GAIN ENHANCEMENT OF PLANAR MONOPOLE ANTENNA WITH CIRCULAR SHAPE USING ARTIFICIAL MAGNETIC CONDUCTOR (AMC) FOR ULTRA-WIDEBAND (UWB) APPLICATIONS

Nofal Varian Perdana[1], Agus Dwi Prasetyo[2], Edwar[3]
[1,2,3]Prodi S1 Teknik Telekomunikasi, Fakultas Teknik Elektro, Universitas Telkom
[1]**nofalvarianp@student.telkomuniversity.ac.id**, [2] **adprasetyo@telkomuniversity.ac.id**, ,
[3]**edwarm@telkomuniversity.ac.id**

Abstract

Ultra-wideband (UWB) antennas that are more widely developed and needed in modern times such as this have many advantages. Having a very wide frequency range of 3.1GHz-10.6GHz makes this antenna has added value at an unnecessary large average cause the efficiency of this antenna is not efficient enough. In addition, directivity also affects the increase in gain, namely the greater the gain, the radiation pattern produced, the energy emitted can focus on the direction of the main beam and the energy can select a larger place.This final project discuss about gain enhancement of plannar monopole antenna with circular shape and Artificial Magnetic Conductor(AMC) ground. By sampling a number of UWB working antenna frequencies it can be seen the average increase in gain of the antenna. For the purposes of validation an antenna is needed to be designed for the prototype to be launched. The prototype be calculated and compared with the simulation results.This result of this final project is the planar monopole antenna with with circular shape using artificial magnetic conductor (AMC)structure for ultra-wideband applications based for the antenna designned and implemented.UWB antenna improves the gain for entire UWB range, a peak gain of 14.51 dBi at 3.6 GHz are obtained.Miniaturized structure with high gain makes this design better candidate,especially for outdoor UWB application.

Keywords: Ultra-wideband(UWB), Gain, VSWR, Radiation Pattern, Planar Monopole Antenna, Artificial Magnetic Conductor(AMC).

1. Introduction

With the gradual growth of communication systems and integrated circuit technologies, an enhancement of the planar antennas performance is becoming more significant in design considerations. This is due to their appealing features, such as low profile, light weight and ease of fabrication. However, a narrow impedance bandwidth of the planar antennas is quite a challenge for researchers. Printed slot antennas are one common type of planar antennas, which are utilized for wireless communications and electronic warfare applications due to the compactness and simplicity.In such design, a planar AMC surface is applied with a narrow operating bandwidth, which covers a measured range from 2.37 to 2.50 GHz. The low operating bandwidth of the AMCs is usually a challenge for UWB structures.Artificial magnetic conductor (AMC) structures in-phase reflection coefficient over the designed frequency band. This feature allows utilizing AMCs as antenna ground plane, which result in low profile antennas for enhancing their impedance and radiation performance[1]. UWB conformal antennas with minimum physical protrusions are important in many modern radar and communication applications for meeting stringent aerodynamic and scattering requirements.The Frequency range of passband is from 3.1GHz to

10.6GHz. The operational bandwidth requirement of these antennas may be more than 100:1, with a concurrent requirement for conformal installation. The antenna height can be as small as 2/50 or less at the lower frequency end. Therefore, a major challenge is to design a proper ground plane for UWB antennas that maintains the antenna's performance over the entire range of operational frequencies, and that provides performance comparable to the antenna in free space.Ideally, one would like to realize a ground that has a reflection coefficient for the tangential electric fields close to +1 for all frequencies. hin this regard, several recent studies have focused onthe use of electromagnetic-bandgap (EBG) structures and AMC as ground planes[2].

2. Basic Theory

2.1 Ultra-Wideband

Ultra-wideband (UWB) technology has been proposed as an alternative air interface for Wireless Personal Area Networks because of its low power spectral density, high data rate, and robustness to multipath fading. The Federal Communications Commission (FCC) has defined an intentional UWB device as that has a bandwidth equal to or greater than 20% of thecenter frequency, or that has a bandwidth equal to or greater than 500 MHz. The FCC has also permitted UWB devices to operate using spectrum occupied by existing radio services as long as emission restrictions, in the form of a spectral mask, are met[3].

2.2 Planar Monopole Antenna

Antenna Planar is a type of antenna that works in the UWB frequency range which is arranged using flat metal and solid wire which is the development of an omnidirectional antenna. Planar antennas have small dimensions, are light and thin. Planar antennas consist of ground plane, substrate, and patch. Planar antennas are often called 2D microstrip differences with microstrip antennas. Modifications occur in the ground plane.

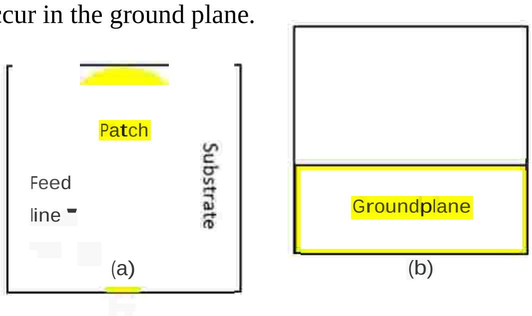

Figure 2 Structure Planar Antenna : (a) Front view (b) Back View

2.3 Artificial Magnetic Conductor (AMC)

Artificial Magnetic Conductor is one of the techniques used to increase gain and bandwidth. This technique can improve antenna performance by increasing current distribution on the waveguide wall which results in a modified radiation slot [4]. On an ordinary planar antenna this technique is placed on the ground plane. The illustration of designing AMC can seen in Figure 3.

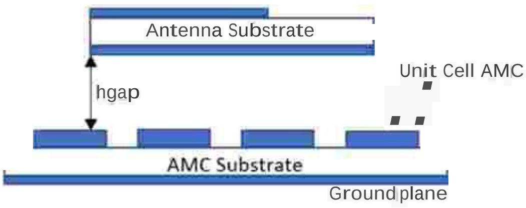

Figure 3 AMC Structure

Metamaterial can be used to manipulate the behavior of electromagnetic waves in antenna and microwave devices. Metamaterial like Artificial Magnetic Conductor (AMC) usuallyimplemented as antenna ground plane replacing the conventional Perfect Electric Conductor (PEC) ground plane[5].

3. Designing

3.1 Designing The Planar Monopole Ultra-Wideband Antenna

The purpose of this research is to get plannar monopole antenna that can works in Ultrawideband by simulating until 5 times to get the antenna that we needed. The first model is we use the full groundplane, second is also full groundplane but add the width, third is we cut the full groundplane to the partial, the fourth is modification the partial groundplane to the half circular, the fifth is added some patch and give the u slot in groundplane of the antenna.

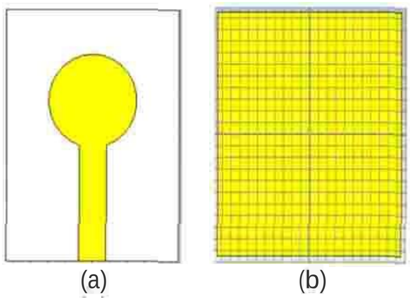

Figure 3.1 The Initial Antenna : (a) Front view (b) Back View

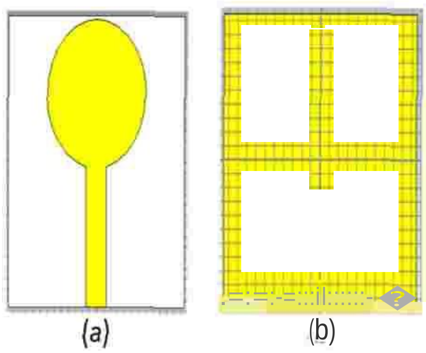

Figure 3.2 The Iteration 2 : (a) Front view (b) Back View

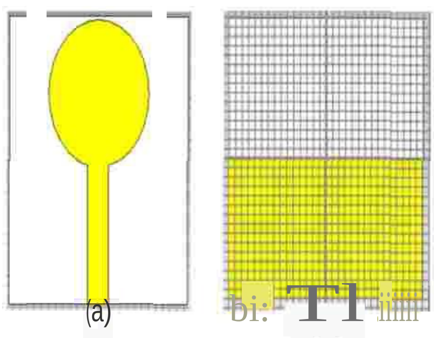

Figure 3.3 The Iteration 3 : (a) Front view (b) Back View

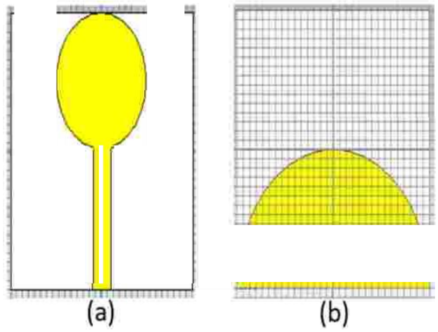

Figure 3.4 The Iteration 4 : (a) Front view (b) Back View

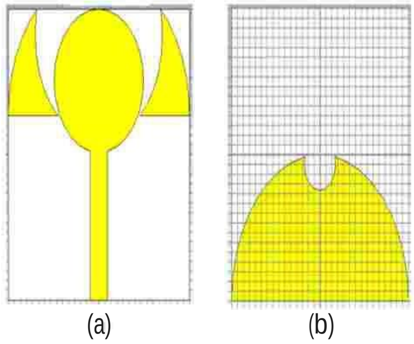

Figure 3.5 The Iteration 4 : (a) Front view (b) Back View

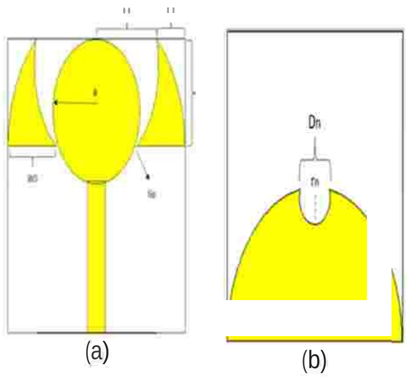

Figure 3.6 The Addition Paramater : (a) Front view (b) Back View

Table 3.1 The Antenna Dimension

Parameter	Value (mm)
Thickness of Substrate(h)	1.6
Thickness of Conductor	0.035
Substrate Width (Ws)	30
Ground plane Width (Wg)	30
Substrate Length (Ls)	30
Ground plane Length (Lg)	30
Feed Width (Wf)	3.05
Feed Length (Lf)	15.5
Radius Patch (a)	7.4
WA	10.2

WB	5
WD	8.2
Gp	0.5
LA	11.08
Dn	5.06
rn	2.53

3.2. Designing The Planar Monopole Ultra-wideband Antenna with AMC

For this design antenna that has 4 times iteration that start with the initial shape rectangular antenna with dimension 5x5 array, the second is added cross slot to rectangular unit cell of AMC then the dimension change to 8x8 array, the third is 6x6 dimension array, the fourt is 5x5 array dimension of AMC.

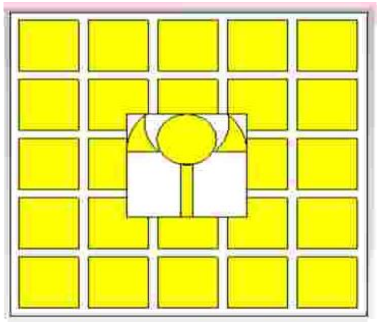

Figure 3.7 The Initial AMC Unit Cell

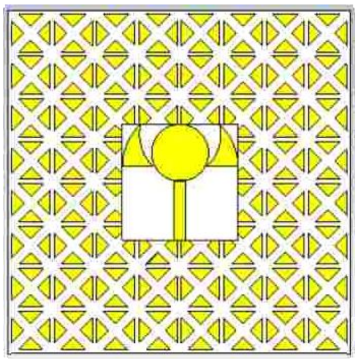

Figure 3.8 The Iteration 1 AMC Unit Cell

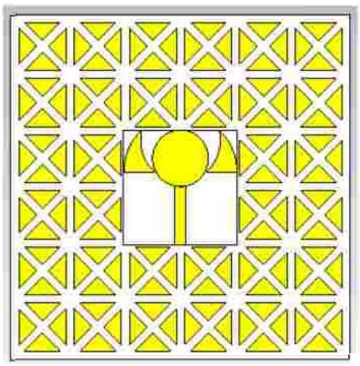

Figure 3.9 The Iteration 2 AMC Unit Cell

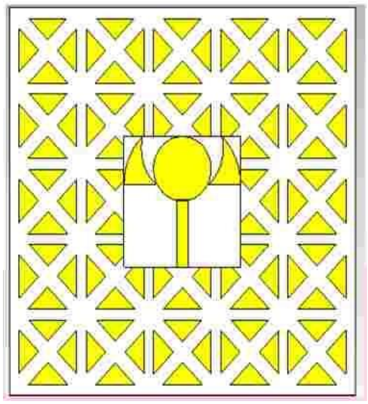

Figure 3.10 The Iteration 3 AMC Unit Cell

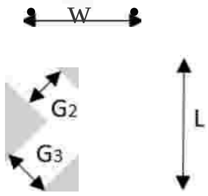

Figure 3.10 AMC Unit Cell Parameter

Parameter	Iteration 3 (mm)
W	10
L	10
G1=G2	2.38
hgap	21

3.3 VSWR and Gain of Planar Monopole Ultra-Wideband Antenna result in Simulation

From the model antenna that simulated this is the result of the gain each model.

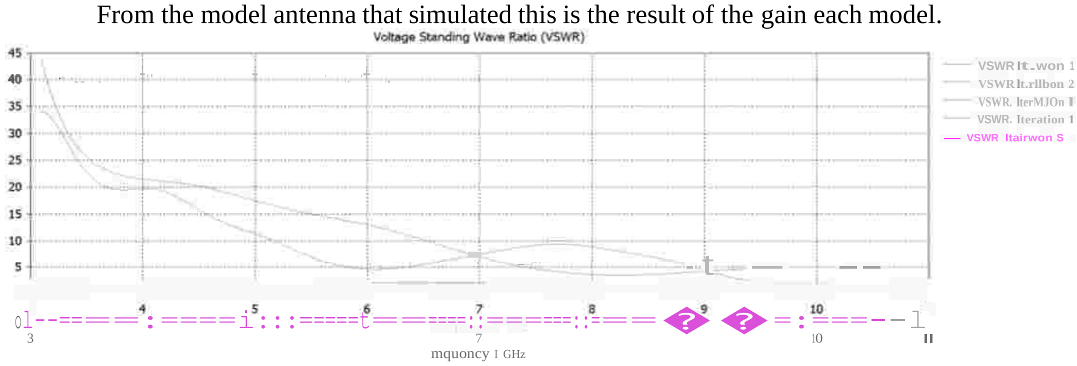

Figure 3.11 VSWR Simulation Result

From Figure 4.1 we can assume that the iteration 5 which the final result it has lowest VSWR value mean that the iteration 5 it has good missmatching between antenna and the transmission line.

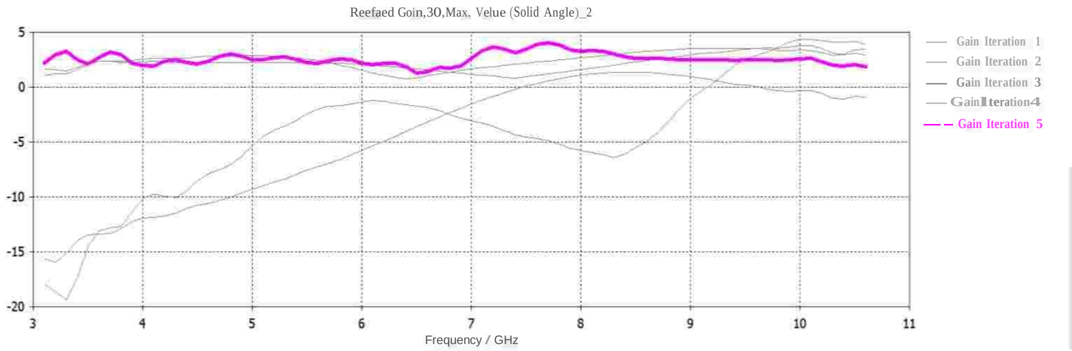

Figure 3.12 Gain Simulation Result

3.4 VSWR and Gain of Planar Monopole Ultra-Wideband Antenna with AMC result in Simulation

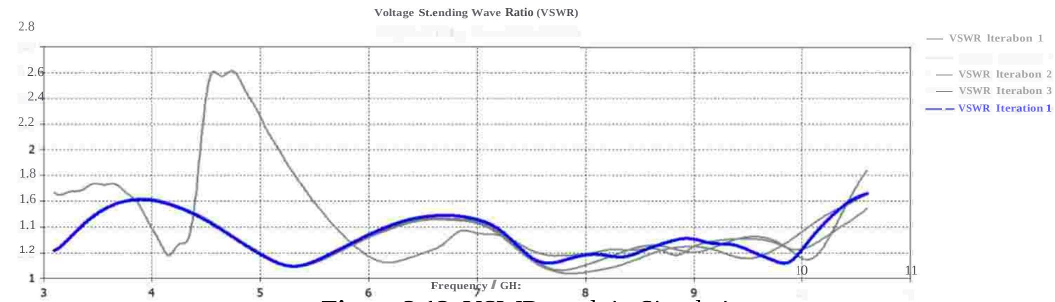

Figure 3.12 VSWR result in Simulation

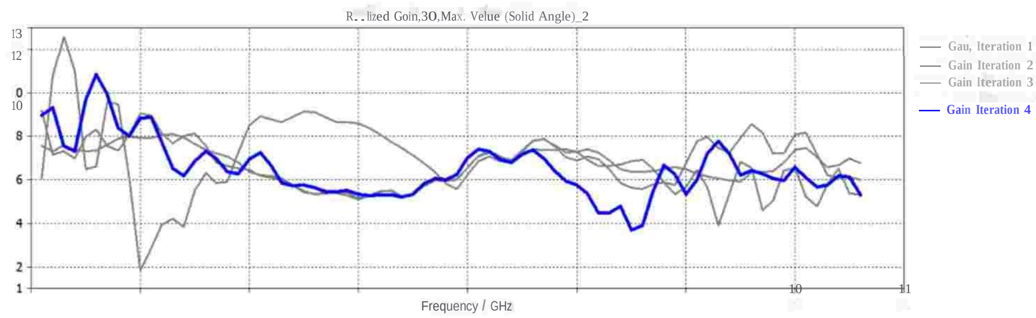

Figure 3.13 Gain result in Simulation

4. Analysis And Result

4.1 Gain Comparison UWB Antenna with and without AMC

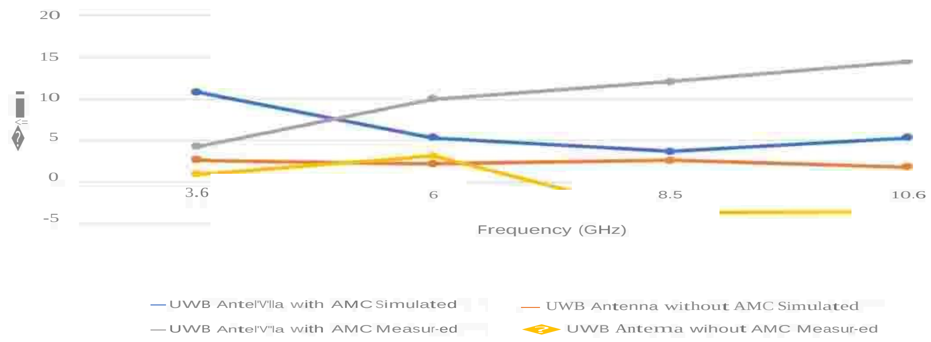

Figure 4.1 Simulated and measured Gain result of UWB antenna design with and without AMC

From Figure 4.1 UWB Antenna with AMC measured it has biggest gain than the simulated and the UWB antenna without AMC, from this graphic we can assume that the AMC method is make the gain of UWB antenna improve.

4.2 Gain Comparison of the Gap

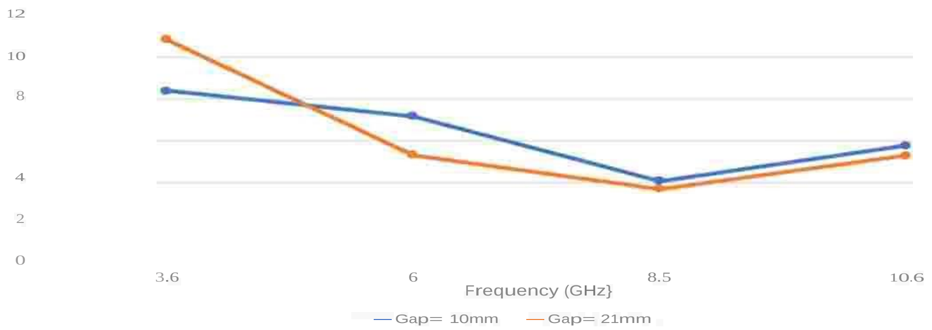

Figure 4.2 Gain variation for different gap dist between antenna and AMC

From Figure 4.2 the value of gain on the 21mm gap it has bigger gain than the 10mm gap, from this graphic we can assume that the gap between antenna and AMC is affect the improvement of gain of the UWB antenna.

4.3 Gain Comparison Dimension array of Unit Cell AMC

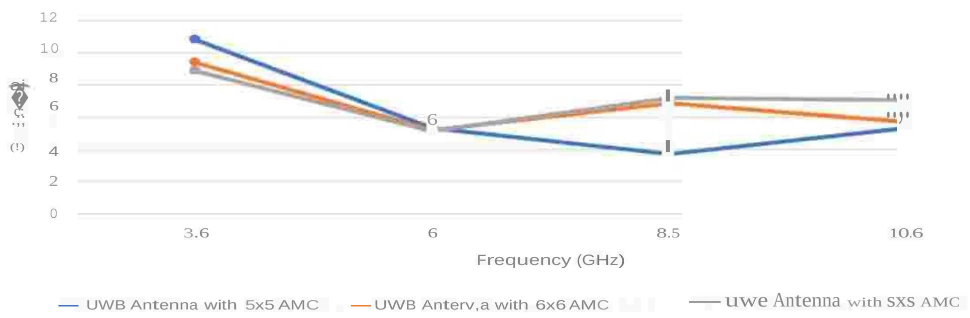

Figure 4.3 Dimension array variation Gain result for different dimension array

From Figure 4.3 the dimension array 5x5 of the AMC it has biggest gain than any other of dimension, we can assume that the dimension array of unit cell AMC is affect the gain improvement of the antenna.

4.4 VSWR Comparison UWB Antenna with and without AMC

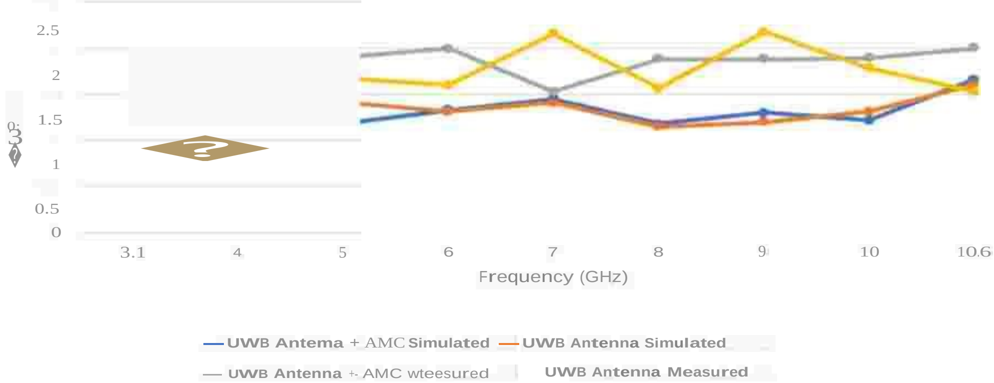

Figure 4.4 Simulated and measured VSWR result of UWB antenna design with and without AMC

In Figure 4.4 we can seen that the value of VSWR simulated and measured is less than 2 which is, the VSWR is has good missmatching although UWB antenna with AMC and without AMC.

4.5 VSWR Comparison of the Gap

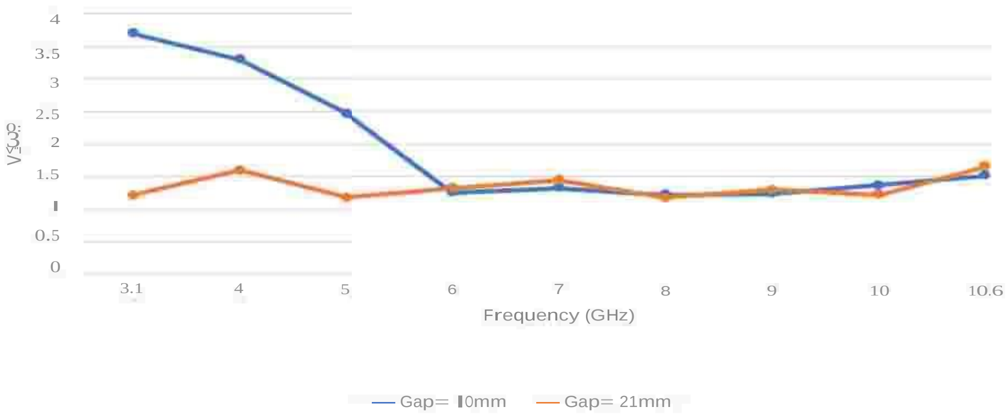

Figure 4.5 VSWR variation for different gap dist between antenna and AMC

In Figure 4.5 the value of VSWR in differences gap that has good value is the 21mm gap, so in this graphic we know that the gap is affect the value of VSWR of UWB Antenna

4.6 VSWR Comparison Dimension array of Unit Cell AMC

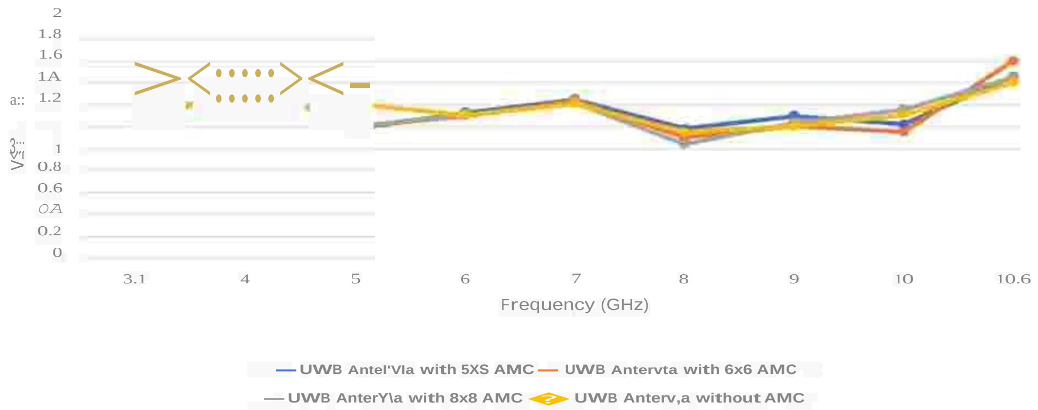

Figure 4.6 Dimension array variation Gain result for different dimension array

From this Figure 4.6 we can assume that the dimension array of the AMC unit cell is not affect the VSWR value, because the VSWR value is less than 2.

5. Conclusion

Conclusions that can be concluded from the results of all processes of design,analysis and simulation using CST software on gain enhancement of planar monopole antenna using AMC structure for UWB applications are as follows:

1. The AMC method is suitable for use in monopole antenna plannars to increase gain, of course the dimensional shape of the antenna and AMC greatly affects the increase in gain in the antenna and the gap in the antenna also affects the resulting gain.

2. To increase the gain using the AMC method will cause the VSWR on the UWB antenna to increase slightly, but the gain will also increase in some working frequencies.

3. There is a differences from simulation and the measurement result from the antenna parameters, this can be occurred by several causes such as the condition is not ideal, the fabrication or human error, interference from another wave and also the connector condition while doing the measurement.

4. The VSWR measurement result shows that the ultra wideband planar monopole antenna has met the specified specification, with value of the VSWR is below 2 with frequency range 3.1 GHz - 10.6 GHz.

5. The changing in groundplane of the antenna by forming the antenna groundplane by using half circular with u-slot can affect the parameters of the antenna such as VSWR and gain of the antenna.

6. The gain enhancement of the antenna in measurement is from the measured is give the improved gain 10.55 dBi at 10.6 GHz and the peak gain is 14.51 dBi

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