Antenna Designing for Ground Penetrating Radar (GPR)

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***Abstract*— This paper presents the research work in which we have designed bow-tie antenna for ground penetrating radar (GPR) system which is having high performance and wide bandwidth. Our aim is to use the antenna for extraction of agricultural soil characteristics. This antenna is designed for the frequency of 200-800 MHz in which lobes of antenna radiate to ground direction. Our aim is designed antenna should having wide bandwidth and ideal gain of 5dB. Aluminum bottom cavity is placed at particular height (λ/4) to maintain unidirectional radiation pattern and wide bandwidth. In this design hexagonal patch has to be introduced near to the opening of slot so that patch get excited by using the concept of coupling effect . PVC plastic pipes are used to connect antenna and aluminium cavity. Both transmitter and receiver antennas is kept apart at minimum distance(λ/2) to attain desired results. The antenna is contoured using HFSS 17.2 software.**

Keywords*— *Antenna Bandwidth (BW), Antenna feeds, Ground Penetrating Radar (GPR), PVC Plastic pipes.

I. INTRODUCTION

GPR systems are based on the detection of the backscattered signal from targets. They work by emitting electromagnetic energy that travels into the ground and by recording the echoes caused by the reflections from any targets. GPR have many applications such as landmine detection, thickness of ice layer detection, void detection, in civil engineering, moisture detection etc. GPR is having three different sections while developing has to be decided, signal processing section, data acquisition and processing section and antenna section[3].

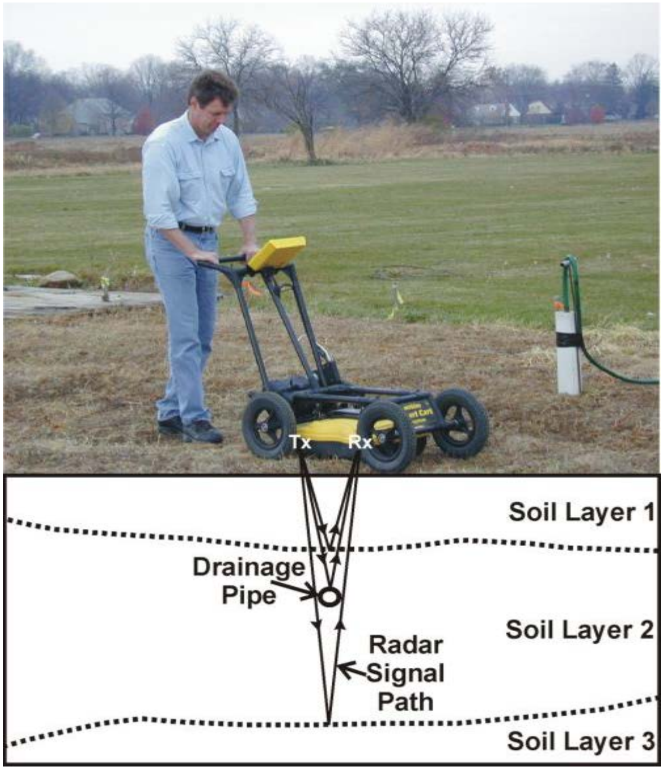

Fig.1. Basic block Diagram of GPR system

Antenna is the dominant part of GPR system, since if the antenna fails to perform transmission and reception of EM signal then there is no role of other sections. In additions important expects are: the wide-bandwidth, high gain, unidirectional radiation patterns and good resolution. It Consist of transmitter antenna, receiver antenna, electronic unit for processing the signals and display and control unit which displays appropriate information to the user. From the above points the motive is we have to design and develop such antenna that can fulfill the desired constraints for the GPR. Also the proposed GPR antenna will work for soil characteristics measurements.

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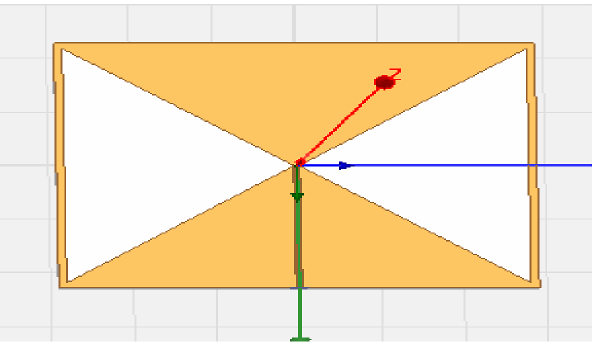
(SAMMER)] as research project at SAMEER laboratories at IIT Bombay (IN).

II. DESIGN STRATEGY OF ANTENNA

Bow-Tie antenna provides wide bandwidth as compare to microstrip patch antenna. Because of simple construction, wide bandwidth, high gain, low front-to-back ratio(FBR), low cross-polarization level, and small size of the bow tie antenna it is so much popular. In bow-tie antenna triangular pieces separated by some space. So to achieve maximum efficiency and directivity it is centrally feed. The feeding structure is done at the gap by designing relevant strip lines.

A. Bow-Tie Slot Antenna for GPR

Basic shape of bow-tie slot antenna is shown in Fig.1A which is designed as length*width(370*238)mm dimensions in HFSS. In Fig.1A yellow part indicates ground plane of bow-tie and the slots of antenna indicated by red color. Design verification is done by changing the different parameters like w1, w2 and space (s). We have set the parameters as per calculation such as L=370mm, W=238mm, w1 & w2 is 0.4mm, s=2.8mm, substrate of FR-4 material having thickness 1.6mm is used. w1 and w2 are conductors and 's' is the space between the conductors (w1 & w2)[1]. The formula for the characteristic impedance of a bow-tie antenna is :



1A. Basic Bow-Tie Antenna

$$Z_C = 120 \ln \operatorname{Cot} \theta_o / 4 \qquad (1)$$

Where θ_o is the opening angle of two triangular pieces of bow-tie.

B. Feeding Structure for GPR Bow-Tie Antenna

We have used strip line feed for this antenna as shown in Fig.1B for the antenna excitation. We kept the length of the transmission line is 119mm which used for feeding and width(s) is 0.4mm as by calculation. Formulae for length and width given below [2].

$$Lp = 4(hs), \qquad (2)$$

$$Wp = 3(2g+ws). \qquad (3)$$

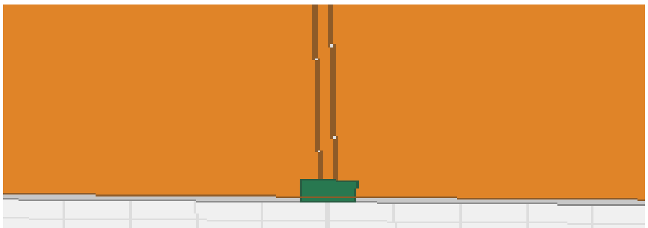


Fig.1B. Feeding Port Structure for GPR Bow-tie Antenna

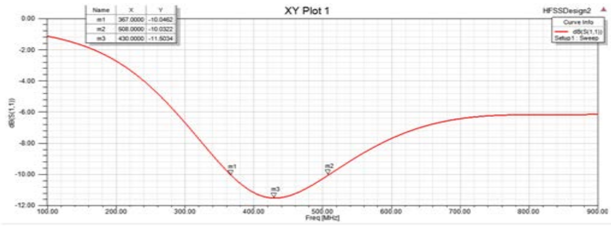
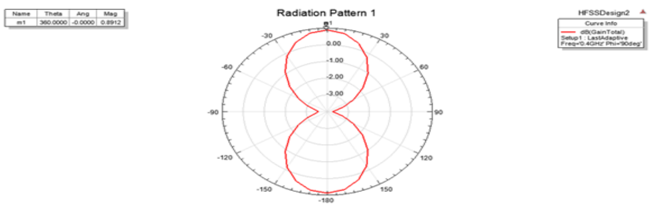


Fig.2B. Return loss of GPR Bow-tie Antenna



Name	Theta	Ang	Mag
m1	360.0000	-0.0000	0.8912

Fig.3B. Radiation Pattern and gain of GPR Bow-tie Antenna

Above figures shows the return loss and radiation pattern. We observed the gain of antenna is not to the desired constraint and also radiation pattern is not in single direction. So to enhance both these parameters we have used concept of bottom cavity which will increase gain and bandwidth also [4].

C. Introducing Bottom Cavity to Antenna

To enhance bandwidth and gain of the antenna, bottom cavity is placed as shown in Fig.1C. Here we have placed only bottom cavity[3]. The bottom cavity is placed at height of 188(λ/4) mm. This distance can be verified parametrically by optimization in HFSS. Return loss of bow-tie slot antenna with bottom cavity is shown in Fig.1C. Radiation pattern of antenna is improved radiating maximum signal to one direction. Gain the antenna 4.41dB at 407MHz frequency.

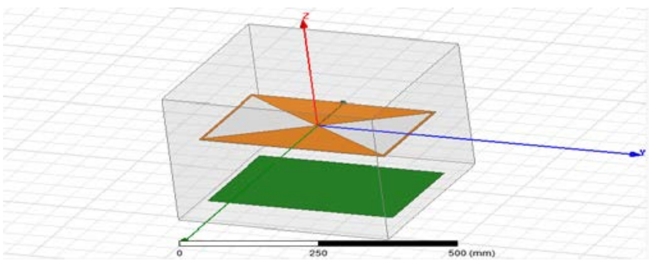


Fig.1C. Bottom Cavity at 188mm(λ/4) Height

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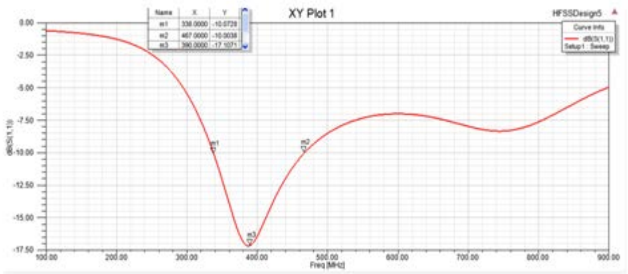
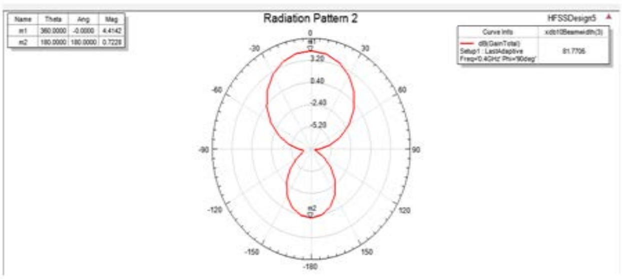


Fig.2C. Return Loss with Bottom Cavity at (λ/4) Height



Name	Theta	Ang	Mag
m1	360.0000	-0.0000	4.4142

Fig.3C. Radiation Pattern and gain with Bottom Cavity at (λ/4) Height

D. *Hexagonal Patch Into Slot of Antenna*

We studied that if the size of antenna increases BW will also increase [2]. Therefore we have connected patch into the slots of the antenna as shown in figure below.

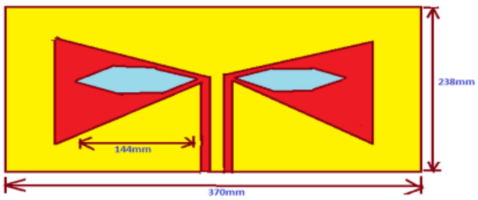


Fig.1D. Introduction of Hexagonal Patch into slots of Antenna

From the Fig.2C we observed that return loss is enhanced but the bandwidth not to the desired constraint. Since we are getting the peak at 522MHZ , we have introduced hexagonal patch having length of 144mm. Patch has to be introduced near to the opening of slots so that patch get excited by using the concept of coupling effect. PVC plastic pipes are used to connect antenna and aluminium bottom cavity.

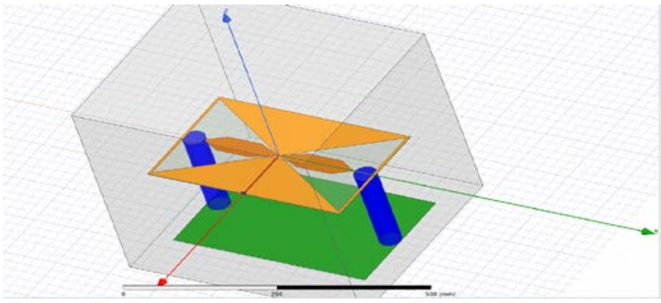


Fig.2D. HFSS Design with Hexagonal Patch

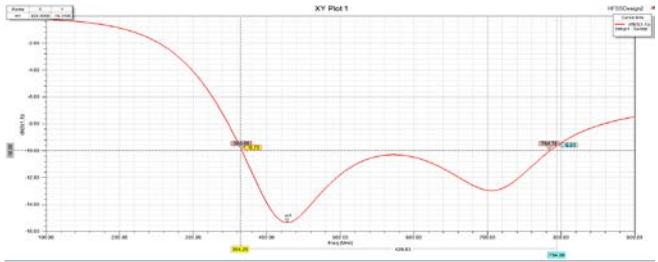


Fig.3D. Return loss of GPR Bow-tie Antenna with Hexagonal Patch

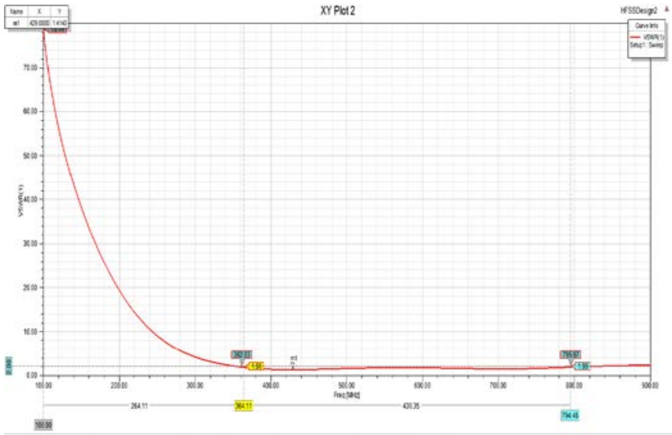
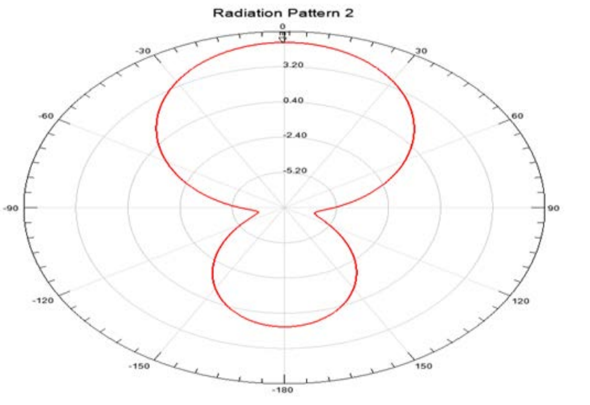


Fig.4D. VSWR of GPR Bow-tie Antenna with Hexagonal Patch



Name	Theta	Ang	Mag
m1	360.0000	-0.0000	5.1258

Fig.5D. Radiation Pattern & Gain with Hexagonal Patch

We have got simulation results as per desired constraints. Bandwidth reaches to 429MHZ and gain almost 5.12dB and VSWR is also less than two.

III. CONCLUSION

We have been studied and designed bow-tie slot antenna for Ground Penetrating Radar(GPR) system. We also seen that because of introduction of bottom cavity we got the radiation pattern in single direction and because of introduction of small hexagonal patch between slots of antennas bandwidth is increased. We got the desired BW of 429MHZ and Gain 5.12dB. We have studied that penetration depth increases due to low frequency. Because of wide bandwidth will get higher data rate and resolution also. So with proper bottom cavity and hexagonal patch we acquired wide bandwidth and gain at proper center frequency.

REFERENCES

[1] C. Guo and R. C.Liu, "Design of a Shielded Antenna System for Ground Penetrating Radar", *Antennas and Propagation Society International Symposium*, pages 1-6, 2009.

[2] Umesh K. Deshmukh, Yogesh K Choukikar, Bhaskar Naik S."Design of CPW Fed bow-tie slot antenna for ground penetrating applications",*IEEE International Conference On Recent Trends In Electronics In-formation Communication Technology*, Pages:1820-1823,2016.

[3] J. Bourgeois and G. Smith. A fully three dimensional simulation ofa ground-penetrating radar: FDTD theory compared with measurements, *IEEE Transactions on Geoscience and Remote Sensing*, Vol.34, pp. 36-44, 1996.

[4] Ranasinghe, H. M. P. B., S. M. P. Senanayake, U. I. P. Senarathne, A.U. A. W. Gunawardena, and D. N. Uduwawala, "Design of a low cost cavity backed wideband bow-tie antenna for ground penetrating radar systems", *8th International Conference on Industrial and Information Systems*, 2013

[5] C. A. Balanis, Antenna Theory Analysis and Design, 3rd ed., New Jersey: John Wiley and Sons, Inc, 2005

[6] David J. Daniels (2004). Ground penetrating radar, 2nd edition, London, United Kingdom

[7] https://en.wikipedia.org/wiki/Groundpenetratingradar

[8] www.google.com