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HIS Backed Bow-tie Antenna for Dual Band Wireless Applications

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***Abstract*— In this paper a bowtie antenna is designed for C band and X- band applications. Using of bow tie antenna provides high bandwidth and ease of design. The antenna is operated in dual band and fed using a co-axial feed. Thae antennas with metallic ground plane suffers with surface waves and leads spurious radiation and reduced gain. The gain increased using High Impedance surface ground plane. The paper presents HIS backed bowtie antenna which resonates at 6.3GHz and 9.4 GHz with 7.2dB gain.**

Keywords*— Bowtie antenna, High Impedance Surface, Gain, dual band

I. INTRODUCTION

These days, microstrip antennas are frequently utilised because of its low profile, compatibility with basic planar structures, and high front-to-back ratio (FBR). However, these antennas have a limited bandwidth by design. Only between 3 and 5 percent of the standard bandwidth is provided by such antennas. The use of a reflector in front of the dipole antenna, which has a significantly broader bandwidth than microstrip antennas, and to obtain minimum back lobe. Since the image current from a horizontal dipole antenna is out of phase when it is positioned over a perfect electric conductor (PEC) reflector and results cancellation of fields and reduces gain. If a Perfect Magnetic Conductor (PMC) surface is employed as a reflector, the image current is in the same direction as the antenna current and increases field. The high-impedance surface (HIS) is a periodic structure that mimics the in-phase reversal feature of PMC. The HIS is a periodic structure with a modest period of surface roughness in comparison to the operational wavelength. The high-impedance surface (HIS) is a periodic structure that replicates the in-phase reversal property of PMC[1,2]. The HIS is a periodic structure with a short period of surface roughness in contrast to the operating wavelength.

The paper proposes an HIS with square patches to act as an artificial magnetic conductor (AMC). To overcome the metallic ground effects of antenna's The bow-tie antenna was incorporated over a square patch HIS array so that it resonates for two bands and provides a broader bandwidth [3]. A typical HIS arrangement is shown in figure 1. Various shapes of antenna structures evolved over the time like square patches[6],T shape [7] etc.

Fig. 1 HIS cross-sectional view

Bow tie antenna provides wide bandwidth compared to other dipole geometries [4,5].

The following section of this paper has discussion about the proposed antenna design and analysis, the simulation results, and the conclusion.

II. ANTENNA DESIGN

A. Design of HIS Ground plane

A HIS ground plane is designed with a 5 × 5 cells on a Fr-4 dielectric substrate with dielectric constant of 4.4 and a height of 1.6 mm waving square patch of 20mm width. The ground plane is designed with dimensions 112mm×112 mm. The Patches are at a height of 1.6mm with a gap of 1mm.The design and simulations are performed in Ansys Electromagnetic suite 2019R3.

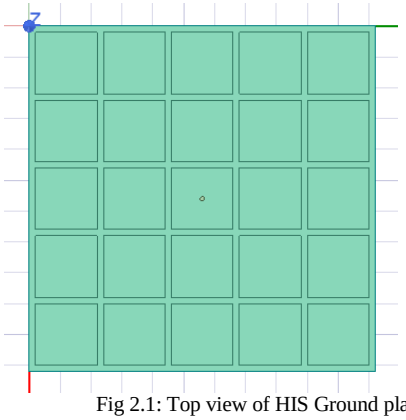

Fig 2.1: Top view of HIS Ground plane

B. Design of Bowtie on metallic ground plane

The bow tie antenna is designed over a FR-4 substrate . The FR4 substrate having dielectric constant of 4.4 with a thickness of 1.6 mm and a loss tangent of 0.0025 is used in the construction of the bow tie antenna. Co-axial feed is used by the antenna. The ground layer patch has a dimension of 112 mm by 112 mm. The substrate is 112 mm x 112 mm, and 3.2 mm distances the from the ground. The bow tie arm length is chosen as 35 mm.

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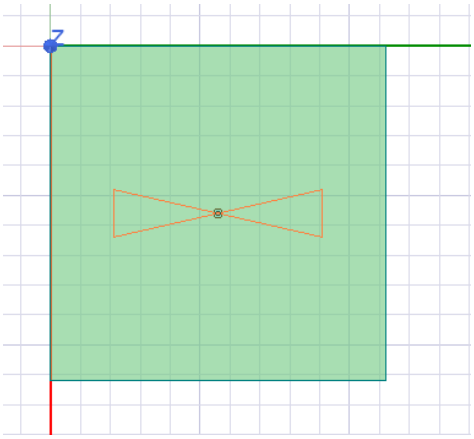

Fig 2.a Bow tie antenna top view

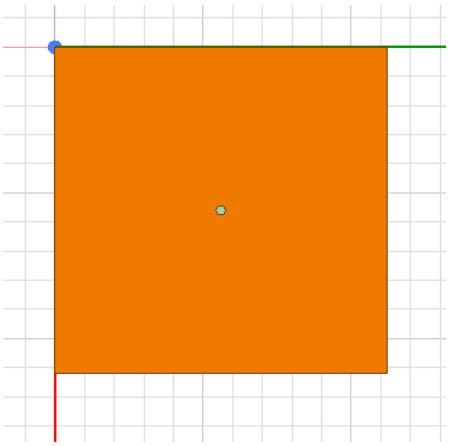

Fig 2.b Bow tie antenna ground plane

C. *Design of Bowtie antenna on HIS ground plane*

The bow tie antenna is designed over a FR-4 substrate. The FR4 substrate having dielectric constant of 4.4 with a thickness of 1.6 mm and a loss tangent of 0.0025 is used in the construction of the bow tie antenna. Co-axial feed is used by the antenna. instead of Ground plane HIS is used as ground plane. The design dimensions are tabulated in Table 1. The design top view and bottom view and side view is shown in figure 3 respectively.

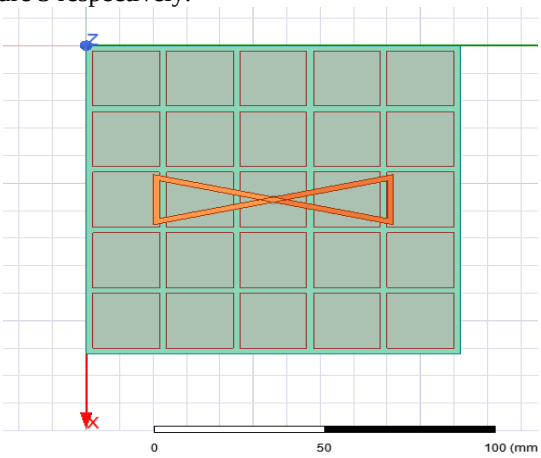

Fig 3.1.a Bow tie antenna on HIS ground plane

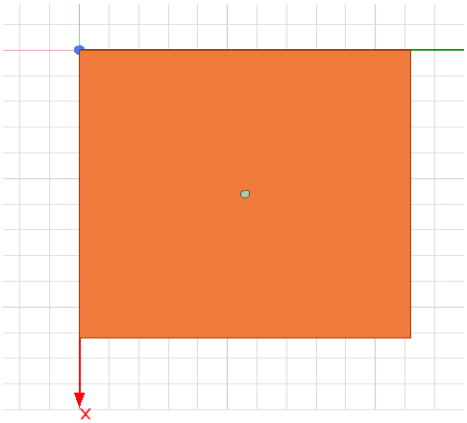

Fig 3.b Bow tie antenna ground plane

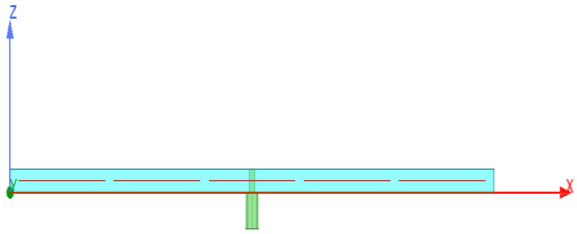

Fig 3.c Bow tie antenna on HIS cross-sectional view

Table 1. Bow tie antenna design dimensions

Parameter	Dimension in mm
Effective Dielectric constant	4.4
Patch Width Wp	20
Patch Length Lp	20
Gap g	1
Length of Substrate Lg	112
Width of Substrate Wg	112
Length of Ground Lg	112
Width of Ground Wg	112
Bow tie arm width	35

III. RESULTS AND ANALYSIS

A. *Bow tie Antenna on metallic Ground Plane*

a. Return loss

The S11 parameter is a measure of reflected power when port is feed. Ideally the return loss must be as low as possible. For commercial antenna applications return loss of -10 dB is acceptable. For antenna Characteristics S11 provides return loss for input port. The return loss response shows that antenna is resonating at 5.2 Ghz and 7.3GHz with S_{11} of -11.5 dB and -28 dB respectively

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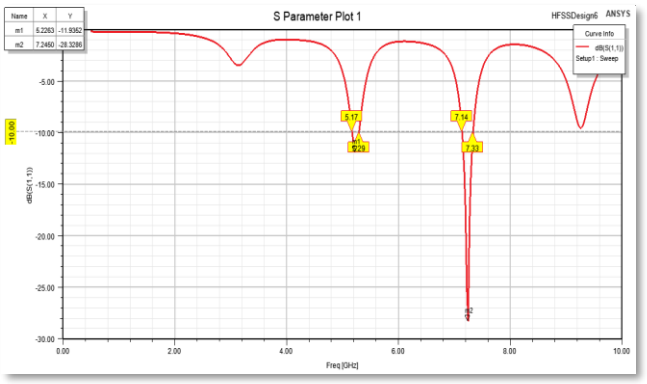

Fig 4.a Return loss of Bow tie Antenna on metallic Ground Plane

b. VSWR plot

The VSWR number should ideally be 1. In practical terms, VSWR should be less than 2. The Bow-Tie antenna with Metallic ground offers VSWR less than 2 at resonance frequencies of 7.2GHz when operating in the frequency range of 1–10 GHz.

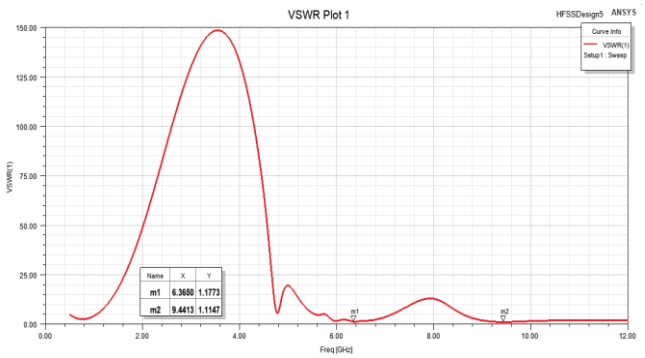

Fig 4.b VSWR of Bow tie Antenna on metallic Ground Plane

c. Radiation Pattern

A graph of the radiated power density to angle called the radiation pattern. A 3D plot or a 2D plot represents the radiation pattern. From radiation pattern, it seen that maximum radiation in upper hemisphere and has very low back lobes.

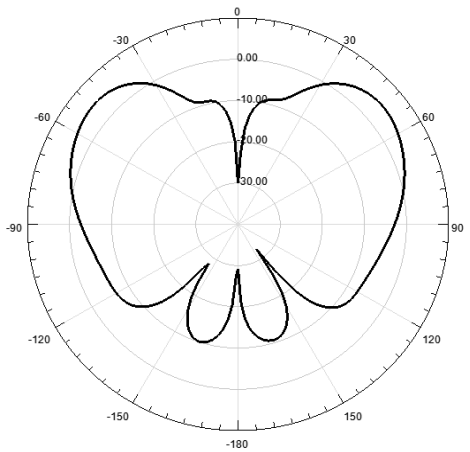

Fig 4.c Radiation pattern of Bow tie Antenna on metallic Ground Plane

d. Gain plot

Gain is the proportion of radiation intensity in each direction to the radiation intensity that would be attained if the antenna's power acceptance were isotopically radiated. The antenna has broadside radiation and peak gain of 4.8 dBi.

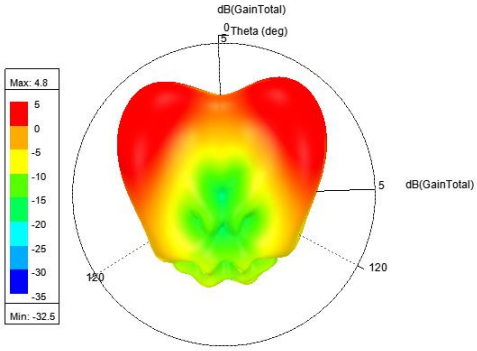

Fig 4.d Gain plot of of Bow tie Antenna on metallic Ground Plane

B. Bow tie antenna on WITH HIS GROUND PLANE

a. Return loss

The S11 parameter is a measure of reflected power when port is feed. Ideally the return loss must be as low as possible. For commercial antenna applications return loss of -10 dB is acceptable. For antenna Characteristics S11 provides return loss for input port.

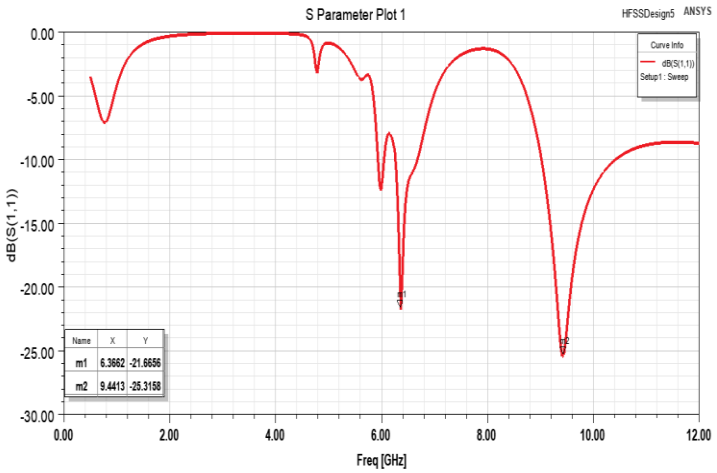

Fig 5a : Return loss of Bow tie Antenna on HIS Ground Plane

b. VSWR plot

The VSWR number should ideally be 1. In practical terms, VSWR should be less than 2. The Bow-Tie antenna backed with HIS offers VSWR less than 2 at resonance frequencies of 6.3GHz and 9.2GHz when operating in the
frequency range of 1–10 GHz. The antenna has very good VSWR of 1.11 and 1.17 at the resonant frequencies.

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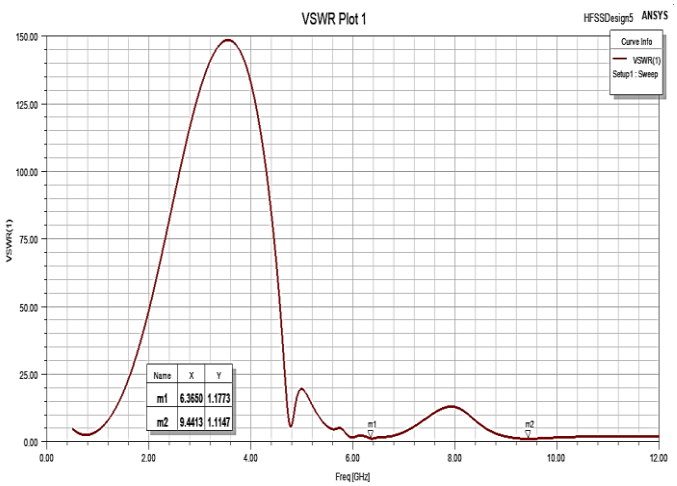


Fig 5.b : VSWR of Bow tie Antenna on HIS Ground Plane

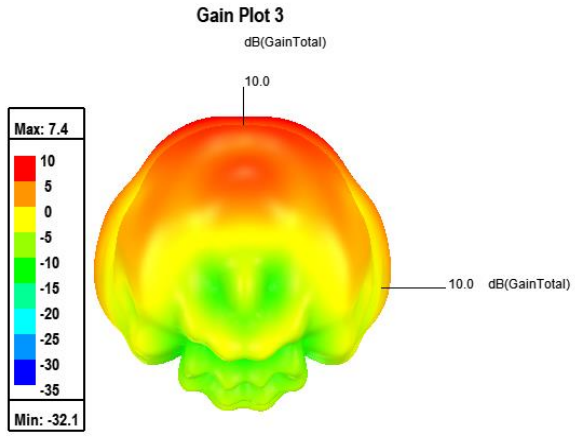
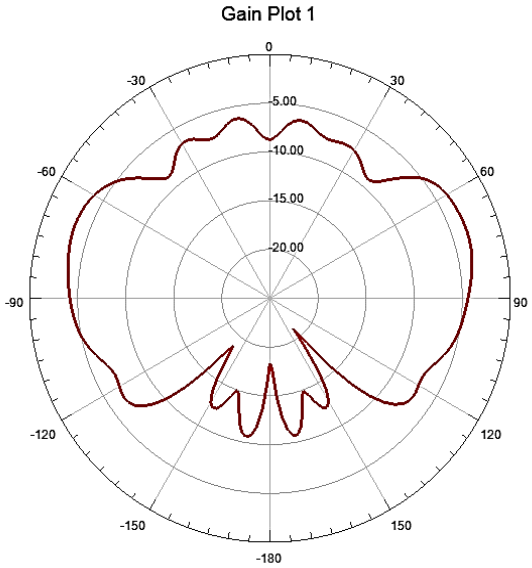


Fig 5.d : Gain plot of Bow tie Antenna on HIS Ground Plane

c. Radiation Pattern

A graph of the radiated power density to angle called the radiation pattern. A 3D plot or a 2D plot represents the radiation pattern. The radiation pattern shows the improved radiation at upper hemisphere and even at raidal axis it has max radiation.

Fig 5.c : Radiation pattern of Bow tie Antenna on HIS Ground Plane



d. Gain plot

Gain is the proportion of radiation intensity in each direction to the radiation intensity that would be attained if the antenna's power acceptance were isotopically radiated. The gain is smaller than the directivity if the efficiency is not 100%. At a resonant frequency the antenna has peak gain of 7.2dBi.

e. Current Density

The current density represents the flow of currents along antenna. The current density plot shows that it has maximum radiation along the taper length of arm and is minimum at center.

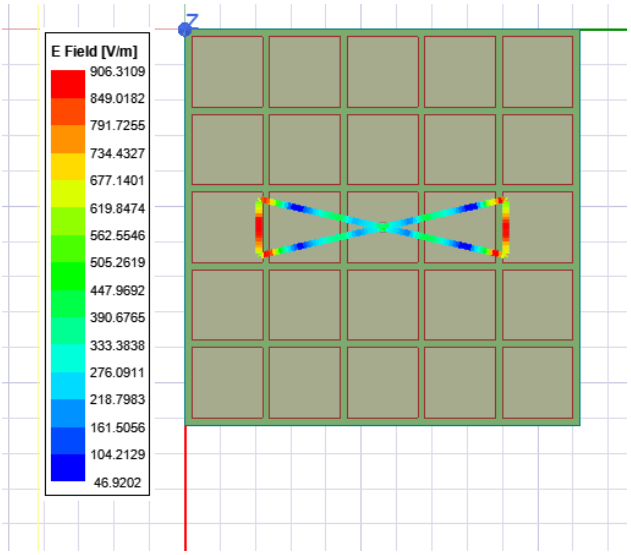


Fig 5.e : current density plot of Bow tie Antenna on HIS Ground Plane

CONCLUSION

For X-band and c band Applications, a dual band bowtie patch antenna is created and tested. The polarization dependent HIS has enabled with its reduced profile. When the HIS is positioned below the bow tie antenna, dual band achieved with frequency of 6.3GHz and 9. 4GHz.At two frequencies, high gain radiation patterns are seen. The developed antenna may be applied in a situation where need of two band operations is required. The designed bow tie antenna has peak gain of 7.2 db.

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