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DESIGN OF RECTANGULAR MICROSTRIP PATCH ANTENNA FOR WLAN AND WiMAX APPLICATIONS

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ABSTRACT

Nowadays in the world of communication schemes the most extensively investigated area is of wireless technology and a study of communication schemes is incomplete without an understating of the operation of the antennas. In the last years of improvement in communication schemes a requisite for the improvement of lightweight, consolidated and cost-efficient antennas which are ability of preserving high performance through an extensive spectrum of frequencies. This technological trend has focused much exertion into the scheme of a microstrip patch antenna. Today, Worldwide Interoperability for Microwave Access (WiMAX) and Wireless Local Area Networks (WLANs) applications are extensively utilizing microstrip patch antenna. In this paper, it proposed a new design for micro-strip patch antenna over WiMAX and WLAN applications. The proposed antenna design uses different frequency band and it is operating within narrowband at this band. This adjusted antenna design provides better performance whence return loss, voltage standing wave ratio (VSWR), impedance matching, gain and radiation pattern.

Keywords: VSWR, frequency, gain, return loss, bandwidth.

1. INTRODUCTION

An antenna is a focused transducer which changes radio-frequency (RF) fields into alternating current (AC) or vice-versa and it is also part of a transferring or receiving scheme which is designed to send or get waves of electromagnetic [1]. A microstrip antenna contains of a tiny metallic conductor that is connected to tiny grounded dielectric substrates. The size reduction of microstrip patch antenna is essential in several of the recent day practical applications, similar which of Wireless Local Area Networks (WLANs), Worldwide Interoperability for Microwave Access (WiMAX) and other mechanisms that based on wireless terminals.

Patch antennas play an important role in recent days' in world of wireless communication schemes. Microstrip antennas are very charming due to their low profile, low wight, conformal to the superficial of targets and plain making. A huge number of microstrip antenna to be utilized in wireless applications have been advanced [2-4].

Scheme of WLAN antennas likewise got popularity with the advancement of microstrip antennas [5-8]. WLANs needs three bands of frequencies: 2.4 GHz (2400-2484MHz), 5.2 GHz (5150-5350MHz) and 5.8GHz (5725-5825MHz). WiMAX has three band (5.2-5.8 GHz). The size of the antenna is efficiently reduced through cutting slot in proper location on the microstrip path. The goals of this paper is to design and analysis a microstrip patch antenna via utilizing HFSS EM simulation. This antenna is designed to work in the range of frequencies between 2.45GHz to 5.2GHz on the FR4-epoxy substrate of thickness 1.6mm, $\mathcal{E}r$=4.7 with a dielectric loss tangent δ=0.025.

2. MICRO-STRIP ANTENNA

Micro-strip antenna is one of the most common kinds of printed antenna. It acts a very important role in recent days in world of wireless schemes. A microstrip antenna in it is easily form is a layered framework with two parallel conductors detached through a tiny dielectric substrate and the conductor. The top part is described as patch which is accountable for radiation and lower part works as a ground plane. Micro-strip patch antenna contains of an emitting patch on one side of a dielectric substrate (FR4) which has a ground plane (Cu) on the other side as presented in Figure-1.

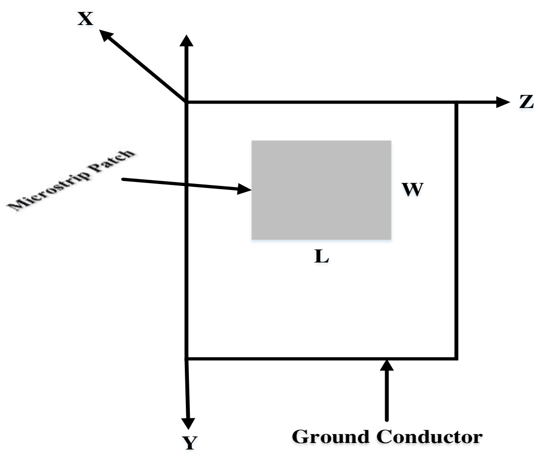

Figure-1. The geometry of physical for microstrip antenna.

A rectangular Microstrip antenna contains of very tinny radiating metallic patch located at small height in one side of dielectric substrate that other plane is grounded. Mostly, a Microstrip contains of rectangular radiating patch element fed with a coaxial line in that length is most critical dimension and slightly less than half wavelength in the dielectric substrate. The radiating patch of Microstrip antenna are of various shapes for example rectangular, circular, elliptical, square, annular ring etc.

There are several advantages of Micro-strip patch antenna such as depressed cost, consolidated size, straightforward framework and similarity with incorporated hardware. It has massive applications such as military, radar schemes, mobile communications, remote detecting and so on. A microstrip radio wire fused with a solitary shorting stake at legitimate part and size is set to give lessening in whole region with deference to an ordinary patch receiving wire. Moreover, the minimal roundabout spellbound patch receiving wires can be accomplished through space stacking on patch. The heap of the spaces or openings in the emanating antenna able to issue wandering of the energized patch superficial present tracks furthermore, bring about bringing down of the full recurrence of the reception apparatus, which relates to a reduced radio wire size for such a reception apparatus, contrasted with a routine circularly spellbound microstrip radio wire at the similar working recurrence. For outline smaller and broadband of antenna receiving wire here shorting strategy utilized with conductive via [9] for suggested and broke down.

This sort of receiving wire had wide information transfer capability and radioactivity design such as a monopole and this receiving wire was advanced on a round antenna radio wire [9] which was shorted focus with an arrangement of conductive. The receiving wire was examined by depression structure.

3. RELATED WORK

In the recent years several researchers focus on developing efficient approaches for wireless networks. Wireless networks have the promising areas of research because of their flexibility and the different applications. Nonetheless, it is still facing several challenges that are under study and evaluation. This unit presents an overview of the usage of microstrip patch antenna for various wireless applications.

It presents scheme of probe fed rectangular microstrip patch antenna for WCDMA utilizing soft computing mechanism, particle swarm optimization. A substrate with dielectric constant of 4.4 and height 1.588 mm has width and feed position at center frequency of 1.95 GHz using Sonnet 13.52. It has been evaluation this design depends on in terms of Voltage Standing Wave Ratio (VSWR) and return loss [10].

On the other hand, it proposed antenna works at 2.4 GHz resonant frequency for wireless local area network (WLAN). In this design exist various shapes of an antenna and this antenna is designed in such a way to care the above resonant frequency. Furthermore, this antenna is applied on FR 4 Epoxy dielectric substrate and it has been evaluating this design depend on return loss and VSWR [11].

Moreover, it proposed a simple microstrip patch antenna contains of metallic patch and ground among that is a dielectric average called the substrate. A simple microstrip patch antenna is designed in CST microwave studio at a resonant frequency of 2.4 GHz. The gain of this designed antenna is 8.27 Db and VSWR of 1.18 [12]. Besides, the simulation tool of IE3D is utilized to investigate of the performance and gain of the microstrip patch antenna. The scheme and simulation of patch antennas is utilized by mobile. The return loss and the different gain plots have been investigated along with the radiation style [13].

Also, it proposed a single feed compact rectangular microstrip antenna for dual band application. This antenna has two resonant frequencies are obtained at 3.68 GHz and 5.74 GHz. The characteristics of this design are studied over utilizing MoM based electromagnetic solver, IE3D. An extensive investigation of the return loss, redaction pattern, gain and effectiveness of the suggested antenna [14]. On the other hand, it proposed the compact microstrip antenna with high gain and broad bandwidth via using Bi-polar mechanism. In this technology the surface is improved and the losses are reduced. In this antenna uses the MATLAB simulator to calculate the parameters and from results it is found that the bandwidth is wider via utilizing this technology and it has been evaluated this antenna in terms of return loss [15].

4. DESIGN SPESIFICATIONS

4.1 Process frequency (f)

The overall dimensions of the antenna have to be chosen suitably so which it can work in this frequencies ranges. The range of frequencies for this design is form 2.45GHz to 5.2GHz.

4.2 Substrate relative dielectric fixed (εr)

The relative permittivity of dielectric substrate is in range 1 to 10. Every substance has value of dielectric permittivity. In this paper, it used FR4-epoxy substrate which has εr = 4.7.

4.3 Dielectric substrate height (h)

The height of the dielectric substrate is chosen as 1.6 mm.

4.4 Antenna measurement

The dimensions of patch antenna in chosen the frequency by the system rectangular patch antenna, compute based on equation 1 and 2.

$$L = \frac{C}{2 * FRE * \sqrt{\varepsilon r}} \quad (1)$$

$$W = C * \frac{\sqrt{\frac{2}{(\varepsilon r + 1)}}}{(2 * FRE)} \quad (2)$$

L and *W* are the dimension of patch antenna. The equation illustrations, rising the dimensions indicate to reducing preferred the frequency. The return loss is a logarithmic ratio gauge in dB which likens the power reflected through the input power from sending line for the

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antenna. The return loss is compute based on this equation:

$$\text{Return Loss} = -20 \log \frac{(Z_A - Z_0)}{(Z_A + Z_0)} \quad (3)$$

4.5 Bandwidth

The bandwidth of the antenna indicates to the range of the frequencies in that the antenna able to work [16]. Usually, the antenna is requisite to give a return loss lower than -10 dB through its frequency bandwidth.

4.6Gain and directivity

The power gain *(G)* is a key performance number that merge the antenna's directivity and electrical capacity. It is normally knowing in the maximum radiation direction each unit area. In addition, it represents how well the antenna change input power into radio waves headed in a set direction.

$$\text{Gain} = \frac{\textit{Power radiated by an antenna}}{\textit{Power radiated by a reference antenna}} \quad (4)$$

5. MATERIALS AND METHODS

5.1 Simulation tools

In this paper, the simulation was used HFSS EM simulation software to design and simulate a microstrip patch antenna. It is a useful tool for modelling electromagnetic structures.

5.2 Proposed design

This paper presents a comprehensive description of the process to model a microstrip patch antenna. Figure-2 is shown the configuration of the patch proposed antenna. In this design, the Lt (length of transmission line) equal to 9.56 mm and Lg (length of ground plane) is 8.56 mm. The dimensions of the proposed antenna are 3cm*3cm. The parametric studies are made to enhance the antenna parameters. It can help to study the influences of the various parameters on the resistance of bandwidth. For the purpose of optimization, three parameters L, W and Wf have been changed and ground plane are kept constant while the optimization is done by three parameters L, W and Wf.

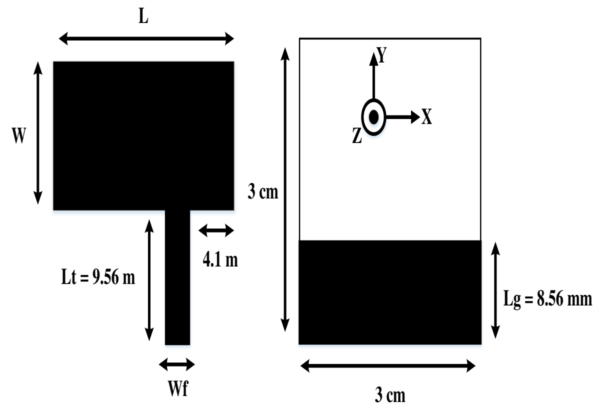

Figure-2. Configuration of the proposed antenna.

5.3 Simulation parameters

The simulation is performed using HFSS WM simulation software. These are simulation parameter used in this design to develop the microstrip patch antenna as illustrated in Table-1.

Table-1. The optimized values of the proposed antenna.

Parameters	**Value** (mm)
Width of the input feed line	2.8 mm
Length of patch, L	10
Wf	2.2
Lt	9.56
Lg	8.65
dimensions	3cm*3cm
Thickness of Substrate	1.6

6. SIMULATION RESULTS

As mention earlier, the optimization is done for this antenna dimension to see the effect of the different parameters to the S parameter result. Two parameters are used for the optimization, which are W and Wf. The variation of return loss with Wf parameter (Width of transmission line) is shown in Figure-3.

It can be observed that decreasing and increasing of Wf lead to decrease the bandwidth. The point of view of impedance bandwidth Wf=2.2mm is larger than other values. Table-2 shows the bandwidth performances with various values. Therefore, the Wf equal to 2.2mm able to be taken as the optimized value to give wider bandwidth. In Table-2 the Wf=2.2mm covers the longer bandwidth in ranges of frequency from 2.45to5.45GH than other values.

Table-2. Bandwidth performances with various values of Wf.

wf (mm)	f_L - f_H (GHz)	**Bandwidth** (GHz)
1.7	3.6-5.1	1.5
2.2	3.4-5.3	1.9
3.3	3.2-4.9	1.7

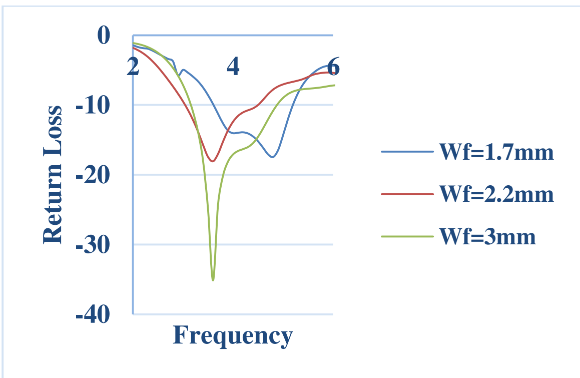

Figure-3. The variation of return loss with different Wf parameter.

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The variation of the return loss with W parameter (width of the transmission line) is shown in Figure-4. Another important finding is which reducing and increasing of the W parameter that indicates reduction the bandwidth. The bandwidth performances with various values are arranged in Table-3. W=15mm has the impedance bandwidth better than other values. Thus, it is used for optimization.

In Table-3 the W=15mm covers the longer bandwidth in ranges of frequency from 2.45-5.45GH than other values.

Table-3. Bandwidth performances with various values of W.

wf (mm)	f_L **-** f_H (GHz)	**Bandwidth** (GHz)
12	3.9-5.6	1.7
10	3.45-5.3	1.85
17	3.1-4.55	1.45

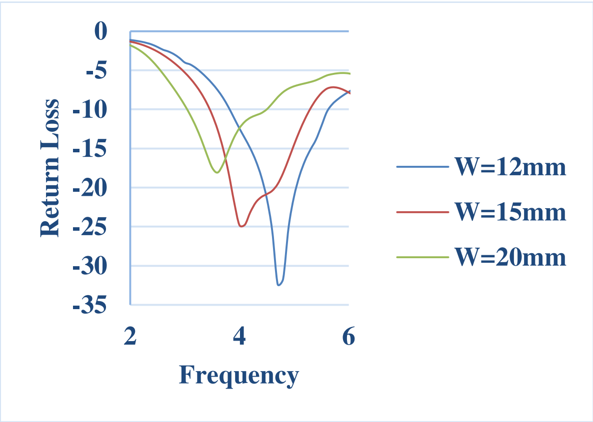

Figure-4. The variation of the return loss with W parameter.

The variation of the return loss with L parameter (length of patch antenna) is indicated in figure 4, the most interesting finding is that increasing of L lead to increase the bandwidth in upper frequency. The performance of the bandwidth is shown in table 3, It is also obvious that the best value for our aim design is L=10mm.

In Table-4 the L=10mm covers the longer bandwidth in ranges of frequency from 2.45to5.45GH than other values.

Table-4. Bandwidth performances with various values of L.

Wf (mm)	f_L **-** f_H (GHz)	**Bandwidth** (GHz)
8	3.27-5.1	1.83
10	3.4-5.3	1.9
17	3.9-6.2	2.3

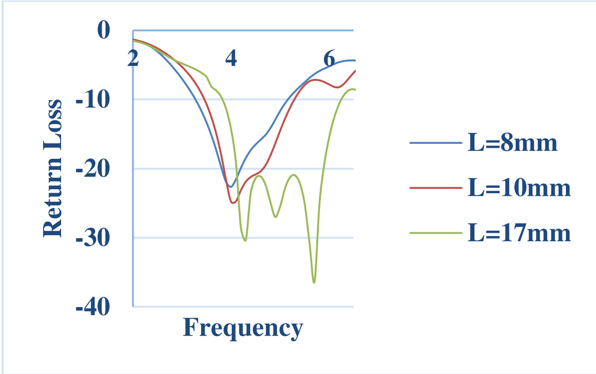

Figure-5. The variation of the return loss with different L parameter.

6.1 Gain

At resonance frequency of 4GHz, the gain is nearly 7.709148dB. The variation of gain for this antenna design for the frequency in the range of 3.3GHz to 5.2 GHz is in between 3.9 dB.

- Maximum gain=8.9 dB at 4.4 GHz
- Minimum gain=5 dB at 3.3 GHz

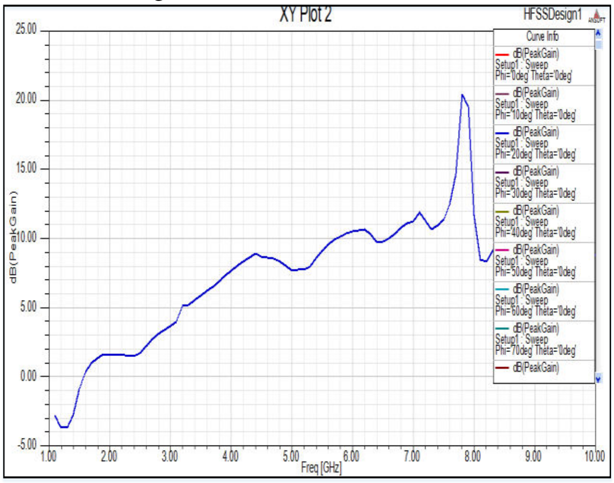

Figure-6. Peak gain (dB) of the proposed antenna.

6.2 S-Parameter results (Return loss and bandwidth)

S- Parameter of this patch is obtained as shown in Figure-5. The S11 parameter is the return loss, which is understand as the ratio of power reflected back from the line to the power communicated into the line. It can be observed that the ranges of frequencies from 3.3 GHz to 5.2 GHz is less than -10dB that the impedance bandwidth is about 45%.

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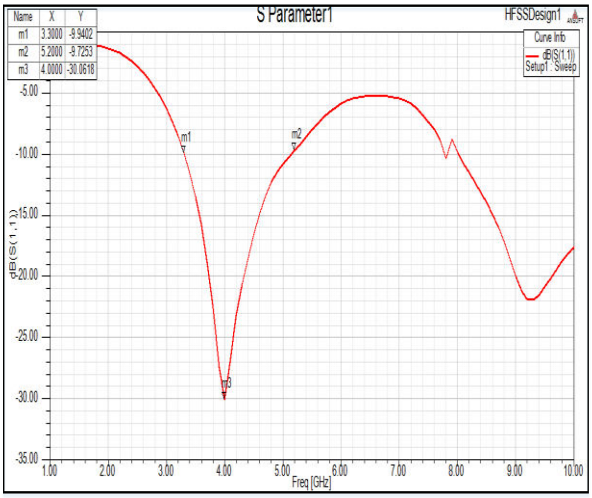

Figure-7. Return loss.

6.3 Voltage standing wave ratio (VSWR)

The Figure-6 shows VSMR of the proposed antenna. The resistance bandwidth of proposed antenna design has a range of frequencies from 3.1 to 5.4 GHz (54%).

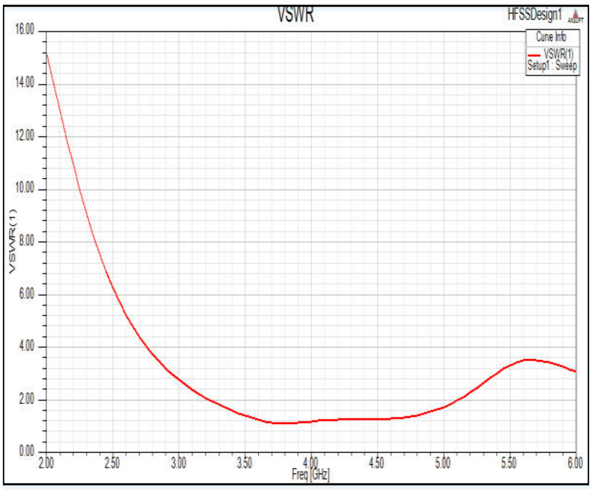

Figure-8. VSMR.

6.4 Z Parameter (Impedance matching)

Z-Parameter is shown in Figure-7. It can be observed that the Z-parameter plot has a good impedance matching in this ranges of frequency (3.3-5.2 GHz) because it is around the 50 ohm. Also it can be seen that the impedance matching of this antenna at resonance frequency = 4GHz is 50i +0 j, which means that it has matching of 50Ω which is exactly the requirement impedance matching of 50 Ω of the SMA connector.

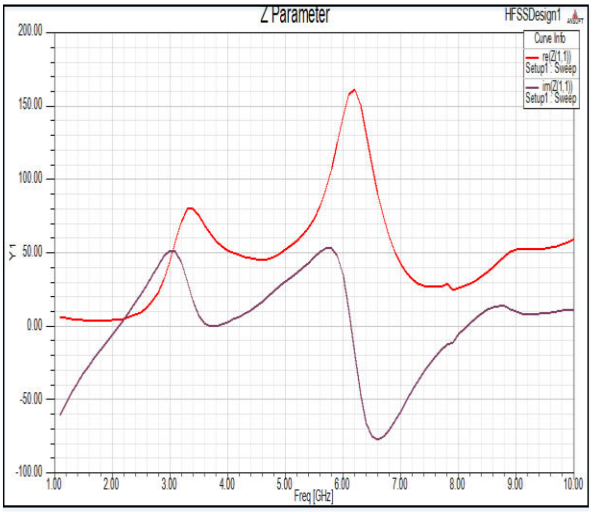

Figure-9. Impedance matching.

6.5 Radiation pattern

The radiation patterns of resonance frequency are also investigated. Figures 6 and 7 is shown the simulated X-Z plane and X-Y plane radiation pattern at the resonant frequency of 4 GHz. The XY plane is E-plane and XZ plane is an H-plane. H plane is omnidirectional with low cross-polarization level. E-plane patterns are similar to donate shape.

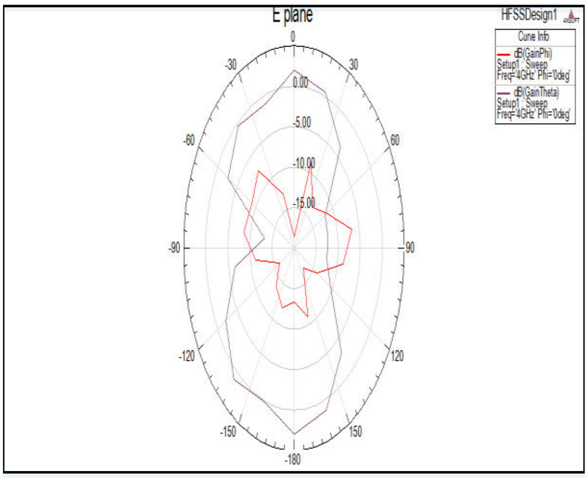

Figure-10. Radiation pattern.

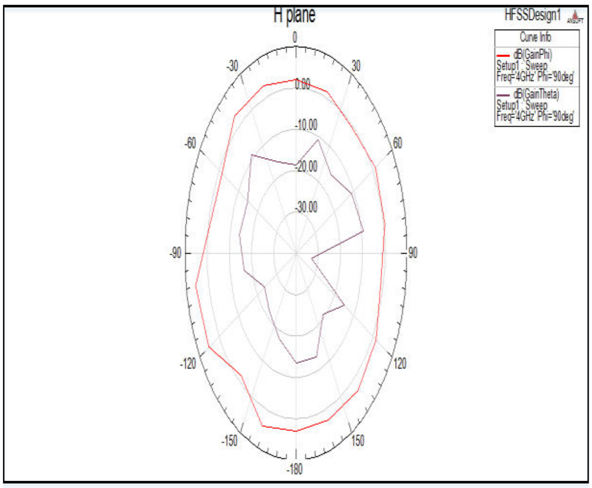

Figure-11. Radiation pattern.

7. CONCLUSIONS

The micro-strip patch antenna is implemented and simulated by HFSS EM simulation software. The high efficiency is aim of design such type of antenna based on WiMAX and WLAN. Bi-polar mechanism is utilized to increase the surface present because of the inductance and therefore the efficiency and return loss is improved. This antenna achieved 90 % bandwidth in the frequency range of 2.4 GHz to 5.3 GHz and the efficiency of antenna is 99%. The VSWR is less than 2 and 1.2 with -30 dB return loss. Therefore, the antenna has better performance with wide bandwidth and better efficiency.

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