DESIGN AND PERFORMANCE ANALYSIS OF MICROSTRIP PATCH ANTENNA USING DIFFERENT DIELECTRIC SUBSTRATES

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ABSTRACT

In recent years, the demand for compact handheld communication devices has grown significantly. Devices having internal antennas have appeared to fill this need. Antenna size is a major factor that limits device miniaturization. In the past few years, new designs based on the Microstrip patch antennas (MSPA) are being used for handheld wireless devices because these antennas have low-profile geometry and can be embedded into the devices. New wireless applications requiring operation in more than one frequency band are emerging. Dual-band and tri-band phones have gained popularity because of the multiple frequency bands used for wireless applications. Reducing antenna size generally degrades antenna performance. It is therefore important to also examine the fundamental limits and parameter tradeoffs involved in size reduction. In the handheld environment, antennas are mounted on a small ground plane. This paper presents the performance analysis of Different shapes Microstrip Patch antenna i.e. Z shape, H shape , E shape by using different dielectric substrate materials, to operate in the frequency range of 0.6 GHz to 2 GHz.

The aim of this paper is to broaden the impedance bandwidth and to maximize the gain, thereby improving the performance of antenna. By comparing different substrates of dielectric material, an appropriate substrate was chosen to design Microstrip antenna. After simulation the antenna performance characteristics such as antenna input impedance, VSWR, Return loss and current density are obtained.

Key Words: E –Shaped patch, H-Shaped patch, Z-patched patch, Microstrip antennas, Ansoft HFSS 13, wideband.

INTRODUCTION

Microstrip antennas are being frequently used in Wireless application due to its light weight, low profile, low cost and ease of integration with microwave circuit. However standard rectangular Microstrip antenna has the drawback of narrow bandwidth and low gain.

The bandwidth of Microstrip antenna may be increased using several techniques such as use of a thick or foam substrate, cutting slots or notches like E shaped[1][5] , Z shaped, H shaped[6][8]patch antenna, introducing the parasitic elements either in coplanar or stack configuration, and modifying the shape of the radiator patch by introducing the slots. In modern communication system the Microstrip patch antennas are widely used due to low profile, low weight, low cost. However, the antennas suffered from narrow bandwidth and low gain. Therefore, different techniques have been proposed in the literature to increase the bandwidth. These techniques include cutting slots in the radiating patch, stacking geometry, shorting pins and introducing slots in ground plane. In recent times, many novel planar antennas have been designed to satisfy the requirements of mobile cellular communication systems. Some Microstrip antennas are also very good choice for applications in communication devices for global positioning system.

In this paper, we present three shapes of antennas like Z shape, H shape, E shape patch antennas which are operated in the range of 0.6GHz to 2GHz which are mainly design to operate in wireless communications.

Physical parametars

width of metallicpatch(w)

$$w=\frac{1}{2f_r\sqrt{\mu_0 \in_0}}$$

length of metallicpatch(L)

$$L = L_{eff} - 2\Delta l$$

where

$$L_{eff} = \frac{c}{2fr\sqrt{\in r_{eff}}}$$

Calculation of length extension

$$\frac{\Delta l}{h} = 0.412\frac{(\in r_{eff} + 0.3)(\frac{w}{h} + 0.264)}{(\in r_{eff} - 0.258)(\frac{w}{h} + 0.8)}$$

Flow chart

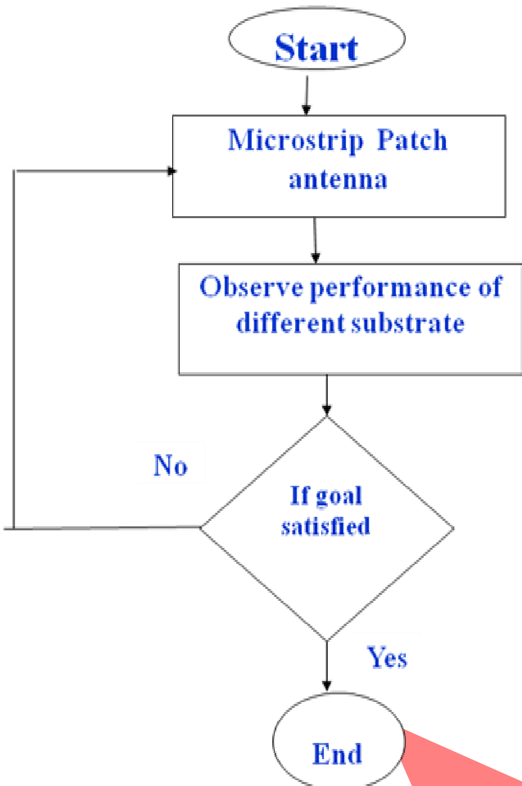


Fig. 1. Flow chart of microstrip patch Antenna.

Description

Step1: Choose the microstrip antenna with required parametars i.e width, length.
Step2:Now observe the performance of antenna using different substrates.
Step3: If goal reached i.e. satisfied with bandwidth, vswr and other parametars goto end.
Step4: Otherwise goto start and change the shape of antenna and observe performance .
This process is continued until the desired characteristics are obtained.

The above flowchart and algorithm is used to all the three shapes of antennas.

ANTENNA DESIGN

In this paper we design three different shapes of antennas such as Z shape , H shape and E shape antennas were designed by using HFSS13.

Z Shape Antenna Design

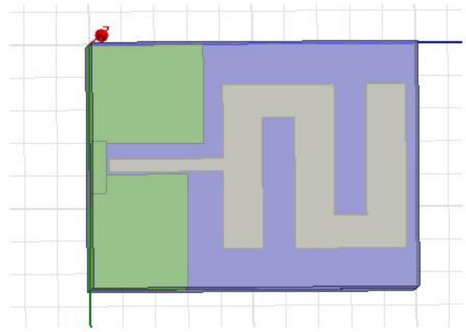


Fig. 2. Z Shape Antenna Design

The antenna is designed using Z-paper substrate having dielectric constant of 3.4.
Length of ground plane Lg = 100 mm,
Width of ground plane Wg = 75 mm,
Length of Antenna L = 56 mm,
Width of Antenna W = 50 mm,
W_f = 3.8 mm,
L_f = 41mm.
The ground plane size is selected as 40 mm x 60 mm, and the relative dielectric constant and the thickness of the substrate are=3.4 and 2.6,respectively.

H Shape Antenna Design [6][8]

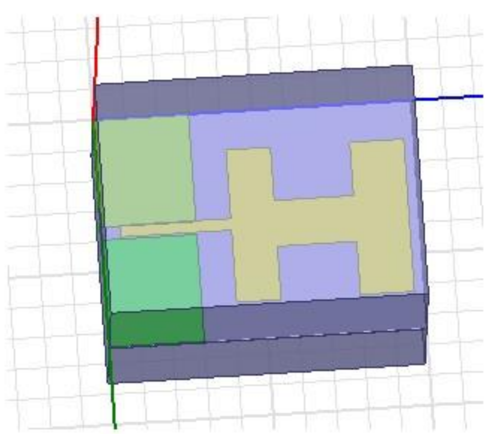


Fig. 3. H Shape Antenna

The physical parametars and flow chart of E shape antenna is similar to the Z shpe antenna.
The antenna is designed using FR4 glass epoxy substrate having dielectric constant of 4.4.
Length of ground plane Lg = 100 mm,
Width of ground plane Wg = 75 mm,
Length of Antenna L = 56 mm,
Width of Antenna W = 50 mm,
W_f = 3.8 mm,
L_f = 41mm.
The ground plane size is selected as 40 mm x 60 mm, and the relative dielectric constant and the thickness of the substrate are=4.4and 2.2 respectively.

E Shape Antenna Design [1][5]

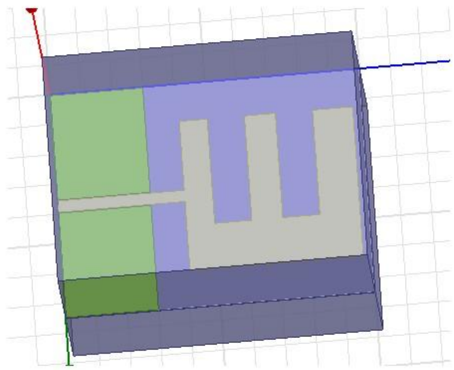
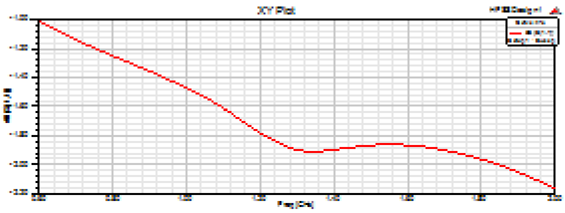


Fig. 4. E Shape Antenna

The physical parametars and flow chart of E shape antenna is similar to the Z shpe antenna.
The antenna is designed using FR 4 glass epoxy substrate having dielectric constant of 4.4.
Length of ground plane Lg = 100 mm,
Width of ground plane Wg = 75 mm,
Length of Antenna L = 56 mm,
Width of Antenna W = 50 mm,
W_f = 3.8 mm,
L_f = 41mm.
The ground plane size is selected as 40 mm x 60 mm, and the relative dielectric constant and the thickness of the substrate are=4.4and 2.2 respectively.

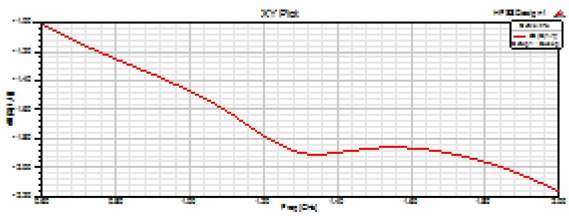
SIMULATED RESULTS

Return loss of Z Shape Antennas using different Substrates



(a)Z paper

Z paper is one type of Substrate Material which is having Relative permittivity of 3.4 and Dielectric loss of tangent 0.08.



(b)Benzocyclobutane

Fig. 5. Return loss of Z shape antenna using substrates a) Z paper b) benzocyclobutane

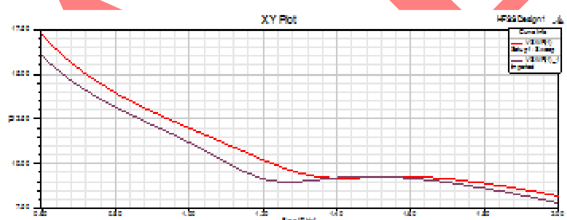
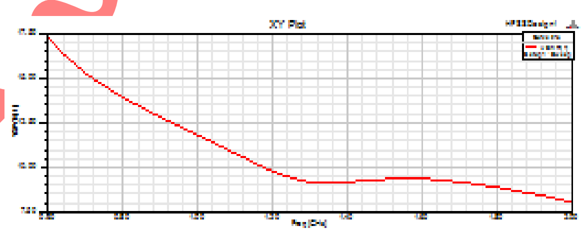
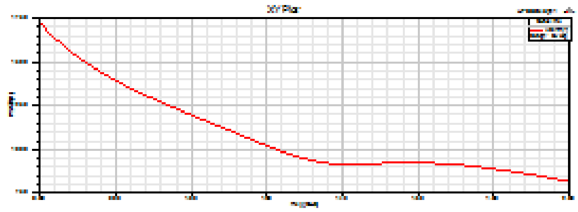


Fig. 6. Returnloss comparison of Z paper and Benzocyclobutane

VSWR of Z Shape Antenna using different Substrates



(c)Z paper



(d)Benzocyclobutane

Fig. 7. VSWR of Z shape antenna using c)Zpaper,d)Benzocyclobutane*:*

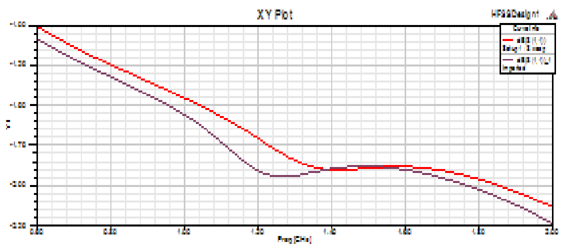
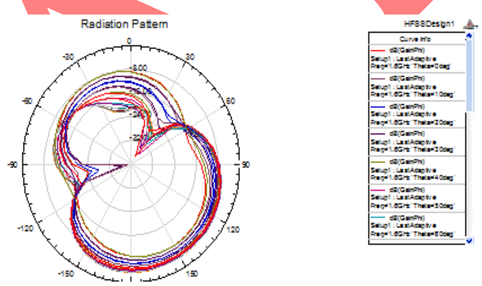
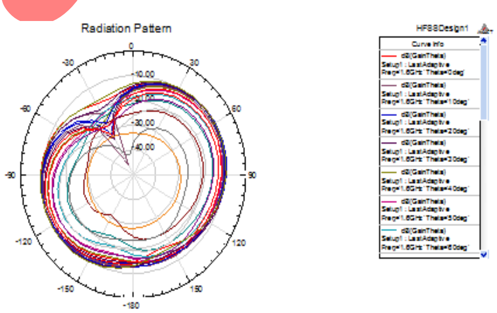


Fig. 8. VSWR comparison of Z paper and Benzocyclobutane

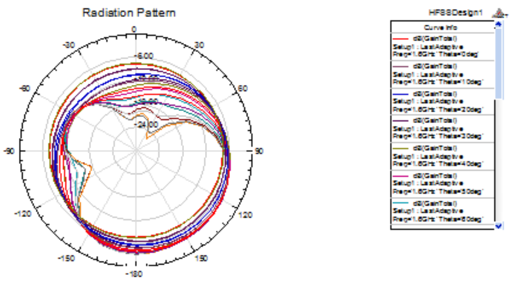
2D Radiation pattern of Z Shape antenna



(e)Gain along phi



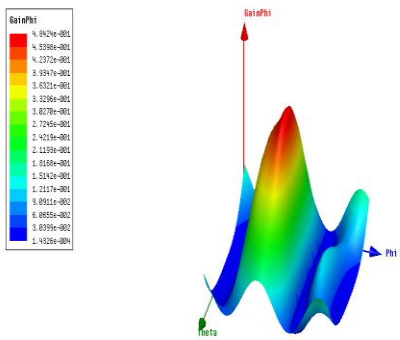
(f)Gain along theta



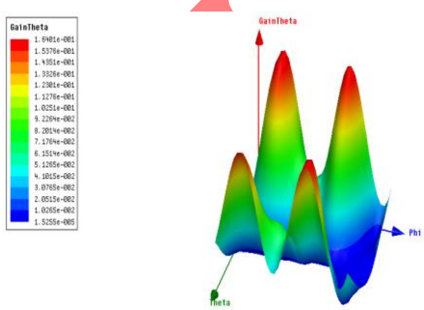
(g)Gain in total

Fig. 9. 2D Radiation pattern of Z shape e) along phi f)along theta g) in total

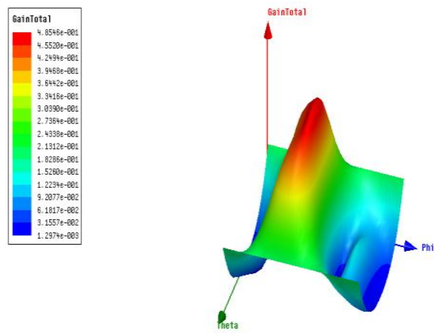
3D Radiation pattern of *Z Shape antenna*



(h)Gain along phi



(i)Gain along theta

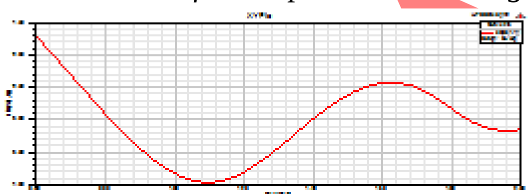


(j)Gain in total

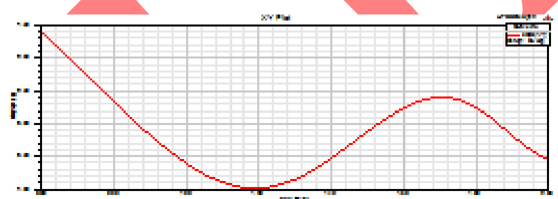
Fig.10 . 3D Radiation pattern of Z shape h) along phi i)along theta j) in total

From fig.5 we observe that the return loss of Z shape antenna is -1.9 db to -2.2 db in the frequency range of 1.4 GHZ to 2 GHZ in case of Z paper substrate. Similarly for benzocyclobutane it is -2 db to -2.1 db.
From fig.7 we observe that the VSWR of Z shape antenna is 9 to 8 in the frequency range of 1.4 GHZ to 2 GHZ in case of Z paper substrate. Similarly for benzocyclobutane it is 8 to 7. The bandwidth utilisation is 20% for Z paper and 25% for benzocyclobutane.
fig.9 & fig. 10 shows 2D and 3D radiation patterns of Z shape antenna.

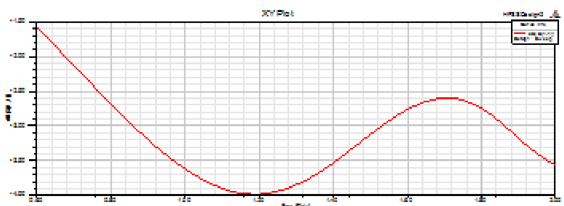
Return loss of H Shape Antennas using different Substrates



(k)FR4 Epoxy



(l)Rogers RT duroid



(m)Teflon

Fig. 11 . Return loss of H shape antenna using substrates k) FR4 l) Rogers RT duroid m) Teflon

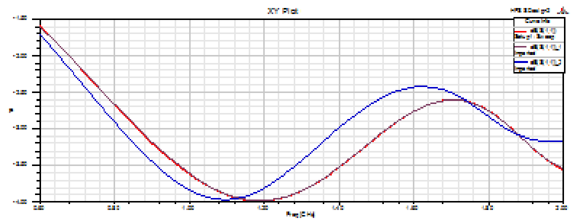
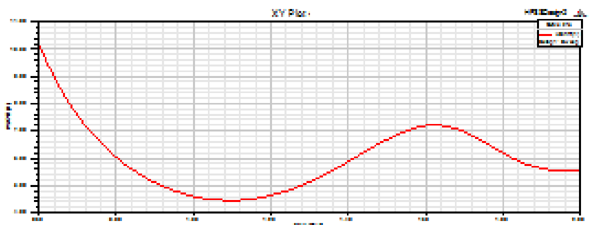
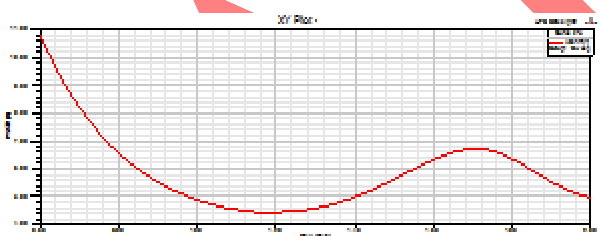


Fig. 12. Returnloss comparison of FR4,Rogers RT duroid and Teflon

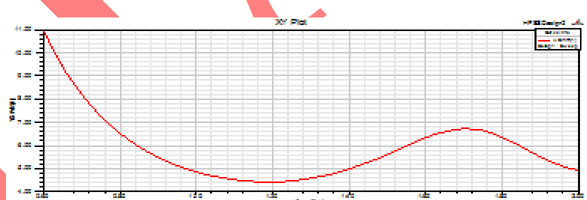
VSWR of H Shape Antenna using different Substrates



(n)FR4 Epoxy



(o) RogersRTduroid



(p) Teflon

Fig. 13. VSWR of H shape antenna using substrates n) FR4 o) Rogers RT duroid p) Teflon

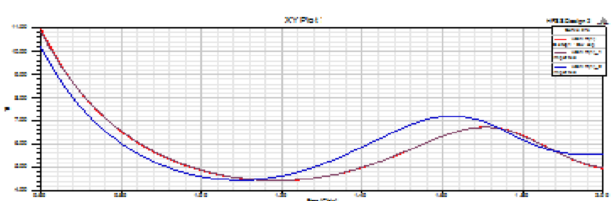
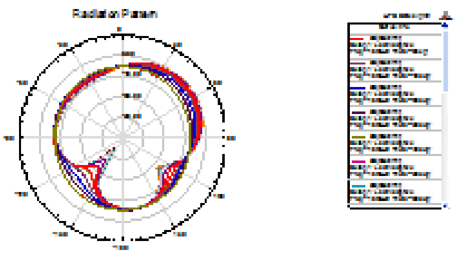
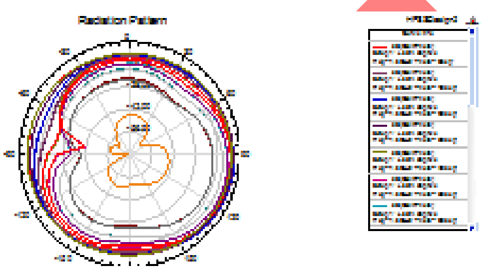


Fig. 14. VSWR comparison of H shape antenna using substrates n) FR4 o) Rogers RT duroid p) Teflon

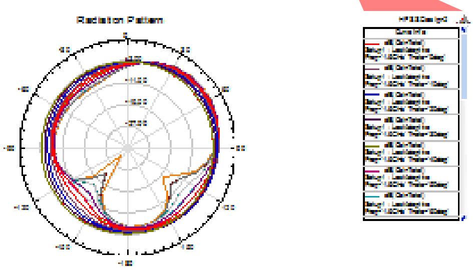
2D Radiation pattern of H Shape antenna



(q)Gain along phi



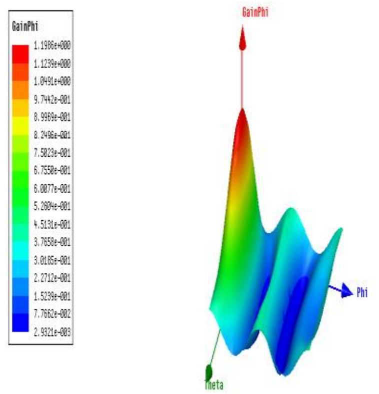
(r)Gain along theta



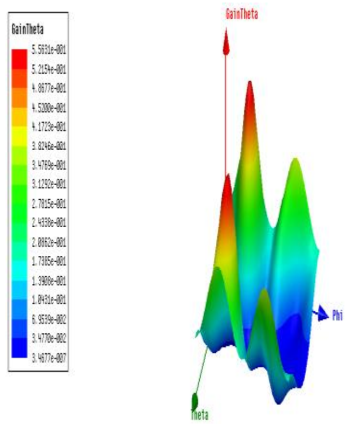
(s)Gain in total

Fig. 15 . 2D Radiation pattern of H shape q) along phi r)along theta s) in total

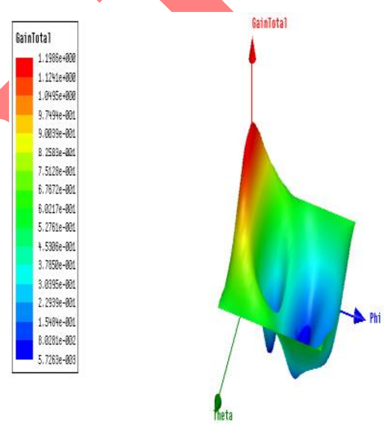
3D Radiation pattern of H *Shape antenna*



(t) Gain along phi



(u) Gain along theta



(v)Gain in total

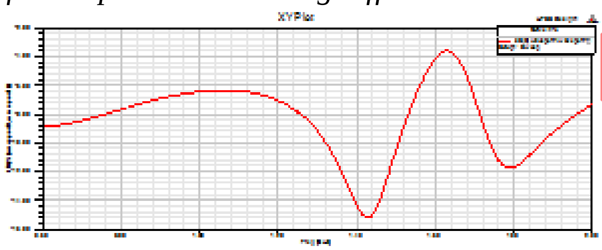
Fig. 16. 3D Radiation pattern of H shape t) along phi u)along theta v) in total

From fig.11 we observe that the return loss of H shape antenna is -4 db to -2. db in the frequency range of 1.2 GHZ to 1.7 GHZ for FR4 Epoxy substrate, for rogers RT duroid the return loss is -4 db to -2.5 db.Similarly for teflon it was -4 db to -2.5 db.

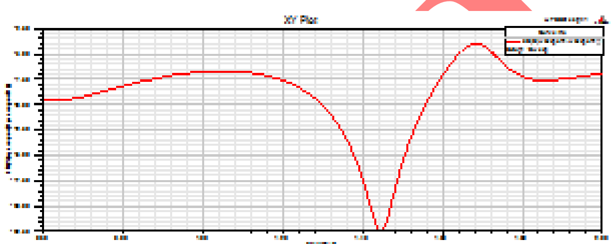
From fig.14 we observe that the VSWR of H shape antenna is 4.5 to 7 in the frequency range of 1.4 GHZ to 1.7 GHZ for FR4 Epoxy substrate. for rogers RT duroid the VSWR is 4.5 to 6.5. Similarly for Teflon it is 4.25 to 6.75. The bandwidth utilisation is 35% for FR4 , 40% for rogers RT duroid and 40% for Teflon material.

Fig.15 & fig. 16 shows 2D and 3D radiation patterns of H shape antenna.

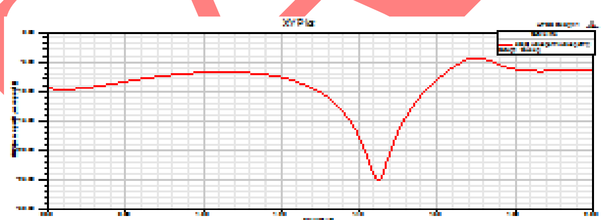
Return loss of E Shape Antennas using different Substrates



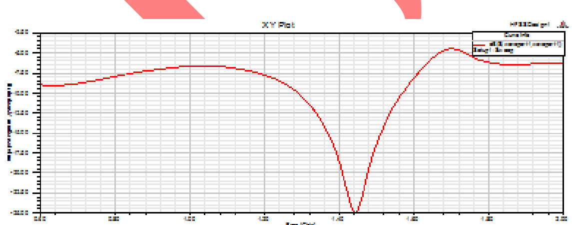
(w) FR4 Epoxy



(x) Benzocyclobutane



(y)Teflon



(z)RT Duroid

Fig . 17. Return loss of E shape antenna using substrates w) FR4x) Benzocyclobutaney)Teflon z) Rogers Rt duroid

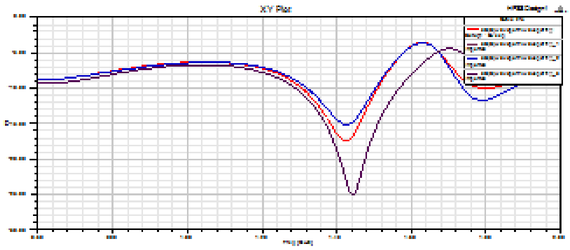
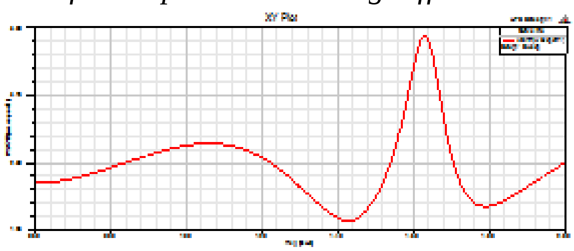
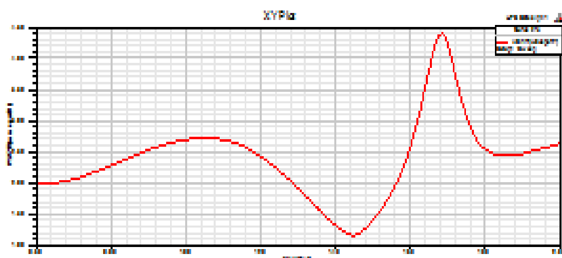


Fig. 18. Return loss comparison of E shape antenna using substrates FR4,Benzocyclobutane , Teflon and Rogers RT duroid

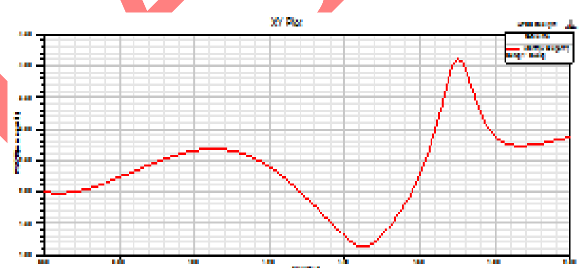
VSWR of E Shape Antenna using different Substrates

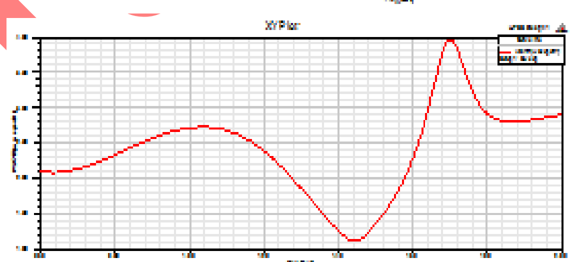


(i) FR4 Epoxy



(ii)Benzocyclobutane





(iii)Teflon (iv) RT Duroid

Fig. 19. VSWR of E shape antenna using substrates i) FR4 ii) Benzocyclobutane iii) Teflon iv) Rogers Rt duroid

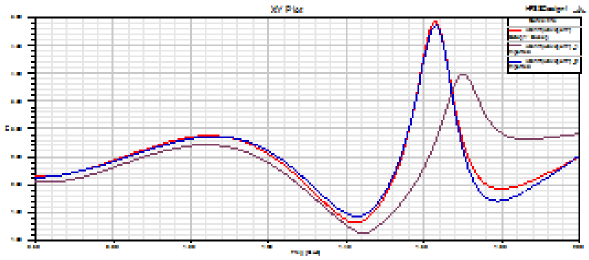
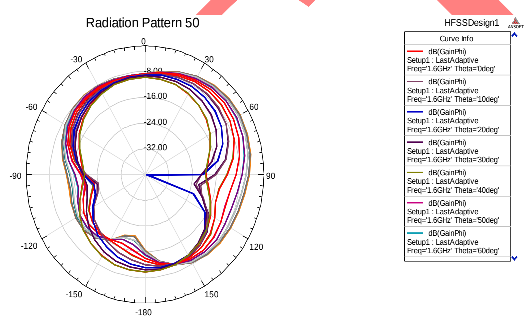
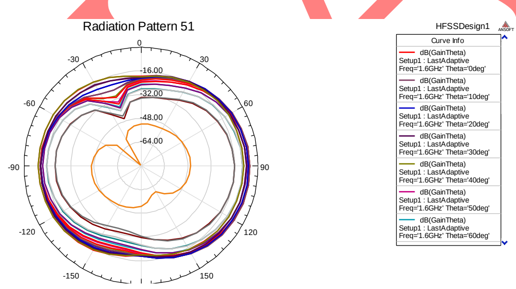


Fig. 20. VSWR comparison of FR4,Rogers RT duroid and Teflon

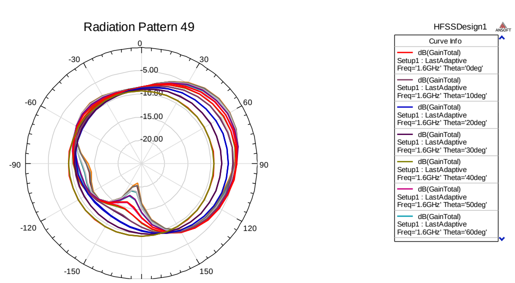
2D Radiation pattern of E Shape antenna



(v)Gain along phi



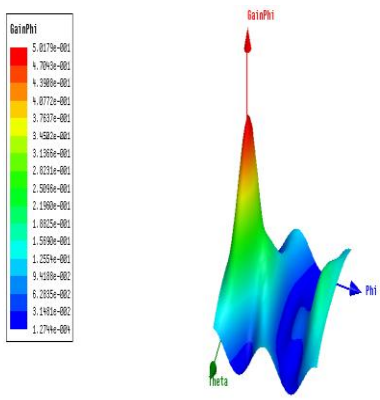
(vi)Gain along theta



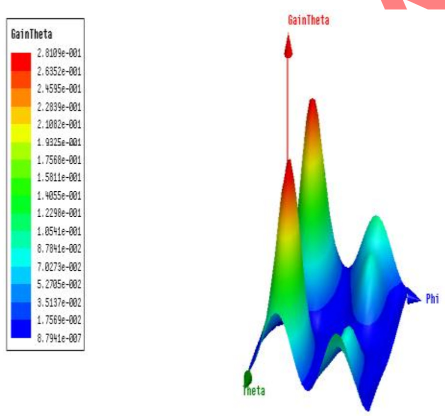
(vii)Gain in total

Fig. 21. 2D Radiation pattern of E shape v) along phi vi)along theta vii) in total

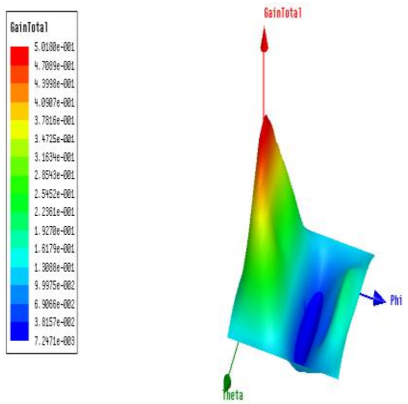
3D Radiation pattern of E Shape antenna



(viii) Gain along phi



(ix)Gain along theta



(x)Gain in total

Fig. 22. 3D Radiation pattern of E shape viii) along phi ix)along theta x) in total

TABLE1

Evaluation results of Z,H and E Shaped Antennas

Antenna shape	Return losses	VS WR	Bandwidth utilization compare with isotropic antenna
Antenna shape: Z Substrate: Benzocyclobutane Frequency range:1.4GHZ to 2GHZ	-2db to -2.1db	8.0 to 7.0	25%

Substrate: Z paper	-1.9db to -2.2db	9 .0 to 8.0	20%
H shape Substrate: Teflon Frequency range: 1.2GHZ to 1.GHZ	-4db to -2.5db	4.25 to 6.75	40%
Substrate: Rogers RT Duroid	-4db to -2.5db	4.5 to 6.5	40%
Substrate: FR4 epoxy	-4db to -2.5db	4.5 to 7.0	35%
E shape Substrate: Rogers RT Duroid Frequency range:1.4GHZ to 1.GHZ	-25db to -5db	1.25 to 4.0	44%
Substrate: Teflon	-25db to -5db	1.25 to 4.5	42%
Substrate:	-22db	1.25	42%

Benzocyclob utane	to -5db	to 4.5	
Substrate: FR4	-15db to -3db	1.5 to 4.5	40%

CONCLUSION

The simulated results show the performance of Z shape, H shape, E shape Microstrip patch antennas. Band width, VSWR, Return loss for these antennas have been caliculated. The results show that E shape antenna has better performance in the range of frequencies (0.6GHz-2GHz), since the VSWR of E shape antenna is 1.25 at 1.4 GHz and the Bandwidth utilisation is 44% when compared with the reference antenna and return loss is -25db. Thus E shaped antenna is found to give much better than Z shape and H shape antennas.

REFERENCES

[1]A.khidre,K.FonfLee,Fanyang, "Wideband Circularly Polarized E-Shape Patch Antenna for Wireless Applications "IEEE trans. Antenna propagation ,vol.52,no.5 pp 219-227.

[2] Ashishkumar "Rectangular Microstrip patch antenna using 'L' Slot Structure" ISTP Trans vol2, issue 2, march 2013, pp 15-18.

[3] Alak Majumder "Rectangular Microstrip patch Antenna using Coaxial probe Feeding Technique to operate in S-Band" IJETT,vol4issue4,april2013,pp 1206-1210.

[4]Y.Sung "A printed Wide-slot Antenna With a Modified L- shaped Microstrip Line for Wideband Applications"IEEE trans on Antenna and Propagation,vol.59,no.10,pp 3918-3922.

[5]Nisha gaur, Devendra Soni "E-Shaped Slotted Microstrip Antenna with Enhanced Gain for Wireless Communication",IJECSE,VIN2-436-441

[6]Xian-Ling Liang and tayeb A.Denidni, "H-shaped Dielectric Resonator Antenna for Wideband Applications" IEEE trans Antenna propagation , vol.7,2008. Pp 163-166

[7]B.sai Sandeep "Design and simulation of Microstrip Array Antenna for Wireless Communications at 2.4 GHz" IJSER, vol3,issue11,nov-2012, pp 1-5

[8]Alak Majumder "Design of an H-Shaped Microstrip Patch Antenna for Applications" IJIAS, vol3, no4pp , 987-994.

[9]WWW.AnsoftHFSS.com.

[10]C.A.Balanis, Antenna Theory: Analysis and Design, second edition, New York , JohnWiley&son's,INC 1999.

[11]D. M. Pozar, "Microstrip antenna coupled to a Microstrip-line," *Electron. Lett.*, vol. 21, no. 2, pp. 49–50, Jan. 1985.