The use of edge cut on microstrip antenna patch with the modified partial ground plane for bandwidth enhancement

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Abstract. This research proposes the use of edge cut on the antenna patch with a modified partial ground plane to overcome the inherent characteristic of the microstrip antenna, which is narrowband. The antenna has to cover all of the LTE frequency bands, which is from 0.824 – 2.4 GHz. FR4 epoxy with a dielectric constant of 4.4 and a thickness of 1.67 mm is used as a substrate for the antenna. The proposed antenna is simulated by an EM Simulator. The simulated results show that the return loss of -18.82 dB and the VSWR of 1.25. These parameters confirm that the antenna is well-matched along with the LTE bands. This wideband antenna has a directional radiation pattern with a maximum gain of 4.65 dB.

1. Introduction

Long Term Evolution (LTE) technology, also known as 4G technology, has been launched in Indonesia since 2013. This technology works in 5 different band frequencies, namely LTE band 1, 3, 5, 8, and 40 as regulated by Peraturan Menteri Komunikasi dan Informatika Republik Indonesia nomor 27 Tahun 2015[1]. Each band has different uplink and downlink frequency ranges.

Mobile communication systems that work on LTE frequencies use antennas to transmit and receive information in the form of radio waves. The antenna used is small, thin, and light. A microstrip antenna is an antenna that meets these criteria. The manufacture of this antenna uses printed-circuit technology so that it can be made in a variety of forms. In contrast, this antenna has a narrow bandwidth [2]. Therefore, it is impossible to cover all of the LTE band frequencies.

Various methods have been proposed to increase the bandwidth. The use of antenna array [3] achieves the bandwidth but the antenna dimension getting relatively larger. The air gaps [4] between the substrate and ground plane acts as an additional layer that presents a challenge in fabrication as well as thickness increased. Then the use of Electromagnetic Bandgap (EBG) structure[5]-[6]. The use of metamaterials with negative refractive index is also an option but provide challenges in analysing [7]. In [8] slit and slot are applied in the patch to get wider bandwidth. Finally, a slot in the form of X is applied in the patch with proximity coupled used as a feeding line to increase the bandwidth [9].

In this study, a rectangular microstrip antenna with the modified partial ground plane and the edge of the patch cut is proposed to have an antenna with a wideband characteristic to meet the required bandwidth for LTE band frequencies. Furthermore, a feeder line that directly connected to the edge of the patch is used as a feeding technique in the antenna.
2. Material and methods

The proposed antenna is based on a rectangular patch microstrip antenna. The antenna will be operated in all of LTE frequency bands (0.824 – 2.4 GHz) which is about 1576 MHz. FR4 epoxy with a dielectric constant of 4.4 and thickness of 1.67 mm is used as a substrate for the antenna. The substrate is relatively cheap and easy to find in the market.

The procedure in [2] is followed to have a preliminary design with a resonant frequency of 1612 MHz, as seen in figure 1. The designed antenna is simulated using an EM simulator software. The simulator evaluates the performance of the antenna whether it meets a required parameter for a good antenna which is return loss (RL) ≤ -10 dB. The simulated result shows that the bandwidth of the antenna is narrowband, as seen in figure 2.

![Figure 1. The preliminary design](image1)

![Figure 2. The simulated result of the antenna for Return Loss](image2)

The proposed antenna should be able to cover all of the LTE frequency bands from 824 MHz to 2400 MHz. The minimum bandwidth target is 1576 MHz. Therefore, the preliminary antenna has to be
optimised by modification on the patch and the ground plane to achieve the required bandwidth. The patch located on the upper side of the antenna is cut on both sides. The cut and its dimension are seen in figure 3(a). Then the ground plane section that is on the lower side where the copper part is reduced in such a way that it stays partially. This partial ground plane is applied two slots with the same dimensions and three slits with size and position as in figure 3(b).

![Figure 3](image)

**Figure 3.** The proposed antenna design

3. Results and discussion
The EM simulator is used to evaluate the antenna in figure 3. The evaluation is measured based on RL (figure 4), Voltage Standing Wave Ratio (VSWR) (figure 5), gain (figure6) and radiation pattern of the antenna (figure7).

![Figure 4](image)

**Figure 4.** The RL of the proposed antenna
As stated before, an antenna has to meet the required parameters of good antenna performance [2]. Figure 4 shows the return loss of the antenna is less than -10 dB along with the targeted bandwidth.
The minimum and maximum frequency are determined based on the required RL at these frequencies. They are 731.3 and 2517.5 MHz respectively. The bandwidth of the proposed antenna is 1786.3 MHz which is wider than the targeted bandwidth. The performance of the antenna also is confirmed by the result of simulated VSWR in Fig.5. It shows that the value of VSWR is below 2 as needed, along with the bandwidth. These parameters, RL and VSWR, show that the antenna is well-matched.

The antenna is also required to have better gain, which indicates how strong a signal an antenna can send or receive in a specified direction. The maximum gain of the antenna from figure 6 is about 4.65 dB. Also, the radiation pattern of the antenna is directional, as shown in figure 7.

All of the parameters of the proposed antenna is presented in table 1. The table shows the comparison of the parameters between the preliminary antenna and the proposed antenna. The value of RL and VSWR in the table is the minimum value that each antenna can get.

| Antenna Parameter | Preliminary | Proposed |
|-------------------|-------------|----------|
| Return Loss (dB)  | -10.310     | -18.82   |
| VSWR              | 1.8         | 1.25     |
| Bandwidth (MHz)   | 30          | 1786.3   |
| (Frequency Range) | (2200 – 2230) | (731.3 – 2517.5) |

These parameters show that the proposed antenna has a wideband characteristic to operate in the desired bandwidth.

4. Conclusions

The proposed antenna that can work in all of the LTE frequency bands has been successfully designed and simulated. The simulation results show that the antenna has RL of -18.82 dB, VSWR of 1.25 with the bandwidth of 1786.3 MHz. The result confirms that the use of edge cut on the patch with the modified partial ground plane can enhance the bandwidth of the antenna.

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