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A Bandwidth Enhanced mmwave Radiator for X-band Applications

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Abstract- This paper introduces a pioneering method to boost the bandwidth of a millimeter-wave (mmWave) radiator tailored for X-band applications. The designed radiator aims for a broader operating bandwidth compared to conventional solutions. The antenna is the central component of all devices used in the communication domain for signal propagation. The intended antenna radiator presented in this work is built with a depth of 1.6 mm over a FR4 substrate. The generic design equations are used to create the microstrip patch antenna initiator. The planned patch antenna's bandwidth is increased by cutting a slot shape within the patch. Furthermore, Defective Ground Structures (DGS) are used in the ground region of the patch antenna to boost bandwidth. A microstrip feed model is offered for excitation of the suggested antenna. High Frequency Structure Simulator (HFSS) is used for electromagnetic simulation of the desired antenna. The suggested antenna is built on a FR4 substrate board and carefully measured with a Vector Network Analyzer (VNA). A wide band spectrum with a maximum return loss value of -19.45 dB is generated and employed in many applications that exist in the X band, which runs from 8 GHz to 12 GHz. The measured return loss values are in the 5G spectrum and are closely matched with the HFSS software simulated values of the proposed antenna which authenticates the fabricated antenna for X band applications. The proposed radiator is designed to achieve a broader operating bandwidth compared to conventional counterparts. To increase bandwidth and return loss values even more, the defective ground constructions will be commenced in the ground plane of the intended antenna. The paper discusses the design process and simulation results, showcasing substantial improvement in bandwidth and specific gain characteristics. This research significantly advances the capabilities of mmWave radiators, particularly within the realm of X-band applications.

Keywords: Defective Ground Structures, Front-to-back ratio, mmwave, Microstrip line feed

1. INTRODUCTION

Every year, the need for communication devices grows at an exponential rate. As the generation of wireless spectrum increases the number of devices in the spectrum is also widely increasing. The addition of communication devices requires much space to accommodate. To overcome this concern, thinner communication devices are inevitable. The data rate increases, and the latency time decreases while moving from the lower mobile communication generations to fifth generation. A wide band spectrum is the necessity of 5G as the data rates are higher [1]. The up gradation of the mobile spectrum to 5G will raise the data traffic and throughput. The numbers of devices connected in the 5G communication spectrum are also on rise than the previous generations of the mobile communications. The radiated frequencies are contained by the mmwave range of 6 GHz to 300 GHz frequency spectrum are suitable for the fifth generation (5G) mobile applications. Since 3G and 4G systems are available globally those systems must be integrated within the 5G network for smooth transition of the available communication devices to 5G which in turn increases the devices connected in the 5G frequency spectrum.

The 5G spectrum lies in the mmwave range which facilitates 5G as an integral component of mmwave spectrum. The wave

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length of the mmwave spectra is of cm to mm range which can make the communication devices much thinner. The wide bandwidth available in the mm wave spectrum will overcome the spectrum shortage available until the fourth-generation mobile communication [2]. Specially modified antennas and communication devices using latest technologies are much needed for the smooth adaptation in to the 5G communication domain. 5G system requires a more energy efficient and less delay time for maximizing the quality of its coverage. The spectral efficiency and energy efficiency of 5G networks must be more than of the previous generation communication networks to make a green communication domain [3].

The front end of a 5G communication network requires transceivers. Transceivers which are the integrated form of the transmitter and receiver are used to attain the communication procedure thinner [4]. Transceivers have antenna as an integral component which forms the basis of communication. Antenna is the basic component available in both transmitter and receiver that is needed for transmission and reception of signals. The size of the antenna for any communication domain depends on its frequency of operation. If the frequency of operation of the available communication devices is very high value, the size of the antenna becomes very undersized and the size of the antenna becomes bigger if the frequency of operation is low. The multiband operation of patch antenna shall be used in different wireless applications [5]. The mmwave domain accommodates very high frequencies in its spectra which makes the wavelength shorter and directivity higher. The shorter wavelength feature of the mmwave spectrum enables the decline in size of the communication antenna [6]. The reduction in size of the antenna due to the high frequency nature of the available mmwave band enhances the compactness of the communication devices.

Improving coverage and optimization of bandwidth are the key highlights of 5G communication. The popular variety of antenna named patch antenna can be used for 5G antenna design, but it has a very narrow bandwidth radiation. Microstrip patch antenna is the most popular variety of antennas with certain limitations in using in real time applications. The patch antenna's narrow band characteristic limits its use in multiband and wide band applications. A wideband radiation is needed for 5G antenna as the communication channels in the fifth-generation communication requires high bandwidth generally [7]. Because most communication applications nowadays require multiband and large bandwidth, the patch antenna and its ground plane can be modified to accommodate the desired radiation properties.

The design of the patch structure determines the operating frequency of a planned patch antenna. Depending on the required radiation, antenna fields can be created in any natural shape and size. By using distortion techniques like defective ground structures (DGS) and defective microstrip structures (DMS), patch antennas' narrowband characteristics can be diminished. You can have little patches etched to your specifications. This is his DMS method, while his DGS method is the engraved piece on the ground plane. The DMS and DGS technologies are both based on the slot antenna idea. To get rid of the broad banding and narrow banding characteristics of microstrip patch antennas, multiple slot configuration dimensions and structures can be incorporated into the patch and ground plane [8].

Directional antennas shall be used in 5G communications to create more directional beams for providing the quality of service to each user. High directive antennas are required in 5G communication to avoid interference with the other available communication networks and devices. The narrow beams generated using the directional antennas are very essential for point-to-point communication [9]. One of the drawbacks of the patch antenna is its narrow band behaviour at the designed resonant frequencies. Encompassing the dielectric substrate with the patch antenna can be done for beam width enhancement. Metallic substrates can be added to the antenna's ground plane, and slot structures can be added to the antenna to reduce its size [10]. To build more compact communication devices, the antenna's length must be reduced.

The frequency channels used in 2G, 3G, and 4G are clogged with available communication devices, making it impossible to hold the data traffic created by those devices. As a result, the Federal Communication Commission (FCC) diagnosed the unused frequencies in the mm wave spectrum and earmarked a portion of the mm wave spectrum for 5G. The high data rate requirement in 5G will be taken care by using different technologies like Multiple Input Multiple Output (MIMO) and other burgeoning technical knowledge. MIMO antennas are used in 5G communications to boost noise reduction and transmission throughput. Regular patch antennas can also be used for this purpose with some structural adjustments. Along with MIMO technology, slot formations are built in the rectangular patch antenna to boost customer service quality. Depending on the size and placement of the feed line, different types of feed lines will produce variable patch antenna behaviour. A wide bandwidth can be achieved by using a simple rectangular patch antenna with microstrip line feed [11].

The self-similar fractal structures available in the nature can be accommodated in the antenna for creating multiband and wide bandwidth characteristics within the same antenna. Many resonant frequencies are created in the antenna due to the modification in the structure. Fractal geometries can be used in the coplanar waveguide (CPW) for better impedance matching and multiband behaviour that can be used in 5G communication [12]. Steerable directional antennas will be utilized in the 5G spectrum to boost wireless network gain and directivity. Radiation losses can be reduced by constructing the antenna in a substrate with reduced thickness and also a high dielectric constant. Array structure of the antenna is created by having a multiple versions of the same antenna in the same substrate. Array antenna concept shall be used for wide area coverage in 5G communication. Combining the antenna array with beam steering technique will increase the gain of the network [13].

Patch antennas require a substrate material, a patch layer on top of the substrate and a ground plane layer at the substrate's foundation. The substrate has a moderate value of loss tangent and generally it is a non-conducting or insulating medium. The patch and ground plane are covered with conducting medium like copper. This arrangement makes the patch antenna looks like a capacitor which has a dielectric material surrounded by the two conduction plates which adds the capacitive value of the antenna. The gaps created by the slots will add up the capacitive values of the antenna. Because the antenna is built on a dielectric substrate, resistive values are also included. Microstrip patch antenna is counterpart to a RLC network. The capacitive and inductive values of the structure combine to contribute to the fundamental resonant frequency. Creating slots in patch or ground plane will alter the values of resistor, capacitor and inductor that are encompassed within the patch antenna and provide a wide bandwidth. The presence of the slots in the patch, ground plane, or both will generate the required radiation. To change the patch antenna's traditional tight band radiation behaviour into a wide band radiation behaviour that can be used in 5G communication, various DMS and DGS forms must be used in the patch and ground plane of the antenna [14].

Sierpinski carpet antenna structure is modified and the partial ground plane structures are implemented and the designed antenna multiband behaviour is analyzed in [15]. The designed patch antenna dimensions shall be optimized for the better performance requirements of the wireless applications [16]. Patch antenna shall be used in wireless and medical diagnosis of ailments [17]. The partial ground plane constructions will be employed to modify the antenna's radiation pattern. To improve performance, the shapes of the partial ground plane structure are adjusted with different shapes [18]. X band of frequencies is used for many applications like radio navigation, radio astronomy, satellite communication, etc.

The work in this paper is discussed as follows: The antenna equations that is used for the design along with the detailed discussion is worked out in the next section, the strategy of designing the microstrip patch antenna initiator using HFSS software is discussed as a subsection, the effect of etching square slot structures in the patch antenna is discussed as a subsection and the effect of DGS in ground plane is discussed as another subsection. The predicted and constructed antennas' return loss values are compared in the pre-final part, and the work's findings and outputs are summarized.. The final section of the manuscript concludes the work.

2. PATCH ANTENNA INITIATOR DESIGN

A FR4 substrate with 16 mm X 22 mm size is picked for creating the basic design of antenna. Based on the proposed equations 1 - 6, a microstrip square patch initiator of size 12 mm X 12 mm is produced across the substrate. The size of the gadget is determined by the antenna's dimensions. The antenna should be made conformal so that it can be an adjunct to the other components of the communication devices within it. The ε_{reff} value of the substrate is computed using the subsequent equation,

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (1)$$

Whereas,

ε_{reff} depicts the Effective dielectric constant

ε_r depicts the Dielectric constant of substrate

h depicts the Height of dielectric substrate

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W depicts the Width of the patch

$$\Delta L = 0.412 \frac{(\varepsilon_{reff} \pm 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.3)\left(\frac{W}{h} + 0.8\right)} \quad (2)$$

The effective length of the microstrip patch L_{eff} in the antenna will be,

$$L_{eff} = L + 2\Delta L \quad (3)$$

For any resonance frequency f_0, the L_{eff} value of the microstrip patch antenna is given by

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (4)$$

Resonance frequency for any TM_{mn} mode of the patch antenna will be given by the following equation,

$$f_0 = \frac{c}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{\frac{1}{2}} \quad (5)$$

Where m and n are the operating modes over the length of designed patch L and width of designed patch W,

The Width W of a patch antenna for an effective radiation is worked out using the following equation,

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon r + 1)}{2}}} \quad (6)$$

Without proper impedance matching in the antenna circuit, supplementary circuits are required for matching the proper impedance. The patch antenna is generally designed to match 50 ohms impedance, but the outer environment will have an impedance value of 377 ohms. The proper impedance matching is needed to transfer the maximum radiated power to the environment from the antenna or receiving the maximum radiated power from the environment to the antenna. When the impedance matching is not proper standing waves are created which affects the efficiency of the designed antenna. Microstrip line feed is used in microstrip patch antenna initiator. This feed has very good, matched impedance capabilities and provides compactness to the communication devices. A microstrip feed line of size 3 mm X 8 mm is designed to feed the excitation in the antenna.

3. PROPOSED ANTENNA STRUCTURE

5G communication has wide bandwidth separate channels that are designated for transferring the uplink and downlink information. The requirement of wide bandwidth channels creates the need of a wide bandwidth spectrum needed for 5G communication. Patch antenna has a narrow band effect in its resonant frequency. The techniques used for inducing the wide bandwidth in a narrow band patch antenna are discussed in the following subdivisions of the chapter.

3.1 PATCH ANTENNA INITIATOR

Figure 1 displays the patch antenna initiator designed by HFSS. The return loss plot of the microstrip patch antenna initiator is shown in Figure 2. The microstrip patch antenna initiator structure radiates in a single narrow band at 9.7 GHz resonant frequency with a generated -20.41 dB as return loss. The bandwidth achieved by radiating the microstrip patch antenna initiator is 800 MHz. The thin narrow band outcome of the initiator shall be varied by inducing slot structures in the patch and ground plane, resulting in a variable modification in the patch antenna's resistance, inductance, and capacitance values. The resonant frequency changes as the comparable RLC network values change.

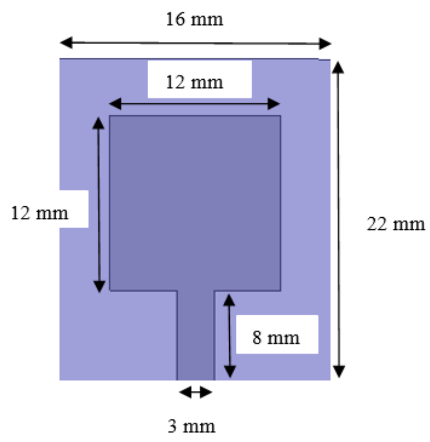

Figure 1 Patch antenna initiator

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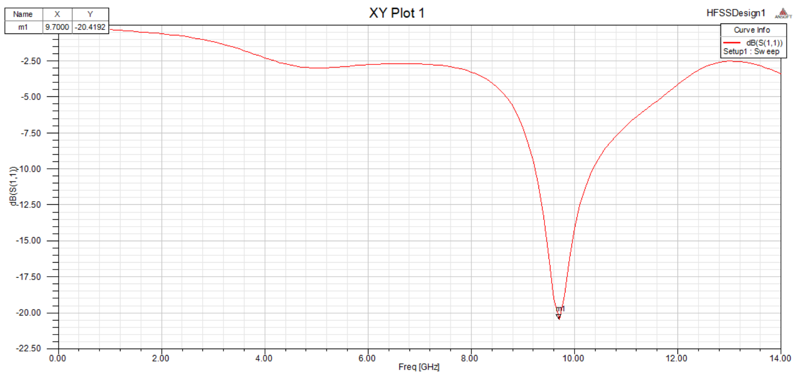


Figure 2 Patch antenna initiator return loss

3.2 SQUARE SLOT STRUCTURES

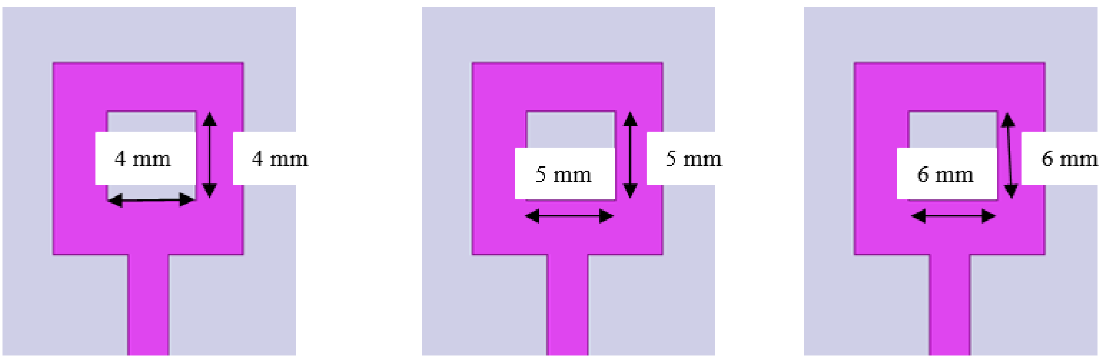
The narrow bandwidth of the microstrip patch initiator needs to be enhanced since a wide bandwidth is essential for 5G applications. Slot antenna is a form of aperture antenna that works on Babinets principle which radiates the excitation given to the antenna. A slot shall be created in any conducting sheets or structures. The shape of slot shall be of any shape that is available in the nature and is chosen based on the required applications. A slot shall be headed in the patch to augment the bandwidth of patch antenna initiator. The created slots will add up to more components to be integrated within the space available for antenna in communication devices. The guided wavelength and the effective dielectric constant values are essential in designing slot in a dielectric substrate. Consider λ_{cutoff} is the cut off wavelength, the guided wavelength (λ_{guided}) of the slot is given by

$$\lambda_{guided} = 1 \Big/ \sqrt{\left(\frac{1}{\lambda_0}\right)^2 - \left(\frac{1}{\lambda_{cutoff}}\right)^2} \quad (7)$$

The slot antenna's effective dielectric constant (ε_{eff}) is calculated as follows:

$$\varepsilon_{eff} = \frac{\varepsilon_{reff} + 1}{2} \quad (8)$$

The square slot in the patch antenna initiator is shown in Figure 3. For comparing the generated results and to discuss the effects of creating the square slots over the patch, the square slot 1 is created with the size of sides as 4 mm, square slot 2 is made with the size of sides as 5 mm and the square slot 3 is formed with the size of sides as 6 mm. Figure 4 shows the return loss values by adding the square slot structures 1, 2 and 3 over the patch.



(a) (b) (c)

Figure 3 (a) Square slot 1 (b) Square slot 2 (c) Square slot 3

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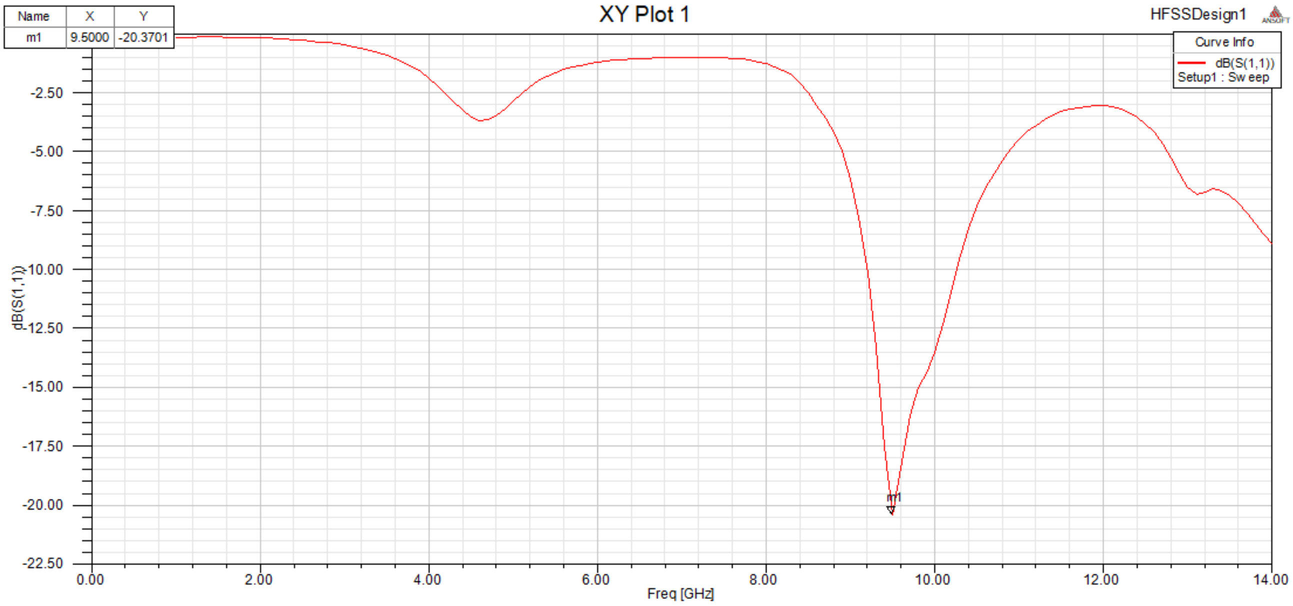
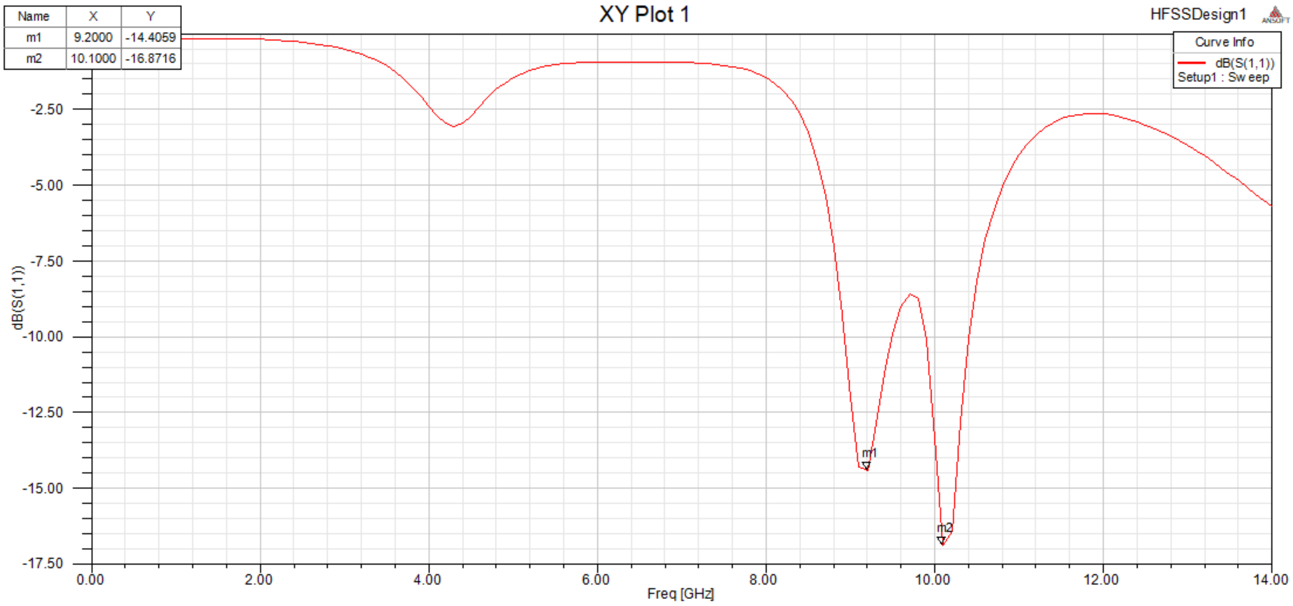


(a)



(b)

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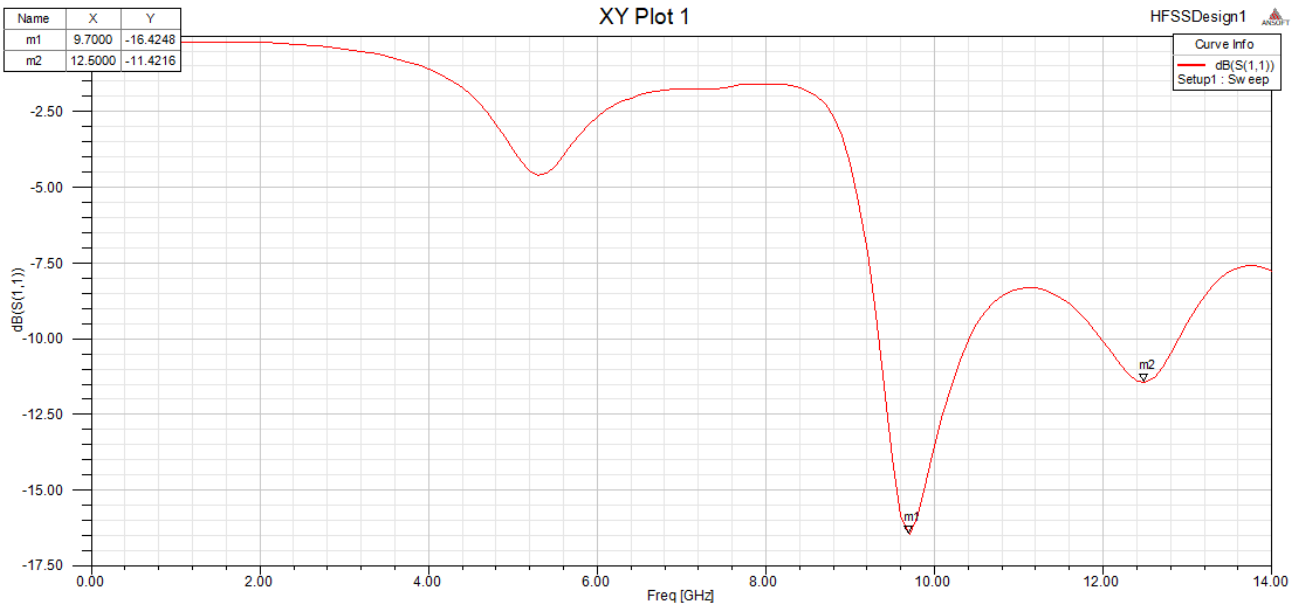

(c)

Figure 4 Return loss plot of (a) Square Slot 1 (b) Square slot 2 (c) Square slot 3

Square slot 1 has its fundamental resonant frequency at 9.5 GHz with -20.37 dB as return loss value and the bandwidth is exerted as 800 MHz that ranges from 9.2 GHz to 10 GHz. The fundamental frequency of the designed structure is slightly shifted as the slot shape is introduced in it. The suggested microstrip patch antenna structure provides two separate resonance frequencies when the side length dimension of the square slot is expanded to 5 mm. Extra resonant frequencies are produced by the same patch initiator due to the multimode properties of the slot antenna. The microstrip patch antenna has a unique resonant frequency of 9.2 GHz with -14.4 dB, as well as a second resonant frequency of 10.1 GHz with -16.87 dB return loss units. The size of the slot structure within the microstrip patch antenna also influences the amount of frequencies produced. The generated first resonant frequency has 500 MHz as bandwidth that starts from 8.9 GHz to 9.4 GHz and the next resonant frequency produces a bandwidth of 600 MHz that initiates from 9.8 GHz till 10.4 GHz. The total bandwidth generated using the square slot 2 is 1.1 GHz. The introduction of the square slot 3 in the microstrip patch antenna structure forms a resonant frequency at 9.7 GHZ with -16.42 dB as the return loss value and the bandwidth is as wide as 1 GHz that ranges from 9.4 GHz to 10.4 GHz. Varying the slots structures dimensions not only varies the number of resonant frequencies but also varies the bandwidth in according with it. The return loss values generated using square slot 2 has wide bandwidth characteristics while comparing with the first and third slot structures.

The comparison of the produced bandwidth that arises due to the etching of the square slots in the microstrip patch antenna along with the created resonant frequencies are tabulated in Table I. Introduction of square slot 1 in the patch antenna initiator creates a bandwidth of 800 MHz and the creation of the next square slot 2 produces the bandwidth of 1.1 GHz. The creation of the square slot 3 in the patch antenna initiator generates a bandwidth of 1 GHz. The creation of square slots 1 and 3 in the patch antenna initiator radiates at one resonant frequency and the creation of square slot 2 radiates at two resonant frequencies. Since the square slot 2 radiates at two different frequencies it is chosen for further bandwidth enhancement. The two different frequencies shall be used as separate channels in mmwave spectrum. The narrow band microstrip patch initiator is converted to multiband and wideband by introducing the square slot structures. The effect of the square slot structures utilized in the designed antenna is analyzed by varying its dimensions. Square slot 2 structure is selected for optimizing it further to improve the radiation characteristics of the antenna. A patch antenna shall be considered as a resonant cavity element with a single narrow band resonant frequency.

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Table I Comparison of square slot structures

Structure	Bandwidth	Number of resonant frequencies
Square slot 1	800 MHz	1
Square slot 2	1.1 GHz	2
Square slot 3	1 GHz	1

3.3 DEFECTED GROUND STRUCTURE

To increase the bandwidth and return loss values even more, the defective ground constructions will be commenced in the ground plane of the intended antenna. To limit the patch antenna's emission characteristics in the appropriate direction, the ground plane is partially faulty. When designing the defected assembly in the ground plane, extreme ground plane defection can degrade the performance of the planned antenna. The defective ground structures must be treated as an LC equivalent circuit [20–22]. To change the radiation properties, the capacitance and inductance values must be obtained. Consider the angular cut off frequency as ω_c, angular resonant frequency as ω_0, g_1 is the prototype value of the Butterworth small pass filter type, Z_0 is the characteristic impedance, c is the swiftness of light then the inductance (L) and capacitance (C) values shall be found by

$$L = \frac{1}{4\pi^2 \, c \, f_0^2} \qquad (9)$$

$$C = \frac{\omega_c}{Z_0 g_1} \cdot \frac{1}{\omega_0^2 - \omega_c^2} \qquad (10)$$

The bandwidth (B) of the wideband patch antenna is the difference between the lower (f_{Lower}) and higher (f_{Higher}) cutoff frequencies.

$$B = f_{Lower} + f_{Higher} \qquad (11)$$

The central frequency ($F_{Central}$) along the antenna bandwidth is given by

$$F_{Central} = (f_{Lower} + f_{Higher}) / 2 = \sqrt{f_{Lower} f_{Higher}} \qquad (12)$$

Fractional bandwidth (BW) is given by the ratio of the general bandwidth of the antenna to its central frequency.

$$BW = B / F_{Central} \qquad (13)$$

Fractional bandwidth (BW) shall be expressed in terms of percentage as

$$\% \, BW = (B / F_{Central}) \times 100 \, \% \qquad (14)$$

The different ground plane structures with several length sizes like full length L, three quarters length 3L/4, half-length L/2 and quarter length L/4 are shown in Figure 5. The ground plane is reduced to three fourth of its size and then to half for widening the bandwidth. The return loss plot of the variety of defected ground structures used in this antenna design is shown in Figure 6. The full ground plane (L) structure radiates at two resonant frequencies with a total bandwidth of 1.1 GHz. When the ground plane is reduced to 0.75 L the radiated bandwidth is enhanced to 3.5 GHz that begins from 9.4 GHz frequency and ends at 12.9 GHz frequency spectrum with a maximum of -18.99 dB. When the ground plane is reduced further to 0.5 L the structure radiates at the bandwidth of 900 MHz that starts from 9.4 GHz until 10.3 GHz frequency band with a maximum of -14.06 dB. The obtained values after reducing the ground plane are much better than the values obtained by introducing the square slots in the patch. The variation in the dimensions of the ground plane decides the number of resonant frequencies along with the bandwidth. The three fourth defected ground plane structure has better return loss characteristics than the full ground plane and half defected ground planes.

Table II compares the bandwidth generated by introducing defective ground structures into the planned antenna. The antenna's emission is adjusted by varying the size of the ground plane. When utilizing a full ground plane, the number of resonant frequencies is two, and when using partial ground plane structures like 0.75 L and 0.5 L, the number of resonant frequencies is one. When the ground plane is decreased to 0.75 L size of the ground plane the bandwidth is enhanced to a limit while comparing with the effect of bandwidth with the full ground plane but once the ground plane is lessened to 0.5 L the bandwidth is reduced than the other varieties of ground plane. According to the findings, of the effect of bandwidth and the number of resonant frequencies, the defected ground plane structure with ground plane size 0.75 L is chosen for the designed antenna.

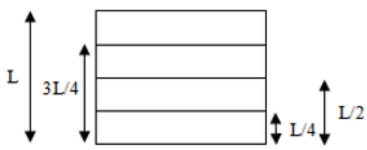
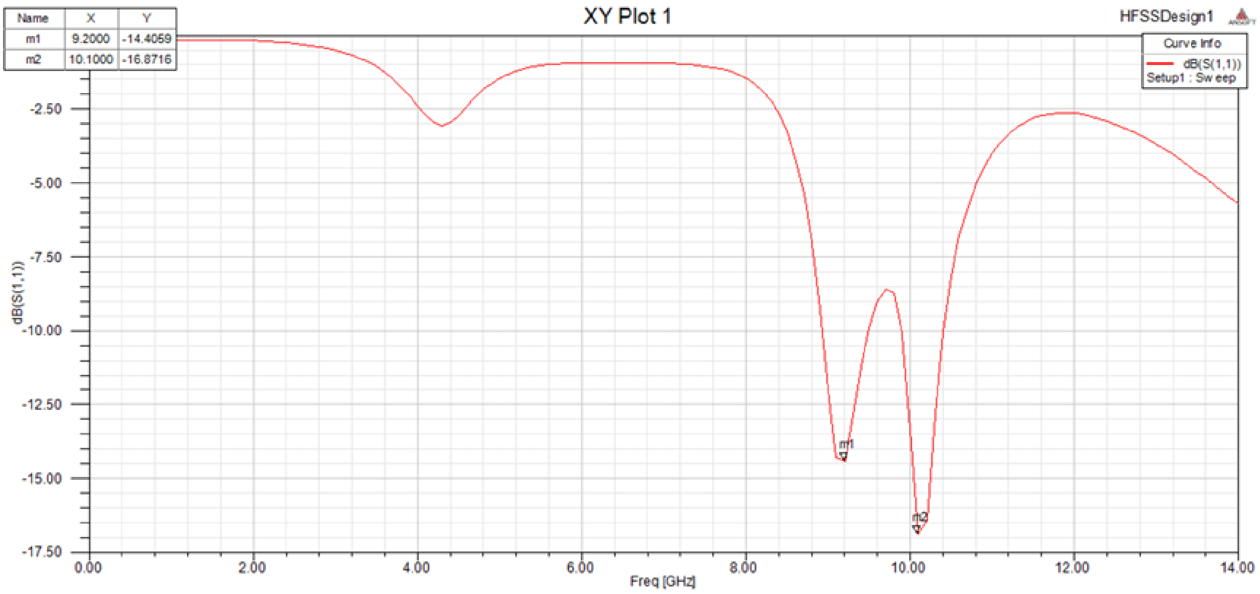
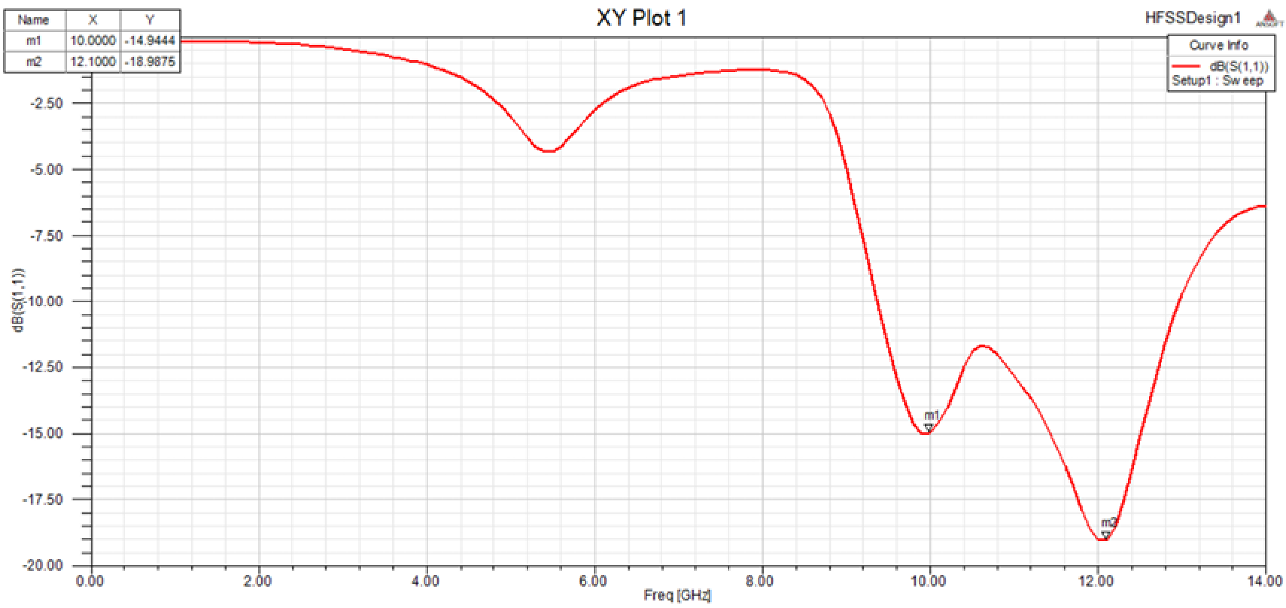


Figure 5 Defected ground structures


XY Plot 1
HFSSDesign1
Name X Y
m1 9.2000 -14.4059
m2 10.1000 -16.8716
Curve Info
dB(S(1,1))
Setup1 : Sweep
dB(S(1,1))
Freq [GHz]

(a)


XY Plot 1
HFSSDesign1
Name X Y
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Curve Info
dB(S(1,1))
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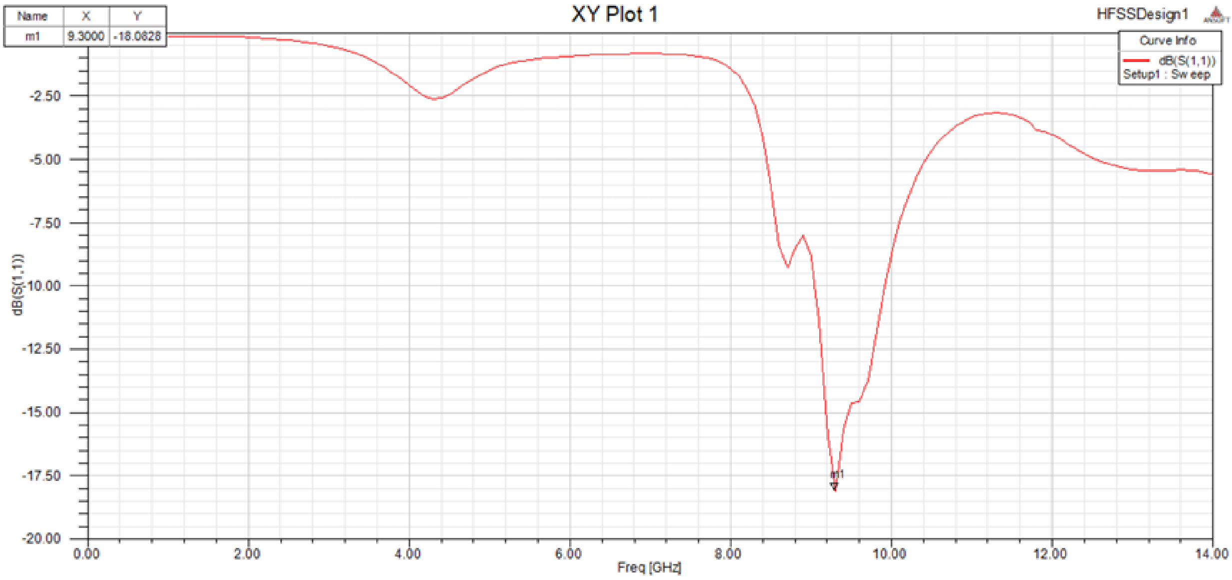
dB(S(1,1))
Freq [GHz]

(b)



(c)

Figure 6 Return loss of Defected ground structures (a) L (b) 0.75 L (c) 0.5 L

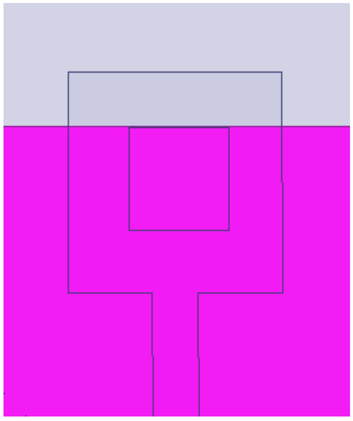


Figure 7 Antenna structure

Table II Comparison of Defected ground structures

Length of Ground Plane	**Bandwidth**	**Number of resonant frequencies**
L	1.1 GHz	2
0.75 L	3.5 GHz	1
1.5 L	900 MHz	1

4 RESULTS AND DISCUSSION

In HFSS simulation, the projected antenna structure is modelled by introducing the square slot 2 in the initial patch antenna initiator and the three fourth (0.75 L) sized partially defected ground structure in the patch antenna assembly's ground plane. Figure 7 depicts a plot of the finalized antenna form that will be built for measurement and comparison with the simulated HFSS results.

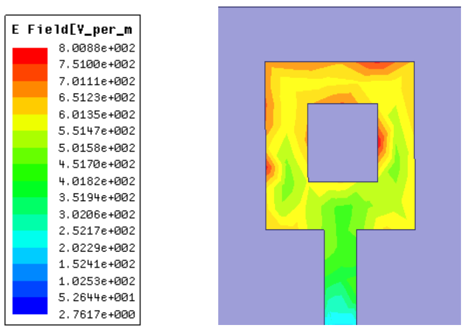


Figure 8 Electric field distribution

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Figure 8 depicts the electric field distribution of the antenna shape that is designed in HFSS. Microstrip feed line is used for impedance matching improvement which in turn increases the performance of the patch antenna. The highest electric field is localized on the patch surrounding the square slot structure during excitation through the proposed antenna structure's microstrip feed line. The remaining part of the antenna has medium and less electric field during the excitation. Hence by adjusting the dimensions of the slot structure, a wideband radiation is achieved.

The below mentioned Figure 9 depicts the magnetic field distribution of the desired antenna configuration during stimulation. During excitation, the maximum magnetic field is observed in the microstrip line feed edges of the antenna. The introduced slot assembly in the patch of the antenna has very little magnetic field radiation. The greatest and minimum sites where the electric field and magnetic field are focused during antenna excitation are required for optimisation of antenna structural factors. Figure 10 depicts the proposed antenna structure's two-dimensional radiation pattern. The radiation shape signifies an Omni directional pattern for the designed antenna that has wide band characteristics. The flow of electric field and magnetic field in the antenna tends to generate the desired radiation in the required direction.

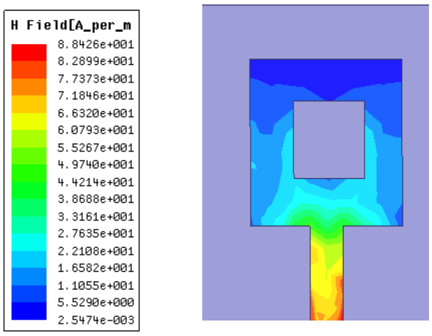

Figure 9 Magnetic field distribution

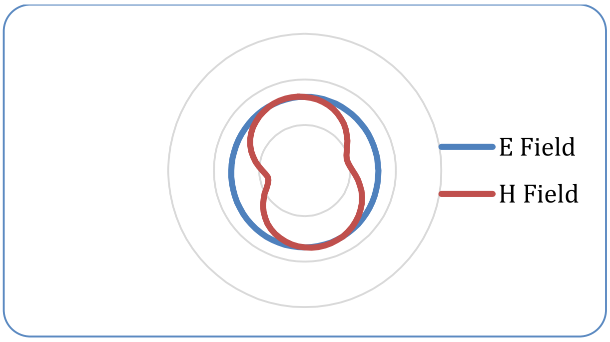

Figure 10 Radiation Pattern

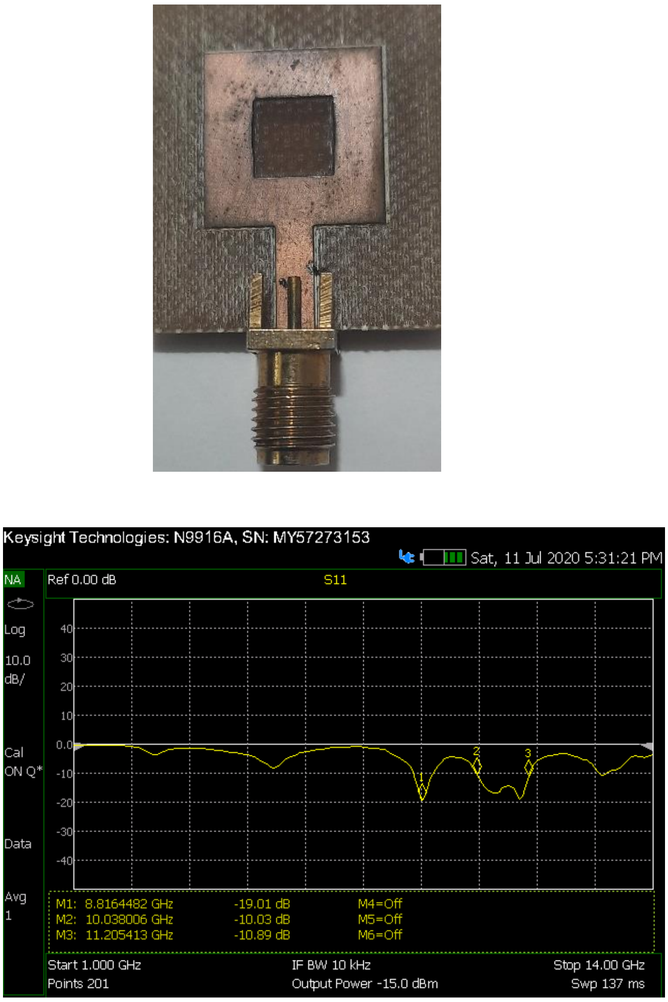

Figure 11 Fabricated antenna and measured plot

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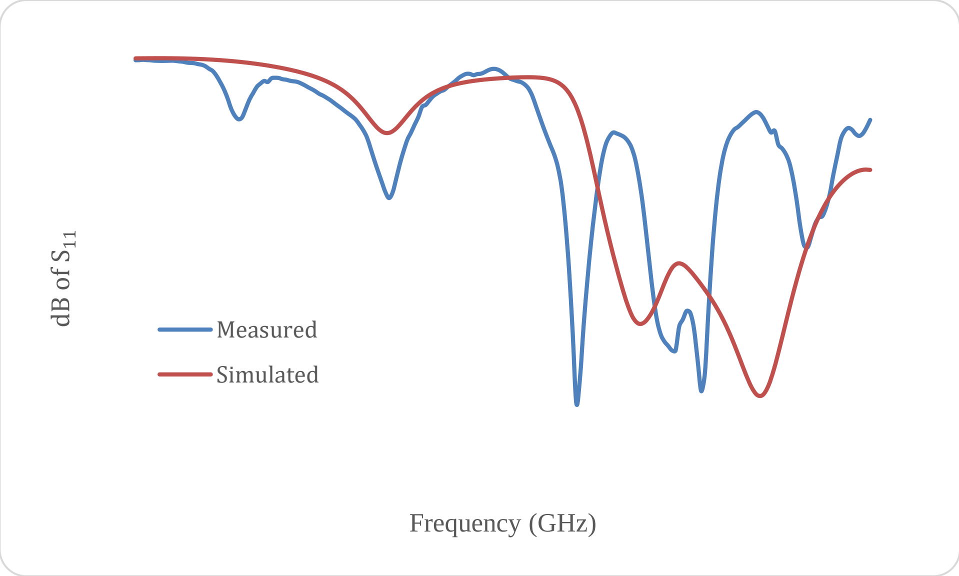

Figure 12 Comparison of simulation and measured values

Antenna design is built on a FR4 substrate with conductive copper coating for the patch and ground plane. The connector pin is soldered to the antenna's microstrip line feed with a soldering iron. As a result, the external connector is directly connected to the microstrip line feed of the antenna. The excitation is given to the microstrip line feed via the connection. The antenna is tested using a vector network analyzer (VNA). Figure 11 shows the produced antenna as well as the observed return loss map. The antenna is intended to operate at two distinct frequencies. The measured first resonant frequency is 8.8 GHz with -19.45 dB. It has a total measured bandwidth as 1.75 GHz. Certain abnormalities that arises in the fabrication and real time measurement of the antenna provides with the slight shift between the simulated values and the measured values.

The similarity of the determined values using vector network analyser and simulation using the HFSS software is shown in Figure 12. When compared to the HFSS simulated return loss values, the measured values are somewhat displaced to the left side of the frequency spectrum, but the wideband character of the simulated antenna is well maintained in the manufactured antenna. The observed return loss values confirm that the built mmwave radiator can be used for X band applications in the communication domain. The swing in the resonant frequencies maybe due to the issues with the external soldering of connector pin with the microstrip line of the fabricated patch antenna and the inaccuracies that arise due to the connection of external connector with the fabricated antenna.

5 CONCLUSION:

An antenna that radiates in the mmwave spectrum is designed over the FR4 substrate. Creating a square shaped slot in the designed microstrip patch antenna initiator introduces multiband properties. The addition of the defective ground plane architecture results in optimal wideband qualities in the mm wave area. A FR4 substrate is used to produce the predicted antenna structure, which is then simulated using HFSS software. The antenna that was produced is evaluated using a vector network analyzer. The reasonable values are closely matched with the modelled values which validates the anticipated antenna. The validated wide band spectrum from the proposed mmwave radiator can be utilized for X band applications that includes 5G frequency band. Substrates having high dielectric constant shall be used in the future work to reduce the radiation losses and create thinner communication devices.

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