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SIMULATIVE ANALYSIS OF DISCONE ANTENNA FOR 2.44 GHZ REGIME USING ANTENNA MAGUS

Amandeep Singh,

Asstt. Prof. in ECE Deptt,

DAV institute of Engineering & Technology, Jalandhar

Neeru Malhotra

Associate Professor in ECE deptt.

DAV institute of Engineering & Technology, Jalandhar

Gagandeep Sharma

Asstt. Prof. in EE Deptt,

DAV institute of Engineering & Technology, Jalandhar

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ABSTRACT

The discone antenna is a monopole variation of the biconical antenna using a small 'ground plane', therefore the discone is a modified dipole shape. Dipole modifications are generally used to obtain wide-band operation without greatly increasing complexity. Wide angle biconical antennas are popular for their wide impedance bandwidth and omnidirectional radiation pattern. The discone variation may be preferred when the reduced physical size or radiation mainly in one half-space is required. The simulated analysis of the antenna shows that we can achieve different degrees of performance in terms of gain, reflection coefficient, VSWR, Input impedance by slightly varying some important parameters of the Discone antenna for 2.44GHz regime. In this paper we have used the antenna designing software i.e., Antenna Magus 2.4.0 evaluation version for the analysation of the several design parameters of the discone antenna. Finally the comparative analysis of different designs has also been discussed here.

keywords— input impedance, 3db beamwidth , ground plane, peak gain, s11, vswr.

1. INTRODUCTION

The discone antenna is a monopole variation of the biconical antenna using a small 'ground plane', therefore the discone is a modified dipole shape [2]. Dipole modifications are often used to obtain wide-band operation without greatly increasing complexity. Wide angle biconical

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antennas are popular for their wide impedance bandwidth and omni directional radiation coverage. The discone variation may be preferred when the reduced physical size or radiation mainly in one half-space is required [1].

So basically A discone antenna is a version of a biconical antenna in which one of the cones is replaced by a disc. It is usually mounted vertically, with the disc at the top and the cone beneath. It is offering a frequency range ratio of up to ~10:1. The radiation pattern in the vertical plane is quite narrow, making its sensitivity highest in the plane parallel to the Earth [5]. A discone antenna typically has at least three major components: the disc, the cone, and the insulator. The disc and cone must be separated by an insulator, the dimensions of which determine some of the antenna's properties [8]. The smaller ground plane provides a size and weight advantage over the monocone while still providing acceptable broad-band performance.

2. FEED MECHANISM AND CONSTRUCTION

The discone antenna is generally fed with one of two possible feed orientations depending on antenna orientation:

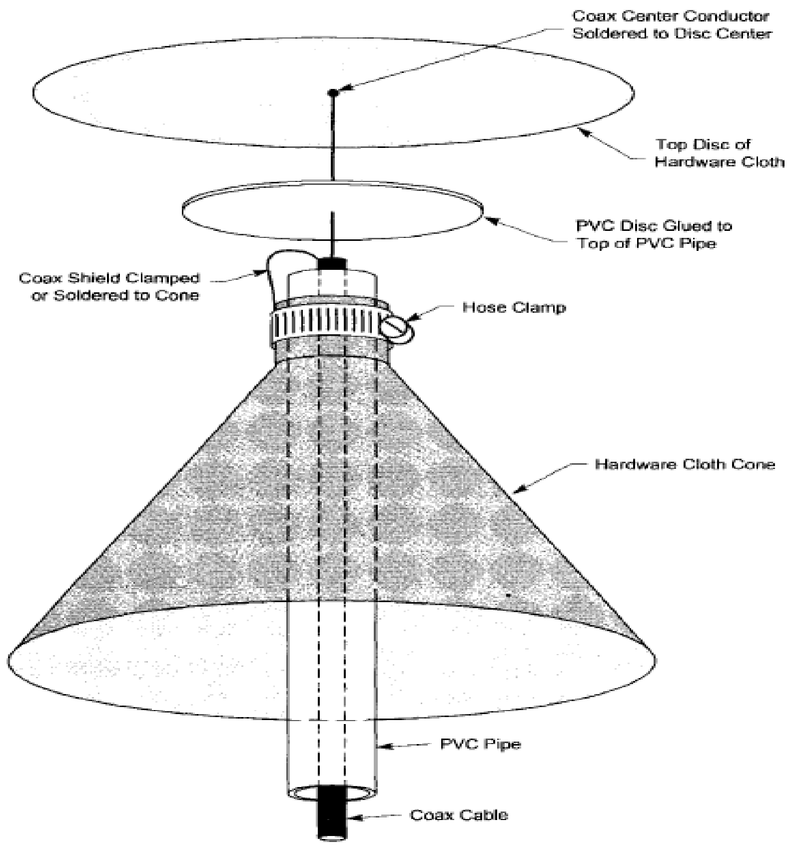

Fig. 1 Discone Antenna [9]

If the cable runs through the cone, the outer conductor terminates at the tip of the cone and is electrically connected there, while the centre conductor runs through the cone-tip and is

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connected to the disc. If the cable runs through the disc, the outer conductor is connected to the disc, while the centre conductor runs through the disc and is connected to the cone-tip. Feed method and construction of a discone antenna is diagrammatically shown above in detail.

Simply stated, a Discone looks like an inverted cone with a round disc placed on its top and insulated from the cone. Amateur ingenuity will quickly bring to mind several ways one could construct such an antenna. Options for construction material and technique are as varied as one can imagine. For the cone and disc. copper window screen can be used with wood strips for inside cone support. For larger antennas, we might consider self-supporting wire for the cone and disc rather than the screen material. Discone antennas for the HF spectrum may be looked like string lights on a pole at Christmas.

3. DIMENSIONS OF DISCONE ANTENNA

It is very important to know about the dimensions of the discone antenna because the parameters of the antenna depends upon the dimensions directly[6], in another way we can say that by varying the physical dimensions of the antenna the optimum parameters may be achieved.

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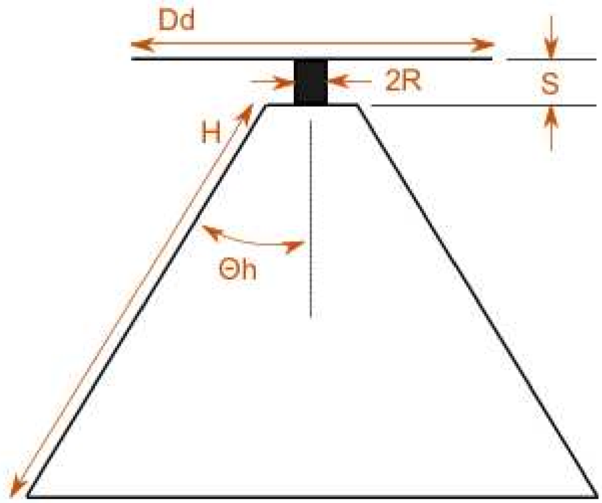

Fig. 2 Side view of Discone Antenna

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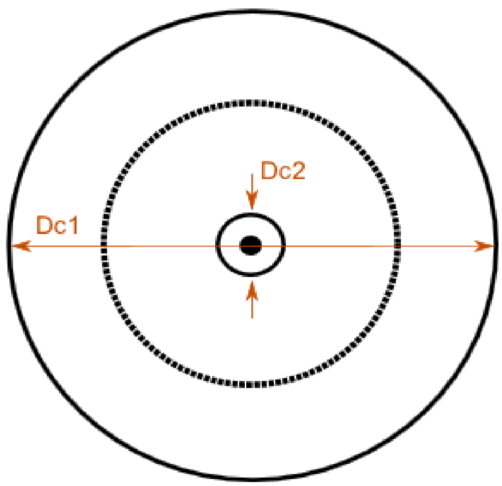

Fig. 3 View into bottom of cone

Figure 2 and 3 shows different views of the discone antenna to clarify about the dimensions of the antenna which are taken into consideration during the designing of antenna for the specific application. The detail of the dimensions are mentioned below.

- f_o Centre frequency.
- Dd Disc diameter.
- R Feed pin radius.
- S Gap between the cone and disc.
- Dc2 Minimum cone diameter.
- H Cone slant height.

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- Dc1 Maximum cone diameter.
- Θh Cone flare angle.

4. RESULTS AND DISCUSSION

At high frequencies, the discone antenna approximates the performance of an infinite monocone antenna [3]. Energy from the feed point spreads over the surface of the cone from the apex towards the base until the vertical distance between the annulus on the cone and the feed point is approximately a quarter of a wavelength, and is radiated. A relatively small amount of energy reaches the end of the cone, where reflected and diffracted waves cause the actual antenna performance to deviate from the ideal infinite monocone performance. The finite size of the feed region also causes deviation from the ideal case, and has the largest effect on high-frequency performance.

There are some important parameters which are required to derive for the analysis of discone antenna. In our experiment we have chosen the parameters as Reflection coefficient, Input impedance, VSWR, and Gain at lower frequency and at centre frequency for which the antenna is designed. In general we have configured three design of the respective antenna by varying some of its important dimensions and

describe the results in the graphical form as well as in the tabular form. The three set of design parameters are given below in the tabular form by using which we have analysed the performance of the discone antenna for the center frequency of 2.44GHz .

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Dimensions	Design1	Design 2	Design 3
f_o	2.44Ghz	2.44Ghz	2.44Ghz
Dd	61.06mm	61.06mm	58.45mm
R	218.4µm	218.4µm	218.4µm
S	327.6 µm	327.6 µm	309.3 µm
Dc2	1.092mm	1.092mm	974.2 µm
H	87.23mm	87.23mm	83.55mm
Dc1	87.23mm	95.42mm	95.43mm
Θh	29.58^0	32.73^0	34.42^0

Table 1. Dimensions of Design1, Design2 and Design 3.

Three design dimensions of discone antenna are mentioned in the table 1. All of these three design are having center frequency at 2.44GHz but other dimensions of the antennas are slightly differentiated by each other as design 2 is having almost all of the dimensions similar to design 1 except the Dc1 and Θh which are maximum diameter of the cone and flare angle of the cone of discone antenna. Design 3 differs from the design 1 and design 2 by the disc diameter 'Dd', gap between the cone and the disc i.e. 'S', minimum cone diameter i.e. 'Dc2', cone slant height i.e. 'H', maximum cone diameter i.e. 'Dc1, and flare angle Θh. We have chosen these

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three design to analyse the effect of change in dimensions of the antenna on the performance parameters of the antenna.

In this work we opted the reflection coefficient S11, input impedance, VSWR, total gain at the minimum frequency and the total gain at the center frequency to analyse the performance of the discone antenna for 2.44GHz frequency. Now let us consider the reflection coefficient or S11 as a first performance parameter and it is observed from the fig 4 in which three coloured graph shows the reflection coefficient variation with respect to the frequency in GHz. These three graphs are derived by using the dimensions of design1, design2, and design3 and shown by different colours. Fig 4 shows the performance of the discone antenna in terms of its parameter as reflection coefficient with respect to frequency. Reflection coefficient of the antenna should be minimum at the frequency of interest and it is clear from the fig. 4 that design 3 is having less reflection coefficient or S11 parameter at frequency 2.44GHz as compare to the design 1 and design 2 of the discone antenna. Detailed analysis of the curves of reflection coefficient w.r.t. frequency can be analysed from table 2.

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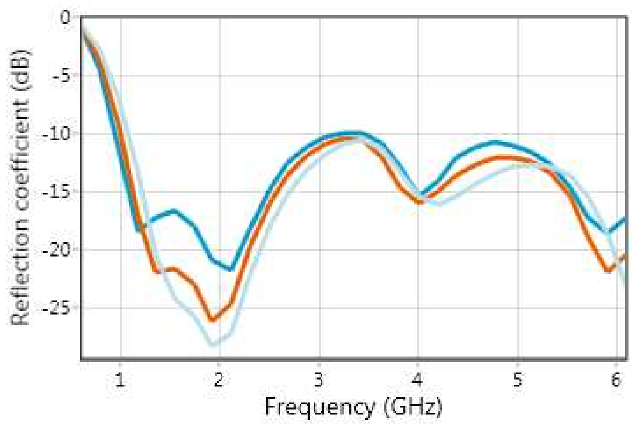

Fig. 4 Reflection coefficient of Discone Antenna

It has been observed from the table 2 that design 1 is having 3 frequencies at which the S11 = -10dB, Design2 and design 3 are having only single frequency at which the S11 = -10dB.

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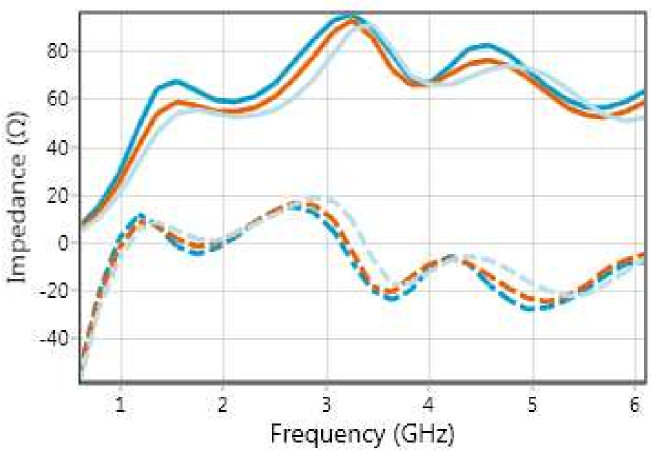

Fig. 5 Input impedance Vs frequency

It is also observed from the table 2 that minimum reflection coefficient or S11 value can only be achieved by design3 which is -28.40dB. All of the measurements are taken by considering the reference impedance@ port1 is 50Ω.

Above figure shows the graphical representation of the input impedance Vs frequency in which hard lines show the real impedances and dashed lines show the imaginary impedances of design 1(blue line), design 2(Golden brown line), and design 3(Grey line) respectively. It is observed from this parameter analysis that design 3 has input impedance 58.09 Ω, which is below the impedance value of other designs but near to the required value i.e 50Ω so again design 3 is better in this way.

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	Design1	Design 2	Design 3
Reference impedance @ port 1	50 Ω	50 Ω	50 Ω
Frequency at which S11 = -10 dB	951.9 MHz 3.247 GHz 3.325 GHz	1.006 GHz	1.077 GHz
Minimum S11 value	-21.79 dB @ 2.124 GHz	-26.28 dB @ 1.935 GHz	-28.40 dB @ 1.935 GHz

Table 2. Reflection coefficient analysis 'S11' for Design1, Design2, and Design3.

	Design1	Design 2	Design 3
Peak real impedance @ frequency	95.56 Ω @ 3.260 GHz	92.70 Ω @ 3.260 GHz	91.11 Ω @ 3.450 GHz
Real impedance @ zero-crossing frequency	27.87 Ω @ 976.9 MHz 66.41 Ω @ 1.519 GHz 58.92 Ω @ 2.032 GHz 94.03 Ω @ 3.139 GHz	27.89 Ω @ 1.028 GHz 58.01 Ω @ 1.661 GHz 55.37 Ω @ 1.912 GHz 91.13 Ω @ 3.196 GHz	27.39 Ω @ 1.098 GHz 90.14 Ω @ 3.374 GHz
Mean real impedance	64.58 Ω	59.94 Ω	58.09 Ω
Mean imaginary impedance	-9.094 Ω	-7.319 Ω	-6.197 Ω

Table 3. Input impedance Vs Frequency analysis of Design1, Design2, and Design3.

Tabular analysis of impedance Vs frequency shows that peak real impedance for design 1 is obtained at 3.260GHz, peak real impedance of design 2 is obtained at 3.260GHz but the peak

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impedance of design 3 is obtained at 3.450GHz. It has also confirmed that the real peak impedance is slightly lower than the other designs. Another important thing table 3 is that design 1and design 2 is having four values of real impedances @ zero crossing imaginary frequencies as well as design 3 is having only two values of real impedances @ zero crossing imaginary frequencies. Mean imaginary frequency of design 3 is also less than the design 1 and design 2.

VSWR is also an important parameter of the antenna analysis. The optimum value of VSWR should be minimum near the frequency of interest which is 2.44GHz in this case study. It can be observed from the figure 6 that grey graph line is very near to zero at the frequency of interest as compare to the blue and golden brown graphs i.e. design 3 is better than the design 1 & design 2. Detailed comparison of all the designs in

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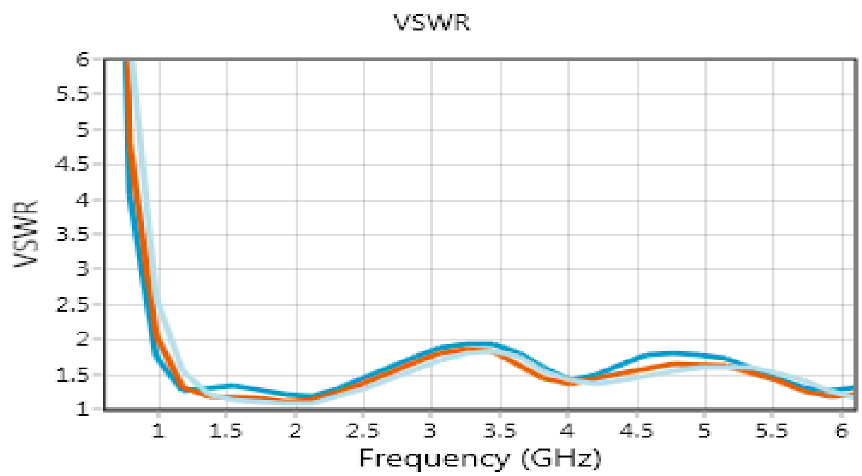

Fig. 6 VSWR Vs frequency

terms of its VSWR can be analysed from the table 4 which shows the frequency of design 3 is 1.097GHz at VSWR = 2 and it is little bit greater than the frequencies of other designs at same VSWR. Minimum VSWR value has been achieved while considering reference impedance @port1 is 50Ω.

	Design1	Design 2	Design 3
Reference impedance @ port 1	50 Ω	50 Ω	50 Ω
Frequency at which VSWR = 2	967.6 MHz	1.000 GHz	1.097 GHz
Minimum VSWR value	1.177 @ 2.124 GHz	1.102 @ 1.935 GHz	1.079 @ 1.935 GHz

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Table 4. VSWR Vs Frequency analysis of Design1, Design2, and Design3.
with design 3 which is 1.079 at frequency 1.935GHz

Above three important parameters that is reflection coefficient, VSWR, and input impedance comes under the heading of “impedance Vs frequency analysis”. Another important analysis is “Gain Analysis” at the lower frequency and at the centre frequency which is 2.44 GHz in this case.

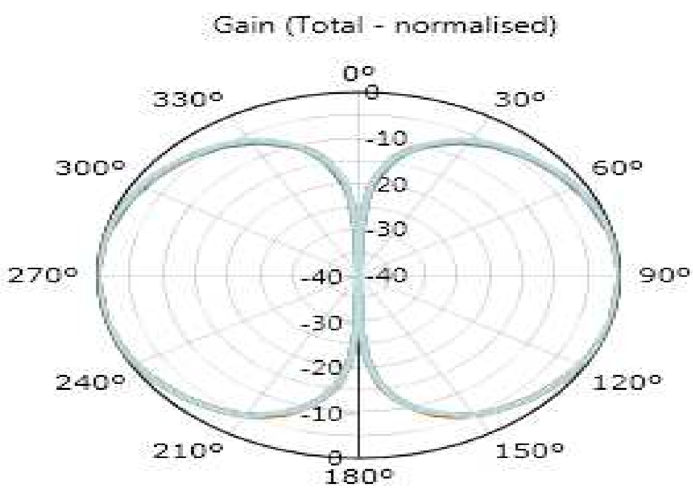

Fig. 7 Gain at lower frequency(1.22GHz)

In this gain analysis the peak gain is 1.708dBi at an angle of θ = 98o , and at the minimum frequency which is 1.22GHz for design 1, peak gain is 1.636dBi at an angle of θ = 96o , and at the minimum frequency 1.22GHz for design 2, peak gain is 1.606dBi at an angle of θ = 96o ,

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and at the minimum frequency 1.22GHz for design3. From these gain values It indicates that gain at frequency 1.22GHz for all the design slightly differs from each other and gain of design3 is lesser than the design1 and design2 but with fractional decimal value. The main 3dB beamwidth is 91.93o for design1, 94.27o for design2, and 95.17o for design3 which indicates that design3 is having higher beamwidth than others at the minimum frequency.

Gain plots for design1,2 &3 at center frequency of 2.44GHz are shown in figure 8

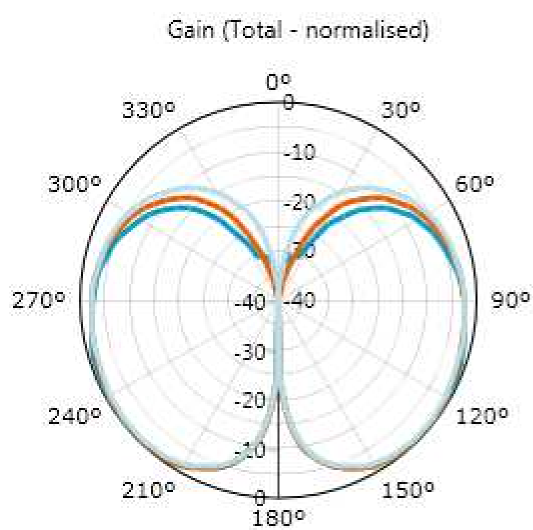

Fig. 8 Gain at centre frequency(2.44GHz)

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Gain plots for all of the design clearly indicated in the fig. above & the mathematical analysis for this is given in the table 6. It has been observed from the table 6 that peak gain for design1 is 3.115dBi at an angle of θ = -132o at the center frequency, peak gain for design2 is 2.832dBi at an angle of θ = -134o at the center frequency, and the peak gain for design3 is 2.488dBi at an angle of θ = 132o at the center frequency. It indicates that the peak gain of design3 is slightly below than the design1 & 2. But this is not a drawback of this design because the minimum required gain for the discone antenna isa 2dBi and the observed gain for the design3 of discone antenna is more than this that's why it is acceptable. The second important parameter of the gain analysis is 3dB beamwidth and it is higher in the design3 as compared to other designs which we can observe from the table6. So it is observed from the above discussion that the impedance Vs frequency parameters are improved in the design3 as compared to the design1 and design2.

	Design1	Design 2	Design 3
Peak gain @ angle (freq) [φ = 0 °]	1.708 dBi @ θ = 98 ° (1.22 GHz)	1.636 dBi @ θ = 96 ° (1.22 GHz)	1.606 dBi @ θ = 96 ° (1.22 GHz)
Main 3dB beamwidth (freq) [φ = 0 °]	91.93 °	94.27 °	95.17 °

Table 5. Gain analysis at minimum frequency(1.22GHz) for Design1, Design2, and Design3

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	Design1	Design 2	Design 3
Peak gain @ angle (freq) [φ = 0 °]	3.115 dBi @ θ = -132 ° (2.44 GHz)	2.832 dBi @ θ = -134 ° (2.44 GHz)	2.488 dBi @ θ = 132 ° (2.44 GHz)
Main 3dB beamwidth (freq) [φ = 0 °]	71.47 °	79.99 °	87.15 °

Table 6. Gain analysis at center frequency(2.44GHz) for Design1, Design2, and Design3

5. CONCLUSION AND FUTURE SCOPE

It is concluded from the above design analysis of three discone antennas for the 2.44GHz regime i.e. design1, design2, and design3 that mainly there are two parameters which are “impedance Vs frequency” and “vertical normalised gain” and five sub parameters belongs to main parameters, those are reflection coefficient, VSWR, input impedance, gain at lower frequency and gain at centre frequency. From the above analysis we can state that the impedance Vs frequency parameters are improved and the gain parameters are little bit decays but not more than the minimum required gain value for the discone antenna design3.

Now it is concluded that :

1. The ripples in the reflection coefficient can be reduced by increasing the flare angle.
2. Decrease in input impedance is achieved by increasing the flare angle.
3. Increase in input impedance by decreasing the flare angle.

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4. The diameter of the disc should be kept at approximately 70% of the maximum diameter of the cone.

5. To increase the operating frequency decrease all the dimensions.

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