

Multi Bands Antenna for Wireless Communication and Mobile System

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Abstract— Wireless and mobile communication is common trend in this era, everyone need internet access to check email, reply message and others that need internet to access it. Frequency bands is natural resource with limited spectrum and cannot create, thus utilize of spectrum and maximize user is required to serve for many users. This letter propose a new antenna design with slots that covered multiple bands common used in mobile communication and long-term evolutions (LTE) system. A single patch antenna operating at 2.6 GHz for LTE band was first designed and then optimization by introducing slots on antenna patch has been done to improve the antenna's bandwidth (BW). As a transmitter antenna requires high gain for effective transmission, air gap and aluminum plate are used as ground element in order to achieve high gain performance. The reflection coefficient of initially designed single patch antenna gives a single band response. However some slots and array elements are introduced into the antenna to obtain multi band response, which covers a few bands. The results obtained from reflection coefficient have shown that the proposed patch antenna is suitable in such telecommunication system applications as GSM, UMTS, LTE, WLAN and WiMAX. The result of simulation reflection coefficient is -34 dB at centre frequency 2.6 GHz and antenna gain is 8.21 dBi. Proposed antenna also made from inexpensive material FR4 that can be found in normal supplier, beside that with ground element made from aluminum material also easy to get with reasonable price.

Keywords— Antenna, Wireless, Microstrip, Slot.

I. INTRODUCTION

SINCE introduced of wireless technology a few decades ago, wireless devices are now commonly used in communication systems, medical and industrial applications, games console, to mention a few. In telecommunication systems, wireless technology is commonly used especially in mobile communication. Nowadays a mobile

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phone is not only used for voice communication but also often used for transferring data, images and videos. Third generation (3G) technology attempts to use a mobile phone for video call and now LTE; while the fourth generation (4G) technology is expected use mobile phone as broadband media, that support high speed data rate. In order to achieve these requirements, several methods have been proposed; and one of such methods is antenna diversity and spatial multiplexing. A new high-gain antenna design for transmitter, operating at LTE band 2.6 GHz, is proposed in this letter.

Frequency band for wireless and mobile communication is natural resources with limited bands and many cellular operator or provider has difficulties to obtain. Some countries with many numbers of operators complain each others because of interference and disturbing service to client. On the other hand with many operator government also has problem to give and control spectrum. Some research have been propose to control and avoid interference in spectrum such as wrote in [1] to design quad bands but limited to receiver device with low gain, the other paper is to achieve high performance in wireless system is by introducing beamforming and smart antenna system with MIMO as in [2-3]. Another references to improve quality and services in wireless communication is implement of full MIMO antenna to the system, where by apply multi antenna that can improve service and data rate of wireless system and also will reduce interference because system has specific antenna to serve every client, some literature has been wrote as [4-5].

In most of the previous researches, it was found that the LTE antenna was mostly used for mobile devices, such as installation in laptop, mobile phone and gadget [6-8]. A design of an antenna with spiral technique mentioned in [9] then in this proposed antenna design introduce some slots to obtain multiple bands antenna. LTE antenna techniques especially for transmitter, have been highlighted in [10-11]; however, the antenna gains are generally low and their radiation pattern is omni directional [12-14]. Wide band antenna is one of the objectives in this proposed antenna design, several method and technique to achieve wideband reflection coefficient such as mention in [15]. The proposed antenna in this study operates at LTE band and has directional radiation pattern. Directional radiation pattern and multiple bands have been introduced in order to obtain a high gain antenna.

II. ANTENNA DESIGN

Typically a transmitter or base station (BS) has multiple antennas for a few sectors of coverage area and high gain antennas are used for efficiency of transceiver. Thus, with the current trends in setting up base transceiver system (BTS), the microstrip antenna technique is usually employed to design a directional antenna [16]. The design of microstrip antenna was started by calculating the basic size of patch. A centre frequency of 2.6 GHz LTE band has been chosen in this design. The material used is FR4 board with following specifications: relative permittivity $\epsilon_r = 4.7$, height $h = 1.6$ mm and $\tan \delta = 0.019$. The basic equation of microstrip antenna was used to calculate width (W) and length (L) of patch [16]. Figure 1 shows basic design of microstrip antenna with length and width of patch.

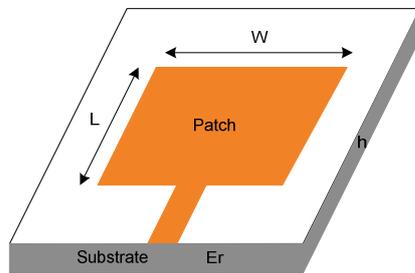


Fig. 1. Basic microstrip antenna.

$$W = \frac{1}{2 f_r \sqrt{\mu_0 \epsilon_0}} \sqrt{\frac{2}{\epsilon_r + 1}} = \frac{v_0}{2 f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

$$L = \frac{1}{2 f_r \sqrt{\epsilon_{eff} \mu_0 \epsilon_0}} - 2 \Delta L \quad (2)$$

where:

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-1/2} \quad (3)$$

$$\frac{\Delta L}{h} = 0.412 \frac{(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.8 \right)} \quad (4)$$

The size of antenna patch has been optimized done to meet reflection coefficient in LTE band 2.6 GHz. Next step is to optimize response in wideband or multiple bands that cover others frequency bands in telecommunication such as GSM, UMTS, WLAN and WiMAX. The single patch antenna design is shown in Figure 2 in which slots have been introduced to achieve wideband and multiple frequency response. Note that all dimensions are in millimetre (mm).

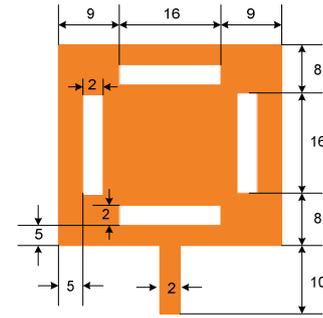


Fig. 2. Single patch antenna design with slots.

As previously mentioned, a BS requires a high gain antenna for efficient transceiver. In this design, an antenna is proposed with array patch to increase gain and which used air gap [17]. The number of patches is 4 x 4; then they are arranged and optimized to achieve optimum reflection coefficient and multiple bands response. Figure 3 shows the complete diagram of proposed antenna with array 4x4. Some transmission lines are introduced as feeding to the port at the back of antenna.

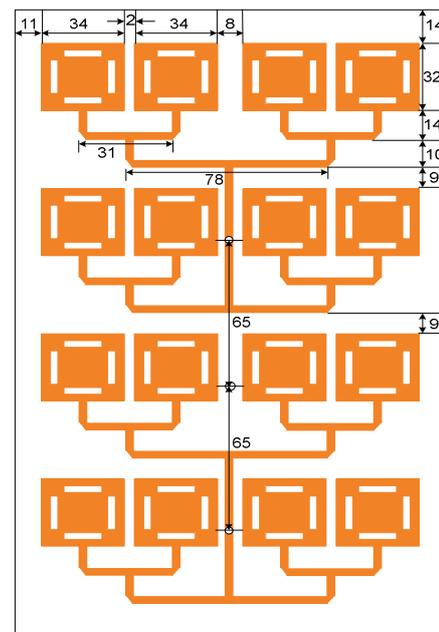


Fig. 3. Proposed high gain array antenna.
(NB: All dimensions are in mm)

The proposed antenna structure is presented in Figure 4, where Figures 4 (a) and (b) represent the feeding line of the patch's bottom layer and the used air gap between ground and antenna patch, respectively. Aluminum of 1 mm thickness was used for antenna ground, while the air gap is 10 mm to the patch antenna. The SMA bulkhead socket of 50 Ohms impedance was used for the antenna port. The typical connector was drawn and simulated by using 3D CST simulation software.

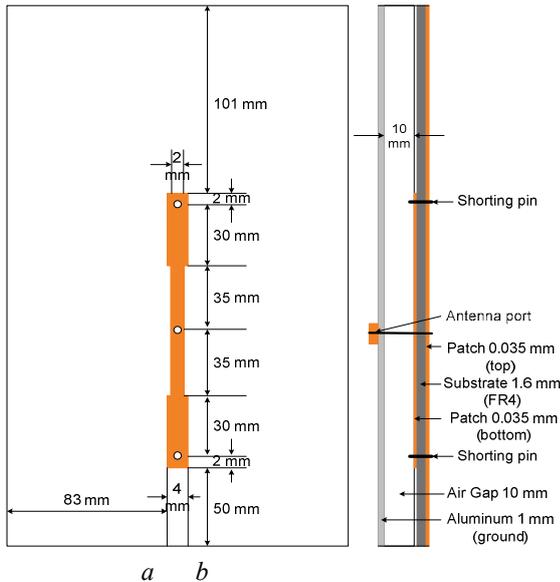


Fig. 4. Proposed antenna structure (a) FR4 back view (b) Side view.

III. MEASUREMENT SETUP

The measurement setup is aimed at testing the antenna E-field and H-field radiation patterns. Graphs are then plotted to analyze the performances. A centre frequency of 2.6 GHz was used for testing the antenna, which complies with the LTE standards. The test results obtained from the measurement would be compared with the standard requirements to ascertain the acceptability of the proposed antenna. The fabricated array antenna is shown in Figure 5 (a), while a SMA connector bulkhead type is shown in Figure 5 (b). As earlier mentioned, the connector is attached at the ground element of antenna for feeding line connection. The radiation patterns of E-field and H-field, as well as antenna gain will be performed in these measurements.

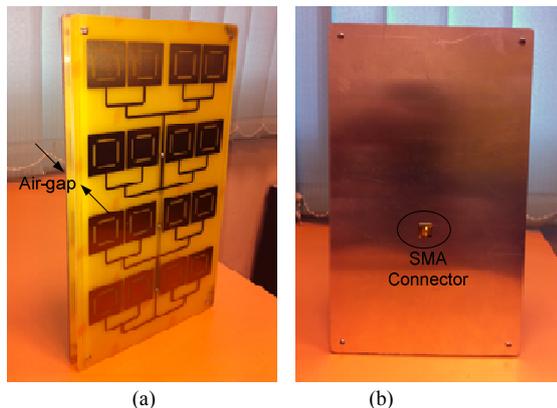


Fig. 5. Fabrications of (a) array antenna (b) ground element.

Figure 6 shows a block diagram of measurement setup of test antenna in anechoic chamber, a transmitter antenna used

to send radio power to be receiving by test antenna and system will record every signal strength values. In this antenna testing, system able to perform automatically to rotate test antenna as represent angle, record and plot a radiation pattern graph in a computer.

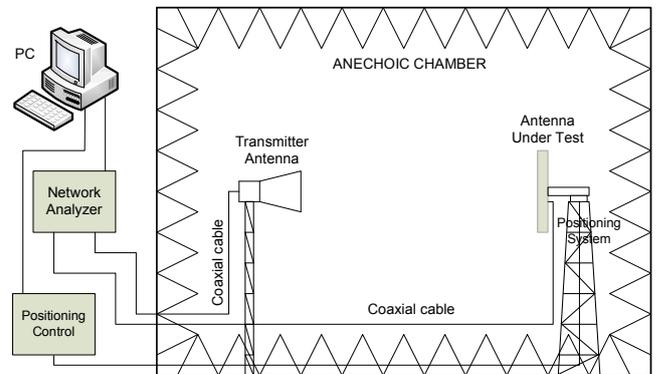


Fig. 6. Block diagram of measurement setup.

Figure 7 shows the test antenna being installed at test gauge in an anechoic chamber room. The test antenna is able to rotate in all directions. Referring to the common measurement setup, a transmitting antenna was used to transmit power to the proposed antenna, and sensitivity of the transmitted signal was recorded by the computer. The antenna performances were measured and tested in terms of both vertical and horizontal radiation patterns. Beside the radiation patterns, other antenna parameters such as gain, efficiency and impedance matching were also measured.

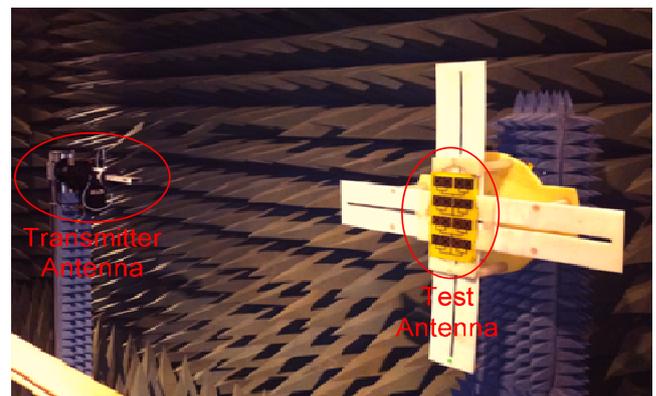


Fig. 7. Test antenna installed at test gauge in anechoic chamber room.

IV. RESULTS AND DISCUSSION

Figure 8 shows basic simulation of single patch antenna and the results of minimum reflection coefficient. By introducing slots and air gap, a better response was obtained in terms of reflection coefficient and antenna gain. Besides, multiband response was also obtained. Some optimization exercises were performed to achieve acceptable response in

reflection coefficient as required and standardized. The air gap was adjusted from 5 mm to 15 mm. 5 samples were run in the parametric study, and the optimal value of air gap (10 mm) was chosen. The slot dimensions (width and length) were also adjusted, by optimization process, and again the optimal values were obtained (slot size is 2 mm by 16 mm). Arrangement of slots location is crucial, because poor results, as in reflection coefficient and radiation pattern, would be obtained if the slots are misplaced.

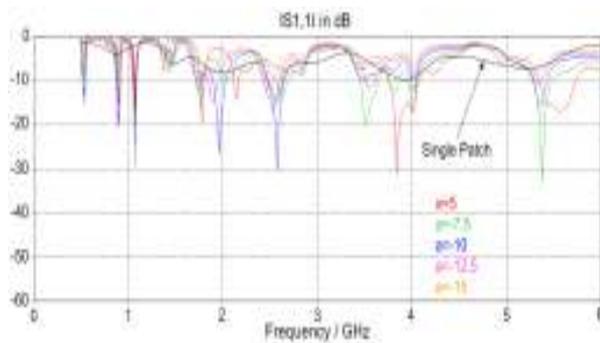


Fig. 8. The antenna array reflection coefficient.

Referring to optimization results presented in Figure 8, slots were introduced in antenna design, and the air gap between patch and ground element was 10 mm. The simulation and measurement results of the final stage of the proposed LTE transmitter antenna are shown in Figure 9. It is observed that both simulated and measured reflection coefficients are in good agreement.

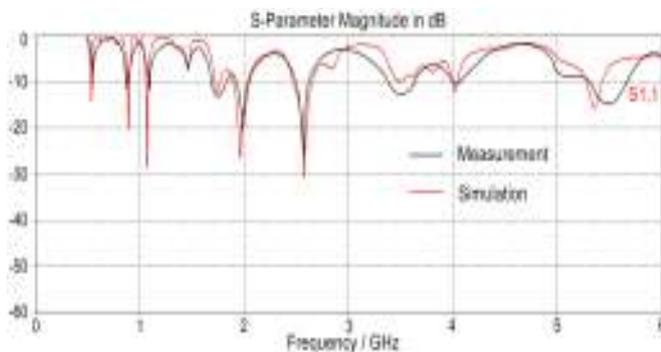


Fig. 9. Proposed array antenna reflection coefficient.

Both the simulation and measurement results have multiple responses, as shown in Figure 9. The most crucial response was observed at 2.6 GHz with maximum reflection coefficient being -34 dB. Other responses are at 900 MHz, 1.7 GHz to 2.7 GHz and 3.5 GHz. The response at 2.0 GHz is wideband, which covers both GSM 1800 and UMTS 2000 bands. The 2.4 GHz band can also be included for Wi-Fi application and the last one, 3.5 GHz covers the WiMAX band and measured results are highlighted in Figure 9. According to the measurement results, the maximum value of reflection coefficient is -26 dB. Note that the main response is also at 2.6 GHz, which is the same as simulation results. Other responses

are scattered to some frequencies starting from 900 MHz until 3.5 GHz as shows in Figure 9. Overall, the proposed antenna has a wideband response of reflection coefficient, which makes it suitable for a variety of wireless technology applications.

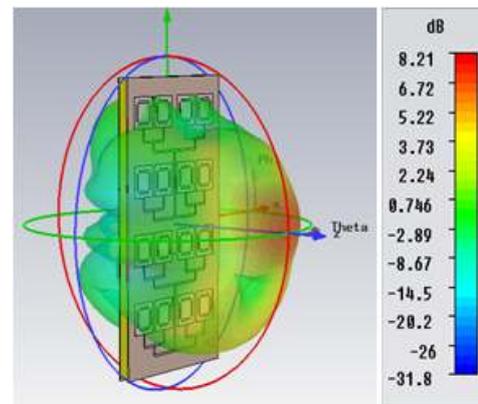
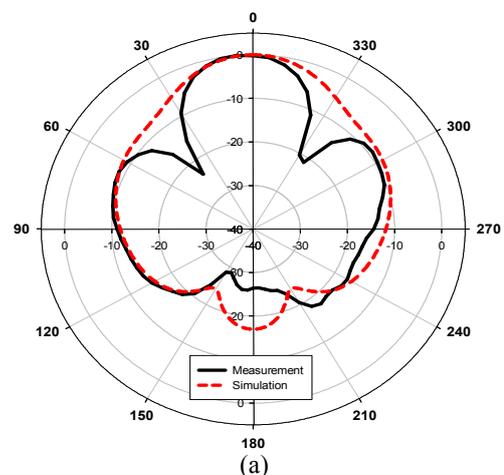


Fig. 10. Array LTE antenna radiation pattern in 3D.

The simulation results of radiation pattern in 3D are shown in Figure 10, where the beamwidth is 44° at -3 dB. The proposed antenna gain, as shown in Figure 10, is 8.21 dBi (maximum); which implies that it is applicable to use in BS due to its narrow beamwidth and high gain.

Measurements of radiation pattern have been done at the center frequency of 2.6 GHz as main response in reflection coefficient. The antenna polar radiation patterns of E-Field and H-Field are shown in Figures 11 (a) and (b) respectively. A directional beam is generated for the E-field at the antenna front, while a minor radiation was generated at the back. Both simulation and measurement results are in good agreement, though with minor shifting in the radiations. The proposed LTE antenna is able to radiate narrow beams forward with narrow beam and minor side lobe on left and right hand sides respectively.



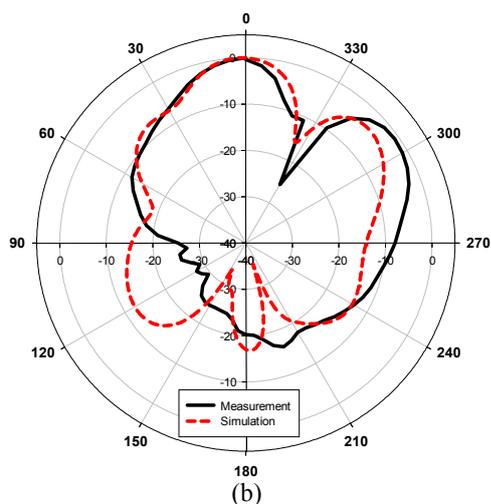


Fig. 11. Proposed antenna radiation patterns
(a) E-field (b) H-field.

V. APPLICATIONS

The proposed multi bands antenna as elaborate in previous is applicable and very potential market in wireless or mobile communication system, with fast growing of mobile communication infrastructure and gadget then most of everyone has smart phone or smart gadget to access internet. To support technology requirement in mobility access such Wireless LAN, Cellular communication, Radio Link, Wireless System, etc.



Fig. 12. Example of current cellular antenna installed.

Figure12 shows an example how current cellular antenna for mobile communication installed in a pole, with many antennas because every system has an antenna such as for GSM band, UMTS bands, LTE bands etc. With implementation of multi bands antenna expected to reduce and save space or area for the antenna and also cost and efficiency of the system.

The antenna with multiple band is not only can be apply in cellular or mobile communication but to others system such as wireless local area network (WLAN) because in the design covered spectrum of 2.4 GHz band. The design of antenna can give efficiency in term of space, cost, maintenance and other because in a packet of antenna with multiple bands. High gain of antenna make the design suitable and applicable for base station or transmitter with required high gain antenna, with this antenna can improve transmission distance and efficiency to the transmitter with minimum transmit power.

VI. CONCLUSION

A high gain antenna has been designed and measured in multiple bands for wireless communication system, especially for telecommunication in LTE band. The proposed antenna was simulated and fabricated using the standard FR4 material. The main response was observed at 2.6 GHz LTE band, with the maximum response being -34 dB. Other responses were also observed at GSM, UMTS, WLAN and WiMAX bands. The antenna also gives a wideband response from 1.7 GHz to 2.7 GHz while the reference of reflection coefficient is -6 dB. The antenna's radiation pattern has been measured in anechoic chamber, and both the simulation and measurement results are in good agreement. Overall, the proposed antenna is suitable for a transmitter due to its narrow beamwidth and high gain antenna.

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