Novateur Publication's
International Journal of Innovation in Engineering, Research and Technology [IJIERT]
ICITDCEME'15 Conference Proceedings
ISSN No - 2394-3696

# GAIN ENHANCEMENT OF COMPACT ULTRA WIDEBAND ANTENNA

Mr. Bipin Bansode
Department of E&TC, Amrutvahini COE, Sangamner, Ahmednagar,India
bipinbansode@gmail.com
Prof. Ramesh S. Pawase
Department of E&TC, Amrutvahini COE, Sangamner, Ahmednagar,India
rameshpawase@gmail.com
Prof. Rekha P. Labade
Department of E&TC, Amrutvahini COE, Sangamner, Ahmednagar,India
rplabade@gmail.com

## ABSTRACT
A trend of portable device integration has arisen in last decade, due to the massive growth of wireless communications, and products are expected to have multiple wireless services with increased gain. As a result, a single, small antenna with the ability to operate effectively over broadband with near optimum gain is desired. Antenna is always designed upon the experience of the designer, which is an onerous and time-consuming work. Some parameters of the antenna, such as gain and S-parameter of monopole antenna, are not simple to control, which leads great difficulty for the designer to modify the structure for proper working conditions. A method is presented which is aimed at increasing the gain of ultra-wide band (UWB) antenna using the Grid Search Algorithm (GSA) without the need to increase its size. The antenna is analyzed by using the Method of moment (MoM) to achieve an ultra wide bandwidth characteristic and a maximum possible gain. The antenna has compact physical structure (30 mm × 33 mm.) and is designed on standard FR4 substrate of 1.6mm with an operating frequency of 6.85 GHz. The simulated frequency response shows an excellent impedance bandwidth of 7.9 GHz or 115.3% over 3.1 to 11GHz for VSWR less than 2. The radiation patterns, peak gain, return loss & VSWR are presented and compared.

## INTRODUCTION
An ultra wide-band (UWB) system uses a low-power spectral density and a short pulse radio signal to send high data-rate information. According to the Federal Communications Commission (FCC), UWB is defined as any signal that occupies a bandwidth at least 500 MHz in the 7.5-GHz range of spectrum between 3.1 GHz and 10.6 GHz [1] One of key issues in the UWB system is to design a compact and very wide-band antenna. A monopole antenna has been widely used in the mobile communication system because of its simple structure and omni-directional radiation characteristic. However, it is not easy to be integrated into the handset or mobile terminal and additionally has relatively narrow bandwidth. A classical printed monopole antenna usually has height of 0.25λo and 10–15% bandwidth. Size of the antenna can be reduced through different geometries of printed monopole element [2]. Size reduction and wide-band characteristic of an antenna can be simultaneously achieved by using the similar method. Recently, a method of moment (MoM) and Genetic algorithm(GA) optimization method is usually used to design a multiband or wide-band characteristic antenna since the attractiveness of the GA over the aforementioned methods is its ability to achieve the desired performance by using single, unique patch shape. However, Grid Search Algorithm (GSA) requires smaller number of evaluations as compared to genetic algorithm (GA) techniques. Being a local optimizer, the convergence of the GSA algorithm is much faster compared to the global optimizer GA. Most of the current electromagnetic simulators also have some built-in optimization tools which can help antenna designers be possible to optimize their antennas with desirable characteristics.

Recently, as the huge advancement of computer speed, some kind of antenna optimization methods have been presented. But the optimized structure is often discontinuous. The electric characteristic of two diagonal-connected blocks is unknown and also leads to great difficulty in fabricating Therefore, a novel way is proposed in this paper to implement computer-aided antenna design with continued border [3].

In this paper, an UWB antenna is analyzed by using Method of moment (MoM) and the maximum gain of the antenna are determined by utilizing the Grid Search Algorithm (GSA). A proposed antenna is fed by a offset 50Ω microstrip line and FR4 lossy epoxy substrate with dielectric relative permittivity of 4.4 with thickness of 1.6 mm.

IJIERT-ICITDCEME'15

## ANTENNA ANALYSIS

Fig. 4 shows the proposed geometry of an ultra-wideband printed monopole antenna with a offset-fed line. In addition, GSA algorithm is implemented to optimize the ground length of printed monopole antenna to obtain the ultra wide-band characteristic. This UWB antenna is modeled in CAD-FEKO and a grid search algorithm in OPTFEKO is used to determine and obtain maximum value of directivity. Fig. 1 shows a flow chart of GSA used in this paper. Most of steps are commonly used in GSA regardless of problems being solved. Each individual is analyzed by using the MOM solver.

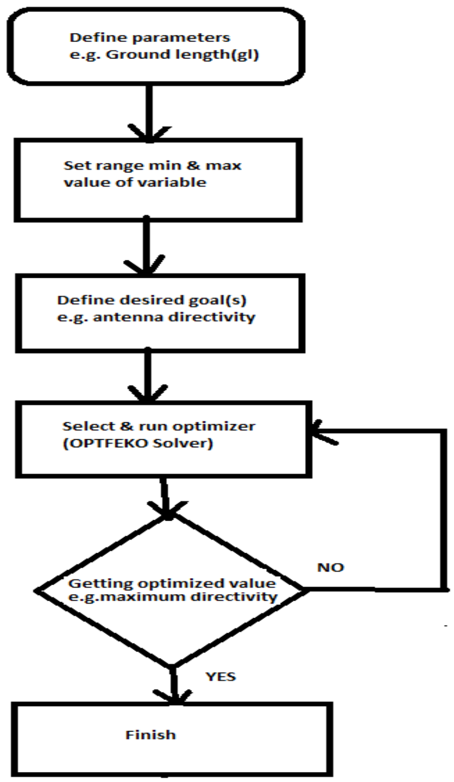


**Fig. 1: Flow chart of the GSA**

## DESIGN OF MSA

The basic MSA is a strip conductor of dimensions L x W on a dielectric having dielectric constant $\varepsilon_r$ and thickness *h* backed by a ground plane. For MSA width is comparable to wavelength to enhance radiation from edges. The substrate thickness is much smaller than the wavelength, therefore MSA is considered to be 2D planar configuration for analysis. The microstrip separates two dielectrics, i.e. substrate and air. Hence most of the electric field lines reside in the substrate and some extend to air. This transmission line cannot support pure TEM mode of propagation since the phase velocities would be different in the air and the substrate. Hence, effective dielectric constant must be obtained in order to account for fringing fields. The value of effective dielectric constant is less than dielectric constant of the substrate, because the fringing fields around the periphery of the patch are not confined in the dielectric substrate, but are also spread in the air.The value of this effective dielectric constant is given by

$$\epsilon_{eff} = \frac{\epsilon r + 1}{2} + \frac{\epsilon r - 1}{2}\left[1 + \frac{12h}{W}\right]^{-\frac{1}{2}}$$

Where, $\varepsilon_{eff}$ is effective dielectric constant and $\varepsilon_r$, *h, W* represent dielectric constant, height and width of the substrate, respectively. For MSA to be an efficient radiator, *W* should be taken equal to a half wavelength corresponding to the average of the two dielectric mediums (i.e., substrate and air).

$$W=\frac{c}{2f_0\sqrt{\frac{\varepsilon r+1}{2}}}$$

For the fundamental $TM_{10}$ mode, the length $L$ should be slightly less than $\lambda/2$.Where $\lambda$ is the wavelength in the dielectric medium

From the voltage and current distribution shown in Figure 2 it is clear that, voltage is maximum and current is minimum along the width of the patch due to the open ends. Therefore, the input impedance of the MSA varies from zero value at its center to the maximum value (200-Ω) at its radiating edges.

Electromagnetic field lines at the edges as shown in Figure 3 can be resolved into normal and tangential components with respect to ground plane.

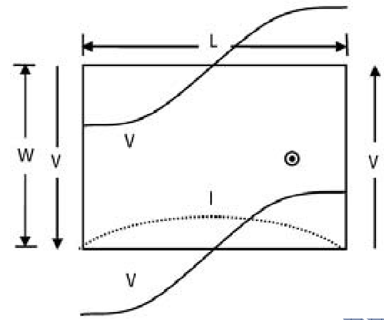


**Fig. 2: Voltage and Current distribution**

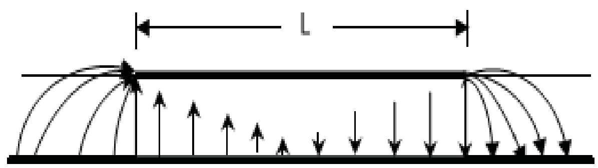


**Fig. 3: E-field distribution**

The normal components of E-field at the two edges along the width are in opposite directions and thus out of phase since the patch is $\lambda/2$ long and hence they cancel each other in broadside direction. The tangential components are in phase; hence the resulting fields combine to give maximum radiated field normal to the surface of the structure. Hence edges along the width can be represented as two radiating slots, $\lambda/2$ apart and excited in phase and radiating in half space above the ground plane. The fringing fields along the width can be modelled as radiating slots increasing electrical length of patch than physical length. This increase in length is given as,

$$\Delta L = 0.412h\left[\frac{(\in eff + 0.3)\left(\frac{W}{h}+0.264\right)}{(\in eff - 0.258)\left(\frac{W}{h}+0.813\right)}\right]$$

Thus at resonance frequency, effective length of the patch is

$$L_e=L+2\Delta L=\frac{c}{2f_0\sqrt{\varepsilon eff}}$$

where, $c$ is velocity of light in free space. The actual length of the patch, $L$ can be determined from above equation.

From these equations, a MSA was designed to operate over UWB frequency range (3.1GHz to 11GHz).The optimized length and width of the MSA was found to be 12 mm and 15 mm, respectively. This MSA was simulated using MoM based EM Simulation Package, CAD-FEKO [3]. For simulations, the FR4 substrate with dielectric constant of 4.4 with thickness of 1.6 mm was considered[2].

ISSN No - 2394-3696

**PARAMETRIC STUDY OF MSA**

The high gain compact UWB antenna has been shown in Fig.4 with optimized dimension. 18mm by 12mm patch on the 33mm by 30mm FR4 dielectric substrate with offset feed on partial ground. It has been observed during simulation that the UWB characteristic of the proposed antenna is heavily dependent on the ground, gap between patch and ground. And feed position so these parameters of antennas should be optimized for maximum bandwidth.

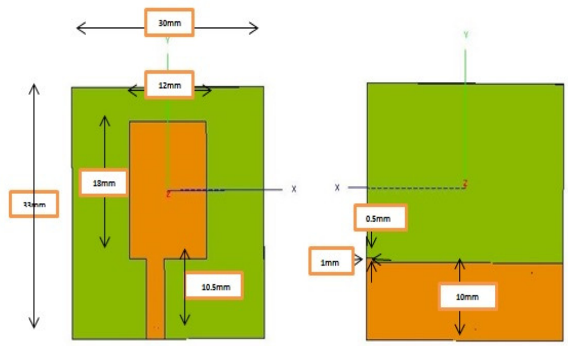


**Fig. 4: Proposed compact UWB antenna**

**A. EFFECT OF GAP BETWEEN PATCH AND GROUND**

The gap between the ground plane and radiating patch is also optimized as it acts as a matching network and improves impedance bandwidth. The gap between the patch and ground is also important for proper impedance matching. Because variation of gap affects the bandwidth of antenna. The proposed antenna has been simulated for various value of the gap between patch and ground plane (g). The simulated results are shown in fig.5. The effect of the gap is clearly visible in the simulated results. The proper matching throughout the band is achieved by optimizing the gap from 0.0 mm to 1.5 mm with the step of 0.5 mm. The optimum value of gap has been achieved 0.5 mm.

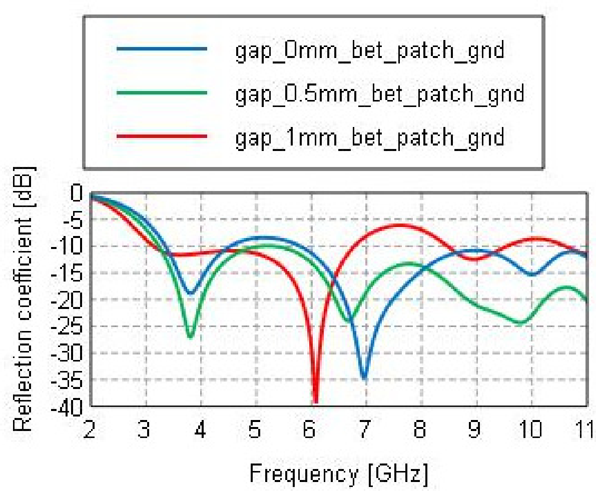


**Fig. 5: Simulated results of gap between patch and ground**

**B. EFFECT OF FEED-POINT LOCATION**

The input impedance of the MSA varies from zero value at its center to the maximum value (200-Ω) at its radiating edges. The feed -point should be located on the patch at a point where input impedance is 50-Ω at resonance frequency. The center of the feed line is taken at origin and feed-point location is given by coordinates ($X_f$, $Y_f$) with respect to origin. There exists a point along the length of the feed line, where RL is minimum. So

ISSN No - 2394-3696

feed position parameters of antennas has been optimized for maximum bandwidth. Therefore, this is considered as optimum feed point location. Thus it is clear that feed location (2, 0) is the optimum feed location for this RMSA.

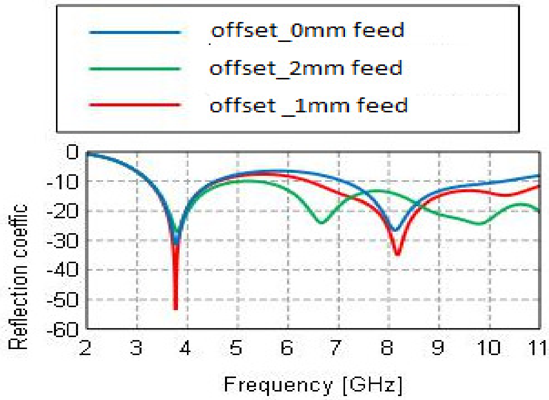


**Fig. 6: Simulated results of feed position**

In fig.7, fig.8 and fig.9 show the curves obtained for return loss and VSWR and radiation pattern of UWB antenna. It is seen that the minimum value of RL, -10.0 dB, occurs at feed location (2,0) throughout entire band(3.18Ghz-11.0GHz).

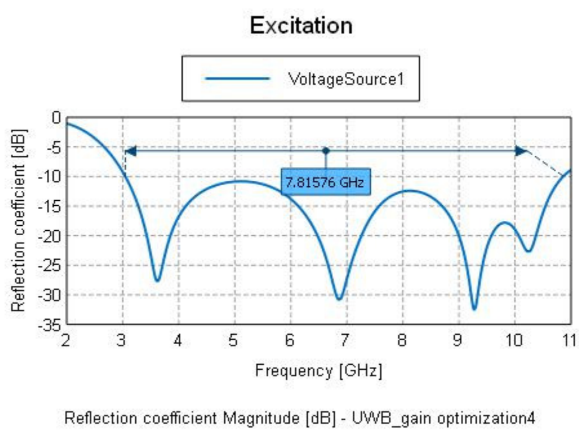


**Fig. 7: Return Loss versus Frequency**

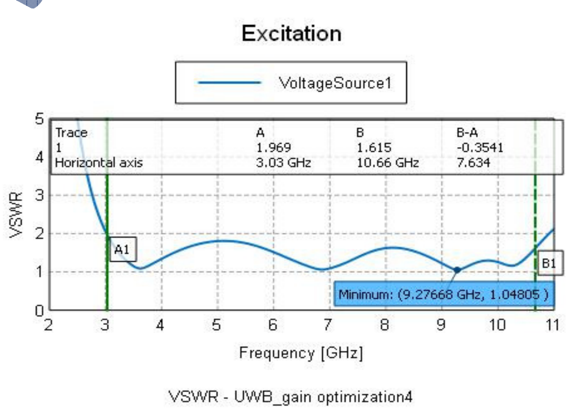


**Fig. 8: VSWR versus Frequency**

Simulated results of proposed MSA exhibits the excellent ultra wide impedance bandwidth of 7.8 GHz (from 3.18 GHz to 11 GHz) corresponds to 115.3% impedance bandwidth at VSWR 2. The VSWR versus frequency of this UWB antenna has been shown in fig.8. This antenna satisfies the bandwidth requirement of Ultra wide band communication system, i.e. from 3.1 to 10.6 GHz.

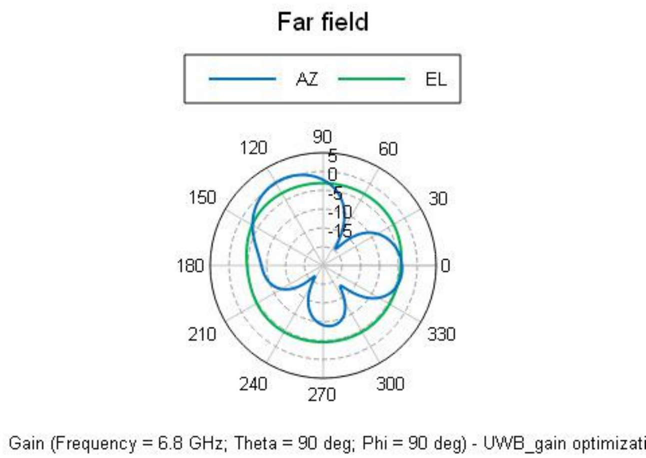


**Fig. 9: Radiation pattern at 6.8GHz**

## C. EFFECT OF GROUND STUB

Other than this, we have also seen that the ground plane size especially the length and width of the ground plane is also an important factor affecting the antenna impedance and gain.

The effect of ground stub has been simulated for various value of stub length (SL) and width (SW).Grid Search Algorithm (GSA) in OPTFEKO is used to determine and obtain maximum value of directivity.

Optimization Variables

| Sr.No. | Name | Beginning value | Minimum | Maximum |
|---|---|---|---|---|
| 1. | SL | 0 | 0 | 10 |
| 2. | SW | 0 | 0 | 10 |

Optimum found for these parameters:

SL = 0.5 mm
SW = 1.0 mm

Optimum Gain Value: 5.32 dB

It is observed we are getting maximum gain 5.32 dB without the need to increase in its size.

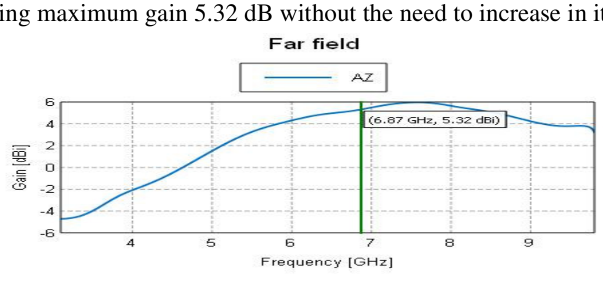


**Fig. 10: Gain of UWB antenna with optimization**

IJERT ICITDCEME'15

**ISSN No - 2394-3696**

## CONCLUSION

An Ultra wide-band antenna with a printed compact MSA structure was demonstrated. The antenna was analyzed by MOM method and optimized by GSA to achieve maximum gain. The measured bandwidth is 7.82 GHz or 115.3% over 3.1 GHz to 11.0 GHz for VSWR less than 2. It is observed we are getting maximum gain 4.8 dB without the need to increase its size. Therefore, the proposed antenna should be useful for ultra wide-band communication system as well as suitable for various military and commercial wideband applications. It is observed we are getting maximum gain 5.3 dB without the need to increase its size.

## REFERENCES

[1] Jeongpyo Kim, Student Member, IEEE, Taeyeoul Yoon, Member, IEEE, Jaemoung Kim, Member, IEEE, and Jaehoon Choi, Member, IEEE "Design of an Ultra Wide-band Printed Monopole Antenna Using FDTD and Genetic Algorithm" IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, VOL. 15, NO. 6, JUNE 2005

[2] Rahul T. Dahatonde, Shankar B. Deosarkar, Design and Parametric Evaluation Of Rectangular Microstrip Patch Antenna For GSM Application, International Journal of Engineering Science and Technology (IJEST)

[3] Junping Geng, Ronghong Jin, Xianling Liang, Hao Wu, Ye Sheng, and Bangda Zhou, "The Study on the Antenna Optimization", PIERS Proceedings, Xi'an, China, March 22-26, 2010

[4] Sidharath M.Tech, ECE DAVIET, Jalandhar Jaspreet Singh M.Tech, ECE DAVIET, "To Study the Effect of Different Substrate Materials on Rectangular Microstrip Patch Antenna Parameters Using HFSS", International Journal of Engineering Research & Technology (IJERT)

[5] P.A. Ambresh, P. M. Hadalgi,"Short Stub Microstrip Patch Antenna on Radiating Edges" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 6, June 2013

[6] M.A.Sulaiman, M.T.Ali, I. Pasya, "A Wing Stub Circular Microstrip Patch Antenna (WSCMPA) with Stable Return Loss and Radiation Pattern" International Journal Of Microwave And Optical Technology, Vol. No.2, March 2013

[7] Mithila R. Ghuge, A.P.Khedkar, Prathamesh U. Indulkar, "A Comparative Study of Gain Enhancement Techniques for Microstrip Patch Antenna" International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 3, Issue 1, January 2014

[8] Radhika Gulhane, Dr. Rajkumar Prof. A.S. Shirsat, Student M.E., SKN COE, Pune. Scientist – E, DIAT , Pune ,Asst. prof., SKN COE, Pune. "Design of Ultra Wideband Antenna with EBG to Improve the Gain" International Journal of Advances in Electrical and Electronics Engineering also Available online at www.sestindia.org/home-ijaeee/ and www.ijaeee.com

[9] Hong-Min Lee, Wong-Sang Choi, "Effect of Partial Ground Plane Removal on the Radiation Characteristics of a Microstrip Antenna" Wireless Engineering and Technology, 2013, 4, 5-12, Published Online January 2013 (http://www.scirp.org/journal/wet)

[10] Islam Md. Rafiqul, Member IEEE, Alam AHM Zahirul, Senior Member IEEE, M. Feroze Akbar J. Khan and Shaker Alkaraki "Design of Microstrip Patch Antenna Using Slotted Partial Ground And Addition Of Stairs And Stubs For UWB Application" Cyber Journals: Multidisciplinary Journals in Science and Technology, Journal of Selected Areas in Telecommunications (JSAT), May Edition, 2012

[11] Atser A. Roy,Joseph M. Mom, Abiem L. Tersoo Dept. of Physics Dept.of Electrical and Electronics,Dept. of Physics University of Agriculture Engineering, University of Agriculture Makurdi, Nigeria,University of Agriculture ,Makurdi, Nigeria "Impact of Feed Point Location on the Bandwidth, Frequency and Return Loss of Rectangular Microstrip Patch Antenna" International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 9, September – 2013

IJERTICTDCEME15