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Performance Evaluation of an Ultra Wideband Slot Antenna

Merin Susan Philip, M. J. Jayashree, Satyabhushan Shukla,
Department of Electronics and Communication
Mar Baselios College of Engineering and Technology Trivandrum & ISRO, Trivandrum

***Abstract*— In this paper, a rectangular stepped slot antenna with ultra wideband is evaluated under change in feed position, feed dimension and slot dimensions. Average peak gain of the slot antenna is 4.25dB and the bandwidth is 12.59GHz.The antenna is linearly polarized with an axial ratio of 40dB. The feed is placed orthogonally crossing the slot at the center to minimize cross polarization. A change in feed position deteriorates the polarization purity and bandwidth. Various changes in parameters affect the overall performance of the antenna. After introducing a metal box, gain has improved to 9.04dB and bandwidth has reduced to 2.359GHz.**

Index Terms— **Peak Gain, Polarization, Slot antenna, Ultra wideband antennas.**

I. INTRODUCTION

Ultra Wide Band (UWB) antenna gains its importance since we have an increasing demand for low profile antenna with large bandwidth and gain. As traditional communication schemes send sinusoidal waves, UWB radio systems transmit only pulses of very short duration. The role of UWB antenna is to transmit these pulses as accurately and efficiently as possible.UWB antenna have high data rate, small emission power, and low cost for short range access and remote sensing applications. Slot antenna with micro strip feed become popular in modern communication system as it has many advantageous features such as low cost and ease of implementation. Yoshimura is the one who first proposed micro strip fed slot/slot line antenna. Theoretical analysis of slot antenna by applying Babinet's principle to a slot [1] as the principle states "when the field behind a screen with an opening is added to the field of a complementary structure, the sum is equal to the field when there is no screen". Babinet's principle suggests methods for handling radio waves at centimetre wavelengths and it is able to aid solution for the leakage of electromagnetic radiation through a hole in a metal wall [6]. Also the analysis of printed linear slot antenna using lossy transmission line model is investigated in [3]. In [2], a U-shaped tuning stub is used to improve matching in a slot antenna backed by reflector gives an impedance bandwidth of 110%. Also an increase in bandwidth can be observed while changing the feed to CPW (Coplanar Waveguide Feed).Techniques are employed to improve the gain and bandwidth of a slot antenna such as changing the feed dimensions, introducing a reflector [2]. Usually, loop antenna and slot antenna are the two classes of horizontally polarized antennas. In [4], a horizontally polarized Omni-directional loop antenna shows a desirable performance over frequency range of 2.35-2.55 GHz. By method of moments and matrix pencil method a full wave

Analysis for a rectangular wide slot antenna fed by a micro strip line has been described [5]. In this paper, the performance of a rectangular stepped slot antenna with micro strip feed with an ultra wide impedance bandwidth (12.59GHz) is evaluated by changing the parameters. Further, studies on the effect of the interaction between feed and slot on impedance bandwidth and radiation patterns is discussed. Also by introducing a metal box, gain and directivity of the antenna is evaluated.

II. SLOT ANTENNA DESIGN AND RESULTS

The slot antenna has a dimension of 57mm x 32mm. FR4 with relative permittivity ε_r=4.4 and thickness 1.6mm is used as the substrate. The dimensions of slot and feed of the antenna are S_{1L} = 20.33mm, S_{1W} = 3.5mm, S_{2L} = 8.32mm, S_{2W} = 8mm, S_{3L} = 9.88mm, S_{3W} =12mm, W_{M1} = 3.2mm, L_{M1} = 11mm, W_{M2} = 1.9mm, L_{M2} = 5mm, W_{M3} = 9.25mm, L_{M3} = 8mm.

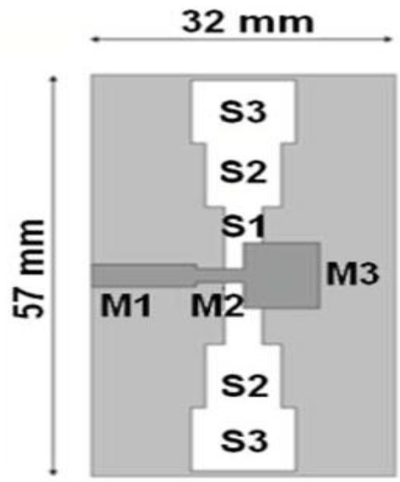

Fig: 1: Antenna Configuration [7]

The design of the slot antenna is shown in Figure: 1. the simulation tool used for designing the antenna is CST Microwave Studio. The ground plane is having the slot. The microstrip feed is placed over the substrate (FR4). The microstrip feed is placed such that it crosses the slot orthogonally at the center to reduce cross polarization.

The S-parameter of the simulated antenna with an impedance bandwidth of 12.59GHz is shown in Figure: 3.

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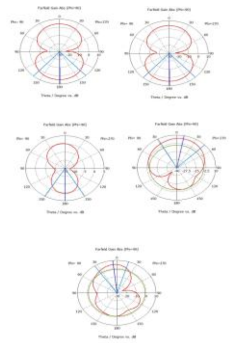

Fig 2: Radiation pattern at different frequencies such as 3.2 GHz, 4GHz, 6 GHz, 9GHz and 10.5GHz

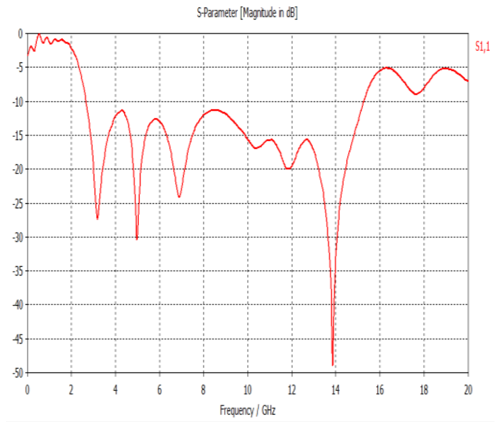

Fig: 3: Simulated S-parameter of the antenna

The simulated radiation pattern obtained at 3.2GHz, 4GHz, 6GHZ, 9GHz and10.5GHz are shown in Figure:2. The gain obtained at 3.2GHz is 3.8dB with an angular width of 86.9 degree. At 4GHz, gain is 4.3dB with an angular width of 83.7 degree. At 9 GHz and 10.5 GHz the gain obtained is 4.9dB.

III. EFFECT OF PARAMETRIC CHANGES IN ANTENNA

A. Change in Feed position

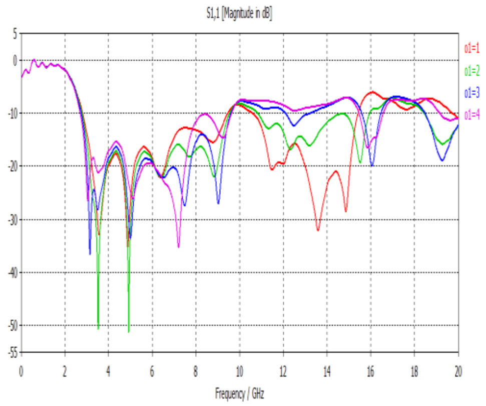

Fig 4:: S-parameter graph showing different feed position effects

When the feed is placed exactly at the center, cross polarization is less. The axial ratio obtained is 40 dB which is definitely linearly polarized. The s-parameter also varies according to the change in feed position which is shown in Figure 4. A decrease in impedance bandwidth as the feed position changes from 1 to 4 is clearly evident from the figure. Here O1 is the change in feed position from centre and the variation in bandwidth with change in feed is depicted in Table I.

Table I. Variation of bandwidth on feed position

Change of feed position from center	Bandwidth
O1=1mm	12.5GHz
O1=2mm	7.25GHz
O1=3mm	7.11GHz
O1=4mm	7.00GHz

B. Change in Slot width & Slot length

The slot width & slot length plays a crucial role for tuning and matching the impedance of the structure to the microstrip line .The effect of changing slot width and slot length is clearly evident from the reflection coefficient graph. Increase in slot length deteriorates the impedance match. A slot length of 9.88- 10 mm gives a good bandwidth of about 12.6GHz.The s-parameter graph for different slot width and slot length are shown in figure 5and 6.The variation of bandwidth against slot length and slot width are respectively shown in Table II and Table III.

Table II. Variation of bandwidth on slot length

Slot length	Bandwidth
S3l=9.00mm	5.02GHz
S3l=9.88mm	12.58GHz
S3l=10.00mm	12.65GHz
S3l=12.00mm	8.72GHz

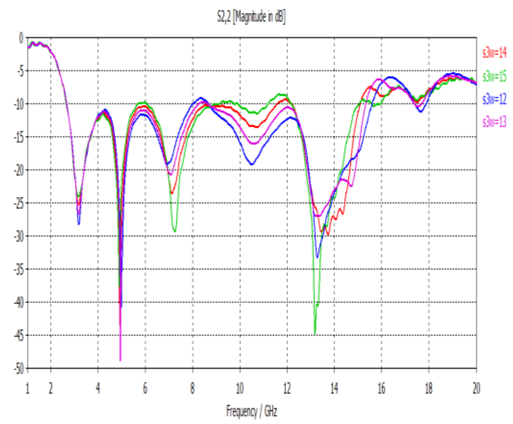

Fig 5: S- parameter graph on different slot length

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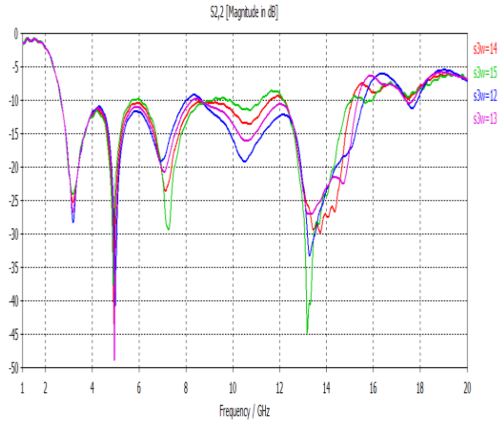

Fig 6: S- parameter graph on different slot width.

Table III. Variation of bandwidth with slot length

Change in slot width	Bandwidth
S3w=12mm	5.23GHz
S3w=13mm	12.49GHz
S3w=14mm	8.63GHz
S3w=15mm	8.33GHz

C. Effect of feedline edge cutting

The micros trip feed is used to match the impedance. When the feedline edges are cut, the bandwidth get reduce to 5.65GHz. The antenna configuration and s-parameter graph are shown in figure 7 and 8.

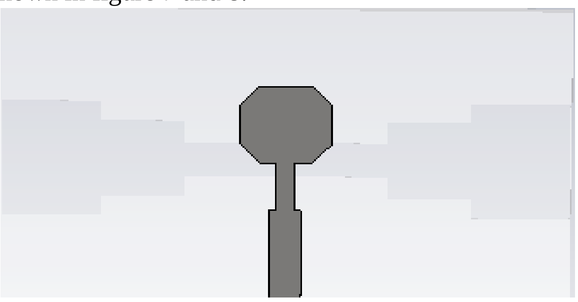

Fig: 7: Antenna configuration

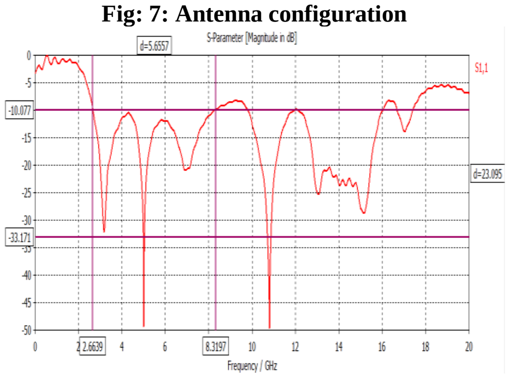

Fig 8: The s- parameter graph of feedline edge cut antenna

IV. SLOT ANTENNA BACKED BY A METAL BOX

The radiation pattern of a slot antenna is bi-directional. In order to make it uni-directional, slot antenna is backed by a metal box. The s-parameter graph and radiation pattern get changed due to the effect of metal box. The s- parameter graph is shown in Figure 10.The bandwidth has reduced to 2.34GHz but the gain has increased to an average of 9.5dB which is really good. Aluminium is the material used here for making the metal box with μ =1.

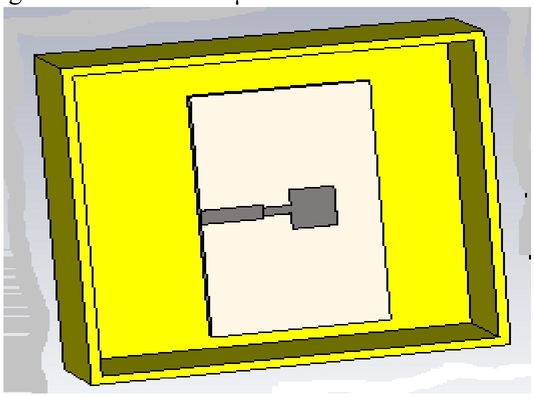

Fig 9: Slot antenna backed by a metal box

The metal box act as a reflector which prevents the backside radiation, normal to the ground. As a result the radiation pattern changes to unidirectional as shown in Figure 11. A square metal box is used with a dimension of 75mm x 75mm as shown in Figure 9.

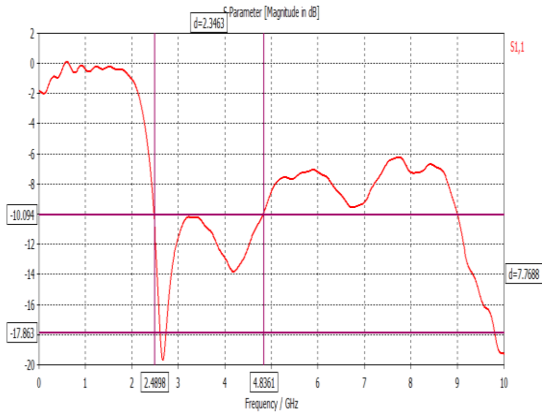

Fig 10: S parameter graph of a slot antenna backed by a metal box

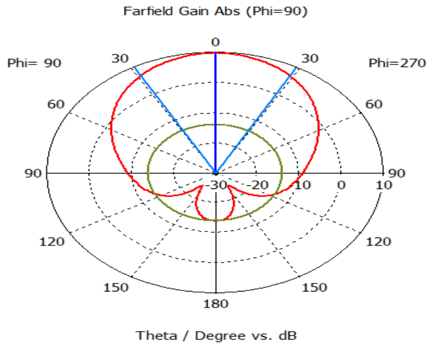

Fig 11: Radiation Pattern of a slot antenna backed by a metal box

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V. CONCLUSION

A rectangular stepped slot antenna is simulated which gives an average gain of 4.25dB and bandwidth of 12.59GHz. The performance of this slot antenna has been evaluated by changing various parameters like slot length, slot width, feed position and feedline edge cutting. The effects of these parameters on gain and bandwidth have also been discussed. The designed slot antenna gives a bi-directional radiation pattern. Finally, the slot antenna with a metal box gives unidirectional radiation pattern with an average gain of 9.5dB and bandwidth of 2.34GHz.The bandwidth of the slot antenna designed in this paper is ultra wide. But this entire bandwidth cannot be used as such, since the WLAN and WiMAX technologies operate within the range of the designed antenna, leading to interferences. This problem can be avoided by notching at WLAN and WiMAX frequencies. Researches are carrying out in this area as a future work.

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