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DESIGN OF A SMALL PATCH ANTENNA AT 3.5 GHZ FOR 5G APPLICATION

Nayla Ferdous[1], Goh Chin Hock[1], Saidatul Hamidah A.Hamid[1], M. Nazri A. Raman[1], Tiong Sieh Kiong[1], Mahamod Ismail[1]

1. College of Engineering, Universiti Tenaga Nasional, Kajang Malaysia

E-mail: Nayla.Ferdous@uniten.edu.my,ChinHock@uniten.edu.my, Saidatul.Hamidah@uniten. edu.my, mohamad.nazri@uniten.edu.my

Abstract. In this paper a low profile patch antenna has been designed for 5G communication application. The resonating frequency has been chosen as 3.5 GHz for 5G application. FR4 epoxy material with permittivity of 4.3 has been chosen for the substrate material which has fire redundant property. The size of the substrate is 25.2×48 mm². The main radiating patch is in a shape of ellipse and the line feed technique is used. The simulation is done by CST microwave studio software. Different parameters like S-Parameter, Antenna Gain, Directivity, Efficiency has been observed. The antenna has a gain of more than 5 dB which is very useful for communication applications. The antenna is designed for 5G communication applications.

1. Introduction

The fifth generation (5G) communication has been widely discussed to provide high data-rate communications in the future. The design and testing of the 5G communication system hinge on the understanding of the propagation channels [1], and a large body of channel measurements is thus required. Currently, 5G mobile systems are broadening their spectrum to support a high data rate. In the World Radio Communication Conference (WRC) in 2015, the 5G candidate frequency bands below 6 GHz have been widely discussed, and the following frequency ranges have been suggested: 470–694, 1427–1518, 3300–3800, and 4500–4990 MHz. Among them, 3.5 GHz has been widely considered, as it can be accepted for most of countries. Therefore this paper was focused on the propagation channel characterizations at 3.5 GHz band.

In the past, 3.5 GHz propagation channel has been studied mainly for the Worldwide Interoperability for Microwave Access (WiMAX) with limited bandwidth [2]–[3][4] or the Broadband Fixed Wireless Access [5]–[6][7]. Few works has been conducted for the 5G wireless propagation channels

Elliptical dipoles were first investigated by N. P. Agrawall et al. in 1998. Elliptical elements offer even better matching than circular elements due to their more oblong from factor and more gradual taper [1]. Dipoles with elliptical elements offer good dipole performance over nearly two octaves. They also exhibit −10 dB return loss for 0.40 λ elliptic dipole height (2 h) in comparison with traditional dipoles whose height must equal approximately half-wave length [2]–[3].

The objective of the study is to design a small antenna for using at 3.5 GHz frequency for 5G application. The antenna has to be small enough to fit inside any small communication devices from new technology. Aim will be to have high gain and efficiency to ensure maximum data transfer.

2. Antenna Design

In Microstrip Patch antenna has three main parts namely Substrate, Patch, Ground Plane. An elliptical Microstrip patch antenna was designed for using in 3.5 GHz band for 5G applications. Substrate is designed using a box having material FR4 EPOXY with dielectric constant (εr) =4.3. The height(h) of the substrate is 1.6mm with respect to z-axis. The ground plane is made at the bottom of the substrate which results in the coplanar waveguide structure. The outer box is designed using air material and assigned with radiation.

Table 1. The Parameters of the Designed Antenna

Parameter	Measurements (mm)
Ellipse Major Axis	22
Ellipse Minor Axis	13
Substrate Length	25.2
Substrate Width	48
Heigth of Substrate	1.6
Matching line Length	18
Matching line Width	2.9
Ground Length	48
Ground Width	10

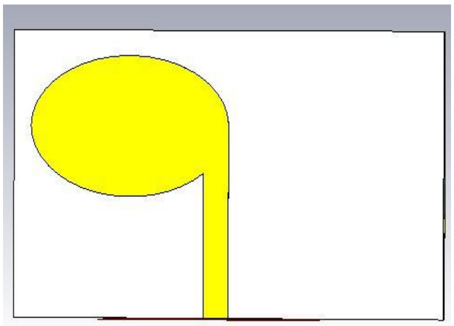


Figure 1. Front View of the Designed antenna

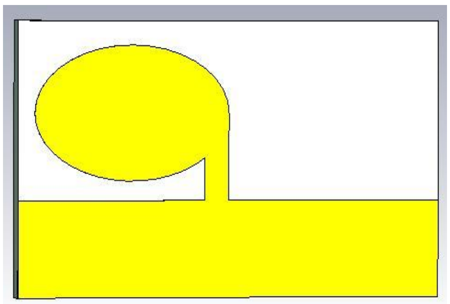


Figure 2. Back View of the Designed Antenna

3. Results and Discussions

This paper was intended to design an antenna which works at 3.5 GHz resonant frequency. Copper has been used as the radiating material and FR-4 (Ɛr =4.3, tanδ =0.015). CST microwave studio has been used to design and simulate the antenna. The performance of the antenna has been observed accurately and then they have been compared.

3.1. S Parameter

Scattering parameter which generally describes the electrical behavior of linear electrical system, this undergoes various steady state stimulation by electrical signal. S parameter describes the input and output relation between ports in an electrical system. As it is known that the resonant frequency(fr) and the return loss can be calculated from the S11 curve of the patch antenna respectively. So the obtained resonating frequency is 3.5 GHz and return loss is -30 dB. This shows that the antenna has very low return loss when it operates at 3.5 GHz frequency. That means a good amount of the signal will be transmitted by the antenna.

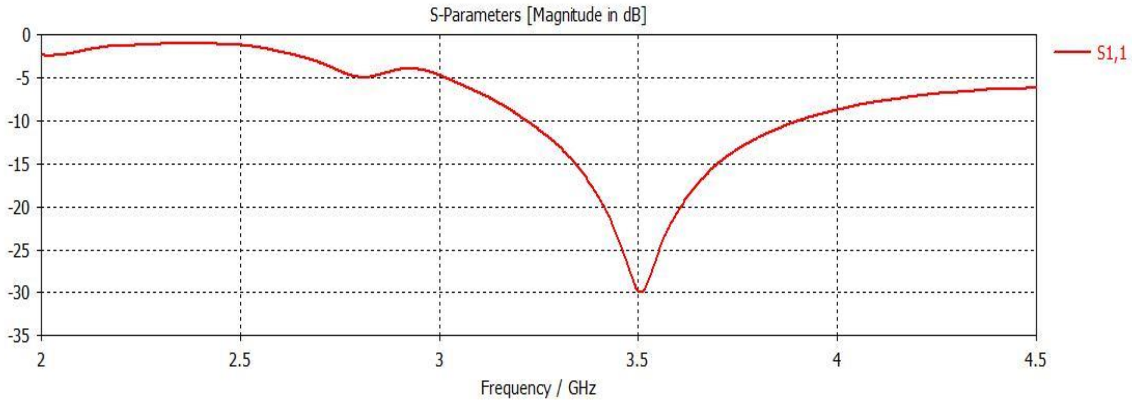
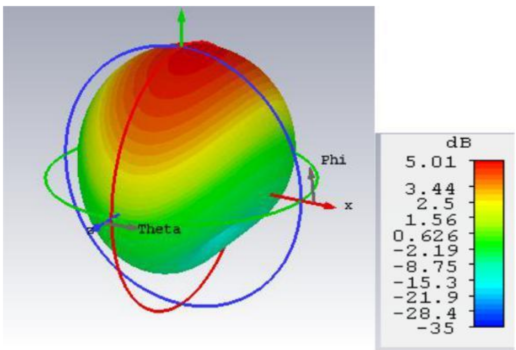


Figure 3. Return Loss or S11 Parameter of the Designed Antenna

3.2. Gain and Efficiency

The antenna gain determines how efficienntly the antenna coverts input power into radio waves headed in a specfied direction [15]. According to the definition of antenna gain ratio of power produced by the antenna from a far-field source on the antenna's beam axis to the power produced by a hypothetical lossless isotropic antenna can be treated as antenna gain. At the operating frequency of 3.5 GHz the antenna has a gain of 5.01 dB. And the efficiency of the antenna is -0.1478 dB or 96.67%. High gain and efficiency shows



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=3.5) [1]
Component	Abs
Output	Gain
Frequency	3.5 GHz
Rad. effic.	-0.1433 dB
Tot. effic.	-0.1478 dB
Gain	5.007 dB

Figure 4. Farfield Radiation Pattern in 3D Form

3.3. Radiation Pattern Directivity

Directivity is a fundamental antenna parameter. It defines the radiation intensity in a specific direction. Directivity plays a very vital role when the antenna is designed to radiate in a specified direction. The directivity of the main lobe of the antenna is 5.15 dBi at 81 degrees in theta direction. The side lobe level is -10.5 dB.

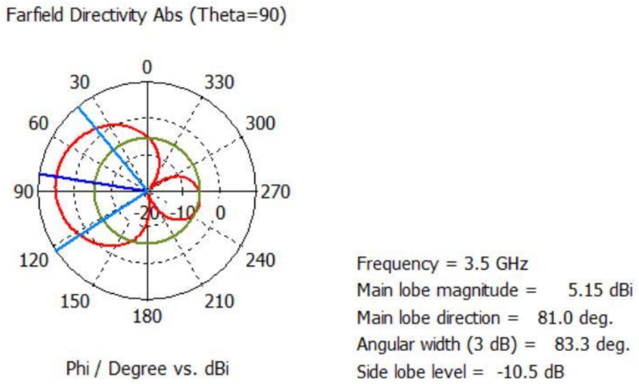


Figure 5. Radiation Pattern

4. Conclusion

In this paper a small elliptical antenna has been designed for using at 3.5 GHz for 5G application. The antenna has a physical size of 25.2 X45 mm^2. It has a return loss of -30dB at 3.5 GHz. Antenna gain is 5.01 dB. The antenna has a very high efficiency of 96.67%.

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