

Wide Band Millimeter Wave Fabric Antenna for 60GHz Applications

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Abstract - A Fabric antenna is used for on body communications. Millimeter wave antenna consists of small beams with high frequency and high directive improves high data communication. It helps us to reduce the barring between user and communication device. This proposed antenna is designed at 60 GHz. It has mainly integrated with wireless sensor network and medical applications. This antenna is designed with the help of HFSS Software. Later HFSS can be explained in the simulation tool. The aim of the paper is, in human body we will insert cloth sensors to monitor different physiological parameters regardless of the patient location. The information passed instantly to the doctor using an external processing unit. In case of any emergency the patient is alerted through appropriate message or alarms. Designed antenna dimensions are 27.3 mm × 8.5 mm × 0.8 mm. Antenna performance is analyzed by using simulated results of reflection co-efficient, VSWR, gain, bandwidth and directivity.

Index Terms – Millimeter waves, Textile antennas, wearable antennas, wireless body area network (WBAN) system.

I. INTRODUCTION

Nowadays, wireless sensor network is a wireless network of clothing procedure equipment. Cloth sensors are used to transmit the information without using wires, they can be inserted on the body or mounted on the surface or may be escort devices which individuals can bear in different position such as pockets, by hand or in bags [1]. Many researchers made lots of research on the development of millimeter wave band [2, 6]. These studies in the development of current using band in many fields like military, space, healthcare, entertainment [7,12]. Researchers are concerns with 60GHZ for wearable cloth patch antenna and body sensor network [3]. Recently MIMO antennas have been developed at the resonance frequency of 2.45 GHZ for ISM (Industrial- Scientific Medical) bands. Wearable antennas are the antennas are specially designed to work while being worn. They are widely used in smart watches, glasses, and go pro action cameras [4, 10].

They are employed in communication systems & have many medical applications because of their attractive features like visibility, malleability, small weight, tiny volume, and low-level productivity cost [6, 8]. Body centric communication has become a crucial part of the 4G mobile communication in the recent years [9, 11]. IEEE802.15. For off-body, on-body communications standardization group has been established. These standardization groups are established to increase the interest in antennas researches for body communication. [13, 15].

II. DESIGN OF ANTENNA

The frequency of millimeter wave fabric antenna is 60GHz. These antennas are used to pass on big pack of data and to decrease the size of the antenna [14]. For calculating the wavelength, the formula is

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{60 \times 10^9} = 5mm(1)$$

Moreover, Millimeter wave fabric antenna were used, the distance between two yagi uda antennas are

$$\lambda / 2 = 5mm / 2 = 2.5mm \quad (2)$$

Two yagi-uda antennas, have one port, eleven directors, microstrip, Substrate, Ground plane and radiation box

A. First Antenna Design

For designing the antenna, a micro strip has three parts. First Microstrip part consists of x size 9.1mm and y size 2mm. The location of the first microstrip is (0, 1.25, 0). Second microstrip part also consists of x size 2.2mm and y size 0.5mm. The location of the second microstrip is (9.1, 2, 0). Third microstrip part consists of x size 0.5mm and y size - 1.2mm. The location of the third microstrip is (10.8, 1.3, 0). The structure of designed microstrip antenna is shown in fig 1. Antenna second part consists of directors. Antenna second part is designed with 11 directors to get high directivity in one direction. Length of the director is 1.3mm and width of the director is 0.5mm. Each director is separated by a distance of 0.7mm. The antenna and microstrip are a separated by a distance of 0.75mm. The y coordinate for all 11 directors is same. All directors are assigned with variable w =1.6 mm. The directors as shown in Fig 1.

TABLE I. DIRECTORS 1 TRANSMISSIONLINE POSITION, WIDTH AND LENGH VALUES

S.No	Directors	X size	Y size	Location
1	D101	1.3	0.5	(12.05,1.6,0)
2	D102	1.3	0.5	(13.25,1.6,0)
3	D103	1.3	0.5	(14.45,1.6,0)
4	D104	1.3	0.5	(15.65,1.6,0)
5	D105	1.3	0.5	(16.85,1.6,0)

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6	D106	1.3	0.5	(18.05,1.6,0)
7	D107	1.3	0.5	(19.25,1.6,0)
8	D108	1.3	0.5	(20.45,1.6,0)
9	D109	1.3	0.5	(21.65,1.6,0)
10	D110	1.3	0.5	(22.85,1.6,0)
11	D111	1.3	0.5	(22.9,1.6,0)

B. Second antenna design

The second antenna location is different but dimensions are same as like first antenna. First antenna and second antenna are separated by a distance of 2.5 mm. For all eleven directors the y location is same. Each director is assigned with Variable $w1 = 6.1\text{mm}$.

TABLE II. DIRECTORS 2 TRANSMISSIONLINE POSITION, WIDTH AND LENGH VALUES

S.No.	Directors	X size	Y size	Location
1	D201	1.3	0.5	(12.05,6.1,0)
2	D202	1.3	0.5	(13.25,6.1,0)
3	D203	1.3	0.5	(14.45,6.1,0)
4	D204	1.3	0.5	(15.65,6.1,0)
5	D205	1.3	0.5	(16.85,6.1,0)
6	D206	1.3	0.5	(18.05,6.1,0)
7	D207	1.3	0.5	(19.25,6.1,0)
8	D208	1.3	0.5	(20.45,6.1,0)
9	D209	1.3	0.5	(21.65,6.1,0)
10	D210	1.3	0.5	(22.85,6.1,0)
11	D211	1.3	0.5	(22.9,6.1,0)

C. Design of ports, substrate, ground plane, and radiation box

The port of antenna is situated to left surface of microstrip beginning. It is to receive signal waves a wave port is selected. The location of the first port is (0, 1.25, 0). The dimensions of the port for y size are 2.5 and the z size is -0.8. The location of the port in second antenna is (0, 5.75, 0). The dimensions for the port y size are 2.5 and the z size is -0.8. shown in Fig. 1. The substrate was designed under the two antennas. The material of the substrate is Rogers Rt/duroid 5880 (tm). It is the best option to accommodate with patient's cloth and offer docility. The location of the substrate is (0, 0.25, 0). Substrate dimensions are x size-27.3, y size- 8.5, and z size -0.8. The ground is created below the lower surface of the substrate and microstrip of antenna. The radiation pattern of the antenna to expand due to discontinuities of transmission line [5]. The location of the ground plane is (0, 0.25, -and 0.8). The dimensions for the ground plane is for x size 10.8 and y size is 8.5. The whole antenna is covered with the radiation box. It allows waves to expand infinitely far into space. It has shown in the Fig. 2

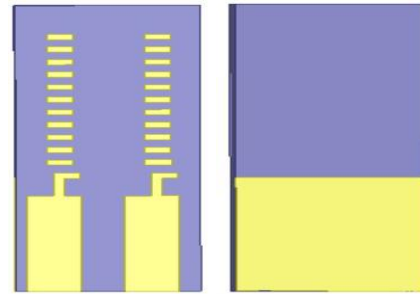


Fig. 1 Top and Bottom view of the designed antenna

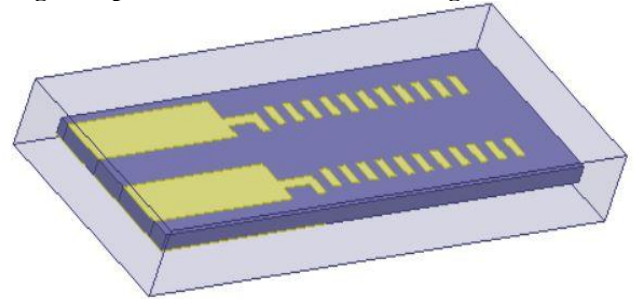


Fig. 2 Closed surface view of the proposed antenna

III. SIMULATION TOOL

The HFSS is mainly used to analyze the electromagnetic radiation from objects. Mainly engineers will use this HFSS for accurate design and high frequency antenna. High frequency structure simulator, zoitan cendes and his students developed. Hfss is a 3-dimensional software. HFSS software helps to rotate our antenna in 3d form. With help of HFSS we can we calculate gain and directivity. E field and H fields can also be calculated in HFSS software. We can design the antenna with high bandwidth and it with very small size. Complex structures can also be designed. Different materials can assign to our designed substrate. Hfss simulator helps to design patch antenna, triangular microstrip antenna, yagi uda antenna and so many different antennas.

IV. SIMULATED RESULTS

S11 and s22 are the simulated reflection coefficients in better performance in the frequency range of 56.3 – 64.9 GHz range. The oscillating frequency of the antenna is around 60 GHZ. HFSS software used for numerical modelling. It has presented in the Fig. 3. VSWR characteristics is displayed in the fig. 4.

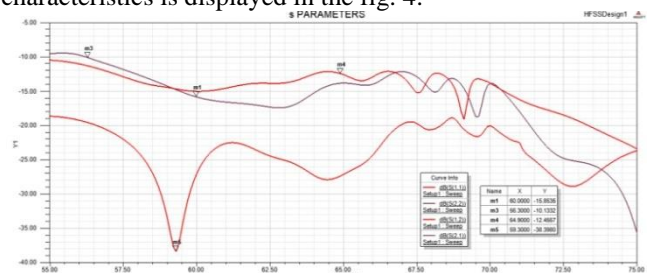


Fig. 3. S parameter characteristics of the designed antenna



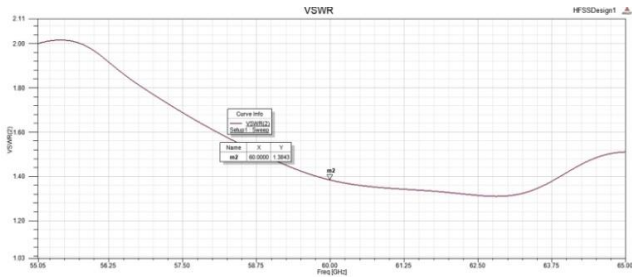


Fig. 4. VSWR characteristics of the proposed antenna

The two modelled microstrip antennas has run at 60GHz and the mutual coupling is remained lower than -15dB shown in the figure 3. It says that 97.9% of power is passed to the radiating element and remaining 3.2% Of is reflected back to source due to mismatching conditions.[16] Radiation pattern refer to, from the antenna the radio waves are the strength of the directional dependence or other source.

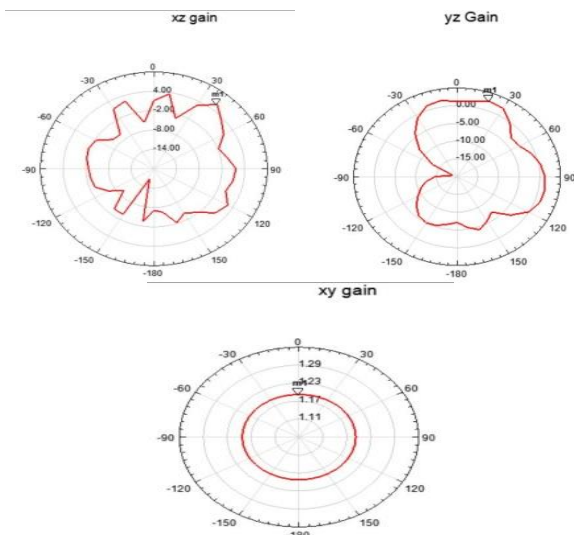


Fig. 5. XZ, YZ, XY gain of the proposed antenna

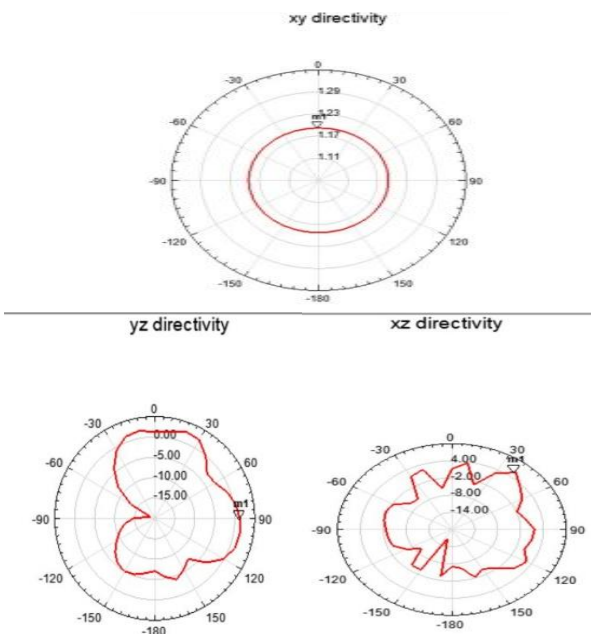


Fig. 6. XY, YZ, XZ directivity of the proposed antenna

It has two formats. One is rectangular format (2D) and the one is polar format (3D). In this XZ and YZ radiation pattern phi is '0deg' and '90deg' respectively. It have presented in the Fig. 5. In this XY radiation pattern, theta is '0deg', phi is '0-360 deg'. It has presented in the figure 5. The simulated results of directivity and gain of fabric antenna is displayed in the table 3. Designed current distribution of the antenna is shown in the figure 7.

TABLE 3. SIMULATED GAIN AND DIRECTIVITY OF THE DESIGNED ANTENNA

Operating Frequency	Direction	Φ	θ	Gain (dB)	Directivity (dB)
60GHz	XY	All	0	1.1608	1.7608
	XZ	0	All	6.042	6.042
	YZ	90	All	2.36	2.36

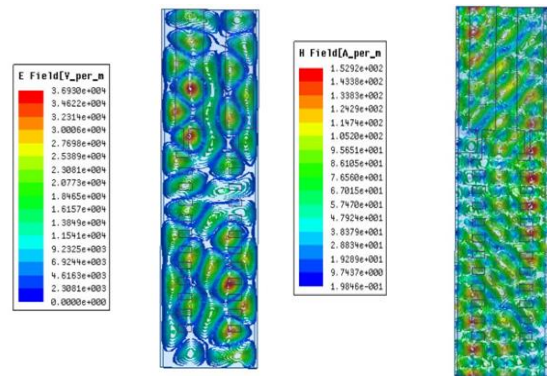


Fig. 7. Current distribution of the proposed fabric antenna

TABLE 4. SIMULATED PARAMETERS OF THE DESIGNED ANTENNA

S.No.	Antenna parameter	Simulated Results
1.	Frequency	60GHz
2.	Gain	6.024dB
3.	Band width	8.6GHz
4.	Directivity	6.042dB
5.	Return Loss (S11)	-16.02dB
6.	VSWR	1.38
7.	Incident power	1W
8.	Radiated power	0.96648W
9.	Reflected power	0.03352W
10.	LHCP	10.396V
11.	RHCP	14.25V

TABLE 5. COMPARISON OF DESIGNED ANTENNA PARAMETER WITH OTHER LITERATURES WORKS

Reference No.	Resonance Frequency (GHz)	Coverage Area (mm)	Return Loss (dB)	Gain (dB)	Bandwidth (MHz)	VSWR
[26]	2.45	90x90x1.6	-10.52	5.90	420	1.8
[22]	2.40	90x100x0.8	-22.13	3.05	500	1.1
[23]	2.40	30x37 x1.6	-15.28	5.20	420	1.4
[24]	5.3	30x30 x1.6	-14.28	5.10	590	1.3
[25]	5.8	40.15x40.15	-15.0	0	370	1.22
[19]	5.8	75x42 x0.8	-14.24	3.12	230	1.32
[20]	5.8	39.80x39.80	-15.36	6.50	709	1.14
[21]	5.8	41x40 x1.6	-14.36	5.90	940	1.32
[18]	5.8	40x40 x1.6	1.1	3.05	563	1.1
[27]	5.5	46x36 x0.8	-13	2.36	124	1.03
Proposed	60	27.3x8.5x0.8	-16.02	6.34	8600	1.38

V. CONCLUSION

A millimeter wave fabric antenna is designed and simulated for on body communications in the frequency range of 56.3–64.9 GHz by using millimeter wave technology. It gives the bandwidth of 8.6 GHz in the operating frequency band. This antenna is solid, easy, soft and good promising results for on high data rate communications. The proposed antenna provides more compact and higher bandwidth than other existing antennas. It has displayed in the table 5. Mutual coupling has a minor interaction on the reflection factor and antenna gain. Especially the proposed antenna is more compact than other existing antennas and provides better performance for large data rate communications and on body communications.

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