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Design of the Rectangular Microstrip Patch Antenna

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Abstract
In high-performance aircraft, spacecraft, satellite, and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, and low-profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communications that have similar specifications.

Keywords: Antenna, Microstrip, Wireless, Communication, Shape, Slot, Parameter, Bandwidth, Frequency.

INTRODUCTION:

This research paper presents a novel technique for design and development of a broadband patch antenna by loading reactively with slots placed in such a manner it closely resembles an E shape for various applications in wireless communications. The antenna was designed for operating in S band (2.0 – 4.0 GHz) frequency range with a linear polarization and it was built as E shaped patch antenna. The feeding arrangement in the presented experimental a model above is a coaxial connector in the ground plane with the center-pin extended to the patch as an inductive probe although other feeding methods could be easily adapted. The developed antenna successfully attains a bandwidth of 18% (VSWR <2) with a central frequency of 2.03 GHz. Also it attains an acceptable value of gain of about 6.3 dB with respect to its central frequency .The measured 3dB Beam width is of about 83.62º and 96.03º in E-plane and H- plane respectively. [1, 2] The designed antenna was successfully developed and tested in a nechoic chamber.

I. Antenna Geometry

The antenna geometry is shown in Fig.1.1. The antenna has a single patch of dimensions (L, W) and a ground plane of dimensions (Lg, Wg) separated by an air substrate (ε_r =1) of height h.

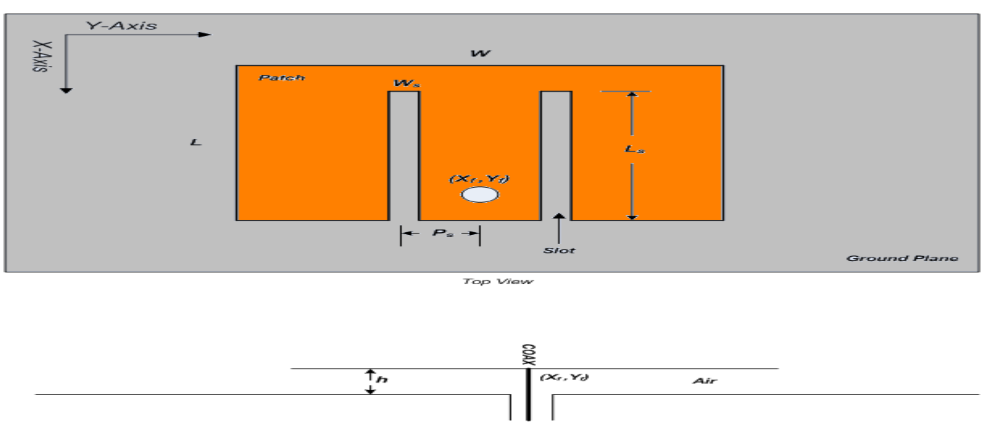

Figure 1.1: E-Patch Antenna Geometry

Two identical parallel slots of dimensions (Ls, Ws, Ps) are incorporated into the patch to enhance its bandwidth. The objective of incorporating slots into the antenna is to add resonant frequencies into the system. The radiating patch is fed by a coaxial probe at a position (Xf, Yf) for proper excitation of the antenna over a wide bandwidth. [3,4] the slot dimensions, the substrate height and the excitation point position play an important role in controlling the broadband performance of the antenna.

The dimensions of the identical slots are obtained by studying the effect of each parameter on the performance of the antenna. This is done by fixing two of the dimensions (Ls, Ws, Ps) while varying the third one.

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Moreover, the effect of the substrate height and the excitation point position are investigated.

II. Effect of Patch Shape on the Bandwidth

1. Rectangular Patch MSA

Starting from the rectangular patch antenna design equations at a given center frequency (f_o = 2.1 GHz), with an air substrate (ε_r =1), the following antenna parameters are obtained: L = 65 mm, W = 77 mm, h = 10 mm, Lg =120 mm, Wg = 120 mm, Probe Radius (Pr) =1mm,(Xf, Yf)=(26.5,0).

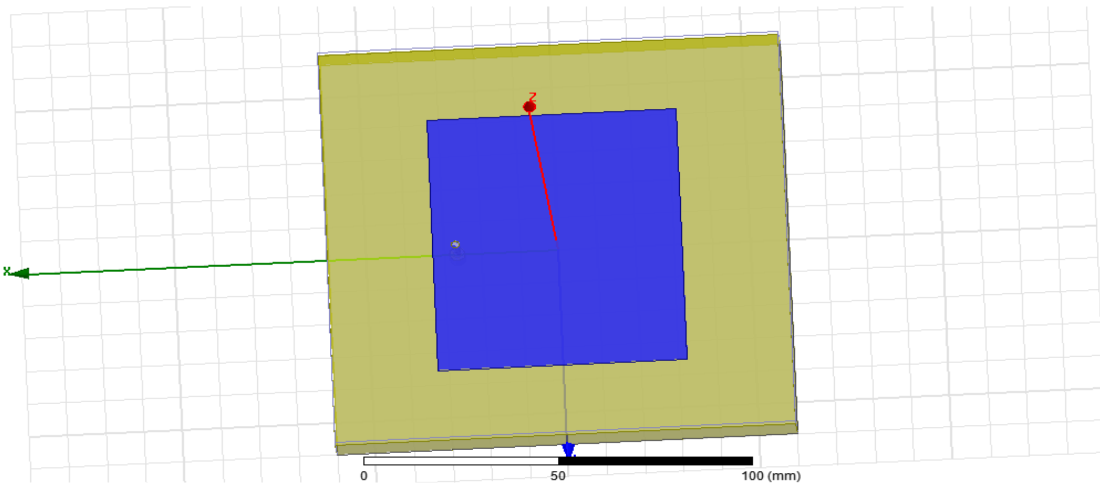

Figure 1.2: Rectangular MSA

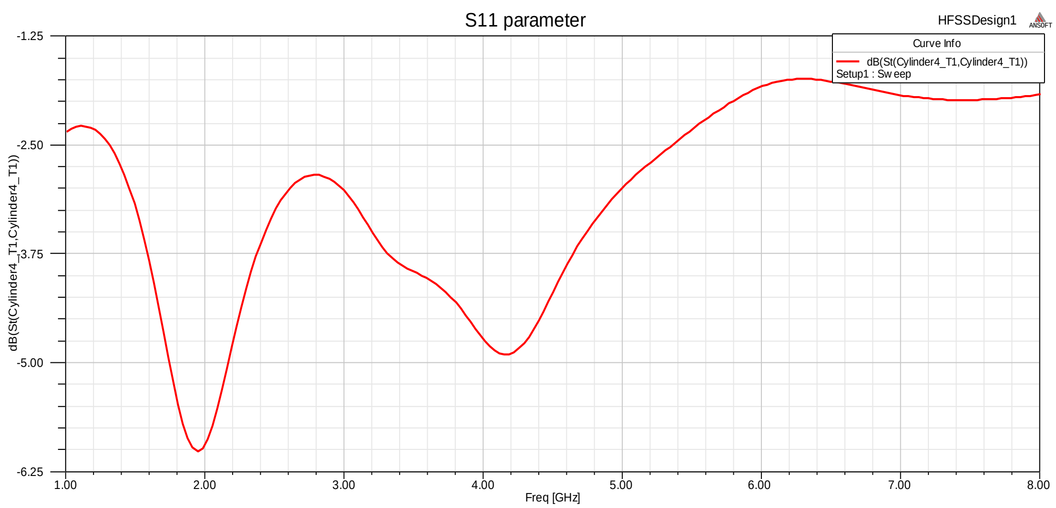

Figure 1.3: S11 parameter of Rectangular MSA

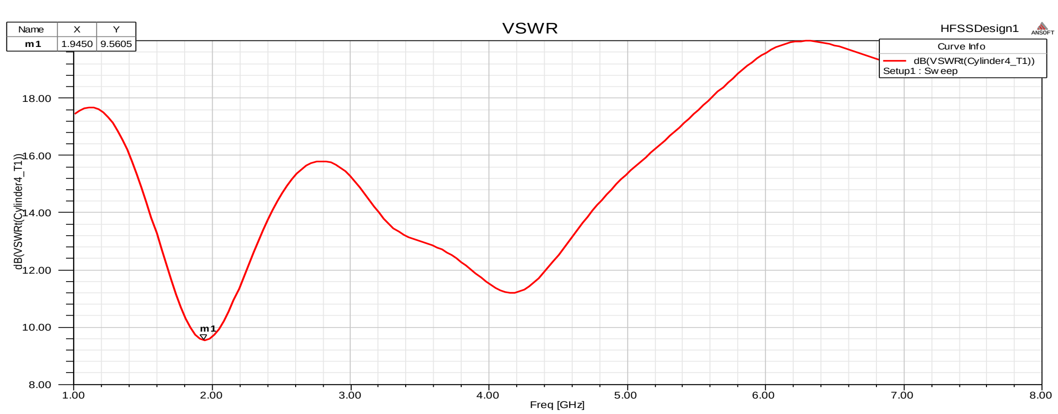

Figure 1.4: VSWR of Rectangular MSA

Fig 1.2 Shows the Rectangular Patch antenna designed with HFSS 13.0, Fig 1.3 Shows the S11 Parameter i.e. Return loss of the antenna and we didn't get any BW so this antenna has very poor performance and Fig 1.4 shows the VSWR Graph which is also very bad so this antenna is not efficient antenna for S band application.

2. E–Shape Patch antenna

To obtain E-Shape patch antenna there is a need to cut two parallel slots of dimension (Ls, Ws, Ps,) = (40 mm, 4mm and 6mm).

Table 1.1 Effect of E- shape patch on BW, Gain and VSWR

Patch Shape	**E- Shape**
Bandwidth (GHz)	Fmax = 2.90 GHz , Fmin =2.16 GHz BW = 0.74 GHz
Gain (dB)	1.58 dB
VSWR (dB)	0.68 dB at 2.54 GHz

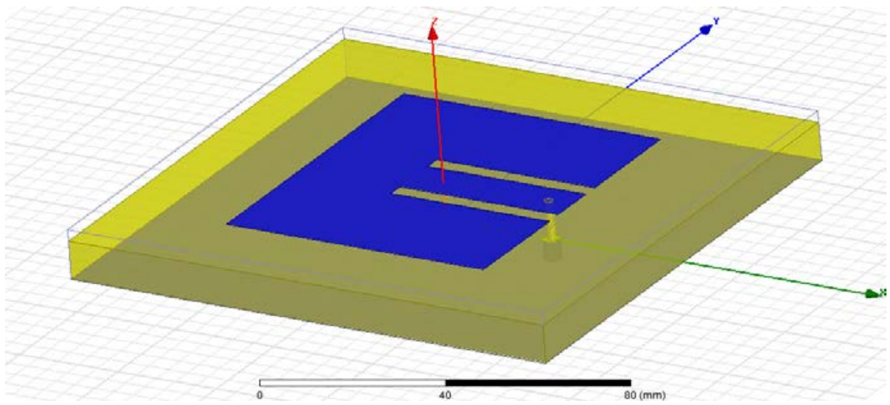

Figure 1.5: E shape MSA with dimension (Ls, Ws, Ps,) = (40 mm, 4mm and 6mm)

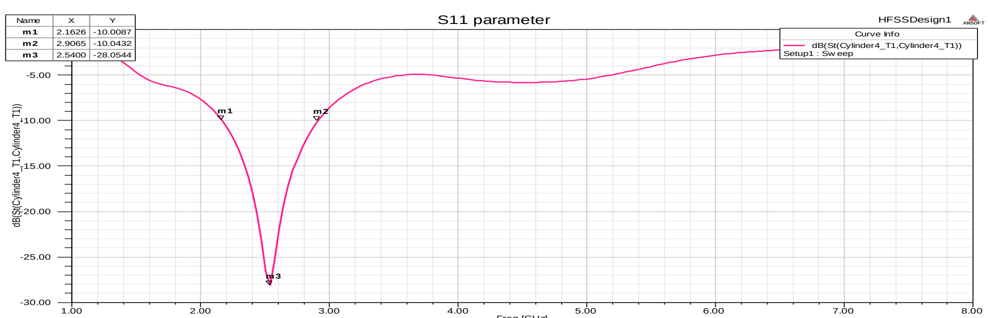

Figure 1.6: S11 parameter of E shapes MSA with dimension (Ls, Ws, Ps,) = (40 mm, 4mm and 6mm)

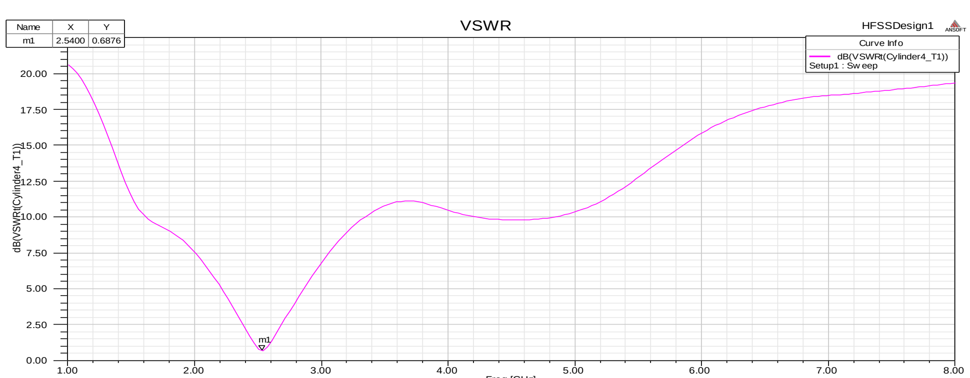

Figure 1.7: VSWR of E shape MSA with dimension (Ls, Ws, Ps,) = (40 mm, 4mm and 6mm)

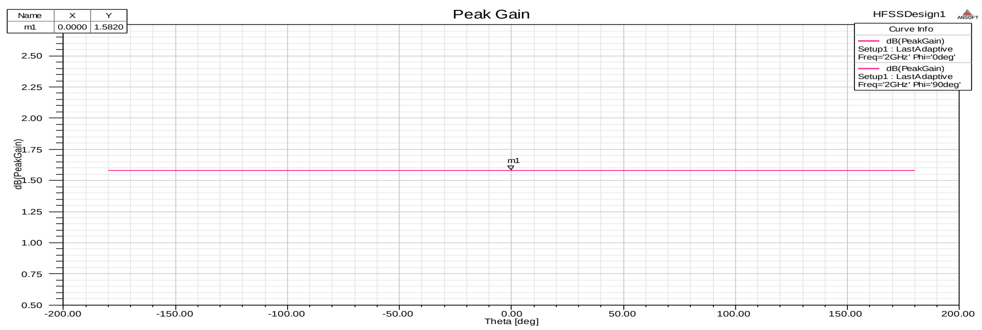

Figure 4.8: Gain of E shape MSA with dimension (Ls, Ws, Ps,) = (40 mm, 4mm and 6mm)

Figure 1.5 shows the E shape antenna simulated by HFSS 13.0, Figure 1.6 shows the S11 parameter of E shape MSA with dimension (Ls, Ws, Ps,) = (40 mm, 4mm, 6mm), which gives the BW of 0.74 GHz. Figure 1.7 and Figure 1.8 shows the VSWR and Gain of E shape MSA with VSWR of 0.68 dB and Gain of 1.58 dB.

3. Comparison between Rectangular and E shape Patch antenna

Table 1.2: Comparison between Rectangular and E shape Patch antenna:

Green Graph = Rectangular Patch	Pink Graph = E shape Patch
BW = Bad Result	BW = 0.74 GHz
VSWR = 9.54 dB	VSWR = 0.68 Db

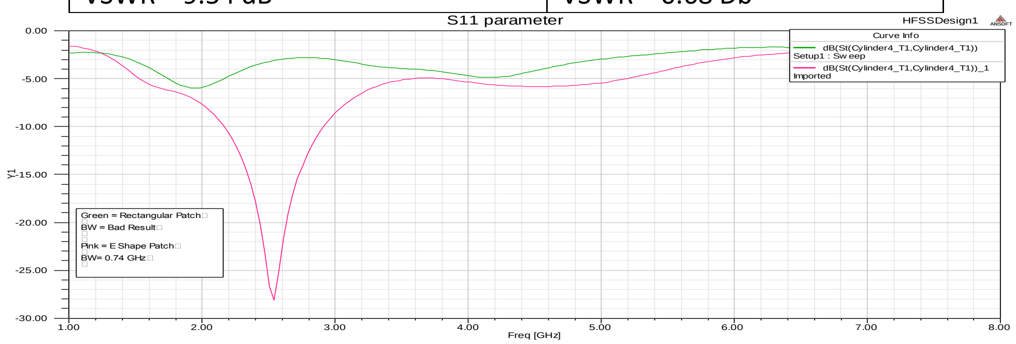

Figure 1.9: S11 Comparison between Rectangular and E chape patch

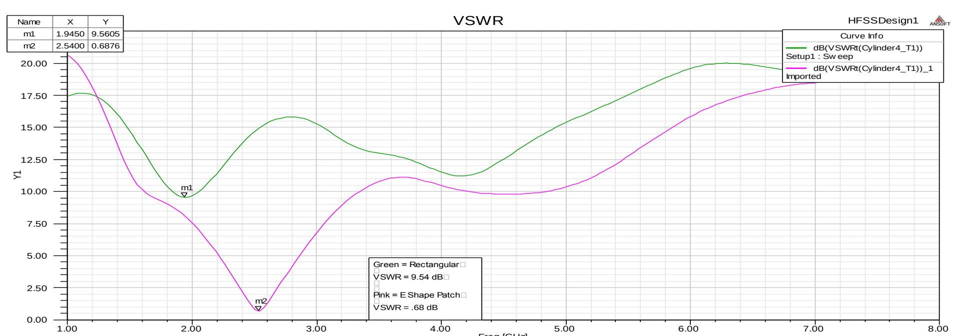

Figure 1.10: VSWR Comparison between Rectangular and E shape patch

Figure 1.9 shows the comparison between S11 parameter of Rectangular and E shape patch. Green graph shows the Rectangular Patch and Pink Graph Shows the E- Shape patch. We get better BW = 0.74 GHz with E- Shape patch, VSWR = 0.68 dB and Gain of 1.58 dB .So E shape antenna is efficient than Rectangular patch.

III. Effect of Antenna Parameters on The Bandwidth

1. Effect of the slot length Ls on the antenna performance

Two identical parallel slots of dimensions (Ls, Ws, Ps) are incorporated into the patch to enhance its bandwidth.

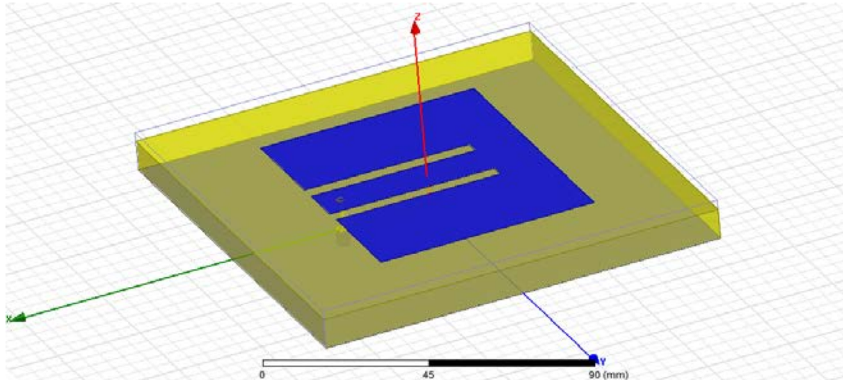

Figure 1.11: E shape MSA

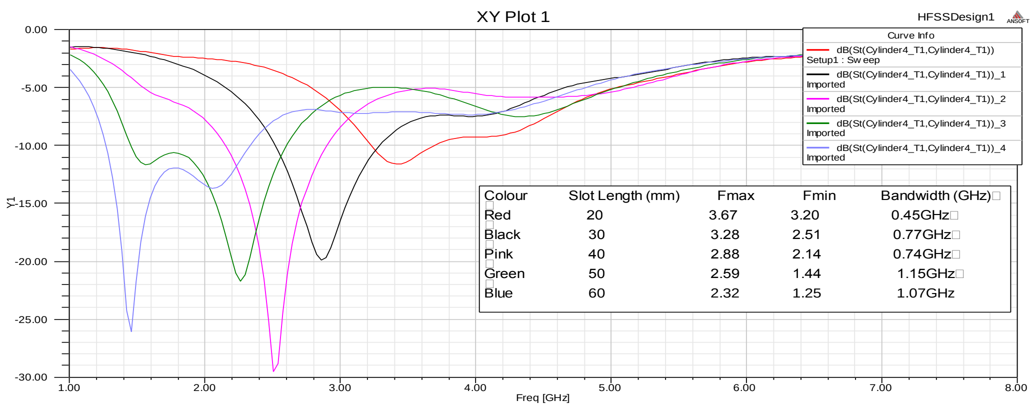

Figure 1.12 S11: Effect of the Slot Length on the Return Loss (Ps = 6 mm, Ws = 4 mm)

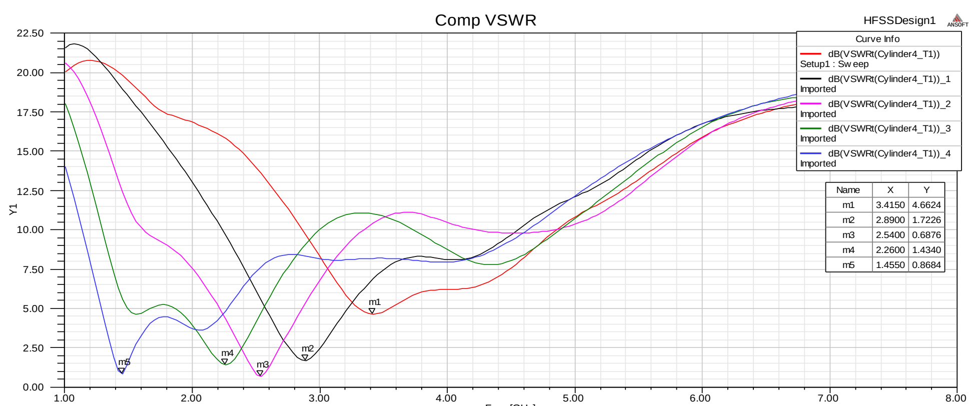

Figure 1.13: VSWR of different Slot Length

Table 1.3: Effect of the Slot Length on the BW and VSWR (Ps = 6 mm, Ws = 4 mm)

Colour	Slot Length (mm)	Bandwidth (GHz)	VSWR (dB)
Red	20	0.45 GHz	4.66
Black	30	0.77 GHz	1.72
Pink	40	0.74 GHz	0.68
Green	50	1.15GHz	1.43
Blue	60	1.07 GHz	0.86

Fig. 1.12 shows the effect of the slot length Ls on the antenna performance. Two resonant frequencies appear as Ls increases. So Ls plays a crucial role in controlling the resonant frequencies of the antenna. We get maximum BW = 1.15 GHz and VSWR = 1.43 dB at Slot Length of 50 mm which is good.

2. Effect of the Slot Position

The effect of slot position Ps is shown in Fig. 1.14. The bandwidth increases as Ps increases and the curves show that Ps is an important parameter in matching the antenna to the feeding point.

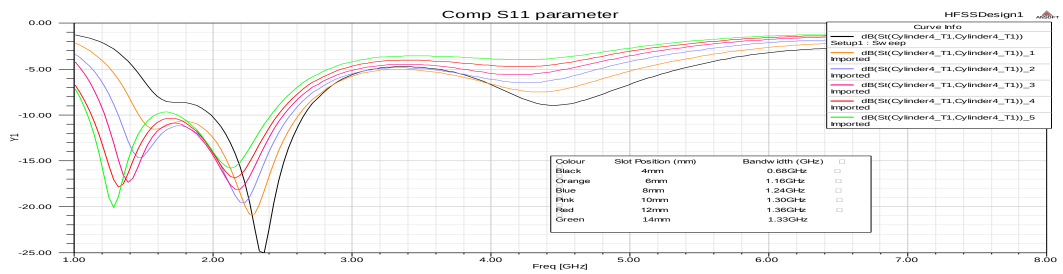

Figure 1.14: Effect of the Slot Position on the Return Loss (Ls = 50 mm, Ws = 4 mm)

Table 1.4: Effect of the Slot Position on BW (Ls = 50 mm, Ws = 4 mm)

Colour	Slot Length (mm)	Bandwidth (GHz)
Black	4	0.68 GHz
Orange	6	1.16 GHz
Blue	8	1.24 GHz
Pink	10	1.30 GHz
Red	12	1.36 GHz
Green	14	1.33 GHz

We Get better BW= 1.36 GHz at Slot position of 12 mm so we use Ps = 12.

3. Effect of the Slot Width

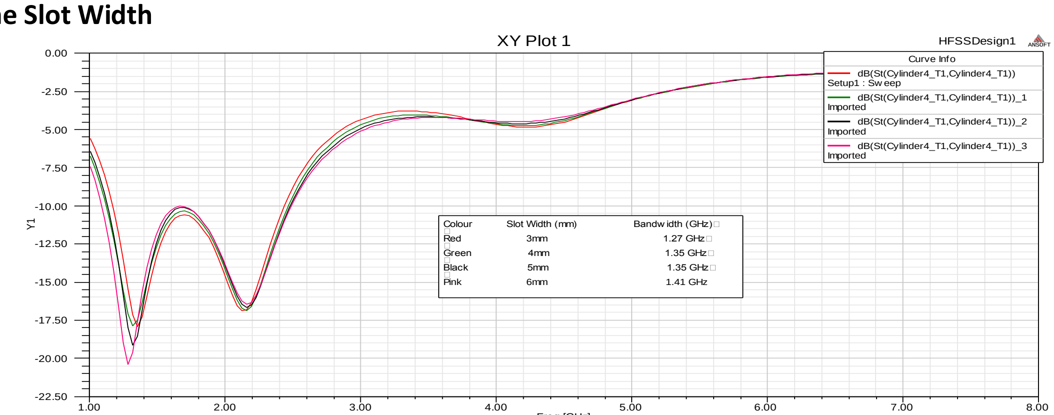

Figure 4.15 Effect of the Slot Width on the Return Loss (Ls = 50 mm, Ps = 12mm)

Table 4.5: Effect of the Slot Width on the Return Loss (Ls = 50 mm, Ps = 12mm)

Colour	Slot Width (mm)	Bandwidth (GHz)
Red	3	1.27 GHz
Green	4	1.35 GHz
Black	5	1.35 GHz
Pink	6	1.41 GHz

As shown in figure 3.5 we get better *BW* = 1.41 GHz at Slot with of 6 mm. And this antenna has two resonant frequencies.

4. Height of Air Substrate (h):

When height of the Air substrate changed from 3 mm to 6 mm with 1 mm of increment then we will see the effect of height of substrate on antenna BW.

Table 1.6: Effect of Height of Air Substrate (h) on BW

Colour	Air Substrate Height (h) (mm)	Bandwidth (GHz)
Red	6	0.67 GHz
Black	8	1.25 GHz
Purple	10	1.41 GHz
Pink	12	0.34 GHz and 0.58 GHz

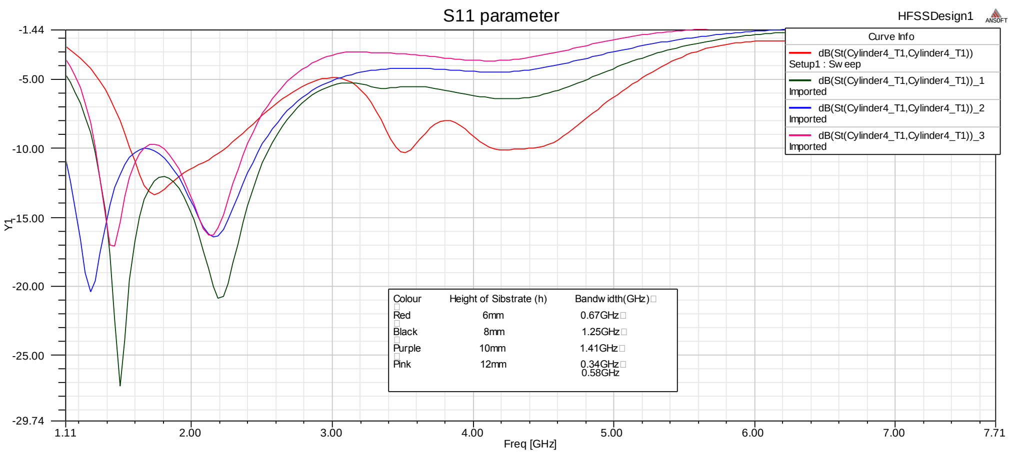

Figure 4.16: Effect of the Air substrate (h) on the Return Loss (Ls = 50 mm, Ps = 12 mm, Ws =6mm)

Figure 1.16 Shows the S11 parameter for different height of Air substrate (h) when (Ls = 50 mm, Ps = 12mm, Ws =6mm).We got highest BW of 1.41 GHz at 10 mm substrate height.

4.1 Feed point position (Fp)

When Position of feeding point changed from (Xf, Yf) = (23, 0) to (27, 0) with 1 mm of increment then we will see the effect Feed point position on antenna BW. We use these parameters to design antenna (Ls = 50 mm, Ps = 12 mm, Ws =6mm, H = 10mm)

Table 4.7: Effect of Feed point position (Fp) on BW

Colour	Feed point Position (Fp) (mm)	Bandwidth (GHz)
Red	23	1.25 GHz
Blue	24	1.45 GHz
Green	25	1.41 GHz
Black	26	1.4 GHz
Yellow	26.5	1.41 GHz
Purple	27	1.38 GHz

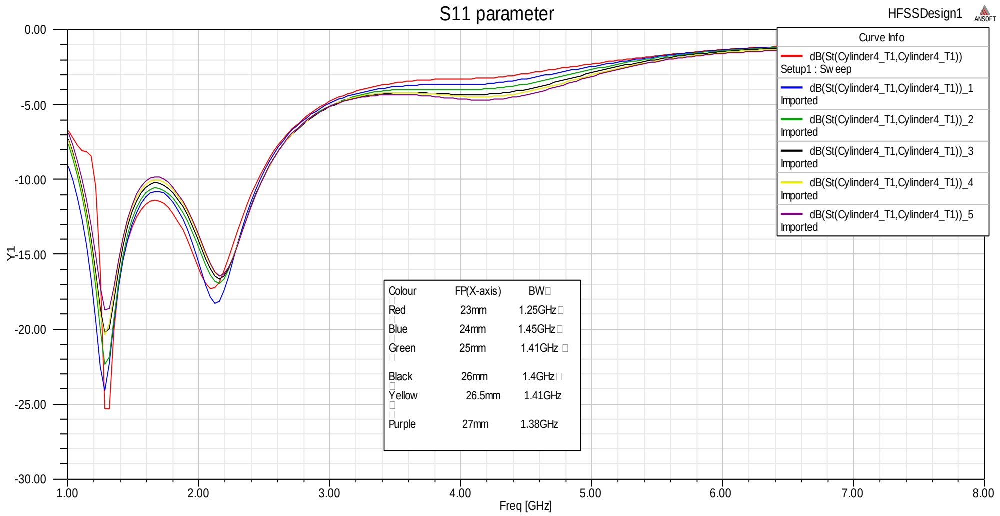

Figure 1.17: Effect of the Feed point position (Fp) on the Return Loss (Ls = 50 mm, Ps = 12 mm, Ws =6mm, H = 10mm)

Figure 1.17 Shows the S11 parameter for different Feed point position (Fp) when (Ls = 50 mm, Ps = 12mm,Ws =6mm,H = 10 mm).We got highest BW of 1.45 GHz at 24 mm Feeding point at X axis.

5. Probe Radius (Pr) when coax radius is 3mm

When Probe Radius changed from 0.5 to 2 mm with 0.5 mm of increment then we will see the effect of probe radius on antenna BW. We use these parameters to design antenna (Ls = 50 mm, Ps = 12 mm, Ws =6mm, H = 10mm and Fp = 24 mm).

Table 4.8: Effect of Probe radius (Pr) when Coax radius is 3 mm on BW

Colour	Feed point Position (Fp) (mm),Cr = 3 mm	Bandwidth (GHz)
Green	0.5 mm	0.29 GHz
Red	1 mm	0.49 GHz 0.62 GHz
Orange	1.5 mm	1.59 GHz
Pink	2 mm	1.85 GHz

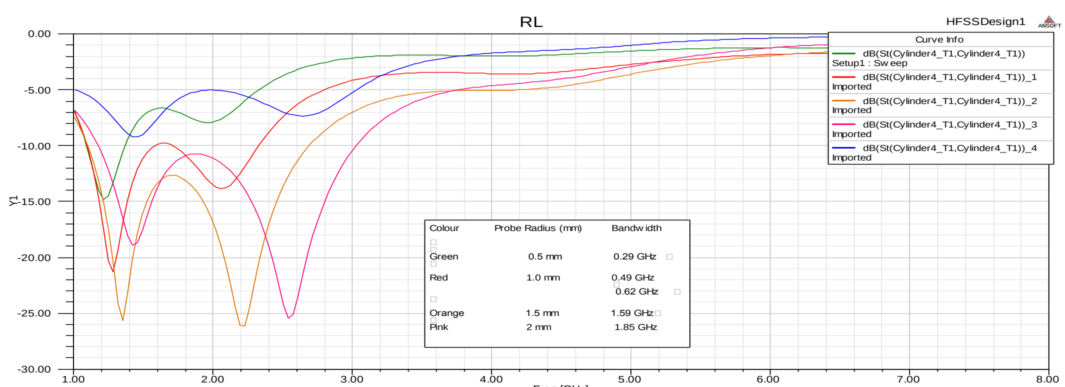

Figure 4.18: Effect of the Probe Radius (Pr) on the Return Loss (Ls = 50 mm, Ps = 12 mm, Ws =6mm, H = 10mm, Fp =24 mm)

Figure 1.18 Shows the S11 parameter for different **Probe Radius (Pr)** when (Ls = 50 mm, Ps = 12mm, Ws =6mm, H = 10 mm, Fp = 24 mm).We got highest BW of 1.85 GHz at 2 mm Probe Radius.

6. References

1. R. Chair, C.L. Mak, K.F. Lee, K.M. Luk, A.A. ''Kishk Miniature wide-band half U-slot and half E-shaped patch antennas''. IEEE Transactions on Antennas and Propagation. **53,** 2645–2652 (2005).

2. M. K. Verma, S.Verma, and D. C. Dhubkarya, "Analysis and Designing of E-Shape Microstrip Patch Antenna for the Wireless Communication Systems", International Conference on Emerging Trends in Electronic and Photonic Devices & Systems, (2009).
3. C. Wood, ''Improved Bandwidth of Microstrip Antennas using Parasitic Elements", IEEE Proc., Pt.H. (1980).
4. R.Garg and A.Ittipiboon, "Microstrip Antenna Design Handbook", Artech House.(2001).
5. G. Kumar and K. P. Ray, "Broadband Microstrip Antennas", Artech House, Norwood, Mass, USA, 2003.
6. M. Wentworth, ''Fundamentals of Electromagnetics with Engineering Applications'', John Wiley & Sons, NJ, USA, 442-445 (2005).
7. S. Satthamsakul, N. Anantrasirichai, C. Benjangkapraset, and T. Wakabayashi, ''Rectangular Patch Antenna with inset feed and modifier ground plane for wide band antennas", IEEE, (2008).
8. K. L. Wong and Y. F. Lin, "Small Broadband Rectangular Microstrip Antenna with chip-resistor loading," Electron. Lett., **39,** 1593- 1594 (1997).
9. K. J. Ng, Z. A. Abdul Rashid and M. Tariqul Islam. ''Broadband Inverted E-shaped Rectangular Microstrip Patch Antennas for 3G Applications''.IEEE National Symposium on Microelectronics 286-289 (2003).
10. E.S .Chang, S. A. Long and W. F. Richards. ''An experimental Investigation of Electrically Thick Rectangular Microstrip Antennas''. IEEE Trans. Antennas Propagat, **34(6)** 767-772 (1986).
11. M.A Martin, B.S Sharif and C.C Tsimenidis, "Probe Fed Stacked Patch Antenna for Wideband Applications", IEEE Trans. Antennas Propagat. **55** 2385-2388 (2007).
12. I. Alla, C. Ian Hunter, H. Andrew Kemp, ''Multi-Band Matching Technique for Microstrip Patch Antenna Receivers", School of electronic and electrical engineering, The University of Leeds IEEE, EUMC.(2007).
13. A. Yasir ,H. Yang and P.Clive , "A 31.5 GHZ Patch Antenna Design for Medical Implants", University of London, International Journal of Antennas & Propagation", article ID 167980, (2008).
14. S. Satthamsakul, N. Anantrasirichai, C. Benjangkapraset, and T. Wakabayashi, "Rectangular Patch Antenna with inset feed and modifier ground plane for wide band antennas", IEEE,(2008).