Novel Linearly Polarized Microstrip Circular Patch Antenna Design in C-Band Frequency for Satellite Communications

Putu Artawan[1]

[1]Physics Department, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Ganesha (Undiksha), Singaraja, Bali, Indonesia,
Email:Scientya@yahoo.com/artawan.putu@undiksha.ac.id

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ABSTRACT
The design of a novel linearly polarized microstrip circular patch antenna in C-Band frequency is presented in this research. The circular patch with truncate square and feeding technique in stripline is adopted in this antenna design. The total size of antenna is 40mm x 40mm. This study has obtained design of novel linearly polarized microstrip circular patch antenna with more optimal characteristics parametric in its application in communications especially in C-Band frequency. The result indicate that the antenna characteristics parametric showed byVoltage Standing Wave Ratio (VSWR≤2) of the proposed antenna is1.06, bandwidth is 740.0MHz (5.18GHz–5.92GHz), reflection coefficient is 0.03and return loss is -30.69dB respectively. The antenna has achieved a stable radiation performance with a maximum gain of 7.46dB in C-Band operating frequency. Novel linearly polarized microstrip circular patch antenna with 50 Ohm impedance and easy integration are making this model suitable forC-Band frequency (4GHz-8GHz) satellite communication applications.Details of the proposed antenna design and results are presented and discussed.

Keywords: Microstrip Patch Antenna, Linear Polarization, C-Band Frequency, Communications

1. INTRODUCTION

Various studies have been conducted on microstrip antenna type [1,2,8,10,11,12,13,14,16], among which is to perform a wide variety of designs and shapes microstrip antenna, by giving the slot [11,12] and patch microstripantenna and adding to the number of the array [15,16].Dual polarized microstrip patch antennas excite two orthogonal modes, which generate vertically polarized electric field and horizontally polarized electric field. Therefore, dual polarized antennas added information by providing two co-polarizations and two cross-polarizations.Microstrip patch antenna have good potential with the characteristics of a thin cross-section for making dual-polarized antennas due to their several attractive features including low profile, the mass that is light weight, low cost, easy to make, compatibility with Microwave Integrated Circuits (MICs) technology and can be made to multifrequency. Microstrip patch antennas have been widely used in high performance satellite. Several works have been reported to overcome drawbacks of the conventional microstrip antenna such as low efficiency and narrow bandwidth. The main problem designing the microstrip antenna is to widening bandwidth and optimizing the gain. In this research, the truncated in circular patch side is a one of the solution to reach wide in bandwidth and optimise in gain performance.Besides, to arranges the electricity field current distribution in vertical polarization. There are several solutions have been proposed to achieve the polarized antenna with wide bandwidth, and optimising the gain. One of the most common solutions consists of using monopol feeding [11,12]. Other solutions using feedline coaxial waveguide in microstrip panel[14] have been reported. The various array technic in microstrip patch antena[15,16,17,18,19] have been proposed to improve polarized antenna with wide bandwidth. Despite the excellent performances, these structures require in array structure which increase the complexity. In this work, a simple feeding structure and truncate circular patch antenna for vertical linear polarization is presented.One type of antenna that will be designed to have the characteristics in question are novel linear polarized microstrip circular patch antenna design[5]. In this study,linear polarized microstrip circular patch antenna design is propose to develope in C-Band frequency for many satellite communications transmisions, wi-fi devices which can be used in WLAN applications. The advantages of C-Band are weatherproof, high throughput (easily support voice/data/imagery/HD video, excels with small antennas, low cost (extremely high MHz-

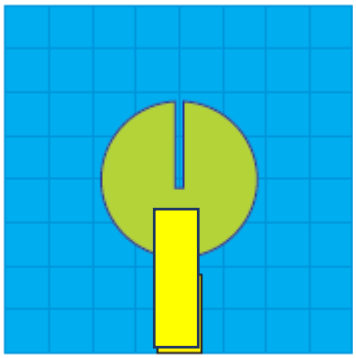
Mbpsefficiency), high link availability, and low probability of interference. The C-Band ranges from 4GHz to 8GHz and is used primarily for radar applications. C-Band used in radar applications including continuous-wave, pulsed, single-polarization, dual-polarization, synthetic aperture radar and phased arrays. C-Band radar frequency sub-bands are used in civil, military and government institutions for weather monitoring, air traffic control, maritime vessel traffic control, defense tracking and vehicle speed detection for law enforcement. The proposed novel linearly polarized microstrip circular patch antenna is afford to operate in [16] C-Band frequency in range 4GHz to 8GHz. The target of novel linearly polarized microstrip circular patch antenna is in 5.5 GHz center frequency, bandwidth more than 5.0%, return loss (S11 parameter) less than –10dB, Voltage Standing Wave Ratio (VSWR) less than 2, gain more than 5dB, and in linear polarization, respectively.

Table 1. Target of The Antenna Parameter

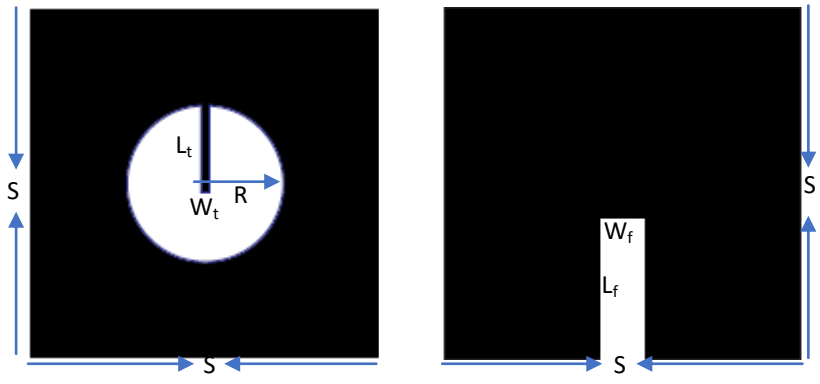
Parameters	**Specification**
Center Frequency	5.5 GHz
Bandwidth	>5.0%
S_{11} (Return Loss)	< -10dB
VSWR	< 2
Gain	>5dB
Polarization	Linear (Vertical)

2. Antenna Geometry And Design

The design procedure starts with the determination of sidelength of the patch using the classical equations [3,4,5]. The following figure is the geometry of the Novel Circular Microstrip Patch Antenna.



(a)



(b)

Figure 1. Geometry of proposed antenna.

The parameters of Novel Circular Microstrip Patch Antenna Design consist of the following table:

Table 2. Dimension Parameter of the Novel Circular Microstrip Patch Antenna Design.

Parameters	Dimension (mm)
S	40
t	0.035
R	9.35
h	1.6
Lt	10
Wt	1
Lf	16
Wf	4.9

Considering the requirements of design such as bandwidth and dielectric constant, the antenna is initially designed to operate in C-Band and consequently optimized to obtain the most efficient size of the patchusing microstrip calculator method.The whole radiating element of the proposed linear polarized circular patch microstrip antenna is centered on the top of a 40x40 mm ground plane. The circular patch has a radius of 9.35mm and is directly printed on a microwave substrate (NPC-220AH) of thickness 1.6mm and relative permittivity 2.17 to reduce the cost. The spacing between line truncate slot is 1mm with 10mm length. The probe of feeds with 4.9mm in width and 16mm in length fedding away from the patch center. The feed arrangement excites 0° and 90° linearly polarized waves.The above specific shape patch for the slots and square shaped patch configuration allow us to obtain a satisfactory 50Ω impedance matching across the frequency band of interest.

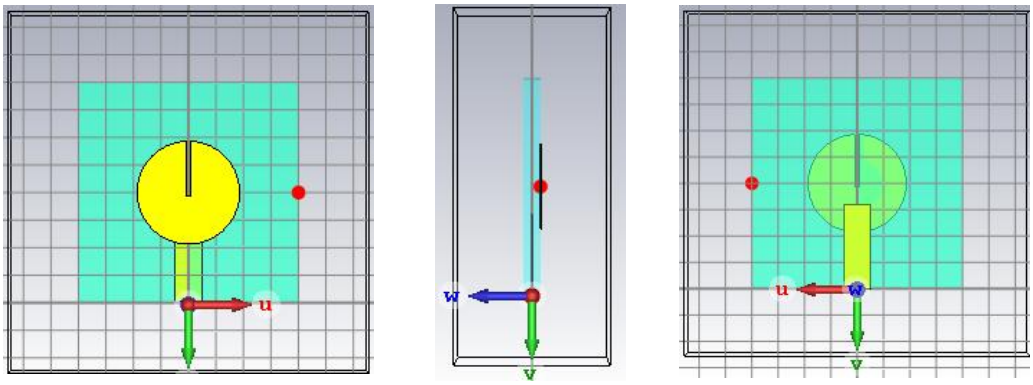
3. RESULTS AND DISCUSSION

Selection method of fabrication [1,2,7,8,12,13] was essential tobe conducted to obtain the results of truly optimal. The results reflect the optimal parameters generated as characteristic of the designed antenna. Fabrication is carried out using Nippon Pillar substrate (NPC-220AH) materialwith UV Photoresist Laminate technique.The result of antenna fabrication shown in Figure 2.

(a) In front of View. (b) Side View. (c) Back View.

Figure 2. The fabricated prototype Novel Circular Microstrip Patch Antenna.

The performance of the proposed antenna has been analyzed and optimized by using CST software. The result of simulation is presented in Figure 3.



(a)TopView. (b) Side View. (c) Bottom View.

Figure 3. Simulation result of Novel Circular Microstrip Patch Antenna.

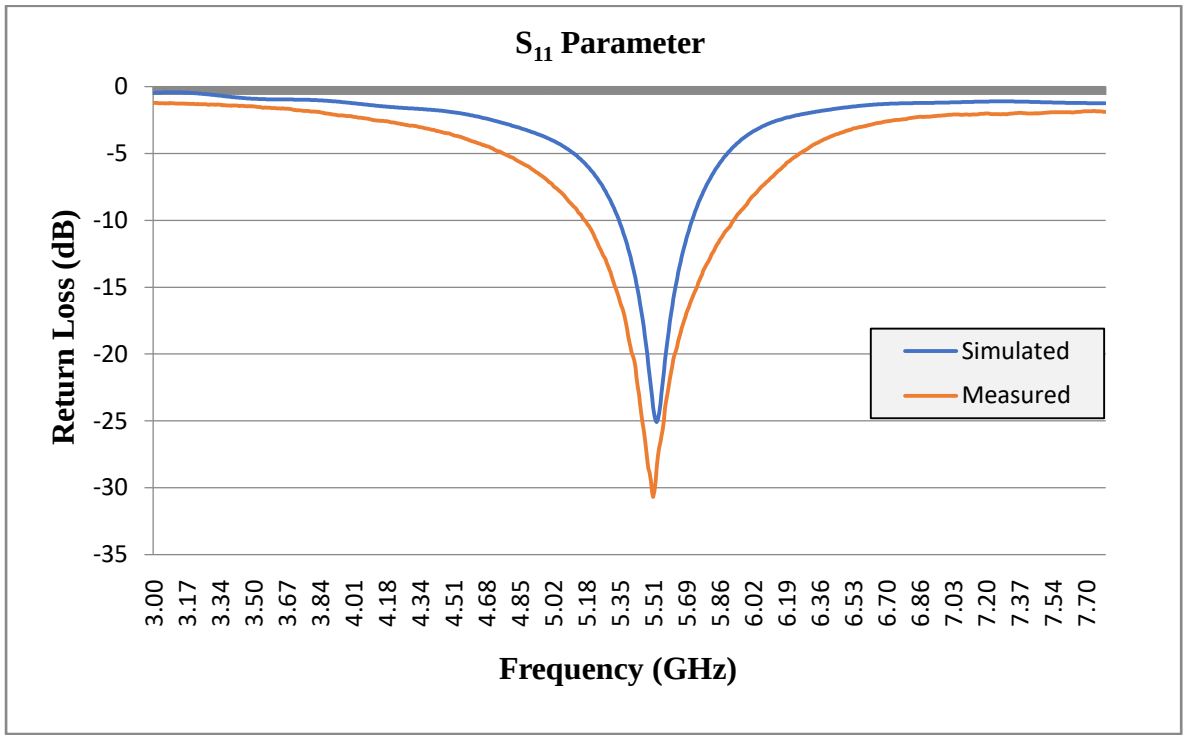
Measuring antenna had been done at Laboratory. In Figure 4 has been shown the measuring process.

(a) Using Network Analyzer. (b) In Chamber.

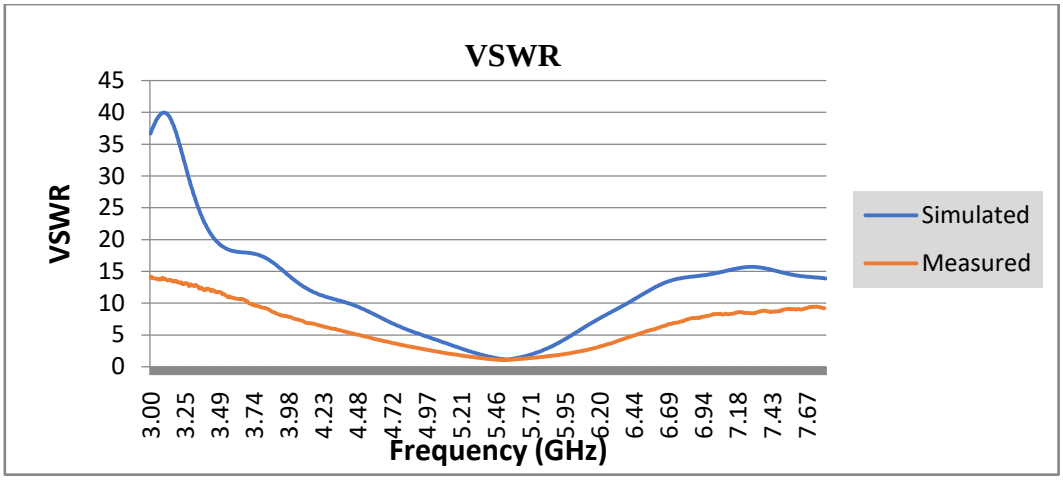
Figure 4. Measuring Process at Laboratory.

Comparing Simulation and Measurement Result

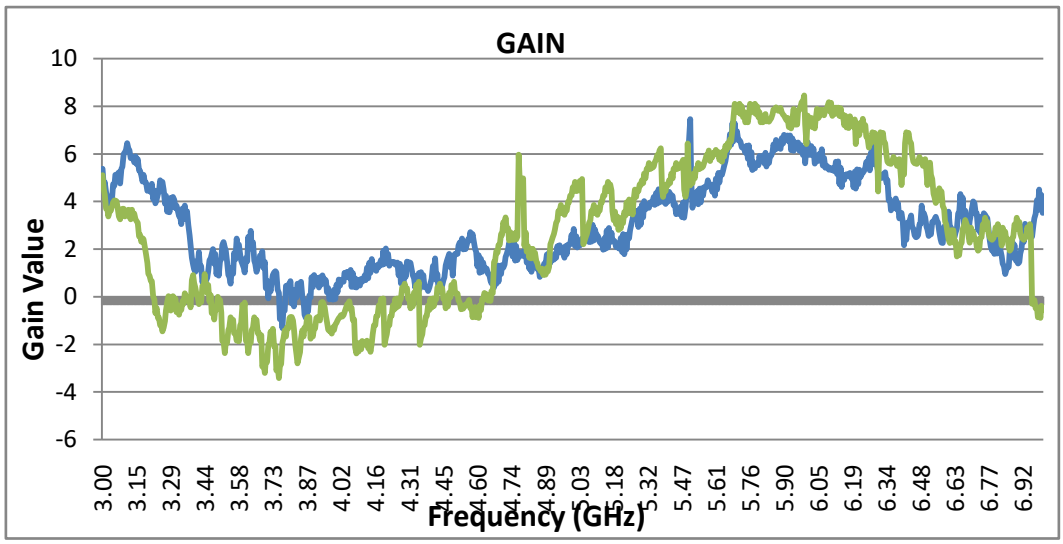
Novel Circular Microstrip Patch Antenna work in 5.53GHz frequency center in bandwidth range aproximately402.0MHz (5.32GHz–5.72GHz). The simulation result shown the antenna works well within the design frequency range. This indicate that the Novel Circular Microstrip Patch Antenna giving the good effect in bandwidth and antenna performance that can be apllied in satellite communication especially in C-Band frequency. The simulation shown in S11 parameter is reflection coefficient 0.05, Voltage Standing Wave Ratio (VSWR) 1.11, return loss -25.09dB and 7.38dB in gain.The measurements shown in 5.51GHz frequency center in bandwidth range aproximately 740.0MHz (5.18GHz–5.92GHz), S11 parameter is reflection coefficient 0.03, Voltage Standing Wave Ratio (VSWR) 1.06, return loss -30.69dB and 7.16dB in gain. The simulated and measured return loss (S11 parameter), VSWR and gainof the proposed antenna is shown in Figure 5.



(a)S_{11} Parameter.



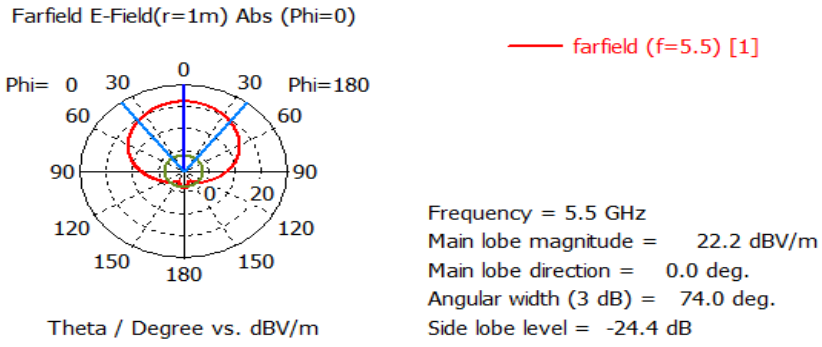
(b) VSWR.



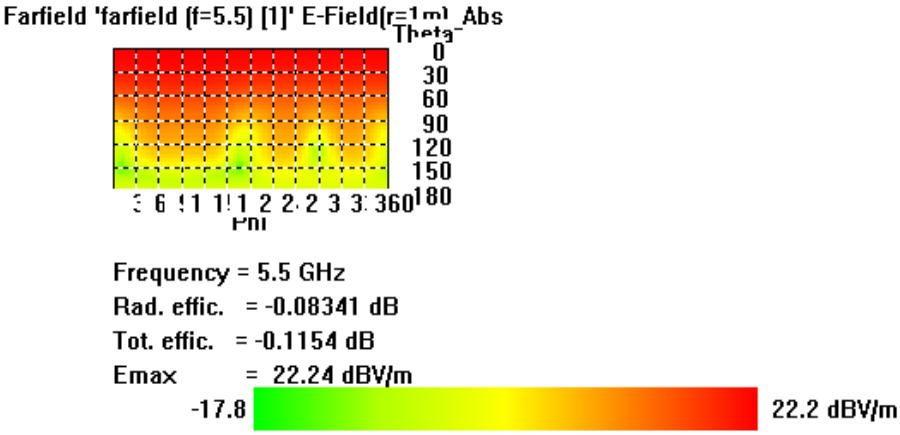
(c) Gain

Figure 5. The result of Novel Circular Microstrip Patch Antenna.

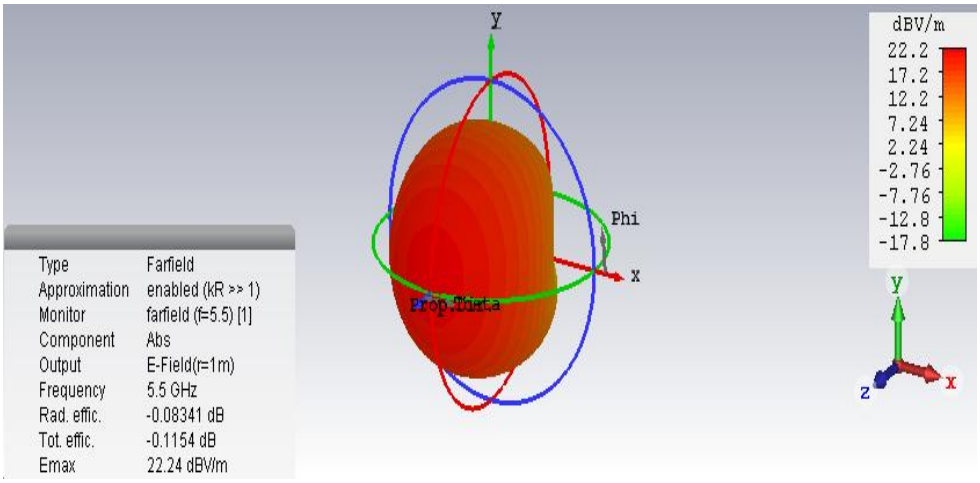
From the (S11 parameter) return loss plot, it can be observed that the antenna has a -10dB bandwidth 7.23% (5.72GHz–5.32GHz) which is in the C-Band region. It resonates at 402.0MHz.From the VSWRgraph(1.11 VSWR) its shown that the antenna is able to transmit the electromagnetic field. And from the gain plot (7.46dB) thats indicate the antenna has a good power to transmit the signal power.Figure 6 shown the polarization for vertical linear polarization of the proposed antenna at resonance frequency of 5.53GHz.



(a) 1D Polarization Pattern.

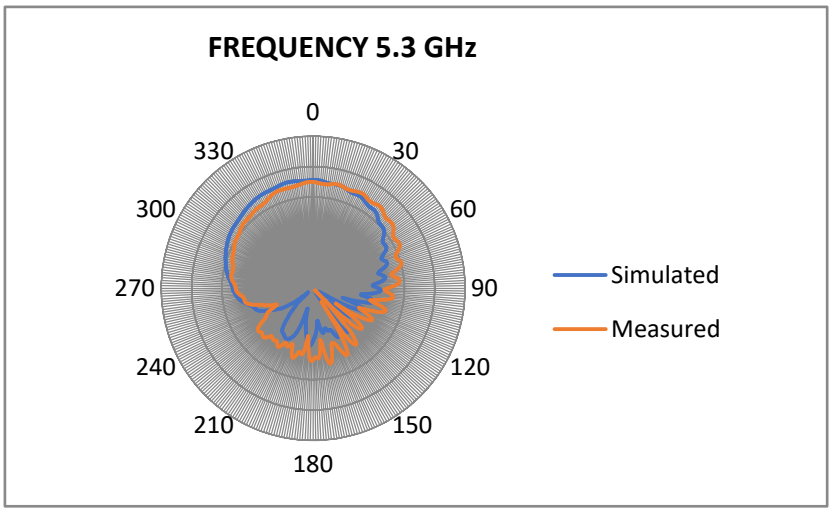


(b) 2D Polarization Pattern



(c) 3D Polarization Pattern

Figure 6. The Polarization of the Circular Microstrip PatchAntenna.



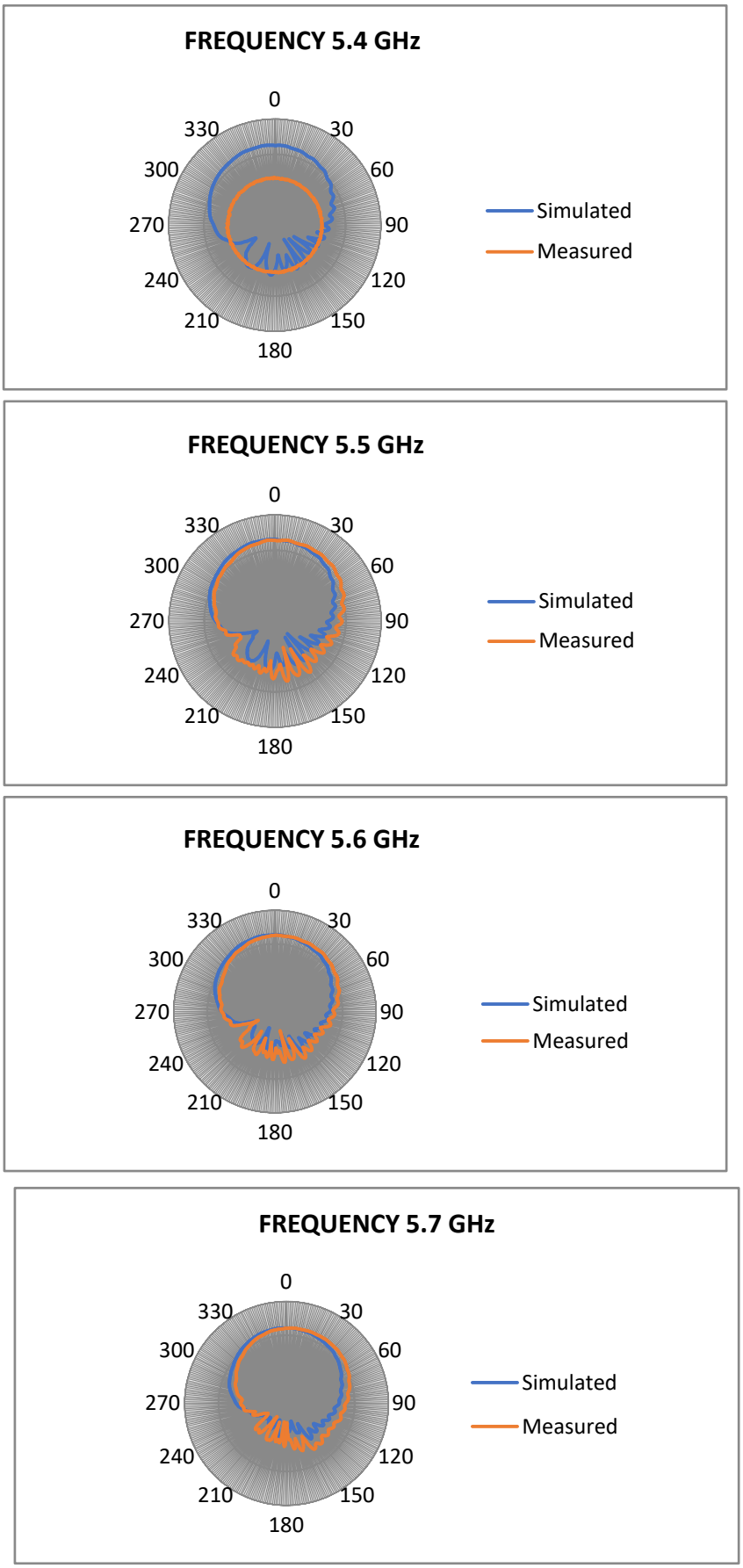


Figure 7. The Polarization of the Circular Microstrip Patch Antenna in (5.3,5.4,5.5,5.6,5.7)GHz Frequency.

The polarization in Novel Circular Microstrip PatchAntenna is linear vertical polarization. A directivity of 7.38dBi is obtained in simulation. This results is compatible for antenna in C-Band frequency. The Circular Microstrip PatchAntenna was tested using Network Analyzer type The Agilent 8510 Vector Network Analyzer.The measured S_{11} indicate that the CircularMicrostrip PatchAntenna compatible in communications application especially in C-Band frequency.Summarizing the comparison between simulated and measured is shown in following table.

Table 3. Summarizing table of simulated and measured results of proposed antenna.

Parameters	fc (GHz)	BW (%)	RL (dB)	VSWR	Γ	Gain (dB)
Simulated	5.53	7.23	-25.09	1.11	0.05	6.43
Measured	5.51	13.43	-30.69	1.06	0.03	7.46

A satisfy Circular Microstripline Array Antenna must have more than 5dB gain in working frequency. The simulation results of the Circular Microstripline Array Antenna obtained of7.46dB gain and the measurement results of the Circular Microstripline Array Antenna obtained of 7.16dB gain. The current distribution on the patch at resonance frequency of 5.5GHz is depicted in Figure 8.

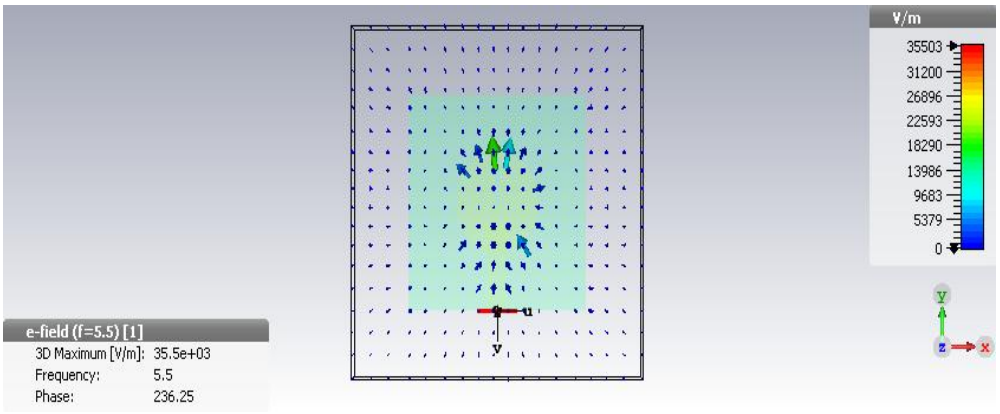


Figure 8. Current distribution of proposed antenna at 5.5GHz frequency.

Arrow sign indicates the direction of current. It can be seen that the current distribution flows at the edge of the patch intensively.

In general, the proposed antenna is designed to operate at C-Band and it can be observed from return loss and gain in antenna design that this antenna is suitable for being used in satellite communication. It can also be observed that an impedance bandwidth of 402.0MHz (7.23%) is obtained due to proper matching. It can be easily observed from the radiation pattern that the designed antenna produces linear vertical polarization radiation pattern. There are some significant advantages if a patch antenna has a stable and symmetrical in radiation pattern.One of the major advantages is that during construction of an antenna, the radiation pattern would be more stable across the operating bandwidth.From the current distribution display, it is observed that at resonant frequency of 5.5GHz, the electric current strongly flows at the edge of the patch especially near the circular of the patch. This indicates that the circular patch dominate the antenna performance. The current distribution flow is restricted due to the circular patch which leads the reduction of cross-polarization level. However, the current distribution at different part of the patch is almost uniform.

4. CONCLUSIONS

Linearly polarized microstrip patch antenna with truncate square in circular patch and feedingstripline has been demonstrated in this study. The circular patch with truncate square and feeding technique makes it possible to have a bandwidth of 13.43% and linear polarization at C-Band. It covers the frequency ranges from 5.18GHz–5.92GHz in 5.51GHz center frequency. This antenna can be easily fabricated on substrate material due to its small size and thickness. The results of characteristic antenna parameter in this paper indicate thats the novel circular microstrip patch antenna with linear polarization can be used in C-Band frequency application and capable supporting satellite communication system.

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