Pertanika J. Sci. & Technol. 25 (S): 1 - 12 (2017)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

# Development of Ultra-Wideband Directional Microstrip Antenna

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## ABSTRACT

The development of Ultra-wideband (UWB) directional microstrip antenna is to offer solutions for problems related to bandwidth, cost, power consumption, and size generation electronic communication equipment. The UWB allows for high-speed wireless connection through a variety of electronic devices and computer within a certain area. It can be used for Internet access and multimedia services with data up to 1 Gbps as well as for radar applications, tracking, determining an object's position. With the development of UWB, the accuracy of the position of an object can be increased either indoors or outdoors. The antenna has an important role in UWB, such as integrated circuit, getting transient characteristics (short impulse response) and the UWB antenna microstrip is design with monopole or dipole antenna. The decline in antenna performance can be prevented using UWB directional microstrip antenna. This research was based on experimental method using a Vivaldi microstrip antenna. It used software 3D electromagnetic simulator. The development of UWB directional Microstrip antenna radiation characteristics of designs that meet the specifications which have VSWR < 2 for the frequency range of 3.1 to 10.6 GHz.

*Keywords:* 3D electromagnetic simulator, directional, microstrip antenna, ultra-wideband

## INTRODUCTION

Communications technology is growing rapidly. The development of a system that works on the 2.4 GHz frequency is inseparable from device / device that are able to change energy or signals in medium guides to the free space (air). This device is called antenna which is a tool to send or receive energy. It is also used to optimise energy radiation in a particular direction (Balanis, 2016). The development of wireless technology has encouraged a new lifestyle that provides convenience to the users of mobile devices such as notebooks (Mirza, Norris, & Stockdale, 2008). Costumers also want the

ARTICLE INFO

*Article history:*
Received: 12 January 2017
Accepted: 02 October 2017

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ISSN: 0128-7680 

same comfort on other devices such as PC, camcorders, mp3 players, digital cameras, HDTV, PDA, mobile phones, and others in a wireless personal area network (WPAN) in their home (Dholakia, 2012). However, currently WLAN and WPAN technologies are not able to meet the needs of high bandwidth which is rapidly growing. Therefore, we need new technology to meet the needs of high-speed WPAN (Chin, Fan, & Haines, 2014).

Ultra-wideband technology (UWB) offers advantages in terms of bandwidth, cost and power consumption for electronic equipment in the next generation (Porcino, Domenico, and Walter Hirt 2003). It also allows for high-speed wireless connections through a variety of devices and PCs within a certain area (WPAN) such as house or office (Roy, Foerster, Somayazulu, & Leeper, 2004). This technology can provide the high bandwidth required to stream data quickly for huge data such as video and audio among electronic devices throughout the home (Sidhu, Singh, & Chhabra, 2007). The antenna plays an important role in UWB communication system. Generally, it must have a compact shape, efficient, easily integrated to circuit and has good transient characteristics or short impulse response (Taylor, 2012). Most antenna design for UWB currently has a radiation pattern similar to a monopole or dipole antenna. When the antenna is brought closer to the walls (Figure 1), metal objects or space body, it causes the antenna performance to decrease due to omni-directional radiation/ bi-directional radiation. If using directional UWB antenna, a decrease in antenna performance can be avoided. Therefore, the development of UWB antenna has a directional radiation needed.

Two microstrip antenna design Array / double arrays are pioneers in designing microstrip antenna (Yang & Rahmat-Samii, 2003). The third microstrip antenna parameters are two arrays bandwidth, return loss and VSWR which essentially meets the application criteria, but the substrate material used (Teflon) is expensive. This study was innovative namely because it used aluminium substrate material to produce an antenna that has a wide bandwidth with a directional radiation pattern.


*Figure 1.* The compact translucent walls radar
*Source:* Brochure XaverTM 400 www.camero- tech.com

Figure 1 shows ultra-wideband radar translucent walls that have attracted attention both in academia and the industry as they play an important role in the field of security, rescue or in the event a building collapses, and natural disasters such as earthquakes  and storms. Among the various innovations on UWB radar invisibility, Xaver wall 400 is the latest product that has operates from 3 GHz to 10GHz as well as provide a high resolution image even after passing 20 mm wall in addition to having radius detection up to 30 cm (Aftanas, 2009).

### Research Purposes

Translucent wall radar is now used by the military to detect the presence of an enemy who is inside a building. In terms of civilian use, translucent wall radar can be used to search for victims trapped in buildings after an earthquake or volcanic eruption. The purpose of this research was to develop an antenna which has a wide bandwidth with a directional radiation pattern.

### The Benefits of Research

The research outcome is to produce an ultra-wideband microstrip directional antenna that can be used for applications translucent wall radar. In addition, this study is expected to contribute to the advancement of science and technology

## METHODS

The study was successful in producing UWB antenna which meant Indonesia didn't need to buy from abroad.

The microstrip antenna produced is compact in size with a very wide bandwidth with a directional radiation pattern and can also be used for UWB radar applications such as wall-penetrating radar.

As antennas are able to obtain information on what is behind the wall, they should be small and light and strong. This requirement is due to the size of the UWB device which is small and mobile.

Thus, a 3D electromagnetic simulator was used to design a microstrip antenna followed by the fabrication process. Antenna return loss, impedance, gain and radiation pattern were measured. The paper is organised as follows: The introduction is followed by literature review and ways to determine antenna specifications; antenna lay out, antenna simulation and simulation iteration to obtain the optimal results. Output of the simulator can be seen in Figure 4.

This study relied on findings of previous researches to come up with a new micros strip antenna design. Thus, this is an original research.

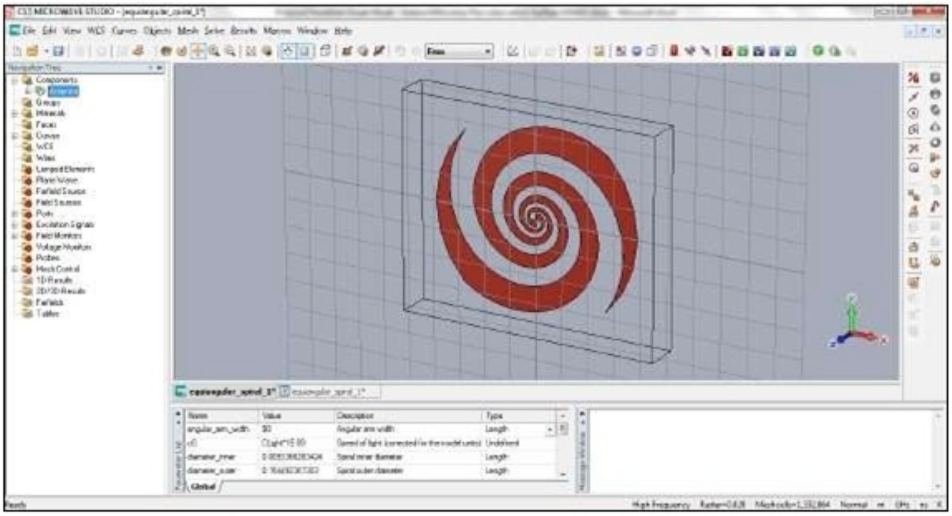


*Figure 2.* Display 3D electromagnetic simulation software

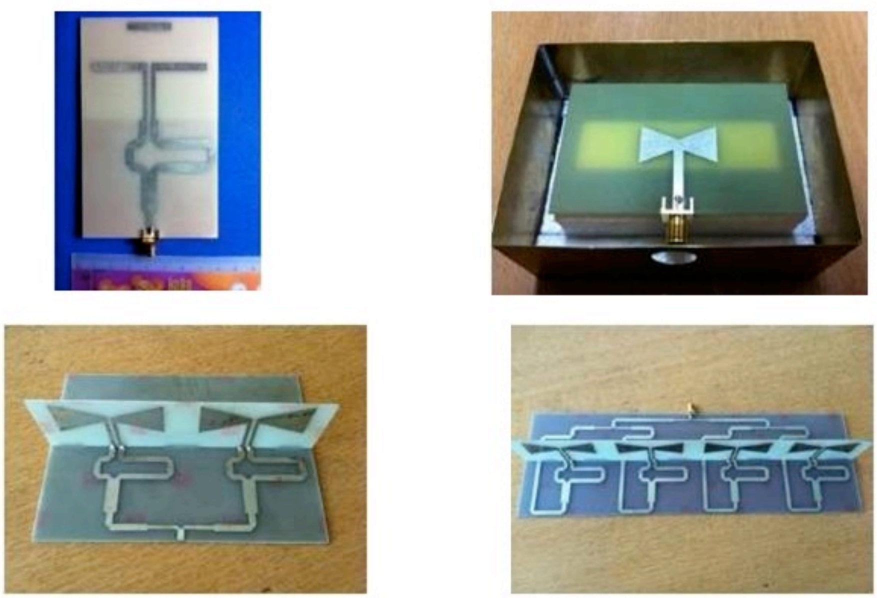


*Figure 3.* Example of antennas

The duration of this study was 8 months and was conducted in the laboratory of telecommunications electronics. Figure 4 shows some of the micros trip antenna developed by previous researchers. These antennas have different functions such as for wall-penetrating radar, rocket tracking, and WiMAX. The antenna measures return loss (S-parameter), VSWR, antenna impedance as well as radiation pattern gain. After completing the fabrication process, the UWB antenna is then measured to determine its performance. Some of the parameters measured include return loss, VSWR, antenna impedance, bandwidth, gain, and radiation patterns. The results are compared with the results of the simulation. The antenna is expected to have better parameters of reference with 3,1 – 10,6 GHz Bandwidth; VSWR≤ 2; Unidirectional Radiation Pattern; Gain minimum ≥ 6 dB.

## RESULTS

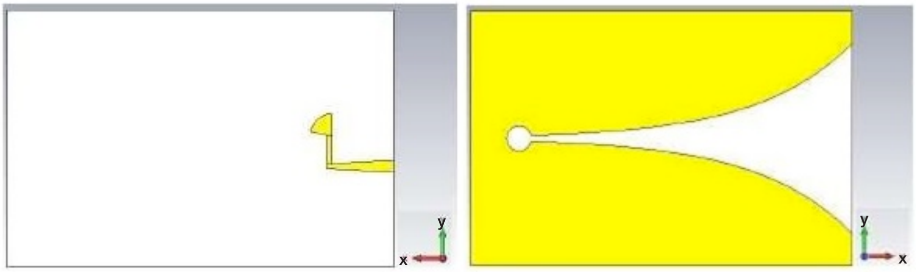
The specifications of a UWB antenna to be created are its bandwidth, the desired gain, VSWR, and radiation pattern of the antenna:

- Bandwidth antenna: 7.5 GHz
- Antenna Working frequency: 3.1 GHz - 10,6GHz
- Gain antenna: 4-8 dBi
- VSWR: 2:1
- The radiation pattern: directional

This research considered the following factors: the ability to simulate a micro trip antenna, the accuracy of the results, the speed in simulating micros trip antennas, features that can be generated from the simulation, and ease of operation. In order to meet predetermined specifications, the research used Vivaldi microstrip antenna.

### Lay Out Antenna

Figure 4 shows the image layout microstrip antenna design front and rear.




(a) (b)

*Figure 4.* Layout the antenna front view (a), Lay out the antenna back view (b)

### Simulation Results

After the simulation, 3D electromagnetic simulator software will be used to display the results of the simulation in the form of multiple antenna parameters such as impulse response in Figure 6, parameter-S in Figure 7, VSWR in Figure 8, antenna impedance in Figure 9, gain in Figure 10 and radiation patterns in Figure 11-17. The impulse response of the antenna designed is shown in Figure 6. In this figure, it can be seen that if the antenna is given an impulse (red curve) then its impulse response is a curve in green.

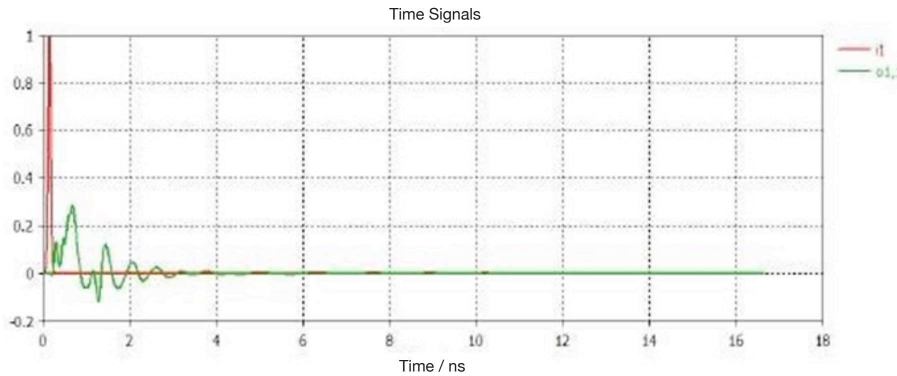



*Figure 5.* Response impulse antenna

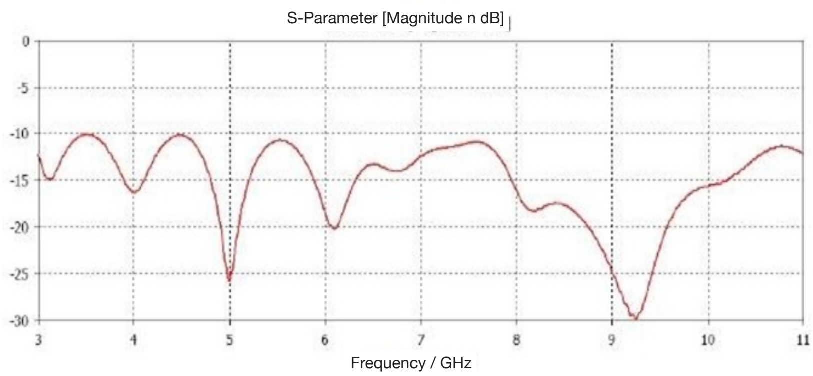



*Figure 6.* Return loss

Figure 6 shows curve measurement return loss result using a simulator.

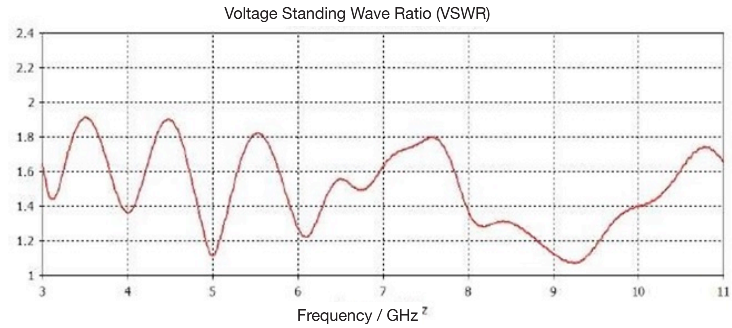
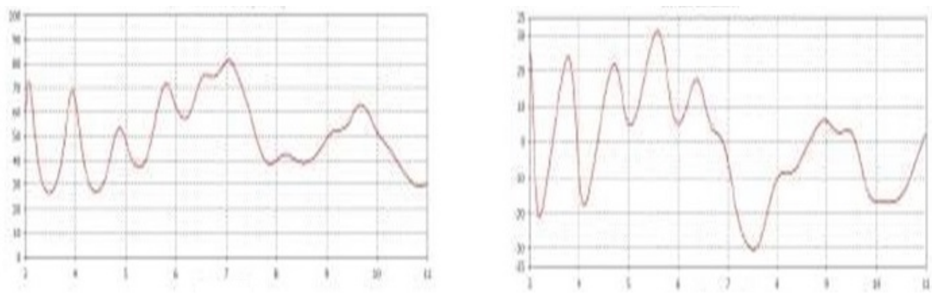



*Figure 7.* VSWR

Figure 7 shows curve measurement VSWR result using a simulator.



(a) (b)

*Figure 8.* The antenna impedance real part (a), the imaginary part (b)

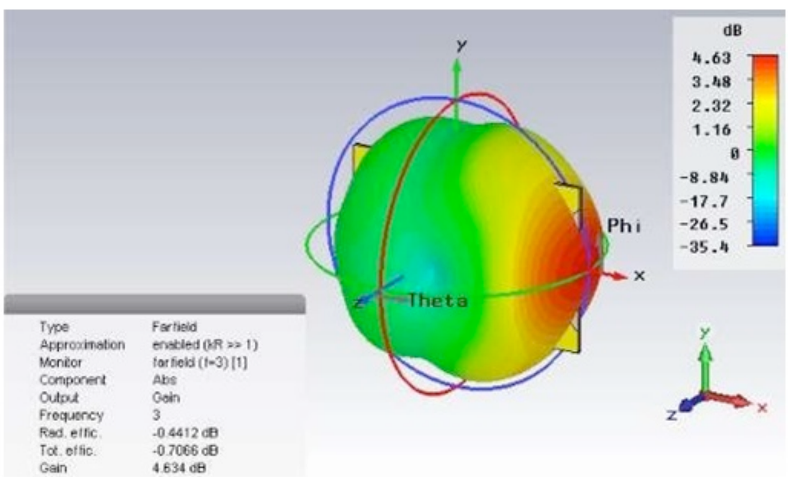



*Figure 9.* Gain and antenna radiation pattern at a frequency of 3 GHz

Figure 9 shows measurement gain and antenna radiation pattern at a frequency of 3 GHz result using a 3D electromagnetic simulator.

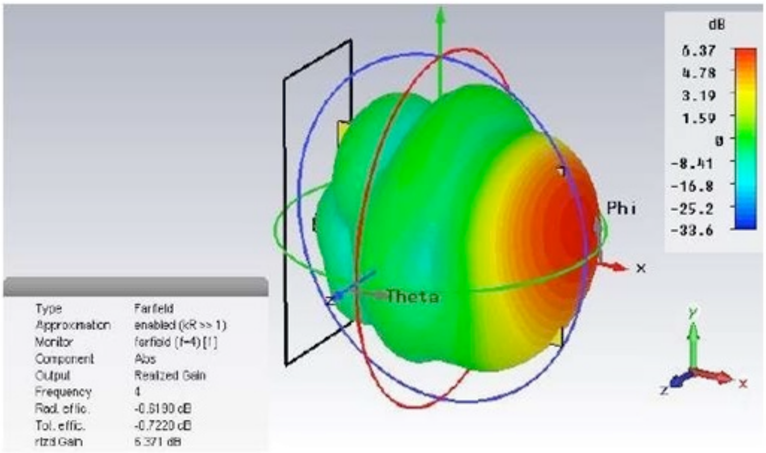



*Figure 10.* Gain and antenna radiation pattern at a frequency of 4 GHz

Figure 10 shows measurement gain and antenna radiation pattern at a frequency of 4 GHz result using 3D electromagnetic simulator.

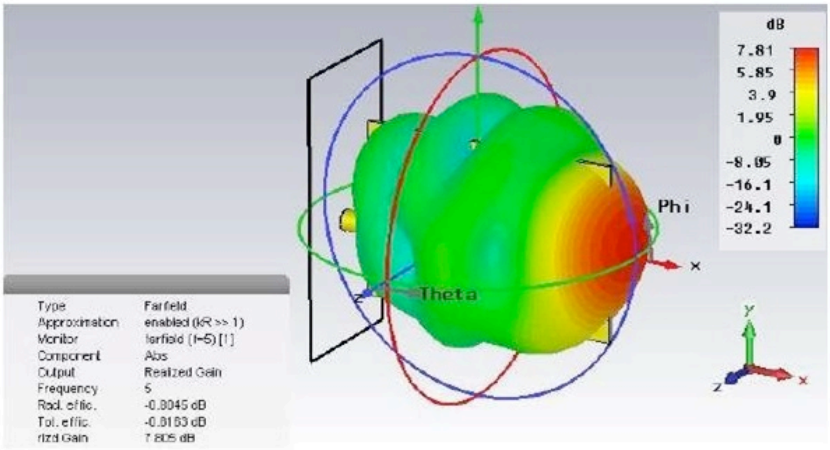



*Figure 11.* Gain and radiation pattern of the antenna at a frequency of 5 GHz

Figure 11 shows measurement gain and antenna radiation pattern at a frequency of 5 GHz using a 3D electromagnetic simulator.

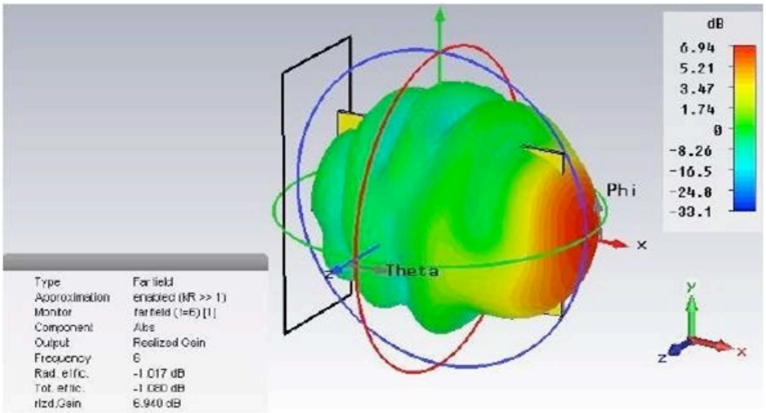



*Figure 12.* Gain and antenna radiation pattern at a frequency of 6 GHz

Figure 12 shows measurement gain and antenna radiation pattern at a frequency of 6 GHz result using 3D electromagnetic simulator.

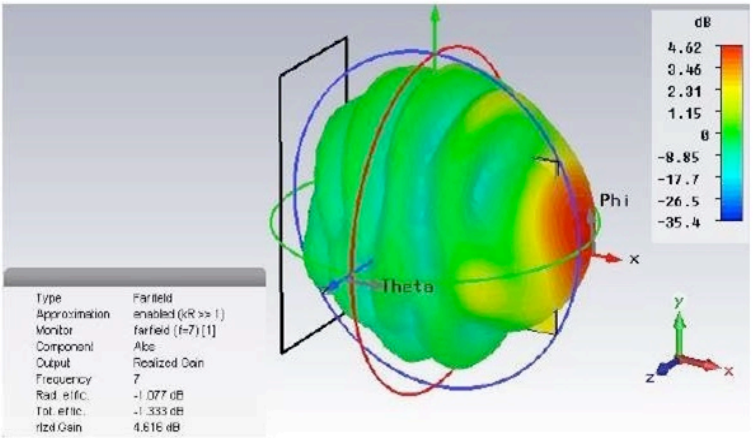



*Figure 13.* Gain and antenna radiation pattern at a frequency of 7 GHz

Figure 13 shows measurement gain and antenna radiation pattern at a frequency of 7 GHz result using 3D electromagnetic simulator.

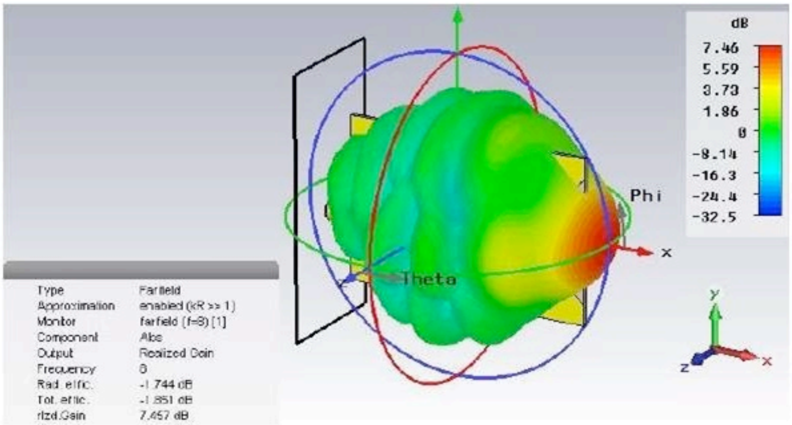



*Figure 14.* Gain and antenna radiation pattern at a frequency of 8 GHz

Figure 14 shows measurement gain and antenna radiation pattern at a frequency of 8 GHz result using a 3D electromagnetic simulator.

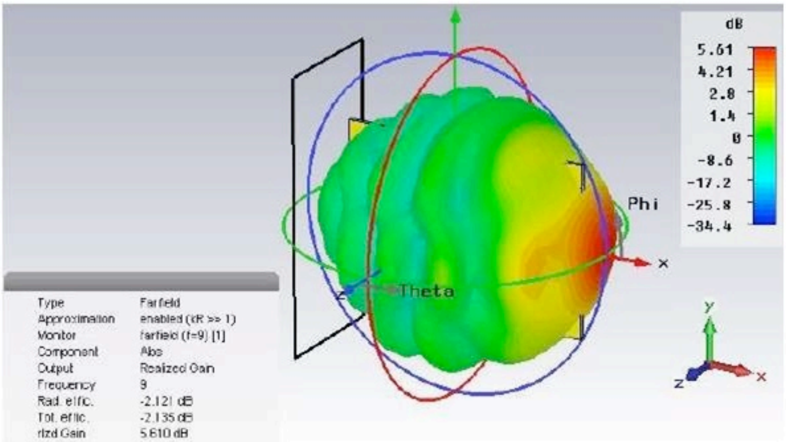



*Figure 15.* Gain and antenna radiation pattern at a frequency of 9 GHz

Figure 15 shows measurement gain and antenna radiation pattern at a frequency of 9 GHz using 3D electromagnetic simulator.

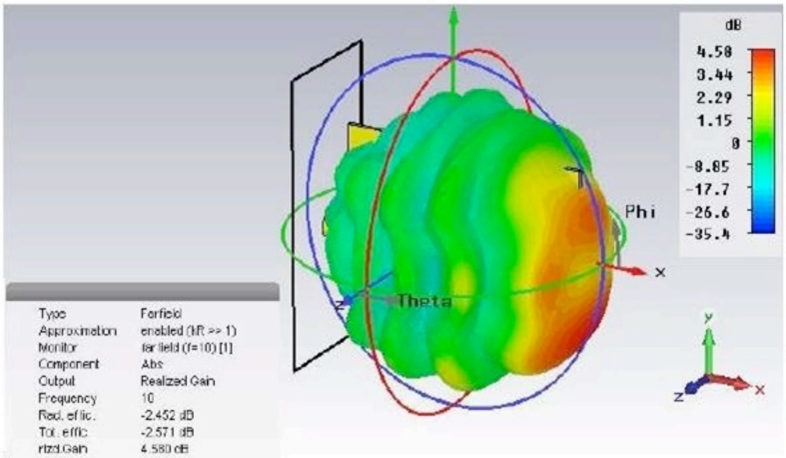



*Figure 16.* Gain and antenna radiation pattern at a frequency of 10 GHz

Figure 16 shows measurement gain and antenna radiation pattern at a frequency of 10 GHz using 3D electromagnetic simulator.

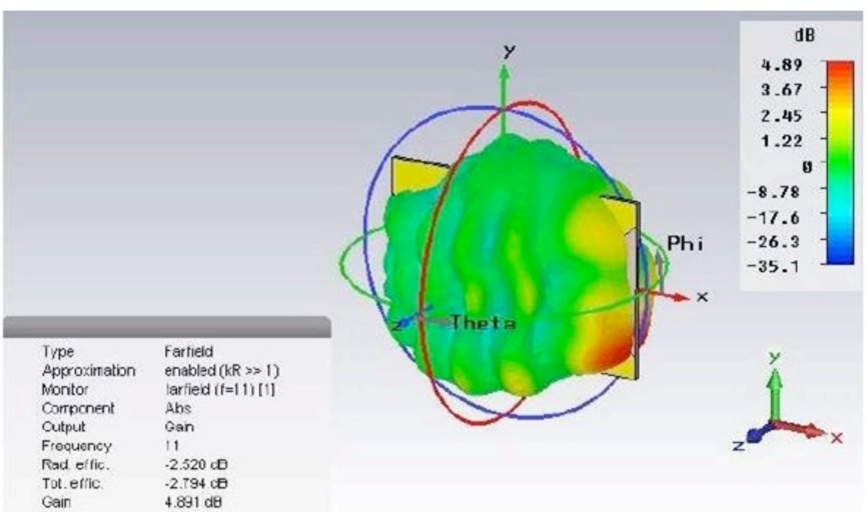



*Figure 17.* Gain and antenna radiation pattern at a frequency of 11 GHz

Figure 17 shows measurement gain and antenna radiation pattern at a frequency of 11 GHz result using 3D electromagnetic simulator. Based on images, it can be seen that the antenna has a gain of about 4.6-7.8 dBi and a directional radiation pattern of a frequency of 3-11 GHz.

## CONCLUSION

This study produced an ultra-wideband microstrip antenna design directional having fulfilled the specifications for VSWR <2 for the frequency range from 3.1 to 10.6 GHz, using microstrip Vivaldi antenna.

The antenna performance can be further enhanced by taking into consideration the following factors:

- Simulation with another substrate material for obtaining the antenna's performance using different materials
- Using other simulators to determine accuracy of each simulator
- Develop new methods to obtain directional radiation pattern in the form of a planar antenna
- Develop new methods to reduce the dimensions of the antenna size.

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