

## LIST OF FIGURES

Figure 1. 1 Massive MIMO system.....	2
Figure 2. 1 The number of connected gadget prediction in year. ....	7
Figure 2. 2 5G Channel Widths.....	8
Figure 2. 3 Block diagram of MIMO Antenna performance. ....	8
Figure 2. 4 Microstrip antenna front view. ....	10
Figure 2. 5 Microstrip antenna side view.....	11
Figure 2. 6 The shape of patch of microstrip antenna.....	11
Figure 2. 7 Rectangular patch with truncated corner. ....	12
Figure 2. 8 Circular patch with X slot.....	13
Figure 2. 9 Circularly polarized microstrip antenna. ....	15
Figure 2. 10 Single feed arrangement for circular polarization (a) LHCP (b) RHCP. .....	21
Figure 3. 1 Flowchart of the research. ....	19
Figure 3. 2 Single feed arrangement for circular polarization (a) LHCP, (b) RHCP. .....	21
Figure 3. 3 MIMO antenna configurations. ....	26
Figure 3. 4 Simulation of Single Rectangular Antenna. ....	27
Figure 3. 5 S-parameter of Single Rectangular Antenna optimization. ....	28
Figure 3. 6 Gain value of Single Rectangular Antenna. ....	28
Figure 3. 7 Angular width of Single Rectangular Antenna.....	29
Figure 3. 8 Simulation of Vertical 2 MIMO Rectangular Antenna Elements. ....	30
Figure 3. 9 S-parameter of Vertical 2 MIMO Rectangular Antenna Elements. ...	30
Figure 3. 10 Gain value of Vertical 2 MIMO Rectangular Antenna Elements....	31
Figure 3. 11 Angular width of Vertical 2 MIMO Rectangular Antenna Elements. .....	31
Figure 3. 12 Simulation of Horizontal 2 MIMO Rectangular Antenna Elements. 32	32
Figure 3. 13 S-parameter of Horizontal 2 MIMO Rectangular Antenna Elements. .....	32
Figure 3. 14 Gain value of Horizontal 2 MIMO Rectangular Antenna Elements. 33	33
Figure 3. 15 Angular width of Horizontal 2 MIMO Rectangular Antenna Elements. .....	34

Figure 3. 16 Simulation of 4 MIMO Rectangular Antenna Elements. ....	35
Figure 3. 17 S-parameter of 4 MIMO Rectangular Antenna Elements. ....	35
Figure 3. 18 Gain value of 4 MIMO Rectangular Antenna Elements. ....	36
Figure 3. 19 Angular width of 4 MIMO Rectangular Antenna Elements.....	36
Figure 3. 20 Simulation of 16 MIMO Rectangular Antenna Elements. ....	37
Figure 3. 21 S-parameter of 16 MIMO Rectangular Antenna Elements. ....	37
Figure 3. 22 Gain value of 16 MIMO Rectangular Antenna Elements. ....	38
Figure 3. 23 Angular width of 16 MIMO Rectangular Antenna Elements.....	39
Figure 3. 24 Simulation of 64 MIMO Rectangular Antenna Elements. ....	40
Figure 3. 25 S-parameter of 64 MIMO Rectangular Antenna Elements. ....	40
Figure 3. 26 Gain value of 64 MIMO Rectangular Antenna Elements. ....	41
Figure 3. 27 Angular width of 64 MIMO Rectangular Antenna Elements.....	41
Figure 3. 28 Simulation of Single Circular antenna.....	42
Figure 3. 29 S-parameter of Single Circular Antenna.....	43
Figure 3. 30 Gain value of Single Circular Antenna.....	43
Figure 3. 31 Angular width of Single Circular Antenna.....	44
Figure 3. 32 Simulation of Vertical 2 MIMO Circular antenna Elements.....	45
Figure 3. 33 S-parameter of Vertical 2 MIMO Circular Antenna Elements.....	45
Figure 3. 34 Gain value of Vertical 2 MIMO Circular Antenna Elements.....	46
Figure 3. 35 Angular width of Vertical 2 MIMO Circular Antenna Elements....	46
Figure 3. 36 Simulation of Horizontal 2 MIMO Circular Antenna Elements. ....	47
Figure 3. 37 S-parameter of Horizontal 2 MIMO Circular Antenna Elements. ...	47
Figure 3. 38 Gain value of Horizontal 2 MIMO Circular Antenna Elements.....	48
Figure 3. 39 Angular width of Horizontal 2 MIMO Circular Antenna Elements.	49
Figure 3. 40 Simulation of 4 MIMO Circular Antenna Elements. ....	50
Figure 3. 41 S-parameter of 4 MIMO Circular Antenna Elements.....	50
Figure 3. 42 Gain value of 4 MIMO Circular Antenna Elements.....	51
Figure 3. 43 Angular width of 4 MIMO Circular Antenna Elements.....	51
Figure 3. 44 Simulation of 16 MIMO Circular Antenna Elements. ....	52
Figure 3. 45 S-parameter of 16 MIMO Circular Antenna Elements.....	52
Figure 3. 46 Gain value of 16 MIMO Circular Antenna Elements.....	53
Figure 3. 47 Angular width of 16 MIMO Circular Antenna Elements.....	54

Figure 3. 48 Simulation of 64 MIMO Circular Antenna Elements. ....	55
Figure 3. 49 S-parameter of 64 MIMO Circular Antenna Elements.....	55
Figure 3. 50 Gain value of 64 MIMO Circular Antenna Elements.....	56
Figure 3. 51 Angular width of 64 MIMO Circular Antenna Elements.....	56
Figure 3. 52 Gain value increment of Rectangular Truncated Corner Antenna. ..	59
Figure 3. 53 Gain value increment of Circular Slotted X Antenna.....	59
Figure 3. 54 Angular width decrement of Rectangular Truncated Corner Antenna.	
.....	60
Figure 3. 55 Angular width decrement of Circular Slotted X Antenna. ....	60
Figure 4. 1 Gain value increment of rectangular antenna. ....	63
Figure 4. 2 Gain value increment of circular antenna.....	64
Figure 4. 3 Angular width decrement of rectangular antenna.....	68
Figure 4. 4 Angular width decrement of circular antenna. ....	68