Design of a triple band rectangular slotted monopole antenna with parasitic line for increased gain and bandwidth

Khushboo Bhardwaj, Devendra Soni

***Abstract*— Antennas have a big role in wireless communication system. Wireless Communication system requires compact, multi band antennas that can dynamically change some of its fundamental parameters such as frequency band, and gain. The novelty of the proposed work lies in using one conducting strips that support operation at different frequencies. Therefore the main motto is to obtain triple band of frequency to improve the frequency congestion in wireless communication system. Triple band Rectangular slotted Monopole antenna with parasitic line is designed by inserting a single strip on antenna because of this the antenna gives enhanced bandwidth with increased gain at all triple band frequencies, which attains a bandwidth of 8.75% for ⏐S11⏐ ≤10dB return loss, 12.69% for ⏐S11⏐ ≤10dB return loss and 5.06% for ⏐S11⏐ ≤10dB return loss at centre frequencies of 2.4GHz, 5.2GHz and 8.1GHz respectively. The work carried here is applicable for ISM band (which is kept reserved for industrial, scientific and medical application), S-band, C-band and X-band at frequencies 2.4GHz, 5.2GHz and 8.1GHz respectively. These three frequencies are also well suitable for wireless communication.**

***Index Terms*— monopole antenna, triple band, WLAN**

I. INTRODUCTION

The new technological trend has focused much effort into the design of a Microstrip patch antenna. Advances in wireless communication technologies are placing greater demands on higher antenna impedance bandwidth and smaller antenna size. The microstrip patch antenna is simply a patch which radiates from one face.

Bandwidth and efficiency of a Microstrip antenna depends upon patch size, shape, substrate thickness, dielectric constant of substrate, feed point type and its location, etc.. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable for higher bandwidth, better efficiency and better radiation, leading to a larger antenna size . These patch the widest and most demanding applications. Dual characteristics, circular polarizations, dual frequency operation, frequency agility, broad band width, feed line flexibility, beam scanning can be easily obtained from these patch antennas. Some popular antenna designs suitable for WLAN and WiMAX operation for 2.4 GHz ,5.4GHZ and 8.1GHZ has been proposed in this paper.

The geometry of the proposed antenna is composed of the triple band with rectangular slotted monopole antenna with parasitic line to derive the enhanced bandwidth and gain. With the evolution of design technology, microstrip antennas have achieved higher bandwidth, mechanical robustness and versatility with respect to resonant frequency, improved polarization pattern and wider impedance bandwidth. Since printed circuit technology is currently widely used to provide smaller and low profile antennas such as monopole antenna for personal and mobile communication devices, this research study will embark on designing a monopole antenna for specific band purposes. The antennas are finding increasing applications in Satellite communications, GPS, WiMax , WLAN and commercial usages especially as base station antennas, antennas for access point.

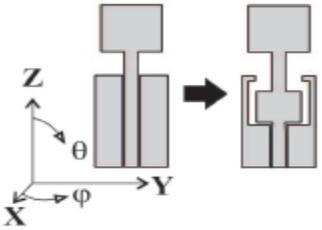


Figure 1 Rectangular Monopole Antenna

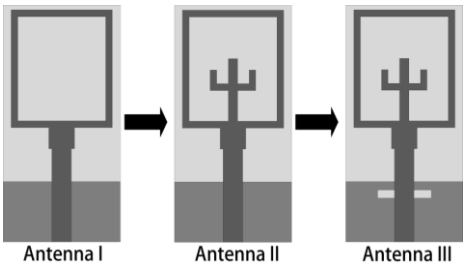


Figure 2 Compact Rectangular Antenna

II. ANTENNA DESIGNING OF MONOPOLE PATCH ANTENNA

The monopole antenna is most commonly used patch structure. The designing parameters of different geometrical monopole antenna which are used to obtain triple band and to perform various operations at resonant frequency. One the technique includes the utilization of substrates with low dielectric constant and slotted patch. Here we can use some specific slot in the radiating patch of antennas. The loading the slots in the radiating patch can cause meandering of the excited patch surface current paths and result in lowering of the antenna's fundamental resonant frequency, which corresponds to the reduced antenna size for such an antenna, compared to conventional antenna at same operating frequency. The parasitic line (strip) is used in antenna which results in proper triple band with enhanced bandwidth and gain at all resonant frequencies.

Design Of Triple Band Rectangular Slotted Monopole Antenna with Parasitic Line

The designing of monopole antenna mainly depends upon three parameters, namely dielectric substrate and its dielectric constant, height of the substrate and resonant frequency. In this dissertation the selected three parameters are:

- Resonant Frequency (f_r) = 5.2GHz,
- Dielectric constant (ε_r) = 4.4
- Height of the dielectric substrate (h) = 1.6mm.

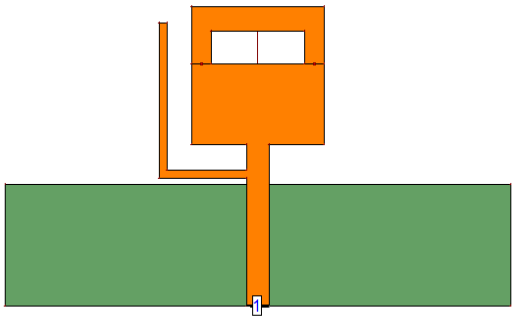


Figure 3 triple band rectangular slotted monopole antenna with parasitic line.

Sr. No.	Parameter	Values
1	Frequency	5.2GHz
2	Length of patch (L)	17mm
3	Width of patch (W)	17mm
4	Substrate height (h)	1.6mm
5	Ground Size (L× W)	70mm× 15mm

Hardware design of triple band rectangular slotted monopole antenna

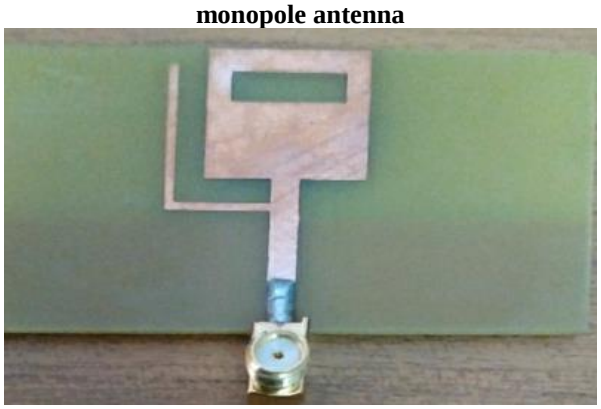


Figure 4 photograph of proposed antenna (a) top view

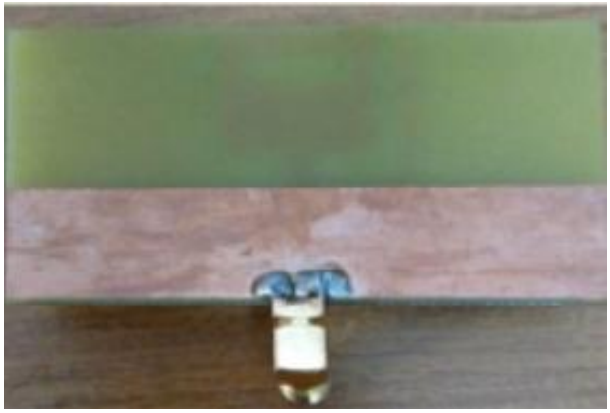


Figure 5 photograph of proposed antenna (b) bottom view

III. Simulation and Results Analysis

The design of the triple band rectangular slotted patch antenna is studied and simulated by using IE3D .The result is measured on VNA.

Here we are going to discuss some results like return loss,VSWR,radiation pattern and gain.It is observed that all results of the parameters i.e return loss, VSWR, radiation pattern and gain are improved at satisfactory level. This antenna gives better results because of parasitic line which is introduced on geometry of antenna. The observed S11 scattering parameter (return loss) of triple band rectangular slotted monopole antenna with parasitic line is shown below

Return Loss or S11 parameter

Return loss is the amount of signal that is reflected back towards the signal source by the device due to an impedance mismatch. It is the measure of hoe well device or line arematched. It is measured in dB. If the value of S11 parameter is 0dB, it means all the power is reflected from the antenna andnothing is radiated. Return loss is shown by graph below on different frequencies ie 2.4GHZ,5.2GHZ 8.1GHZ

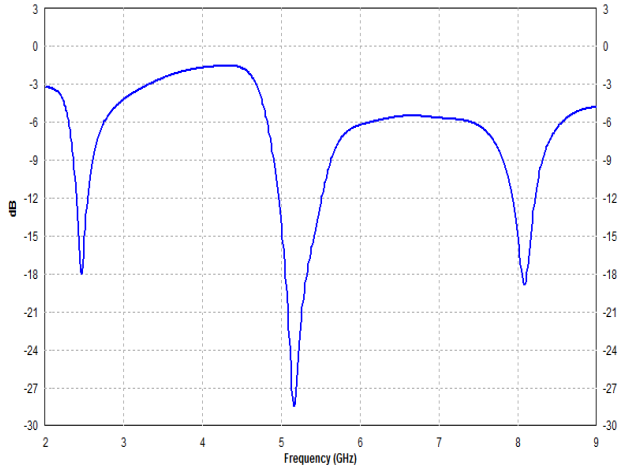
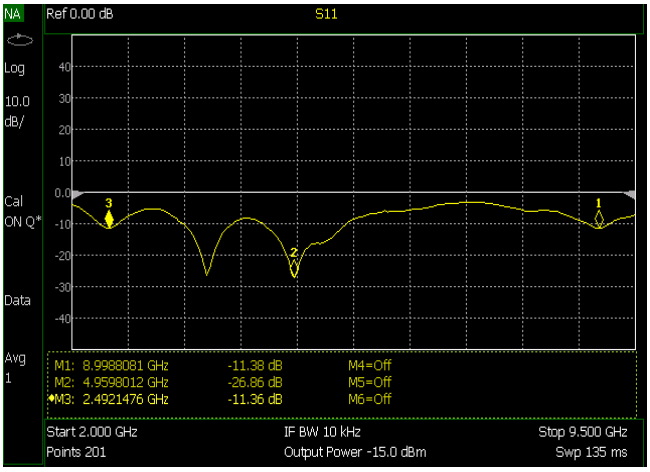


Figure 6 return loss v/s frequency

Measured results of return loss on VNA



VSWR

VSWR stands for voltage standing wave ratio.it is the measure of impedance matching of the characteristics impedance line or waveguide. Simply it shows the amount of mismatching between antenna and the feed line connecting to it. The range of values for VSWR is from 1 to ∞.

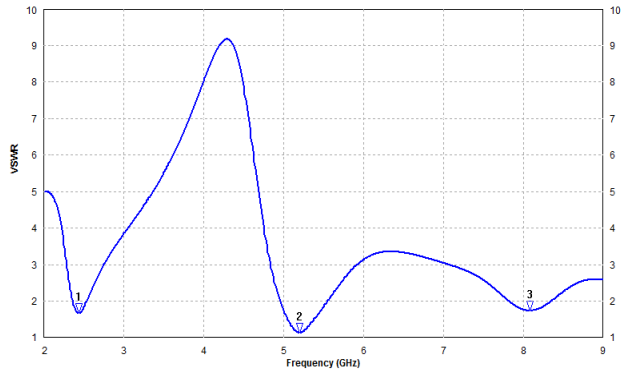
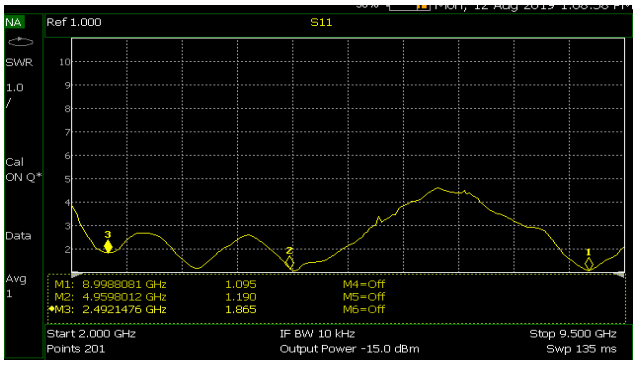


Figure 7 VSWR v/s frequency

MEASURED RESULT OF VSWR ON VNA



Gain v/s frequency graph of triple band rectangular slotted monopole antenna

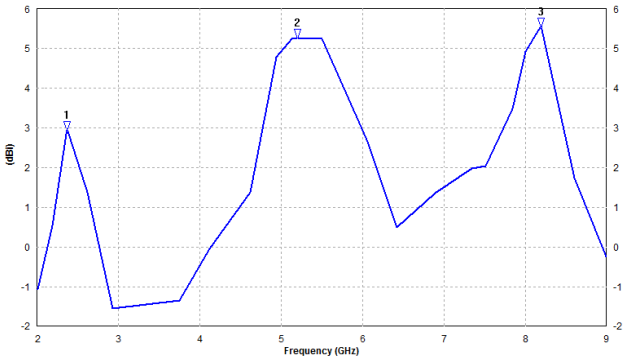
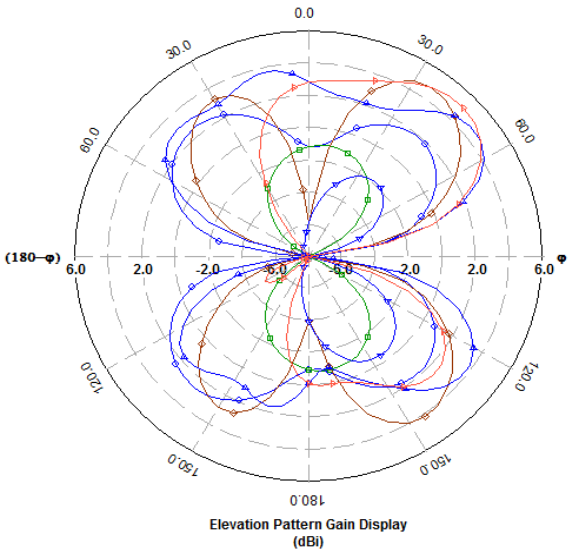


Figure 8 gain v/s frequency

Radiation pattern of triple band rectangular slotted monopole antenna



Results of Triple Band Rectangular Slotted Monopole Antenna with Parasitic Line

Sr. No.	Parameters	Triple band Rectangular Slotted Monopole Antenna with Parasitic Line		
1	Resonant Frequency	2.47 GHz	5.2 GHz	8.08GHz
2	Return Loss	-18.01 dB	-28.48 dB	-18.91dB
3	Bandwidth	210MHz	660 MHz	410MHz
4	Gain	3.0 dBi	5.25 dBi	5.60dBi
5	VSWR	1:1.28	1:1.07	1:1:25

IV. CONCLUSION

A compact triple band rectangular slotted monopole antenna with parasitic line designed for use in wireless communication systems utilizing the 2.45GHz ISM & S- band , 5.2GHz C-band and 8.08GHz X-band .The antenna presented here have bandwidth more than 100MHZ which is more than required. The monopole antennas were successfully important. It shows the good enhance impedance bandwidth of 680MHz about 12.7% at resonant frequency 5.2GHz. Its return loss was -28.48dB. This antenna has wide application in defence system, mobile communication, and ultra wide band. Overall this antenna is well suitable for wireless communication systems lamented results in terms of efficient performance.

REFERENCES

[1]C. A. Balanis, "Antenna Theory-Analysis and Design", John Wiley & Sons Inc. New York, 1997.
[2]P.K.M, S.Kumar, R. Jyoti, VSK Reddy and PNS Rao, "Novel Structural design for compact and broadband patch antenna" *IEEE*, Oct. 2010.
[3]Girish Kumar, K.P.Ray "Broadband Microstrip Antennas" Artech House, Boston *ISBN 1-58053-244-6*, 2003.
[4]Kin-Lu Wong "Compact and Broadband Microstrip Antennas" John Wiley & Sons Inc. New York, *ISBN 0-471-22111-2*, 2002.
[5]M.T. Islam "Broadband E-H shaped micro strip patch antenna for wireless systems" *PIER 98*, pp.163-173, 2009.
[6]K.Fong Lee, K.F.Tong, "Microstrip patch antennas –Basic characteristics and some recent advances" *Proceedings of IEEE*, pp.1-12, 2012.
[7]7.Kai F.L., S.L.S. Yang, A.A.Kishk and K.M.Luk, "The versatile U-slot patch Antenna" *IEEE Antenna and Propagation Magazine*, vol.52, no.1, pp.71-88, Feb. 2010.
[8]R.Caso, A.A Serra, M.R. Pino, P.Nepa and G. Manara, "A wideband slot coupled stacked patch array for wireless communication" *Antenna and wireless propagation letters*, vol.-9, pp. 986-989, 2010.
[9]S.A. Naghdehforushha, H.Oraiz, "Design of a Rectangular Metallic Monopole Antenna with Protruding Normal Plates for Applications in UWB Communication" *Progress In Electromagnetic Research C*, Vol. 51, pp.161-167, 2014.
[10] G. Madanan and D.Das, "A Compact Reactangular Monopole Antenna Design with an over feed for an improved uwb performance" RADIOENGINEERING, Vol. 27, No. 1, 2018.
[11] M. Alibakhshikenari, BAL S. Virdee and Chan Hwang See, **"**Wideband printed monopole antenna for application in wireless communication systems" IET Microwave. Antennas Propag. Vol. 12 Iss. 7, pp. 1222-1230, 2018.
[12] S. Baudha and S. K. Dhakad, "Miniaturized Compact Super Broadband Printed Monopole Antenna" IEEE Xplorer, 978-1-5090-5913-3/17, pp-30-33, 2017.
[13] Kang Ding and Cheng Gao, "A Broadband Circularly Polarized Printed Monopole Antenna with Parasitic Strips" IEEE Antennas and Wireless Propagation Letters, pp. 1536-1225, 2017.
[14] M. K. Khan, M.I. Khan, "Design of a Printed Monopole Antenna with Ridged Ground for Ultra Wideband Applications" Progress In Electromagnetic Research Symposium (PIERS),pp.4394-4396, 2016.
[15] Li Li, Xiaoliang Zhang, Xiaoli Yin and Le Zhou, "A Compact Triple-Band Printed Monopole Antenna for WLAN/WiMAX Applications" IEEE Antennas and Wireless Propagation Letters, VOL. 13, NO. 9, pp. 1536-1225, 2014.