DESIGN OF MICROSTRIP MONOPOLE ANTENNA FOR WIRELESS APPLICATIONS

[1]Dr.S.Aruna, [2]B.Tejaswini, [3]M.Sumasri,[4]N.Uma Devi,[5]P.Rajeswari,[6]M.Karuna Priya

[1]*Dr.S.Aruna, Head of the department, Department of Electronics and Communication Engineering, Andhra University College of Engineering for Women.*

[2,3,4,5,6]*Students, Department of Electronics and Communication Engineering, Andhra University College of Engineering for women.*

---***---

Abstract - A great deal of attention has been received for designing an efficient multiband antenna module to achieve the desired character within the effective operating frequency band. Compact printed microstrip monopole antennas are one of the most important multiband antenna structures which can be useful for many wireless applications including GPS, WLAN, LTE, WiMAX (worldwide interoperability for microwave access X), RFID, and UWB. The proposed design consists of two compact and broadband microstrip monopole antennas with different dimensions and characteristics. Microstrip monopole antenna have been designed CST-studio and implemented prototypes mounted on FR4 substrate.

To enhance the gain of the proposed monopole antenna, a linear array consisting of only two monopole elements is designed. The proposed monopole antennas are simple designs and compact in size, the presented monopole designs have been verified and optimized for two center frequencies having the required bandwidth of Wi-Fi, LTE, and WiMAX applications.

***Key Words*: Microstrip antenna, Broadband monopole antenna, Dual-band monopole antenna, compact monopole.**

1.INTRODUCTION

The present time is witnessing a very rapid growth of wireless communications, for which antennas with very large bandwidths are in strong demand so that various applications are covered with fewer or preferably with an antenna. Software and hardware development of communication systems has been rapid growth to cover many wireless applications. This includes Broad Band (BB), Wide Band (WB), and Ultra-wideband (UWB) microwave transceivers.

In the last two decades, the microchip antenna configuration is popular in the rapid development of wireless communication due to its size, weight, cost, and installation microstrip antenna consists of radiating patch printed on one side of the dielectric substrate and ground plane on the other side of dielectric. One of the prominent use of a printed antenna is mobile satellite communication and medical applications. However, in spite of their popularity, microstrip antennas suffer from some drawbacks which are narrow impedance bandwidth, low gain, efficiency, and Inefficient radiation. The drawback of having narrow bandwidth of a microstrip antenna can be avoided by using a printed monopole antenna which is slightly different from a microstrip antenna in structure.

In high data rate wireless communication at GHz frequencies, the antenna should be small in size, have large bandwidth, and possess omnidirectional radiation characteristics, all these requirements can be easily met by the printed monopole antennas. To achieve large bandwidth for a printed monopole antenna the arm of the strip is to be broadened only beyond the rim of the ground plane to form a rectangular printed monopole antenna. For proper matching of the printed monopole with the microstrip feedline, the width of the feed, dielectric constant (ε_r), and thickness(h) of the substrate are to be chosen using the standard microstrip line design equations.

In this paper, a single microstrip monopole antenna has been first proposed and analyzed, which is referred to as Compact Microstrip Antenna (CMP). Second, a linear array consisting of two monopole elements has been designed to enhance the gain. An extension to this, we design a linear array consisting of four monopole elements with an overall size of 38×72mm^2 to achieve more gain.

SYSTEM REQUIREMENTS:

SOFTWARE: Computer Simulation Technology (CST)

CST STUDIO SUITE 2019

Dassault Company.

Operating System: Windows 7/8/9/10/11

HARDWARE: FR4 Epoxy (Substrate Materials)

2. DESIGN METHODOLOGY:

I. PROPOSED MONOPOLE ANTENNAS-DESCRIPTION AND DESIGN

In this section, three compact and broadband microstrip monopole antennas have been proposed, designed, and presented. These are single compact monopole antenna (CMP), compact linear array antenna of two monopole elements and compact linear array antenna of four monopole elements. The proposed monopole antennas are mounted on FR-4 substrate (height h of 1.6mm, tangential loss δ of 0.025, dielectric constant of 4.7 and conductor thickness T of 0.035mm), and they are fed by a transmission of width W1 and length L1 (50.0 Ω line).

1. SINGLE MICROSTRIP MONOPOLE ANTENNA

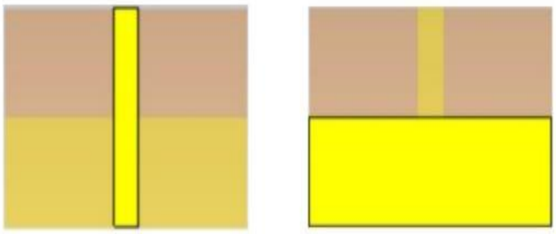


Fig. 1. (a) Top-View **Fig. 1. (b) Bottom-view**

Fig.1. Single microstrip monopole antenna

In above Fig. 1, shows single microstrip monopole antenna which is designed using CST software.

$$L_e < Lm < L_o \qquad (1a)$$

Lo denotes the free-space quarter wavelength

$$(L_0 = \frac{\lambda_a}{4} = \frac{C}{4f_0})$$

Lsg denotes the substrate guided quarter wavelength

$$(L_{Sg} = \frac{\lambda Sg}{4} = \frac{c}{4f_0\sqrt{\epsilon_{Sub}}})$$

Leg denotes the effective guided quarter wavelength

$$(L_{eg} = \frac{\lambda_{eg}}{4} = \frac{c}{4f_0\sqrt{\epsilon_{eff}}})$$

Le denotes the average effective quarter wavelength

$$(L_e = \frac{\lambda_e}{4} = \frac{L_{sg}+L_{eg}}{2})$$

$$\epsilon_{eff} = 0 \cdot 5(\epsilon r + 1) + 0 \cdot 5(\epsilon r + 1)(1 + 12\left(\frac{h}{W1}\right))^{-0.5} \qquad (1b)$$

Where ϵ_{eff} denotes the effective dielectric constant of the conventional microstrip transmission line.

First set of design equations (2a, 2b and 2c) are proposed and verified by simulation and further proof is done by the fabrication and measurement. Dimensions of the compact microstrip monopole antenna including substrate length Lsub, substrate width Wsub, and partial ground length Lg are calculated based on two novel sets of proposed design equations. Those equations sets are referred to as the first design set (Dgn. #1) and the second design set (Dgn.#2) respectively. The first set of the design equations is given by:

$$Wsub = 2.5Lm \qquad (2a)$$

$$Lsub = 2Lm \qquad (2b)$$

$$L_g \geq L_m \qquad (2c)$$

And the design equations of the second set are given by:

$$Wsub = 2Lm – Tw \qquad (3a)$$

$$Lsub = Lg + Lm \qquad (3b)$$

$$\frac{L_m}{4} \leq T_w < \frac{L_m}{2} \qquad (3c)$$

$$\frac{L_m}{4} \leq L_g < Lm \qquad (3d)$$

Where, the parameters Tw is used to optimize the substrate width, while the parameters Lg and Lm are used to control the antenna resonance frequency as well as the operating bandwidth. Second, the compact and broadband microstrip monopole array (MPA) antenna with indicated dimension symbols is shown in figure 2. In this case the monopole array length Lma is given by:

$$L_{ma} = L_m + \Delta L_m \qquad (4a)$$

$$\frac{Lm}{8} < \Delta L_m < \frac{L_m}{2} \qquad (4b)$$

In fact, ΔL_m can be precisely determined using the optimizer of the CST simulator (parametric study). Dimensions of the proposed microstrip monopole array antenna (MPA) including substrate length Lsub1, Substrate width Wsub1 , and partial ground length Lg1 are given by:

$$w_{sub} < W_{sub} < (\frac{w_{sub}}{2} + 2(N-1)L_{ma}) \qquad (5a)$$

$$Lsub = Lg1 + Lma \qquad (5b)$$

$$Lg1 = 2Lg + LT + L1 + W4 \qquad (5c)$$

The equations are derived and then proved using the simulation and the measurement results.

Table I: Optimized dimensions (in mm) of the CMP (F1 and F2) based on the proposed design equations (Eq.(2) and Eq.(3))

	Dgn.#1		Dgn.#2	
	F1	F2	F3	F4
Lm	18.3	11.65	19.55	12.15
Lg	18.3	11.65	13.0	5.0
Tw	-	-	7.0	5.0
Lsub	2.0 Lm	2.0Lm	Lm + Lg	Lm + Lg
Wsub	2.5Lm	2.5Lm	2Lm – Tw	2Lm – Tw
W1	3.0	3.0	3.0	3.0
W2	3.0	3.0	3.0	3.0
εr	4.7	4.7	4.7	4.7
εeff	3.53	3.53	3.53	3.53
h	1.6	1.6	1.6	1.6

2. LINEAR ARRAY OF TWO MONOPOLE ELEMENTS

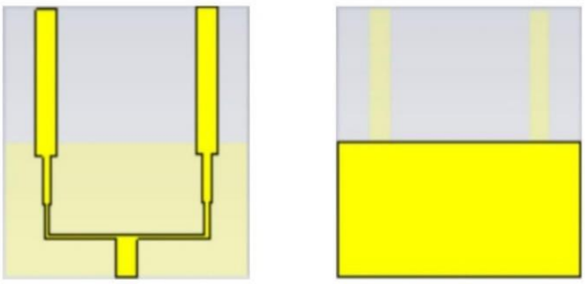


Fig. 2. (a) Top View **Fig. 2. (b) Bottom View**

Figure. 2: Linear array of two monopole antenna

Table 2. Optimized dimensions (in mm) of the linear array of two monopole antennas (Dgn #2 at F2) based on the proposed design equations (Eq. (2) through Eq. (5)).

Parameters	Value
Wsub1	36
W1	3
W2	3
W3	1.2
W4	0.6
Lsub1	38
Lm	12.15
ΔLm	4.15
La	24.4
L1	4.6
L2	15.8
LT	6.8
Lg1	21.7
Tw	6.4

3. LINEAR ARRAY OF FOUR MONOPOLE ANTENNA

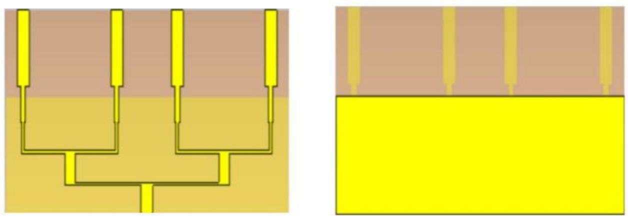


Fig. 3. (a) Top view **Fig. 3. (b) Bottom view**

Figure. 3: Linear array of four monopole antenna

Table 2. Optimized dimensions (in mm) of the linear array of four monopole antennas.

Parameters	Value
Wsub	72
lsub	38
W1	3
W2	3
W3	1.2
W4	0.6
L1	4.6
Lm	14.2
f	5.3
h	1.6
th	0.035
Lg1	24
La	24.4
Lt	6.8
w5	3

4. RESULTS &ANALYSIS

A. MONOPOLE ANTENNA AT 3GHz

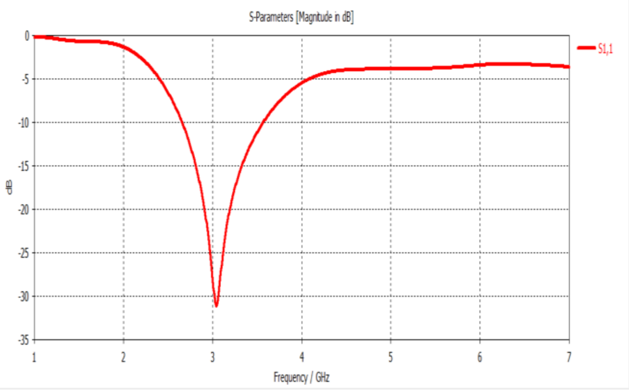


Fig (i) S-Parameter in dB of monopole antenna at 3GHz

B. MONOPOLE ANTENNA AT 5GHz

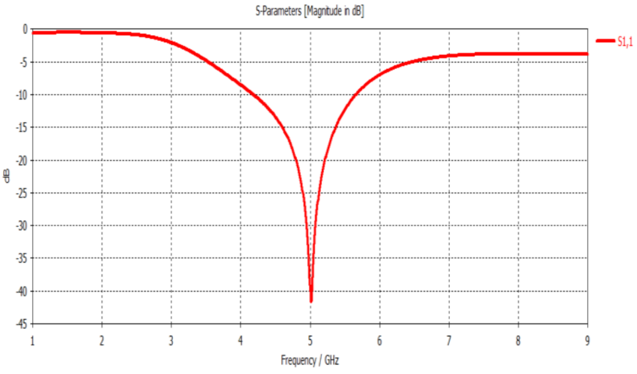


Fig (ii) S-Parameter in dB of monopole antenna at 5GHz

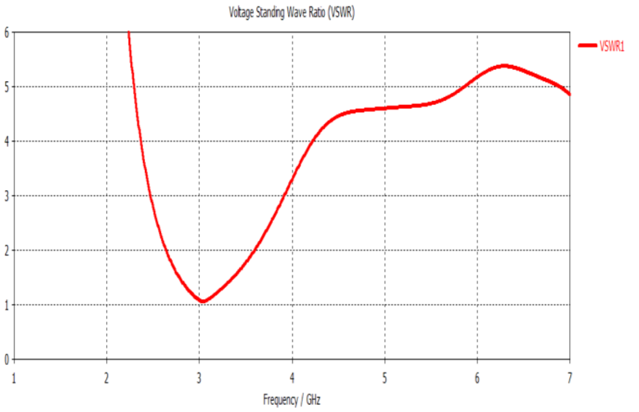


Fig (iii) VSWR of monopole antenna at 3GHz

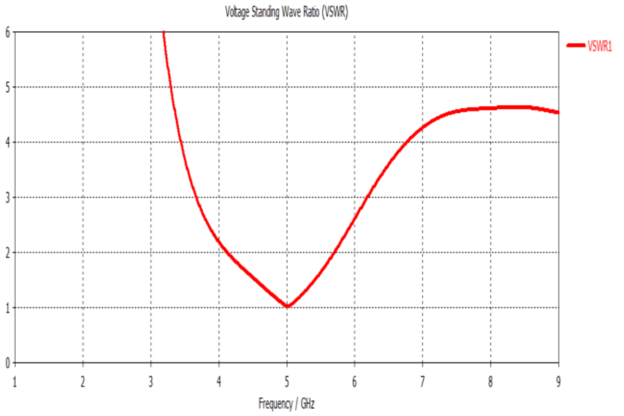


Fig (iv) VSWR of monopole antenna at 5GHz

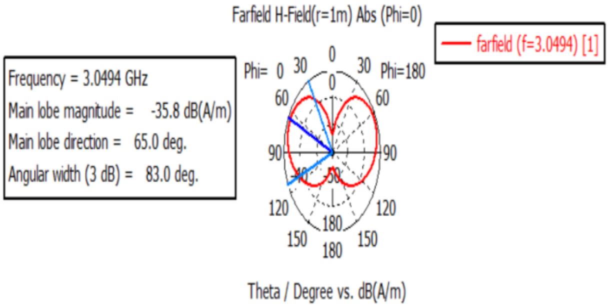


Fig (v) Radiation pattern of at 3GHz(H-Field at Φ=0)

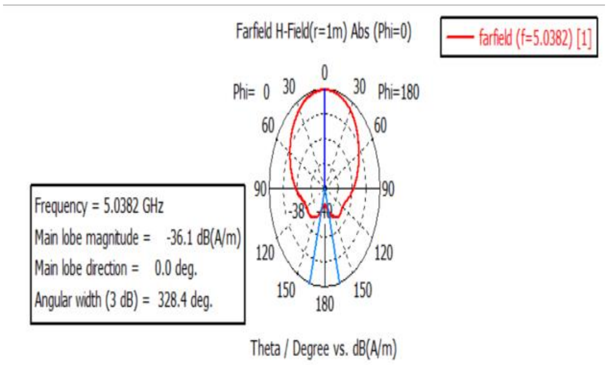


Fig (vi) Radiation pattern of at 5GHz(H-Field at Φ=0)

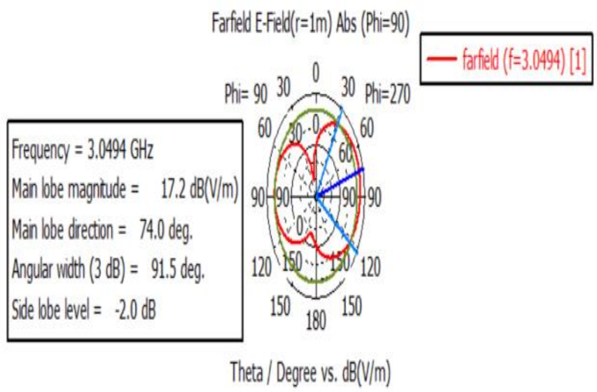


Fig (vii) Radiation pattern of monopole antennas 3GHz(E at Φ=90)

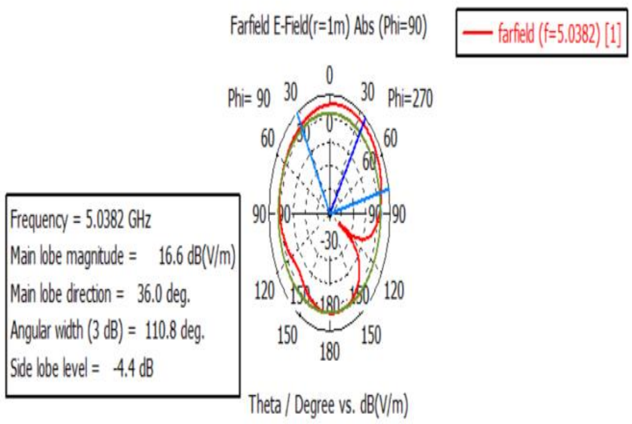


Fig (viii) Radiation pattern of monopole antennas at 5GHz(E at Φ=90)

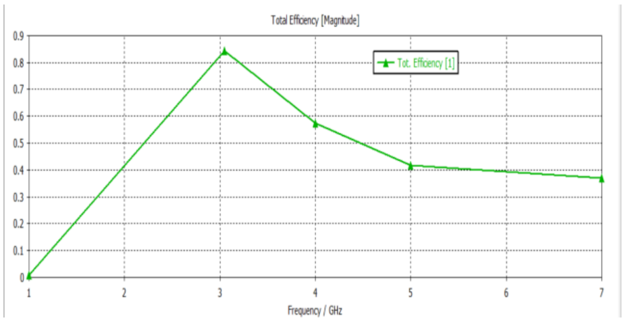
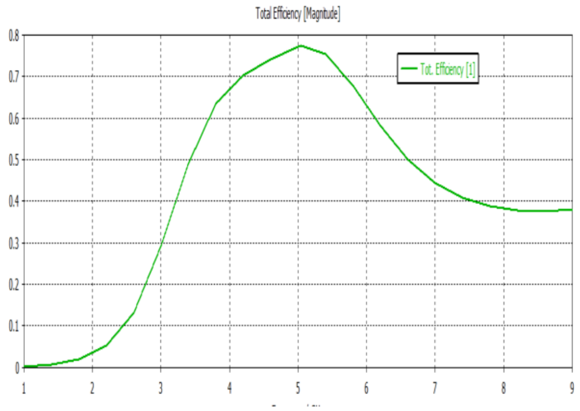


Fig (ix) Total Efficiency of monopole antenna at 3GHz



Fig(x)Total Efficiency of monopole antenna at 5GHz

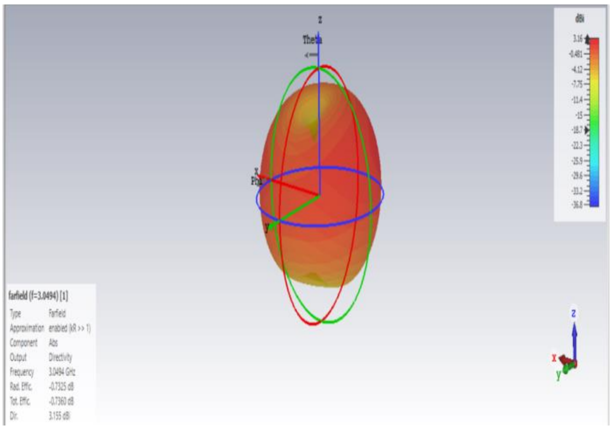


Fig (xi)Far field of monopole antenna at 3GHz

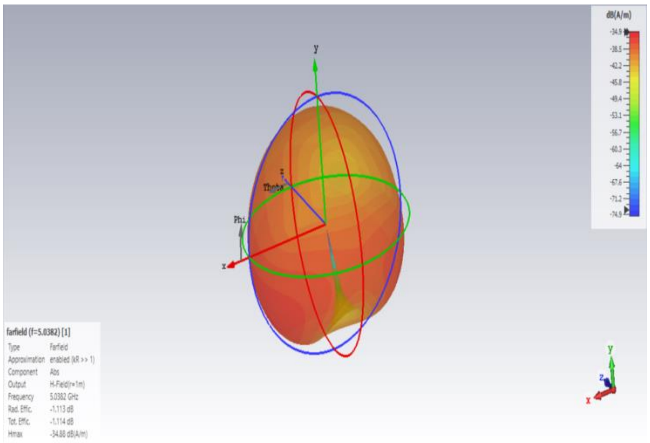


Fig (xii) Far field of monopole antenna at 5GHz

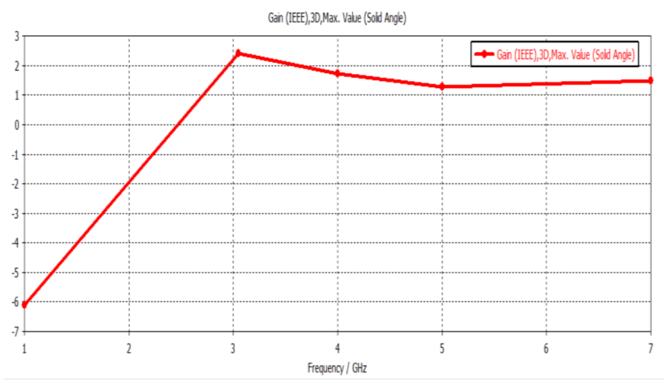


Fig (xiii) Gain of monopole antenna at 3GHz

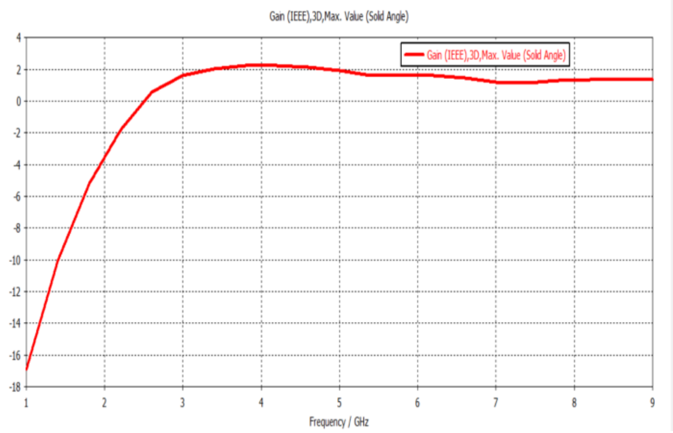


Fig (xiv) Gain of monopole antenna at 5GHz

C. TWO MONOPOLE ANTENNA (5 GHz)

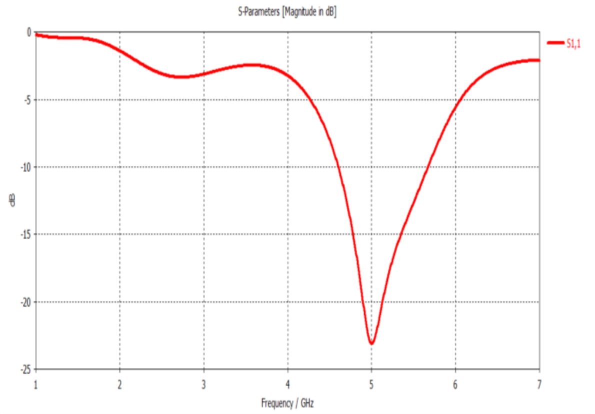


Fig (i) S-Parameter in dB of dual monopole antenna

D.FOUR MONOPOLE ANTENNA(4.776 GHz)

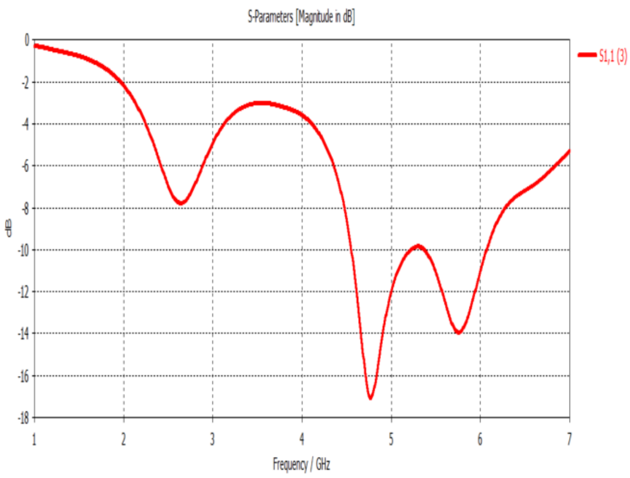


Fig (ii) S-Parameter in dB of dual monopole antenna

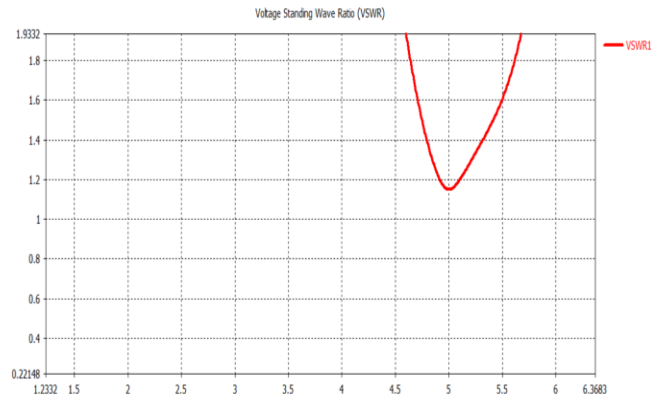


Fig (ii) VSWR of dual monopole antenna

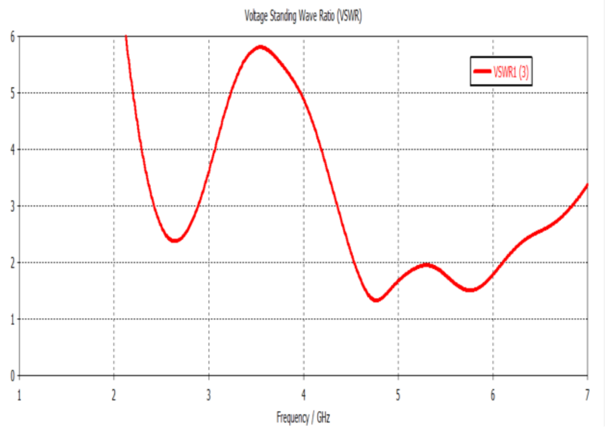


Fig (ii) VSWR of four monopole antenna

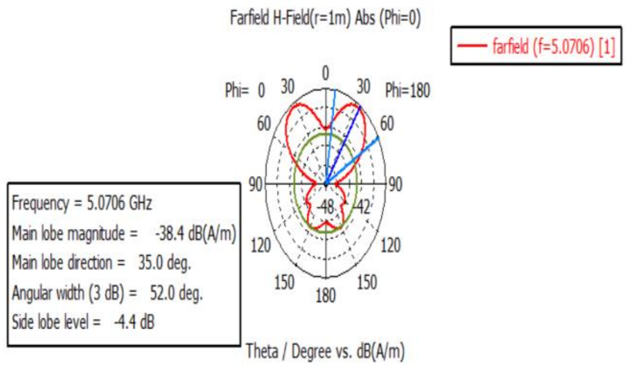


Fig (iii) Radiation pattern of dual monopole Antenna (H-Field at Φ=0)

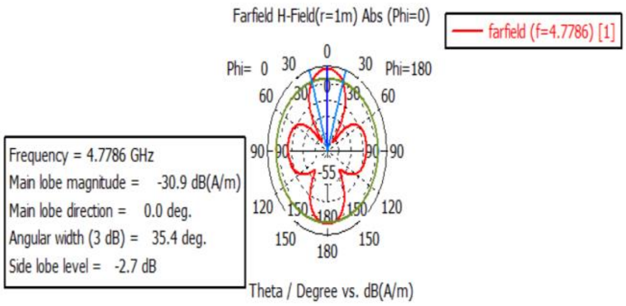


Fig (iii) Radiation pattern of four monopole antenna (H-Field at Φ=0)

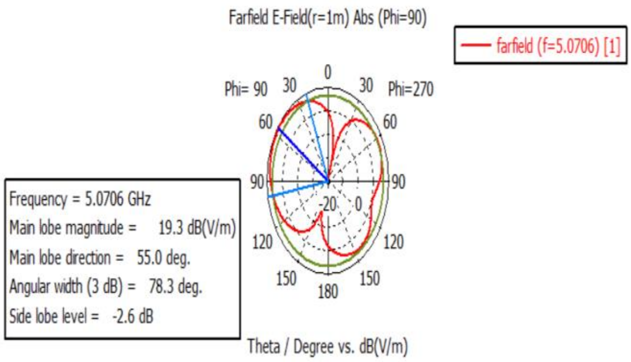


Fig (iv) Radiation pattern of dual monopole antennas at 5GHz(E at Φ=90)

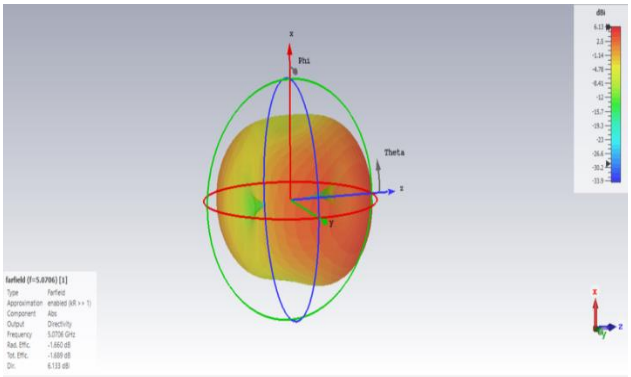


Fig (vi) Farfield of dual monopole antenna

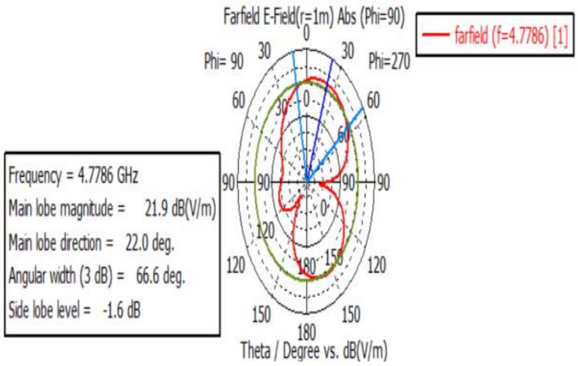


Fig (iv) Radiation pattern of four monopole antennas at 4.776GHz(E at Φ=90)

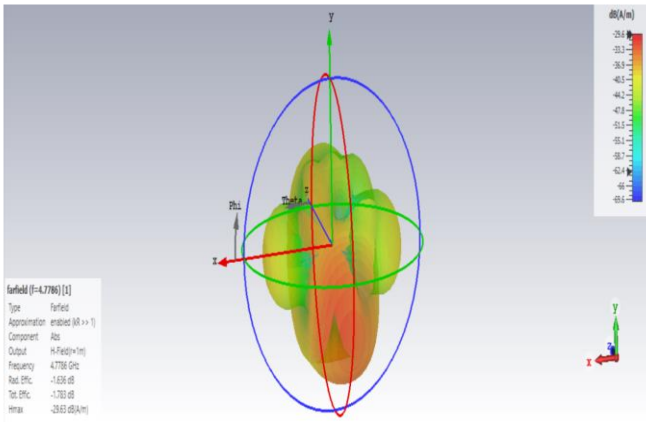


Fig (vi) Farfield of four monopole antenna

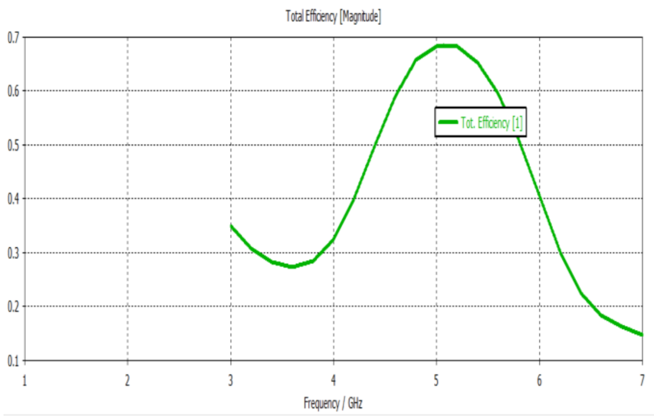


Fig (v) Total Efficiency of dual monopole antenna

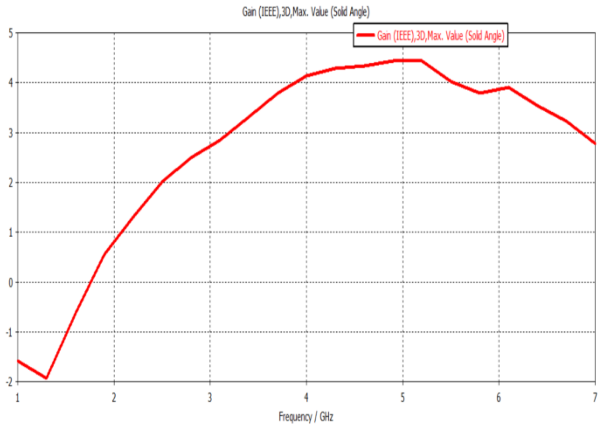


Fig (vii) Gain of dual monopole antenna

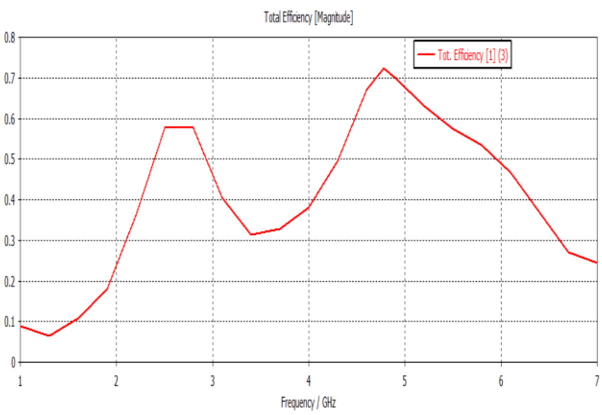


Fig (v) Total Efficiency of four monopole antenna

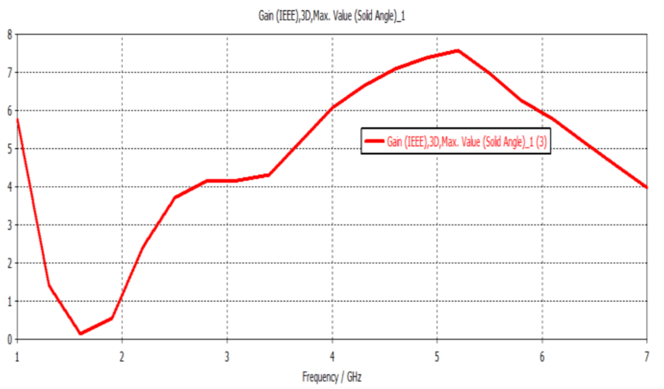


Fig (vii) Gain of four monopole antenna

5. CONCLUSION

A broadband microstrip monopole antenna has been proposed, designed, fabricated, and presented. The monopole antenna designs are based on two sets of proposed equations, andthey are simulated using the CST-simulator. These design equations have been verified through a detailed parametric study, and the monopole antenna performance has been investigated and optimized. Excellent Omni-directive pattern, low VSWR, adequate maximum gain, and broad bandwidth have been achieved. Moreover, a linear array of two monopole elements and four monopole elements has been designed, optimized, and fabricated to enhance the maximum gain. The proposed array has been achieved good efficiency, large bandwidth, directive pattern with moderate high gain (8.0 dBi), and low VSWR. Reasonable agreement has been achieved between measured and simulated results.

6. ACKNOWLEDGEMENTS

We would like to express our sincere thanks to our Head of the Department (ECE) **Dr.S.ARUNA** for encouragement extended by her. It is our privilege to acknowledge with deep sense of gratitude to our project guide whose supervision, inspiration and valuable discussion has helped us tremendously to complete our project. Their guidance proved to be the most valuable to overcome all the hurdles in the fulfillment of this mega project on **"Design of Microstrip Monopole Antenna for Wireless Applications".**

7. REFERENCES

[1] C. A. Balanis, Antenna Theory: Analysis and Design, 3rd ed. New York, NY, USA: Wiley, 2005. [2]J. D. Kraus and R. J. Marhefka, Antennas for All Applications. New York, NY, USA: Wiley, 2002.

[3] K.-L. Wong, Broadband Microstrip Antennas. Hoboken, NJ, USA: Wiley, 2002.

[4] Z. N. Chen and Y. W. M. Chia, Broadband Planar Antennas: Design and Applications. Hoboken, NJ, USA: Wiley, 2006.

[5] M. Bank and M. Haridim, ''A printed monoole antenna for cellular handsets,'' Int. J. Commun., vol. 3, no. 2, pp. 54–61, 2009.

[6] R. S. Kshetrimayum, ''Printed monopole antennas for multiband applications,'' Int. J. Microw. Opt. Technol., vol. 3, no. 4, p. 2, 2008.

[7] C. F. Tseng, C. L. Huang, and C. H. Hsu, ''Microstrip-fed monopole antenna with a shorted parasitic element for wideband application,'' Prog. Electromagn. Res. Lett., vol. 7, pp. 115–125, 2009.

[8] J. R. Panda, A. S. R. Saladi, and R. S. Kshetrimayum, ''A compact printed monopole antenna for dual-band RFID and WLAN applications,'' Radioengineering, vol. 20, no. 2, pp. 464–467, 2011.

[9] M. Tareq, Z. Afroze, and R. Ahmed, ''Design and performance analysis of compact microstrip-fed multiple edge slotted monopole antenna for wideband applications,'' Int. J. Sci.Res. Publications, vol. 4, no. 9, pp. 1–8, 2014.

[10] M. Dongre, P. K. Singhal, S. Kushwah, and T. Gupta, ''Triple band hexagonal meander- line monopole antenna for wireless applications,'' Int. J. Innov. Appl. Stud., vol. 3, no. 4, pp. 953–958, 2013.

BIOGRAPHY

B.Tejaswini

Electronics & Communication Engineering

Andhra University College of Engineering for women