A Wideband Rectangular Patch Microstrip Antenna using Quad-Slotted Ground Plane

Rudy Fernandez¹, Muhammad Auliam Ilham¹, Hanalde Andre¹, Firdaus²

¹Electrical Engineering Dept., Universitas Andalas ²Electrical Engineering Dept., Politeknik Negeri Padang

*rffernandez@eng.unand.ac.id

Abstract. This research proposes the use of a quad-slotted ground plane in enhancing the bandwidth of rectangular patch microstrip antenna. A feeding line is used for exciting the antenna patch. On the ground plane, there are 4 slots which are designed in a rectangular form with the same dimension. Each slot has a height of 22.5 mm and a width of 15.4 mm. The antenna is designed on FR4 epoxy which has a dielectric constant of 4.4 and a thickness of 1.67 mm. The result shows that the return loss of -14.51 dB in the operating frequency of 1,810 MHz in the LTE Band 3 Frequency, VSWR is 2.19 and the gain is 3.2 dBi. The achieved bandwidth of 200 MHz can cover the frequency range of the LTE Band 3.

1. Introduction
In Indonesia, Long Term Evolution (LTE) operating frequencies have been regulated by the Indonesian Government in Peraturan Menteri Komunikasi dan Informatika Republik Indonesia nomor 27 Tahun 2015. The LTE Frequencies comprise of 5 bands which are band 1, 3, 5, 8 and 40. Band 3 has a frequency range for the uplink from 1710 MHz to 1785 MHz and the downlink from 1805 MHz to 1880 MHz [1]. Band 3 provides uplink and downlink capacity of at least 150 MHz in total. This technology is designed to improve network capacity and speed [2], uses an antenna such as a microstrip antenna. Unfortunately, the antenna has a disadvantage which is a narrow band.

Diverse methods have been developed to broaden the bandwidth of the microstrip antenna. In [3], using a dual-layer substrate is applied to increase the bandwidth on band 40 LTE. An additional patch layer is put on top of a single layer antenna. The additional layer has the same dimensions as a single layer antenna layer but with no ground plane. The increased bandwidth requires a thicker antenna dimension. Research in [4] designs an array antenna with a dual-layer substrate for bandwidth enhancement. It can cover the band 3 LTE frequency range but with a relatively larger antenna dimension. Moreover, applying a rectangular ring slot etched on the patch is used for enhancing the bandwidth of an LTE antenna [5]. This antenna structure does not satisfy the required bandwidth. The three separate radiating elements are used in [6] resulting in a complexity design. Furthermore, the use of metamaterial with negative refractive index is chosen but requiring a challenge in analyzing [7]. Given the design and result of previous researches, this paper proposes a simple antenna design with four quad slots on the ground plane to get a wider bandwidth.
2. Methodology
A simple and conventional rectangular patch microstrip antenna is used as a basic design to operate in the center frequency of Band 3 LTE. As a substrate for the antenna, FR4 epoxy with a dielectric constant of 4.4 and a thickness of 1.67 mm is chosen. The substrate is economical and easy to find in the market.

The design of the antenna follows the outline and procedures as in [8] as seen in figure 1(a). It is optimized using an EM simulator software to meet a required parameter for a good antenna which is return loss ≤ -10 dB. The result shows that the return loss is achieved but with a narrow bandwidth as in figure 1 (b).

![Figure 1. The design of a conventional antenna (a) and simulated result (b)](image)

To cover the uplink and the downlink of Band 3 LTE, the antenna requires the bandwidth of 170 MHz. Regarding this requirement, this research proposes a quad slot over the ground plane. Each slot has the same dimension in a rectangular form with a fixed length of the gap between the slots.

In the initial design, the slot has a width of 5 mm and a length of 20 mm. After simulated and optimized, the width and the length get increased, becoming 15.4 mm and 22.5 mm respectively as shown in figure 2.

![Figure 2. The geometry of the proposed slot in the ground plane](image)
The increase followed by slight adjustment in the patch which is the length reduced as in figure 3.

![Figure 3. The geometry of the proposed antenna](image)

### 3. Result and Discussion

The proposed antenna is simulated using an EM simulator to show the performance of the antenna. It is based on the antenna parameters which are return loss, VSWR, gain, and radiation pattern.

![Figure 4. The simulated return loss (a) and VSWR (b)](image)

![Figure 5. The simulated radiation pattern of antenna](image)
Figure 4 (a) and (b) shows that the return loss of the antenna in operating frequency is around -17.91 dB and VSWR is 1.296. The bandwidth is 192.8 MHz in the frequency range of 1706.9 – 1899.7 MHz, whereas the gain of the antenna is 3.2 dBi. The simulated radiation pattern of antenna is shown in figure 5.

The hardware realization of the rectangular microstrip patch antenna with quad-slots is carried out by fabricating the simulated antenna. The fabricated antenna is shown in figure 5.

![Fabricated Antenna](image)

**Figure 6.** The fabricated antenna in front view (a) and back view (b)

The performance of the fabricated antenna is measured by connecting to a Network Analyzer based on the antenna parameters. The return loss and VSWR of both simulated and fabricated antenna are compared in figure 6.

![Comparison of Return Loss and VSWR](image)

**Figure 7.** The comparison of simulation (dashed line) and measurement (solid line) result in return loss (a) and VSWR (b)

The result data of the antenna parameter for simulation and measurement are compared and presented in table 1.

| Antenna Parameter | Simulation  | Measurement |
|-------------------|-------------|-------------|
| Return Loss (dB)  | -17.91      | -14.51      |
| VSWR              | 1.29        | 2.19        |
| Bandwidth (MHz)   | 192.8       | 200         |
| (Frequency Range) | (1706.9 – 1899.7) | (1710 – 1910) |
From table 1 shows that even the return loss and VSWR of simulation results has slightly better value than measurement results. In terms of bandwidth, both results can cover the frequency range of Band 3 LTE while the measurement bandwidth is wider. Overall, the simulation result shows a good agreement with the measurement result.

4. Conclusion
The proposed antenna can cover the operating frequency range of band 3 LTE. The simulated antenna shows a good agreement with the fabricated antenna. The measurement result shows that the return loss of -14.51 dB in the operating frequency of 1,810 MHz in the LTE Band 3 Frequency, VSWR is 2.19 and the gain is 3.2 dBi. The quad-slotted in the ground plane is proven to enhance the bandwidth which is 200 MHz.

Acknowledgment
This research is funded and supported by a research grant for Dosen Jurusan Teknik Elektro Unand and by an International Conference Grant program from Universitas Andalas Tahun Anggaran 2019.

References

[1] Menkominfo, “Peraturan Menteri Komunikasi dan Informatika Republik Indonesia Nomor 27 Tahun 2015 tentang Persyaratan Teknis Alat dan atau Perangkat Perangkat Telekomunikasi Berbasis Standar Teknologi Long Term Evolution,” in Kementerian Komunikasi dan Informatika Republik Indonesia, 2015, pp. 1–11.
[2] 3GPP, “TS 136 101 - V8.3.0 - LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (3GPP TS 36.101 version 8.3.0 Release 8),” 2008.
[3] R. Fernandez and F. A. Pratama, “Penggunaan Dual-Layer Substrate untuk Meningkatkan Bandwidth Antena Mikrostrip pada Frekuensi LTE,” J. Nas. Tek. Elektro, vol. 7, no. 2, pp. 117–121, 2018.
[4] R. P. Hariyadi, Tommi. Megantara, “Directional 2x2 MIMO Microstrip Antenna Design and Optimization for LTE Band-3 Application,” in 2018 5th International Conference on Information Technology, Computer and Electrical Engineering (ICITACEE), 2018, vol. 5, pp. 161–166.
[5] C. Chiang, P. Liu, C. Tseng, and C. Hsu, “Planar Microstrip-fed Rectangular Antenna for LTE Applications,” in 2018 International Conference on Microwave and Millimeter Wave Technology (ICM2T), 2018, vol. 7, no. 2, pp. 1–4.
[6] U. Kumar, D. K. Upadhayay, and B. L. Shahu, “Improvement of performance parameters of rectangular patch antenna using metamaterial,” in 2016 IEEE International Conference on Recent Trends in Electronics, Information and Communication Technology, RITEICT 2016 - Proceedings, 2017, pp. 1011–1015.
[7] Y. Zhao, “Dual-wideband microstrip antenna for LTE indoor base stations,” Electron. Lett., vol. 52, no. 8, pp. 576–578, 2016.
[8] C. A. Balanis, ANTENNA THEORY, 3rd ed. New Jersey: John Wiley and Sons, Inc., Publication, 2005.