Multilayer antenna with AMC ground plane for 5G Applications

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ABSTRACT – This paper studied regarding a design of multilayer antenna operated at frequency of 28 GHz. The antenna was designed in a form of proximity coupled-feed with artificial magnetic conductor as a ground plane. The performances are compared between the antenna with perfect electric conductor ground plane and antenna with artificial magnetic conductor ground plane in terms of return loss, bandwidth and gain. The multilayer antenna with artificial magnetic conductor ground plane are improved the bandwidth and offering a good result in gain as well. The bandwidth and gain that offered by the antenna with artificial magnetic conductor ground plane is 1.713 GHz and 8.998 dB, respectively, which compared to antenna with perfect electric conductor ground plane. The increment of bandwidth and gain is up to 65 % and 30 %, respectively.

1. INTRODUCTION

The millimeter-wave applications give a larger bandwidth and need multi-Gb/s data wireless communication on a short range [1]. The 5G mobile system is a network that within a range of a millimeter-wave communication systems and offer multi-gigabit communication services [1]. This generation offers more improvements in services over 4G networks and provide a larger bandwidth to the consumers. Therefore, the antenna recommended in a 5G network must at least have a gain of 12 dB and the bandwidth more than 1 GHz [2-4].

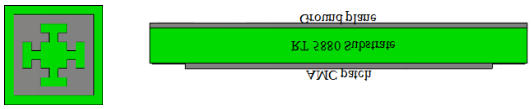
Microstrip patch antenna (MPAs) have interesting characteristics since its low profile, compact in size, easy to design, low cost, applicable for planar and non-planar surfaces [2]. However, the limitation of a microstrip patch antenna is narrow in bandwidth [2]. Several methods are applied in other to improve the bandwidth such as increasing a thickness of substrate, reducing a substrate permittivity and use a multi-layered substrate [2-3].

The work planned in this paper offer a bandwidth up to 1.7 GHz and the gain 8.998 dB with AMC as a ground plane compared to antenna with PEC ground plane. The antenna is designed and simulated by using Computer Simulation Technology (CST).

2. METHODOLOGY

2.1 AMC design structure

The work is started with a designing AMC structure at frequency of 28 GHz as shown in Figure 1. The substrate used is RT 5880 with a thickness of h = 0.254 mm, dielectric constant of ε_r = 2.2 and loss tangent of $\tan\delta$ = 0.0009. The size of single unit AMC structure is 2.7221 mm x 2.7221 mm. The gap between the substrate and the AMC patch is 0.25 mm.



(a) Top view (b) Bottom view

Figure 1 A unit cell AMC structure

Figure 2 display the simulated reflection phase varies frequency. The reflection phase is pointed at the frequency of 28 GHz and at a 0° of a reflection phase. The value of bandwidth is obtained from a phase shift between $\pm 90°$ at the curve of the reflection phase [4]. As shown in Figure 2, the AMC structure provides the bandwidth around 6.17 % within a frequency range of 27.029 GHz to 28.819 GHz.

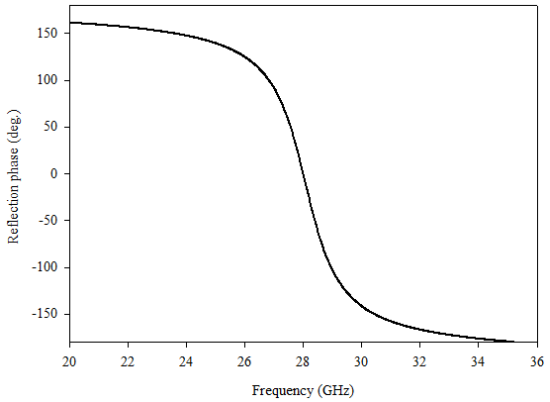


Figure 2 Reflection phase of the single unit AMC structure

2.2 Proximity-coupled feed antenna structures

Figure 3 represents a design of multilayer antenna with PEC ground plane. The configuration consists of first layer with a RT 5880 substrate (green colour) and radiating patch (gray colour). The second layer consists of RT 5880 substrate (green colour) and feed line (gray colour). The PEC ground plane is located at the bottom of second layer of antenna.

Figure 4 shows the construction of the multilayer antenna with AMC ground plane. antenna with array AMC structure. The 5x5 array AMC structure is applied as a ground plane which located on the bottom of the

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antenna structure. The chosen of number of array AMC structure plays the important factors in order to enhance the antenna performances.

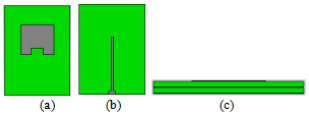

Figure 3 Proximity coupled-feed antenna with PEC ground plane (a) First layer (b) Second layer (c) Bottom view

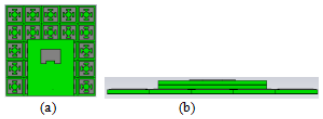

Figure 4 Proximity coupled-feed antenna with AMC ground plane (a) Antenna with AMC ground plane (b) Bottom view

3. RESULTS AND DISCUSSION

The simulated return loss of the designs is shown in Figure 5 which is compared between antenna with PEC ground plane and antenna with AMC ground plane. The graph shows that the return loss is below than -10 dB which a standard value for the antenna design specification. The value of return loss is used to determine how many signal is reflected back to the antenna. The more signal is reflected, the less signal is delivered to the load. The return loss of the antenna with PEC ground plane is -12.64 dB while the antenna with AMC ground plane is -34.511 dB. It is shows that the reflected signal for the antenna with AMC ground plane is less compared to the antenna with PEC ground plane.

The bandwidth is determined at -10 dB of return loss. The bandwidth that offered by the antenna with PEC ground plane is 1.04 GHz in a range of 27.454 GHz - 28.494 GHz. When the AMC is attached to the antenna as a ground plane, the bandwidth is increase up to 1.713 GHz in a range of 27.264 GHz - 28.977 GHz. The increment of the bandwidth is up to 60 % when AMC is attached as the antenna ground plane.

The main objective of applying AMC as the antenna ground plane is to reflect the wave without any phase reversal that will propagate through the antenna ground plane in order to improve the gain of the antenna. Figure 6 presents the radiation pattern of both antenna structures. The gain for antenna with PEC ground plane is 6.972 dB while the gain for antenna with AMC ground plane is 8.998 dB. The increment is up to 30 % when array AMC is attached as a ground plane to the antenna. Besides that, the radiation pattern of antenna with AMC ground plane is more focus and slightly decrease compared to the antenna with PEC ground plane.

4. CONCLUSION

The finding shows that the performances is increased when AMC is attached as a ground plane of the antenna. The bandwidth for the antenna with PEC and AMC ground plane is 1.713 GHz and 1.04 GHz, respectively. The gain of the antenna with PEC and AMC ground plane is 8.998 dB and 6.972 dB, respectively. Other than that, the lobe size is slightly decreased when the array AMC is attached as a ground plane on the proximity coupled-feed microstrip antenna structure. Therefore, it can be concluded that the AMC structure is helpful as a ground plane of the antenna structure for the aim to enhance the antenna performances.

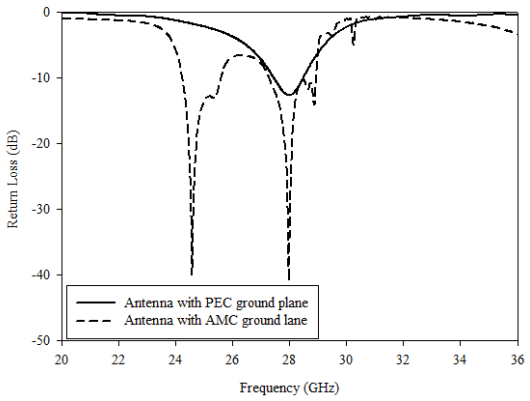

Figure 5 The return loss of antenna structures

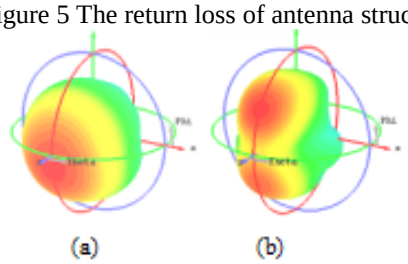

Figure 6 Radiation pattern of antenna structures (a) antenna with PEC ground plane (b) antenna with AMC ground plane

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REFERENCES

[1] Niu, Y., Li, Y., Jin, D., Su, L., & Vasilakos, A. V. (2015). A survey of millimeter wave communications (mmWave) for 5G: opportunities and challenges. *Wireless Networks*, *21(8)*, *2657-2676*.

[2] Firdausi, A., & Alaydrus, M. (2016). Designing multiband multilayered microstrip antenna for mmWave applications. *Radar, Antenna, Microwave, Electronics, and Telecommunications (ICRAMET), 2016 International Conference on* (99-102). IEEE.

[3] Amin, M. M., Mansor, M. F., Misran, N., & Islam, M. T. (2017). 28/38GHz dual band slotted patch antenna with proximity-coupled feed for 5G communication. *Antennas and Propagation (ISAP), 2017 International Symposium on* (1-2). IEEE.

[4] Malekpoor, H., & Jam, S. (2016). Improved radiation performance of low profile printed slot antenna using wideband planar AMC surface. *IEEE Transactions on Antennas and Propagation*, *64*(11), 4626-4638.

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