International Journal of Academic Research and Development
ISSN: 2455-4197
Impact Factor: RJIF 5.22
www.academicsjournal.com
Volume 3; Special Issue 2; March 2018; Page No. 144-148

Design of UWB antenna and transmit/receive of soil parameter through underground communication

Vandana Laxman Bade
Department of Electronics &Telecommunications, G. H. Raisoni College of Engineering & Management, A'nagar Ahmednagar, Maharashtra, India

Abstract
Wireless Underground Sensor Networks (WUSN) consists of buried sensors nodes which are expected to communicate through the soil. The significantly high attenuation caused by the soil properties is the main challenge for their feasibility. This paper tries to elaborate the design of a compact Wide Band Antenna, which is used as vehicle mounted ground penetrating Radar to identify landmines. The aim of this paper is to design a micro strip patch antenna as a Ground Penetrating Radar operating in the WiMAX band of 3.51 GHz with micro strip feeding. This paper presents the design of Micro strip patch antenna with slot for wide band applications. The micro strip patch antenna with slot have been on FR4 substrate (*g*r=4.3) with overall size of 40mm x 40mm.The proposed antenna with DGS ground offers excellent wide-band performance ranging from 3.20 GHz to 3.70 GHz. The antenna exhibits bandwidth of 520 MHz. The simulated radiation pattern of micro strip patch has been observed nearly omnidirectional. Such type of antenna can be used for UWB system. This paper also studies the impact of the soil on performances of a new small wide band buried antenna and then analyzes the effect of depth of penetration of the communication link from underground to above ground. This study includes the effect of soil depth. The simulations results show that with short distances underground to above ground UWB wireless communication is possible.

Keywords: wireless underground sensor networks, wide band, antenna, defleced ground structure (DGS), ground penetrating radar (GPR), underground communication, and soil medium

1. Introduction

The technologies of WSN (wireless sensor network) are enormously developed in active area of research. The various application of the UWB antenna has attracted hugely improved in resent year such as in navigation, i n underground mines, security, agriculture security. [1][2]. in this paper the technology is basically depend on the underground UWB antenna and above ground UWB antenna transmitting and receiving respectively [4] This underground sensor network node i.e UWB antenna plays important role in resent research and this buried UWB antenna has various application such as sensor network, traffic control [1]. Ultra wide band technology is as a system that occupied over 500MHz of bandwidth or occupy a fraction bandwidth of 20%or greater Based on the antenna point of view, UWB technology covers today three major types of applications (a) Ground Penetrating Radars (GPR), (b) Signal intelligence and detection and (c) modern UWB operating in a 3.1 to 10.6 GHz frequency band [6].

Around every 22 minutes somewhere in this world is somehow or the other is killed or injured by the landmine. Exorbitant amount of land go unused due to the fear of land-mines. Sophisticated technology used to detect the landmines basically metal detectors, nuclear magnetic resonance, and thermal imaging and electro optical sensors. The landmine de-tection by ground penetrating radar (GPR) has become one of the main challenging applications for ultra-wide band (UWB) radar technology. Non-destructive method uses electromag-netic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum, and detects the reflected signals from subsurface structures. [7] in this paper according to buried antenna UWB tech- nology a three type of communication is deploying under- ground sensors nodes and above ground transceivers that is communicate through soil. First is underground to underground communication link, second is underground to above ground communication link, third is above ground to underground communication link [3] this is depend on the location of the transmitter and receiver and depth of buried antenna. [4] In this paper the using UWB buried antenna measure the parameters like depth of soil, channel attenuation between the antenna, properties of wave propagation, return loss, ground conductiv- ity [4]. Here the electromagnetic wave propagation character- istics in underground environment like soil water, moisture
texture have been presented which is basically depend on electromagnetic field theory [5, 3]. The UWB wireless sensor network is studied by using simulation and its measurements and calculated various parameters. The simulation are per-formed using HFSS software. The properties of soil which impact on performance of attenuation, conductivity and return loss that depends on depth, frequency and soil moisture. The operational frequency band and burial depth that impact the path loss with increasing and decreasing frequency. In this paper it was found that wave propagation above the ground faster than below the ground. The operational frequency band (3.5 to 3.7Ghz) gives the better performances of the simulation.

This paper is organized as: The Section II introduces related work on UMB technology. The Section III gives a detailed description about our proposed model for wide band Antenna. In Section IV we explained design methodology. Section V will explain impact of soil on ultra wide Antenna. In Section VI we given comparison table of UMB technology. Finally, we give conclusions in Section VII.

2. Related Work

H.ZEMMOUR, Antoine DIET explain impact of soil on UWB buried antenna and their performance is calculated also burial depth on a small UWB buried antenna, return loss and soil moisture as well as various communication links are studied for ultra wide band (WUSN) application [1] Hamadache zemmour. It is observed that experimental result for the channel attenuation versus frequency and different position of the UWB buried depth. On other hand the strong impact on the underground to above ground of soil moisture and burial depth. In underground to above ground communication link with the rising of soil moisture that increase the attenuation of the propagating signal, if when we increase the frequency range. From this research it is studied that soil is denser than air and gives the high complex permittivity [1]

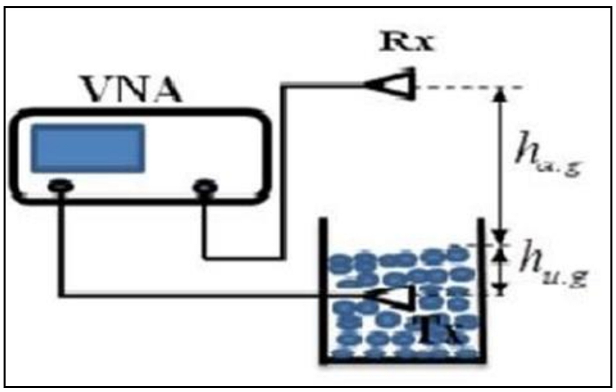

Fig 1: Measurements setup

Fig.1 shows that underground to above ground transmitting and receiving antenna communication investigate the impact of soil on UWB buried antenna performance. Transmitting antenna hug and is placed underground and hag is=1cm is placed above ground with some height and parameters is calculated using vector network analyzer (VNA). A channel models based on time domain are developed for the under-ground above ground, underground-underground and above ground-underground electromagnetic wave channel that gives the effect of environments parameters like soil moisture, soil composition and parameters of the system like operating frequency and gain of antenna, and the depth of burial antenna. In [3] Huxiaoxa and Gao Chao it is studied that properties of soil which directly impact on communication link.

The resent research based on WSN that depends on EM waves and focus on the agriculture irrigation control thatmoni- tor soil conditions like water and mineral content [2] also focus reliable reporting of soil moisture under different whether condition. In [2], Vonod, Hong the aim of the experiments and simulation results is that build a sensor network to regulate adequate water flow to the tress that shows the maximum yield and conservation of waters. This research is designed for the monitoring, reporting and regulating soil moisture condition for typical farm.

3. Proposed Wide Band Antenna Design

The realized prototype and structure of the proposed new small UWB buried antenna and its optimal geometric parameters are given in Fig.2. It has a circular shape. It is based on a

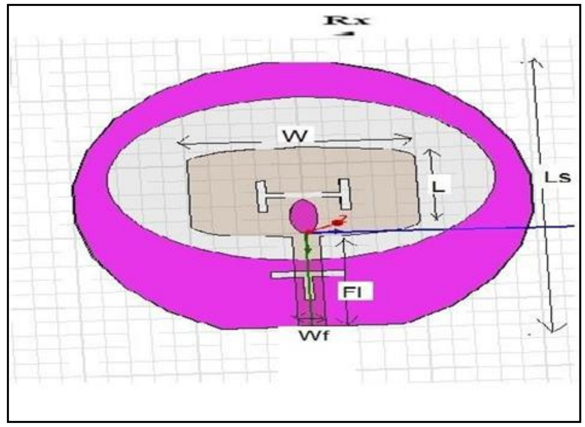

Fig 2: The proposed UWB buried antenna: a) design with its geometric parameters

Modified rectangular radiator, with two half elliptical shapes at its horizontal edges and a central H-slot. The radiator patch is fed by a 50 micro-strip line. The ground plane of the antenna consists of a circular patch with a wide elliptical slot, a small T-slot and an elliptical parasitic element. The different slots and the parasitic element are added to improve and satisfy the performance requirements of the small sized monopole antenna. Signal transmission is achieved by means of an SMA connector welded to the micro-strip feed line and ground. The antenna is designed for lower UWB-WUSN operating (3.21 3.73GHz), considering the low cost Fr4 substrate with 1.6mm thickness. Its performances depend on its geometric parameters. An optimization approach based on the tradeoff between miniaturization and operating bandwidth has been studies.

4. Design Methodology

The formulas for calculating the length, width and value of air gap are taken from [8]. The value of resonant frequency (Fr) is 3.5 GHz and dielectric constant of the substrate (r) is
4.4 And Height of dielectric substrate (h) is 1.6mm. Next step is to calculate the other parameters like length and width of micro strip patch is given as follows:

Step 1: Calculation of Length of Patch (L)-

The effective length due to fringing is given as
For c=3*10ˆ11 mm/s, reff=3.99, fo=3.5GHz We get Leff

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad .... \quad (1)$$

=19.98 mm. due to fringing the dimension of the patch as increased by L on both the sides, given by equation no (2)
For W=25.08mm, h, =1.53mm, reff=3.99.We get L=0.70mm

$$\Delta L = 0.412h \frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Hence the length the of the patch is: L= Leff-2L=26.78 mm

Step 2: Calculation of the width of Patch (W)
The width of the Microstrip patch antenna is given as for square patch we take W=1.5L. Therefore W=30.78 mm.

Step 3: Calculation of Substrate dimension
For this design this substrate dimension would be Ls=L+2*6h=40mm, Ws=W+2*6h=46mm

Step4: Feed width
The first step is to compute the proper feed line width Wf to obtain a 50 ohm line. This is calculated by following formula

$$z = \frac{377}{\sqrt{\varepsilon_r}\left(\frac{W}{t-1.57}\right)} \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where, Z=Impedance=50ohm,
εr =dielectric constant=4.4(FR4 substrate).
W= width of patch, t=thickness of substrate=1.6mm. From this we got:
Wf =3mm with Z=50ohms.

Step 5: Feed length
Lam=c0/f=85mm fl=lam/4* √4.4 =11mm fl=11mm,

5. Impact of Soil on Ultra Wide Antenna

This section, simulation results of the impact of soil on buried antenna and communication link are presented. The Analysis is conducted as illustrated in Fig.3, with h is the separation distance between the Tx-buried antenna and Rx antenna, 10cm ha is the aboveground node height and hb is the underground node burial depth.

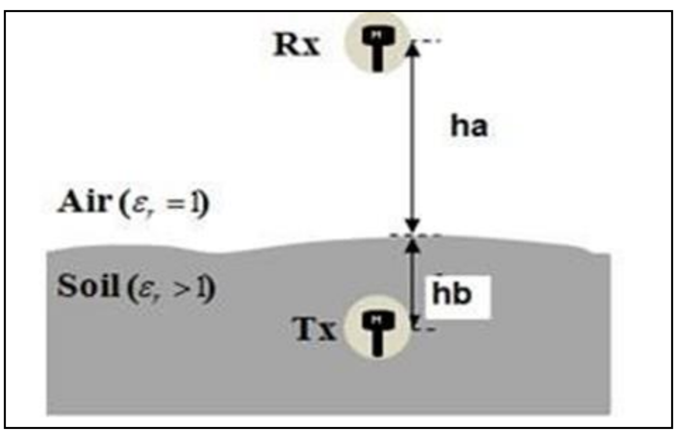

Fig 3: Communication model

The soil presents a higher permittivity compared to that of the air, which shortens the wavelength of incident electromagnetic wave traveling through it. We take permittivity of soil is 2.5.The simulated reflection coefficient of the antenna in free space and buried under the ground is shown in Fig.4. In the buried antenna case, the sample of soil is considered for five volumetric water content values (VWC=0)
Return loss indicates the amount of power that is lost to load and does not return as reflection. Return loss is a

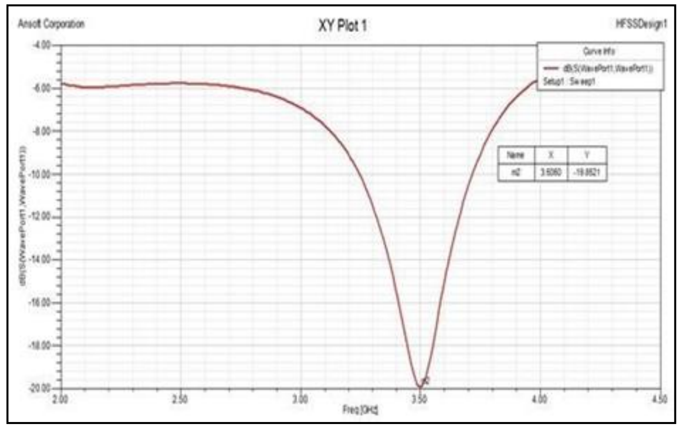

Fig 4: Return loss of proposed antenna

Parameter similar to VSWR to indicate how well the matching between transmitter and antenna has taken place. Ideal value of return loss is around -10dB which corresponds to VSWR of less than 2. As shown in figure.4, the value of Return loss is -19.85dB.

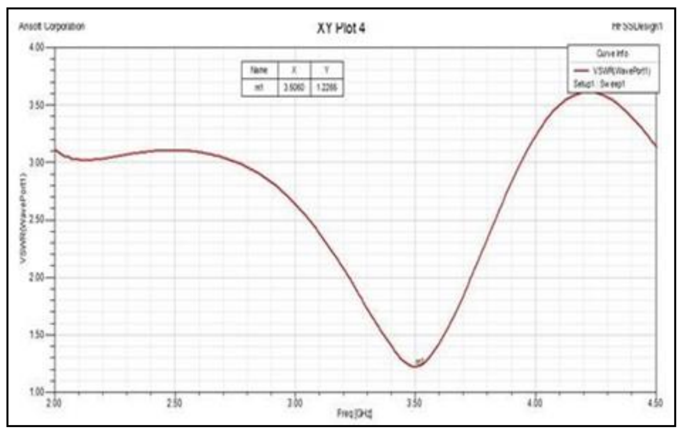

Fig 5: VSWR

The ratio between the maximum voltage and the minimum voltage along the transmission line is defined as the Voltage Standing Wave Ratio or VSWR. The VSWR, which can be derived from the level of reflected and forward waves, is also an indication of how closely or efficiently antennas terminal input impedance is matched to the characteristic impedance of the transmission line. An increase in VSWR indicates an increase in the mismatch between the antenna and the transmission line. As shown in figure.5 the value of VSWR is 1.23 with 520MHz bandwidth.
From the figure.6, it can be noted one is Tx antenna ante other Rx antenna. The return loss change when the antenna is buried underground because of the high permittivity of the soil.
From the figure.6, it can be noted one is Tx antenna ante other Rx antenna. The return loss and insertion loss (S21) change when the antenna is buried underground because of the high

permittivity of the soil. To investigate the effects of the soil moisture and distance, for values of VWC (0%) are

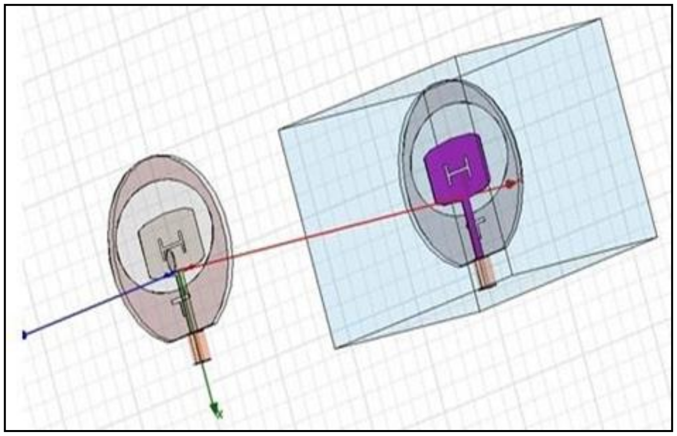

Fig 6: Tx and Rx wideband proposed antenna

Considered, while the Tx antenna burial depth is kept fixed at 10cm. shown in Fig.7 The results illustrate the increase of attenuation upto -28.38db when the distance increases.

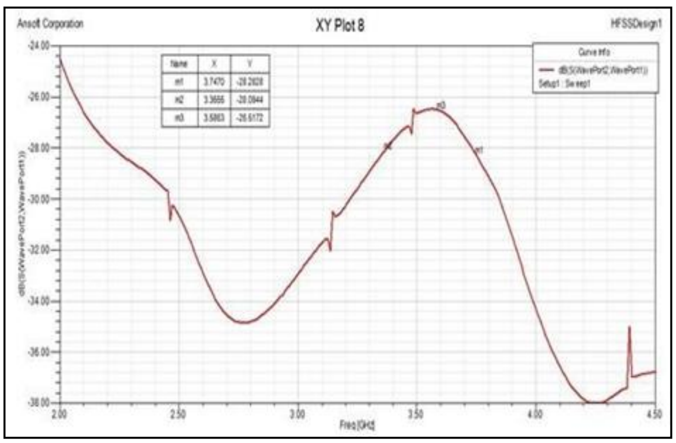

Fig 7: S21 of wideband proposed antenna

In many cases, the protocol of an E-plane and H-plane sweep or pattern is used in the presentation of antenna pattern data. The E-plane is the plane that contains the antennas radiated electric field potential while the H-plane is the plane that contains the antennas radiated magnetic field potential. These planes are always orthogonal. Irectivity, side lobe level and front to back ratio. The simulated radiation pattern of micro strip patch has been observed nearly omnidirectional with 1.8db gain in Figure.8.

The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. As stated earlier, an antenna cannot radiate more total energy than is delivered to its input terminals. All antennas, if 100% efficient will radiate the same total energy, for equal input power, regardless of pattern shape. Antenna radiation patterns are typically presented in the form of a polar plot for a 360 degree angular pattern in one of two sweep planes. As shown in figure.9, the value of Directivity is 1.78db with omnidirectional pattern.

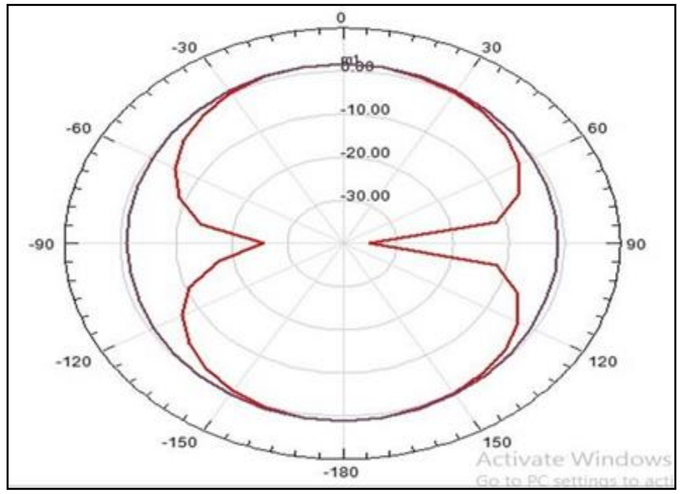

Fig 8: Radiation pattern in E & H Plane

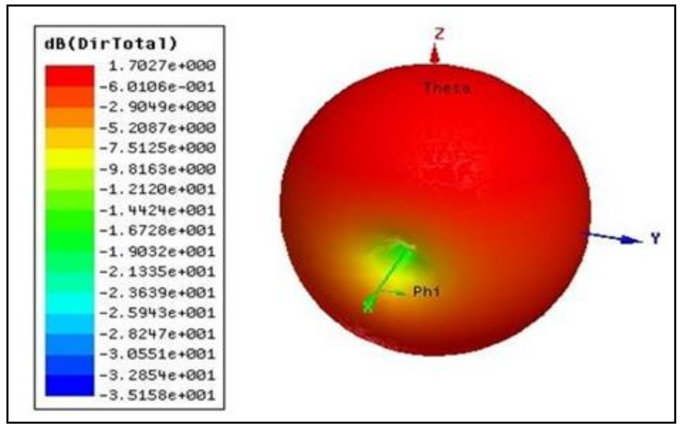

Fig 9: Directivity

Sr. No.	Shape of MSA	Freq (GHz)	Return Loss(dB)	VSWR	Bandwidth (MHZ)	Directivity (dB)
1.	Simple patch with gnd slot	3.51	-15.63	1.39	115	2.45
1.	UWB antenna with ellipse slot in gnd	3.58	-26.00	1.12	450	1.65
2.	UWB antenna with T slot and ellipse slot in gnd	3.50	-19.85	1.22	525	1.70

Fig 10: Comparison between above systems

6. Comparison Table

The work started with basic rectangle antenna with resonant frequency 3.5GHz and bandwidth of 115MHZ. the same antenna was converted wide elliptical slot, and an elliptical parasitic element which resulted into higher shift in frequency of operation at 3.58GHz.This result shows an increase band-width of antenna. To improve more bandwidth a small T-slot is added in GND plane introduced. As seen in fig.10, we got maximum bandwidth 520 MHz

7. Conclusion

In this paper, the impacts of soil moisture and burial depth on a new small UWB buried antenna return loss as well as on the communication link are analyzed for ultra wideband wireless underground sensor networks applications. It is noticed that the bandwidth of the patch antenna increased, compared to simple patch antenna. On the other hand, it is observed that soil moisture and burial depth have a strong impact on the underground to aboveground communication link. In simulation results it is shown that attenuation of about

-28dB at 10cm burial depth is observed in the case of dry specific soil. This attenuation rises with distance increased. The proposed antenna is used for wireless WiMAX 3.3/3.5Ghz (3.2-3.7GHz) band applications.

8. References

1. Zemmour H, Antoine DIET. Impact of soil on UWB Buried Antenna and communication link in IR-UWB WUSN Application, 12th Euro- pean Radar conference. 2015; 43(6):334-337.
2. Parameswaran V, Zhou H, Zhang Z. Irrigation control using wireless underground sensor networks, 6th International Conference on Sensing Technology (ICST), 2012, pp. 653-659.
3. Xiaoya H, Chao G, Bingwen W, Wei X. Channel modeling for wireless underground sensor networks, 35th Annual Computer Software and Applications Conference Workshops, Munich, 2011.
4. Kesar A, Weiss E. Wave propagation between buried antennas, IEEE Transactions on Antennas and Propagation, 2013; 61(12):6152- 6156.
5. Vuran M, Akyildiz I. Channel model and analysis for wireless underground sensor networks in soil medium, Fourth International Conference on Intelligent Computation Technology and Automation, Physical Communication 3, Elsevier, 2010, pp. 245-254.
6. A UWB Monopole, Ping Cao1, Yi Huang2, T Antenna For GPR Appli- cation and Jingwei Zhang3] Chen, Zhi Ning, Michael Yan Wah Chia. Broadband planar antennas: design and applications, John Wiley & Sons, 2006.
7. A UWB Monopole, Ping Cao1, Yi Huang2, Antenna For GPR Appli- cation and Jingwei Zhang3, pages, 2011, 308-312.
8. Stuntebeck E, Pompili D, Melodia T. Wireless underground sensor networks using commodity terrestrial motes, 2nd IEEE Workshop on Wireless Mesh Networks, WiMesh 2006, Reston, VA IEEE, 2006.
9. Dobson M, Ulaby F, Hallikainen M, El-Rayes M. Microwave di- electric behavior of wet soil-Part II: dielectric mixing models, IEEE Transactions on Geoscience and Remote Sensing. 1985; 23(1):35-46.
10. Akyildiz I, Stuntebeck E. Underground wireless sensor networks: research challenges Ad Hoc Networks 4 (Elsevier), 2006, pp. 669-686.