



Design of Bandwidth Enhanced Rectangular Microstrip Patch Antenna With Rectangular Slot Using Partial Ground Plane Technique For UWB Applications

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Abstract – In this paper, design of Rectangular Microstrip Patch Antenna with Rectangular slot is proposed for Ultra Wide Band Application. . Microstrip feedline of 50Ω characteristic impedance is used to feed the patch. Partial ground plane technique is used to convert narrow band characteristics of Microstrip Patch antenna into wide band characteristics. FR-4 Epoxy Dielectric Substrate is used for design having $\epsilon_r = 4.4$ and having standard thickness of 1.58mm. The design was optimized by using CST Microwave Studio TM 2011 software to obtain most suitable configuration in terms of desired value of Return Loss, VSWR and Bandwidth for antenna.

Keywords: Rectangular Microstrip Patch Antenna, Partial Ground Plane, UWB, Bandwidth, Return Loss, VSWR, Gain.

I. Introduction

Now day's wireless gadgets has become a part of human life. A lot of electrical and electronic devices around us are using wireless system to communicate or operate. Antenna is an essential unit of wireless system which radiates electromagnetic waves into the space by converting electric power given at the input into the radio waves. At the receiver side antenna again receive these radio waves and convert them back into the electrical power^[1-2]. Antenna is widely used in cellular phones, smart phones, satellite communications, DTH service, spacecraft, radars, wireless door phones, laptops, tablets and wireless computer networks^[3]. Microstrip antennas are perfect for these application as it is light weight and can be easily integrated into antenna arrays or into microwave printed circuit boards. But these have a major drawback of narrow frequency bandwidth^[2]. Today's wireless systems work over wide band of frequency^[4] and hence the antenna should be capable for the same. In this research, an attempt is made to modify a narrow band antenna to work as ultra wide band antenna. By using techniques like partial ground plane^[5], slotting the patch, etc wide band characteristics have been observed^[6]. In microstrip antenna, a metallic layer of particular shape is bonded on a dielectric substrate which forms a radiating element and another continuous metallic layer on the other side of substrate as ground plane. Not only the basic shapes but any continuous shape can be used as the radiating patch^[7]. For satisfactory performance of antenna $VSWR < 2$ and Return Loss (R.L.) $< -10\text{dB}$ throughout the entire ultra wide band range^[8].

II. Description of work

A narrow band Rectangular Microstrip patch is designed. Then using partial ground plane technique wide band characteristics is observed by changing the parameters like length, width of antenna and length, width of ground plane. Effect of substrate thickness on return loss and frequency bandwidth has also been observed. Performance Analysis of designed antenna has been optimized in CST Microwave StudioTM 2011 software which utilizes finite Integration Technique for Electromagnetic Computation^[9]

III. Antenna Design Configuration

3.1 Rectangular Patch Antenna with rectangular slot:-

Rectangular Patch Antenna with rectangular slot on patch is shown in Fig1. Partial ground plane structure is used in place of ground plane structure to convert narrow band antenna into wide band antenna. FR-4 Epoxy Dielectric Substrate is used for design having $\epsilon_r = 4.4$ and having standard thickness of 1.58mm. Microstrip feedline of 50Ω characteristic impedance is used to feed the patch. The antenna design process is started by initially taking 8.2 GHz as resonant frequency. Performance of designed antenna has been optimised by varying the parameters of antenna given below in table 1

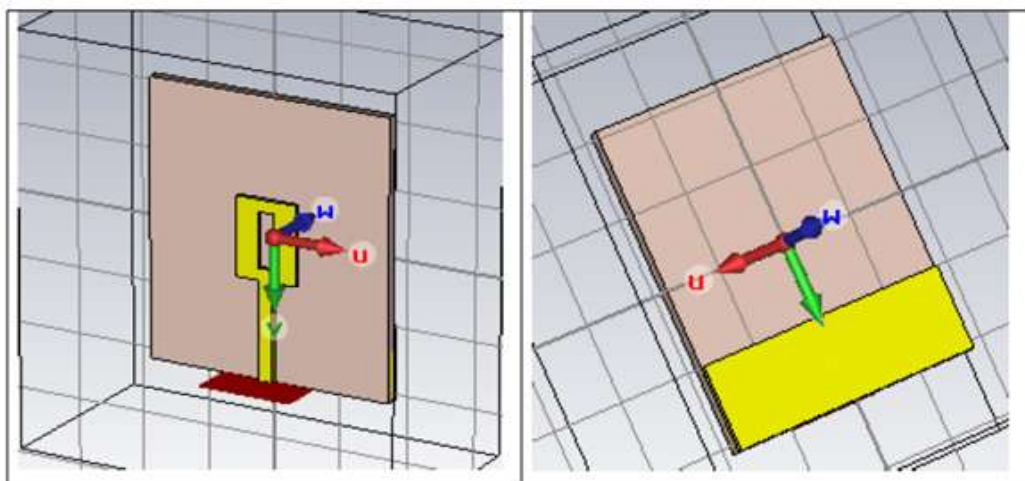


Fig. 1 Front and back view of Rectangular patch Antenna with slot on Patch.

3.2 Description of designed antenna:-

Table 1 represents Dimension of designed Rectangular patch Antenna with slot

Parameters	Description	Value(mm)
Lf	Length of feedline	7
Wf	Width of feedline	2
L1	Length of slot	5
W1	Width of slot	2
Lsub	Length of substrate	17
Wsub	Width of Substrate	20
Lp	Length of Patch	8
Wp	Width of Patch	11
Lg	Length of ground plane	4
Mt	Thickness of Patch	0.07
h	Thickness of Substrate	1.58

IV. Result and Discussion

The return loss, VSWR, gain and directivity of designed antenna for resonant frequency of 8.2 Ghz is shown below in Fig 2. (a, b, c, d) respectively .

It is observed that design achieves the return loss of -11.25 dB and bandwidth of 7.3 GHz (3.87- 11.17GHz) for resonant frequency of 8.2 Ghz and corresponding VSWR is 1.75.

The design antenna have Gain of 3.71 dB and Directivity of 4.58 dB These results make it suitable for UWB application.

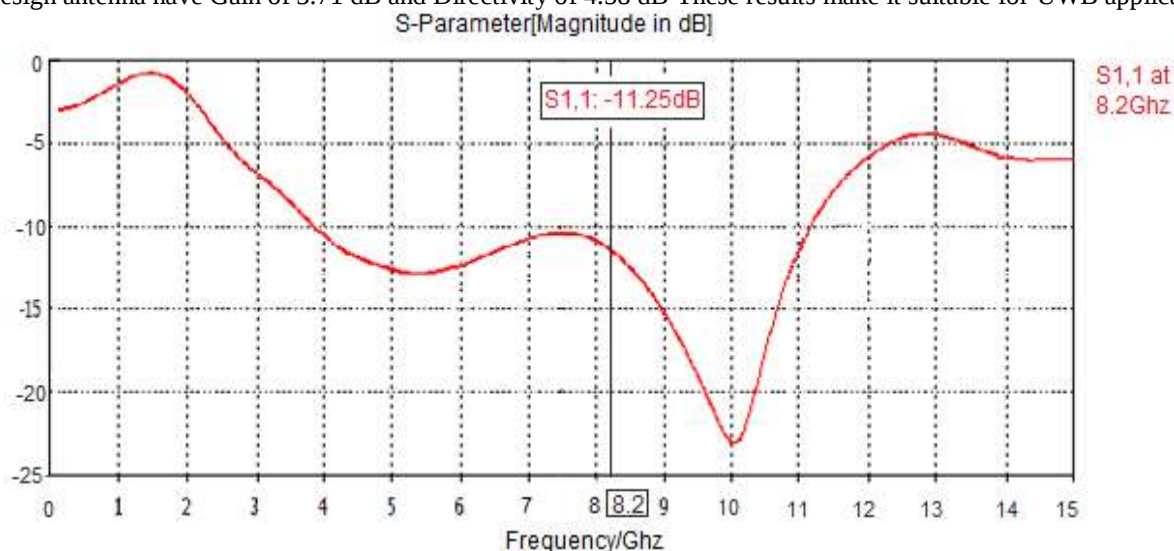


Fig. 2(a) Return Loss versus Frequency Plot

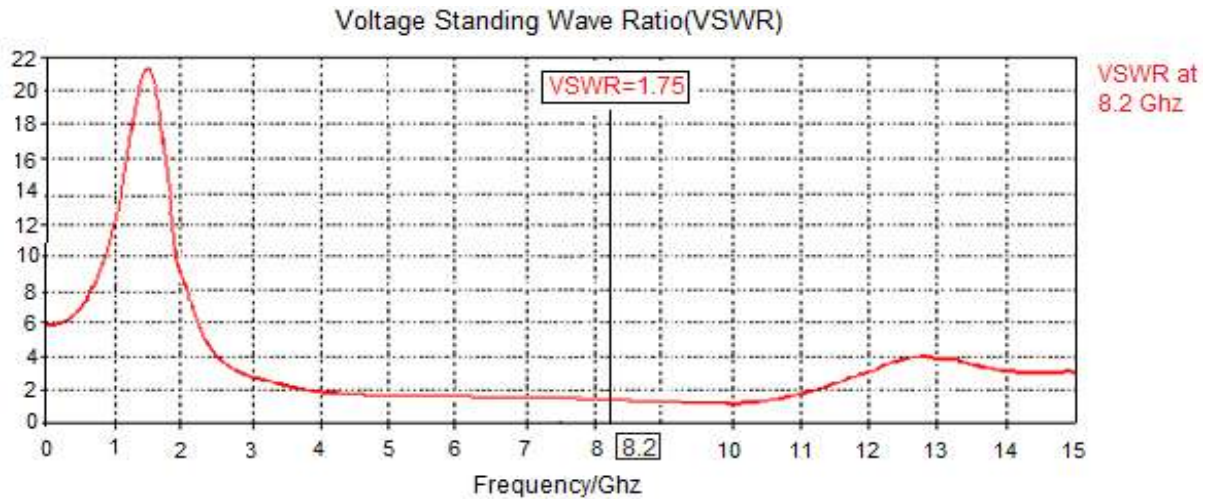
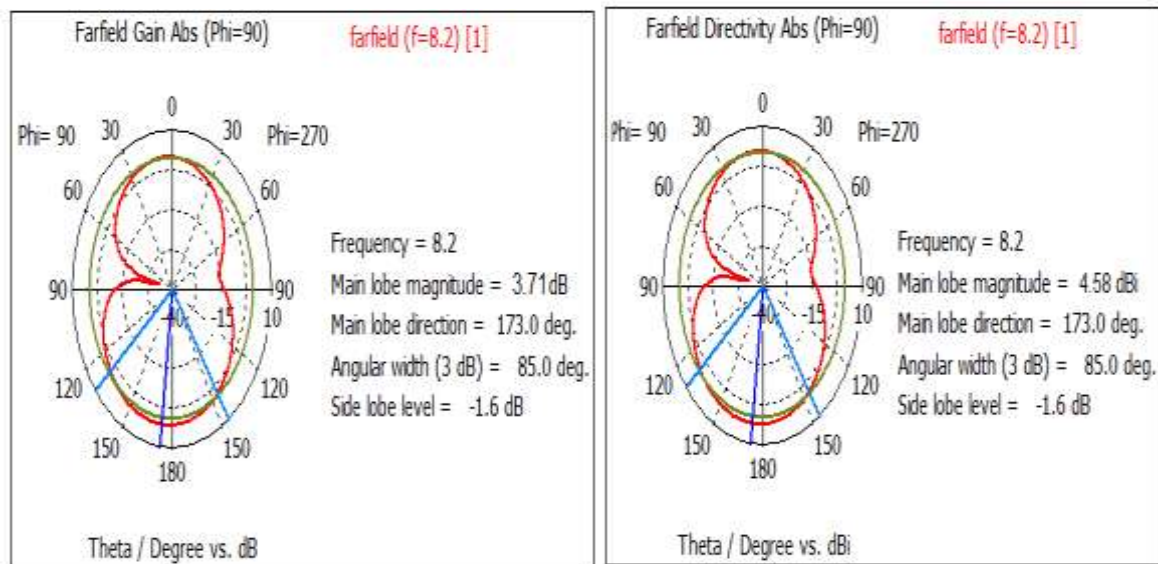


Fig. 2(b) VSWR versus Frequency Plot



2D Radiation pattern plot for- Fig. 2(c) Gain= 3.71 dB

Fig. 2(d) Directivity = 4.58 dB

4.1 Effect of Substrate Thickness on Return Loss, VSWR and Bandwidth:-

The results have been tabulated below for ease of understanding.

Table 2 Variation of thickness of substrate:-

No. Of Iteration	Substrate Thickness	Dielectric Constant	Operating Bandwidth (GHz)	Band width (GHz)	Return Loss (dB)	VSWR
1.	1.4	4.4	5.0-7.2 GHz 8.6-11.17 GHz	2.20 GHz 2.57 GHz	-8 dB	2.32
2	1.58	4.4	3.87-11.17GHz	7.30 GHz	-11.25 dB	1.75
3	1.65	4.4	3.8-11.17 GHz	7.37 Ghz	-12.10 dB	1.66
4	1.70	4.4	3.7-11.17GHz	7.47 GHz	-13.20 dB	1.56

Return Loss Plot for Various values of Substrate Thickness is shown below in Fig 3(a, b, c,d).

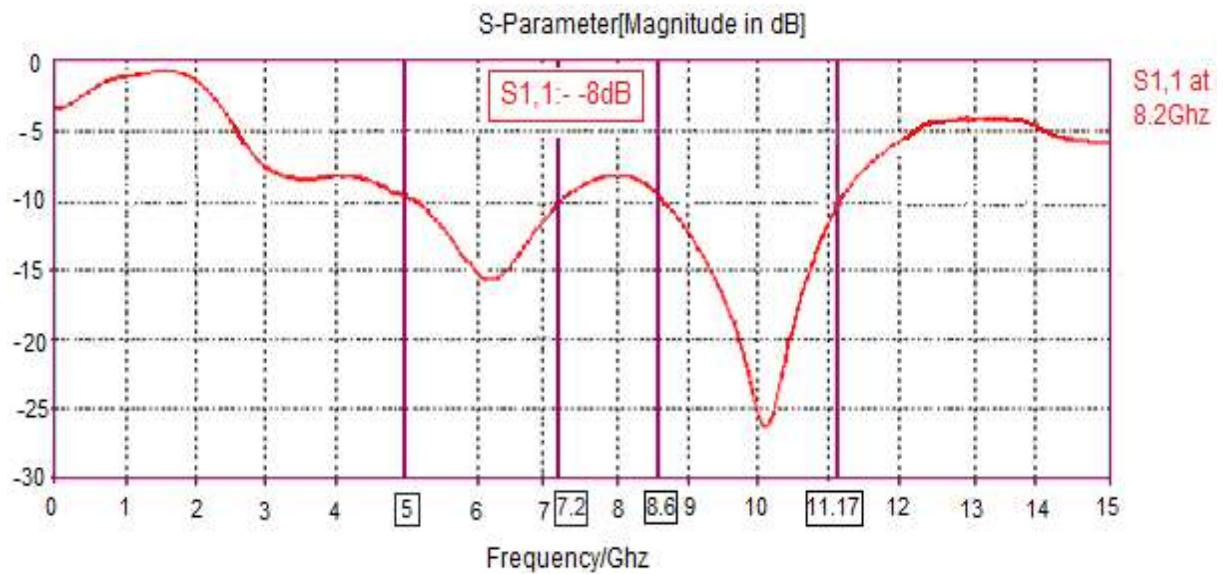


Fig. 3(a) Return Loss versus Frequency Plot for $h=1.4\text{mm}$, Return Loss = -8dB, BW=2.2 & 2.57GHz

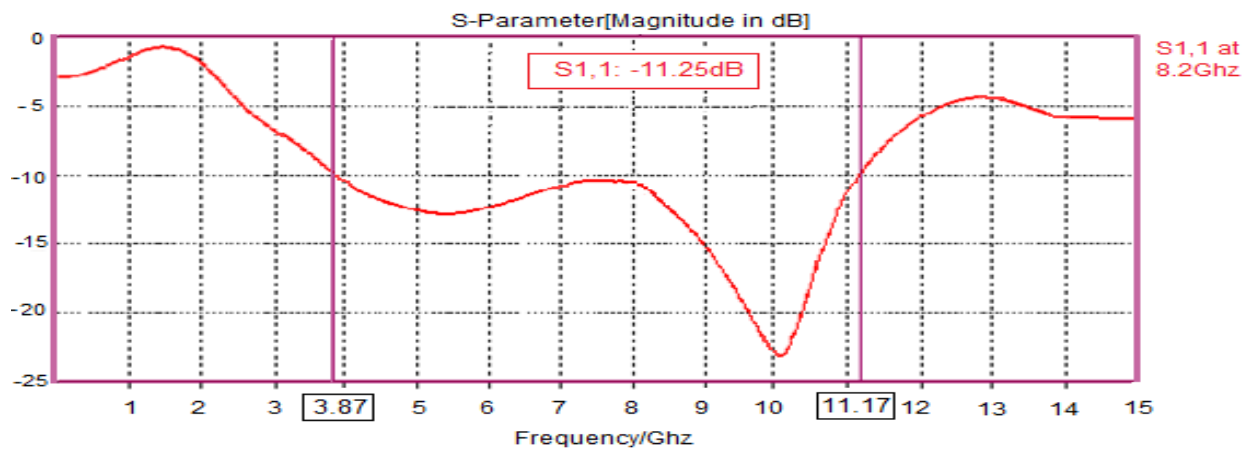


Fig 3(b) Return Loss versus Frequency Plot for $h= 1.58\text{mm}$, Return Loss = -11.25dB, BW=7.30 GHz

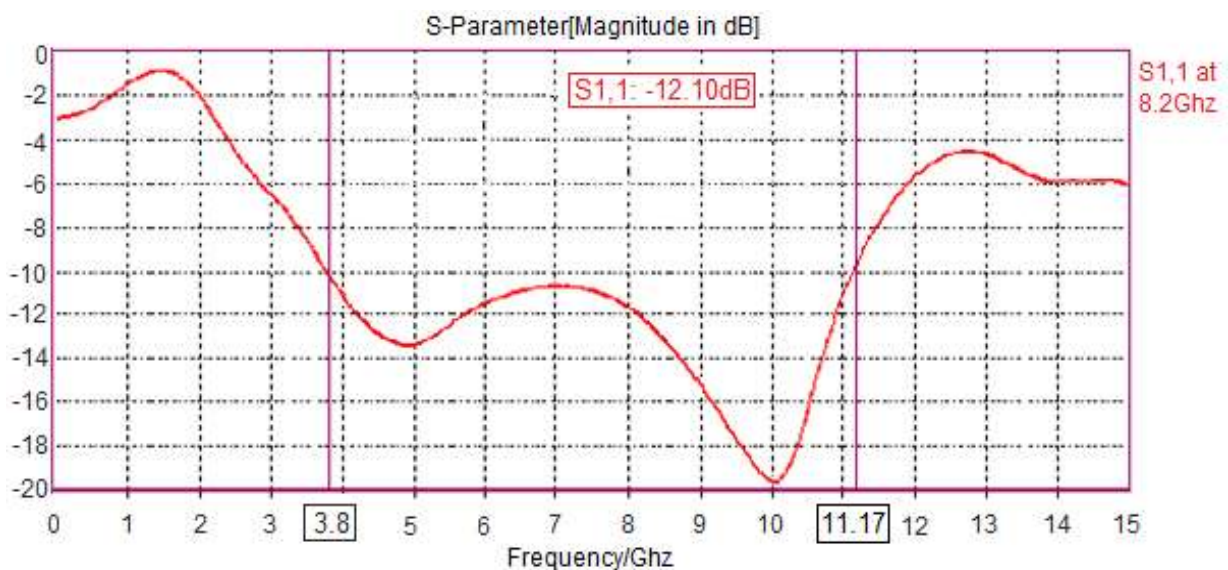


Fig. 3(c) Return Loss versus Frequency Plot for $h = 1.65\text{mm}$, Return Loss = -12.10dB, BW=7.37 GHz

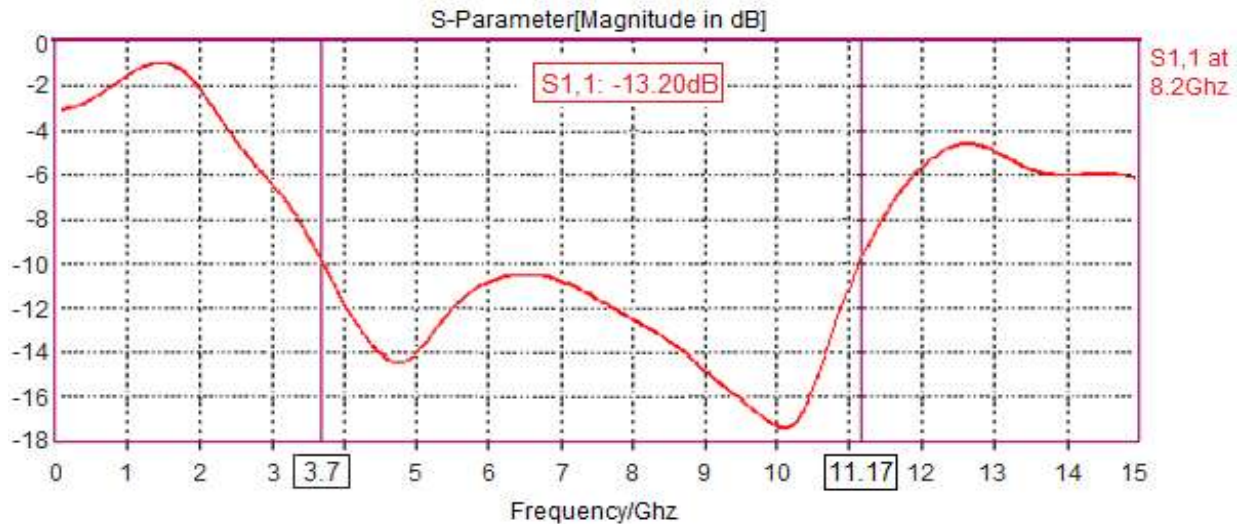


Fig 3(d) Return Loss versus Frequency Plot for $h = 1.7$ mm , Return Loss = -13.20dB, BW=7.47 GHz

From above plot we can say that with increase of substrate thickness bandwidth of patch antenna increases and value of Return loss and VSWR decreases which indicates that the radiation efficiency and performance of antenna improves with increases of substrate thickness. But it will make antenna bulky.

Thickness of substrate, can also be used for matching between feed line and patch so that maximum power can be transmitted from source to antenna and losses can be minimized.

V. Conclusion

In this paper, rectangular microstrip patch antenna with rectangular slot on patch is designed and simulated over CST microwave studio. Effect of variation of Substrate Thickness on Return loss, V.S.W.R and Bandwidth of Antenna has also been studied. Following conclusions can be made on the basis of above study:-

- 1) The designed antenna attains return loss of -11.25 dB and bandwidth of 7.3 GHz (3.87- 11.17GHz) for resonant frequency of 8.2 GHz and corresponding VSWR is 1.75. The design antenna have Gain of 3.71 dB and Directivity of 4.58 dB. These above results make it suitable for UWB application.
- 2) Partial ground plane technique is a simple and effective technique for attaining ultra wide band characteristics.
- 3) With increase of thickness of substrate, bandwidth of patch antenna increases and value of Return loss and VSWR decreases, but it will make antenna bulky.
- 4) By using thicker substrate and with proper coupling and feeding scheme radiation efficiency of patch antenna can be improved so that maximum power can be transmitted from source to antenna and losses can be minimized.

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REFERENCES

- [1] C.A. Balanis, "Antenna Theory Analysis and Design", 3rd Edition, New Jersey, John Wiley and Sons, 2005
- [2] Ramesh Garg, Prakash Bhartie, Inder Bahl, Apisak Ittipiboon, "Microstrip Antenna Design Handbook", pp. 1-68, 253-316 Artech House Inc. Norwood, MA, 2001.
- [3] Sana Ullah, Murad Ali, Md. Asdaque hussain, kyung sup kwak, "Applications of UWB Technology", *IEEE*, July 2010.

- [4] Suhana Rashid, Chandan Kumar Chakrabarty, "Bandwidth Enhanced Rectangular Patch Antenna Using Partial Ground Plane Method For WLAN Applications". The 3rd National Graduate Conference (NatGrad2015), Tenaga National University, Putrajaya Campus, Malaysia ,8-9 April 2015.
- [5] Parul Bansal, Ekambir Sidhu, Sonia Goyal, "Comparative Study of Notched Circular Slotted and Rectangular Slotted Microstrip patch antennas (MPA) for wideband applications" National Conference on Advances in Engineering and Technology, IJERA ISSN: 2248-9622 , 29th March 2014.
- [6] Abhishek Viswanathan, Rajasi Desai, "Applying Partial-Ground Technique to Enhance Bandwidth of a UWB Circular Microstrip Patch Antenna" IJSER, Volume 5, Issue 10, October-2014, ISSN 2229-5518.
- [7] Gary Breed, "An introduction to DGS in Microstrip Circuits", High frequency Electronics Summit Technical Media, LLC, November 2008.
- [8] S. Mishra, P. Wankhade and A. Sahu, "Design and analysis of T and U shaped slots with truncated corner rectangular microstrip patch antenna for return loss enhancement," *2016 Symposium on Colossal Data Analysis and Networking (CDAN)*, Indore, 2016, pp. 1-7, doi: 10.1109/ CDAN. 2016.7570902
- [9] <https://www.cst.com/products/cstmws>.