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GROUNDING EFFECT ON THE PERFORMANCE OF UWB ICE-CREAM CONE ANTENNA

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Graphical abstract

Abstract

In this paper, presents the grounding effect on the performance of UWB Ice Cream Cone Antenna communication. This planar antenna designed on a FR4 substrate with the dielectric thickness, 1.6 mm and the dielectric constant ε_r, 4.7. An analysis results for antenna with different parameter for width of feed as a ground has been investigated. The antennas were designed and simulated by using CST Microwave Studio Simulation. The proposed antenna performs from 4 GHz to 11 GHz spectrum band. The return losses, S_{11} for the suggestion antenna must be below than -10dB and voltage standing wave ratio, VSWR less than 2. The best grounded single ice cream cone antenna performance was obtained at 5.688 GHz with antenna sizes is 12 mm x 14.5 mm. The antenna gives omnidirectional radiation characteristics from UWB spectrum band requirement with reasonable gain values.

Keywords: Ice cream cone antenna, Ultra Wide-Band, S_{11}, VSWR, omnidirectional radiation pattern.

Abstrak

Kertas ini membentangkan kesan pembumian ke atas antena ais krim kon terhadap prestasi komunikasi UWB. Antena ini direka di atas substrat FR4 dengan ketebalan dielektrik, 1.6 mm dan εr pemalar dielektrik, 4.7. Satu analisis terhadap parameter garisan lebar yang berbeza merujuk sebagai pembumian telah dikaji. Antena direka dan disimulasi dengan menggunakan CST Microwave Studio Simulasi. Antena yang dicadangkan beroperasi pada spektrum lebar jalur 4GHz hingga 11 GHz . S_{11} bagi antena cadangan mesti berada di bawah daripada -10dB dan nisbah gelombang voltan berdiri, VSWR kurang daripada 2. Pprestasi antena ais krim kon telah diperolehi pada 5,688 GHz dengan saiz antena adalah 12 mm x 14.5 mm. Antena yang dicadangkan menghasilkan ciri-ciri corak sinaran omnidirectional daripada jalur spektrum UWB dengan nilai gandaan yang munasabah.

Kata kunci: Antena ais krim kon, Ultra Wide-Band, S_{11}, VSWR, corak sinaran omnidirectional

1.0 INTRODUCTION

Ultra Wideband communication is a digital data transmitting over wide frequency spectrum. UWB communication is using extremely low powered radio signal and short-pulse through a short distance.

The systems are suited to indoor applications. UWB systems are widely used due to the background noise is minimal. The Federal Communication Commission (FCC) has mandated that UWB radio transmission call legally operate in the range from 3.1

GHz – 10.6 GHz at a limited transmit power -41.3dBm/ MHz [1]

2.0 ICE-CREAM CONE ANTENNA REVIEW

Several ice-cream cone antennas have been proposed. UWB ice cream cone antenna was proposed. [2], an array ice-cream cone antenna [3], a modelling unloaded ice-cream cone antenna [4], an ice-cream cone antenna [5] and compact ice cream cone antenna [6].

An ice cream cone antenna has printed on the FR4 substrate with sizes of board dimensions 40 mm x 25 mm. Parameter of rectangular length have been studied [2]. The antenna performance was obtained return loss below than -10dB and VSWR is < than 2.

An array ice-cream cone antenna for UWB communication application also has been designed [3]. The antenna operates between 3.1 to 10.6 GHz. The proposed antenna printed on a FR4 substrate with thickness 1.6mm² and relative permittivity of ε_r, 4.4. The total size of the antenna is 70 mm x 80 mm. The antenna radiation patterns are approximately omnidirectional.

A modelling unloaded ice-cream antenna has been proposed [4]. The antenna offers higher efficiency without complication of resistive load. It is radiate short pulses with very good accuracy and little loss of radiation efficiency. The antenna has better performance in respect to the reflection from antenna transmission to the end of the antenna. The antenna gain is very little distortion and the strongest radiated field with the return loss is below than -10dB.

A Roger RT Duroid 5880 substrate with the areas of dielectric substrate are 15 × 13.5 mm² and a dielectric constant of 3.38 has been proposed. VSWR is less than 2. Ice-cream cone antenna has higher gain at 3GHz but lower gain between 6 Ghz to 8Ghz [5].

A novel Ultra Wibeband (UWB) antenna has proposed [6]. This planar monopole has microscrip feed and fabricate on Roger RT Duroid 5880 substrate with board dimension 34 mm times 17.65 mm. The effect of varying the antenna feed angle as the ground plane has been investigated. The best performance showing VSWR less than 2 for frequency band of 3.1 GHz to 5.8 GHz and 6.5 GHz to 9 GHz.

3.0 ANTENNA DESIGN

The antenna designed by combination of circular, triangular and rectangular patch. The element of circular patch was calculated using Balanis, 1982 given [7]. The length of triangular patch element was determined by Rajesh K *et al*. [8] and the dimension of rectangular patch is using equation by Pozar D.M [9].

The calculation value is use into CST Microwave Studio Simulation. The calculated design be adjusted by parametric method to achieve the antenna operate between 4 to 11 GHz which is UWB spectrum band requirement. The antenna is fabricated on a thin FR4 substrate of relative permittivity of ε_r, 4.4 with thickness 1.6 mm.

Figure 1 shows the geometry of the single ice-cream cone antenna after adjusted by parametric method using CST Microwave Studio Simulation. The size of proposed antenna is 12 mm x 14.5 mm with parameter wr =12 mm, hr = 1 mm, wf = 3.25 mm, and hf = 1.5 mm. The dimension board of antenna is 20 mm x 20 mm.

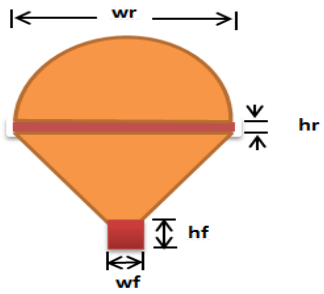

Figure 1 Geometry of proposed antenna

4.0 SIMULATION RESULT

The antenna operated from 4.2 to 11 GHz referred to simulated return loss, S_{11} diagram by using CST Microwave Studio Simulation. Their respective figure is shows in Figure 2. The best return loss performance is -51.95 dB and obtained at 5.688 GHz for width of antenna feed line, 3.25 mm.

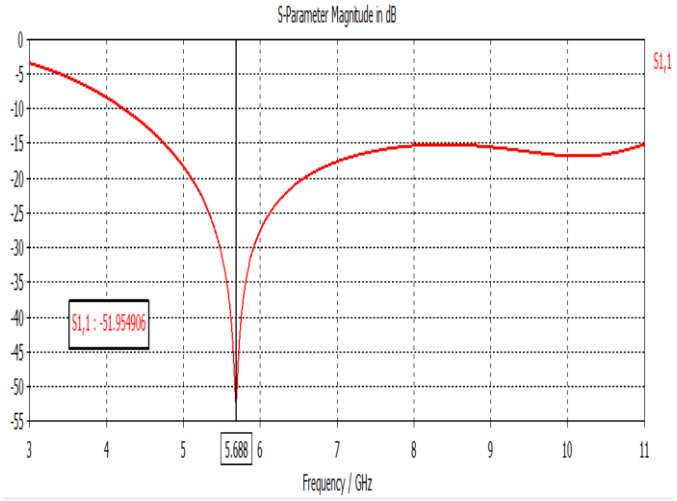

Figure 2 Simulated return loss, S_{11} in dB

The simulated VSWR of single ice cream cone antenna as illustrated in Figure 3. VSWR simulation has met the required bandwidth of UWB which is below than 2. The best VSWR performance is 1 and obtained at 5.688 GHz for weight of feed, 3.25 mm.

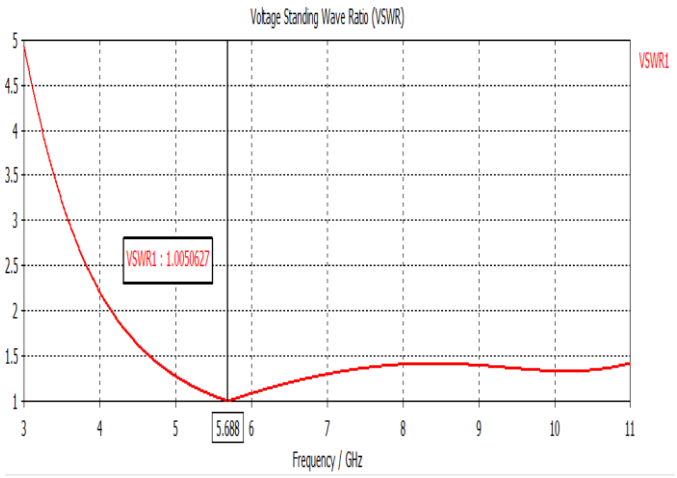

Figure 3 Simulated VSWR of ice cream cone antenna

Figure 4 and Figure 5 show return loss, S_{11} simulations of the ice cream cone for different width by antenna feed line as an antenna grounded has been simulated by using CST Microwave Studio Simulation. The simulated S_{11} is referring to the width of differences feed line samples.

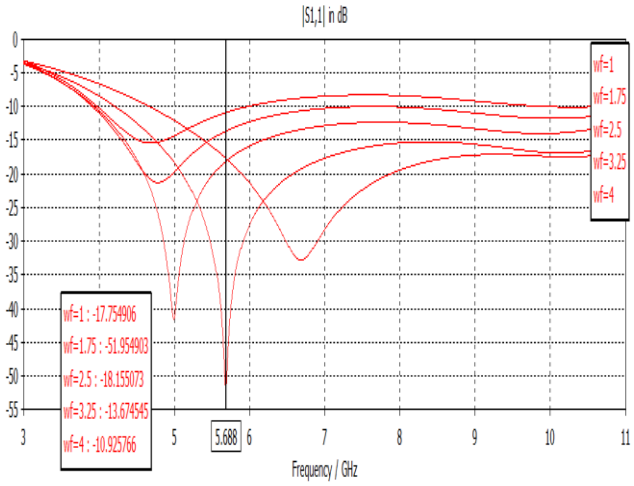

Figure 4 Width of differences antenna feed line samples at 5.688 GHz

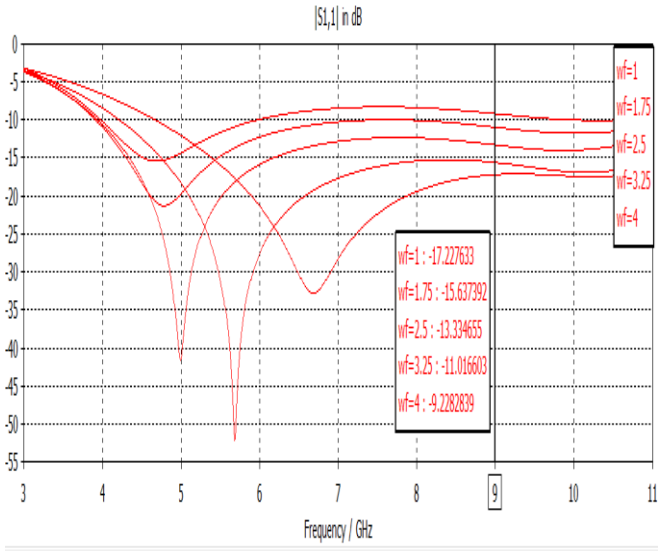

Figure 5 Width of differences antenna feed line samples at 9 GHz

The width of 1 mm has a poor impedance matching which causes the return loss to go up to -10dB at some particular frequencies of UWB bandwidth. At width of 1.75, 2.5, 3.25 and 4 mm the antenna shows a good impedance matching with return loss being below -10 dB at UWB bandwidth. The return loss will effect when the width of feed line of planar is varied. The width of feed line of 3.25 mm is more suitable when compared with the others because of all the return loss of all frequency ranges is the smoothest below -10 dB and the resonant frequency of 5.688 GHz is the maximum return loss of -51.95 dB. This meant that the antenna has a much stronger radiation at 5.688 GHz frequency. The antenna is typically design to be low loss, ideally the majority of the power delivered to the antenna is radiated.

Table 1 shows the simulated S_{11} and VSWR for different width by antenna feed line. It has been observed that the lower cut off frequency of the frequency band of the operation antenna increases with decrease in parameter for width by antenna feed line. It also displayed the VSWR increase with increase in width by antenna feed line. A good impedance match is indicated by return loss greater than -10dB and VSWR less than 2. The simulation result shows that varying parameter for width by antenna feed line has relation effect on antenna performance.

Table 1 Simulated S_{11} and VSWR for different width by antenna feed line at 5.688 GHz

Width (mm)	S_{11} (dB)	VSWR
1	-17.75	1.3
1.75	-51.95	1.0
2.5	-18.16	1.282
3.25	-13.67	1.523
4	-10.93	1.794

Table 2 displayed the VSWR of different width by antenna feed line. The VSWR will be increases when parameter of width by antenna feed line increase. The simulation result shows that varying parameter for width by antenna feed line has relation effect over UWB spectrum band on antenna performance.

Table 2 Simulated VSWR for different width by antenna feed line at 5.688 GHz and 9 GHz

Width (mm)	VSWR at 5.688 GHz	VSWR at 9 GHz
1	1.3	1.319
1.75	1.0	1.4
2.5	1.282	1.549
3.25	1.523	1.782
4	1.794	2.056

Figure 6, 7, 8, 9, 10 and 11 show the comparison of radiation patterns for ice-cream cone antenna at differences width of antenna feed line with respect to different frequency levels. Figure 8 has a maximum omnidirectional radiation pattern of the antenna at 5.688 GHz. The radiation patterns at 5.688 GHz and 9 GHz for different lengths of antenna feed line doesn't seem to have much effect on the radiated power beam.

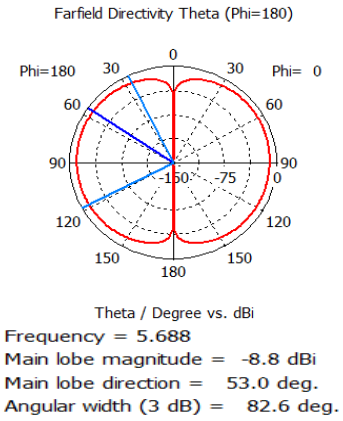

Figure 6 Simulated radiation pattern of antenna for feed line width 1.75 mm at 5.688 GHz and theta cuts for 180°

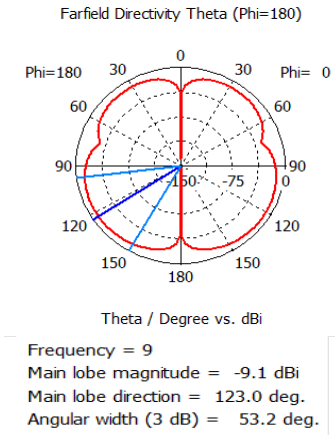

Figure 7 Simulated radiation pattern of antenna for feed line width 1.75 mm at 9 GHz and theta cut for 180°

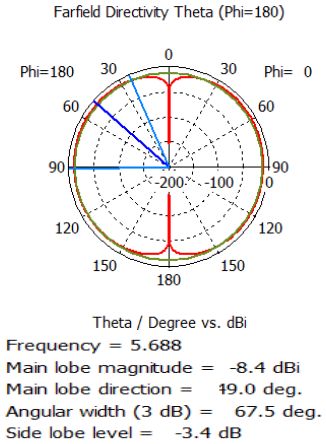

Figure 8 Simulated radiation pattern of antenna for feed line width 3.25 mm at 5.688 GHz and theta cuts for 180°

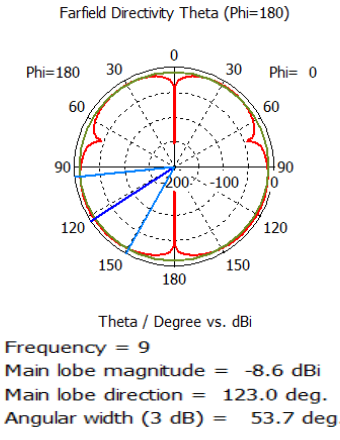

Figure 9 Simulated radiation pattern of antenna for feed line width 3.25 mm at 9 GHz and theta cut for 180°

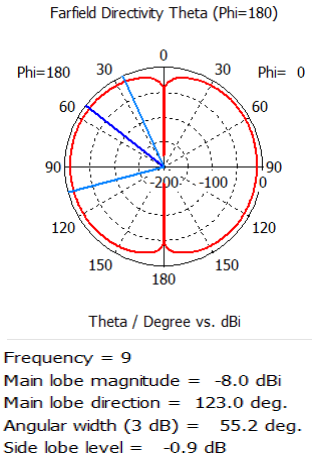

Figure 10 Simulated radiation pattern of antenna for feed line width 4 mm at 5.688 GHz and theta cuts for 180°

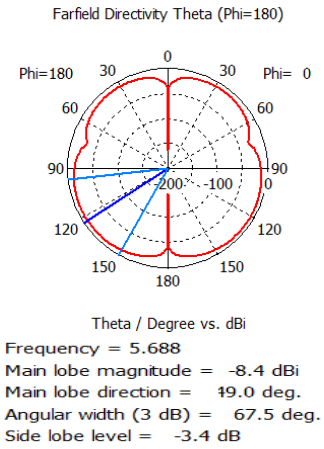

Figure 11 Simulated radiation pattern of antenna for feed line width 4 mm at 9 GHz and theta cut for 180°

5.0 CONCLUSION

In this paper, a single UWB ice-cream cone antenna has been successfully proposed, designed and analyzed by using CST Microwave Studio Simulation. This planar antenna is successfully operates between 4 to 11 GHz which is achieves UWB spectrum band requirement. The antenna has maximum omnidirectional at 180° azimuth plane. The simulated are required to a different width by antenna feed line. The feed line antenna is as an antenna grounded. The feed line antenna has relation effect on antenna performance. The size proposed antenna is 12 x 14 mm^2 with VSWR is less than 2. Future work can be proposed to design an ice – cream cone for UWB antenna at extremely low power level. The smaller the size of the designed antenna is getting longer life for power supply.

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