4:	Variation of reflection coefficient with various shape parameters (a) w_3 and (b) l_2	138
Figure 6.5:	Effect of protruded ground plane on S-parameters	139
Figure 6.6:	Simulated and measured <i>S</i> -parameters of the proposed planar monopole MIMO antenna	140
Figure 6.7:	(a) Simulated 3D and (b) Measured 2D far field radiation patterns at 0.777GHz, 1.9GHz, and 2.5GHz.	141
Figure 6.8:	Variation of calculated total efficiency and measured peak realized gain with frequency	142
Figure 6.9:	(a) Actual mobile environment with antenna elements and (b) Effect of mobile environment on <i>S</i> -parameters	146
Figure 6.10:	Model of antenna elements locations of (a) SAM Head and PDA Hand (Talk mode), (b) PDA Hand (Data mode), and (c) Dual Hand (Read mode)	146
Figure 6.11:	Variation of <i>S</i> -parameters of PMA in the user proximity (a) Talk mode, (b) Data mode, and (c) Read mode	148

Figure 6.12:	(a) Total efficiency, (b) ECC, and (c) Multiplexing efficiency, of the SAM Head and PDA Hand (Talk mode) for PMA	149
Figure 6.13:	(a) Total efficiency, (b) ECC, and (c) Multiplexing efficiency, of the PDA Hand (Data mode) for PMA	151
Figure 6.14:	(a) Total efficiency, (b) ECC, and (c) Multiplexing efficiency, of the Dual Hand (Read mode) for PMA	152
Figure 6.15:	Variation of power loss in user proximity at different frequencies of PMA (a) 0.777 GHz, (b) 1.9 GHz, (c) 2.1 GHz, and (d) 2.5 GHz	154