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The analysis of distance variation on microstrip Broadband bow tie antenna (BBTA)

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Abstract-This paper focuses on the effect of distance variation between the triangles in a bow tie antenna which basically consists of two triangles shaped metals facing towards each other separated by a distance and arranged in a configuration of a bow tie structure. It is generally feed through a coaxial cable at the centre of the separation distance to achieve an impedance matching. It is the preferred structure because of its simplicity and capability of transmitting and receiving broad range of frequencies and hence known as broadband bow tie antenna (BBTA).

Keywords-BBTA, bow tie, impedance matching

I. Introduction

Generally, the basic aim of a microstrip antenna designer is to have a compact size with broad bandwidth besides a high gain, cost effectiveness, etc. These miniature broad bandwidth antennas have gained popularity from the early few decades due to its various characteristics such as light weight, low posture, substrate surface conformability, cost effectiveness, easy attainment with other circuits and broad bandwidth. With these various characteristics, it is now the choice of an antenna designer to choose a proper design and shape according to the need and application. Since, bow tie shape is simple to construct and is capable of transmitting and receiving broad range of frequencies and hence known as broadband bow tie antenna (BBTA) .In simple words, Bow tie antenna can be defined as two triangular segments of flat plates aligned in the shape of a bow tie, along with the feed point at separation portion between the tips of the two triangles. Since, this bow tie shape is designed from a rectangular patch antenna, so it will follow all the design characteristics of the basic rectangular microstrip antenna such as zero electric field at the center, positive high at one side and minimum at the other side [1]. These high and low electric fields change their position according to the instantaneous phase of the applied signal. These high and low electric fields never halt at the boundary of the patch as in a cavity; instead beef up to some degree in the outer periphery [2]. Similarly in the bow tie antenna electric field depends on the instantaneous phase of the applied signal at the gap between the two triangles. The bow tie antenna is popular for its simple construction, wide bandwidth, high gain, low (FBR) front-to-back ratio, low cross-polarization level, and small size. Since, it consists of two triangular pieces separated by a gap so to achieve maximum efficiency and directivity it is centrally feed. The feeding of this structure is done at the gap by designing relevant strip lines that are connected to a coaxial feed, which is integrated on one of the substrate edges. There are a variety of broadband techniques are developed such as introducing multiple resonances through inserting impedance networks, lowering the quality factor (Q) by selecting proper radiator shape or lowering the dielectric constant and many more It is known that the factors affecting the bandwidth of a microstrip patch antenna are primarily the shape of the radiator, the feeding scheme, the substrate and the arrangements of radiating and parasitic elements. Essentially, the broad bandwidth of a microstrip patch antenna can be attributed to its low Q value and simultaneously well excited multiple resonances. If the antenna is considered as a high-Q filter, lowering the Q by reducing the energy around the radiator or increasing losses broadens the bandwidth at its resonance. Alternatively, by inserting a broadband impedance network between the antenna and the feeder, good matching over a broad frequency range can be attained. If two or more adjacent modes are well excited simultaneously, the bandwidth can be twice or more than that for the single resonance.

Among the various broadband techniques available only lowering the quality factor Q by selecting the radiator shape is the basic technique used in this paper. Researchers have proved that the antenna shape affects the impedance bandwidth, even for the same maximum dimensions. But, the bandwidth improvement is quite limited [3-4].

II. Designing of a bow tie antenna

Initially, a rectangular entity is taken which is then modified for a bow tie shape. Therefore, for this only length and width are required. The basic dimensions of a rectangular patch antenna design (L, W, h, permittivity) determine the operation of an antenna.

The initial parameter necessary for any antenna design is its resonant frequency which can be calculated from the following equation

$$F_r \approx c \,/\, 2L\sqrt{\epsilon_r} = \frac{1}{2L\sqrt{\varepsilon r \varepsilon o \mu o}} \quad (1)$$

The resonant frequency determined is of 7.4 GHz Next important parameter is the resonant length of an antenna which can be calculated from the following equation

$$L_R = \frac{1}{2fr\sqrt{\varepsilon r \varepsilon o \mu o}} \quad (2)$$

This equation includes the following terms with first order correction for the extension of edge due to the fringing fields:

L_R =resonant length of an antenna
fr= resonant frequency of the designed antenna
εr = relative permittivity (dielectric constant) of the substrate
C = speed of light in free space
εo = free space permittivity
µo = free space permeability
Basically, relative permittivity of the substrate regulates the fringing fields in inversely proportional relationship that means lower permittivity have wider fringes and hence better radiation. Decreasing the permittivity also increases the antenna's efficiency and hence the bandwidth. The input impedance and the radiation pattern of an antenna is regulated by its width in the inversely proportional relationship i.e. the lower the input impedance is, wider the patch becomes[5]. But as the permittivity increases impedance of an antenna also increases. Therefore high permittivity will allow the compaction of an antenna. Mathematically, the width of an antenna can be calculated as

$$W = \frac{c}{2fr\sqrt{(\varepsilon r+1)/2}} \quad (3)$$

The bandwidth of an antenna is regulated by its height in a direct proportional relationship which in turn also increases the efficiency.

In fact, it is proved from the fact "an antenna occupying more space in a spherical volume will have a wider bandwidth. Mathematically, bandwidth can be calculated from the following equation

$$B.W. = \frac{(\varepsilon r-1)W}{\varepsilon r^{\wedge}2 \quad L}h \quad (4)$$

Using these basic equations[4,5] for dielectric constant of 4.4, parameters for rectangular patch antenna was found which was then modified for the bow tie structure and it was found that Length=45.4mm and width=30mm will yield the best simulation results for bow tie antenna.

III. Simulation results and graphs

Initially bow tie structure was constructed from a rectangular shape which is a basic geometrical shape. The following figure 1 shows a 2D bow tie structure.

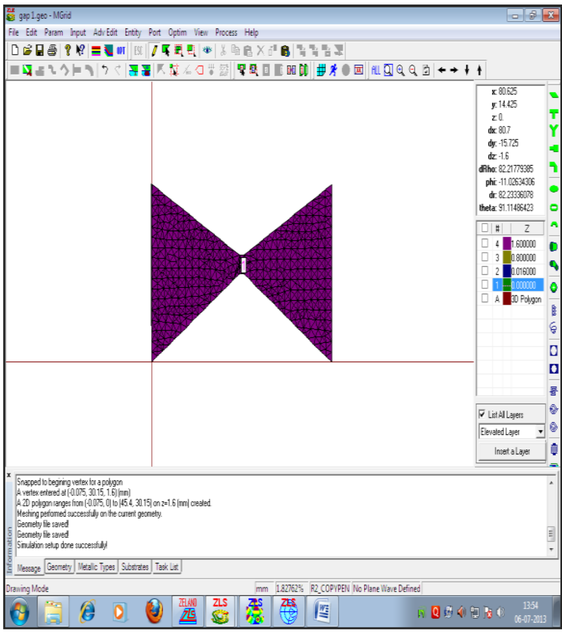

Figure1

Bow tie structure in 2 dimension

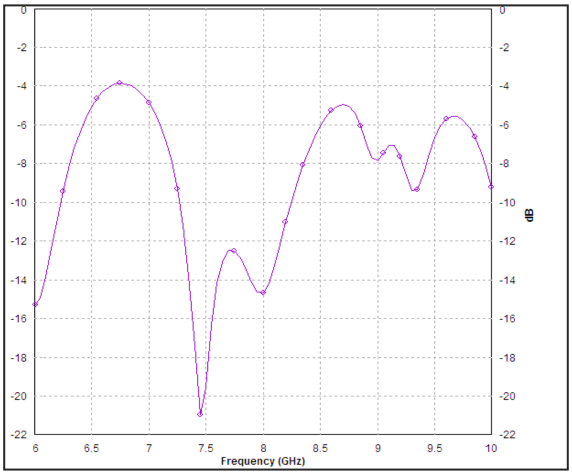

Figure 2 The reflection coefficient graph for a gap length of 1.4mm

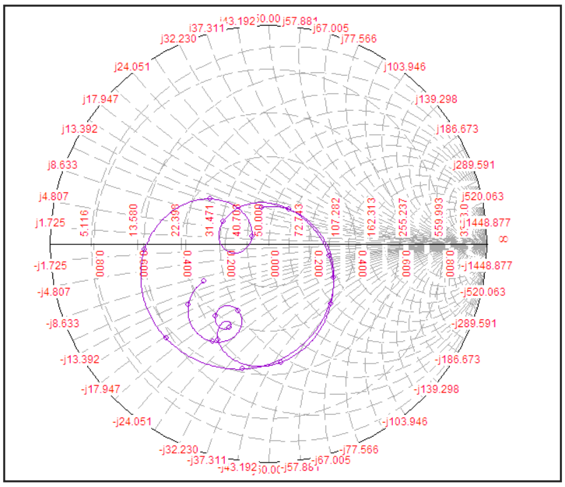

Figure 3 The smith chart plot for impedance matching in a bow tie structure for a gap length of 1.4 mm

Figure 2 basically helps in determining the resonant frequency and bandwidth of an antenna. The lowest dip point corresponds to the resonant frequency; in this case it is 7.4 GHz. The above figure 3 helps in determining the reflections or losses occurring in a bow tie antenna due to impedance mismatching. Since, this antenna is centrally feed through a coaxial cable having an impedance of 50 ohms, so it becomes necessary to have an antenna impedance of 50 ohms.

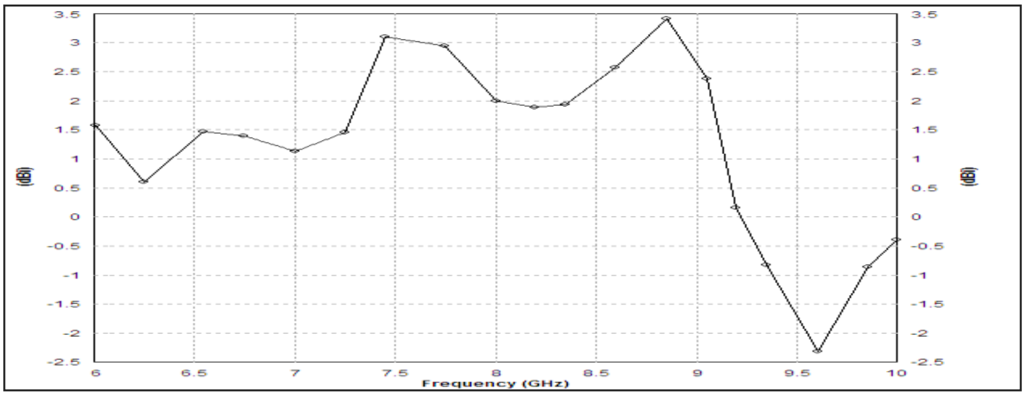

Figure4 Total field gain plot against frequency for gap length=1.4mm

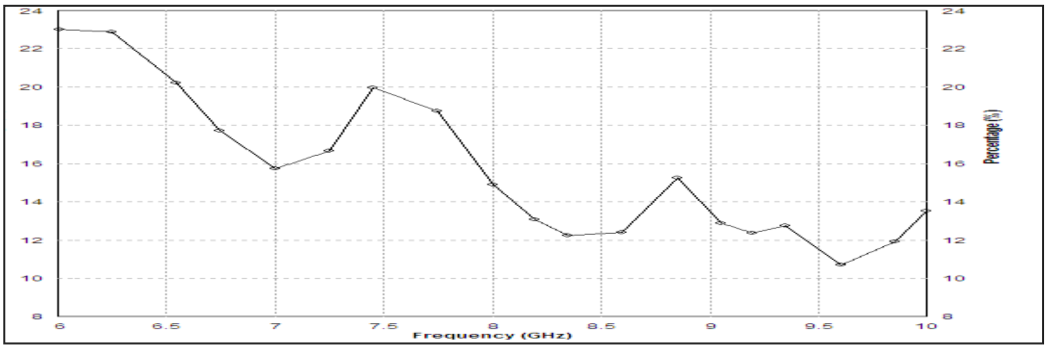

Figure5 Efficiency plot against frequency for gap length=1.4mm

After having known the resonant frequency it is necessary to have the knowledge of the gain and efficiency of a bow tie antenna at resonant frequency which is well determined from the above plots for a gap length of 1.4mm. as, it was stated earlier that gap length of 1.4 mm yields the best simulation result , so therefore graphs associated with this gap length is considered here and comparison table for various gap lengths is shown in the table 1.

Table 1 comparison Table for various gap lengths

S.no.	Gap length(mm)	Resonant Frequency(GHz)	f_h ,f_l (GHz)	Bandwidth (%)	Efficiency (%)	Gain(db)
1	1	9.048	9.3,8.8	5.52	16.65	1.08
2	1.4	9.096	9.4,8.7	7.7	15.9	0.37
3	2	8.08	8.25,7.75	6.4	14.04	1.7
4	5	6.20	6.4,6.0	6.2	26.33	1.25
5	10	6.25	6.4,6.1	4.8	26.77	1.20
6	20	9.80	9.9,9.6	3.07	14.55	0.6
7	30	9.94	10,9.8	2.0	20.50	2.31

IV. Results and Conclusion

The basic aim of designing antenna at microscale is that gain should be positive high. From the simulation results it's clear that initially gain increases till 3.2 db for the gap length of 1.4mm and then decreases for all values. Secondly, Bandwidth also increases till 12.82% for a gap length of 1.4 mm and then decreases for all values. Thirdly, efficiency keeps on increasing as the gap length increases. Last, but not the least, gap length of 1.4mm yields the best impedance matching among the various gap lengths of same length and width i.e. 45.4 mm and 30 mm respectively. Hence, gap length of 1.4 mm is the satisfied gap length for the analyzed broadband bow tie antenna (BBTA).It can be used for various applications such as ground penetrating radar, data, telecommunications (VoIP) and IPTV services (triple play), smart grids and metering and long distance communication[6-10]

V. References

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