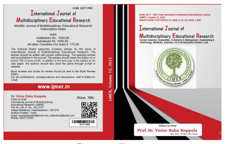
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DESIGN AND SIMULATION OF FLEXIBLE BOW TIE SLOT ANTENNA FOR GPR APPLICATIONS

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Abstract

Now a days communication plays an important role in daily life. All communication systems must have an antenna and they are commonly rigid in structure. Its size and shape vary depending on the application. Due to advancement in semiconductor technology all electronics devices become portable. So portable communication systems must require a portable antenna, i.e. this antennas must be small in size, light weight, ease of fabrication and must have low cost. Technology improved to use flexible printed circuit boards (PCB) in communication systems. This force to make flexible antennas for these devices. This paper describe the design and analysis of flexible Bow tie slot antenna in free space with High Frequency Structure Simulator (HFSS) software. Leather is used as substrate. Different geometries of this antenna are simulated, parameters are noted and compared with standard reference antenna. This enables to use this antenna with shoe for ground penetrating radar (GPR) applications.

Keywords: Ink Jet Printed, Flexible Bow Tie Slot Antenna, CPW Feed, GPR Technology.

Introduction

Here inkjet printed antenna is using which minimizes material wastage as com- pared to lithography. Coplanar Wave Guide (CPW) feeding is used here which eliminate the need of balun transformer for impedance matching. Antenna designs on leather have been reported in [2],[3] but the fabrication process is not described which can be difficult depending on the structure of the antenna [1]. Slotted bow tie antenna on leather is presented in [1] but this does not explain various effects of flexibility in detail. This paper proposed various effects of slots and flexibility on slotted bow tie antenna.

Various types of bow tie antennas are present now a days. Selection of antenna depends on the purpose for which it intended to use. This antenna can be used in portable Ground Penetrating Radars (GPR) where light weight and flexibility is a prime concern [4]. It can also be used in wearable landmine detection purposes. So, this type of antenna must have low return loss, low profile, low production cost, light weight, good bandwidth and easy to fabricate.

Antenna Parameters [5-7]

Radiation Pattern

The basic term “radiation” means that, the distribution of power through respective field of antenna. An antenna radiation pattern or antenna pattern is defined as “A mathematical function or a graphical representation of radiation properties of the antenna as a function of space coordinates”.

Radiation Intensity

Radiation intensity in given direction is defined as the power radiated from an antenna per unit solid angle. The radiation intensity is far field parameter and itcan be obtained by simply multiplying the radiation density by the square of the distance.

Directivity

Directivity of an antenna defined as the ratio of radiation intensity in given direction from the antenna to the radiation intensity averaged over all directions.The average radiation intensity is equal to the total power radiated by the antenna divided by 4.

Gain

Absolute gain of an antenna is defined as the ratio of intensity, in a given direction to the radiation intensity that would be obtained if power accepted by antenna were radiated isotropically. The radiation intensity corresponding to isotropically radiated power is equal to the power accepted by the antenna divided by 4.

Antenna Efficiency

It is the Ratio of Radiated power to the electrical power that the Antenna receives from the transmitter.

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Half power and Full null Bandwidth

The half power beam width is defined as in a plane containing the direction of maximum of a beam the angle between two direction in which the radiation intensity is one half the maximum value of the beam often the term beam width is used to describe the angle between any two point on the pattern such as the angle between 10dB points. In this case the specific point on the pattern must bedescribed the 3-dB beam width.

Bandwidth

The bandwidth of an antenna is defined as the range of frequency with in which the performance of antenna with respect to some characteristics conform to specified standard. The bandwidth can be considered to be a range of frequency on either side of centre frequency where the antenna characteristics are within acceptablevalue of those at centre frequency.

Voltage Standing Wave Ratio

The standing wave ratio (SWR), also known as the voltage standing wave ratio (VSWR), is not strictly an antenna characteristic, but is used to describe the performance of an antenna when attached to a transmission line. It is a measure of how well the antenna terminal impedance is matched to the characteristicimpedance of the transmission line.

Input Impedance

Input impedance is defined as "the impedance presented by an antenna at it terminals or the ratio of voltage to current at pair of terminals or the ratio ofthe appropriate component of the electric to magnetic fields at a point".

Polarization

In general polarization of an antenna is referred as, the orientation of radiation of that antenna. Polarization of an antenna in given direction is defined as the polarization of the wave transmitted by the antenna. When the direction is not stated the polarization is taken to be polarization in direction of maximum gain. In practice polarization of the radiated energy varies with direction from the centre of the antenna so that different part of the pattern may have different polarization. There are 3 type of polarization profiles those are Linear polarization, Elliptical polarization and Circular polarization.

Front to Back Ratio

The Front to Back Ratio (FBR) of an antenna is the ratio of power radiated in the front/main radiation lobe and the power radiated in the opposite direction (180 degrees from the main beam). This ratio tells us the extent of backward radiation and is normally expressed in dB. This parameter is important in circumstances where interference or coverage in the reverse direction needs to be minimized.

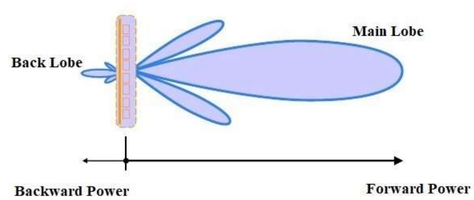

Figure 1. Structure of lobe

Review of Literature

Vignesh Shanmugam Bhaskar, Eng Leong Tan, and Li King Ho Holden Design of Wideband Bowtie Slot Antenna Using Sectorially Modified Gielis Curves: The SMGCs are used for the slot profile to improve the bandwidth while maintaining the antenna size. BSAs are built on FR4 and RO5880 substrates providing fractional bandwidths of about 90.3% (1.7 GHz to 4.5 GHz) and 71.4% (2.7 GHz to 5.7 GHz) respectively. Adding a meander shaped slot to the TBSA favors ultra-wideband operation at the expense of increased antenna size. Adding meander shaped slot to the conventional BSA may lower the cut-off frequency, but it requires larger ground plane (antenna size) than BSA to obtain stable radiation pattern [8].

Y.-L. Chen, C.-L. Ruan, and L. Peng A novel ultra-wideband bow-tie slot antenna in wireless communication systems: This antenna provide an UWB with return loss less than 10 dB from 9.5 GHz to 22.4 GHz. The bandwidth is up to 80%, which is quite better than the traditional bow-tie slot antenna. It has the merits of high speed transmission

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rate, lower power consumption and simple hardware. In this paper, by adding two small sectors to the bow-tie slot and changing the ordinary sharp corners to round corners, the bandwidth is enhanced largely to 80%. The proposed antenna can provide Band Width for most part of X-band (9.5 12.4 GHz), part of K-band (18.0 22.4 GHz) and the whole Ku-band (12.4 18 GHz) [9].

Syed M. Sifat, Mohamed Mamdouh M. ali, Shoukry I. Shams and Abdel-razik Sebak High Gain Bow-tie Slot Antenna Array Loaded with Grooves based on Printed Ridge Gap Waveguide Technology: Gap waveguide is one of the emerging technologies in 5G and mm-wave appli- cations due to their low cost, low losses and high power handling capability. A groove-based wideband bow-tie slot antenna array is designed at 30 GHz based on printed ridge gap waveguide technology (PRGW). The gain of the proposed slot antenna is enhanced by using a horn-like groove. It shows a -10 dB impedance bandwidth from 29.5 to 37 GHz (22%). The fabricated prototype achieves a high gain of 15.5 dBi and a radiation efficiency higher than 80% over the operating frequency bandwidth [10].

Research Methodology

Since this antenna used for GPR applications, the frequency of operation de- termines the penetration depth. When frequency increases the penetration depth will decrease and when frequency decreases the penetration depth will increase. Penetration depth not only depends on the frequency alone but it also depends on the soil properties. For high resolution image wide bandwidth is required. When frequency increases the resolution will increase but the penetration will decrease. Moderate gain is desired to meet link budget requirements.

GPR systems must be portable[11]. Ground Penetrating Radar systems take many forms, but all systems have the core components that include, transmitting and receiving antennas, pulse generating electronics, receiver electronics, a control computer, and data storage. The pulse generating electronics produce an electromagnetic pulse that is then broadcast, or radiated, by the transmitting antenna as an electromagnetic wave. The electromagnetic wave then interacts with the surrounding environment, some of the wave gets reflected back and some of the wave disperses. The receiver antenna then picks up the wave that has been reflected back. Antenna can also be used for radio astronomy and imaging systems.

Design guidelines for Bow tie antenna

1. To increase (decrease) frequency of operation, decrease (increase) arm length
2. To improve impedance match, decrease substrate thickness and permittivity
3. To increase gain, substrate thickness and permittivity must decrease
4. To increase input impedance, decrease flare angle
5. Coplanar Waveguide (CPW) feed can be used with slot antenna to eliminate the need of balun when it is driven by coaxial cable
6. Gap between Bow tie antenna is a critical factor to improve bandwidth
7. Smaller feed gap low frequency response is affected
8. Larger feed gap high frequency response is affected
9. Curving sharp corners will increase the and widthThis paper focus on two configurations
10. Along length wise bend with radius 40, 50 and 60mm
11. Along width wise bend with radius 40, 50 and 60mm

Result and Discussion

Bow tie antenna with slot A

Figure shows a Bow tie antenna with slot A. This slot having dimension 7x1.5mm is introduced from the wider end of the slot at a slanted distance of 17mm.Flat structure of this antenna will give a bandwidth of 490MHz with a return loss of -13.21dB for a resonant frequency of 2.1GHz. It shows a peak realised gain of3.1528dB with a front to back ratio of 1.0032. –[12]

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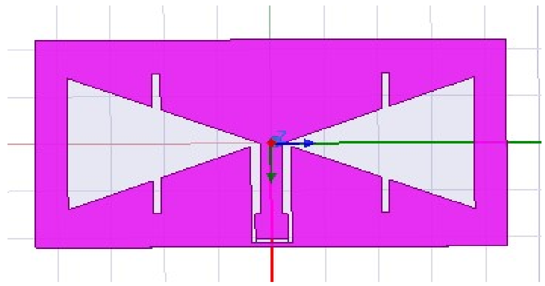


Figure 2 Slot A introduced on Bow tie antenna

Radius of curvature :40mm

Width wise

A curvature radius of 40mm in width wise will give a bandwidth of 670MHz with a return loss of -14.17dB for a resonant frequency of 2.1GHz.It shows a peak realised gain of 2.3557dB with a front to back ratio of 1.1331 [13]

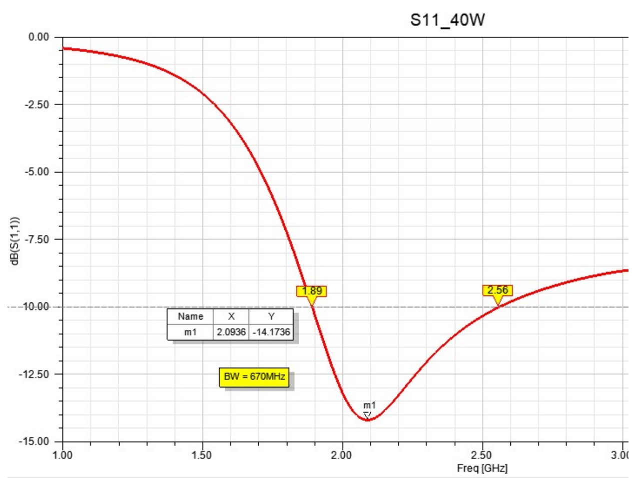


Figure 3: Return loss Vs Frequency

Length wise

A curvature radius of 40mm in length wise will give a bandwidth of 350MHz with a return loss of -11.58dB for a resonant frequency of 2.1GHz.It shows a peak realised gain of 3.1699dB with a front to back ratio of 1.0816

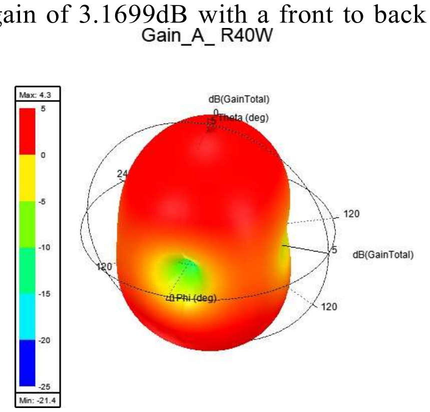
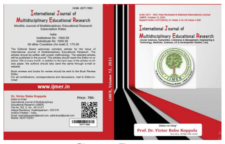


Figure 4: 3D Polar plot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Radius of curvature :50mm
Width wise

A curvature radius of 50mm in width wise will give a bandwidth of 620MHz with a return loss of -13.48dB for a resonant frequency of 2.1GHz.It shows a peak realised gain of 2.6479dB with a front to back ratio of 1.147

Length wise

A curvature radius of 50mm in length wise will give a bandwidth of 440MHz with a return loss of -15.77dB for a resonant frequency of 2.1GHz.It shows a peak realised gain of 3.2664dB with a front to back ratio of 1.0616 [14]

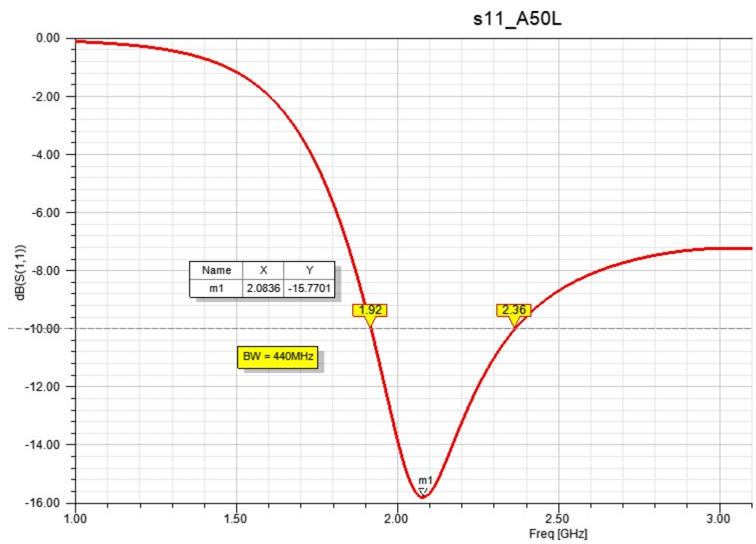

Figure 5: Return loss Vs Frequency

Radius of curvature :60mm
Width wise

A curvature radius of 60mm in width wise will give a bandwidth of 500MHz with a return loss of -12.7dB for a resonant frequency of 2.1GHz.It shows a peak realisedgain of 2.8479dB with a front to back ratio of 1.1403

Length wise

A curvature radius of 60mm in length wise will give a bandwidth of 410MHz with a return loss of -12.13dB for a resonant frequency of 2.1GHz.It shows a peak realised gain of 3.2061dB with a front to back ratio of 1.0593. [15]

Conclusion

The main objective of this work is to design and simulate an antenna which is suitable for portable GPR applications for a frequency of 1.8GHz, 1.9GHz and 2.1GHz.Here is a summarizing of work that were carried out in order to meet the designing goals.

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