Active Integrated Microstrip MIMO Antenna for Gain Enhancement

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***Abstract*—This paper discusses an active integrated microstrip antenna with multiple input and multiple output (MIMO) 2x2 element design. The active component as power amplifier is integrated with the rectangular patch antenna for gain enhancement at port 2 and port 4. The feeding technique used is aperture coupled to easily integrate the passive antenna with the power amplifier. Simulation result shows that the passive antenna excites gain of 2.5 dB at frequency 2.35 GHz, while with the addition of power amplifier is 16.15 dB. Therefore a gain enhancement of 13.65 dB is achieved. The measured gain of the active integrated antenna at port 2 is 11.6 dB while at port 4 is 11.4 dB. Moreover, measurement result shows impedance bandwidth of 190 MHz at port 2 while 200 MHz at port 4.**

Keywords—active integrated antenna; MIMO; power amplifier; gain enhancement.

I. INTRODUCTION

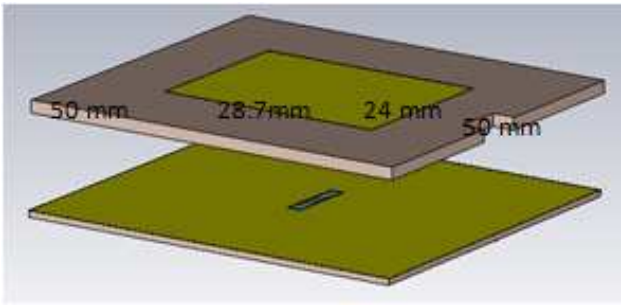
Multiple-input-multiple-ouptu (MIMO) is used for advanced communication systems like WiFi, WiMAX and LTE [1]. This technology can increase the data rate transfer, has higher network capacity and better reliability [2]. Moreover, to support communication systems especially for customer premises equipments (CPE), therefore there is a need to have communication devices with characteristics low profile, light and compact.

Microstrip antenna is a suitable candidat for this requirement. However, due to small size, usually this results to low antenna gains. To enhance the gain without enlarging the antenna or arraying the antenna, several methods were conducted. Some have used double negative superstrate (DNG) [3] and metamaterial superstrate [4].These methods have increased to 2 dB of antenna gain. Another method for gain enhancement is integrating the passive antenna with active components for power amplifier or known as active integrated antenna (AIA).

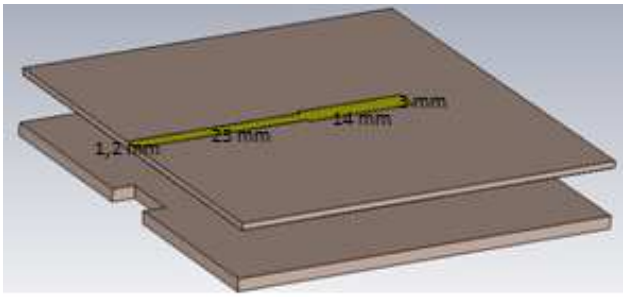
Many publications about microstrip antenna was designed with MIMO characteristic [5]-[6], however for AIA MIMO configuration, the author have not found any related publications. Publications were found about AIA with power amplifier was for other applications like for GPS [7] and WLAN PCMCIA [8]. Therefore, in this paper an AIA with MIMO 2x2 characteristic is proposed for gain and bandwidth enhancement.

II. DESIGN OF PASSIVE ANTENNA

The passive antenna design is microstrip aperture coupled antenna as depicted in Fig.1 was designed using substrate FR4 with dielectric permittivity 4, height 1.6 mm for the first substrate and o.8 mm for the second substrate. Fig. 1(a) shows the exploded top view of the antenna design, while Fig.1(b) shows the exploded bottom view. From the top view, the first substrate consists of a rectangular patch antenna without any ground in the back of the first substrate. The top of second substrate consists of a hour-glass shape slot on the ground plane, while the bottom of the second substrate is the feed line.



(a)



(b)

Fig.1 Passive antenna design (a)top view (b) bottom view

This passive antenna design is configured to form MIMO 2x2 element antenna. This means, two antennas for transmitter (Tx) and two antennas for receiver (Rx). The MIMO antenna design is shown in Fig.2. It consists of for ports. Ports 2 (two)

and 4 (four) is for the Tx while port 1 (one) and 3 (three) for the Rx.

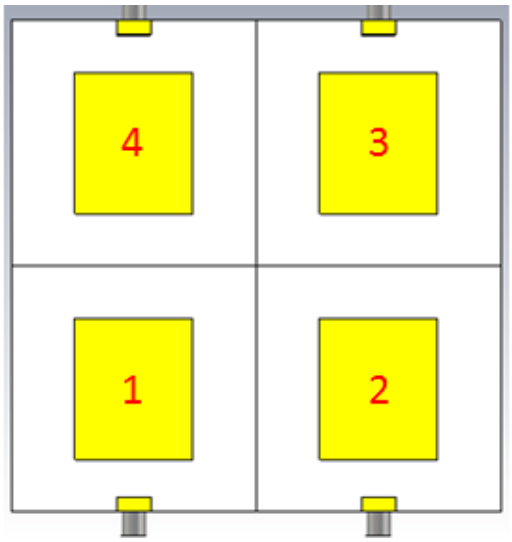


Fig.2. Design of Antenna MIMO 2x2 element

The simulation result of the passive antenna MIMO 2x2 element is shown in Fig.3 and Fig.4. Fig. 3 shows that the impedance bandwidth of the antenna is 50 MHz, from 2.32 GHz untill 2.37 GHz. The mutual coupling varies from -18 dB to -29 dB. The higher mutual coupling result occurs at ports placed near to each other, they are port 1 with 2, port 1 with 4, port 2 with 3 and port 3 with port 4. The lower mutual coupling results occurred at port 1 with port 3 and port 2 with port 4 due to farther distance of patch placement.

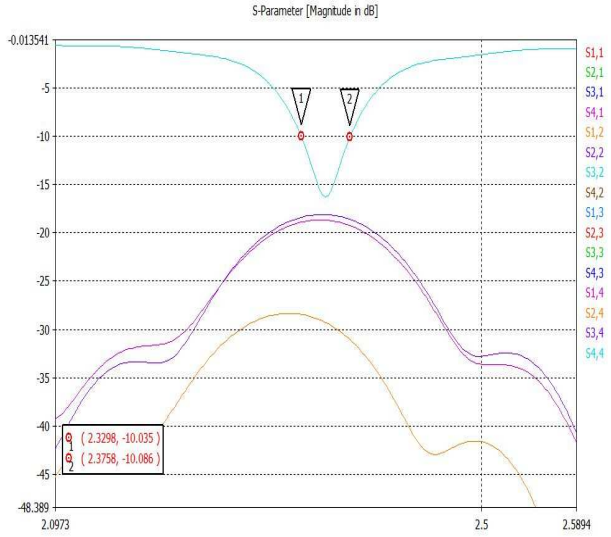


Fig.3. Simulation Result S-parameter of passive antenna MIMO

Fig. 4 shows the radiation pattern and gain of the passive MIMO antenna at port 2. The gain of the antenna at frequency 2.35 GHz is 2.508 dB. The antenna gain is still rather low; therefore to enhance the gain, the passive antenna is integrated with active components and become active integrated antenna (AIA).

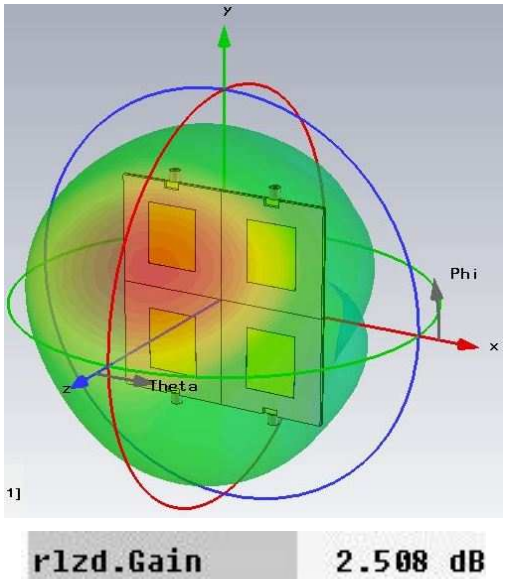


Fig.4. Simulation Result of Radiation Pattern and Gain Antenna at Port 2

III. DESIGN OF ACTIVE ANTENNA

To enhance the antenna gain, power amplifier was designed as depicted in Fig.5. The AIA was designed using CST, ADS and software tools. The output of the power amplifier is integrated as the input impedance of the antenna by integrating the power amplifier with the antenna feed line.

The simulation result of this AIA is shown in Fig.6 and Fig.7. Fig. 6 shows that the AIA has enhanced the impedance bandwidth of the antenna and become 191 MHz. The antenna now works from 2.27 GHz to 2.46 GHz. This bandwidth enhancement is due to the influence from the bandwidth of the power amplifier.

In addition, the mutual coupling effect of the AIA shows a significant reduction. The simulation result was taken from ports 2 and port 4 which was added with the power amplifier. The result was from -35 dB to -38 dB. Comparing this result with the result from the passive antenna, therefore there is a reduction of mutual coupling from 9 dB to 17 dB.

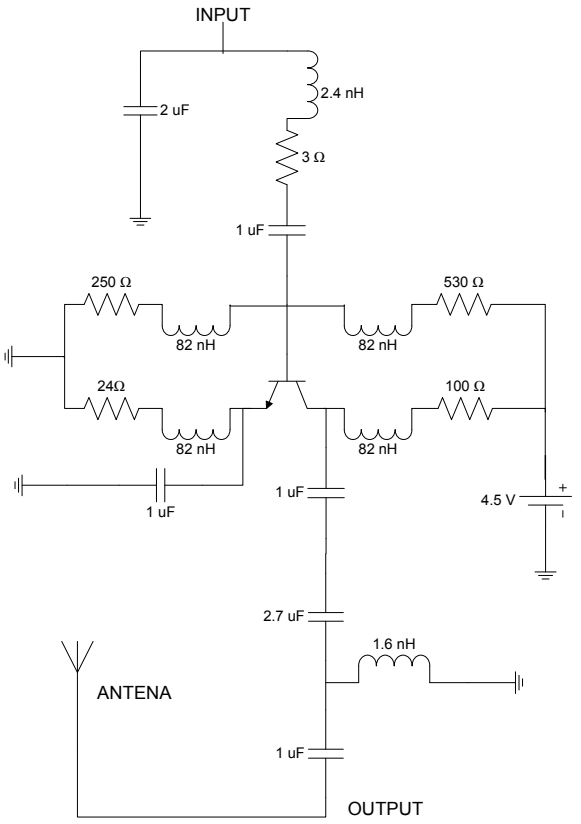


Fig. 5 Design of Power Amplifier

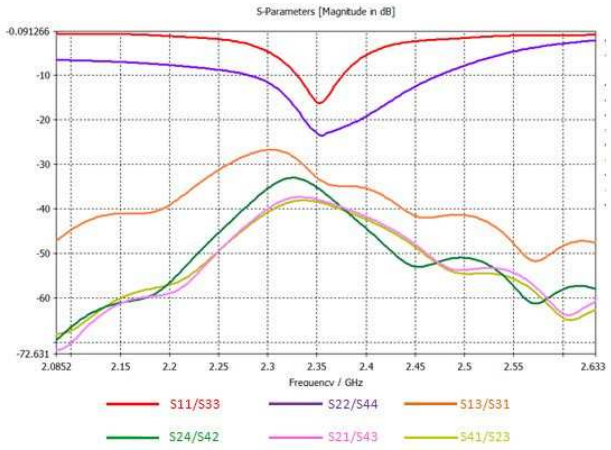


Fig. 6. Simulation Result S-parameter of AIA MIMO

The radiation pattern and antenna gain of the AIA MIMO is shown in Fig. 7. Bandwidth enhancement occurred which is shown that the AIA has gain of 16.15 dB.

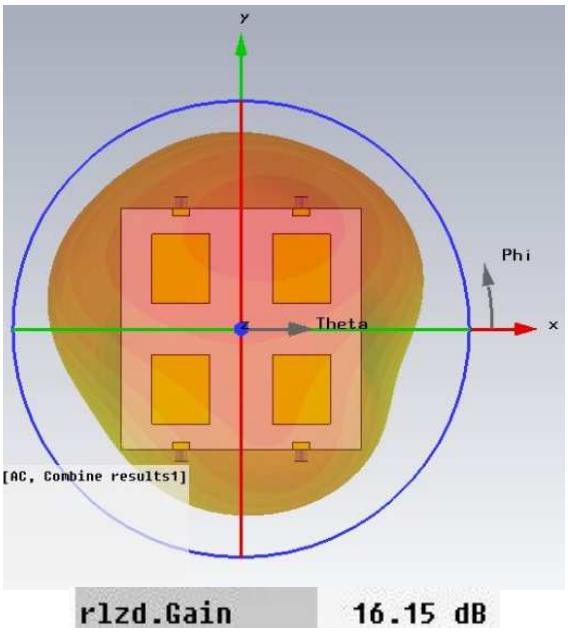
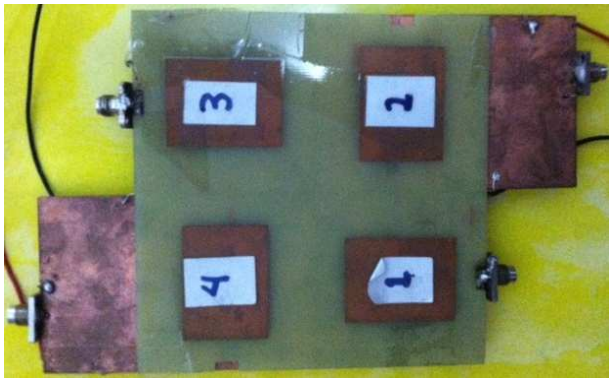


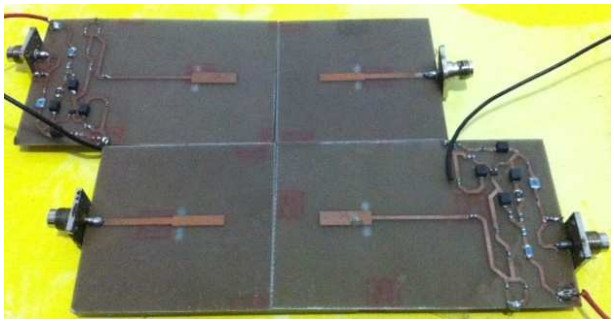
Fig. 7. Simulation Result of Radiation Pattern and Gain Antenna at Port 2 and Port 4

IV. MEASUREMENT RESULTS

The AIA was fabricated and shown in Fig. 8. The antenna was measured in anechoic chamber at Electrical Engineering Department, Universitas Indonesia. The Fig. 8(a) shows the top view of the AIA, while Fig.8(b) shows the bottom view where the power amplifier is integrated to the feed line at port 2 and port 4.



(a)



(b)

Fig. 8. Photo of the fabricated AIA (a) top view (b) bottom view

The measured result of the AIA is shown in Fig. 9. Measured result of the impedance bandwidth was taken at port 2 and port four. The results are bandwidth enhancement at both ports. At port 2, the impedance bandwidth measured was 190 MHz, while at port 4 achieved 200 MHz.

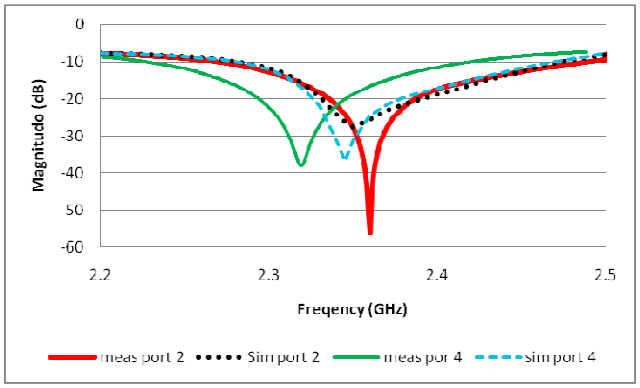


Fig. 9. Measurement Result of AIA MIMO

Moreover, the antenna gain was also measured at both ports. The passive antenna gain was 3.27 dB; therefore gain enhancement was also achieved. At port 2, the AIA measured gain was 11.6 dB, while at port 4, the gain measured was 11.4 dB.

By comparing the simulation and measurement results, the results show similar characteristic which are bandwidth and gain enhancement due to the integration of the active components to the passive antenna. The slight shift of the frequency and lower measured antenna gain is due to imperfect fabrication condition occurred which can influence the input impedance of the antenna.

V. CONCLUSIONS

An active integrated antenna with MIMO 2x2 elements was designed, fabricated and measured. The AIA resulted in enhancement of impedance bandwidth and gain. The simulation result of the impedance bandwidth of the antenna was increased to 191 MHz with gain to 16.15 dB. The measured result of the AIA also shows similar result with impedance bandwidth of 190 MHz and gain of 11.6 dB at port 2, while at port 4 has bandwidth of 200 MHz and gain 11.4 dB.

ACKNOWLEDGMENT

This work is partially funded by Ministry of Education under IPTEK grant with contract number: 4134/H2.R12/HKP.05.00/2013.

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