Designing a tri-band microstrip antenna for targetting 5g broadband communications

Ahmad Firdausi [1*], *Galang* Hakim [2] and *Mudrik* Alaydrus [3]

Department of Electrical Engineering, Universitas Mercu Buana, indonesia

Abstract. One of the technologies that has wireless application nowadays was 5G mobile communication.This paper presents the designing of a Tri-band microstrip antenna for targeting 5G broadband communications,This element antenna has 3x3 rectangular patches with feeding line structures are branched. With the use of double feeding proximity coupling structure, we intend to maximize antenna bandwidth, therefore the antenna cover range tri-band frequency from 40 GHz to 70 GHz. The reflection factor comparation between simulation and measurement has a minimum with respective frequency at 45.3 GHz, 57 GHz, and 66 GHz. The total measurement bandwith 11.5 Ghz. With this combination tecnique, the proposed antenna is a promising candidate for 5G communication systems.

1 Introduction

Wireless communication is on one of the frontier technologies that has been widely used in modern application. It was the modern technologies that has evolved in very fast way. One of the technologies that has wireless application nowadays was 5G mobile communication. 5G wireless mobile communication that employs millimeter wave offers high speed wireless data transfer. Because of this wireless data transfer feature, this technologies has been developed into different field such as Internet of Things (IoT), Smart Cities, Etc [1].

The use of milimeter wave frequency has an impact in decrease of the mobile phone antenna dimensions. The conventional antennas was replaced with microstrip antenna structure. With its features such as small and light weight, the microstrip patch antenna has emerged as the best candidate for mobile communication device [2]. Problems arise because the nature of its application, a 5G applications that employs millimeter wave has a very wide frequency spectrum from 30 GHz to 300 GHz [3].

To solve this problem, we proposed a tri-band microstrip antenna design to be used in millimeter wave frequency for targetting 5G application. Several researches have been made for this particular topic but the closes one is by Bondarik-Sjoberg [4].

[*] Corresponding author: ahmad.firdausi@ymail.com

2 Microstrip antenna design

In this research,we propose a proximity coupling [5] to be used in microstrip antenna design, because from previous research the proximity couple technique produced a significant increase in bandwidth . The Microstrip antenna was to be design at following band, first band was 45.3 GHz, Second Band was 57 GHz, and the third band was 66.6 GHz. This frequency bands was allocated for the mobile communication following the regulation of the allocation usage designation by the National Telecommunications and Information Administration Office of Spectrum Management USA [6]. The tri-band microstrip antenna design is based on double microstrip antenna that has been reasearch as a milimeter wave application [7].

2.1 Design of the Ground Structure

Based on design of the ground structure by Bondarik-Sjoberg, we proposed to applied the same design to coupling the patches on the top antenna side. Figure 1 shows ground structure for antenna design. Geometry for ground structure was *L= 10 mm, W = 5 mm*. Proximity couple combination design patch grid in the radiating element is applied for microstrip structure tri-band antenna characteristics. The antenna substrate is Rogers RO3003 (ε_r =3, tan δ=0.0013) with a thickness of 0.51 mm.

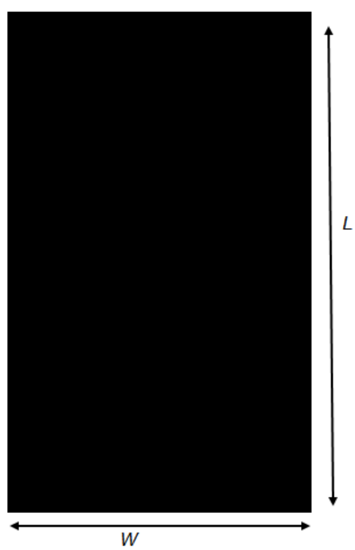


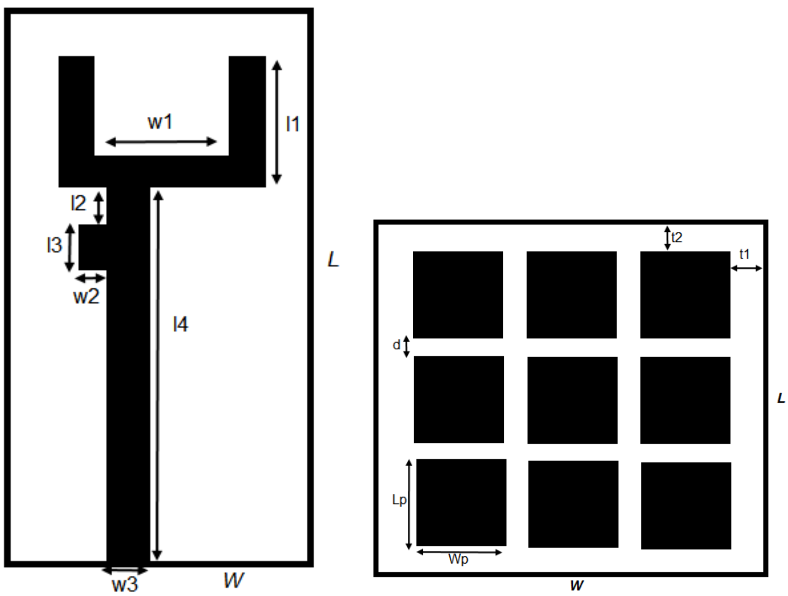
Fig 1. Ground structure

2.2 Design Feeding Structure

The line feeding structures are branched, therefore for radiating elements there are two feeding point. Figure 2 shows the feeding element structures. To maximize antenna bandwidth the double feeding structure (double-fed proximity) was used [8, 9]. We also applied stub in feeding system to adding the antenna multiband characteritic. The stub at feeding line also function as a capacitive stub that works to reduce inductive that produce in the double feeding system [10]. The stub design length was *l*3 = 0.38 mm and has width *w2*=0.25 mm. See table 1 for another additional dimensions that needed for feeding structure.

Table 1. Dimension of feeding antenna

Symbol	Dimension (mm)
W	5
L	10
w1	1.2
w2	0.25
w3	0.4
l1	1.4
l2	0.25
l3	0.38
l4	6



(a) (b)

Fig 2. (a) Feeding structure , (b) Radiating elements structure

2.3 Design of the patch layer 2 structure

Table 2. Dimension of radiating elements

Symbol	Dimension (mm)
W	5
L	5
t1	0.45
t2	0.51
d	0.25
Lp	1.16
Wp	1.2

The final antenna structure is constituted by two layers. The first layer (bottom layer), there are feeding structure that connect with 50 Ω microstrip line that feeding the second layer. On the second layer (upper layer), the radiating elements structures are multiple rectangular patch antennas design. This element has 3x3 rectangular patches with no interconnected between patched.

3 Simulation and measured results

In this research, we use ANSY Electronic Desktop HFSS version 16 to simulate the final antenna design. The three dimensional radiation pattern simulated by HFSS is shows at figure 4, it has gain about 5.66 dBi

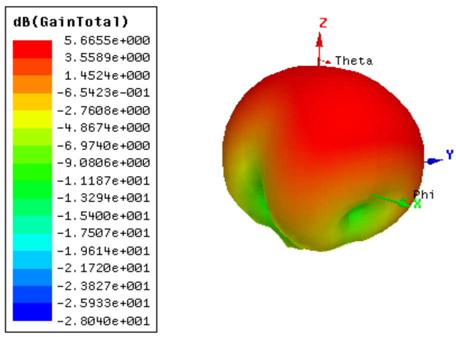
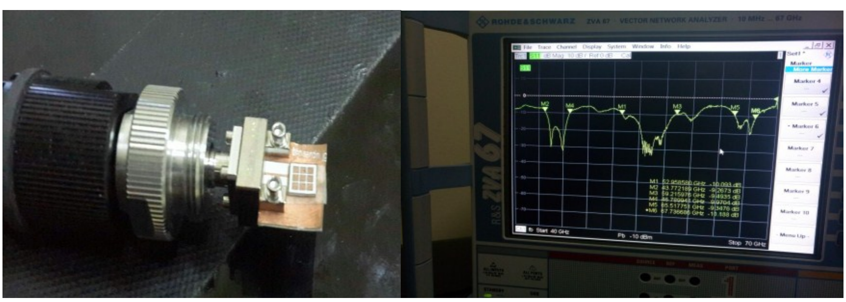


Fig. 4. The microstrip antenna simulation for three dimensional radiation pattern



(a) (b)

Fig. 5 The final antenna design (the feeding, the rectangular patch structure, and ground at back side substrate) after fabricated. (b) The measured reflection factor of the antenna.

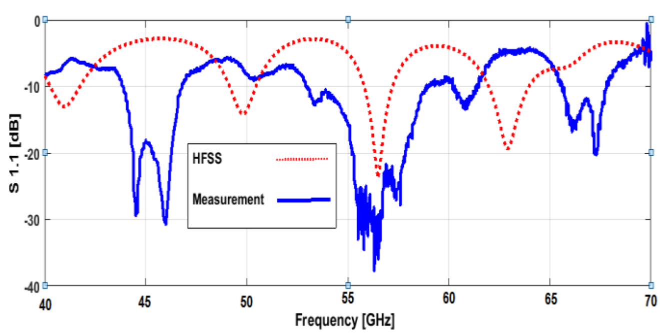


Fig. 6. The reflection factor antenna with HFSS (dashed) and measured (solid).

Figure 6 shows the measurement result for the final antenna design. The minimum reflection factor measurement (solid curve) is at 45.3 GHz, 57 GHz, 66.62 GHz. The total measurement bandwith was 11.5 Ghz. The minimum reflection factor simulation (dashed curve) is at 41 GHz,50 GHz , 57 GHz ,63.2 GHz. There is a shifting in frequency at about 3 GHz from simulation and measurement reflection factor comparison results.

4 Conclusion

This microstrip antenna design was working at 45.3 GHz, 57 GHz, 66.62 GHz frequency range. This is the product of adding the stubs to the feedline design that can produce multi frequency. The tuning stub combine with proximity coupling for patches has produce the required bandwidths at respected frequency, this techniques produce total bandwidth of 11.5 GHz. There is a shifting in frequency at about 3 GHz from simulation and measurement reflection, we believe this is happen because fabrication antenna was not very precision and inaccuracy in placing the upper layer in the prototype during measurement

References

1. Suresh Borkar & Himangi Pande, Application of 5G Next Generation Network to Internet of Things, International Conference on Internet of Things and Applications(IOTA) (2016)
2. Shivangi Verm,Leena Mahajan,Rajesh Kumar,Hardeep Singh Saini,Naveen Kumar ‘A Small Microstrip Patch Antenna for Future 5G Applications’, 5th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) (2016)
3. P. Roy, R. K. Vishwakarma, A. Jain, and R. Singh, “Multiband Millimeter Wave Antenna Array for 5G Communication,” pp. 4–7, (2016)
4. Bondarik and D. Sj, “Gridded Parasitic Patch Stacked Microstrip Antenna with Beam Shift Capability for 60 GHz Band,” vol. **62**, no. January, pp. 319–331, (2015)
5. Dian Widi Astuti; Ahmad Firdausi; Mudrik Alaydrus ‘Multiband double layered microstrip antenna by proximity coupling for wireless applications’,15th International Conference on Quality in Research (QiR) : International Symposium on Electrical and Computer Engineering.,(2017)
6. United States Frequency Allocations The Radio Spectrum,U.S. Department Of Commerce National Telecommunications and Information Administration Office of Spectrum Management, (January 2016)
7. S. K. Goudos, A. Tsiflikiotis, D. Babas, and K. Siakavara, “Evolutionary Design of a Dual Band E-shaped Patch Antenna for 5G Mobile Communications,” pp. 17–20, (2017)
8. Bondarik, “Investigation of Reconfigurability for a Stacked Microstrip Patch Antenna Pattern Targeting 5G,” pp. 1202–1205.
9. J.-Y. Sze, and K.-L. Wong, ”Bandwidth enhancement of a printed wide slot antenna fed by a microstripline with a fork-like tuning stub,” Proceeding of ISAP, Japan, pp.1159-1162 (2000)
10. Ahmad Firdausi; Mudrik Alaydrus “Designing multiband multilayered microstrip antenna for mmWave applications”, International Conference on Radar, Antenna, Microwave, Electronics, and Telecommunications (ICRAMET) (2016)