IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 7, Issue 1, January 2018

Design of Coaxial Feeding Elliptical Microstrip Patch Antenna for Wireless Communication

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Abstract: In this paper, the design of a coaxial feeding elliptical microstrip patch antenna (MSA) for a device in wireless communication is presented. In this design, the technique of using rectangular and C-shaped slits for the patch has been used in order to improve the parameters of the antenna. The proposed technique has demonstrated that it is capable of increasing the gain. Using this technique not only causes the antenna gain to increase but also it leads to extending the 3-dB bandwidth of antenna and other antenna parameters as it has been mentioned in this paper. Hence, the elliptical microstrip patch antenna is designed for wireless communication application that operates at 2.45 GHz with its physical dimension (length of 138.143 mm, width of 138.143 mm and height of 3.245 mm) and its parameters (directivity of about 8.28 dBi, gain of 8.1 dB and return loss of -17.85 dB). The commercial electromagnetic software such as CST Microwave Studio has been used to analyse simulations and design structures of antenna.

Keywords: Elliptical Microstrip Patch Antenna (EMSA); Gain; Slit-Slot Rectangular and C shaped slit Microstrip Patch Antenna; Coaxial Fed

I. INTRODUCTION

Wireless Communication is need of world. In this current century cannot imagine without cellular mobile or cell phone. It is undeniable that wireless technology offers many convenient advantages in vehicular networks, global information, industrial facilities and other facilities because when someone, who is travelling with any wireless devices, has to not be concerned about bringing all of connecting cables. Microstrip is a kind of transmission line which is used to transmit microwave frequency signals, and can be fabricated utilizing printed circuit board technology. It is composed of a dielectric layer conducting strip, which is known as the substrate [1]. This separates the microstrip from a ground plane. Microwave elements such as couplers, antennas, power dividers, filters etc. can be designed from microstrip, the whole appliances existing as the form of metallization on the substrate. Therefore, microstrip is much less expensive than other traditional transmission lines such as waveguide technology [2].

In today's world, Microstrip Patch antennas (also called printed antenna) are a common antenna that are widely utilized. It is used in various domains for instance in satellite communication, mobile, missile systems, GPS, military purposes etc. Due to its light weight and compact shape, and it is easy to implement because its construct is less complex [3]. The patch is generally constructed from conducting material such as gold, copper or silver and can take any possible shape like rectangular, elliptical, circular, square, triangular, or some other common shape, which are commonly applied to design antenna [4]. Moreover, it can be designed to other different geometrical form that each of various geometrical patches affects the current distribution on the antenna. The radiating patch and the feed lines are generally etched on the dielectric substrate. The range of the length (L) of a rectangular patch is usually ($0.3333\lambda_0$ < L < $0.5\lambda_0$), where λ_0 is the wavelength of free-space. The thin patch, which is represented by a character (Mt), should be much less than λ_0 (Mt<< λ_0), where Mt is the patch thickness. The range of the height (h) of the dielectric substrate is typically ($0.003\lambda_0 \le h \le 0.05\lambda_0$) and the substrate dielectric constant (ε_r) usually has a range between 2.2 and 12, i.e. ($2.2 \le \varepsilon_r \le 12$) [5].

There are many various methods can be used to feed microstrip patch antennas (MSA), the most important methods of feeding are microstrip line, coaxial feed, aperture coupled Feed and proximity coupling. In this present investigation coaxial feed method has been used. The inner coaxial connector stretches through the substrate and is also conjoined to the radiating patch. The outer conductor of the probe connector is linked to the ground plane [6,7] as depicted in Fig. 1.

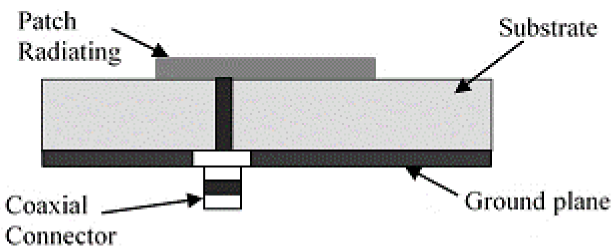

Fig. 1: Elliptical microstrip antenna fed by Coaxial

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II. RELATED WORK

The coaxial feeding technique was studied and designed by using CST Microwave Studio software. In this case, number of trial methods have been performed to achieve good impedance matching [8]. There are many different softwares can be used to simulate antennas like SONET-LITE, MATLAB, ADS, IE3D, CST Microwave Studio, ANSOFT-Designer, HFSS [9]. There are various shapes of microstrip patch antenna (MPA) such as rectangular, ring, triangular, circular, square, elliptical [10], etc. In present paper elliptical microstrip patch antenna (EMPA) is designed.

III.DESIGN OF ANTENNA

The RT-Duroid (5880) dielectric material is used for antenna. Its dielectric constant (ε_r) is 2.2 and thickness (*h*) is 3.175 mm and loss tangent of 0.0009. The resonance frequency of the antenna is taken as 2.45 GHz. The first radius of the patch *(a)* and second radius of the patch *(b)* of proposed antenna are different, because the geometric shape of antenna is elliptical shape and is determined as 23.024 mm and 24.024 mm respectively. Fig. 2 indicates the geometric shape of proposed coaxial feeding of the elliptical microstrip patch antenna for an application as shown below.

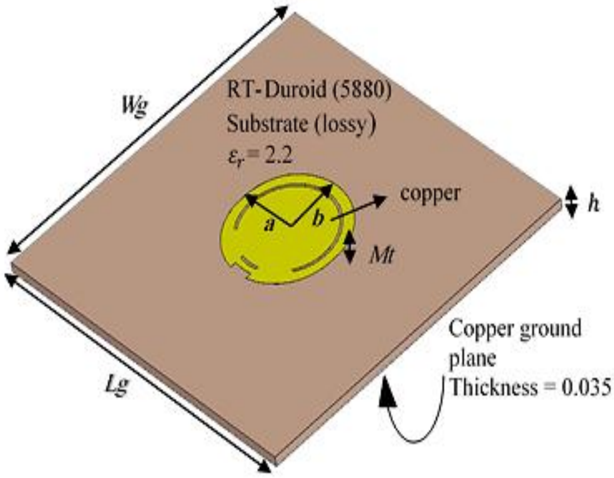

Fig. 2: Geometric shape of proposed coaxial fed elliptical microstrip patch antenna

A. *Design Parameters of Antenna*

The antenna is printed on substrate and is excited by coaxial feed line which is designed at point (4.15335, 0) for 50 ohm. The height of the ground plane (*Mt*) which is made of PEC (Perfect Electric Conductor) material and beneath the substrate is 0.035 mm. The length (*Lg*) and width (*Wg*) of the ground plane are taken to be three times the diameter of patch for simulation purposes (i.e. 3×46.0477 mm) and the height of the elliptical patch antenna (*Mt*) which is also made of material Perfect Electric Conductor is 0.035 mm as shown in fig. 2. The outer conductor is made of substrate material from top of ground plane to bottom of ground and inner conductor (from top of patch to bottom of ground plane) is made of material of PEC because the designed antenna is fed by co-axial probe. The outer and inner radius of coaxial cable is 0.914 mm and 0.397 mm respectively as illustrated in Fig. 3.

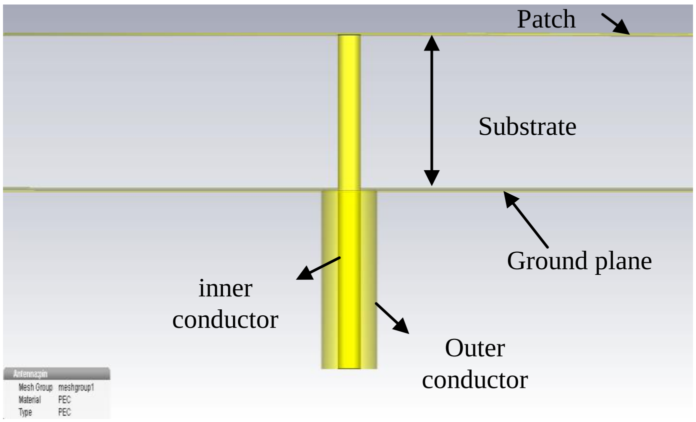

Fig. 3: Bottom view of the designed microstrip patch antenna

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ISO 3297:2007 Certified
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B. Design Slits of Patch Antenna

the proposed elliptical patch antenna is made of copper and C- slit is printed on elliptical patch that inner (ri) and outer radius (ro) of C- slit is 18.524 mm and 19.524 mm respectively. Slit-Slot Rectangular is also is printed on Microstrip Patch Antenna that its dimensions are (2 Wr x 8 Lr) mm as shown in Fig. 4.

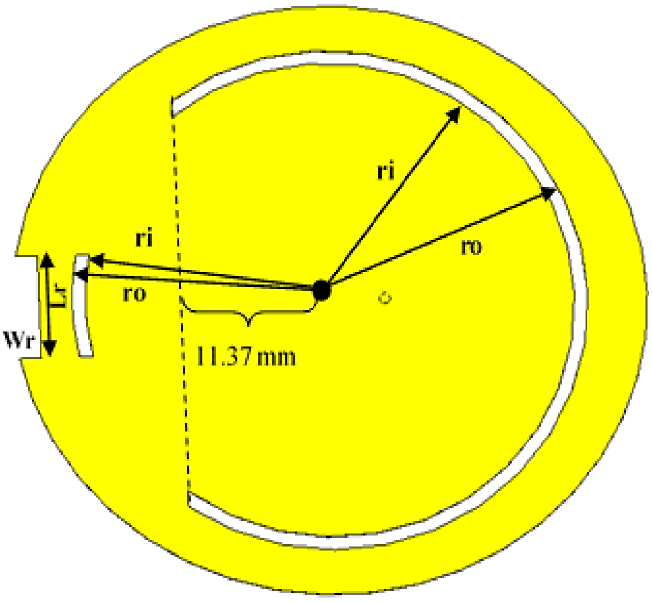

Fig. 4: Top view of the elliptical patch antenna

IV. RESULT AND DISCUSSION

In order to simulate and demonstrate the result of performance parameters of the proposed microstrip patch antenna, a commercial software has been required for the design. In that case, CST Microwave Studio 2017 is used which is applied widely for designing waveguide aperture antennas, wire antennas, patch antennas, etc. Since this software has the ability to examine the performance of antenna design such as; gain, directivity, S-parameters, antenna efficiencies, voltage standing wave ratio (VSWR) and some other parameters. The first parameter of this antenna that has been achieved from the simulated structure is gain (G) of the antenna as shown in fig. 5.

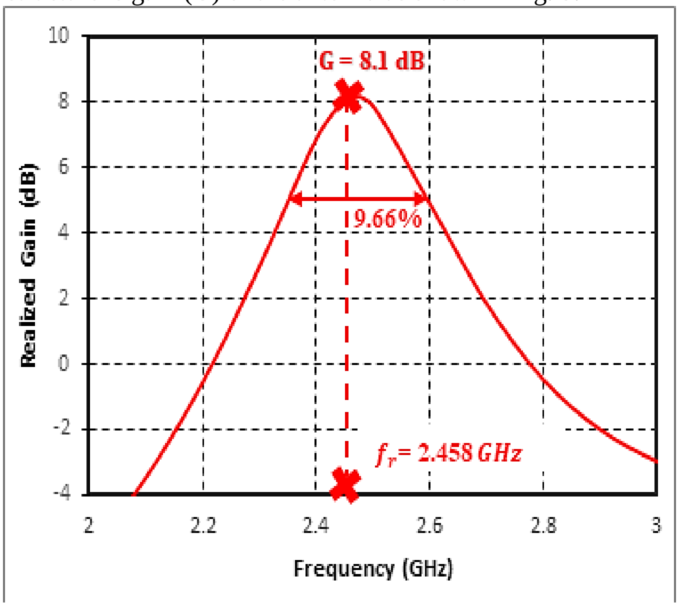

Fig. 5: Simulated realized gain versus frequency of the Elliptical Microstrip Patch Antenna.

The above graph illustrates gain of the traditional microstrip antenna that is about 8.1 dB with the 3-dB bandwidth provided is about 9.66% at the frequency operation 2.458 gigahertz (GHz), which is slightly more than the required resonant frequency (2.45 GHz). The most other significant parameters in antenna design is its directivity because if any one of the antenna parameters, in particular, gain and directivity is not optimal, the performance of the radiating patch

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will radiate arbitrarily and deteriorate [11]. The maximum directivity that has been achieved for the traditional patch antenna is around 8.28 dBi as indicated in fig. 6.

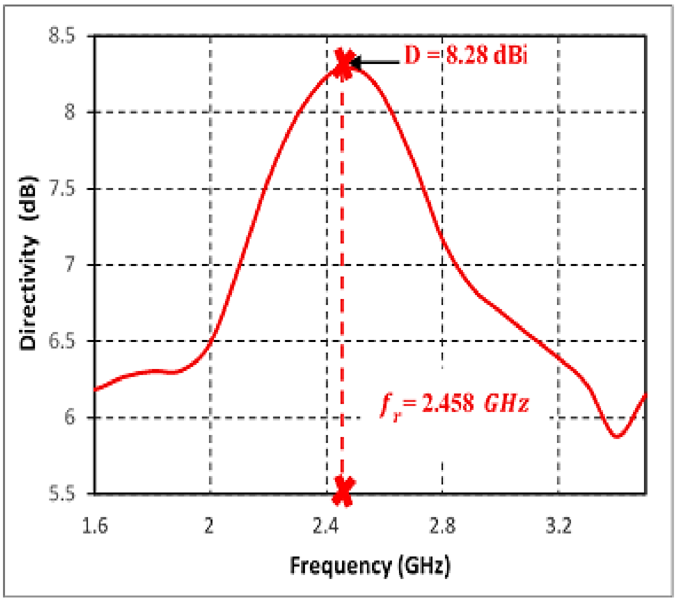

Fig. 6: Simulated broadside directivity versus frequency of the Elliptical Microstrip Patch Antenna (EMSA).

In the simulated fig. 6, directivity achieved by the microstrip patch antenna that has been shown above, is about 8.28 dBi, for an operating frequency of 2.458 (GHz). Likewise, another essential parameter that can be produced while using the same software is the S11 parameter. This parameter is known as return loss. It is responsible for selecting a specific range of frequency to operate antennas, as well as, informs the user how much power is returned or reflected from the transmitted power to the antenna. Although, the value obtained for S11 becomes more negative, the return loss decreases which minimizes the reflection coefficient and increases the received power by the antenna [11]. For this designed antenna the return loss (S11) generated is less than -17 dB as shown in fig. 7.

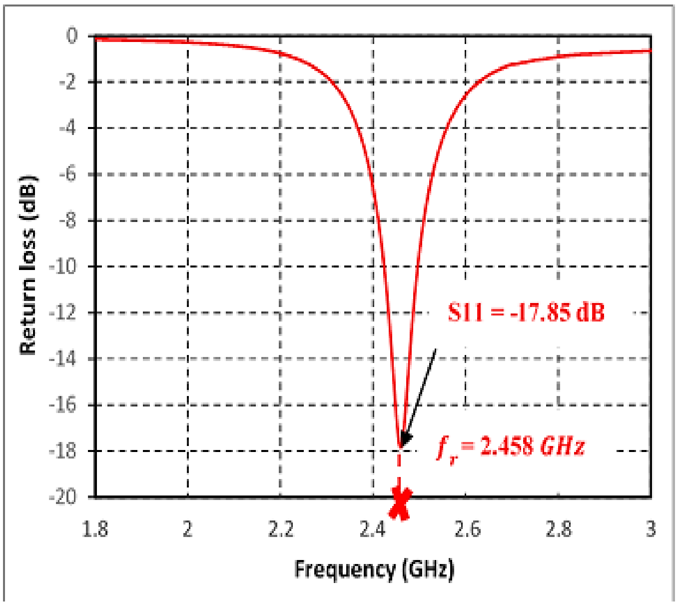

Fig. 7: Simulated return loss (S11- parameter) versus frequency of the EMSA.

In this study, radiation pattern is also an important parameter to the field pattern of antennas. Since, it is responsible for distributing the radiation energy of the antenna over a specific surface (free space) and indicates how electromagnetic energy radiated by antennas. Hence, a 3- dimensional plot of the antenna radiation pattern has been plotted with its polar plots as depicted in figure below.

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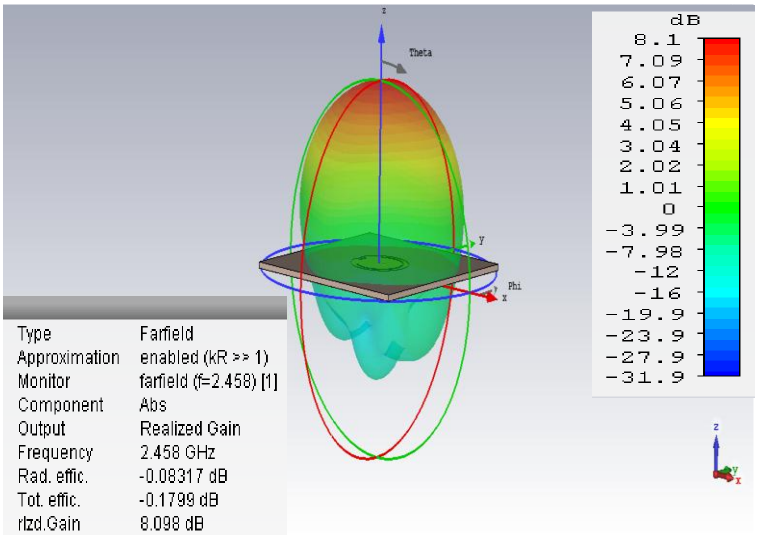
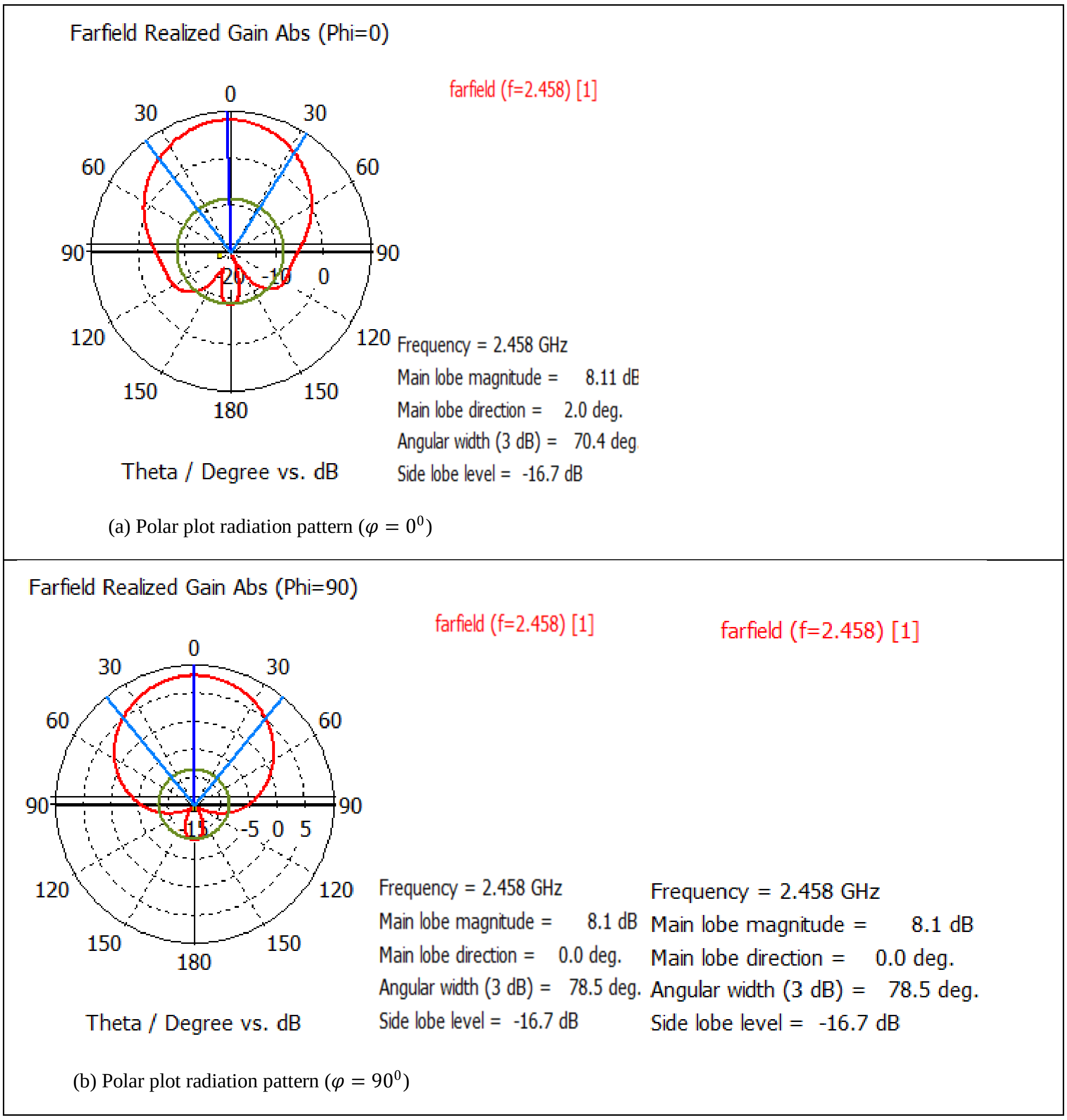


Fig. 8: 3-Dimensional plot of the antenna radiation pattern



(a) Polar plot radiation pattern ($\varphi = 0^0$)

(b) Polar plot radiation pattern ($\varphi = 90^0$)

Fig. 9: Polar plot radiation pattern of the antenna for $\varphi = 0$ and $\varphi = 90$ degree

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As can be seen in figures 9, the radiation pattern of the antenna consists of some minor lobes which are undesired in wireless networks. Since, they waste the amount of energy of the electromagnetic wave signals during radiation. However, these lobes are sufficiently small as compared to the main lobe and the structure of the antenna. These low lobes are an added advantage for using the antenna in high gain antennas for fixed wireless communications.
As a result, and according to the CST microwave Studio, it can be determinates that the main performance parameters of the antenna configuration with elliptical patch as shown in table below:

TABLE 1
Results of Parameters of MSA

Antenna Parameters	Value	Unit
Gain (dB)	8.1	dB
Directivity (dBi)	8.28	dBi
Return loss (dB)	-17.85	dB
Voltage Standing Wave Ratio (VSWR)	1.294	-
3-dB Bandwidth	9.66%	-

V. CONCLUSION AND FUTURE WORK

In this study, an individual coaxial fed microstrip patch antenna for an application at resonant frequency 2.45 GHz for ISM band has been demonstrated and designed using commercial software (CST Microwave Studio). The proposed antenna illustrates the percentage of 3-dB bandwidth of about 9.66% with reflection coefficient of -17.85 at 2.45 GHz. The maximum achievable gain for the antenna is 8.1 dB with the maximum directivity achieved by the microstrip patch antenna is about 8.28 dBi, for an operating frequency. The physical dimensions (i.e. length and width) of ground plane for the patch antenna based on the centre frequency have been determined to be 138.143 mm by 138.143 mm with height of 3.245 mm.
The elliptical patch dimensions are 23.024 mm by 24.024 mm respectively. The proper impedance matching of the square antenna is obtained by adapting the coaxial feeding design. Moreover, the proposed antenna demonstrates a clean and distinct stable radiation pattern over the frequency band which makes the structure desirable for wireless communication applications. Although this antenna was designed for an application at resonant frequency 2.45 GHz, the design concept can be used for other frequency bands by adding dielectric substrate layers or cutting various slots on the designed patch for the proposed antenna. Work is continuing to achieve even better results with enhancing gain, bandwidth and others antenna parameters for wireless communication applications. In addition, this design is still not fabricated because at our institute there is no fabrication facilities, so it makes a gap for this paper and is a next aim for us.

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ISO 3297:2007 Certified
Vol. 7, Issue 1, January 2018

BIOGRAPHY

Hiwa Taha Sediq was born on 23 of June 1981 in a small town (Shaqlawa) where belongs to the capital city of Kurdistan in Iraq. He was awarded Bachelor's degree in Physics in 2005 from the University of Salahadden in Erbil. After his graduation, he was working for computer department as a teacher for 5 years and in charge of internet unit for 2 years in Shaqlawa Technical Institute and he is also assistant head of information technology department at the same institute. He received the M.Sc. degree in Communication Engineering from University of Birmingham in Unite Kingdom in 2013. He desired to pursue higher education, thus he enrolled for Ph.D. degree in Electronic, Radio and Communication Engineering Department at Bonch University in Autumn 2017 in Russian. He is presently a Ph.D. student and his prime research interest is in the areas of communications with focus on its application in microstrip patch antenna.