EIGHT-ELEMENT MIMO ANTENNA FOR 5G SMARTPHONE APPLICATIONS

S.Alamelu alias Rajasree [1], V.Banu Harinithaa [2], K.Bharat [3], T.Balaji [4]

[1].*Assistant professor, Electronics and communication, Sri Ramakrishna Engineering College, TamilNadu, India*

[2]*Student, Electronics and communication, Sri Ramakrishna Engineering College, Tamil Nadu, India*

[3]*Student, Electronics and communication, Sri Ramakrishna Engineering College, Tamil Nadu, India*

[4]*Student, Electronics and communication, Sri Ramakrishna Engineering College, Tamil Nadu, India*

ABSTRACT

This paper aims to implement an Eight Element MIMO antenna design for 5G smartphone applications with S11<-10 dB, better bandwidth, high gain, good isolation, full radiation coverage, and good radiation efficiency. The Envelope Correlation Coefficient (ECC) and Diversity Gain (DG) are calculated to analyze the MIMO antenna characteristics. The antenna design on an FR4 dielectric whose permittivity and loss tangent are 4.4 and 0.025 respectively. It is operating at the frequency range of 2 to 9 GHz.

Keywords — *permittivity, radiation coverage, Diversity Gain, Envelope Correlation Coefficient.*

1. INTRODUCTION

The antenna is our electronic eyes and ears of the world. They are our links with space. With the rapid growth of the wireless communication system, future technologies need an antenna with concluded best application. Antenna plays a vital role in the field of wireless application. MIMO-UWB antennas as 8*8 performance and benefits, such as low weight, low profile, and low cost, making them the ideal choice for communication systems engineers. The performance and advantages of UWB antennas such as low weight, low profile, and low cost made them the perfect choice for communication systems engineers. They can integrate with microwave circuits and therefore they are very well suited for applications such as cell devices, WLAN applications, and navigation systems. Substrates are designed, and the results are compared to slot antennas that arise from inset feed with edge feed design and analysis, to determine which design technique is the best for obtaining good bandwidth and return loss. The feed is designed to work at the maximum GHz range, and the approximation coupled antenna is constructed with the position of the feed to find out various field intensities such as electrical and magnetic field intensity, polarization, passivity, and polar plots obtained using then the respective return losses and the bandwidth range.

2. LITERATURE SURVEY

In the present work, we have designed a USB - MIMO antenna for band applications. In the literature survey, some of the researchers have reported the rectangular, circular, triangular, and ring micro-strip antennas. But in these designs, the gain is limited, and return loss is not up to the mark. The below review gives a clear picture of problems that need to be solved, actual planning, and conducted study.

2.1 Multi-Band MIMO Antenna Design with User-Impact Investigation for 4G and 5G Mobile Terminals.

Naser Ojaroudi Parchin (2019) proposed a design of a multi-band slot antenna array applicable-for fourth-generation (4G) and fifth-generation (5G) smartphones. The design is composed of double-element square-ring slot radiators fed by micro-strip-line structures for easy integration with radio frequency (RF)/Microwave circuitry. The slot radiators are located on the corners of the smartphone printed circuit board with an overall

dimension of 75× 150 mm2. The proposed multiple-input multiple-output antenna is designed to meet the requirements of 4G and 5G mobile terminals with essential bandwidth for higher data rate applications.

2.2 Using a split-ring resonator, a dual-polarized UWB–MIMO antenna with ac band-notched characteristics.

Irene (2018) proposed a design of the dual-polarised hybrid eight-antenna array working with-inside the 2.6-GHz band for 5G verbal exchange multi-enter multi-output (MIMO) operation with-inside the cellphone is presented. The proposed hybrid antenna array factors are symmetrically positioned alongside the lengthy edges of the cellphone, and they're composed of distinctive four-antenna array sorts that showcase orthogonal polarisation. A prototype of the proposed eight-antenna array is synthetic and measured. Envelope correlation coefficient and channel capability also are calculated to assess the MIMO performances of the proposed antenna array.

2.3 Polarisation- orthogonal co- frequency dual antenna pair suitable for 5G MIMO smartphone with metallic bezels.

Le Chang (2019) proposed the idea of UWB as a short-range, wireless communication protocol that like Bluetooth or Wi-Fi – uses radio waves. But it differs substantially in that it operates at a very high frequency. As its name denotes, it also uses a wide spectrum of several GHz. One way to think of it is as a radar that can continuously scan an entire room and precisely lock onto an object like a laser beam to discover its location and communicate data.

2.4 Ultra-wide-band 8-port MIMO antenna array for 5G metal-frame smartphones.

Zhang (2019) proposed the idea of polarisation-orthogonal co-frequency dual antenna pair suitable for a fifth-generation (5G) multiple-input multiple-output (MIMO) smartphone with metallic bezels. The proposed spatial-reuse dual antenna pair consists of a split on the metallic bezel and a slot on the mainboard ground, where the slot is centred on the split. Two orthogonal degenerate characteristic modes operating at half wavelength including in-phase current and slot modes can be excited on the same antenna structure.

2.5.A switchable 3-D-coverage-phased array antenna package for 5G mobile terminals.

Naser Ojaroudiparchin (2020) proposed an idea of a new design of a millimetre-wave (mm-Wave) array antenna package with beam steering characteristics for the fifth generation (5G) mobile applications. To achieve a broad 3D scanning coverage of the space with high-gain beams, three identical sub-arrays of patch antennas have been compactly arranged along the edge region of the mobile phone PCB to form the antenna package.

3. PROPOSED WORK

The above-mentioned papers reveal the design of an Ultra-Wide-band 8*8 MIMO antenna. Considering the quality of the antenna and to improve the efficiency by making optimum return loss, the proposed design has been exhibited to define the process as acceptable and compact antennas Ultra-Wide-band patch antennas for our required applications.

4. METHODOLOGY

This project aims to optimize and analyze off UWB antenna with slot gaps to improve the bandwidth of the antenna. During the designing process of the Antenna, will try to increase the bandwidth of the Antenna as much as possible using mathematical analysis and ADS Software, and using different design and feeding techniques to enhance the bandwidth of the antenna such as proximity coupled feed, edge feed antenna, insert feed antenna, then compare the return loss bandwidth and the performance for each design. The proposed method has advantages like the antenna being easy to integrate with MICs and MMICs. They are robust when mounted on rigid surfaces of devices. Feed-line and matching networks can be simultaneous with the antenna structure.

Parameter	Ws	Ls	Hs	Wf	Lf	D
Values (mm)	34	34	1.6	6	3.2	7.5
Parameter	hs	W	L	W1	L1	R
Values (mm)	1.6	1	11	1.5	1.5	11.5
Parameter	r1	r2	r3	Wsub	Lsub	Hsub
Values (mm)	8.5	8	14	75	150	1.6

Table 1. PARAMETER VALUES OF SINGLE ELEMENT MIMO ANTENNA

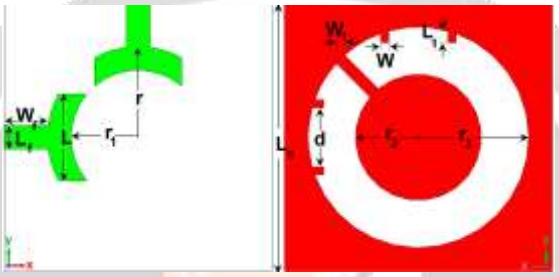

Fig 4.1 TOP AND BOTTOM LAYER OF – SINGLE ELEMENT MIMO ANTENNA

4.1 Design MIMO Antenna

Substrate: The substrate properties such as its dielectric constant, and loss tangent have a good effect on the antenna characteristics. This paper is a detailed study of the effect of various substrate materials on antenna properties. The MIMO antenna is analysed for different substrates using the software ADS.

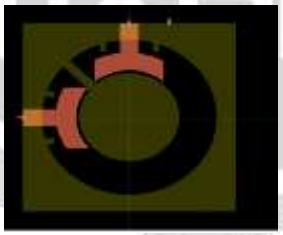

Fig 4.2 SUBSTRATE

Patch: A patch antenna is a type of antenna with a low profile, which can be mounted on a surface. It consists of a planar circular "patch" of metal, mounted over a larger sheet of metal called a ground plane.

Ground: A ground plane is a flat or nearly flat horizontal conducting surface that serves as part of an antenna, to reflect the radio waves from the other antenna elements.

To validate the capability of a UWB - MIMO antenna design,

1. Envelope Correlation Coefficient (ECC)
2. Diversity Gain (DG)

are the two important parameters to be investigated.

ECC= |SmmSmn + SnmSnn|2 /(1-|Smm|-|Smn|2)(1 — |Snm|2 – |Snn|2)*

DG = 10√1- (ECC)2 = 10√1- (0.04)2 = 9.9919968 dB

5. SOFTWARE DESCRIPTION

The ADS Main Window enables you to create and manage ADS workspaces. A workspace is an organizer where you can group everything about a design such as libraries, technology, schematic, layout, simulation data, and Momentum data. The entire ADS user interface and simulation operate within a currently opened workspace. The File View page of the Main window allows you to traverse your existing workspaces. To open any of these workspaces, select and right-click on the workspace and choose Open Workspace or double-click on the selected workspace.

6. NEED FOR ANTENNA

As a signal in free space propagates in the form of an electromagnetic wave, it requires transmitting and receiving ends. So, an antenna allows the propagation of electromagnetic waves from one end to another, in the form of EMW without the need for a wiring system. It acts as a transducer that converts an RF signal into an EM wave at the transmitter and an EM wave back to an electrical signal at the receiver. Antennas do so by producing electric and magnetic fields from the applied signal and combining the two fields to form an electromagnetic wave. As the two fields show perpendicularity to each other.

7. 5G COMMUNICATION FOR MOBILE COMMUNICATION

It offers a faster pace, less latency, and extra capability than 4G LTE networks. It is one of the fastest, maximum strong technology the sector has ever seen. That approach has faster downloads, lots of decreased lag, and has a big effect on how we live, paint, and play. 5G pace and different connectivity blessings are predicted to make groups greater green and deliver customers get right of entry to greater data quicker than ever before. Connected cars, clever stadiums, and superior gaming—all of them will all rely on.

8. RESULTS AND DISCUSSIONS

For the desired range of solution and sweep frequency based on our application defined, the resulting output obtained is as follows :

1. Return loss
2. Gain plot
3. ECC

All these values have been obtained for our proposed models to define and conclude the best alternative output as a suitable desired antenna type.

9. SOFTWARE IMPLEMENTATION OUTPUT

DESIGN OF SINGLE ELEMENT MIMO ANTENNA AND ITS SIMULATED OUTPUT :

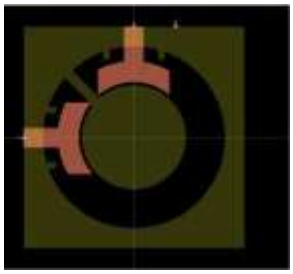

Fig 9.1 DESIGN OF SINGLE ELEMENT MIMO ANTENNA

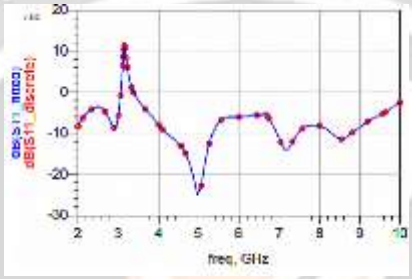

Fig 9.2 SIMULATED RETURN LOSS OF SINGLE ELEMENT MIMO ANTENNA

DESIGN OF EIGHT-ELEMENT MIMO ANTENNA AND ITS SIMULATED OUTPUT:

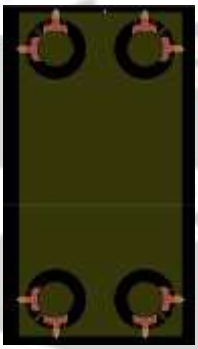

Fig 9.3 DESIGN OF EIGHT ELEMENT MIMO ANTENNA

Figure 9.3 show the top and bottom layers of the prototype. The MIMO smartphone antenna is implemented on a cheap FR4 substrate. 50-Ohm loads are employed for the elements, not under measurement to measure the characteristics of the MIMO system and eliminate the other elements' mutual effects.

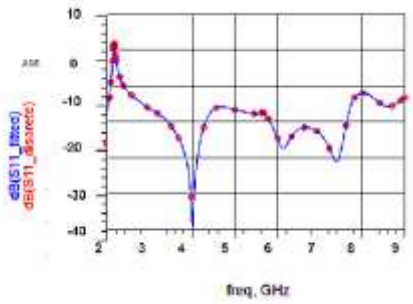

Fig 9.4 SIMULATED RETURN LOSS OF EIGHT ELEMENT MIMO ANTENNA

Figure 9.4 illustrates the return loss from the measured and simulated results of the proposed UWB-MIMO smartphone antenna. It is shown that the MIMO antenna design offers a return loss below -10db.

Fig 9.5 SIMULATED 3D GAIN PLOT OF EIGHT ELEMENT MIMO ANTENNA

Envelope Correlation Coefficient tells us how independent, antenna radiation patterns are.

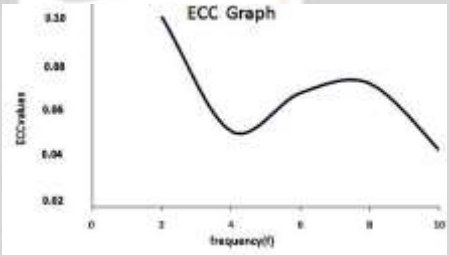

Fig 9.6 ENVELOPE CORRELATION COEFFICIENT (ECC)

10. CONCLUSION

Comparing the result that gets from the insert feed with edge feed design and analysis, and decide which design technique is the best, which obtains good bandwidth and return loss. The project will use the best possible matching techniques in such a way so that there will be a minimum return loss. Design proximity coupled feed UWB MIMO antenna and observe how this design improves the bandwidth.

11. REFERENCES

1. Chang, L.; Yu, Y.; Wei, K.; Wang, H. Polarization- orthogonal co- frequency dual antenna pair suitable for 5G MIMO smartphone with metallic bezels. IEEE Trans. Antennas Propag. **2019**, 67, 5212–5220.

2. Ojaroudiparchin, N.; Shen, M.; Zhang, S.; Pedersen, G.F. A switchable 3D-coverage phased array antenna package for 5G mobile terminals. IEEE Antennas Wirel. Propag. Lett. **2016**, 15, 1747–1750.

3. Parchin, N.O.; Jahanbakhsh Basherlou, H.; Al-Yasir, Y.I.; Ullah, A.; Abd-Alhameed, R.A.; Noras, J.M. 'Multiband MIMO antenna design with a user-impact investigation for 4G and 5G mobile terminals. Sensors **2019**, 19, 456.

4. Irene, G.; Rajesh, A. Using a split-ring resonator, a dual-polarized UWB–MIMO antenna with IEEE 802.11ac band-notched characteristics. J. Comput. Electron. **2018**, 17, 1090–1098.

5. Liu, D.Q.; Luo, H.J.; Zhang, M.; Wen, H.L.; Wang, B.; Wang, J. An extremely low-profile wideband MIMO antenna for 5G smart-phones. IEEE Trans. Antennas Propag. **2019**, 67, 5772–5780.

6. Zhao, A.; Ren, Z. Wideband MIMO antenna systems based on coupled-loop antenna for 5G N77/ N78/ N79 applications in mobile terminals. IEEE Access **2019**, 7, 93761–93771.

7. Zhang, X.; Li, Y.; Wang, W.; Shen, W. Ultra-wideband 8-port MIMO antenna array for 5G metal-frame smartphones. IEEE Access **2019**, 7, 72273–72282.

8. Jiang, W.; Liu, B.; Cui, Y.; Hu, W. High-isolation Eight-Element MIMO array for 5G smartphone applications. IEEE Access **2019**, 7, 34104–34112.