MATEC Web of Conferences **140**, 01006 (2017)
ICEESI 2017
DOI: 10.1051/matecconf/201714001006

60 GHz Milimeter-Wave Antennas for Point-to-Point 5G Communication System

[1]A.S.*Aishah*, [1]Beson Mohd Rashidi Che, [1]S.N.*Azem*i, [1]S.A.Al Junid

[1]Advance Communication Engineering,
Center of Excellent School of Computer and Communication Engineering.
Universiti Malaysia Perlis,
1st Floor, Pauh Putra Main Campus,
02600 Arau, Perlis,
Malaysia.
aishahshukre@gmail.com

Abstract. In this paper microstrip patch antenna for millimeter-wave is proposed. Evolution of shape microstrip antenna are designed which is from rectangular antenna to triangle antenna and changed to triangle with slot. The proposed antenna configuration achieved for covering 5G wireless system. The lowest return loss of the antenna is -29.23dB which is triangle with slot and the maximum gain obtained is 8 db at the 61.93 GHz for the triangle antenna. This antenna are suitable for the 5G wireless application for short range and high rate communication system.

1. Introduction

Nowadays, the 5G technology for wireless systems becomes attractive and huge demand from the end users. The new 5G wireless system starts to formulate in a more concrete method, they will be incorporated into the new 5G wireless system. The 4G wireless system have already been initiated in some of the countries and is going to be in other soon. However, major problem is power consumption still persist even with the presence of 4G system[1]. Therefore The need for 5G wireless system came in order to solve the issues and the requirement of high data rate on 5th generation wireless system is going on and expected to be initiated by 2020, and the significant growth in the customers demand for wireless communication using handsets has created the need for important development of antenna design as a basic part of any wireless system [2].

The user and service provides demand wireless unit with antenna that small and compact, cost effective and low profile. This paper proposed, a microstrip antenna capable to fulfil most of the wireless system requirement using milimeter-wave frequency. The frequency spectrum band for milimeter-wave lies between 30GHz-300GHz in electromagnetic spectrum[5]. The free space wavelength in this band is order of 1 milimeter to 10 milimeter thus permit the use of small size of antenna. The path loss proportional to frequency square so at this high frequency band path loss is high. In 2001, Federal Communication Commission (FCC) released the unlicensed milimeter-wave band around the 60GHz frequency[1],[4] This band is of immense interest due to the availability of universal unlicensed spectrum around 60GHz for short-range communication system such as indoor and underground communication and high speed wireless application [2],[3] Antennas for communication system at 60GHz shuld have a high bandwidth to achieve high data rate and should have a high gain to compensate the high path loss ath these frequencies [4]. The advantages of microstrip antenna for point-to-point operate at 60GHz is proposed which has a fast data rate and reliable gain. The gain is enhanced by inserting the slot into the patch and the most optimized results are discussed in the following sections . Microstrip antenna for wireless system application in operate 60GHz are proposed which has a faster data rate and high gain. The gain is enhanced by inserting the slot into the patch and the most optimized results are discussed in the following sections.

2. Essential of 5g Milimeter-Wave Antenna

Three antenna shapes are proposed in this project, which is rectangular antenna, triangle antenna and hexagon antenna, label with dimension in figure 1. The antenna is designed on a RogerRT5880 substrate of thickness (0.127mm) and relative permittivity of 2.2, loss tangent of 0.0009 and CST Microwave Studio is used for simulation proposed. The design of basic a basic patch antenna begins with the calculation of the

dimension or antenna design specifications. The operating frequency of the antenna must be determined before calculation can begin. For this design we need to choose an operating frequency of 60 GHz.
The width of the antenna *(W)* and the length (L) of both feed from the centre of the path were two tuneable parameters. The line feed is attaching a (SMA) connector at the bottom. The quarter-wave transformer is used as matching network and allocated in the middle of 50 ohm feed-line and patch design. Basically the antenna is designed using a transmission line model. For patch antenna design, a rectangular patch antenna will be designed as a limitation of time to study and optimization.

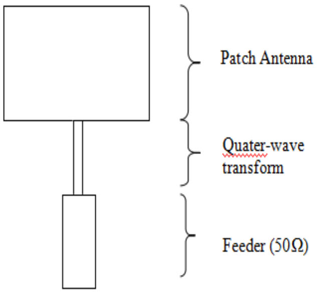

Figure 1: Single Patch antenna using Quarter-wave

The design procedure was to first estimate the width (W) and length *(L)* of the patch antenna. Below show the calculation by using the equation from (1) to (4) a parameter of the antenna, it will carry out εreff = effective dielectric constant, W = patch width, *L* = patch length, *ΔL* = patch length extension.

W = Width patch

$$\frac{Co}{2fo}\sqrt{\frac{2}{\varepsilon r+1}} \tag{1}$$

ε_{reef} = effective dielectric constant

$$\frac{\varepsilon r+1}{2}+\frac{\varepsilon r+1}{2}\left[1+12\frac{h}{w}\right]^{\frac{1}{2}} \tag{2}$$

ΔL = Patch length extension

$$\left[\frac{(\varepsilon reff+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{w}{h}+0.8\right)}\right] \tag{3}$$

L = Length

$$\frac{\lambda}{2\sqrt{\varepsilon reff}}-2\Delta L \tag{4}$$

From the formula, theoretically calculated width and length of the top radiating patch for 60 GHz resonance are found to be 2mm and 0.5mm, respectively. However, the dimension have been adjust and optimized to meet requirement of the resonant frequency and other characteristics. The design parameter are obtained from several parametric studies and suitable patch and slot size are selected for high gain. The primary design parameter are listed in Table 1.

Table 1 : Initial Design Paremeter

Parameter	Value
Thickness (h)	0.127 mm
Dielectric constant (ε_r)	2.20
Loss tangent	0.0009
Patch Size (W x L)	1.84 x 1.50 mm^2
Ground Plane (W_g x L_g)	3.6 x 4.3 mm^2
Total Antenna Profile	3.6 x 4.3 x 0.127 mm^2
Substrate	Roger RT5880

The geometry of the three shape microstrip antenna designed for 60 Ghz is shown in fig. 3. The antenna has overall dimension of only 1.8 x 1.50mm^2 . A copper plate as a ground with dimension 3.6 x 4.3 mm^2 and thickness is 0.035mm.

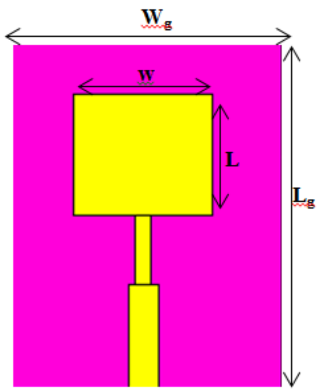

Figure 2: Geometry of the antenna

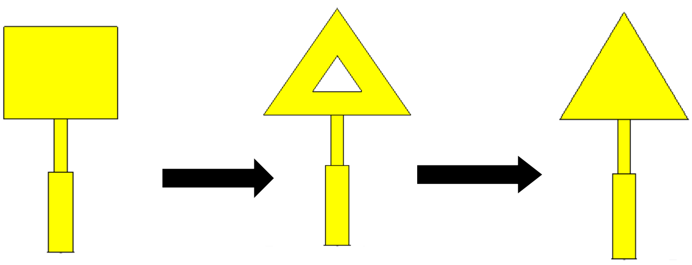

Figure 3 : Evolution shape of the antenna

3. Simulation And Result

The simulation of the proposed antenna is performed using Computer Simulation Technology (CST) Microwave Studio commercial software program. The simulated results of the reflection coefficients $|S_{11}|$ for the proposed milimeter-wave antenna are illustrated in Fig. 4. It is apparent that the proposed antenna can cover millimeter-wave bands of 60 GHz for $|S_{11}|$ less than -10. The simulated maximum realized gain of the proposed antenna . A stable gain for rectangular antenna with a value 7.32 dB in the frequency at 60 GHz and with return loss -20.89 dB is observed and gain at 8 db for triangle antenna with frequency at 61.93 GHz with -10.155 db return loss, meanwhile for trianglewith slot antenna the gain is 7.75 db at frequency at 56 GHz and return loss is -29.23 db. Simulated results demonstrate that the antenna is characterized by omnidirectional patterns.

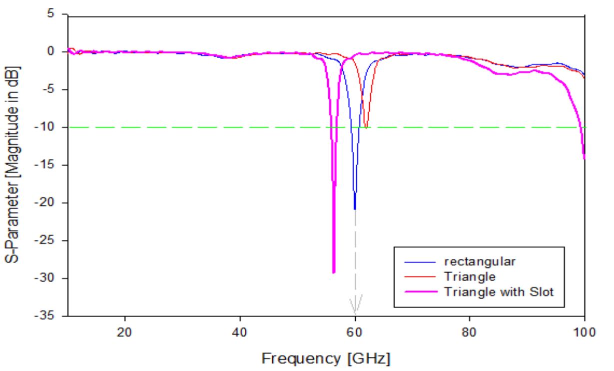

Figure 4: Simulated S_{11} characteristics of the three different antennas [magnitude in dB]

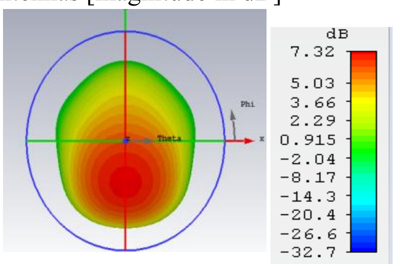

Figure 5a : 3D radiation pattern for rectangular antenna

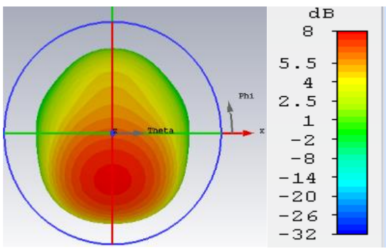

Figure 5b : 3D radiation pattern for triangle antenna

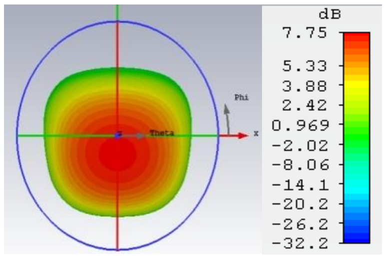

Figure 5c: 3D radiation pattern for triangle with slot

Table 2 : The Final Performance Antenna Configuration

Antenna Shape	Return Loss in db	Gain in db	Frequency range (GHz)
Rectangular	-20.89	7.3	60 GHz
Triangle	-10.155	8	61.93 GHz
Triangle with slot	-29.23	7.55	56.35

Table 2 summarizes the final antenna performances. The perforances of the proposed antenna such as return loss, gain and frequency rang.Gain is highly sensitive to change of the slot, truncated, and shape of the antenna. Thus, the slot of the antenna are adjusted to get the optimized result as high gain and return loss of the antenna.

4. Conclusion

In this paper, the design of a milimeter-wave antenna has been proposed for a short range and high speed rate wireless application 60 GHz. The antenna configuration is designed and analysed by using CST software based on the finite element method. From the anaylsis, its can be concluded that the different shape of the antenna can influence the return loss, gain and frequency. The triangle with slot antenna has a good result of return loss ,S_{11} compare to rectangular and triangle antenna, meanwhile for the best gain is rectangular antenna. As we can see, the result of simulation antenna are achieved for the 5G wireless communication.

Acknowleddgements
This work was supported by High Ministry of Eduacation Malaysia under the Fundamental Research Grant Scheme (FRGS) #9003-00556

References

1. Alam, M. S., Islam, M. T., Misran, N., & Mandeep, J. S. (2013). A Wideband Microstrip Patch Antenna for 60 GHz Wireless Applications. *Elektronika ir Elektrotechnika*, *19*(9), 65-70.

2. Kathuria, N., & Vashisht, S. (2016, March). Dual-band printed slot antenna for the 5G wireless communication network. In *Wireless Communications, Signal Processing and Networking (WiSPNET), International Conference on* (pp. 1815-1817). IEEE.

3. Smulders, P. (2002). Exploiting the 60 GHz band for local wireless multimedia access: Prospects and future directions. *IEEE communications magazine*, *40*(1), 140-147

4. Biglarbegian, B., Fakharzadeh, M., Nezhad-Ahmadi, M. R., & Safavi-Naeini, S. (2010, July). Optimized patch array antenna for 60 GHz wireless applications. In *Antennas and Propagation Society International Symposium (APSURSI), 2010 IEEE* (pp. 1-4). IEEE.

5. Goyal, R. K., & Sharma, K. K. (2016, September). T-slotted microstrip patch antenna for 5G Wi-Fi network. In *Advances in Computing, Communications and Informatics (ICACCI), 2016 International Conference on* (pp. 2684-2687). IEEE

6. Hannachi, C., & Tatu, S. O. (2016). Performance comparison of 60 GHz printed patch antennas with different geometrical shapes using miniature hybrid microwave integrated circuits technology. *IET Microwaves, Antennas & Propagation*.

7. Garg, R., & Long, S. A. (1988). An improved formula for the resonant frequencies of the triangular microstrip patch antenna. *IEEE transactions on antennas and propagation*, *36*(4), 570.

8. Karnfelt, C., Hallbjorner, P., Zirath, H., & Alping, A. (2006). High gain active microstrip antenna for 60-GHz WLAN/WPAN applications. *IEEE Transactions on Microwave Theory and Techniques*, *54*(6), 2593-2603.

9. Li, W. (2007, February). Performance of Ultra-Wideband Transmission over 60GHz WPAN Channel. In *Wireless Pervasive Computing, 2007. ISWPC'07. 2nd International Symposium on*. IEEE.

10. Md.Mamunur Rasid, Saddam Hossain, "Antenna Solution for Milimeter wave Mobile Communication (MWMC): 5G*," International Journal of Scientific Research Engineering & Technology (IJSRET)*, ISSN 2278-0882, vol. 3, issue 8, 2014