Design of Dual-Band Bow-Tie Slot Antenna By Using HFSS

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Abstract: In this design, a modified loop strips of bow tie slot antenna fed by lengthened asymmetric coplanar waveguides to improve gain and for better impedance matching at X-band and C-band. In this designed bow-tie slot antenna obtained value of flat gain is 6.0 dBi in the range of (12.6 GHz to 13 GHz). Because of asymmetric coplanar waveguide good return loss and VSWR (<=2) and at operating frequency of 3 GHz were observed. The simulated results of return loss calculated at different frequencies obtained are, -11.75 dB, -30.51 dB, -13.966 dB, -17.99 dB and -13.52 dB. The obtained VSWR (Voltage Standing Wave Ratio) values are 1.696, 1.361, 1.501, 1.288 and 1.547 and the obtained gain values are 2.04 dBi, 4.54dBi, 0.51 dBi, -0.90 dBi, 6.04 dBi at 5.2 GHz, 7.6 GHz, 9.2 GHz, 11 GHz and 12.8 GHz respectively. The simulated results are obtained by using HFSS (High Frequency Structural Simulator) software (15.0).

Keywords:-Bow-tie slot antenna, X-band and C-band, HFSS, Return loss, Gain, VSWR.

1. Introduction

In the Modern Communication Network, for the purpose of improving Gain and Impedance matching in the antenna, designs are playing a vital role.so, a special care has been taken by the researchers to move towards the designing of new and modern shapes of antennas. Antenna is a transducer that converts electrical quantities into electromagnetic quantities and vice versa. This antenna having dual band multi frequency feature and constitute by a primary and secondary bow tie slots Antennas are used in Global Position in System (GPS), satellite communications system, and personal communications system. In this paper I have proposed an improved bow-tie antenna with reduced metallization based on the phenomenon that the majority of the current density was confined to the edge of patch. After the centers of the triangular parts were removed, the performance of antenna did not have significant variation and studied the influence of slot width and the extended angle on the CPW-fed bow-tie slot antenna. By changing the slot width, a 36% bandwidth and gain of 5.59dbi (VSWR<2) was obtained when the extended angle was 20^0[2]. Studied the performance of the CPW-fed bow -tie slot antenna with different flare angles of the bow-tie slot. The results showed that a higher gain of 5.54dbi was achieved when the flare angle is 90^0[2]. analyzed the influence of all the antenna parameters in this communication, a new type of broadband and high-gain bow-tie slot antenna fed by an asymmetric CPW (ACPW) is presented. To achieve a high gain both CPW slots are lengthened and an ACPW with different lengths of slots are formed and also, by introducing two loop strips in the bow-tie slots, the gain is further increased. The gain at beam peak 6.0 at a frequency range of (12.6GHz to 13GHz). The conventional or stacked slot antennas are not easy to achieve miniaturization owing to their thick substrates for gain enhancement. The planar bow-tie antennas are preferred due to the superior characteristics on size, gain, and bandwidth performances.

However, the dual or multi-band designs for the planar bow-tie antennas are still lacked. This paper proposes a dual-band bow-tie slot antenna design for C-band and X-band applications. The designed antenna made of Asymmetric coplanar waveguide (ACPW) feeding with the inductive coupling .The twin bow-tie slots with special slotting arrangement provides independent tuning mechanism for the individual bands. Measured results include the operation frequencies in 4.65GHz ~ 5.78 GHz and 6.93GHz ~ 7.97 GHz and 9.06GHz~13with the gains of 2dBi and 5.6 dBi and 6.0 for low-band and high-band respectively.

II. Design of Bow –tie slot Antenna

The proposed bow tie antenna is shown in figure 1.it consists of ground plane on one side of dielectric substrate. The white parts on ground is slots and gray part is metal. The antenna fed with asymmetric coplanar waveguide to improve the impedance matching to decrease the return loss. The antenna is realized on the Rogers RT/duroid5880(tm) substrate with ε_r= 2.2 and h=1.6mm.its dimension is 53mm×25.25mm.

First, the working mechanism of ACPW is investigated by analyzing surface current distribution. The magnitude and vector plot of surface current density at 3 GHz is studied. It shows that the cur-rent in the center strip conductor mainly flows along the slot due to a larger S_w . In this case, the additional slot path gives rise to a cascaded capacitance C_s . The larger the l_3 is, the larger the capacitance C_s . The increased C_s will cause the resonant frequency of antenna decrease. Also, the additional slot path introduces the phase delay in the two branches by adjusting l_3 .by increase l_3 from 0 to l_3=5.4 *and* l_3' *is* from 0 to3.4 the antenna resonates more because of asymmetric coplanar waveguides by adjusting the l_3 and l_3' and S_w of asymmetric coplanar waveguide .the antenna gives both asymmetric coplanar waveguides lengthened so that gives better gain at X band when compared to other *l3'*= 0 case.

The proposed antenna gives better gain (6.0dbi) at the high frequency range that is 12.6GHz to 13GHz range. And the l_3'=0 the gain is less but the l_3'=3.4 get good gain at high frequency in the X-band and also increases impedance matching characteristics. And also one more important design to enhancing the gain is loop strips are introduced that are at the middle of slot antenna which is in figure. after enhancing the loop strip and *l3'* that is loop strip perimeter 39.85mm the gain improves of 4.48dbi to 6.0dbi the gain is increased by 1.52dbi because of increase of *l*3' and loop strip perimeter.

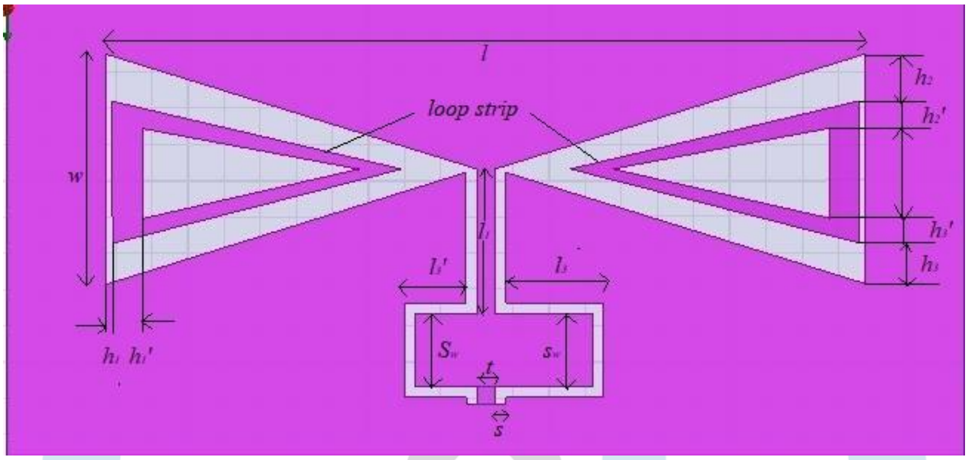


Fig .1: Design of bow tie antenna (l_3'=3.4)

TABLE 1

Optimized dimensions of the antenna

Parameter	*l*	w	s	t	l_1	l_3	S_w	l_3'
Value (mm)	42	12.7	0.6	1	8	5.4	4	3.4

Parameter	h_1	h_1'	h_2	h_2'	h_3	h_3'
Value(mm)	*0.33*	*1.65*	*2.6*	*1.5*	*2.25*	*1.37*

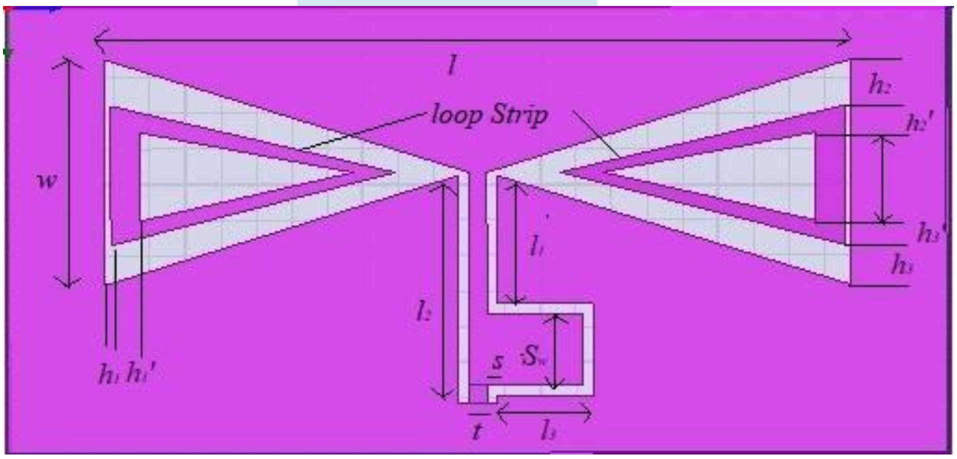


Fig. 2 : Design of bow tie antenna(l_3'=0)

Parameter	l	w	s	t	l_1	l_2	l_3	S_w
Value (mm)	42	12.7	0.6	1	8	13	5.4	4

Parameter	h_1	h_1'	h_2	h_2'	h_3	h_3'
Value(mm)	*0.33*	*1.65*	*2.6*	*1.5*	*2.25*	*1.37*

III. RESULTS

Return loss: S11 discusses how much power is reflected from load to source in the radio wire, and in this way is known as the reflection coefficient or return misfortune. The simulated return losses obtained are -11.75dB, -30.51dB, -13.96dB, -17.99dB and -13.52dB at 5.1 GHz, 7.6 GHz, 9.2 GHz, 11 GHz and 12.8GHz respectively.

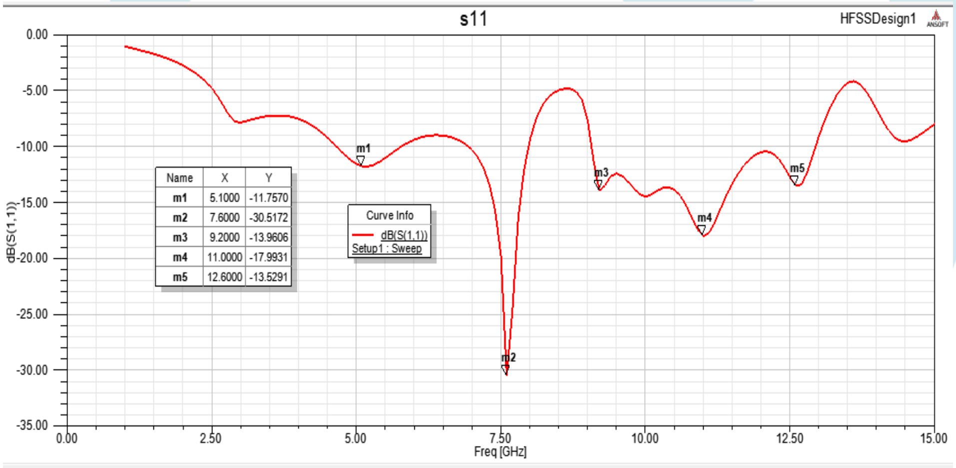


Figure.3: Return loss

VSWR:

VSWR is a measure of how effectively radio-recurrence control is transmitted from a power source, through a transmission line, into a heap. The VSWR values are shown in below Figure.

The simulated VSWR (Voltage Standing Wave Ratio) values obtained are 1.69, 1.36, 1.50, 1.28 and 1.54 at 5.1 GHz, 7.6 GHz, 9.2 GHz, 11 GHz and 12.8GHz respectively.

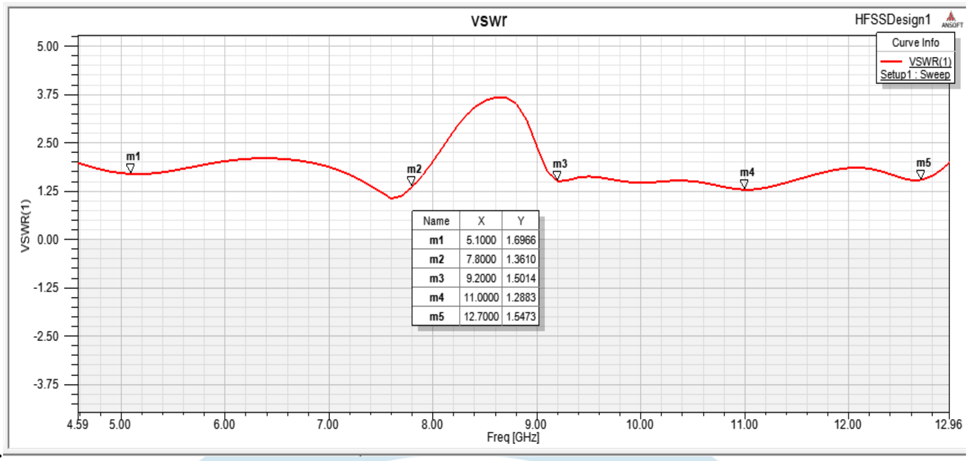


Figure.4:VSWR values

Gain: It is the ratio of power delivered by the antenna from a source on the antenna's beam axis to the power delivered by a lossless antenna.

The simulated gain values obtained are 2.06, 4.54, 0.51, -0.90, 6.04 at 5.2GHz, 7.6GHz, 9.2GHz, 11GHz,and 12.8GHz respectively

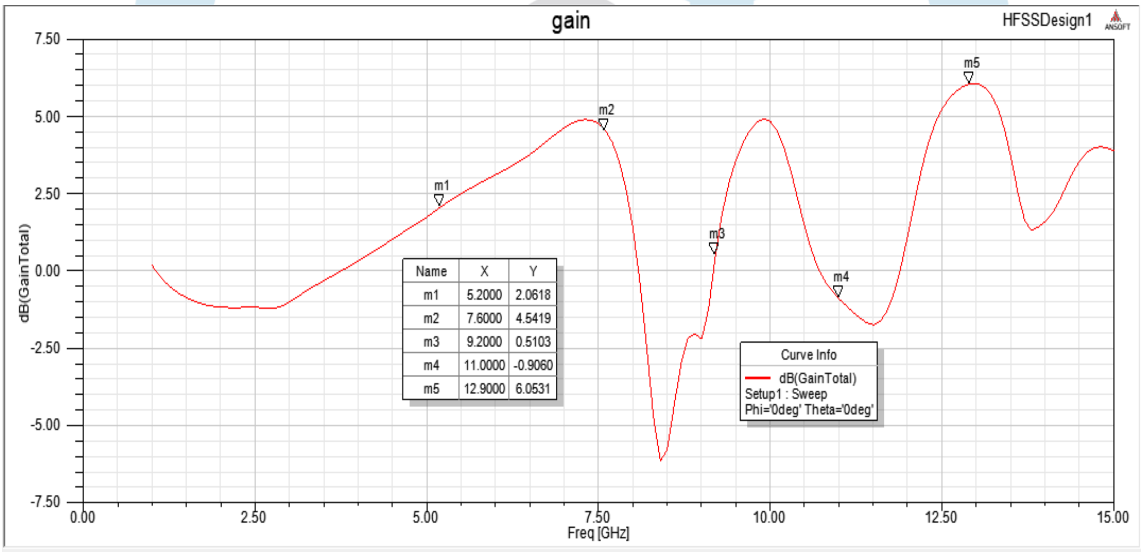
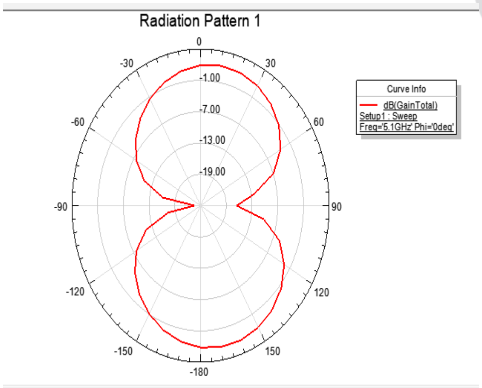
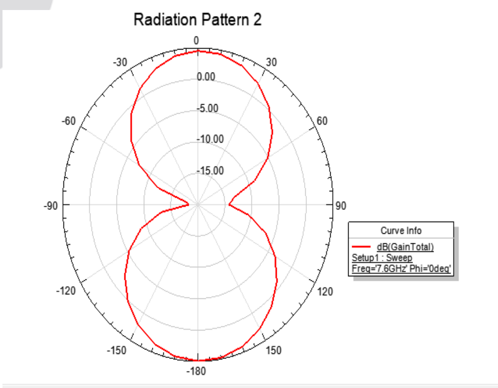


Fig.5: Frequency vs Gain plot

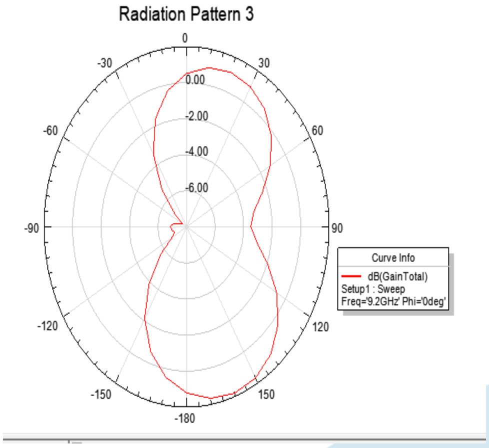
***Radiation pattern*:** A radiation pattern is defined as the variation of power radiated by an antenna as a function of the direction away from the antenna. This power variation as a function of the arrival angle is observed in the antenna's far field.



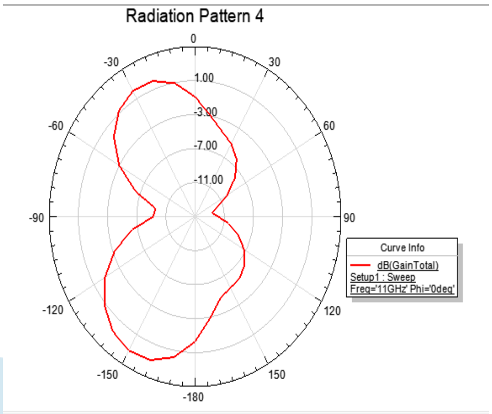
Radiation Pattern at 5.2GHz



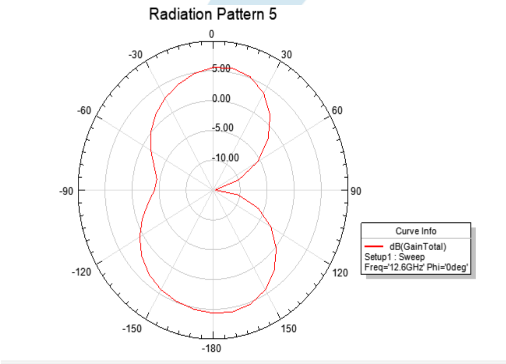
Radiation Pattern at 7.6GHz



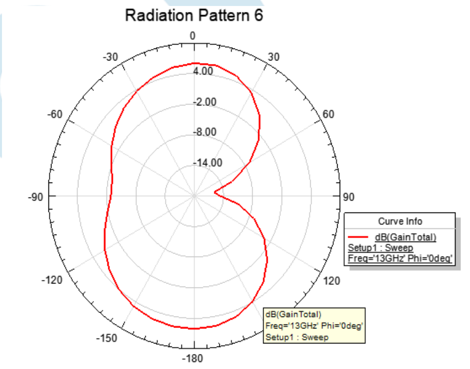
Radiation Pattern at 9.2GHz



Radiation Pattern at 11GHz



Radiation Pattern at 12.6GHz



Radiation Pattern at 13GHz

The overall Gain of proposed bow- tie slot antennaa as shown in figure below:

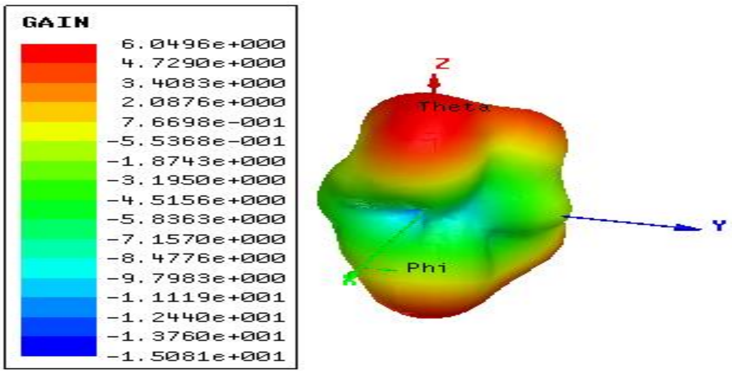


Fig.6.Maximum peak Gain

This tabular form shows that simulated results of proposed bow-tie slot antenna

S.no	Frequency (GHz)	Return loss(db)	Gain(dbi)	VSWR
1	5.2	-11.75	2.04	1.696
2	7.6	-30.51	4.54	1.361
3	9.2	-13.96	0.51	1.501
4	11	-17.99	-0.90	1.288
5	12.9	-13.52	6.04	1.547

Conclusions:

Simulation and experiment studies of a new bow -tie slot antenna fed by asymmetric CPW in dual-band operation are presented in this paper. The final designed antennas has the gains at 4.48dBi when *l3*'=0, and 6.04 dBi when *l3*'=3.4 and at 12.6 GHz and 12.8 GHz, respectively, applicable for Military, Radar and Satellite systems. The additional frequency tuning by the slot lengths and angles are investigated in detailed for design convenience. This proposed antenna would be useful for the next generation of multi-band wireless communications.

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