

Performance Analysis of CPW Fed Multiband Microstrip Patch Antenna

K.C.B. Rao¹ and Ravi Kishore Maddugaru²(✉)

¹ Department of Electronics and Communication Engineering,
University College of Engineering, JNTUK, Vizianagaram, AP, India
cbraokota@yahoo.com

² Department of Electronics and Communication Engineering,
Sri Sivani College of Engineering, Chilakapalem, Srikakulam, AP, India
mrkishore7709@gmail.com

Abstract. Multiband microstrip antennas are significantly popular due to their ease of fabrication, thin profile, conformal and adaptability to dual and triple band applications. The impedance matching, polarization purity, low spurious radiation with optimum gain condition between the line and patch depend on the type of feeding technique used. The present paper describes the design and simulation of Multiband microstrip patch antennas with different feeding techniques and analyzed using Finite Element Analysis Method based HFSS (High Frequency Structure simulator) software. A new compact multiband planar CPW fed Microstrip antenna is proposed in this work. The performance of the proposed multiband antenna is analyzed, and compared with edge and coaxial feeding techniques in terms of different radiation characteristics including Return loss, Gain, VSWR, Front-to-Back Ratio etc.

Keywords: Multiband · Coaxial feed · Edge feed Coplanar Waveguide (CPW) · Resonant frequency · VSWR · Return loss · HFSS 13.0

1 Introduction

Today's small wireless communication devices challenge antenna designers for developing thin, convenient and high performance antennas that have the capability to meet the industry requirements. Many geometrical structures have been proposed with different degree of achievement in enhancing antenna characteristics. Efficient antenna modules are required to provide optimum access for multiple applications.

A multiband microstrip antenna is an antenna designed to operate in multiple bands of frequencies for compact integrated circuit based applications. These antennas are more popular due to their efficient features such as ease of fabrication and compatibility with monolithic microwave integrated circuits (MMICs). The utilization of Multiband MPAs has become diverse because of their small size and light weight. While designing the antenna, choosing the effective method of feeding is essential in order to satisfy the industry requirements. Efficient transfer of power between radiating structure and feed structure without spurious radiation and surface wave losses is essential. The spurious feed radiation leads to undesired cross polarization.

MPAs can be fed with numerous methods including edge, coaxial, Strip line, proximity and aperture coupling. In this study a comparative analysis have been done considering three popular feeding techniques. In the present paper a Multiband microstrip patch antenna is designed and fed with edge, coaxial and Coplanar Waveguide (CPW) coupling mechanisms and compared the performance with respect to different antenna radiation characteristics.

This paper is structured as follows. Section 2 describes methodology followed for design of all the three microstrip patch antenna geometry. Section 3 shows the results explaining antenna parameters like Radiation pattern, Return loss, VSWR, Gain with specifications tabulated and finally Sect. 4 is conclusion.

2 Methodology

2.1 Antenna Design

This paper presents three models of multiband microstrip antennas based on the transmission model of analysis. First of all we have to choose a dielectric constant and substrate height to design an antenna as these are the basics for the designing. They were chosen according to the design frequency of operation. The chosen substrate material is FR4epoxy with dielectric constant 4.4. The width of the patch of the antenna chosen is 25 mm with length 32 mm and substrate thickness of 1.57 mm according to the required model of analysis. The material chosen for patch is copper having the relative permeability (μ_r), electrical conductivity (σ) and relative density (ρ) of 1.0, 5.8×10^7 (S/m) and 8900 (kg/m^2) respectively. The proposed multiband antennas are fed with

- (1) Edge feeding
- (2) Coaxial feeding
- (3) Coplanar waveguide (CPW) feeding.

2.1.1 Edge Fed Multiband Microstrip Patch Antenna

A conducting strip is directly connected to the patch edges at any one end of the microstrip patch antenna. The dimensions of the strip are very less comparing with patch dimensions. Ease of fabrication, simplicity in modeling as well as better impedance matching made this feeding method more popular and advantageous. However, the antenna is affected with surface waves, spurious feed radiation due to increment in the substrate thickness. This feeding scheme provides narrow bandwidth. The geometry of the edge feeding in HFSS platform can be observed in Fig. 1. The dimensions of the multiband antenna can be observed in Fig. 2 and specifications in Table 1.

2.1.2 Coaxial Fed Multiband Microstrip Antenna

The most common type of feeding technique used is co-axial or probe feed. In this method, the inner conductor is directly connected to the patch and outer conductor to the ground. This technique is more popular since the input impedance can be easily matched by choosing the desired location of feed inside the patch. The spurious

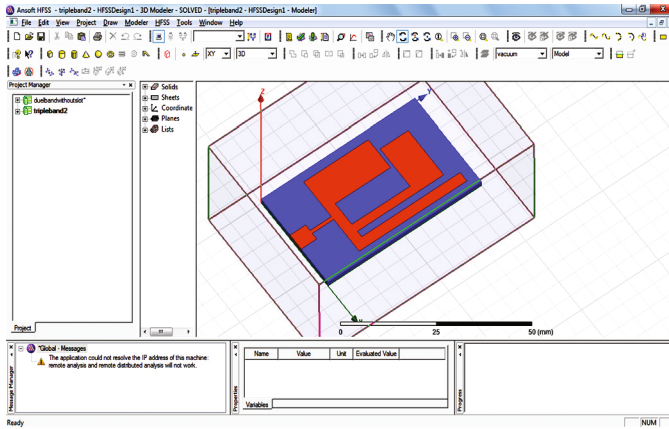


Fig. 1. Design of edge fed antenna in HFSS

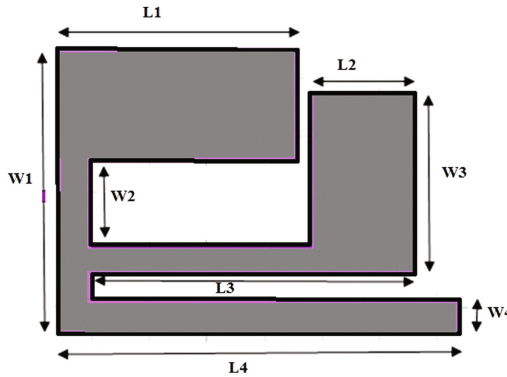


Fig. 2. Geometry of proposed multiband antenna

Table 1. Table design specifications of multiband antenna

Dimension	L1	L2	L3	L4	W1	W2	W3	W4
Specification (mm)	17.5	10	23	32	25	07	14	05

radiation is decreased in this method. However, the fabrication of the antenna is complex procedure in this model since a hole has to be drilled in the substrate to make the antenna completely planar. The bandwidth of the model is narrow. And for thicker substrates, the increased probe length makes the input impedance more inductive, which leads to the mismatching. This feeding scheme provides narrow bandwidth. The coaxial cable is connected to patch directly by drilling the grounded dielectric substrate at position (0, -16.5, 0). The geometry of the edge feeding in HFSS platform can be observed in Fig. 3.

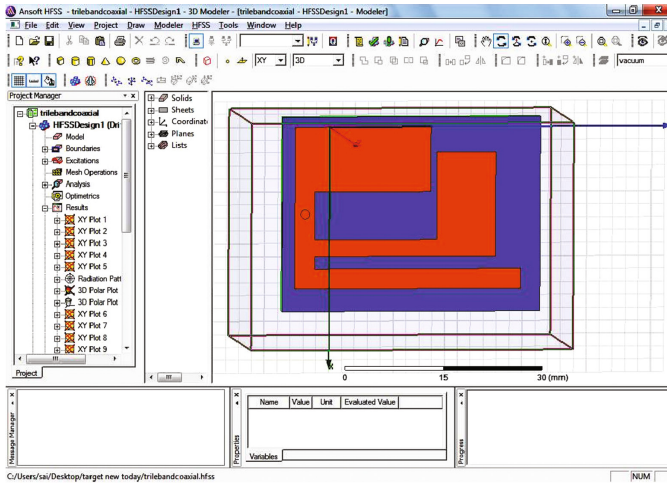


Fig. 3. Design of coaxial fed antenna in HFSS

2.1.3 Coplanar Waveguide (CPW) Coupled Multiband Antenna

CPW feeding is popular due to its high gain with less radiation losses and ease of fabrication. This feeding method facilitates easy shunt as well as series surface mounting of active and passive devices and eliminates the need for wrap around and via holes. CPW consists of center conductor and ground planes printed on the same surface of dielectric slab. The mutual coupling between adjacent lines is minimized by attaching the metallic ground plane on the same surface with predetermined spacing. However, this method is suffering with high frequency losses due to over moding. CPW side strip generates both odd and even mode currents that can cause mode coupling. The proposed

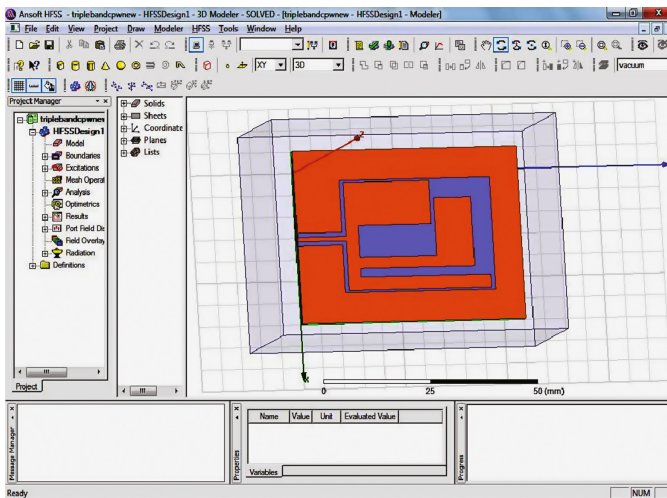


Fig. 4. Design of CPW fed antenna in HFSS

multiband antenna is conductor backed CPW fed multiband antenna, which consists of a U-shaped metallic slot around the strip at the top of the substrate and an additional ground plane at the bottom surface of the substrate. This plane provides mechanical support and also acts as a heat sink for the circuits with active devices.

The geometry of the CPW feeding in HFSS platform can be observed in Fig. 4. The dimensions of the multiband antenna can be observed in Fig. 5 and specifications in Table 2.

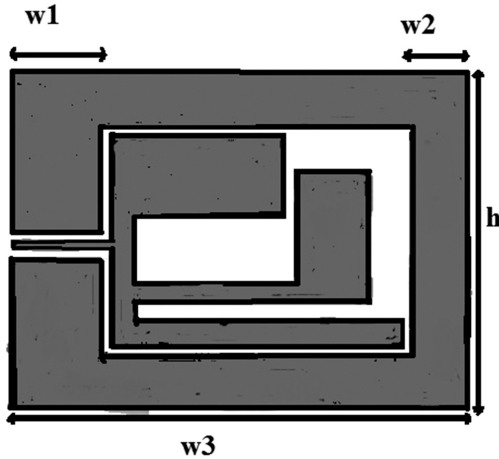


Fig. 5. Geometry of proposed CPW fed multiband antenna

Table 2. Design specifications of CPW fed multiband antenna

Dimension	W1	W2	W3	h
Specification (mm)	55	7	10	40

3 Results and Explanations

The construction with the combination of epoxy substrate enables the antenna to radiate with low VSWR to avoid the reflections. All the dimensions are optimum for effective radiation pattern with good directivity in the given operating frequencies.

3.1 Return Losses

Return loss is defined as

$$R = 20\log_{10} |K| \tag{1}$$

Where K is the reflection coefficient. The Return loss is related with the VSWR and operating frequencies. The simulated results of all the return losses can be observed in Figs. 6, 7 and 8.

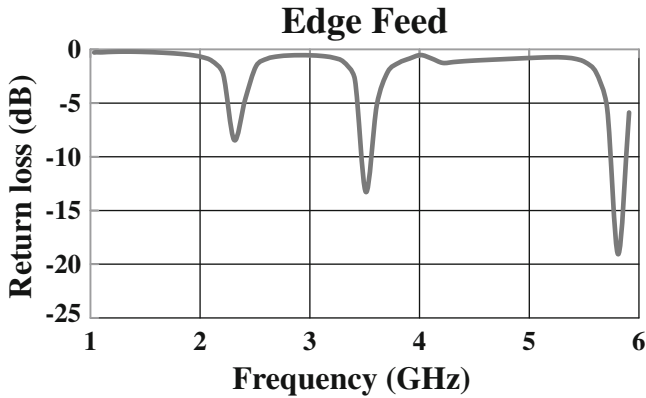


Fig. 6. Return losses of edge fed multiband antenna

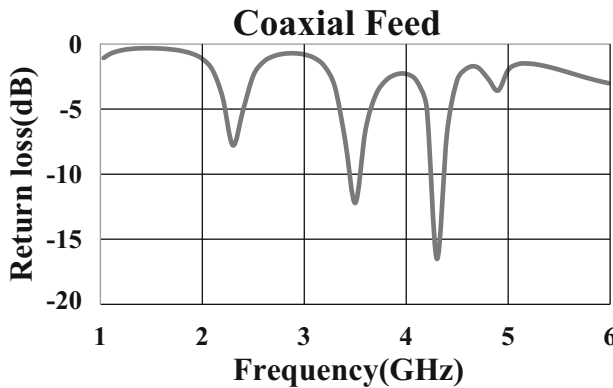


Fig. 7. Return losses of coaxial fed multiband antenna

The simulation results of return loss show that the edge fed multiband antenna can resonate at 3.5, 5.8 GHz with the minimum return loss of -19.47 dB while the co-axial fed multiband antenna at 3.5 and 4.3 GHz with minimum return loss of -16.53 dB. The proposed CPW fed multiband antenna can effectively radiate at 3.5, 6.9, 7.5 and 8.2 GHz with return losses of -25.50 , -17.00 , -21.00 and -23.20 dB respectively with optimum bandwidths. It can be observed that the proposed CPW fed antenna radiates with better impedance matching and better Bandwidth compared with other two antennas.

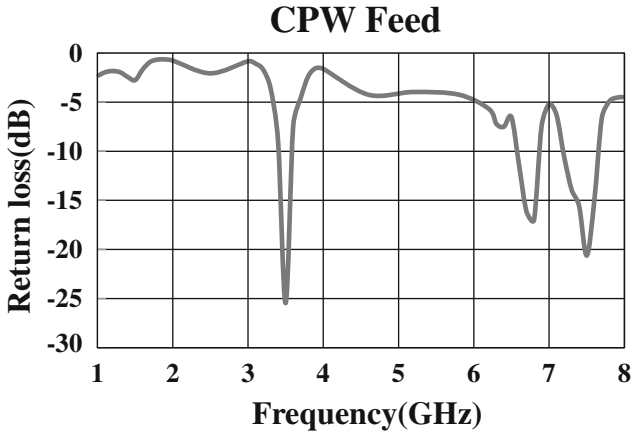


Fig. 8. Return losses of CPW fed multiband antenna

3.2 Radiation Pattern

The two dimensional radiation patterns can be plotted by taking the variation of the absolute value of field strength or power as a function of θ . This curve gives the necessary Directional characteristics of the antenna include HPBW, FNBW, Direction of Propagation, FBR etc. Significant changes in the values of thickness of the substrate, dielectric constant of the substrate, shape of the patch, effective length, Feed position, W/L Ratio effect the Directional characteristics of the Proposed microstrip antenna. The radiation pattern visualizes the propagation characteristics of the antenna for optimization. The 2D Field radiation patterns of designed antennas can be observed in Figs. 9, 10 and 11.

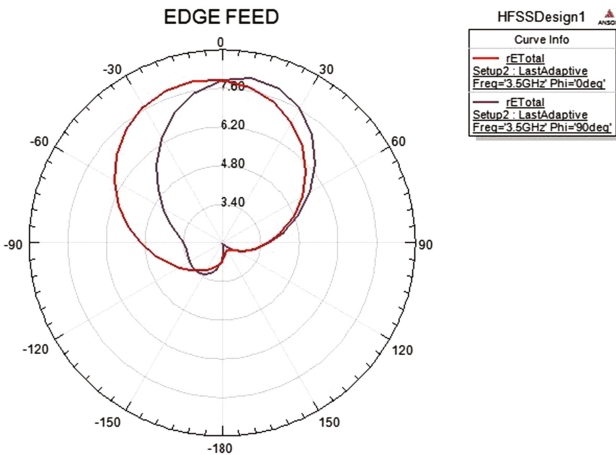


Fig. 9. 2D field radiation pattern of edge fed antenna

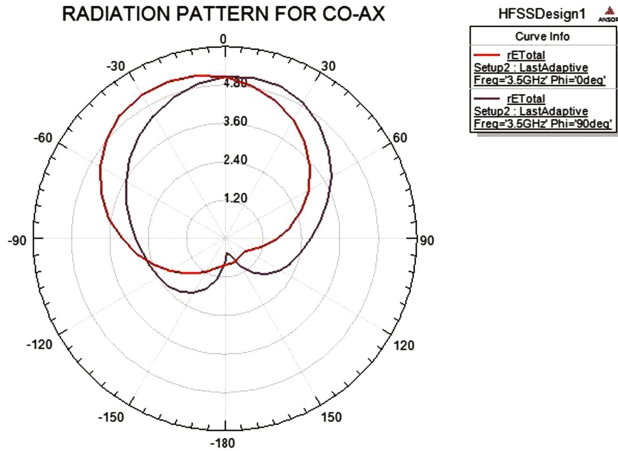


Fig. 10. 2D field radiation pattern of co-axial fed antenna

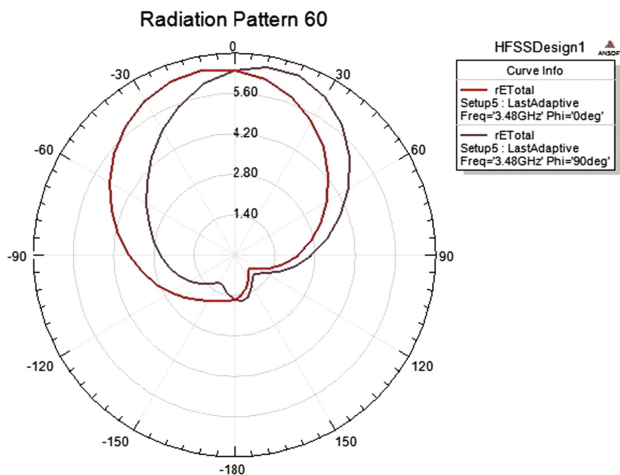


Fig. 11. 2D field radiation pattern of CPW fed antenna

3.3 3-D Radiation Pattern

The radiation pattern is the variation of the power radiated or electric field intensity or absolute Gain as a function of three dimensional space coordinates. It is main concentration for the wide band applications. The 3D Field radiation patterns of designed antennas can be observed in Figs. 12, 13 and 14.

The 2D, 3D radiation patterns of the three antennas show that the radiation in the maximum direction is good with optimum Beam widths for edge and CPW fed antenna

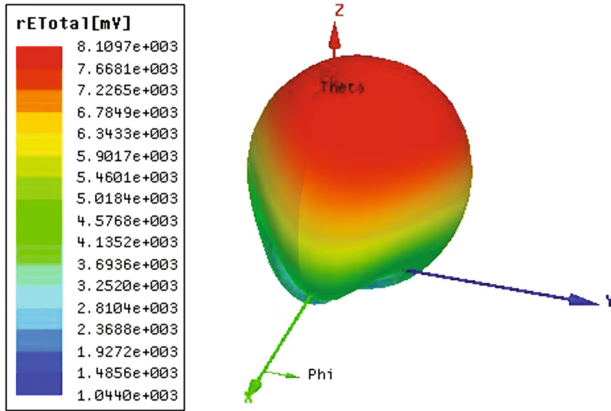


Fig. 12. 3D-view of radiation pattern for edge fed antenna

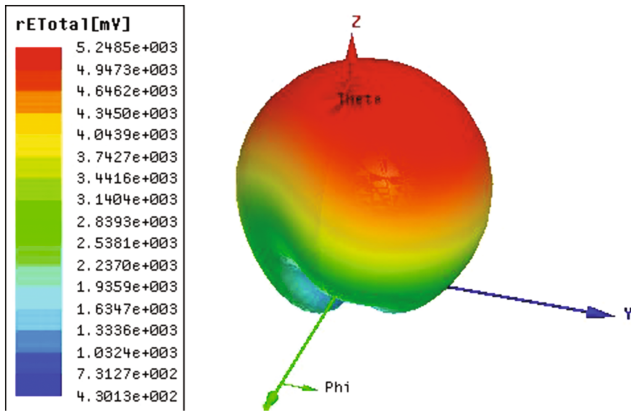


Fig. 13. 3D-view of radiation pattern for coaxial fed antenna

compared with coaxial feed due to the less dielectric losses. The optimum value of directivity is achieved in the proposed CPW antenna.

3.4 Radiation Characteristics

The radiation characteristics of proposed multiband antenna with different feeds are tabulated in Table 3. It is observed that the CPW feed exhibit better directional characteristics than the other two in terms of Return losses, Gain, VSWR and FBR. But the Efficiency is observed to be comparatively less than the other feeding techniques.

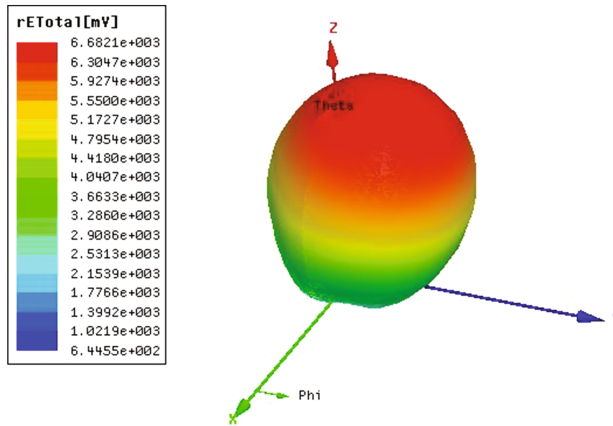


Fig. 14. 3D-view of radiation pattern for CPW fed antenna

Table 3. Radiation characteristics of multi band antenna

S. No	Parameter/Frequency	Edge feed		Coaxial feed		CPW feed	
		3.5 GHz	5.8 GHz	3.5 GHz	4.3 GHz	3.48 GHz	7.5 GHz
1	Max U (W/sr)	0.0872239	0.119666	0.0365335	0.0343482	0.0592179	0.190956
2	Peak directivity	2.72023	4.19172	0.925114	0.990527	2.91077	6.36298
3	Peak gain	1.12892	1.53398	0.498644	0.443221	1.853747	2.41556
4	Peak realized gain	1.09611	1.50381	0.459105	0.431642	0.744171	2.39969
5	Radiated power (W)	0.402949	0.358757	0.496268	0.43577	0.255662	0.37713
6	Accepted power (W)	0.970942	0.980331	0.920706	0.973875	0.871654	0.993428
7	Incident power (W)	1	1	1	1	1	1
8	Radiation efficiency (%)	42	37	54	45	29.33	37.96
9	Front to back ratio	5.25	21.098	31.1673	4.63254	46.7872	121.24
10	Return loss (dB)	-11.2929	-19.47	-12.19	-16.53	-25.50	-21.00
11	VSWR	1.7468	1.2355	1.6246	1.5487	1.573	1.4602

4 Conclusion

In this paper, a new compact multiband planar microstrip patch antennas using FR4epoxy substrate were proposed. The antennas were excited with Edge, Coaxial and CPW feeding techniques. Finite Element Method based tool, HFSS (High Frequency Structure Simulator) software version 13.0 was used to design the antennas. The performances of all the feeding techniques were analyzed in terms of bandwidth, gain, return loss, VSWR, FBR and radiation pattern. The design was optimized to meet the best possible results. Substrate used was FR4epoxy which has a dielectric constant of 4.4 with different substrate thicknesses. The results show that all the three multiband antennas are able to operate with 3.5, 5.8, 4.3 and 7.5 GHz of frequencies for substrate thickness 1.57 mm. The results also show that the coplanar waveguide (CPW) coupled

multiband microstrip antenna exhibits good radiation characteristics with improved Bandwidth than the other two comparatively. Due to the frequency of operation and compact area occupied, the proposed antennas are well suited for different devices used in wireless and C-band applications.

References

1. Kim, T.H., Park, D.C.: Compact dual-band antenna with double L-Slits for WLAN operations. *IEEE Antennas Wirel. Propag. Lett.* **4**, 249–252 (2005)
2. Azim, R., Islam, M.T., Misran, N., Cheung, S.W., Yamada, Y.: Planar UWB antenna with multi-slotted ground plane. *Microw. Opt. Technol. Lett.* **53**(5), 966–968 (2011)
3. Jaw, J.L., Chen, J.K.: CPW-fed hook-shaped strip antenna for dual wideband operation. *J. Electromagn. Wave Appl.* **22**, 1809–1818 (2008)
4. Ghosh, C.K., Roy, A., Parui, S.K.: Elevated CPW-fed slotted microstrip antenna for ultra-wideband application. *Int. J. Antennas Propag.* (2012). Article ID 425919
5. Huq, K.R.M., Siraj, A.S., Khan, M.I., Shama, N.: Design of a triple band microstrip patch antenna for cellular and wi-fi application. In: 3rd International Conference on Informatics, Electronics and Vision (2014)
6. Balanis, C.A.: *Antenna Theory*, 2nd edn. Wiley, New York (1997)
7. Kumar, G., Ray, K.P.: *Broadband Microstrip Antenna*. Artech House, London (2003)
8. Bhartia, P., Bahl, I., Garg, R., Ittipiboon, A.: *Microstrip Antenna Design Handbook*. Artech House, London (2000)
9. Stutzman, W.L., Thiele, G.A.: *Antenna Theory and Design*, 2nd edn. Wiley, New York (1998)
10. Guney, K.: Resonant frequency of a tuneable rectangular microstrip patch antenna. *Microw. Opt. Technol. Lett.* **7**, 581–585 (1994)
11. Abu Tarboush, H.F., Budimir, D., Nilavalan, R.: Connected U-slots patch antenna for WiMAX applications. *Int. J. RF Microw. CAF* (2008)
12. Pozar, D.M.: Microstrip antennas. *Proc. IEEE* **80**(1), 79–91 (1992)