Engineering and Technology Journal e-ISSN: 2456-3358

Volume 10 Issue 11 November-2025, Page No.-7825-7839

DOI: 10.47191/etj/v10i11.15, I.F. – 8.482

Comparative Analysis of Different Line Feeding Methods of Circular Microstrip Antenna for Wearable Applications

Husain Bhaldar[1], Mehnaz Ustad[2]

[1]Senior QA Engineer, Metacube Software Private Limited, Jaipur, Rajasthan, India.

[2] Salesforce Automation QA, Talent Arabia, UAE.

ABSTRACT: This paper is illustrated the small and wide band edge & inset fed circular microstrip antenna for on body communication. This work proposes an antenna consisting of a circular patch of radius 14 mm and two square slits of $5mm^2$ and $10mm^2$. The partial ground plane is used having dimensions of 28mm X 86mm in which the antenna is radiating with patch of copper foil. To describe the wearable applications, top and bottom planes of proposed antenna are separated by light weight jeans fabric of dielectric constant of 1.7 and thickness of 1mm. Further, the different antenna parameters are analyzed for the operating frequencies of 2.45 GHz, 6.47 GHz and 11.95 GHz for WiFi, WiMAX application. The results indicate that the enhanced bandwidths are achieved at these frequencies of the order of 811 MHz and 4.48 GHz for inset line feeding and 4.32 GHz and 1.19 GHz for inset feed with slot at feed point. Also this antenna has been tested on body and provided the enhanced bandwidth & good efficiency. The organization of the paper is as follows.

KEYWORDS: C band, Circular microstrip, returns loss, SHF, Wi-Fi, WiMAX.

1: INTRODUCTION

Wireless body area network (WBAN) is emerging field in the wireless communication in today's era, due to ease of fabrication & light in weight of wearable microstrip antenna is preferred as compared to conventional antennas. The microstrip patch antennas are usually prepared for wireless communication due to its properties light weight, compact size etc. Due to use of textile material for the development wearable antennas, wireless body area network (WBAN) has been rapidly increasing in the field of wearable technology. The wearable antennas easily fabricated into clothes and it is used for medical, sport wear, civil & satellite applications etc. Circular microstrip antennas are beneficial over other structures, due to its characteristics such as low cost, light weight and ease of fabrication. The present scenario of wireless communication needs the multiband antennas for SHF applications and IEEE radar C band applications.

The textile material used for antenna designing can be categorized into 2 types, natural and man-made textiles. The electro-textile material is obtained by using synthetic man-made material which is combination of copper & cotton polymer. Normally the textile material used to enhance the bandwidth of microstrip antenna, because textile material has very small dielectric constant. It also minimizes the surface wave losses. But the physical dimensions of antenna increases in case of textile antennas compared with large dielectric substrate antennas.

The microstrip textile antenna can be designed by considering the different properties of textile fabric such as bending, stretching & wetness conditions. The bending may change antenna performance due to change in operating length of antenna, so select the textile material which could not affect the antenna performance. The frequency range Wi-Fi application varies from 2.4GHz to 2.483GHz. The frequency band used for WiMAX is of 2.3GHz to 3.3GHz in India.

Nikhil Kumar Singh. et al. (2016) observed that proposed antenna operating at three frequency bands of 3.42GHz, 9.73GHz & 11.17GHz and it has been used for multiband application. The wearable antenna has been designed on jeans material and used for on human body communication [1]. H.K.Bhaldar. et al. (2020) studied the microstrip textile antenna for Wi-Fi communication and antenna has been resonating at frequency of 2.45GHz & provided return loss of -15.76dB with directivity of 8.05. The antenna is designed with rectangular shape & jean as dielectric material to get wide bandwidth [2]. Carlos. et al. (2018) designed on body wearable antenna designed at ISM band of frequency 2.45GHz & radiated at -18dB of return loss & also a robust snap on button textile antenna designed at 2.45GHz and provided return loss of -25dB [3,4]. Pranita Manish et al. (2018) observed and analyzed the microstrip textile antenna simulated at 2.45GHz with different dielectric fabric materials such as Cotton, Polyester, Cordura and Lycra. The values of return losses at 2.45 GHz frequency for respective textile material have studied -32dB, -35dB,-29dB and -31dB [5].

Anurag Saxena. et al. (2018) designed the antenna operating at the multiple frequencies from 5.3GHz to 10.15GHz and provided the bandwidth of 62.78%, return loss of -25dB at 5.44GHz & -24db at 8.05GHz. The author used the moon strip line structure of patch [6]. Idellyse and Rama Reddy.et al.(2018) proposed the circular polarized textile antenna and U slot conical antenna which is designed at ISM band of frequency range 2.4GHz to 2.45GHz, the values of S11 parameter -35dB & -20dB are observed at resonating frequencies [7-8]. Sweety Purohit.et al. (2014) simulated the light weight wearable antenna using jeans material at the resonant frequency of 2.45GHz. When antenna used for on body communication, the SAR is very important parameter considered for wearable application and the standard SAR value used is of 1.6 W/kg of tissue [9]. Jiahao Zhang et.al (2017) observed the miniature feeding network for aperture coupled antennas designed at frequency of 2.4GHz – 2.483GHz with gain of 5.6dBi. The author has studied various shapes of coupling aperture such as ring, H-shaped, rectangular, E shaped, cross etc. at various frequencies in ISM band [10].

The Yiye Sun. et al. (2014) designed the circular patch with thin feed line and has rectangular ground plane. The bandwidth of designed antenna has been enhanced due to use of tapered feed line. The proposed antenna used at ultra-wide band application for frequency range of 2.8GHz to 16GHz [11]. Punith S. et al. (2020) studied and the implemented the multiband antenna resonating at 23.9GHz, 35.5GHz and 70.9 GHz and used for 5G communication. The antenna has been analyzed to achieve the return losses of -19.97dB, -22.73dB and -21.96dB for the above mentioned operating frequencies [12]. S. Kumar. et al. (2018) analyzed and implemented the co-planar fed antenna at ISM band for implantable on the body with bio sensor for on body communication. The proposed antenna designed with loop structure and it is radiating with return loss of -37dB [13]. Seyed Mohsen. et al. (2019) designed the multiband CPW fed microstrip wearable antenna for operating frequency of 3.2GHz to 16.3GHz for ultra-wide band application. The compact antenna is implemented on the body and in the air; the efficiency observed on the body is greater than in the air located antenna [14]. Sandeep Singh Sran. et al. (2020) studied and analyzed the wearable fractal antenna operating at 2.53GHz, 4.9GHz and 7.6GHz for S, C, and X band application. The proposed antenna improved the gain and bandwidth at these resonant frequencies [15]. A. Deviovanni. et al. (2018) proposed the high gradient linacs for hadron therapy for the frequency range of 3 to 5.7GHz. The proton beams are radiated by using hadron therapy with energies 70 and 230Mev [16].

In the wide band antenna design the different line feeding are used. In this paper edge & inset line feeding methods are used to design antenna for wearable application. The feeding methods used to design microstrip antenna is categorized in to two types given below.

1. Contact type
2. Non-Contact type

Contact type: In this type, the thin microstrip line is directly attached to the radiating patch of an antenna. The antenna is excited by voltage source connected to this fed line & RF power is transferred. The total power delivered to antenna depends upon the proper impedance matching between source and antenna. So depends upon microstrip feed line width, the antenna impedance is calculated & matched with source impedance. The contact type feeding also has two categories as follows.

I. **Edge line feed**: This feeding method is ease to fabricate and provides low bandwidth. In this type, the microstrip line is directly attached to the edge of radiating patch. The size of feed line is very small as compared to geometry of patch.

II. **Inset line feed**: This method is best to improve the bandwidth and efficiency of antenna. To get proper impedance matching small cut is inserted on both side into the patch. The size and location of cut is adjusted to get exact impedance matching. If impedance is properly matched, applied RF power will be transferred to an antenna. This will lead to enhance the efficiency & bandwidth of an antenna.

Non- Contact type: In this method, radiating patch is not directly attached to feed line. In this method electromagnetic coupling principle is used to transfer RF power to an antenna. It also has two types- Proximity & Aperture Coupling.

The section 2 describes the antenna design and detailed configuration followed by results and discussions in section 3. Section 4 discusses measured results and comparison between simulated and fabricated results followed by conclusions in section 5.

Section 2: Antenna Design & Configuration

In today's era microstrip antenna frequently used in wireless communication for different frequency bands. The geometry of microstrip antenna has resonating patch & bottom ground plane made of conducting material which is separated by the dielectric materials such as FR4, Rogger etc. as shown in figure 1.

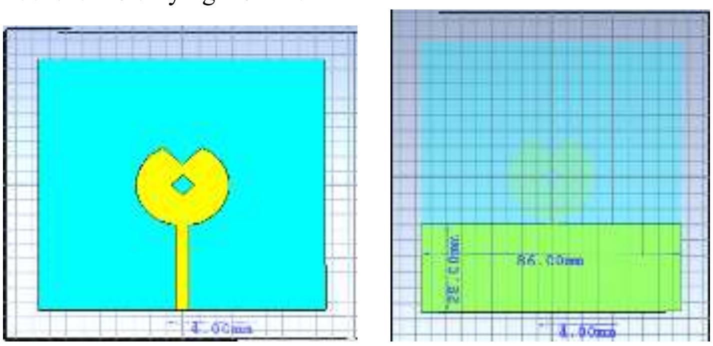
Figure 1: Microstrip Patch Antenna

In the proposed study, the circular microstrip textile antenna with edge & inset line feeding method is designed at ISM band of frequency of 2.45GHz. The microstrip antenna is designed with maximum efficiency for wireless applications in the frequency band of 2.4GHz to 2.485GHz for Wi-Fi communication. The radius of circular patch is of 14mm calculated using equation 1 and top patch consist of two square slits of dimension $5mm^2$ & $10mm^2$ as shown in figure 2. The bottom ground plane is made partial of size 86mm x 28mm which provides the additional two frequency bands at 6 GHz & 12GHz.The top patch & ground plane made with copper foil of thickness 0.035mm. The jean is used as substrate material with dielectric constant 1.7 with substrate thickness of 1mm, so that designed antenna is wearable, light in weight & compact in size. The antenna design is demanding for flexible textile (fabric) antennas, in which textile antenna can easily attach to the clothes. The selection of the proper feeding method for microstrip antenna is an important task, to get proper impedance matching. In this proposed study, the comparative analysis of edge and inset line feeding methods has been carried out to design the wearable circular microstrip antenna.

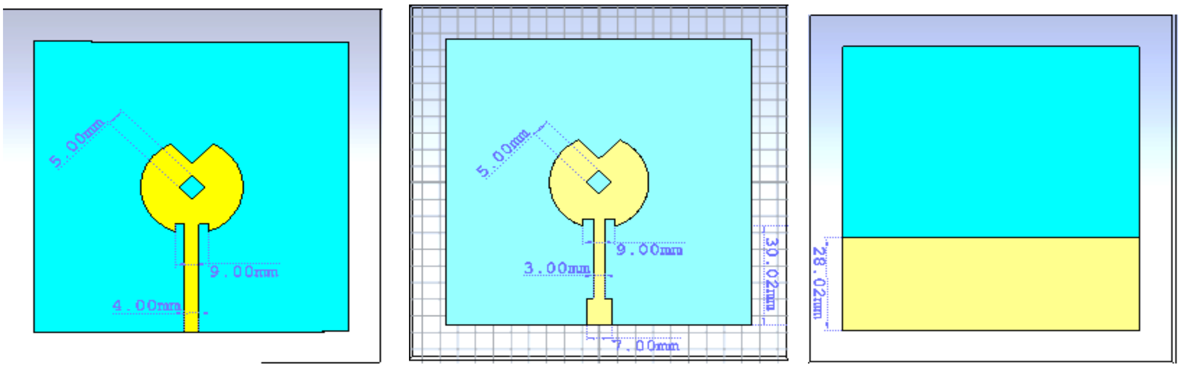
The proposed microstrip antenna with edge feeding is proving three frequency bands 2.32GHz, 6.47GHz &12GHz as shown in figure 2a. These frequency bands are used for Wi-Fi, WiMAX communication. The mobile WiMAX used in three frequency bands which are 2.3- 2.4GHz, 2.5- 2.7GHz and 3.4- 3.6GHz.As per the IEEE 802.11 to 16, the WiMAX is used in broadband wireless communication. The frequency band allocated to WiMAX IEEE 802.16a is varying from 10 – 16GHz and for IEEE 802.16d or IEEE802.16-2004 varies from 2- 11GHz. This frequency band is implemented to interface with OFDM or OFDMA for broadband wireless communication.

The designed antenna with inset line feeding is also proving three frequency bands 2.37GHz, 5.23GHz & 6.89GHz and the design is further modified with inset feed, small slot is inserted at the feed point of proposed antenna. Because of this slot at feed point the bandwidth of antenna is increased to large extend & it provides four frequency bands at the operating frequency of 2.45 GHz, 3.18GHz, 5.91GHz &11.70GHzwhich is shown in figure 2b. It has been observed that bandwidth increased from 700MHz to 4.32GHz with inset line feed compared with edge feeding method. The designed antenna is used for Wi-Fi, WiMAX, SHF and IEEE radar C band applications of frequency range of 2GHz to 11.56GHz.The analysis of feed line width & its reference impedance have been calculated for various dimensions of feed line width.

The analysis of both edge and inset line feeding methods are carried out in this paper to compare the various parameters of antenna such as return loss, VSWR, directivity & bandwidth as shown in table 2.The designed antenna is excited with voltage source connected to microstrip feed line of impedance 50ohm.The proposed antenna has been simulated in CST Microwave Studio the various antenna parameters have been observed. The figure 3 shows geometry of fabricated microstrip textile antenna and the fabricated antenna is tested with Anritsu VNA.



2a



2b

Figure 2: Proposed antenna 2a: Top view of proposed antenna with edge feed& 2b: Top view of proposed antenna with inset & partial ground plane

3a

3b

Figure 3: Picture of fabricated circular microstrip textile antenna. 3a: Top & Bottom view with edge line feed, 3b: Top & Bottom view of inset line feed.

The radius of circular patch microstrip antenna is calculated for resonant frequency of 2.45GHz & dielectric constant of 1.7 by using equation 1[2].

$$f_{mn} = \frac{c}{2\pi a\sqrt{\varepsilon r}} x'_{mn} \qquad \text{eq (1)}$$

Where
c = speed of light
Fmn = Resonating frequency for mn mode
a = Radius of patch
Xmn= Constant for mn mode
εr= Relative dielectric constant of substrate

The table 1 shows design parameter of circular microstrip antenna.

Table 1 : List of Antenna Parameter

Antenna Parameter	**Dimensions (mm)**
Dielectric constant εr	1.7
Radius of patch a	14mm
Length of slitL1	5mm
Width of slit W1	5mm
Length of slitL2	10mm
Width of slit W2	10mm
Length of ground plane Lg	28mm
Width of ground plane Wg	86mm
Width of feed line Wf	4mm
Substrate height hs	1mm
Substrate thickness ht	0.035mm

Section 3: Result & Discussion

In order to get best analysis & validation, the comparison of simulated and the measured return loss, VSWR and bandwidth values of proposed antenna are discussed.

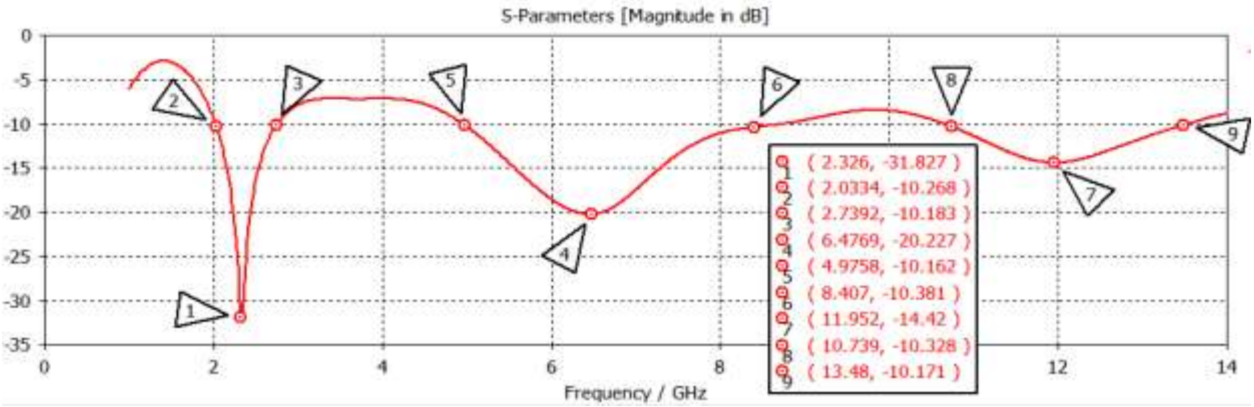
I) **Return Loss**: The S_{11} parameter must be maintained minimum at -10dB, to get good radiation. From figure 4, it has been observed that designed antenna have three different return loss graphs as follows:

a) Figure 4a shows the return loss of designed antenna with edge feed, it has been seen that antenna provided the three frequency bands & the values of return losses are -31.827dB at a frequency of 2.3268GHz, -20.227dB at a frequency of 6.47GHz and -14.42 dB at a frequency of 11.952GHz.The bandwidth observed at these frequency bands are 700MHz, 3.43GHz and 2.75GHz.

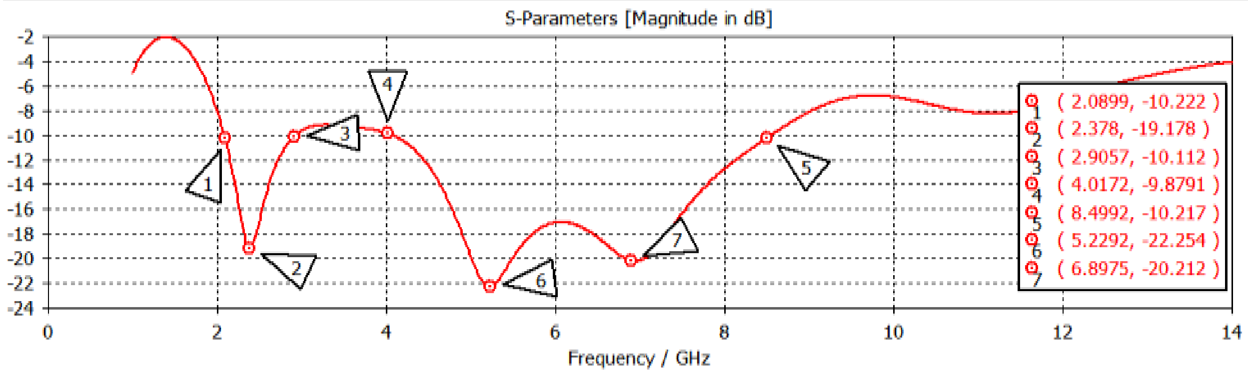
b) Figure 4b shows the return loss of designed antenna with inset feed, it has been seen that antenna provided the two frequency bands & the values of return losses are -19.17dB at a frequency of 2.378GHz and -22.25dB at a frequency of 5.23GHz. The bandwidth observed at the 1st resonant frequency band is of 811MHz & the very large bandwidth at 2nd resonant frequency band is of 4.48GHz as compared with edge feed.

c) Figure 4c shows the return loss of designed antenna with inset feed with square slot at feed point, it has been seen that antenna provided the two frequency bands & the values of return losses are -11.27dB at a frequency of 2.45GHz and -14.70dB at a frequency of 11.7GHz. The 1st band provided the large bandwidth at the resonant frequency of 2.45GHz is of 4.32GHz & the bandwidth at 2nd resonant frequency band is of 1.19GHz. The bandwidth is enhanced in inset line feed as compared to edge line feed due to square slot is used at feed point and the size of ground plane is reduced to 28 x 86mm.The above said bandwidths have been enhanced by using low value of dielectric constant of jean and partial ground structure.

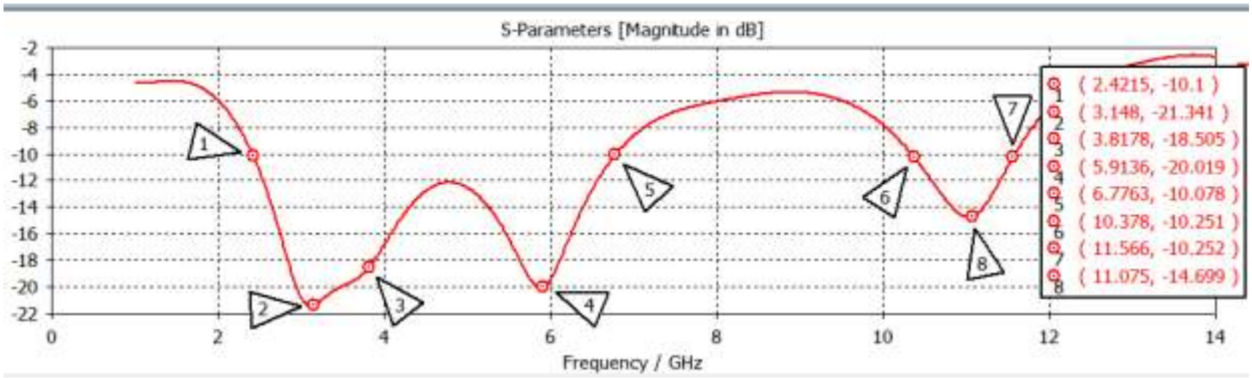
The fractional bandwidths are also calculated & the results are improved which is shown in table 3, when value of S11 is less than -10dB.



4a



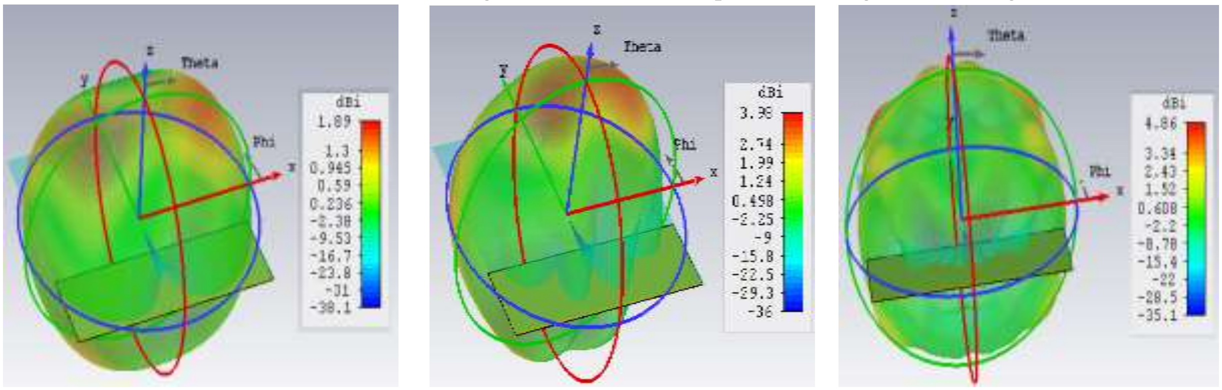
4b



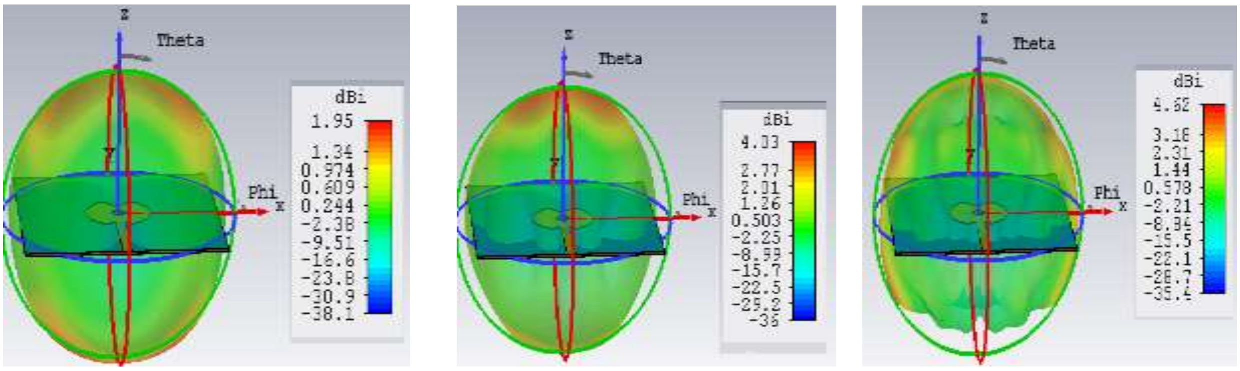
4c

Figure 4: Return loss versus frequency plot of proposed antenna: 4a: Edge feed, 4b: Inset feed &4c: Inset with slot at feed point

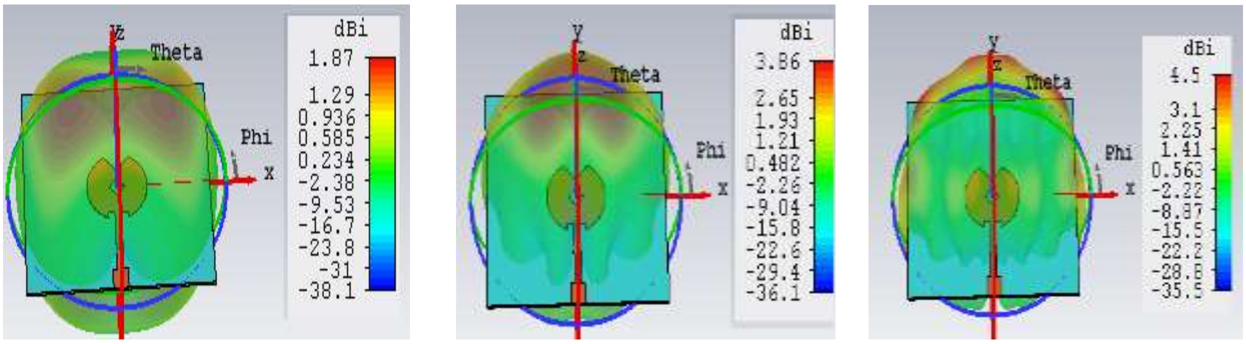
II) 3D Radiation pattern proposed antenna: It has been observed that, From the figure 5, 3D radiation pattern of the antenna with edge & inset feed. The designed antenna have provided 3 different directivities for edge feeding at the frequencies of 2.4GHz, 6.47GHz & 12GHz are 1.89 dBi, 3.98 dBi& 4.86 dBi as shown in 5a, for inset feeding at the frequencies of 2.37GHz, 5.23GHz & 689GHz are 1.95 dBi, 4.03 dBi & 4.62 dBi as shown in 5b and for inset with square slot at feed point at the frequencies of 2.45GHz, 5.91GHz & 11.7GHz are 1.87 dBi, 3.86 dBi & 4.5 dBi as shown in 5c.It has been concluded that inset line feed provided good results compared with edge line feeding method.



5a



5b



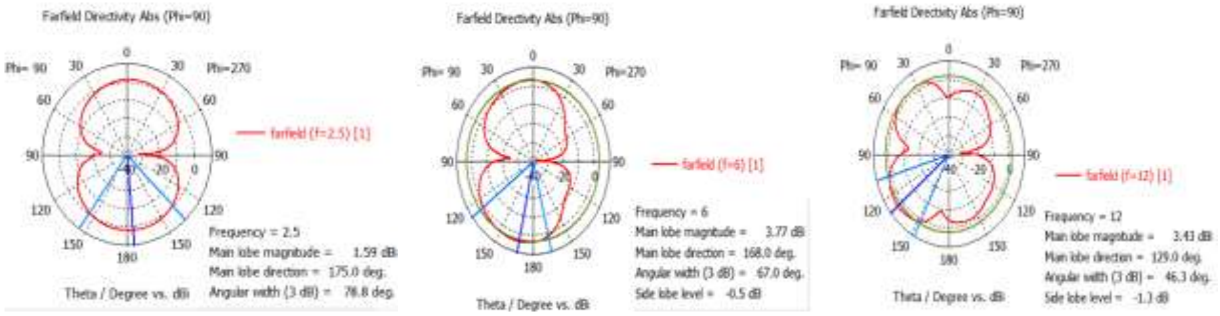
5c

Figure 5: 3D Radiation pattern the proposed antenna 5a: edge feed, 5b: Inset feed& 5c: Inset feed with slot.

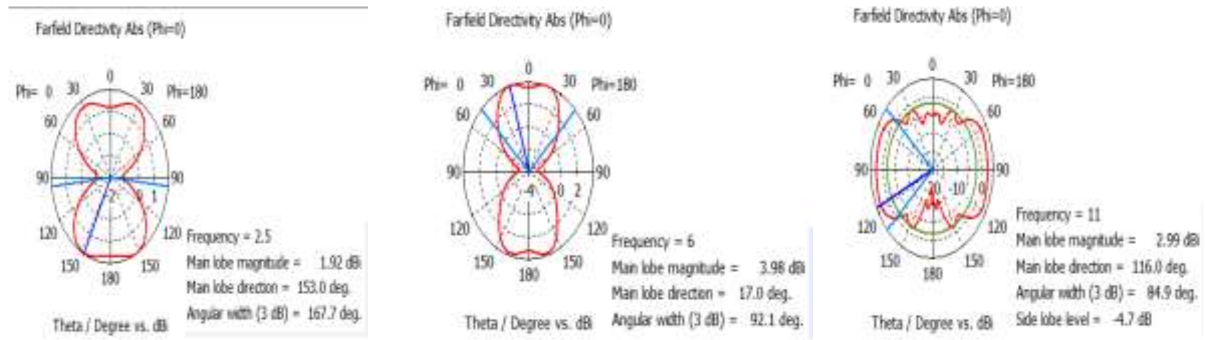
III) 2D Radiation pattern of proposed antenna: From figure 6, it has been concluded that polar plot of designed antenna with edge & inset line feed. The 2D polar plot of edge feeding is shown in figure 6a, It has stated that the main lobe direction of 175˚, 168˚ & 129˚at and angular bandwidth of 78.8˚ with magnitude of 1.58dB, 67˚ with magnitude of 3.77dB & 67˚ with magnitude of 3.77dB at three frequency bands 2.5GHz, 6GHz &12GHz.

The 2D polar plot of inset line feeding is shown in figure 6b, It has seen that the main lobe direction of 157˚, 17˚ & 126˚at and angular bandwidth of 162.2˚ with magnitude of 1.92dB, 92.1˚ with magnitude of 3.98dB & 84.9˚ with magnitude of 2.99dB at three frequency bands 2.5GHz, 6GHz &11GHz. The 2D polar plot of inset line feeding is shown in figure 6c, It has seen that the main lobe direction of 153˚, 17˚ &116˚at and angular bandwidth of 170.4˚ with magnitude of 1.86dB, 95.7˚ with magnitude of 3.83dB & 84˚ with magnitude of 2.96dB at three frequency bands 2.5GHz, 6GHz & 11GHz.

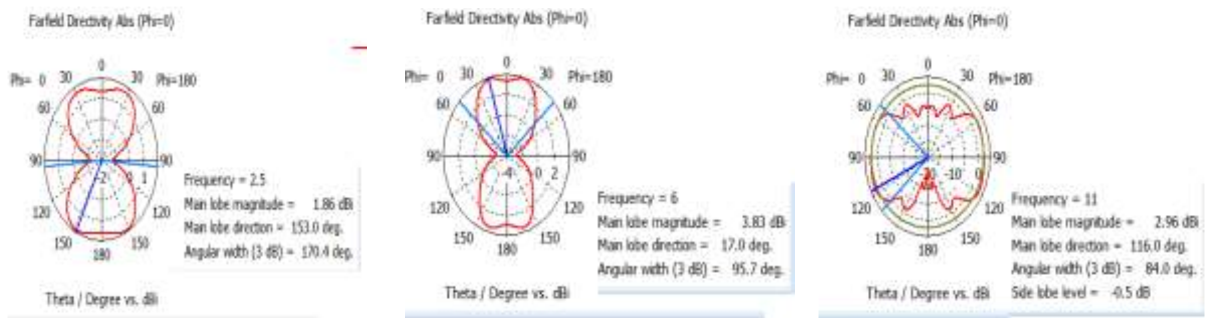
It has also observed from figure 6, that the back radiation is very small at all three frequency bands due to use of proper ground plane.



6a



6b

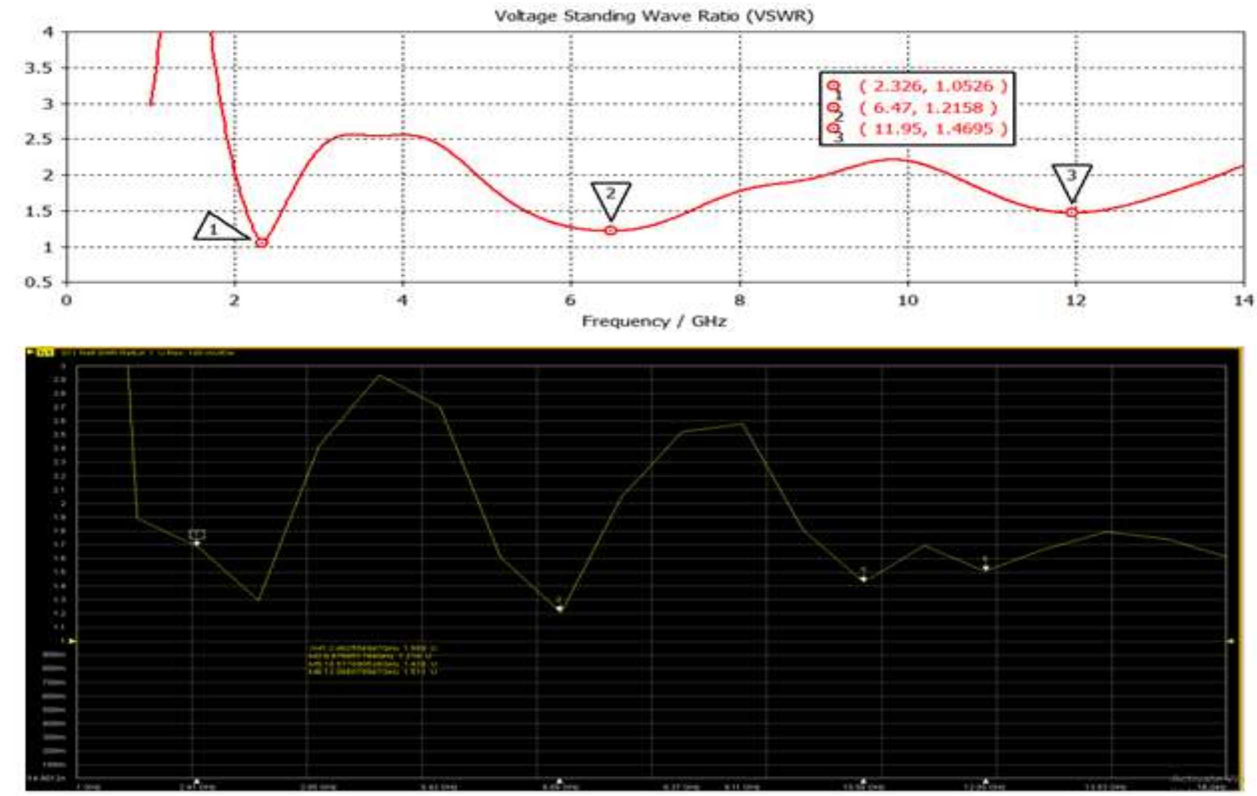


6c

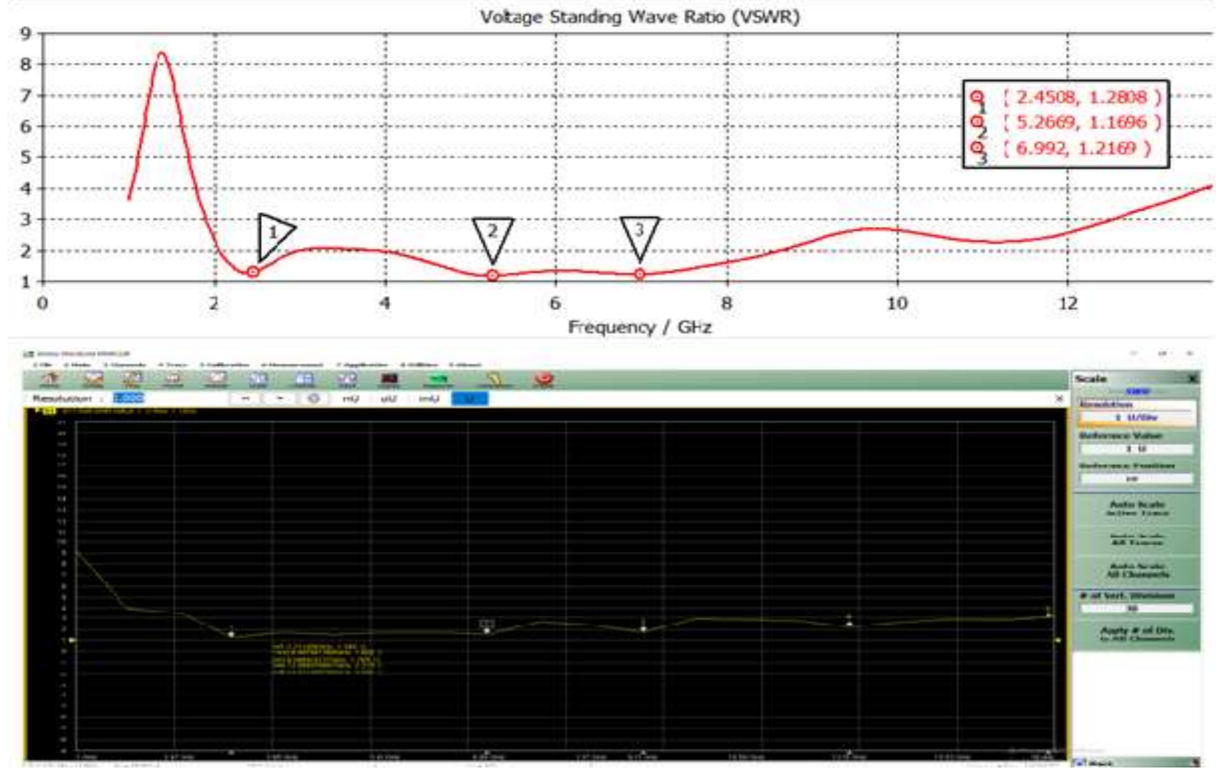
Figure 6: Polar plot of the proposed antenna 6a: Edge feed, 6b: Inset feed & 6c: Inset feed with slot

IV) VSWR of proposed antenna: From figure 7, it has been concluded that the value of VSWR for different feeding methods as shown below.

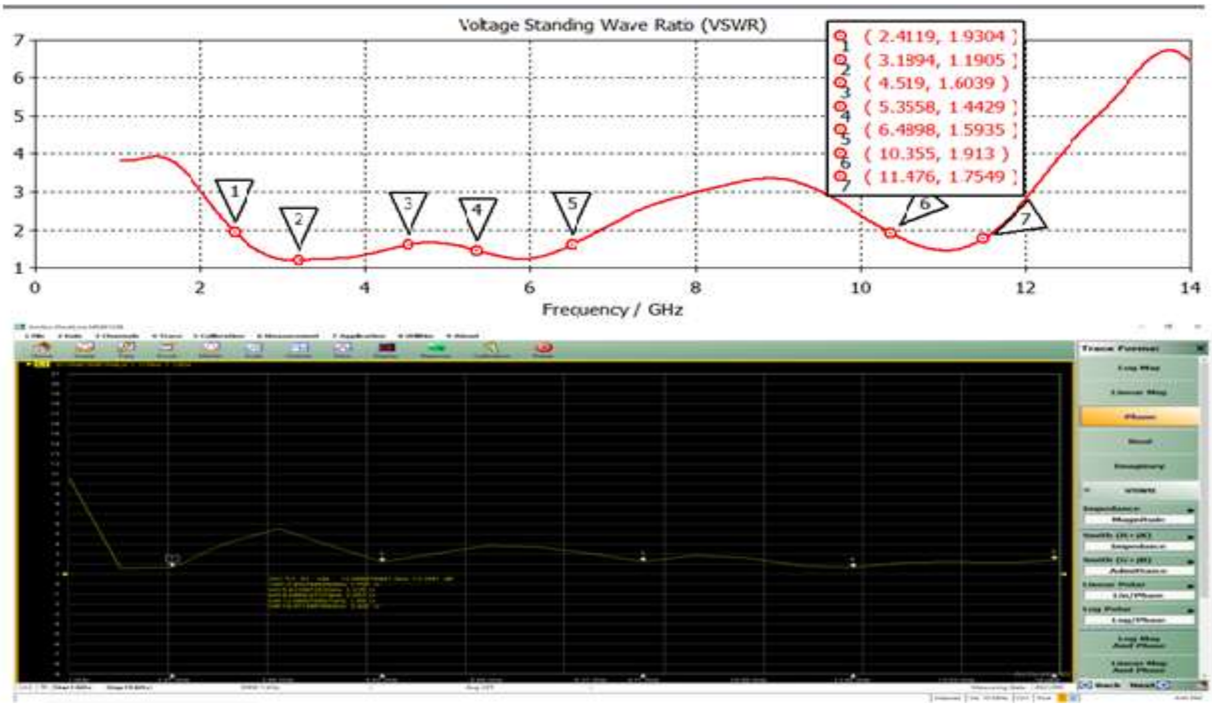
The values of VSWR for egde feeding are 1.05, 1.21 & 1.46 at 2.32GHz , 6.47GHz & 11.95GHz frequeincies as shown in figure 7a. The values of VSWR for inset feeding are 1.28, 1.16& 1.21 at 2.45GHz , 6.99GHz & 11.95GHz frequeincies as shown in figure 7b and for inset with slot at feed point are 1.93, 1.19, 1.59& 1.5 at 2.4GHz , 3.18GHz, 6.99GHz & 11GHz frequeincies as shown in figure 7c. The VSWR value describes the proper impedance matching between feed line & source applied so it must be between 1 to 2 for effiecient working of antenna. The simulated and fabricated VSWR values are perfectly matching as shown in figure 7.


Voltage Standing Wave Ratio (VSWR)
(2.326, 1.0526)
(6.47, 1.2158)
(11.95, 1.4695)
Frequency / GHz

7a


Voltage Standing Wave Ratio (VSWR)
(2.4508, 1.2808)
(5.2669, 1.1696)
(6.992, 1.2169)
Frequency / GHz

7b



7c

Figure 7: VSWR of simulated & fabricated antenna 7a: Edge feed, 7b: Inset feed & 7c: Inset feed with slot

V) Efficiency: The efficiency of anenna gives idea of the amount of incident power is utilized for radiation. The radiation efficiency antenna differs from the total efficiency of antenna due to loss takes place because of the impedance mismatching.

The total efficiency is given by equation 2

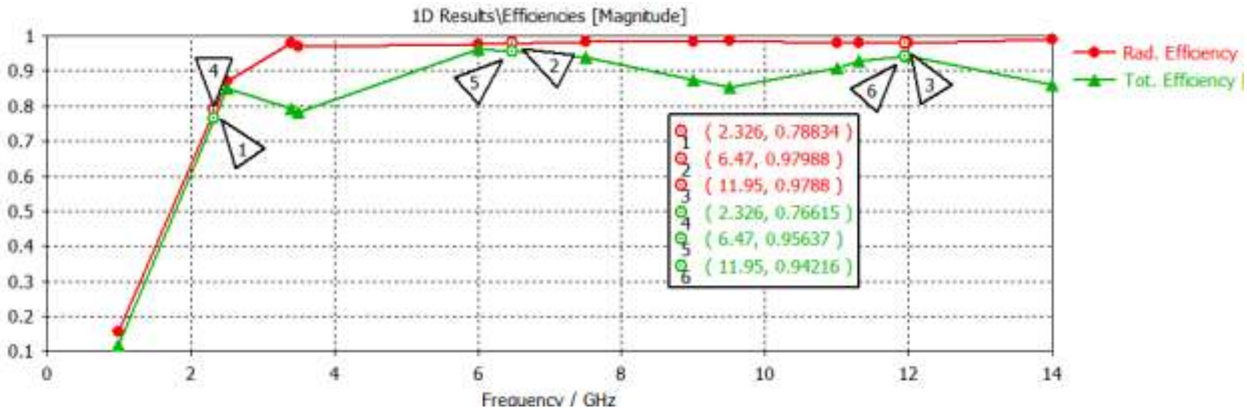
$$Et = Zl * Er \qquad \text{eq (2)}$$

where Et = Total Efficiency , Er = Radiation Efficiency & Zl = Impedance mismatch loss.

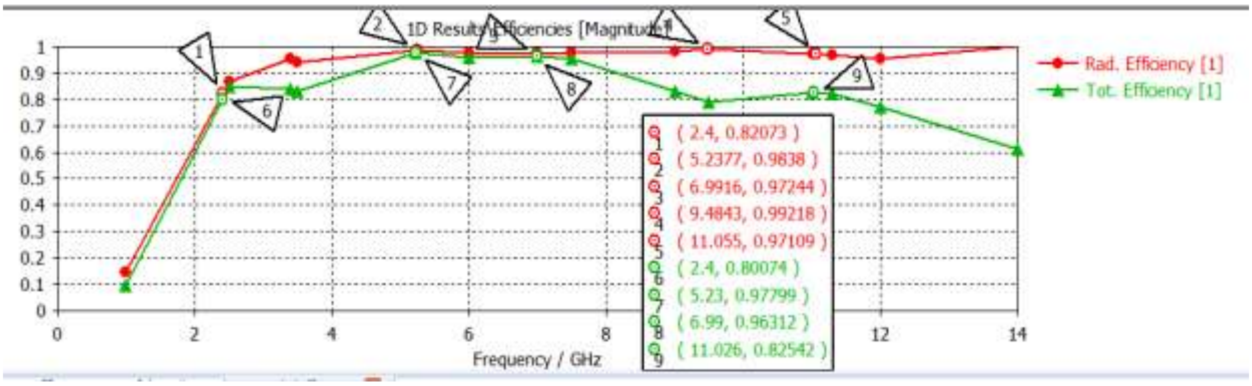
From Figure 8, it has been observed that the proposed antenna radiated at 3 frequancy bands. The radiation and total efficiecy for edge feeding are 78.83% & 76.61% at a frequency of 2.32GHz , 97. 98% & 95.63% at a frequency of 6.47GHz and 97.88%& 94.21% at 11.95GHz as shown in figure 8a.

The radiation and total efficiecy for inset line feeding are 82.07 % & 80.7% at a frequency of 2.37GHz , 98.38% & 97.79% at a frequency of 5.23GHz and 97.24% & 96.31% at 6.89GHz as shown in figure 8b.The radiation and total efficiecy for inset line feeding with slot at feed point are 90.5 % & 84% at a frequency of 2.45GHz , 99.19% & 97.88% at a frequency of 5.91GHz and 99.33% & 97.98% at 11.7GHz as shown in figure 8c.

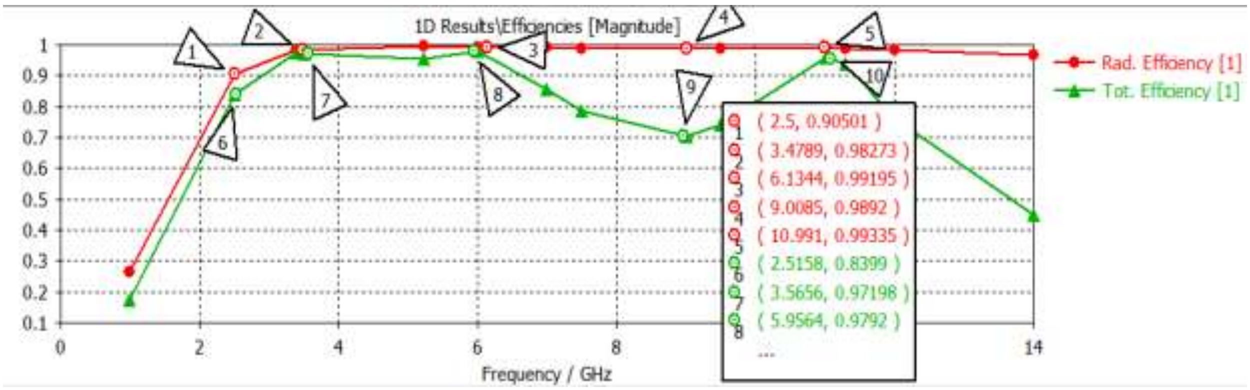
It has been concluded from above discussion that inset line feeding provided the 99% total & radiation effeciencies.



8a



8b



8c

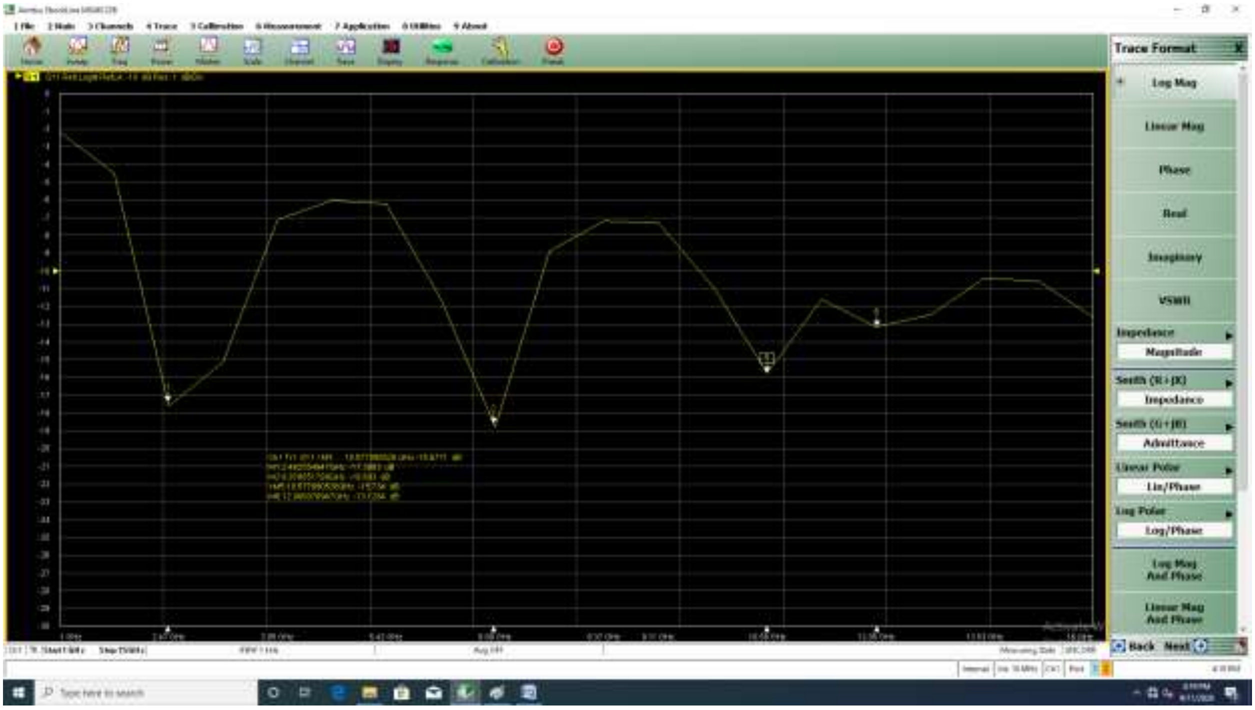
Figure 8: Radiation & total efficiency of the proposed antenna, 8a; Edge feed, 8b: Inset feed & 8c: Inset feed with slot

VI) Reference Impedance: The input impedance of antenna depends on the width of feed line & the position of X-Y axis. If the proper impedance matches the radiation efficiency of antenna increases. The Zref has been analized by selecting the different values of inset feed line width to get 50ohm impedance & X-Y position at Xmin = -3.5mm, Xmax=3.5mm, Ymin=-43mm & Ymax=-37mm which is shown in table 2.

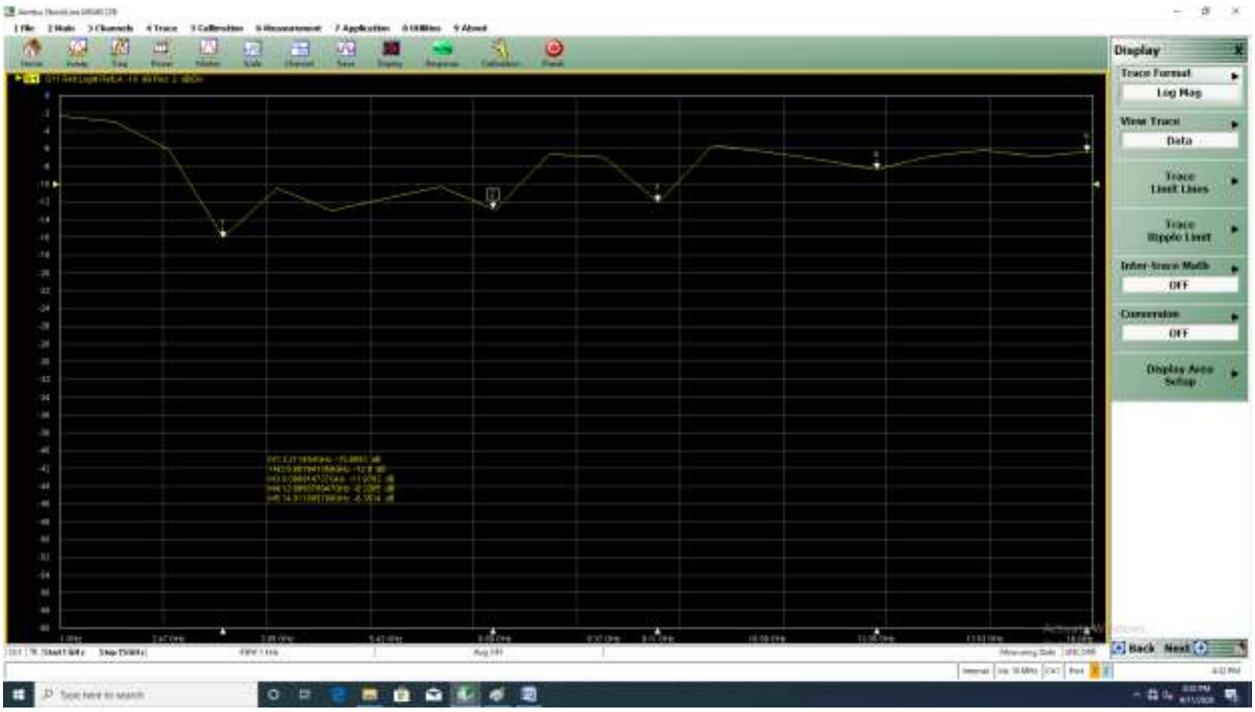
Table 2: Analysis of Zref for inset line feeding

Xmin in mm	Xmax in mm	Ymin in mm	Ymax in mm	Zref in ohm
-5	5	-43	-32.5	30
-6	6	-43	-33	29
-5	5	-43	-32	32
-4.5	4.5	-43	-31	35
-4	4	-43	-38	38
-4	4	-43	-37	40
-3.5	3.5	-43	-37	49
-3	3	-43	-35	59

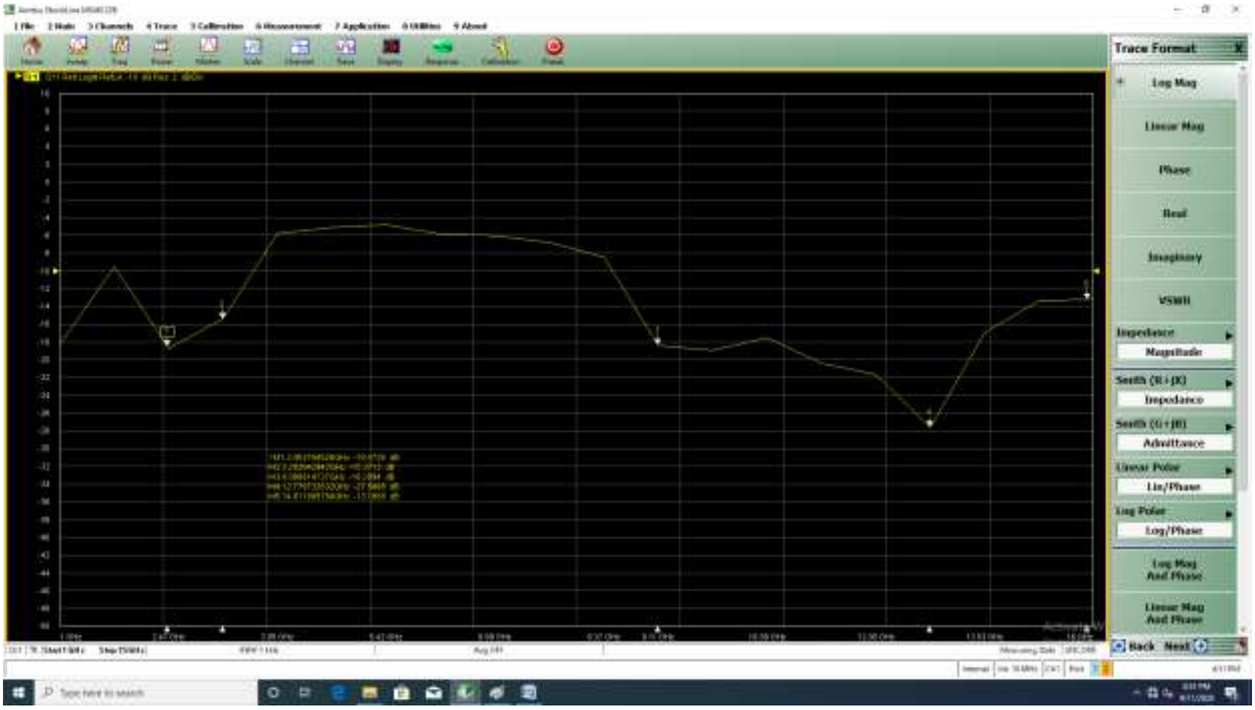
Section 4: Measured Results: From figure 9, it has been observed that the return loss of fabricated antenna operating at three frequency bands of 2.46GHz with return loss of -17dB, 6.33GHzwith return loss of -18.03dB and10 -12GHz with return loss of -15dB for edge line feed as shown in figure 9a. In the inset feed the return loss of -12dB, -15.03 & -11dB at the operating frequencies of 2.47GHz, 3.2GHz & 4GHz as shown in figure 9b and for inset with slot at feed point the return loss of -10.6dB, -10.03dB & -27dB for the frequencies of 2.45GHz, 3.2GHz & 12-14GHz as shown in figure 9c. For designed antenna simulated and experimentally tested results are approximately same.


Trace Format
Log Mag
Linear Mag
Phase
Real
Imaginary
VSWR
Impedance
Magnitude
Smith (R+jX)
Impedance
Smith (G+jB)
Admittance
Linear Polar
Lin/Phase
Log Polar
Log/Phase
Log Mag And Phase
Linear Mag And Phase
Back
Next

9a


Display
Trace Format
Log Mag
View Trace
Data
Trace Limit Lines
Trace Ripple Limit
Inter-trace Math
OFF
Conversion
OFF
Display Area Setup
Back
Next

9b



9c

Figure 9: Return loss of fabricated antenna, 9a; Edge feed, 9b: Inset feed & 9c: Inset feed with slot

The table 3 shows that the comparison of simulated results of designed antenna for edge & inset line feeding methods and table 4 shows that the comparison of proposed work carried out & previous work done. The table 4 also illustrates that inset line feed method provides the proper impedance matching of 50ohm of X-Y position at Xmin = -3.5mm, Xmax=3.5mm, Ymin=-43mm & Ymax=-37mm which is shown in table 2. This size of feed line provides the enhanced bandwidth & better efficiency shown in table 4.

Table 3 Simulated Results

Parameters	**Edge Line Feed**			**Inset Line Feed**			**Inset Line Feed with slot**			
	F1 2.32GHz	F2 6.47GHz	F311.95 GHz	F1 2.37GHz	F2 5.23GHz	F3 6.89GHz	F1 2.45GHz	F2 3.14GHz	F3 5.91GHz	F4 11.7GHz
Application	**WiFi**	**WiMAX**	**5G**	**WiFi**	**WiMAX**	**5G**	**SHF & IEEE C band Radar communication**			
S11 dB	-31.82	-20.22	-14.42	-19.17	-22.54	-20.12	-11.27	-21.34	-20.19	-14.70
VSWR	1.05	1.21	1.46	1.28	1.16	1.21	1.89	1.44	1.50	1.19
Directivity in dBi	1.89	3.98	4.86	1.95	4.03	4.62	1.87	1.90	3.86	4.5
Radiation Efficiency (%)	78.83	97.98	97.88	82.07	98.38	97.24	90.50	98.23	99.19	99.33
Total Efficiency (%)	76.61	95.63	94.21	80.70	97.79	96.31	84.00	97.18	97.88	97.98
Bandwidth	700MHz	3.43GHz	2.75GHz	811MHz	4.48GHz		4.32GHz			1.19GHz
%fractional BW	30.17	53.00	23.00	34.21	85.82		108.75			10.70

Table 4 Comparison between proposed antenna design with other literature reported

Refer Ence	chnique	Substrate and εr	Operating frequency GHz	Overall Dimensions mm	S11 Parameters dB	Bandwidth/ % Bandwidth	VSWR	Applications Mentioned
[1]	Circular shape & edge line feed	Jeans Er = 1.7	Triple bands 3.4, 9.7, 11.17	Radius 14 ground plane 86x30	-17, -18, -26	50MHz, 200MHz & 700MHz	NA	Wireless power transmission
[2]	Rectangular shape & Inset feed	Jeans εr = 1.67	Single band 2.45	W=45, L= 53, Hs=2.84 & full ground	-15.76	60MHz	1.38	Wi-Fi communication
[3]	Dual mode, Rectangular ring and inset feed	On body phantom	Single band 2.45	Patch 52.2 x 52.2 ground plane 80 x80	-31	NA	NA	On Body communication
[4]	Reconfigurable antenna, back to back snap on button	Foam with air	Dual band 2.45 & 5.8	L1= 60, W1= 55	-15 & -18	NA	Between 1 to 2	Wearable textile antenna
[5]	Rectangular patch for different substrate	Cotton 1.60, Polyester 1.90, Lycra 1.90 and Cordura 1.50	2.4	WxL= 46x53, 43x50, 43x50, 48x54	-32, -35, -29, -31	97, 40, 50, 48	2.4, 1.0879, 1.0944, 1.0917	NA
[6]	Moon strip shape for Multiband	Jeans εr = 1.7	5.44 & 10.15	Moon diameter 26 & substrate 50 x 50	-24 & -23	NA	NA	Satellite application
[7]	Circular – polarized textile antenna diamond shape	Thin textile spacer 1,65 to 1.75	ISM 2.4	Diamond s=23.3, ca=5.6,lg=17.28 line feed	-35	7.2% fractional	NA	Wearable garments
[8]	Dual band, rectangular dual L shape	Jeans cloth εr =1.7	Dual band 3.17 & 5.04	Wp =25, Lp= 40	-24, -18	100 & 30	1.86 & 1.79	Military
[9]	Wearable textile antenna	Jeans εr =1.6	2.45	Rectangular shape Wp=54, Lp=46.6	-32.57	NA	1 to 2	Wearable application
Proposed Work	**Circular shape patch with edge & inset line feeding**	**Jeans εr =1.7**	**Triple band 2.45, 6.47 & 11.95**	**Circular patch R=14, slits of 5x5 & 10x10, Ground plane 86 x 28**	**-31.8,-20.2 & -14.4 for edge. -14 to -22 for inset**	**700, 3430 & 2750 for edge.4.48GHz & 4.32GHz for inset feed**	**1.05, 1.21 &1.46 for edge. 1.19 to 1.5 for inset**	**Wi-Fi, WiMAX, SHF, IEEE C band radar communication**

Section 5: Conclusion

In the proposed work, the comparative analysis of edge & line feeding for circular microstrip textile antenna is done. The circular microstrip textile antenna has been designed at the ISM band of 2.45 GHz frequency. From the comparison results of edge & line feed, it has been observed that, the inset line feeding provided the best results at 2.45GHz, 3.18GHz, 5.91GHz& 11.7GHz frequencies. From obtained results, it has been concluded that the bandwidth is enhanced of order 4.48GHz &4.32GHz due to use of inset line feeding method.

Also it has been concluded that the proposed antenna is radiating with efficiency around 99% at multiple frequency bands from 2.45GHz to 12 GHz.

ACKNOWLEDGEMENT

The author is thankful to the review committee and my organization Metacube Software Private Limited, Jaipur for providing support and motivation to carry out research work.

REFERENCES

1. Nikhil Kumar Singh, Vinod Kumar Singh, Naresh B", Textile antenna for microwave wireless power transmission", International Conference on Computational Modeling and Security (CMS2016) Procedia Computer Science 85 (2016) 856-861.
2. Husain Bhaldar, Sanjay Kumar Goware, Mahesh S Mathpati, Ashish A Jadhav", Design of high gain wearable rectangular microstrip textile antenna for wireless application", International Journal of Innovative Technology and Exploring Engineering (IJITEE) DOI: 10.35940/ijitee.C8478.039520 ISSN: 2278-3075, Volume-9 Issue-5, March 2020.
3. Carlos Mendes, Custódio Peixeiro, " On-Body transmission performance of a novel dual-mode wearable microstrip antenna ", IEEE Transactions On Antennas And Propagation, VOL. 66, NO. 9, SEPTEMBER 2018.
4. Shengjian Jammy Chen, Damith Chinthana Ranasinghe", A robust snap-on button solution for reconfigurable wearable textile antennas", IEEE Transactions On Antennas And Propagation, VOL. 66, NO. 9, SEPTEMBER 2018.
5. Pranita Manish Potey, Kushal Tuckley, "Design of wearable textile antenna with various substrate and investigation on fabric selection", 3rd International Conference on Microwave and Photonics (ICMAP 2018), 9-11 February 2018.
6. Anurag Saxena,Vinod Kumar Singh,"A moon-strip line antenna for multi-band applications at 5.44 GHz resonant frequency",4th International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB-18), 2018.
7. Idellyse Martinez and Douglas H. Werner, "Circular-polarized textile based antenna for wearable body area networks", IEEE transaction 978-1-5386-7102-3/18/$31.00© 2018 IEEE.
8. Rama Sanjeeva Reddy & Amulya kumar, "Dual band circular polarized wearable antenna for military applications", 2018 International CET Conference on Control & Communication, July 2018, 978-1-5386-4966-4/18/$31.00 ©2018 IEEE.
9. Sweety Purohit, Falguni Raval, " Wearable textile patch antenna using jeans as substrate at 2.45 GHz", International Journal of Engineering Research & Technology, ISSN 2278-0181, Vol 3, issue 5 may 2014.
10. Jiao Zhang, Sen Yan and Guy A.E Vandenbosch," Miniature network for aperture- coupled wearable antennas", IEEE Transactions on Antennas and Propagation, Vol.65, no. 5 may 2017.
11. Yiye Sun, Sing Wai Cheung, Tung Ip Yuk, "Design of a textile ultra-wideband antenna with stable performance for body-centric wireless communications", Published in IET Microwaves, Antennas & Propagation Accepted on 3rd July 2014 doi: 10.1049/iet-map.2013.0658.
12. Punith S, Praveenkumar S K, Abhinandan and Mohammed Ahmed, "A novel multiband microstrip patch antenna for 5g communication", published in Science Direct, Procedia Computer Science 171 (2020) 2080-2086.
13. S. Ashok Kumar, Arun Raj, T Shanmugananthan, "Analysis and design of cpw fed antenna at ism band for biomedical applications", Alexandria Engineering Journal (2018) http://dx.doi.org/10.1.1016/j.aej.2017.02.008, 57, 723-727. Available at www.elsevier.com/locate/aej.
14. Seyed Mohsen and Majid Afsahi, " Compact and ultra-wideband cpw fed square slot antenna for wearable applications", International Journal of Electronics and Communications (AEU), 106 (2019) 108–115. Contents lists available at Science Direct.
15. Sandeep Singh Sran, JagtarSivia, " ANN and IFS based wearable hybrid fractal antenna with dgs for s, c, and x band application", International Journal of Electronics and Communications (AEU), PII:S1434-8411(20)31206-1, DOI:https://doi.org/10.1016/j.aeue.2020.153425, 18 August 2020.
16. A. Degiovanni , R. Bonomi, S . Verdu and R. Wegner, " High gradient RF test results of S- band and C-band cavities for medical linear accelerators", Nuclear Inst. and Methods in Physics Research, A 890 (2018) 1–7, https://doi.org/10.1016/j.nima.2018.01.079
17. Bhaldar, H. K., Gowre, S. K., & Ustad, M. S. (2022), Design of Circularly Polarized Compact Size Wearable Antenna for UWB and 5G Application. IETE Journal of Research, 69(11), 7735–7746. https://doi.org/10.1080/03772063.2022.2054868, 2022.
18. Husain K. Bhaldar, Sanjay Kumar Gowre, Mahesh S. Mathpati, Ashish, A. Jadhav, Mainaz S. Ustad, Pavan Mankal & Veerendra Dakulagi (2021)," Design of Circular Microstrip Textile Antenna for

UWB Application", IETE Journal of Research, DOI:10.1080/03772063.2021.1982416, 2021.

19. Husain Bhaldar, S. K. Gowre, M. M. Mathpati, M. S. Ustad, A. A. Jadhav and P. Mankal, "Multiband Microstrip Textile Antenna for WiFi/WiMAX/5G Communication," 2021 IEEE 4th International Conference on Computing, Power and Communication Technologies (GUCON), Kuala Lumpur, Malaysia, 2021, pp. 1-10, doi: 10.1109/GUCON50781.2021.9573799.
20. Husain Bhaldar, S. K. Gowre, M. S. Mathpati, A. A. Jadhav, and M. S. Ustad, "Design of wearable multiband Circular Microstrip Textile antenna for WiFi/WiMAX communication," Engineering And Technology Journal, Vol. 6, no. 03, pp. 798–806, 2021. DOI:10.47191/etj/v6i3.01.
21. Husain Bhaldar, Gowre, S.K., Mathpati, M.S., Jadhav, A.A., Ustad, M.S. (2021). Analysis and Design of E Shaped Dual Band Microstrip Textile Antenna for Wireless Communication. In: Pawar, P.M., Balasubramaniam, R., Ronge, B.P., Salunkhe, S.B., Vibhute, A.S., Melinamath, B. (eds) Techno-Societal 2020. Springer, Cham. https://doi.org/10.1007/978-3-030-69921-5_18.