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# Design of a C- Band Circular Polarization Microstrip Antenna

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**Abstract.** The development of circularly polarized microstrip antenna is an interesting topic in current research, due to its superiority in various applications. In this work, the design of a circular polarization antenna that will be operated in the C-band range will be described. The developed antenna is intended to be used for Synthetic Aperture Radar (SAR) applications. Through this application, various targets or areas on the surface of the earth, such as buildings, soil and land can be observed. To get the ideal antenna characteristic, in this research the various parameters in antenna design will be simulated. A software CST Studio will be operated in this simulation. Based on the simulation results, the optimum parameters are obtained in term of reflection coefficient, VSWR, axial ratio, and gain. The reflection coefficient of the antenna (S11) is obtained at -19.75 dB and VSWR of 1.23. Meanwhile, the axial ratio and gain of the antenna were obtained at 2.66 dB and 2.1 dBi, respectively. Based on this simulated results, antenna design is potential to be developed and fabricated for SAR sensor applications.

## 1. Introduction

In remote sensing technology, a Synthetic Aperture Radar (SAR) sensor played an important role such as mapping, oceanography, disaster monitoring, land use, land classification and various other applications. Moreover, the SAR sensor can be implemented measure land surface changing due to landslide or land subsidence [1]. The SAR technology can be operated with very high accuracy measurements to millimeter order [2]. In measurement, SAR sensors collect information from the target or area observed based on the back scattering signal returned by the object or area. Therefore, an antenna has a very important role as a transmitter and receiver signal to and from the target.

In previous works, several antennas for SAR sensor have been developed [3]-[6]. All the antennas in previous work is developed on L band frequencies, as a result, the size of the antenna in the array configuration is quite large. For the antenna to be installed on unmanned aerial vehicle (UAV), a large size of the antenna will be difficult to carry and requires a large space in the UAV. The smaller antenna, antenna is developed at c band frequency so it is easy to install on UAV and lighter. One way to reduce the size of the antenna is to change the working frequency to be higher like a C-band.

Several C-band antennas have been produced for many applications. Most of the antennas produced work with linear polarization. The purpose of this work is to present a C-band microstrip



antenna with circular polarization. The circular polarization is beneficial since the future SAR requires a sensor that insensitive to Faraday rotation effect and produces more information from the target. The circular microstrip antenna with hole at center is adopted in this antenna design [7]. Circular polarization is generated by setting the phase difference on the two feeds. In next section, the design of proposed antenna and research result will be discussed in section two and three, respectively. Finally, the conclusion from this work will be presented in the last section.

## 2. Antenna Design

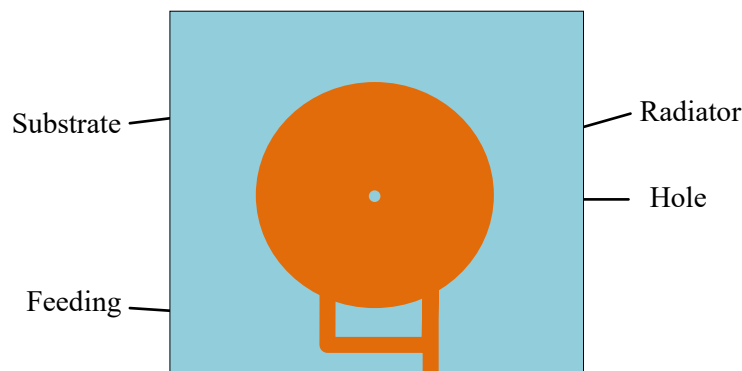
The C-band antenna is designed to satisfy the specified SAR sensor parameters as listed in Table 1. In this design, a Nippon Pillar substrate (NPC-H220A) is used having a thickness 1.6 mm, a dielectric constant  $\epsilon_r = 2.17$  and a loss tangent  $\delta = 0.0005$ .

**Table 1.** Antenna parameter for SAR sensor

| Parameters           | Specification |
|----------------------|---------------|
| Center Frequency     | 5.3 GHz       |
| S11                  | < -10 dB      |
| VSWR                 | < 2           |
| Axial Ratio          | < 3 dB        |
| Polarization (Tx/Rx) | RHCP/LHCP     |
| Main Lobe            | 4-7 dBi       |

As shown in Table 1, the proposed antenna is designed to operate at C-Band with center frequency 5.3 GHz. Reflection coefficients (S11) and voltage standing wave ratio (VSWR) is targeted less than -10dB and 2, respectively. To satisfy the circular polarization requirement either Left Handed Circular Polarization (LHCP) or Right Handed Circular Polarization (RHCP), the axial ratio of the antenna design is regulated less than 3 dB.

In this design, a circular microstrip antenna with hole in the centre is impelented. To produce circular polarization, two feeds with phase difference of  $1/4 \lambda$  are used in the proposed antenna. Design of the proposed antenna is illustrated in Figure 1.



**Figure 1.** Geometry design of the proposed antenna.

The radiator of the proposed antenna is placed on the top with a distance of 1.6 mm from the ground. Ground of the antenna is at lower part under the substrate. A hole is positioned at center of the radiator. The feeding net work is attached to the radiator directly on the top of antenna surface.

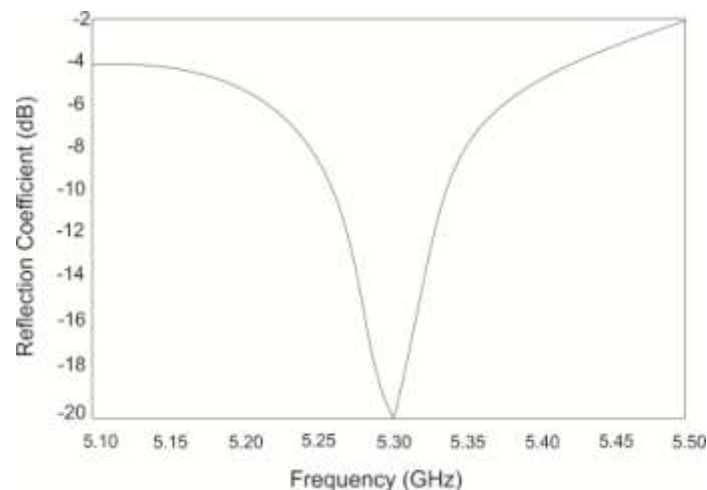
### 3. Result and Discussion

Based on the simulation results, the optimum parameters of the antenna are obtained. Parameters of the antenna consist of radius of the hole, feeding width, length and width of the substrate or ground, and radiator radius. The optimum of these parameters is listed in Table 2.

**Table 2.** Optimum parameter of the antenna design

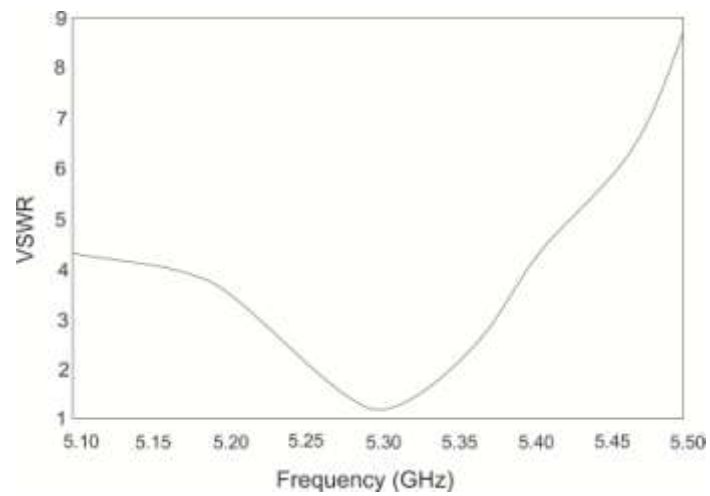
| Parameters              | Size (mm) |
|-------------------------|-----------|
| Radius of the hole      | 0.984     |
| Feeding width           | 1.85      |
| Length of the substrate | 14.71     |
| Width of the substrate  | 35.79     |
| Radiator radius         | 19.45     |

Using the parameters in Table 2, the characteristics of the proposed antenna design are obtained as shown in Figures 2 to 5. In Figure 2, the reflection coefficient (S11) as a function of frequency is plotted. The reflection coefficient at centre frequency 5.3 GHz is obtained of 20 dB. The simulated result of S11 shows the working frequency of the antenna ranging from 1.26 GHz to 5.34 GHz at -10dB. Based on S11 characteristic, the antenna design can be realized and operated on C-band frequency.

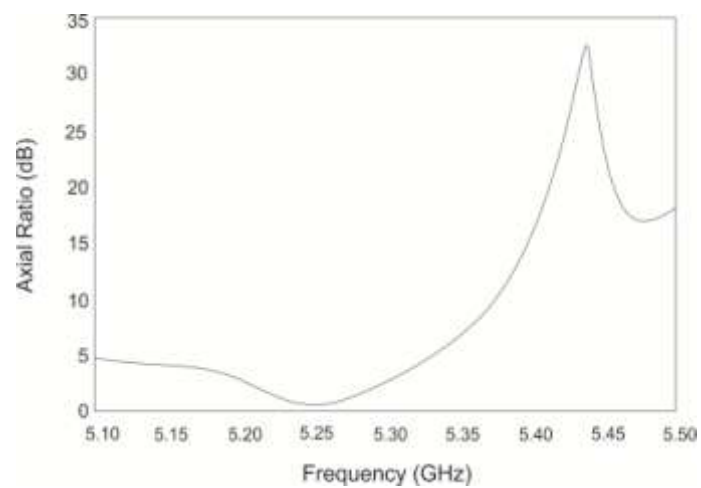


**Figure 2.** Reflection coefficient plotted as a function of frequency.

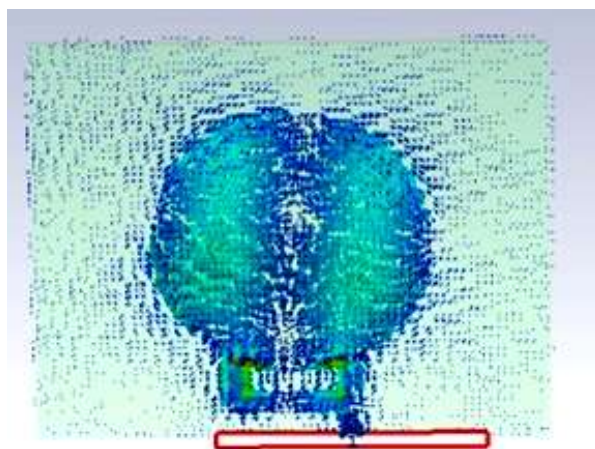
Figure 3 present the VSWR characteristics of the antenna. A satisfy antenna must have VSWR less than 2 in working frequency. The simulation results show the VSWR of the antenna deign obtained of 1.23. Thus, it can be concluded that the antenna works well within the designed frequency range. The polarization characteristic of the antenna is shown through the axial ratio (AR) as presented in Figure 4. The perfect circular polarization can be obtained for 0 dB axial ratio. However, the perfect circular are very difficult to produce in a circular polarization antenna. Therefore, the axial ratio of less than 3 dB can still be classified as circular polarization antennas. The simulation results show that the Axial Ratio of the antenna obtained is 1.35 dB. This result show the designed antenna can be classified as a circular polarization. A simulated axial ratio bandwidth of 2.8% is obtained from 5.22 GHz to 5.37 GHz. The direction of circular polarization can be investigated using surface current as shown in Figure 5. In this design, the surface current shows the type of polarization obtained is Left Handed Circular Polarisation (LHCP).



**Figure 3.** VSWR

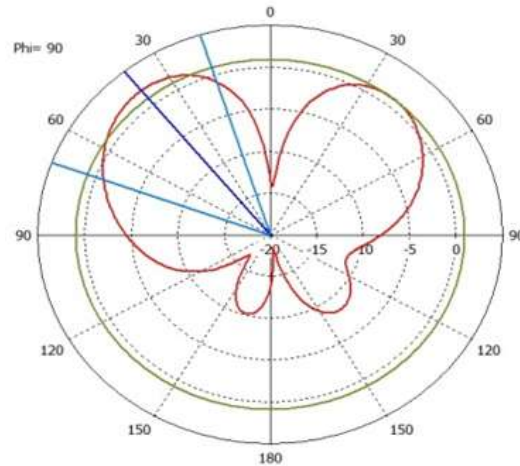


**Figure 4.** Axial ratio ( $AR$ ) plotted as a function of frequency.



**Figure 5.** Surface Current.

The performance of the antenna in terms of radiation pattern is presented in Figure 6. A maximum gain of 2.1 dBic is obtained in simulation. This gain is still acceptable for the antenna at C band frequency. The main lobe of the antenna radiation is generated in  $45^\circ$  direction.



**Figure 6.** The radiation pattern of the antenna design in the theta plane ( $x - z$  plane).

#### 4. Conclusion

A design of C-band circular polarization microstrip antenna has been presented in this paper. In general, the designed antenna can be operated in working frequency at centre frequency 5.3 GHz. The satisfy characteristics are obtained in term of reflection coefficient, VSWR, axial ratio, surface current and radiation pattern. Based on this simulation results, the proposed antenna can be implemented as transmitter and receiver in SAR sensor system.

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