Button Antenna for Wireless Body Area Network Applications

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Abstract

This document designs and studies a button-shaped patch antenna for four different patch shapes. The coaxial feed is used for high impedance matching and better radiation patterns. The button antenna is designed with Fr4 epoxy substrate material. The Model 1 button antenna resonates at a frequency of 6.2174 GHz, has a reflection coefficient of 20.1970 dB, provides a bandwidth of 261 MHz (6.1307 GHz - 6.3920 GHz), and the maximum observed gain is 5.023dBi. The Model 2 button antenna resonates at 6.4523 GHz with a reflection coefficient of 35 dB and provides a bandwidth of 120 MHz (6.211 GHz - 6.3317 GHz) and the maximum observed gain is 4.7689dBi. The model 3 button antennas resonates at a frequency of 6.4523 GHz, has a reflection coefficient of 49 dB, and provides a bandwidth of 120 MHz (6.2111 GHz - 6.3317 GHz) and a maximum observed gain of 4.7925dBi. The Model 4 button antenna resonates at 5.8844 GHz frequency respectively with a reflection coefficient of -26.5 dB and offers the Bandwidth of 226 MHz (5.7487 GHz – 5.9749 GHz) and the maximum gain observed as 4.7957dBi. The compact design proves the antenna suitable for WBAN applications.

Keywords: Coaxial feed; Fr4 Epoxy; Wearable antennas; WBAN.

1. Main Test

In modern technology, wireless communication offers many possibilities to share information with each other at any time. Wireless Body Area Network (WBAN) is becoming a special application of this ubiquitous technology. A wearable antenna is a type of antenna that is designed to function when it is worn. Due to the high demand for civil and military portable electronic systems, wearable antennas are receiving increasing attention from researchers and engineers. [1]–[4]. The two main challenges of designing this type of antennas are the proximity to the human body and the size must be as small as possible [5], [6]. In some cases, the designed antenna must communicate with the off-body devices installed nearby [7]. These wearable antennas must have a flexible design together with textile materials, and the flat structure is suitable for the clothing itself [8]. When designing such an antenna, we must pay attention to the various characteristics of the materials used and their impact on the performance of the antenna [9]. Compared with other effects, this loss is more prominent, and because the human body is in the near-field area of the antenna [10], [11], it has a strong influence, and the frequent changes of S11 affect the efficiency of the antenna. Due to the unidirectional radiation pattern of this proposed antenna, human body will not suffer as radiation can keep to the outside [12].More information about antennas including an overview of antenna specific terms is given in [13].

The antenna design is based on different patches. The physical characteristics possessed by this antenna are low weight, thin substrate thickness. These wearable antennas must have flexible design and fabric elements, and the planetary structure is consistent with the garment itself [8]. When designing such an antenna we should focus on the various characteristics of the materials used and their effect on the operation of the antenna [9]. Compared to other results such losses are popular and have a strong effect on the human body in the vicinity of the antenna field [10], [11], which affects the efficiency of the antenna due to frequent changes in S_{11}.

2. Illustrations

Before designing the antenna, a band of frequency is chosen for better outcomes [14]. The four simulated models of the button antenna are shown in fig. 1,2,3,4. The button antenna is designed with FR4 epoxy, the dielectric constant (εr) is 1.6 and the loss tangent (δ) is 0.02-0.03. The four proposed patches are designed to operate at frequencies 6.21GHz, 6.45GHz, 6.452GHz and 5.88GHz. The radius of the substrate of all the four models is constant i.e. 13mm and the patch radius varies in each model. The circular-shaped patch with a circular slot is designed to resonate in the required communication frequency band. The optimized design parameters of the button antenna are tabulated in table 1, 2, 3, 4 and 5. The simulation of the button antennas is done by using HFSS (high frequency structure simulator) software [15].

2.1 **Model-1 button antenna:**

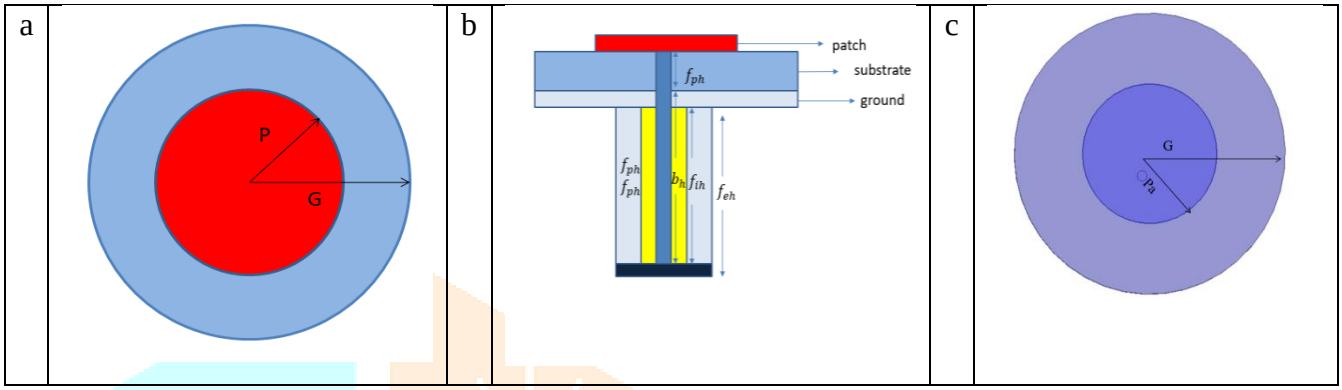


Fig. 1.Geometry of Button Antenna (Model 1) (a) Representation of top view of model-1 button antenna; (b) Representation of side view of model-1 button antenna; (c) Simulated design of model-1 button antenna..

Table 1. Design parameters of button antenna.

Parameter	Value(cm)
Ground & Substrate Radius	1.3
Patch Radius	0.645
Dielectric height	0.16

Table 2. Measurements

Material	Parameter	Value(cm)
PEC	Feed external radius (Fe)	0.159
PEC	Feed internal radius (Fi)	0.047
PEC	Feed patch radius (Fp)	0.047
PEC	Bindage radius (B)	0.12
-	Port radius (P)	0.159

Table 3 Measurements

Parameter	Value(cm)
f_{eh}	0.9
f_{ih}	0.9
b_h	0.9
f_{ph}	0.16

2.2 Model-2 button antenna:

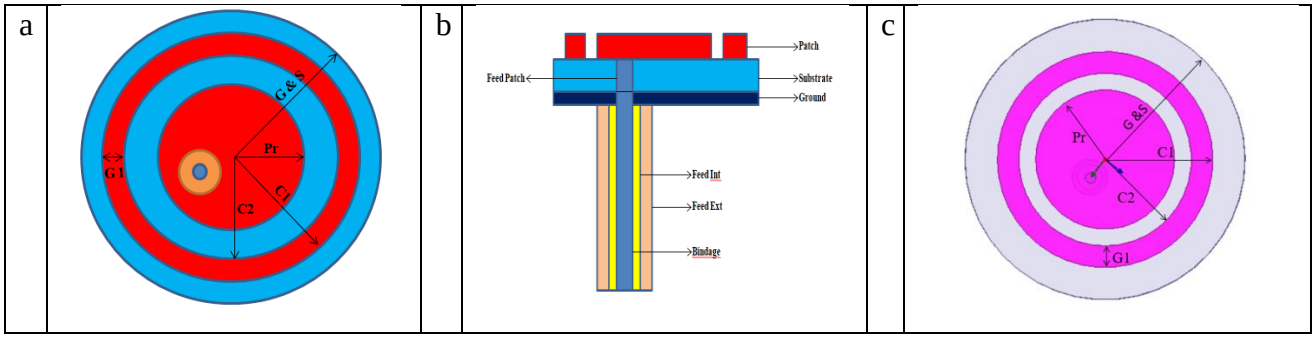


Fig.2. Geometry of Button Antenna (Model 2) (a) Representation of top view of model-2 button antenna; (b) Representation of side view of model- 2 button antenna; (c) Simulated design of model-2 button antenna.

Table 4 Design parameters of button antenna

Parameter	Value(cm)
G	1.3
S	1.3
C_1	1
C_2	0.8
P_r	0.645
G_1	0.2

2.3 Model-3 button antenna:

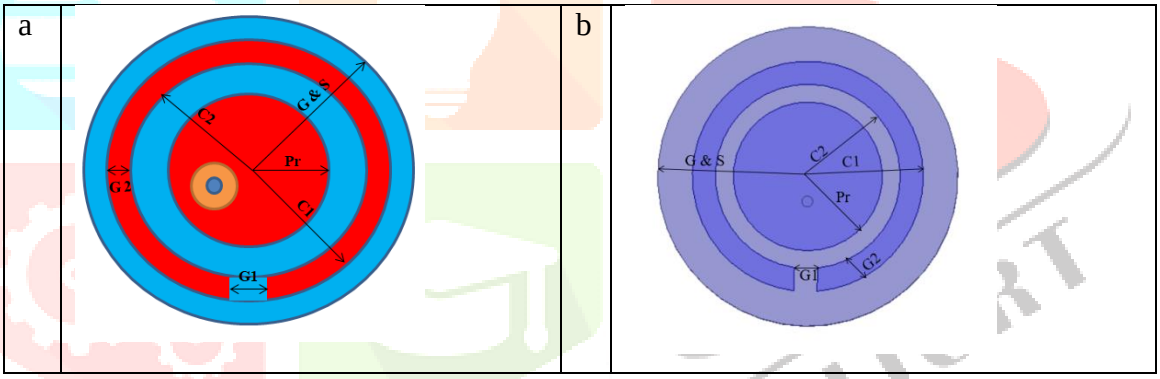


Fig.3.Geometry of Button Antenna (Model 3) (a) Representation of top view of model-3 button antenna; (b) Simulated design of model-3 button antenna.

Table. 5 Design parameters of button antenna

Parameter	Value(cm)
G	1.3
S	1.3
C_1	1
C_2	0.8
P_r	0.645
G_1	0.3
G_2	0.2

2.4 2.4Model-4 button antenna:

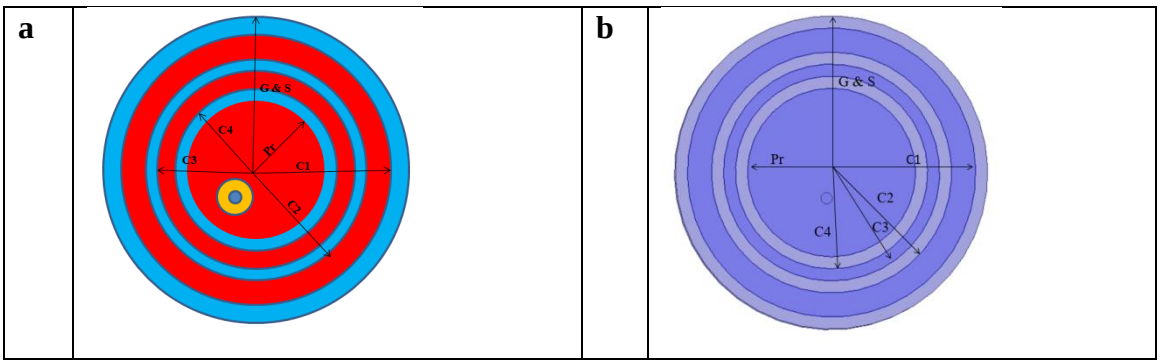


Fig.4.Geometry of Button Antenna (Model 4) (a) Representation of top view of model-4 button antenna; (b) Simulated design of model-4 button antenna.

Table. 6 Design parameters of button antenna

Parameter	Value(cm)
C_1	1.2
C_2	1
C_3	0.8
C_4	0.7
P_r	0.645
G	1.3
S	1.3

3. Results and Discussion

The reflection coefficient response (S_{11}) of the simulated button antennas is shown in figures 5,6,7,8. It can be seen from the figures that the four operating frequencies 6.2174 GHz, 6.4523GHz, 6.45GHz and 5.8844GHz are resonated with -20.1970dB, -35dB, -49dB and -26.5dB reflection coefficients and a bandwidths of 261 MHz (6.1307 GHz - 6.3920 GHz),120MHz(6.211 GHz– 6.3317 GHz), 120MHz(6.211 GHz– 6.3317 GHz) and 226 MHz(5.7487GHz– 5.9749 GHz)respectively.

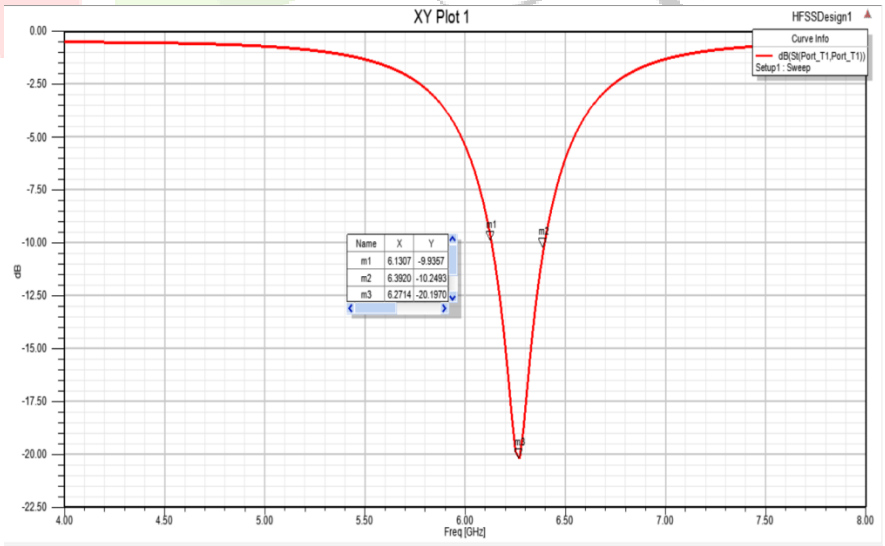


Fig. 5. S11 of model-1 button antenna at -20.197dB

The reflection coefficient response (S_{11}) of the simulated model-1 button antenna is shown in 'figure 5'. From the 'figure 5' the operating frequency 6.2174 GHz, is resonated with -20.197 dB, reflection coefficients and a bandwidths of 261 MHz (6.13 GHz -6.39 GHz).

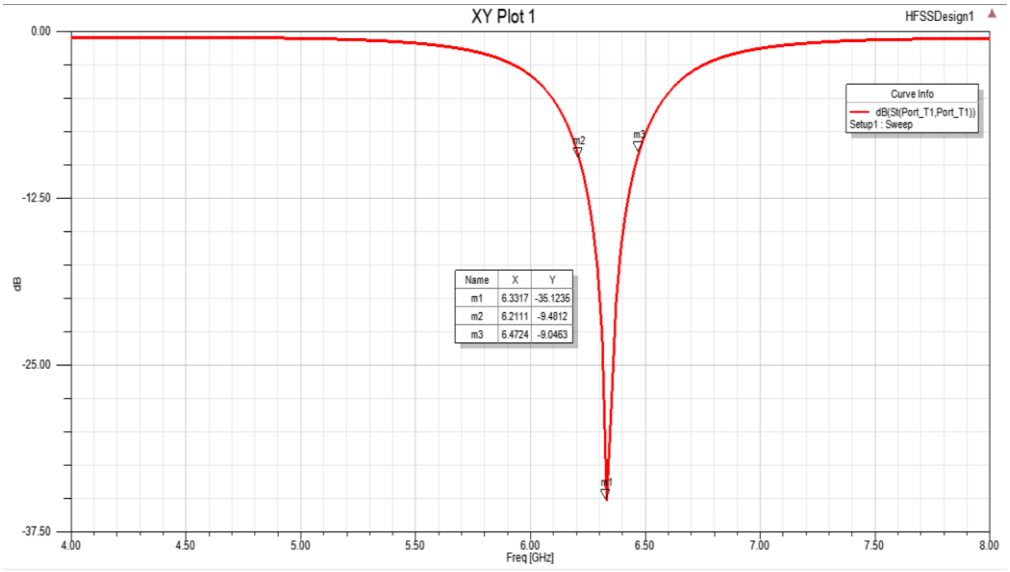


Fig .6. S11 of model-2 button antenna at -35dB

The reflection coefficient response (S11) of the simulated model-1 button antenna is shown in 'figure 6'. From the 'figure 6' the operating frequency 6.4523 GHz, is resonated with -35 dB, reflection coefficients and a bandwidths of 120MHz (6.211 GHz – 6.3317 GHz).

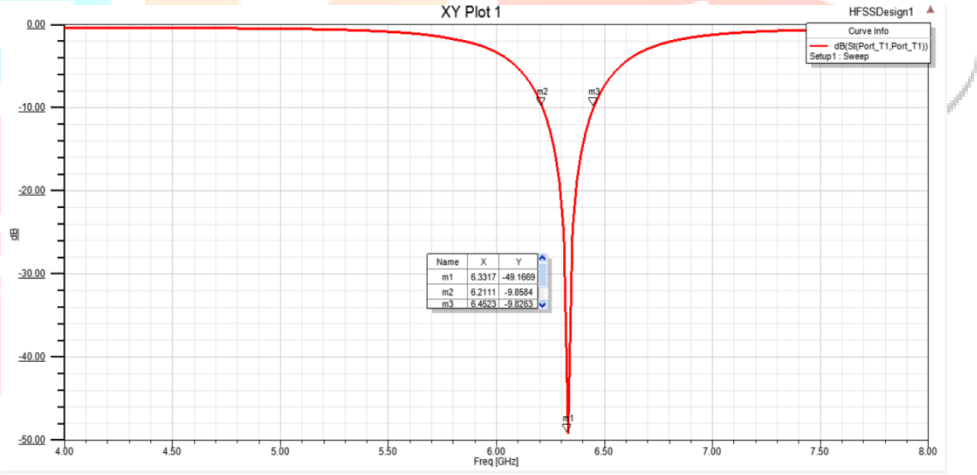


Fig. 7. S11 of model-3 button antenna at -49dB

The reflection coefficient response (S11) of the simulated model-1 button antenna is shown in 'figure 7'. From the 'figure 7' the operating frequency 6.4523 GHz, is resonated with -49 dB, reflection coefficients and a bandwidths of 120MHz(6.211 GHz – 6.3317 GHz).

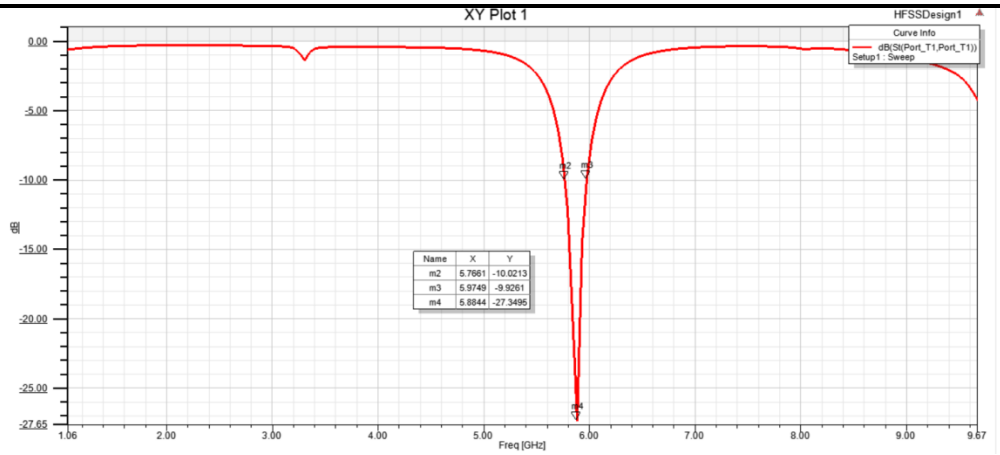
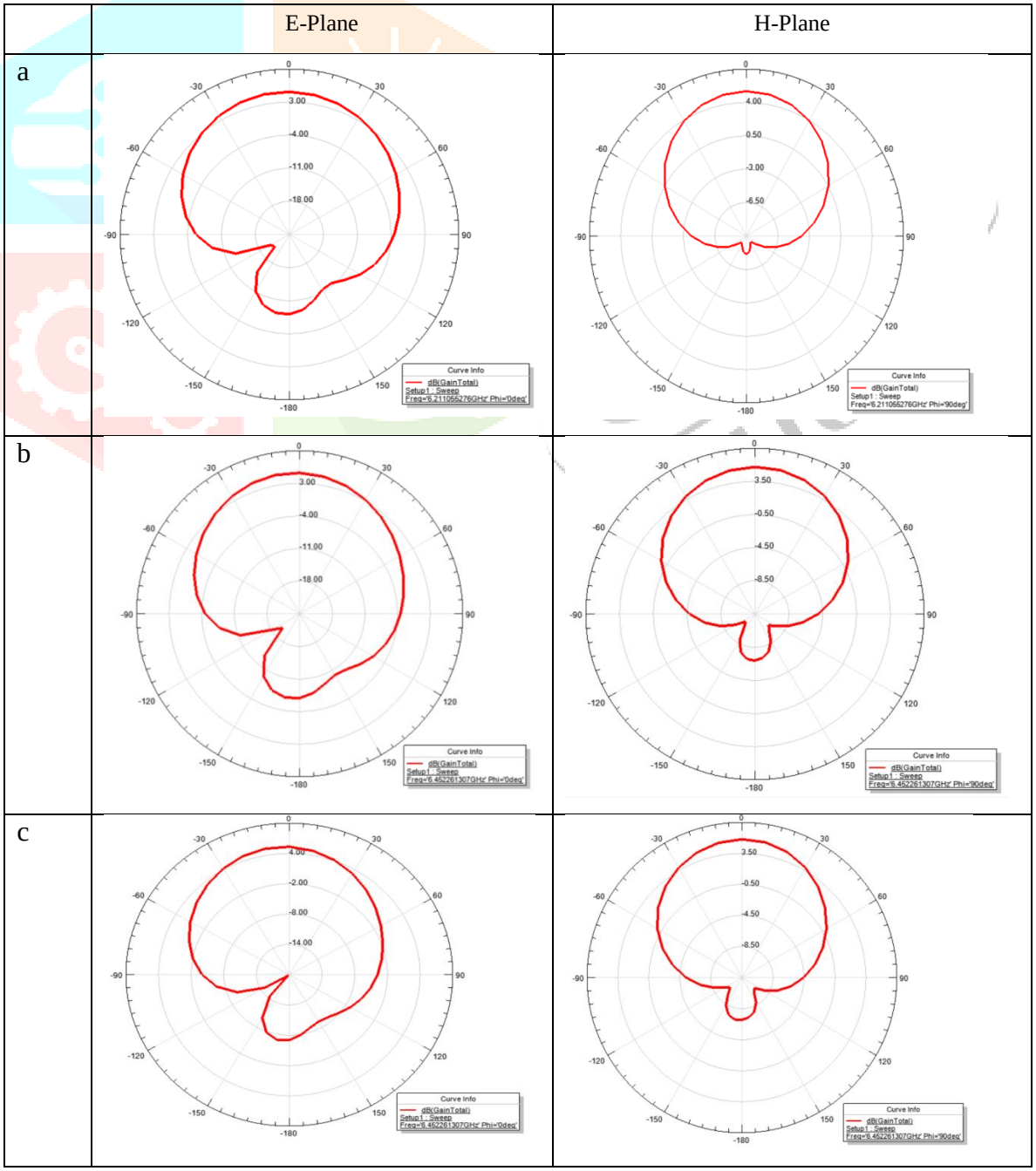


Fig. 8. S11 of model-4 button antenna at -26.5dB

The reflection coefficient response (S11) of the simulated model-1 button antenna is shown in 'figure 8'. From the 'figure 8' the operating frequency 5.8844 GHz, is resonated with -26.5 dB, reflection coefficients and a bandwidths of 226MHz (5.7487 GHz – 5.9749 GHz).



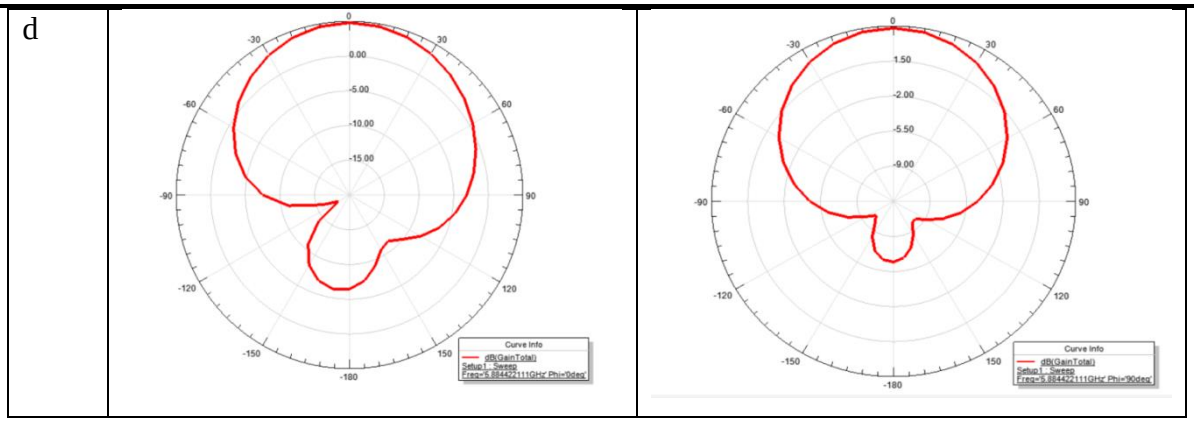


Fig.9 E-field and H-field radiation patterns of button antenna (a)6.2174 GHz, (b)6.4523 GHz, (c)6.4523 GHz, (d)5.8844 GHz

The simulated and measured E-Field and H- Field radiation patterns of the geometry of proposed button antenna at 6.2174GHz as shown in Fig.9(a). The E and H Field obtained having $\Theta=0^0$ and $\Theta=90^0$. The simulated and measured E-Field and H- Field radiation patterns of the geometry of proposed button antenna at 6.4523GHz as shown in Fig. 9(b). The E and H Field obtained having $\Theta=0^0$ and $\Theta=90^0$. The simulated and measured E-Field and H- Field radiation patterns of the geometry of proposed button antenna at 6.4523z as shown in Fig. 9(c). The E and H Field obtained having $\Theta=0^0$ and $\Theta=90^0$.The simulated and measured E-Field and H- Field radiation patterns of the geometry of proposed button antenna at 5.8844z as shown in Fig. 9(d). The E and H Field obtained having $\Theta=0^0$ and $\Theta=90^0$.

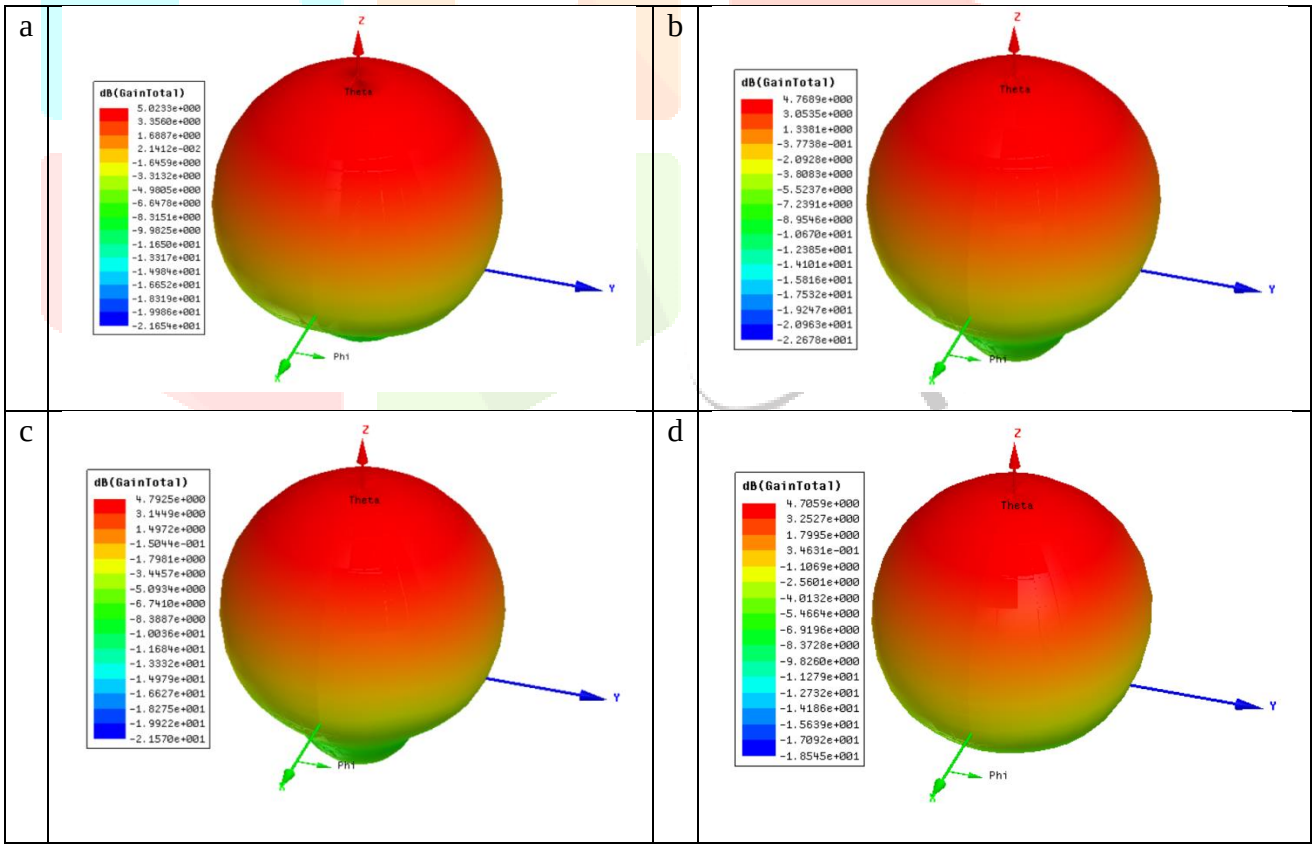


Fig.10 3-D Gain of button antenna at resonant frequencies (a)6.2174 GHz, (b)6.4523 GHz, (c)6.4523 GHz, (d)5.8844 GHz.

The 3D-gain plots of the model-1 button antenna are shown in figure 10(a). The maximum gain of 5.023dBi is observed at 6.2174 GHz frequencies. The gain is observed low at 1GHz frequency. The 3D-gain plot of the model-2 button antenna is shown in figure 10(b). The maximum gain of 4.7689 dib, is observed at 6.4523 GHz frequencies. The gain is observed low at 1GHz frequency. The 3D-gain plot of the model-3 button antenna is shown in figure 10(c). The maximum gain of 4.7925

dBi, is observed at 6.4523 GHz frequencies. The gain is observed low at 1GHz frequency. The 3D-gain plot of the model-4 button antenna is shown in figure 10(d). The maximum gain of 4.7957 dBi, is observed at 5.8844 GHz frequencies. The gain is observed low at 1GHz frequency.

Table.7. Simulation measurements for button antenna:

Model	Operating frequency (GHz)	Reflection coefficient (dB)	Bandwidth (MHz)
1	6.2174	-20.1970	261MHz (6.1307 GHz – 6.3920 GHz)
2	6.4523	-35	120MHz (6.211 GHz – 6.3317 GHz)
3	6.4523	-49	120MHz (6.2111 GHz – 6.3317 GHz)
4	5.8844	-26.5	226MHz (5.7487 GHz – 5.9749 GHz)

4. Conclusion

Different models of button antenna are designed and analysed with different patch shapes. The button antenna is designed using Fr-4 Epoxy as a substrate material. The Dielectric constant (Єr) is equal to 4.4 and Height of substrate is equal to 1.6mm is considered as the proposed antenna. The model-1 button antenna resonates at 6.2174 GHz frequency respectively with a 11 of -20.1970 dB and offers a Bandwidth of 261 MHz (6.1307 GHz – 6.3920 GHz) and the maximum gain observed as 5.023 dBi. The model-2 button antenna resonates at 6.4523 GHz frequency respectively with a 11 of -35 dB and offers a Bandwidth of 120 MHz (6.211 GHz – 6.3317 GHz) and the maximum gain observed as 4.7689 dBi. The model-3 button antenna resonates at 6.4523 GHz frequency respectively with a 11 of -49 dB and offers a Bandwidth of 120 MHz (6.2111 GHz – 6.3317 GHz) and the maximum gain observed as 4.7925 dBi. The model-4 button antenna resonates at 5.8844 GHz frequency respectively with a 11 of -26.5 dB and offers a Bandwidth of 226 MHz (5.7487 GHz – 5.9749 GHz) and the maximum gain observed as 4.7957 dBi. The performance of the antenna is good. The HFSS v 15.0 software is used for the design and simulation of the proposed antenna.

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