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Comparison of Different Bow-Tie Antenna for Wireless Communication

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***Abstract*— In this paper, author has presented a Comparative Study of Different types of Bow-Tie Antenna which specifically used for the application in Wireless Communication Domain. In contrast, it will provide a separate way where we can utilize this type of Microstrip Structures. With virtue, designed prototypes entail greater success in achieving better bandwidth, gain with a motive controlling radiation. Also it acts as a way where it can as assure miniaturizations for which Bow-Tie Antennas act as good entity. All the simulation has been carried out by FDTD Solver.**

***Index Terms*—Bow Tie Antenna, Wireless Communication.**

I. INTRODUCTION

Much attention has been given to the Commercial UWB systems, since Federal Communications Commission (FCC) permitted the new radio transmission technology in February 2002 [1]. Considerable research efforts have been put into UWB radio technology worldwide, while non-digital part of UWB system, i.e. the transmitting and receiving antenna's, remains a particularly challenging topics. Patch antenna's are used in wireless communication systems because of following features; light weight, low cost and ease of the fabrication. As a drawback, it is well known that the bandwidth of the patch antenna is narrow.

Next generation wireless communication systems demand an antenna to exhibit multiple bands that are not harmonically related. A bowtie antenna is made from a bi-triangular sheet of metal with the feed at its vertex and is used due to its light weight and broadband properties. Many methods have been employed to increase bandwidth of the planar bowtie antenna such as the use of tapered slot, bowtie arms, double side and different feed structures [2].

After deep examination of bow-tie antenna literature, one can conclude that there is a problem of matching each side of the bow-tie antenna to suitable practical feeding port (usually 50ohm SMA connector). The bow-tie antenna like biconical antenna requires to be fed via 300- balanced transmission line [3]. Therefore, in order to feed the dipole by an 50ohm SMA connector, the designer has to follow one of two ways. The first way is to use a balun transformer, which is difficult to be implemented, due to its limited bandwidth and sometimes it requires an complicated shape, as well as an extra size [4], [5]. The second way uses multi section microstrip line of different widths or a gradually widened microstrip line, to work as an impedance transformer for matching them [6].

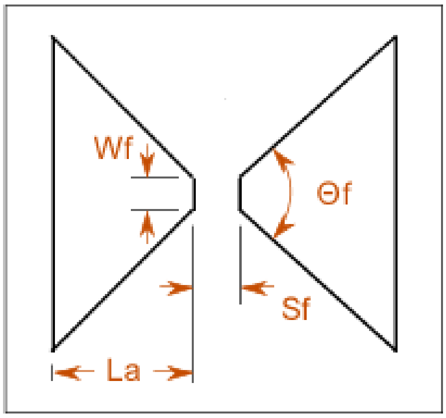
In this paper, the author has presented Different Types of a Bow-Tie Antenna that satisfies it's occupancy for application in the Wireless Communication Domain. For each and every prototype FR-4 Substrate and Rogers RT 5870 Substrate are generally used.

II. DESIGN OF PROTOTYPES

A. *Bow-Tie Antenna*

Modified dipole shapes are often used to obtain wide-band operation without increasing the complexity of the antenna. The bow-tie antenna represents one of the simplest dipole variations, and provides reasonable wide-band performance in spite of its simplicity. The antenna is popular in frequencies ranging from UHF up to the millimeter wave range and has application in arrays.

The bow-tie antenna performance is not sensitive to small parameter variations, improving robustness to manufacturing tolerances. While the bow-tie antenna as in provides more on reasonable wide-band performance, this is not a high gesture performance antenna; demanding applications may call for as such more complex design's. The resistively loaded bow-tie antenna is a practical candidate for pulse radiation, e.g. for the Ground Penetrating Radar applications [7], [8] as in Figure-1 with the Constructional Parameters in Table-I.



(a)

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(b)

Figure-1. Structure of Designed Antenna or Prototype-I.
(a) Top-View (b) Side View.

Table-I
Constructional Parameters of Prototype-I

Parameters	Dimensions in mm
Arm Length, La	21.07
Feed Width, Wf	0.832
Feed Gap, Sf	0.832
Flare Angle, θf	60^{o}

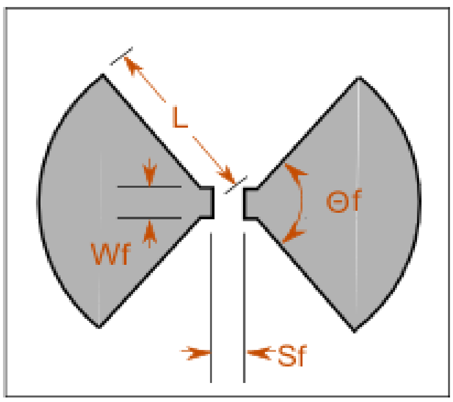
Substrate Details:

1. FR-4
2. Relative Permittivity-4.3
3. Height of Substrate-1.6 mm

B. *Rounded Bow-Tie Antenna*

Modified dipole shapes are often used to obtain wide-band operation without increasing the complexity of the antenna. The rounded bow-tie antenna represents a fairly simple dipole variation, and provides good wide-band performance in spite of simplicity. This antenna is popular for frequencies ranging from UHF up to the millimeter wave range, and has also found application in arrays.

The rounded bow-tie is closely related to the conventional (triangular) bow-tie; the rounding results out in an impedance frequency response that is much flatter than that of the regular bow-tie. For transient applications (i.e. when short duration pulses are used), bow-tie antennas with the rounded edges as demonstrate better performance as reflections from the ends occur at the same time instant. Pulse radiation can be further improved by resistive loading [9]. Though, a rounded bow-tie antenna performance is not sensitive to every small parameter variations, improving robustness to manufacturing tolerances as in Figure-2 with Constructional Parameters in Table-II.



(a)

(b)

Figure-2. Structure of Designed Antenna or Prototype-II
(a) Top-View (b) Side View.

Table-II
Constructional Parameters of Prototype-II

Parameters	Dimensions in mm
Arm Length, L	60.93
Feed Gap, Sf	2.082
Feed Line Width, Wf	2.082
Flare Angle, θf	73^{o}

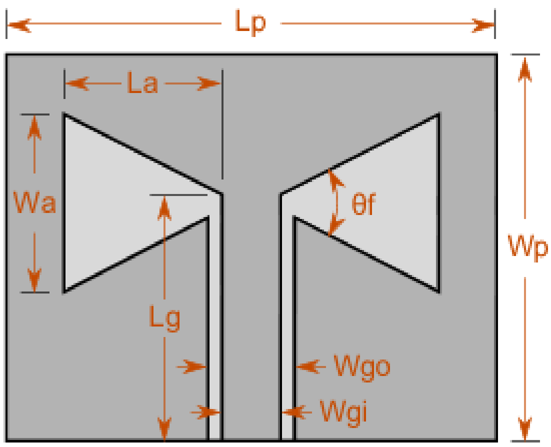
Substrate Details:

1. Rogers RT Duroid 5870
2. Relative Permittivity-2.33
3. Height of Substrate-0.787 mm

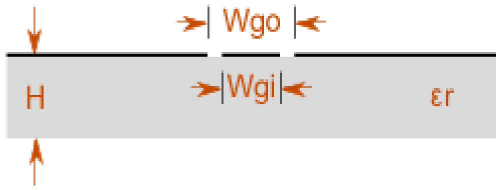
C. *CPW Fed Bow-Tie Antenna*

Modified dipole shapes are often used to obtain wide-band operation without increasing the complexity of the antenna. The bow-tie antenna represents one of the simplest dipole variations, and provides reasonable wide-band performance in spite of its simplicity. Slot antenna's have several appealing advantages over the microstrip antenna's: they provide wider bandwidth, good impedance matching, and the possibility of obtaining bidirectional and unidirectional radiation patterns. Slot antennas are usually fed by coplanar waveguide (CPW).

Coplanar waveguides are preferable to microstrip lines for several reasons, such as their low dispersion, the ability to effectively control their characteristic impedance, and their ease of integration with active devices. As the antenna fed by an ungrounded CPW has the advantage of ease of fabrication owing to its single metallisation and dielectric layers [10] as in Figure-3 with the Constructional Parameters in Table-III.



(a)



(b)

Figure-3. Structure of Designed Antenna or Prototype-III
(a) Top-View (b) Side View.

Table-III
Constructional Parameters of Prototype-III

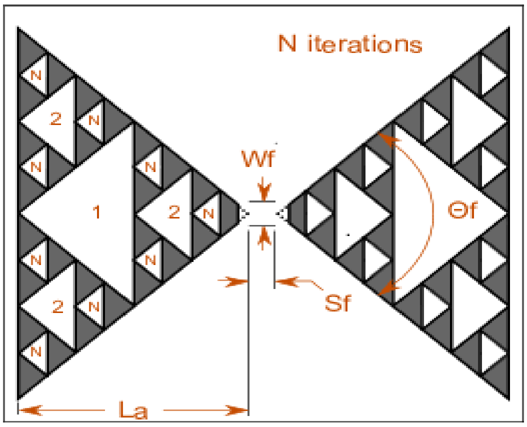
Parameters	Dimensions in mm
Arm Length, La	16.71
Arm Width, Wa	19.84
Flare Angle, θf	60^o
Plate Length, Lp	52.75
Plate Width, Wp	50.13
CPW Length, Lg	33.42
CPW Inner Width, Wgi	2.622
CPW Outer Width, Wgo	3.162

Substrate Details:

1. FR-4
2. Relative Permittivity-4.3
3. Height of Substrate-1.6 mm

D. Sierpinski Bow-Tie Antenna

The self-similarity for the case of fractal geometries lend them to arise of multi-band antenna designs. A simple fractal geometry that provides on multi-band performance in antenna applications is the Sierpinski gasket. The characteristics of the Sierpinski gasket results in antenna bands which is generally spaced approximately a factor 2 apart. Other band spacing's are also possible by modifying the Sierpinski geometry. The antenna performance (pattern and impedance) in each of band are identical, up to the point where truncation and substrate effects come into. This makes the Sierpinski Bow-Tie suitable for applications where the matched multi-band performance is important. Physically the Sierpinski Bow-Tie [11], [12] is as quite similar to the Standard Bow-Tie, similar in construction techniques may be used as in Figure-4 with the Construction Parameters in the Table-IV.



(a)

(b)

Figure-4. Structure of Designed Antenna or Prototype-IV
(a) Top-View (b) Side View.

Table-IV
Constructional Parameters of Prototype-IV

Parameters	Dimensions in mm
Arm Length, L	66.09
Feed Gap, Sf	0.142
Feed Line Width, Wf	0.142
Flare Angle, θf	60^o

Substrate Details:

1. Rogers RT Duroid 5870
2. Relative Permittivity-2.33
3. Height of Substrate-0.787 mm

III. EXPLORATION OF OUTCOMES

A. Bow-Tie Antenna

The entire corresponding simulated outcomes were obtain--ed by the use of CST-MWS as shown in Figure-5, Figure-6 & Figure-7 respectively.

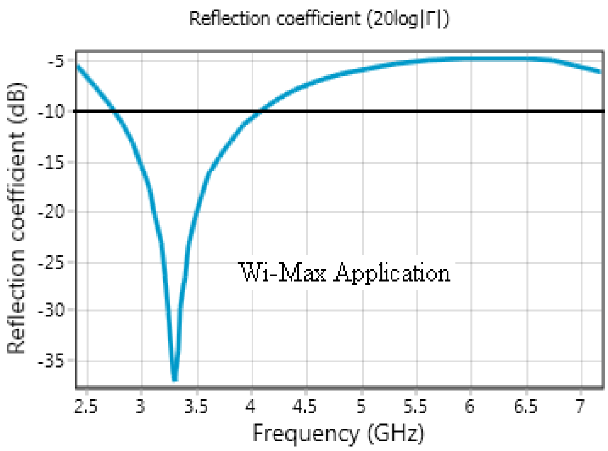


Figure-5. S_{11} Characterstics of Prototype-I.

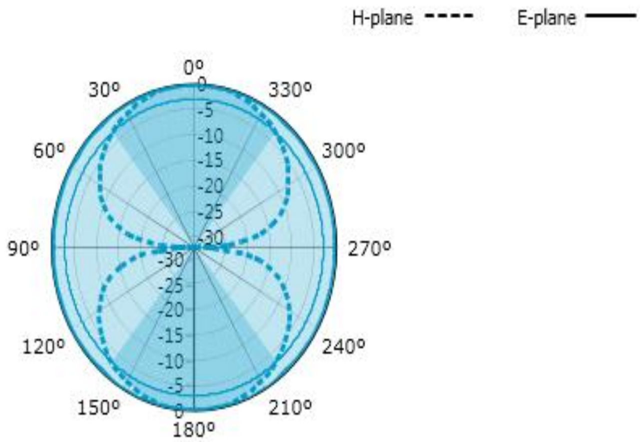


Figure-6. Radiation Pattern of Prototype-I.

In the above cases, author has presented S_{11} Characterstics and Radiation Pattern of Different Aspects of Bow-Tie based Antenna's. They produce quite amazing results because they heal out a property called End-Fire that put significant impact.

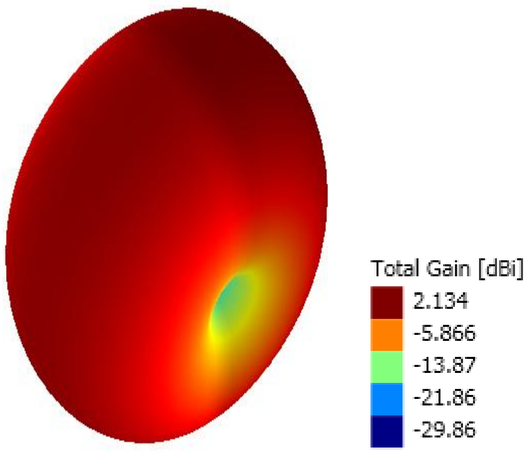


Figure-7: Gain Pattern of Prototype-I.

B. Rounded Bow-Tie Antenna

The entire corresponding simulated outcomes were obtain--ed by the use of CST-MWS as shown in Figure-8, Figure-9 & Figure-10 respectively.

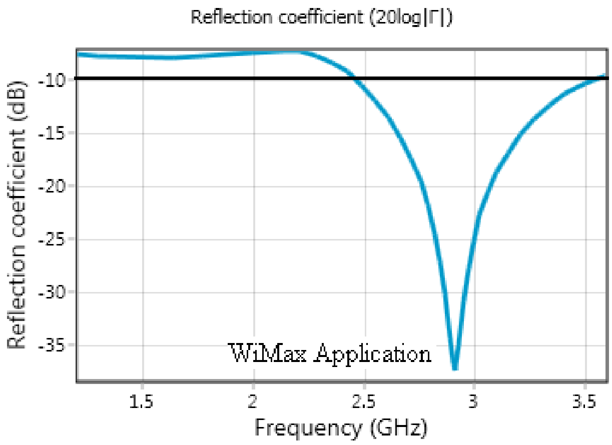


Figure-8. S_{11} Characterstics of Prototype-II.

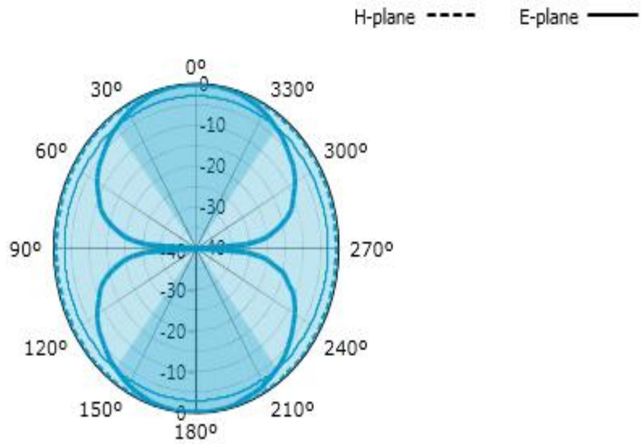


Figure-9. S_{11} Radiation Pattern of Prototype-II.

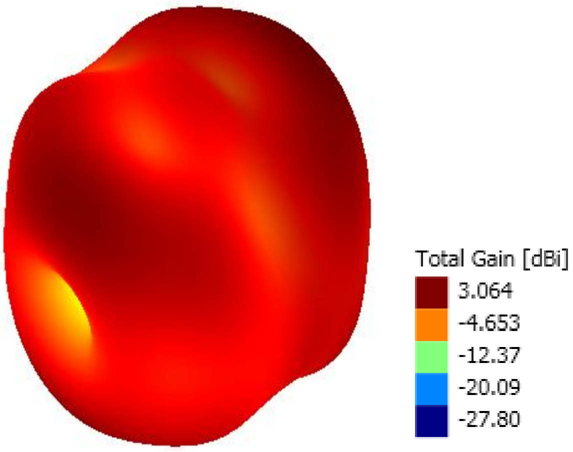


Figure-10: Gain Pattern of Prototype-II.

C. CPW Fed Bow-Tie Antenna

The entire corresponding simulated outcomes were obtain--ed by the use of CST-MWS as shown in Figure-11, Figure-12 & Figure-13 respectively.

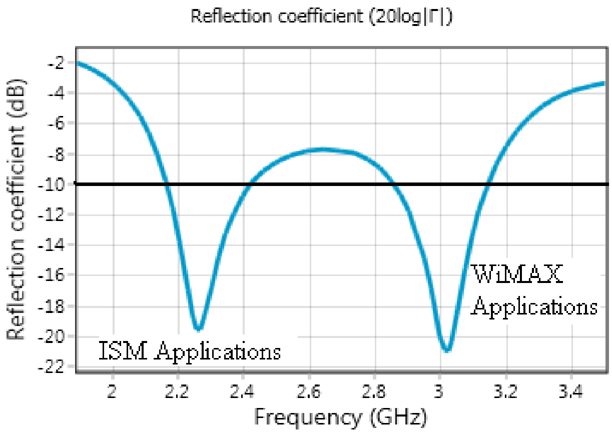


Figure-11. S_{11} Characterstics of Prototype-III.

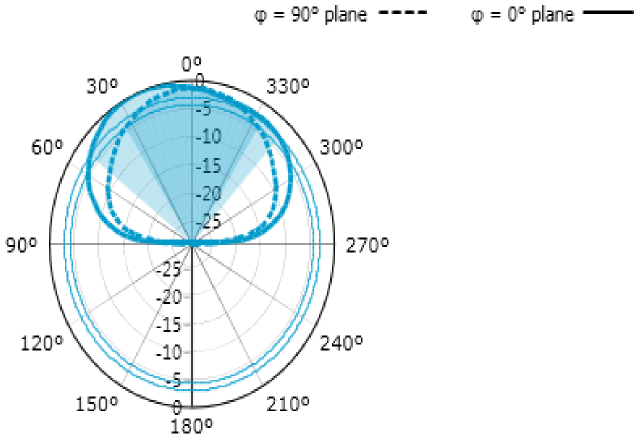


Figure-12. Radiation Pattern of Prototype-III.

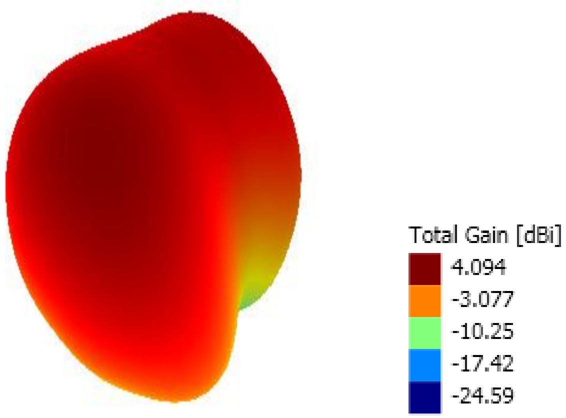


Figure-13: Gain Pattern of Prototype-III.

D. *Sierpinski Bow-Tie Antenna*

The entire corresponding simulated outcomes were obtain--ed by the use of CST-MWS as shown in Figure-14, Figure-15 & Figure-16 respectively.

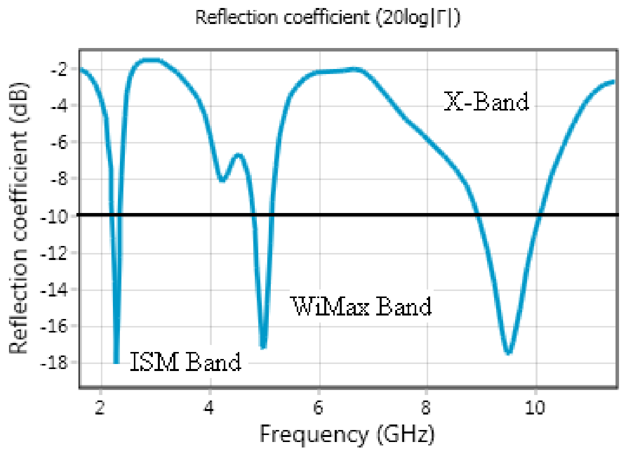


Figure-14. S_{11} Characterstics of Prototype-IV.

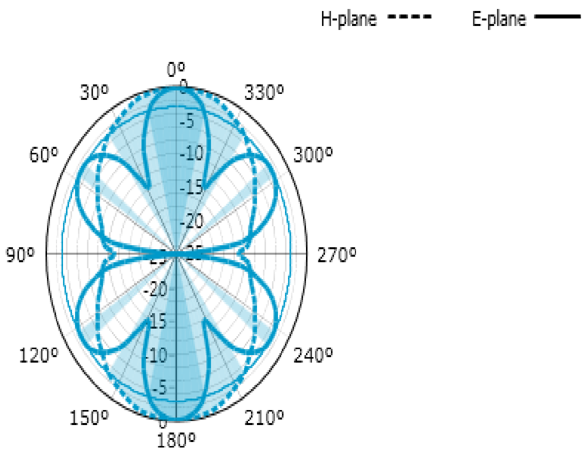


Figure-15. Radiation Pattern of Prototype-IV.

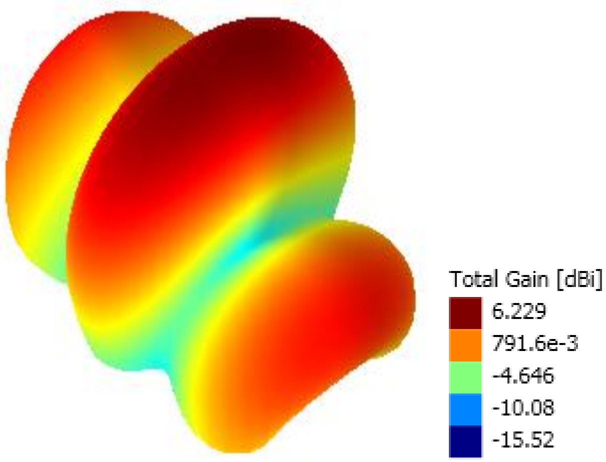


Figure-16: Gain Pattern of Prototype-IV.

IV. CONCLUSION

In this paper, the author has presented Comparative Study of Different Types of Bow-Tie Antenna used for mainframe Applications in Wireless Communication Domain. All details regarding the Design, Analysis and Modelling of Prototypes was well presented along with their individual behaviour for specific Applications.

APPENDIX

A. Design Guidelines for Bow-Tie Antenna

This can be explained as:

- The reference impedance is 250 Ω. The design aims to maximize bandwidth over which both radiation pattern and impedance performance is acceptable by designing for VSWR < 3 at the minimum frequency.
- To increase (decrease) frequency of operation, decrease (increase) the arm length.
- To improve the impedance match, decrease the substrate thickness and permittivity.
- To increase gain, decrease the substrate thickness and permittivity.

B. Design Guidelines for Rounded Bow-Tie Antenna

This can be explained as:

- The antenna characteristics usually vary less with frequency for the flare angles of close to 60 degrees, i.e. Design's around 250 Ohm.
- To increase (decrease) frequency of operation, decrease (increase) the arm length.
- To improve the impedance match, decrease the substrate thickness and permittivity.
- To increase (decrease) input impedance, then we find decrease (increase) the flare angle.

C. Design Guidelines for CPW Fed Bow-Tie Antenna

This can be explained as:

- The reference impedance is at 50 Ω. The design aims to maximize the bandwidth over in which radiation pattern & impedance performance is acceptable by designing for |S11| < -10 dB at the centre frequency.
- To increase (decrease) frequency of operation, decrease (increase) the arm length.
- To improve the impedance match, decrease the substrate thickness and permittivity.
- To increase gain, decrease substrate thickness & permittivity.

D. Design Guidelines for Sierpinski Bow-Tie Antenna

This can be explained as:

- To increase (decrease) frequency of operation, decrease (increase) the arm length.
- To improve the impedance match, decrease the substrate thickness and permittivity.
- To increase the number of available fractal bands, increase number for fractal iterations.
- To increase (decrease) input impedance, we have decrease (increase) the flare angle.

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