International Journal of Computer Science and Software Engineering (IJCSSE), Volume 4, Issue 4, April 2015
ISSN (Online): 2409-4285 www.IJCSSE.org Page: 102-106

# Quintuple Microstrip Patch Antenna with E-slot at Different Rotation Angles

**Bashar B. Qas Elias**

Department of Computer Engineering Techniques, Al Nisour University College, Baghdad, Iraq

*basharbahaa1989@yahoo.com*

**ABSTRACT**

This paper presents an effective designs procedure for a single and dual band microstrip antenna for S-band (2GHz, 2.29GHz ,2.31GHz, 2.36GHz, 2.37GHz, 2.38GHz, 2.60GHz, 2.63GHz, 2.67GHz) which are used in many applications. Quintuple patch antenna with E-slot (ellipse arms) is presented in this paper. This slot is rotate in five cases with the following angles (45,135,180,225 and 315) degree and in each step of rotation, the antenna parameters are studied. The minimum value of return loss among the whole cases is 34.18dB, achieved at 2.38GHz, when the maximum gain is 15dB. Other parameters results for the suggested designs such as voltage standing wave ratio (VSWR), bandwidth and current distribution are also studied in this paper. The designs are simulated using "FEKO simulation software version (7.0)" and the proposed antenna is fed by a coaxial cable.

***Keywords:*** *Microstrip patch antenna (MSA), return loss, gain, VSWR, E-slot.*

## 1. INTRODUCTION

The current demand of the wireless applications development ranging from WLANs, Bluetooth, GSM and more applications requires more efficient, flexible antennas and the multiband frequencies are needed [1]. A microstrip patch antenna have an important benefits compare with the other antennas, such as low profile, light weight and low cost [2][3]. Microstrip patch antennas suffer from a narrow bandwidth, low gain [4]. Many techniques are used to get rid of these disadvantages. There are different feeding techniques for designing microstrip antenna (MSA) [5], in this paper for the matching impedance at 50Ω, a coaxial cable is used. FEKO simulation software based on method of moment (MOM) is used for analyzing the suggested designs [6].

## 2. ANTENNA DESIGN

In general configuration, microstrip patch antenna consist of a patch as a top plane, ground plane at the bottom and substrate layer with dielectric constant ( $\varepsilon_r$ ) and thickness (h) between them. Antenna is fed by one of the feeding methods. In this paper coaxial cable is fed the antenna at the feed point.

The structure of the proposed antenna consists of quintuple patch with E-slot. The vertical and horizontal arms of this slot is designed as ellipse shape with dimensions ( $R_1$ , $R_2$ and $R_3$ ) as shown in Fig1.

All the dimensions of the proposed antenna are presented in the Table1.

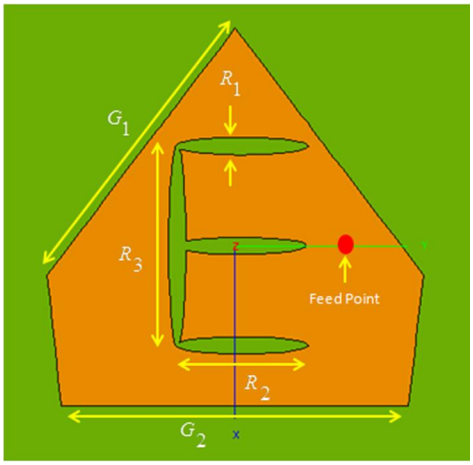



*Fig. 1. Quintuple microstrip patch antenna with E-slot*

*Table 1: The dimensions values of the proposed MSA*

| Parameter | Value (mm) |
|---|---|
| $G_1$ | 107.004 |
| $G_2$ | 120 |
| $R_1$ | 3 |
| $R_2$ | 23 |
| $R_3$ | 35 |
| Dielectric constant ( $\varepsilon_r$ ) | 1.001 |
| Ground plane | Infinity |
| Substrate Thickness (h) | 5 |
| Feed point | (-1, 38.5) |

After the design process, E-slot within the patch is rotated in five steps with the specific angles as shown in Fig2, and in each case the feed point is constant.

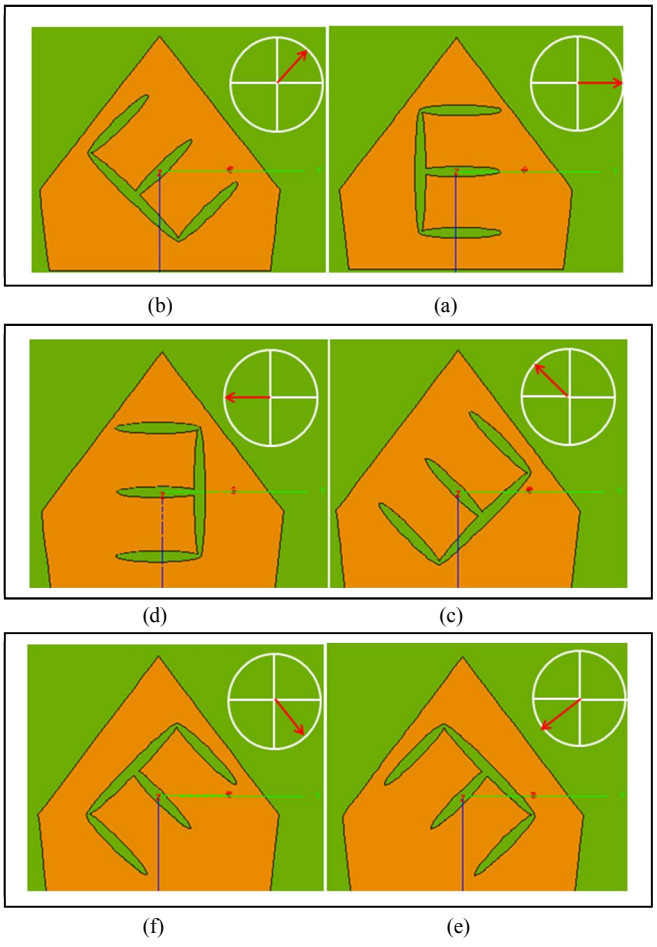



*Fig. 2. Quintuple microstrip patch antenna with different rotation angle of the E-slot: (a): Standard (b): 45 degree (c): 135 degree (d): 180 degree (e): 225 degree (f): 315 degree.*

## 3. RESULTS

One of the most significant parameters in antennas is return loss, it is defined in dB and it is measure the matching between lines [7]. As shown in Fig3, the minimum value of return loss is achieved at 2.38GHz which is equal to 34.18dB in the case of 45 degree of rotation angle of the E-slot.

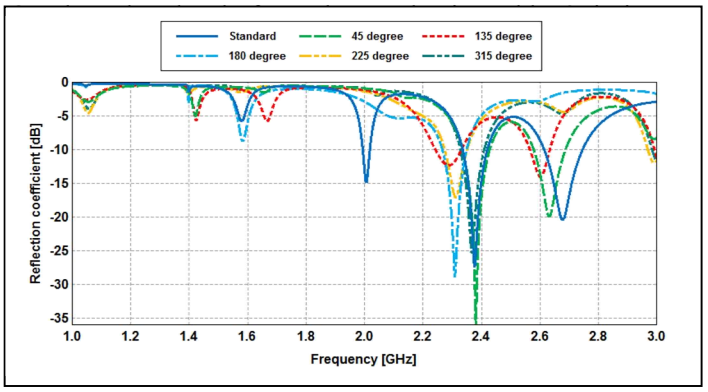



*Fig. 3. Return losses of the quintuple microstrip patch antenna with different rotation angle of the E-slot*

*Table 2: Return losses results of the proposed MSA in all cases of rotation angle of the E-slot*

| Rotation angle of the E-slot | Resonant Frequency ( $f_r$ ) in (GHz) | Reflection Coefficient (S11) in (dB) |
|---|---|---|
| Standard (Without Rotate) | 2.0 | -14.45 |
| | 2.37 | -26.49 |
| | 2.67 | -20.34 |
| 45° | 2.38 | -34.18 |
| | 2.63 | -19.82 |
| 135° | 2.29 | -12.25 |
| | 2.60 | -12.25 |
| 180° | 2.31 | -27.81 |
| 225° | 2.31 | -16.98 |
| 315° | 2.36 | -25.04 |

Voltage Standing Wave Ratio (VSWR) is defined as the "ratio of the maximum to minimum voltage of the antenna" [8]. The minimum value of VSWR as shown in the simulation results of FEKO software is 1.08 at 2.38GHz in the case of 45 degree of E-slot rotation, which is represented the power reflected by the antenna. Other VSWR results are presented in Fig4 and Table 3 respectively.

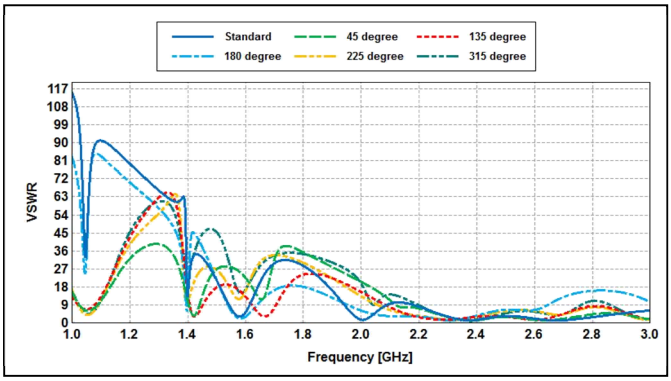
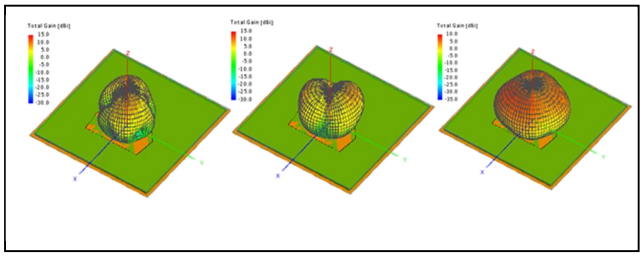



*Fig. 4. VSWR of the quintuple microstrip patch antenna with different rotation angle of the E-slot*

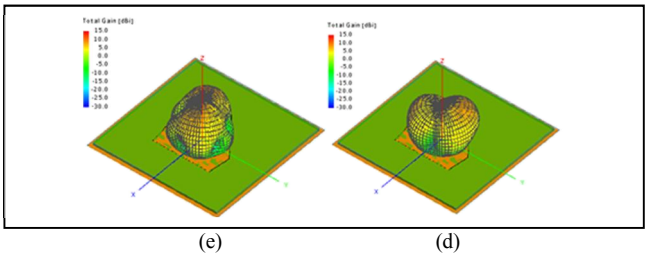
*Table 3: VSWR results of the proposed MSA in all cases of rotation angle of the E-slot*

| Rotation angle of the E-slot | Resonant Frequency ($f_r$) in (GHz) | Voltage Standing Wave Ratio (VSWR) |
|---|---|---|
| Standard (Without Rotate) | 2.0 | 1.52 |
| | 2.37 | 1.12 |
| | 2.67 | 1.22 |
| 45° | 2.38 | 1.08 |
| | 2.63 | 1.23 |
| 135° | 2.29 | 1.65 |
| | 2.60 | 1.51 |
| 180° | 2.31 | 1.12 |
| 225° | 2.31 | 1.34 |
| 315° | 2.36 | 1.13 |

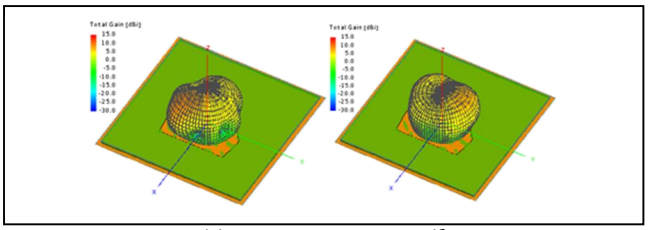
In the next step, Fig5 and Table 4 shows a high gain of MSA which is computed for different resonant frequencies in each case of rotation. It is observed that the maximum value is 15dB for some angles and 10dB for other values.



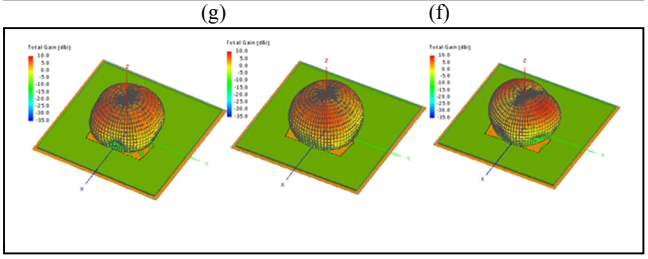
(c) (b) (a)



(e) (d)



(g) (f)



(j) (i) (h)

Fig. 5. Gain of the quintuple microstrip patch antenna with different rotation angle of the E-slot at resonant frequencies in X-Y plane: (a) Standard at 2.0GHz (b) Standard at 2.37GHz (c) Standard at 2.67GHz (d) $45^O$ at 2.38GHz (e) $45^O$ at 2.63GHz (f) $135^O$ at 2.29GHz (g) $135^O$ at 2.60GHz (h) $180^O$ at 2.31GHz (i) $225^O$ at 2.31GHz (j) $315^O$ at 2.36GHz.

*Table 4: Gain results of the proposed MSA in all cases of rotation angle of the E-slot*

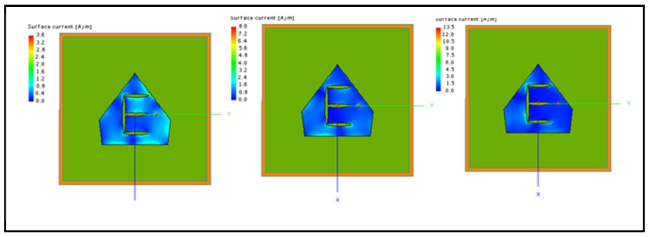
| E-slot Rotate Angle | Resonant Frequency ($f_r$) in (GHz) | Gain (dB) |
|---|---|---|
| Standard (Without Rotate) | 2.0 | 10 |
| | 2.37 | 15 |
| | 2.67 | 15 |
| 45° | 2.38 | 15 |
| | 2.63 | 15 |
| 135° | 2.29 | 15 |
| | 2.60 | 15 |
| 180° | 2.31 | 10 |
| 225° | 2.31 | 10 |
| 315° | 2.36 | 10 |

The difference between the higher and the lower frequencies of the band is known as a bandwidth (BW). The maximum frequency is 131MHz achieved for $45^O$ rotation angle of E-slot MSA, other bandwidth results are shown in the Table 5.

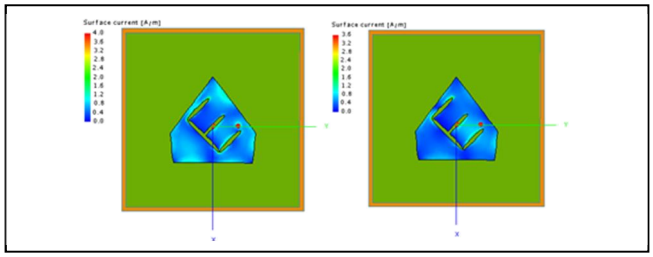
*Table 5: Bandwidth results of the proposed MSA in all cases of rotation angle of the E-slot*

| E-slot Rotate Angle | $f_{Hi} - f_{Lo}$ | BW (MHz) |
|---|---|---|
| Standard (Without Rotate) | 2.019-1.995 | 24 |
| | 2.422-2.335 | 87 |
| | 2.747-2.616 | 131 |
| 45° | 2.428-2.338 | 90 |
| | 2.689-2.58 | 109 |
| 135° | 2.335-2.243 | 92 |
| | 2.635-2.567 | 68 |
| 180° | 2.351-2.27 | 81 |
| 225° | 2.354-2.275 | 79 |
| 315° | 2.411-2.33 | 81 |

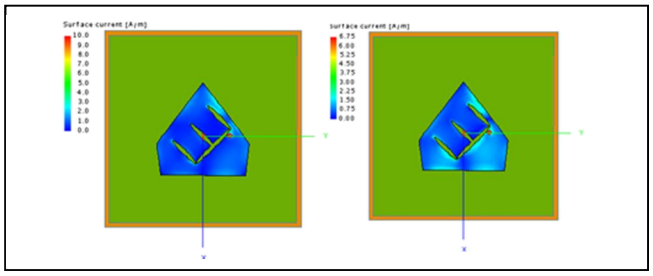
Finally, the current distribution in MSA is shown in Fig6 at different frequencies for all the steps of E-slot rotation.



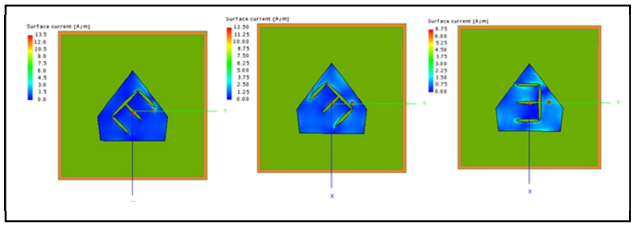
(c) (b) (a)



(e) (d)



(g) (f)



(j) (i) (h)

*Fig. 6. Current distribution of the quintuple microstrip patch antenna with different rotation angle of the E-slot at resonant frequencies in X-Y plane: (a) Standard at 2.0GHz (b) Standard at 2.3GHz (c) Standard at 2.6GHz (d) $45^O$ at 2.3GHz (e) $45^O$ at 2.6GHz (f) $135^O$ at 2.2GHz (g) $135^O$ at 2.6GHz (h) $180^O$ at 2.3GHz (i) $225^O$ at 2.3GHz (j) $315^O$ at 2.3GHz.*

## 4. Conclusions

A quintuple microstrip patch antenna has been designed and simulation by using FEKO software, the E-slot shape has been cut inside the patch. This slot is rotated in different rotation angles ( $45^O$ , $135^O$ , $180^O$ , $225^O$ and $315^O$ ).. High gain of 15dB, return loss of 34.18dB, voltage standing wave ratio of 1.08 and bandwidth of 131MHz are the best results among all the cases of the proposed antennas in this paper. S-band antennas suitable for the applications of mobile satellite communication.

## Acknowledgments

I would like to express my sincere thanks and gratitude to all those who gave me assistance in the preparation and the creation of this research.

## REFERENCES

[1] Alaa I. Abunjaileh, Ian C. Hunter, Andrew H. Kemp, Multi-band Matching Technique for Microstrip Patch Antenna Transceivers, European Microwave Conference, October 2007, Munich Germany, 254-257.

[2] Alois Holub, Milan Polivka, A Novel Microstrip Patch Antenna Miniaturization Technique: A Meanderly Folded Shorted-Patch Antenna, IEEE, 2008.

[3] Mohammad Tariqul Islam, Norbahiah Misran1, Mohammed Nazmus Shakib and Baharudin Yatim, Wideband Stacked Microstrip Patch Antenna for Wireless Communication, IEEE, 2008, 547-550.

[4] Mohammad Tariqul Islam, Norbahiah Misran1, Mohammed Nazmus Shakib and Baharudin Yatim, Analysis of Broadband Slotted Microstrip Patch Antenna, IEEE, 2008, 758-761.

[5] Bashar B. Qas Elias and Hussein Mohammed, MICROSTRIP PATCH ANTENNA PERFORMANCE IMPROVEMENT

FOR 2.45 GHz APPLICATIONS, IJCAR, Vol.3, Issue.1, 33-43, January 2015.
[6] FEKO Suite 6.0 User manual, EM Software and Systems S.A Pvt Ltd, 2010.
[7] Bashar B. Qas Elias and Hussein Mohammed, Bandwidth Enhancement of A microstrip Patch Antenna for C-band and X- band By Using New Structure of Defected Ground Technique, IJCSMC, Vol.4, Issue.1, January 2015, 426-432.
[8] Constantine A.Balanis, "ANTENNA THEORY - Analysis and Design", Second Edition: Reprint 2007, John Wiley Publications.

## AUTHOR PROFILES:

**Bashar B. Qas Elias** Completed his B.Sc. in Electrical Engineering from AL-Mustansiriya University 2011, Baghdad, Iraq. M.Sc. in Electrical and Electronic Engineering from Eastern Mediterranean University, 2014, Famagusta, North Cyprus. Now he is Assistant lecturer in Al Nisour University College, Department of Computer Engineering Teqniques in Baghdad, Iraq.