International Journal of Emerging Technologies in Engineering Research (IJETER)
Volume 5, Issue 11, November (2017) www.ijeter.everscience.org

A Rectangular Microstrip Patch Antenna with Slot for Wireless Communication Applications

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Abstract – In this paper, a compact rectangular microstrip patch antenna with a slot fed by a microstrip line for wireless communication applications is investigated. In this configuration, the rectangular patch performs the functions of an effective radiator and the feeding structure of the slot opening in the ground plane. By adjusting the structural parameters, the investigated antenna is developed to resonate at two various frequencies; one is from the rectangular microstrip patch antenna (MPA) and the other from the slot opening. The designed model has a rectangular patch with the resonant frequency of 5.4 GHz of unlicensed national information infrastructure (UNII) and a slot with a resonant frequency of 2.45 GHz (Industrial, Scientific, Medical). The physical and geometrical parameters of these resonators are oscillating to achieve the required performance parameters. In order to resolve the exploit of the investigated antenna, practical parameters such as return loss, bandwidth, voltage standing wave ratio (VSWR), and radiation pattern are investigated by the simulation of the structure with high frequency structure simulator (HFSS). The investigated antenna configuration is suitable for wireless communication applications.

Index Terms – Microstrip patch antenna, dual band operation, microstrip feed line and wireless communications.

1. INTRODUCTION

A microstrip patch antennas (MPA) are in great demand due to the rapid development of wireless communications towards the wireless local area network applications. Therefore, consideration of microstrip patch antenna is reasonable to apply because of its advantages such as ease of compatibility with any circuits, low profile, less cost and ease of fabrication. Hence a patch antenna can be expected to have a more bandwidth. The different types MPAs such as circular, rectangular, squares and ring slot shapes [1]-[10] have been described in literature. Circular and rectangular patch antennas are having attractive features over the square and ring slot shapes.

The dual band rectangular patch antenna wit slot resonator configuration [3] to attain dual band frequency operation for wireless communications applications is proposed. The investigated structure can be considered as the combination of MPA and other radiating resonator, such as a slot resonator. These two elements are tightly coupled together and oscillate at various frequencies. Their radiation patterns have different performance for wireless communication applications.

The prosperity patch antenna [11] resonators in feeding systems need systematic knowledge to couple the resonators and components. However, the resonant feeding system placed in these described models, such as microstrip-fed aperture-coupled, co-axial probe coupling, co planar slot feed and CPW-fed slot arrangement offers more flexibility and is directly compatible with different mounting surfaces. In this configuration, in order to avoid via holes, the microstrip feed line is recommended [17]. The microstrip line placed on the same substrate of rectangular patch that could be placed directly over the feed line. The advantage of microstrip feed is easy to model, simple to match by controlling the inset feed position, low spurious radiation and easy to fabricate.

To perform the model, the implemented dual-band rectangular patch [13]-[15] antenna with slot opening [12] is designed for applications of wireless communications. It includes of upper (5.4 GHz) and lower (2.45 GHz) frequencies of the dual-band antennas [8] are initially controlled by rectangular patch and slot respectively. The proposed dual-band patch antenna has the maximum radiation in free space.

To emphasize the model, the proposed dual band rectangular patch antenna with slot is designed for wireless local area network applications (WLAN) [6]-[7] .It consists of upper band (5.4 GHz) and lower band (2.45 GHz) frequencies of the dual band antennas are essentially reasonable by the MPA and slot space respectively. This model has the features of small in size, straightforward design and can attain dual band frequency operation with various radiation patterns.

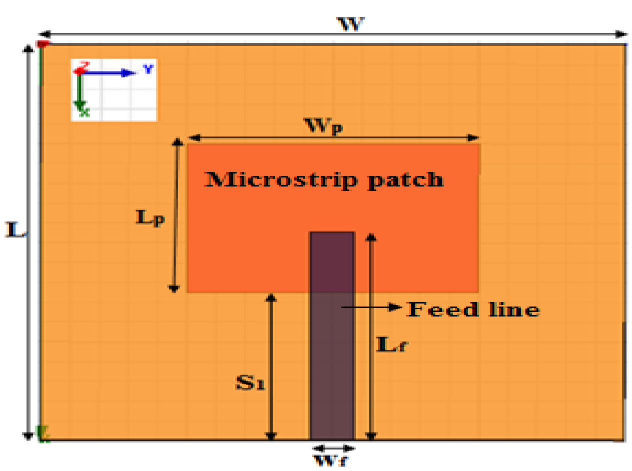
2. ANTENNA CONFIGURATION

The dual band rectangular microstrip patch resonator antenna with slot opening fed by microstrip line is designed. The hybrid model is includes two different types of resonators; it consists of rectangular patch and slot.

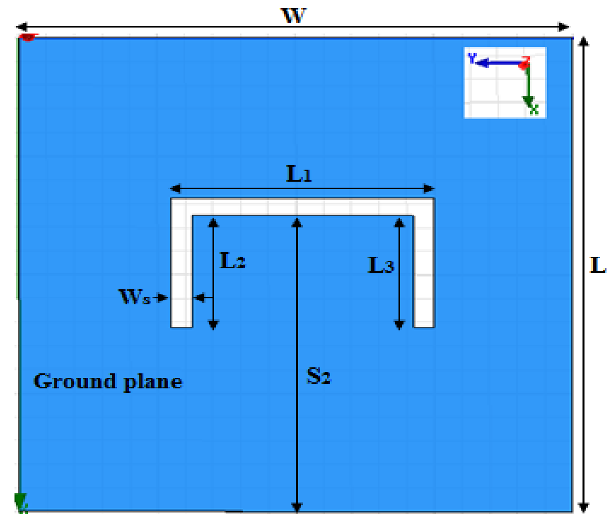
The proposed hybrid [16] structure, the rectangular [3] patch antenna oscillates at 5.4 GHz (UII) and slot [12], oscillates at 2.45 GHz (ISM) which is reasonable for wireless communications. These two radiating resonators are tightly coupled together and resonate at various frequencies. By varying for the radiating resonators' position, a compact dual-band or frequency-tunable hybrid MPA can be modeled. The feed line is placed on the substrate at midpoint of the substrate.

Figure 1 exhibits the side view of the proposed antenna for a wireless communications. The suggested antenna has the dimensions of 40 mm × 40 mm × 1.6 mm, and a FR-4 with a relative permittivity of 4.4 is used as a substrate. It consists of a rectangular MPA and a center-fed microstrip line which is printed on an FR-4 substrate of thickness 1.6 mm and relative permittivity ε_r =4.4. The ground plane is printed on the FR-4 substrate with a dimension of 40x40 (L x W) mm^2. The rectangular patch has a length L_P=23 mm, width W_P=25 mm and offset distance S_1 = 8.5 mm as shown in Figure 1. The 50-Ω feeding line has a length of L_f =22 mm and a width of W_f =3.0 mm.

In this model, a new type of resonator such as slot etched in ground plane is intended to achieve lower frequency (2.45 GHz) band. The structure of slot is as shown in Figure 1. It is well-known that by choosing a high permittivity substrate, a greater size reduction can be achieved. For this reason, the substrate selected for the antenna has been FR-4 (ε_r=4.4).



(a)



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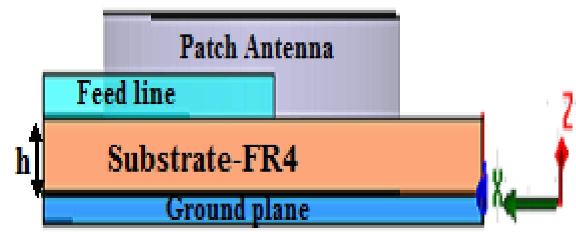


(c)

Figure 1 Proposed Patch antenna with slot: (a) Top view; (b) Bottom view; (c) Side view

The design consideration for the lower excited slot antenna is consists of three rectangular slots with different length and fixed width W_S=0.5 mm as shown in Figure 1, different rectangular slot lengths are L_1=18 mm, L_2=6 mm, L_3=6 mm and offset distance of slot is S_2 = 26 mm. By adjusting the-slot parameters, the proposed antenna can operate in two bands, and a good impedance match for the operating frequencies can be easily obtained. By adjusting the structure parameters, the rectangular patch and slot resonates at 5.4 GHz and 2.45 GHz subsequently.

3. SIMULATED RESULTS AND DISCUSSIONS

Figure 2 exhibits the simulated return loss of the intended hybrid MPA. The lower excited band is due to the slot while the secondary band is due to the rectangular microstrip patch antenna. It represents-40 dB return loss at 2.45 GHz and-35 dB return loss at 5.4 GHz. Note that there are no frequencies to be annoyed outwardly the existence of rectangular patch, that is, the full resonate slot mode is induced by the rectangular patch.

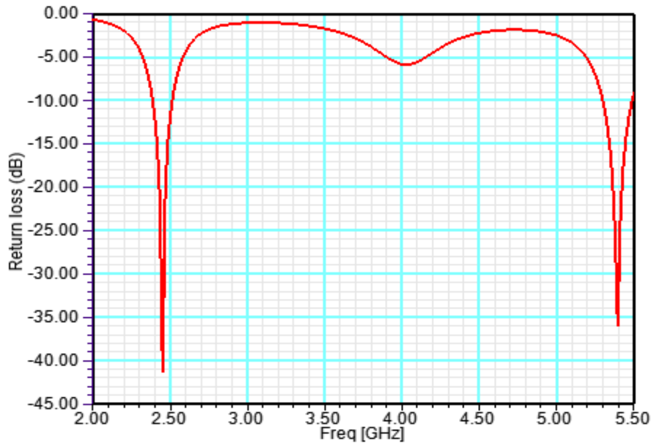


Figure 2 Simulated return loss at ISM band and UNII band

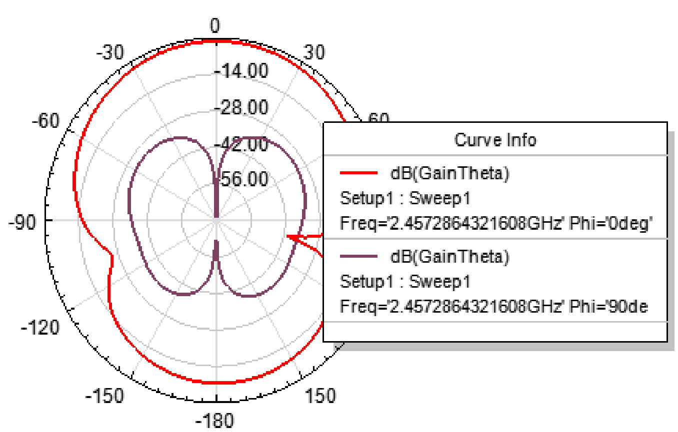
The return loss is another way of expressing mismatch. It is a logarithmic ratio measured in dB that compares the power reflected by the antenna to the power that is fed into the antenna from the transmission line. The relationship between SWR and return loss is the following:

$$\text{Return loss}(dB) = 20\log_{10}\frac{SWR}{SWR-1}$$

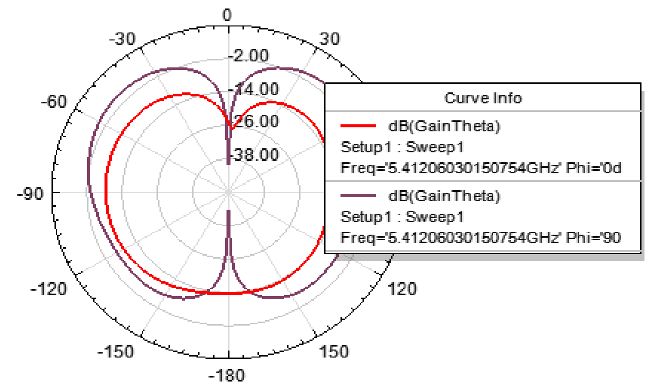
The term bandwidth simply defines the frequency range over which an antenna meets a certain set of specification performance criteria. The important issue to consider regarding bandwidth is the performance tradeoffs between all of the performance properties described above. There are two methods for computing an antenna bandwidth. An antenna is considered broadband if $f_H/f_L \geq 2$.

Narrowband by %

$$BW = \frac{f_H - f_L}{f_0} x100\%$$

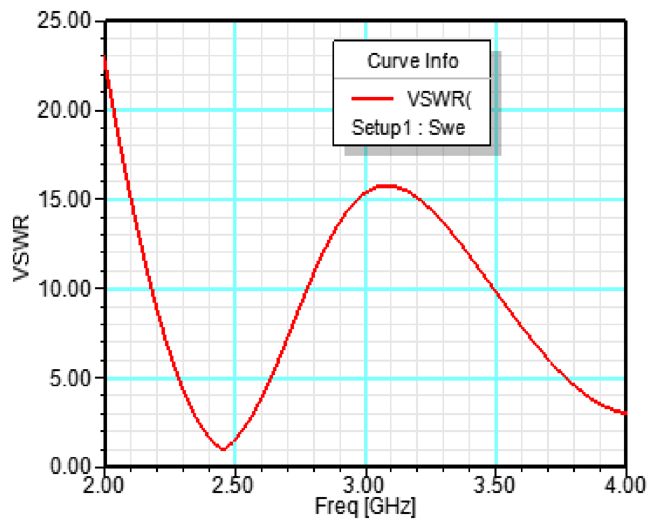


(a)

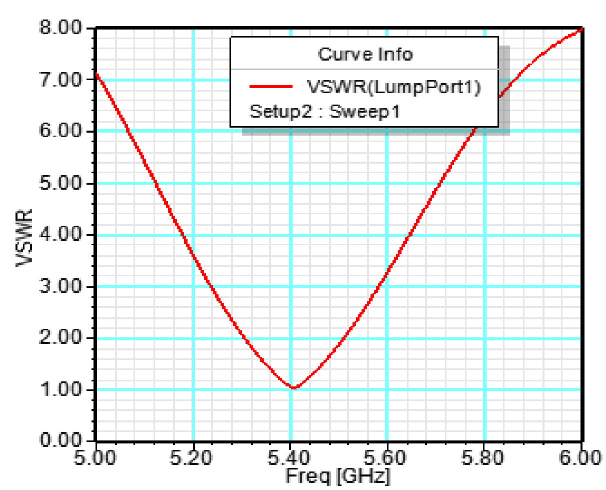


(b)

Figure 3 Simulated radiation patterns at: (a) ISM; (b) UNII



(a)



(b)

Figure 4 Simulated VSWR at ISM and UNII

The radiation pattern of the simulated antenna structure at 2.45 GHz and 5.4 GHz with phi=0 (deg) and phi = 90 (degree) are represented in Figure 3. The proposed antenna radiates a maximum in the broadside direction at 5.4 GHz and slot – opening resonator is radiating the waves in bidirectional at 2.45MHz. The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. All antennas, if 100% efficient radiate the same total energy for equal input power regardless of pattern shape. Radiation patterns are generally presented on a relative power dB scale. It can be show in polar plot 360 degree

The voltage standing wave ratio (VSWR) of the intended model is as represented in Figure 4.It is gives as analysis of the mismatch between the load and the transmission line. For ideal case value of VSWR is 1 and for good impedance matching. The VSWR of investigated antenna is 1.2 at 2.45 GHZ and 1.1 at 5.4 GHZ. The VSWR indicate that how closely or efficiently an antenna's terminal input impedance is matched to the characteristic impedance of the transmission line. The large number of VSWR, the greater the mismatch between the antenna and the transmission line.

4. CONCLUSION

A dual band rectangular microstrip patch antenna with slot space sustained by microstrip line is designed to achieve double frequency operation. The recommended rectangular patch resonator and slot - space resonators are operates at the upper band (5.4 GHz) and lower band (2.45 GHz) correspondingly. The proposed model has been simulated and it is observed that return loss of -40 dB, -35 dB at the resonant frequencies of 2.45 GHz and 5.4 GHz respectively. The designed antenna configuration has small in volume, less weight, low cost, effective feeding structure and sufficient operational bandwidth, such that it is reasonable for wireless communications applications.

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