

Folded Shorted Patch Antenna with Slots for Wireless Applications



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Abstract: The Folded shorted patch antenna is used to measure the performance of the antenna by changing the slots. In this paper three different patterns are projected by incrementing the slots. The antenna size is very tiny when compared to conventional patch by folding the shorted patch. The gain, efficiency, radiation pattern and return loss are computed and the numbers of slots are increased for the three proposed antennas. The antennas demonstrate different frequency bands which can be utilized for many wireless applications.

Keywords:- Folded Shorted Patch, Wireless Application, gain, directivity, beam width, efficiency, radiation pattern

I. INTRODUCTION

Mobile and wireless communication systems are still in need of low-cost, small size antennas that can be integrated within a packing structure. Microstrip patch antennas are more commonly used for portable wireless devices. Bandwidth enhancement plays a vital role in all antenna designs. Impedance bandwidth can be improved by means of increasing the substrate thickness. The antenna size can be further reduced by folding the patch or by using shorting walls and shorting posts. In order for attaining size reduction, design simplicity and robustness slots are implemented on the patch. Slot antennas may be used at UHF and microwave frequencies for greater control of radiation pattern. It can also be used for tuning the performance of the antenna.

A number of techniques have been proposed to reduce the size of the antenna. An M shaped slot antenna and four H shaped shorted patch antennas with reduced dimensions are developed to reduce the dimension of the patch antenna. Antenna size is reduced using the length of the shorting wall smaller than the patch, but it may get affected by reflection, scattering and depolarization [1, 3]. A chip-size antenna was designed at the operating speed of 5.62 GHz and fabricated by the means of wafer-level packaging techniques [2].

There are two design techniques available namely Folded Shorted Patch Antenna and Novel FSPA structure. The former antenna operates with the help of small ground plane and the latter antenna works with the four pairs of slot rooted into a ground plane [4]. Antenna dimension can also be reduced by using high dielectric constant material for antenna substrate, by introducing slots on resonating patch and by folding the antenna to form two layer structures to reduce the antenna size [5, 7]. Cross slots can be made on patch to provide high radiation efficiency and to design antennas that can operate as a transmitter and receiver [6]. By using air as a dielectric in between two folded patches and using a probe feed will improve the performance of the antenna [8]. Near-field antenna is designed by folding the antenna both the sides or by using shorting pins to connect the patch with the ground plane [9-10]. By introducing shorting posts the bandwidth of the antenna can be improved [11-12].

The fame of the antenna has raised due to the invent of the advancement in wireless communication field. The parameters such as wide bandwidth, compact size, light weight, ease of fabrication, low cost etc are always challenging trends for the researchers [13]. The main characteristics of the antennas such as wideband and multiband are accomplished by microstrip patch antenna (MPA) [14–16]. The simple MPA patch antenna printed on the Printed Circuit Board (PCB) which includes the ground plane, dielectric substrate and radiated patch component [17, 18]. Fractal shapes means it has uneven fragments with a collection of compound geometry paved the way for designing multiband antennas [19–21]. At present there are huge amount of fractal shapes available and the fractal geometries are Minkowski, Koch, Hilbert, Mendar, Peano, Giusespe etc [22, 23]. The two main properties namely Self Similarity and Space filling gained popularity in field of antenna [24, 25]. Self similarity determines different dimensions and the Space filling reduces the area occupied in the total area and also both plays a significant task in miniaturization [26, 27]. The frequency of the Fractal antenna may be inclined by the dimension of ground plane [28, 29]. The performance with the fractal antenna exist with a combination of two or more fractal shaped antennas must be designed and the various parameters are considered they are VSWR, gain, directivity, return loss, bandwidth, etc. [30].

In this paper, three different antennas are designed by increasing the number of slots. The slots are used to improve

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the electric field distribution by acting as the capacitive coupling loading structure to achieve the electric field strength. To have a compact size three shorting structures are introduced to diminish the antenna dimension. The proposed antenna is located over a ground plane made of copper. The back radiation through the ground plane can be minimized by using a larger ground plane. A suitable dielectric substrate is used to strengthen the conducting patch. Wire feed is used to stimulate the antenna in order to connect the conducting patch with the ground plane. The different antenna configurations are discussed in section II and the different parameters analyzed are discussed in section III. The designed antennas operate at different frequencies so that it can be used for many wireless applications. The three antennas achieve an operating bandwidth from 1GHz to 3 GHz. So that they can be used in many applications like mobile phones, Bluetooth, WI-Fi and LTE. The use of these shorting structures operates like the quarter wavelength antenna and it is also noted that as the number of slots increases the operating band decreases. These two advantages make the antenna to be integrated

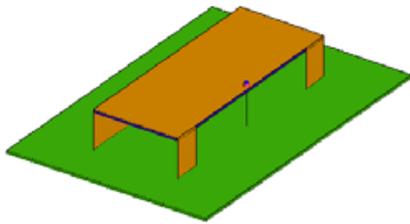


Fig. 1: Proposed Folded Shorted Patch Antenna

Table 1: Properties of Copper

Parameters	Values
conductivity σ	5.96e7
permeability μ_r	1.256e-6

Table 2: Dimensions of the Proposed Antenna

Dimension parameter	Values
L_1 (mm)	56
L_2 (mm)	40
W_1 (mm)	38
W_2 (mm)	16
Width of the slot (mm)	0.4
Dielectric constant ϵ_r	4.4
Loss tangent	0.02

The three different configurations of the proposed antenna were shown in Fig. 2. In type (a) a single slot is etched on the patch. The slot width is made very small of about 0.4mm to achieve good performance. This antenna is excited by placing the wire feed at 0.8mm from the edge of the patch. In type (b) a slot is made across the slot in type (a). This antenna is excited by placing the feed point away from the second slot. In type (c) two more slots are made on the slot in type (a). Antenna design parameters are given in Table 2.

with in the wireless devices and can be used in many wireless applications.

II.ANTENNA DESIGN

The proposed antenna is shown in Fig 1. It comprises of a ground plane made of copper with a suitable size of 56(L) × 38(W) mm² and a thickness of 0.4 mm. The slot is made over a patch supported by a 0.4mm thick FR4 substrate with dielectric constant of about 4.4 and loss tangent of 0.02. The antenna is fed by means of wire feed. A shorting wall of size 40 × 6.4 mm is made at one end of the antenna and a pair of stubs of dimension 5 × 6.4 mm is made at the other end. These shorting structures will connect the ground plane with the dielectric. The main purpose of these shorting structures is to reduce the antenna size. Therefore the antenna size is reduced from half-wavelength to quarter-wavelength. The ground plane should have high conductivity; therefore copper is used as the ground plane. The properties of copper are given in Table 1.

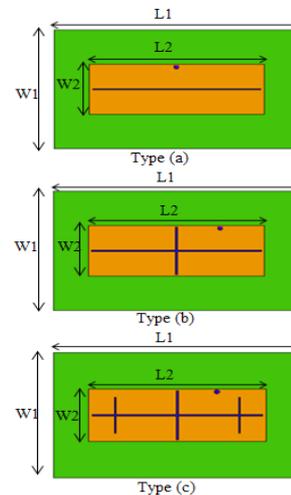


Fig. 2: Proposed Folded Shorted Patch Antenna with Type (a). Single Slot. Type (b). Two Slots. Type (c). Four Slots

III.RESULTS AND DISCUSSION

The scattering parameter for the three types of antenna configuration is shown in fig. 3. Fig. 3(a) shows the return loss of type (a) antenna configuration with a single slot. It covers the operating band of 3GHz and a return loss of -12.9db. This antenna is 42.95% efficient and produces a gain of 1.43db. It covers the licensed 3GHz mobile communication band. Fig. 3(b) shows the scattering parameter for type (b) antenna configuration with a slot across the first slot. The operating frequency is reduced in this configuration. Here two operating bands are produced at 1.2GHz and 2.8GHz, with a return loss of -9 db and -7.9 db respectively. At 2.8GHz the antenna shows an efficiency of 41.38% and a gain of 1.9db. This frequency range is used for Bluetooth and Wi-Fi applications Fig. 3(c) shows the scattering parameter for type (c) antenna configuration with four slots. Here the operating frequency is further reduced from the type (b) configuration. At 2.6

GHz this antenna is 56.39% efficient and produces a gain of 2.12db. It can be used for LTE application.

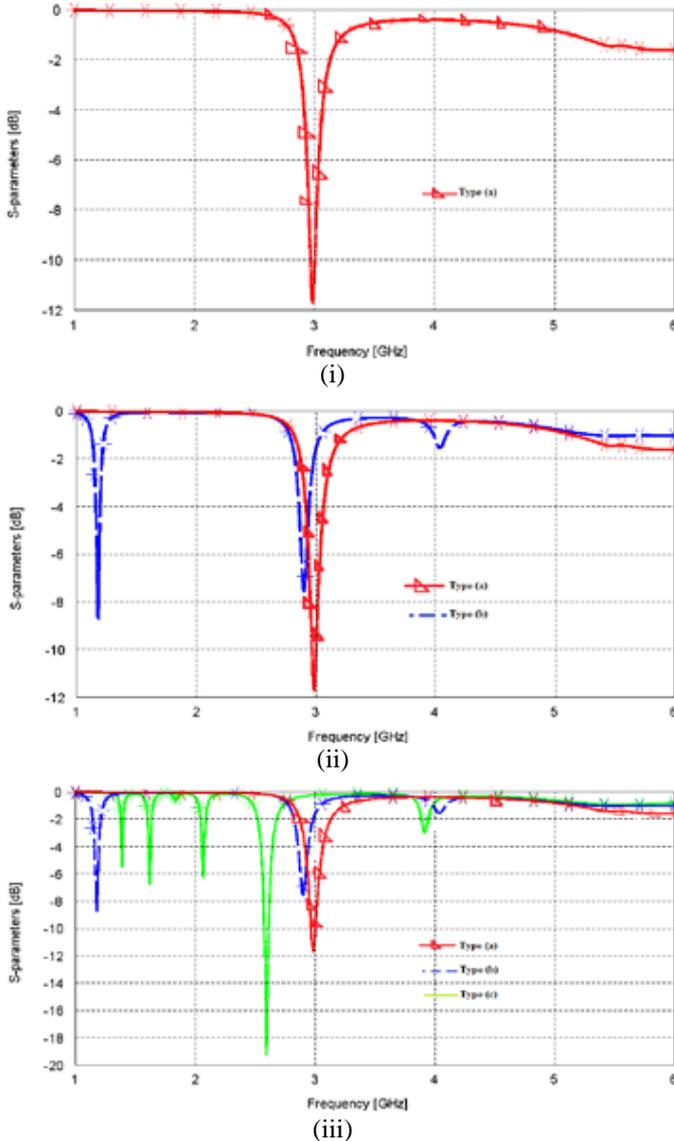


Fig. 3: Simulated Scattering Parameter for (i) Type (a) Configuration. (ii) Type (b) Configuration. (iii) Type (c) Configuration

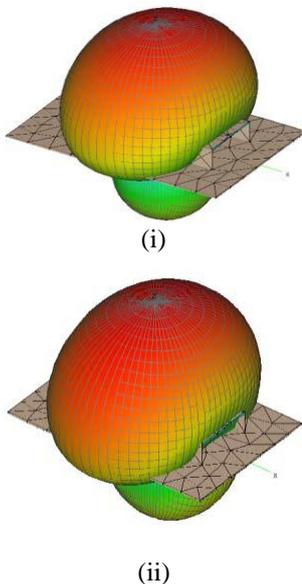


Fig. 4: Radiation Pattern of (i) Type (a). (ii) Type (b). (iii) Type(c)

Fig. 4 shows the radiation pattern exhibited by the three antenna configurations. The proposed antenna shows almost same radiation pattern with high electric field at the top in all three configurations.

IV.PARAMETER ANALYSIS

A. Return Loss

The return loss is measured in dB and it is used to denote the mismatch in terms of logarithmic ratio. The return loss compares the power that passes through and the power reflected from the antenna through the transmission lines.

Type (a) gives a return loss of -13dB at 3GHz, type (b) shows -7.9dB at 2.8GHz and type (c) shows -19.5dB at 2.6 GHz. Return Loss is calculated using the formula,

$$RL = 20 \log_{10} \frac{|VSWR + 1|}{|VSWR - 1|} \quad (1)$$

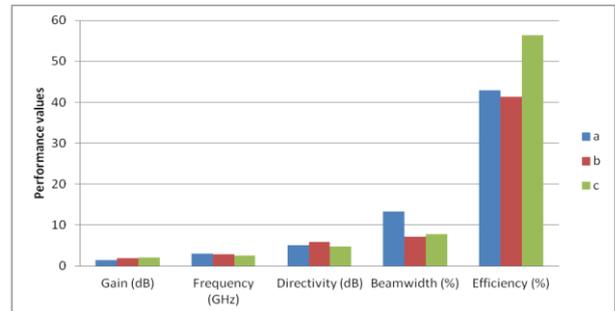


Fig. 5 Graphical representation of simulated parameters of the proposed antenna

B. Efficiency

To calculate the efficiency ratio of the antenna, the ratio of the entire power emitted by the antenna and the net power acknowledged by the antenna from the transmitter associated. Type (c) antenna is 56.39% efficient at 2.6 GHz comparing to other antennas. Efficiency is estimated by means of the formula,

$$\epsilon = PR/PT \quad (2)$$

C. Gain

The ratio of the maximum radiation is defined by accelerating antenna in the given direction from a reference antenna which is achieved by gain. By comparing the three configurations type (c) gives high gain of about 2.12dB and 2.6GHz.

$$G = kD \quad (3)$$

Where, k = efficiency factor.

D. Directivity

The directivity is measured to attain the proportion of the greatest radiation and average radiation power. Here the type (b) configuration antenna is more directive with about 5.8dB at 2.8GHz. Formula for directivity is,

$$\text{Directivity} = 10 \times \log_{10} [D/D_{\text{ref}}] \quad (4)$$

E. Bandwidth

Antenna is operated at the range of frequency is monitored and measured by the bandwidth of an antenna. The gain of type (a) configuration antenna is less compared to other configuration, but it has the highest bandwidth of about 13.3% compared to other configurations. It is calculated using the formula,

$$\text{Bandwidth} = [(FH-FL)/FC] \times 100 \quad (5)$$

V.CONCLUSION

Thus the performance of a folded shorted patch antenna with three different patterns by changing the number of slots was presented in this paper. The use of shorting structures makes the antenna perform as a quarter wavelength antenna. As the number of slots increases the operating band decreases. These are the two advantages that make it possible to integrate the antenna within a wireless device. The three antennas are compared with different parameters such as efficiency, return loss, radiation pattern, bandwidth and gain. These antennas display diverse band of frequencies which can be operated for many wireless applications like LTE, Wi-Fi and mobile phone applications.

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