Performance Enhancement of Semicircular Shaped Array Antenna using Metasurface

H. Lago[1]*, M. F. Jamlos[2], A. Narbudowicz[3], P. J. Soh[4], A. R. Haron[1], C.M.N.C. Isa[4], M. H. Limbah[1]
[1]Faculty of Engineering, Universiti Malaysia Sabah, 88400, Kota Kinabalu, Sabah, Malaysia
[2]Faculty of Mechanical Engineering, Universiti Malaysia Pahang (UMP), 26600, Pekan, Pahang, Malaysia
[3]Telecommunications and Teleinformatics Department, Wroclaw University of Science and Technology, Wroclaw, Poland.
[4]Advanced Communication Engineering Centre (ACE), School of Computer and Communication Engineering, Universiti Malaysia Perlis (UniMAP), 01000, Kangar, Perlis, Malaysia
* herwansyahlago@gmail.com

Abstract—**This work studies the integration of a semicircular shaped array antenna into an Artificial Magnetic Conductor (AMC) which resonate at the desired operating frequency of 9.41 GHz. The proposed AMC performs as a high impedance surface with a high permeability (approximately 7.08) at 9.41 GHz, with a perfect magnetic conductor characteristic. As result, the AMC is able to be stacked adjacent to the semicircular shaped. The simulation results show that the AMC has successfully enhanced the gain and efficiency of the antenna to 9.55 dB and 97% respectively compared to 8.44 dB and 96% without AMC. Besides that, a slight bandwidth improvement, from 395 MHz to 398 MHz can be observed with the AMC. Both simulated and measured results show a good agreement in term of reflection coefficients and radiation patterns.**

Keywords—AMC, array antenna, performance enhancement

I. INTRODUCTION

Nowadays, in wireless applications, it is necessity to improve the antenna performance in terms of gain, efficiency and bandwidth. One method is by utilizing a Perfect Electric Conductor (PEC) [1]. Normally PEC method will result in a bulky antenna structure. This is due to the gap between the PEC and radiator, which cannot be placed next to each other due to the production of image current which will flows in opposite direction to the source. As a result, these currents will be canceling each other. Hence, it will cause degradation of the antenna's performance especially the radiation capability.

Despite that, this drawback can be reduced by integrating the antenna with a Perfect Magnetic Conductor (PMC). The PMC is capable to form a reflected current that has the identical phase as the incident current. Typically, the PMC structure will produce reflection coefficient with zero phase and unity magnitude [1-2]. However, PMC is a substance that cannot be naturally found in nature. Nevertheless, artificial magnetic conductor (AMC) is an alternative to the PMC which is categorized as a type of metamaterial. AMC is able to generate reflection coefficient with phase range of -90º to 90º and exhibit itself as a PMC at certain frequencies [3]-[7]. Besides its PMC-like behavior, AMC can be placed near to the radiator without degrading the antenna's performance due to their behavior and physical characteristics such as low profile and ease to be fabricated [8-9]. Furthermore, this will allow to directly study and analyze the impact of the AMC by using a microstrip patch antenna which is generally known with a low gain, low efficiency and narrow bandwidth (approximately 5%) [10]. AMC is also capable to realize a high permeability and performed as high impedance surface.

This paper proposed an AMC unit cell with a high permeability and low permittivity of 7.08 and 0.83 respectively. Next, the combination of multiple AMC unit cell will form the AMC plane and then integrated onto the semicircular shaped array antenna. As results, the gain, efficiency and bandwidth of the antenna are improved up to 9.55 dB, 97% and 398 MHz respectively.

II. ARRAY ANTENNA DESIGN

The semicircular shaped array antenna is shown in Fig. 1. This antenna implements coupled transmission lines to improve the effectiveness of the energy distribution towards the semicircular shaped elements. Each semicircular shaped patch is dimensioned at about a quarter-wave length at 9.41 GHz. A 50 Ω SMA connector is used to feed the antenna through side feeding technique while a ground plane is placed at the bottom layer.

This semicircular array antenna is planned and simulated on a substrate known as Taconic TLY-5, which is 3184.6 μm thick. This substrate has the relative permittivity (ε_r) of 2.2. Meanwhile, copper is used for the radiating patch, transmission line and ground with a thickness of 0.035 mm. The dimensions of this structure are tabulated in Table I. The integration of AMC will affect on the patch size where it will miniaturize the patch size due to the characteristics of the AMC itself.

TABLE I. DIMENSION OF THE ANTENNA.

Parameter	Antenna [mm]	
	without AMC	with AMC
L	35	35
W	39.5	39.5
F_1	15.5	15
F_2	7.5	7.5
F_3	5.42	5.42
F_4	3.8	3.8
C_1	6.3	5.6
C_2	9.7	8.8
G_1	1.6	1.6
G_2	2.6	2.6