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MINIATURIZED PLANAR ULTRA-WIDEBAND SLOT ANTENNA WITH AN INTERFERENCE SUPPRESSING CAPABILITY

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ABSTRACT: *A microstrip-fed ultra-wideband printed monopole antenna is presented in this article. The advantages of this miniaturized antenna are capability to eliminate the interference from wireless local area network (WLAN) frequency band and wide impedance bandwidth (IBW). To provide an ultra-wideband of 124.55% (3.05–13.12GHz) simply the aperture of ground plane is adjusted. Furthermore by embedding a pair of T-shaped stubs (PTSS) in the slot a band notched from 4.98 GHz to 5.96 GHz is realized. These functionalities are obtained while the total dimension of the antenna was 20 × 18 × 1.6 mm^3. In this article analysis of antenna parameters like radiation characteristics, survey of surface currents and antenna gain will be presented.* © 2016 Wiley Periodicals, Inc. Microwave Opt Technol Lett 58:813–817, 2016; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.29678

Key words: *microstrip-fed; slot antenna; band notched; WLAN*

1. INTRODUCTION

Recently development of ultra-wideband (UWB) systems for miniaturized antenna that are suitable from financial aspect to fabricate and they have acceptable radiation pattern in omni-directions cause to be more popular to implement. Printed monopole antennas (PMA) have interesting characteristics as the following: (i) ultra wide bandwidth impedance, (ii) ease of fabrication technology, (iii) acceptable radiation characteristics and (iv) possessing very light weight. Then these properties of mentioned antennas cause to raise the popularity of them for researchers and UWB system designers. Most essential researches start in this case from the release of the UWB frequency range by the Federal Communications Commission (FCC). From that time, UWB systems developed as a wireless communication technology and become suitable for small range commercial and interior fast communication applications. In

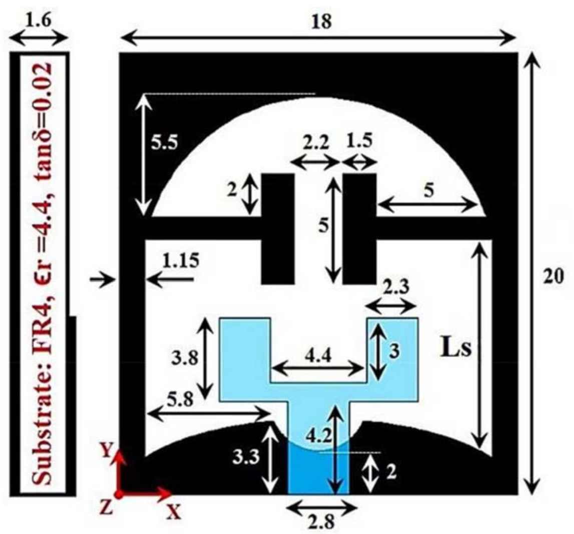

Figure 1 Dimensions and configuration of purposed antenna (all units are in mm). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

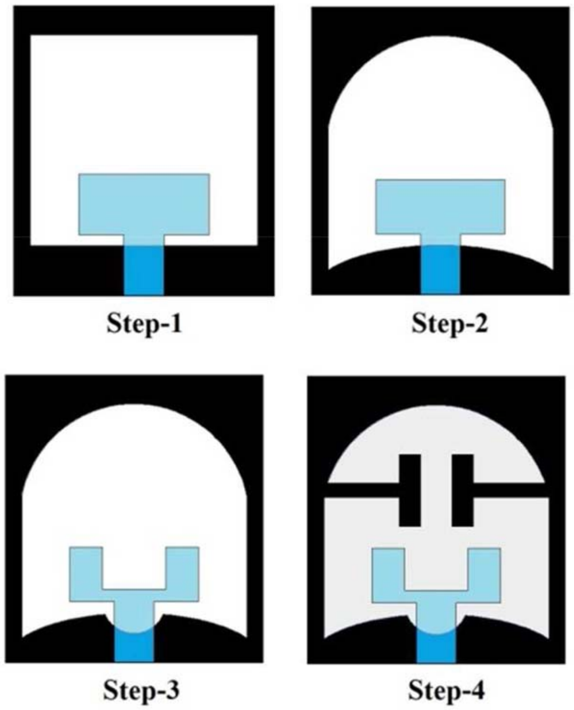

Figure 2 Steps of gradual perfection of designed antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

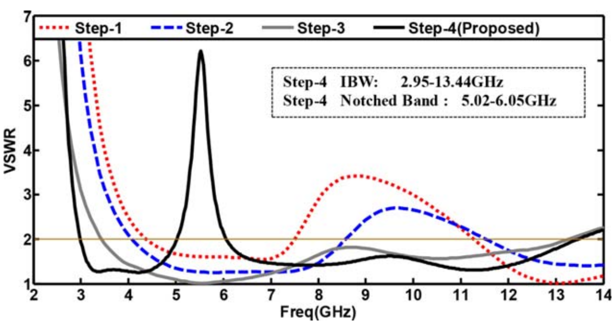

Figure 3 Simulated VSWR curve for steps of designing purposed antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

February of 2002 the FCC changed its' rules in the application of radio wideband applications and defined the 7.5 GHz (3.1–10.6 GHz) bandwidth for wideband applications [1].

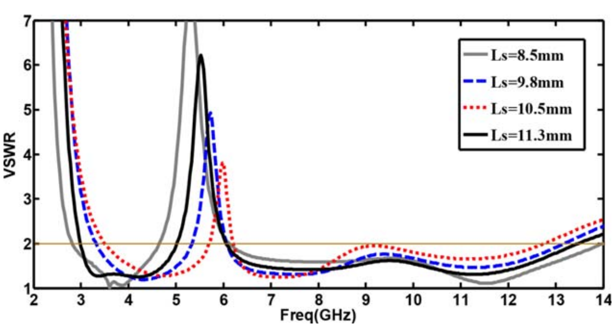

Figure 4 Simulated VSWR curve for changing length of L_s. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

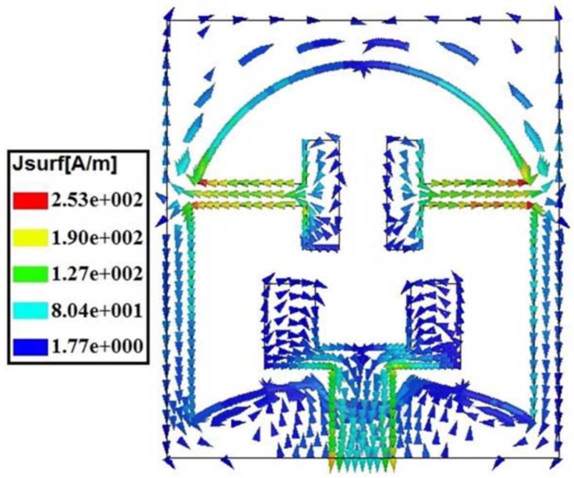

Figure 5 Surface currents distribution of antenna for 5.45 GHz frequency. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

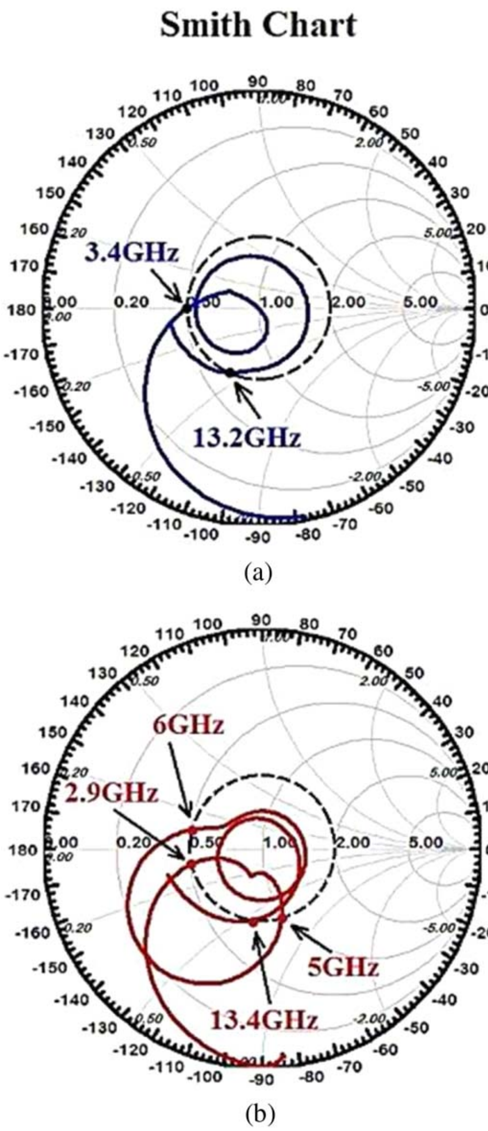

Figure 6 Smith chart for (A) antenna without two T-shaped and (B) introduced antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

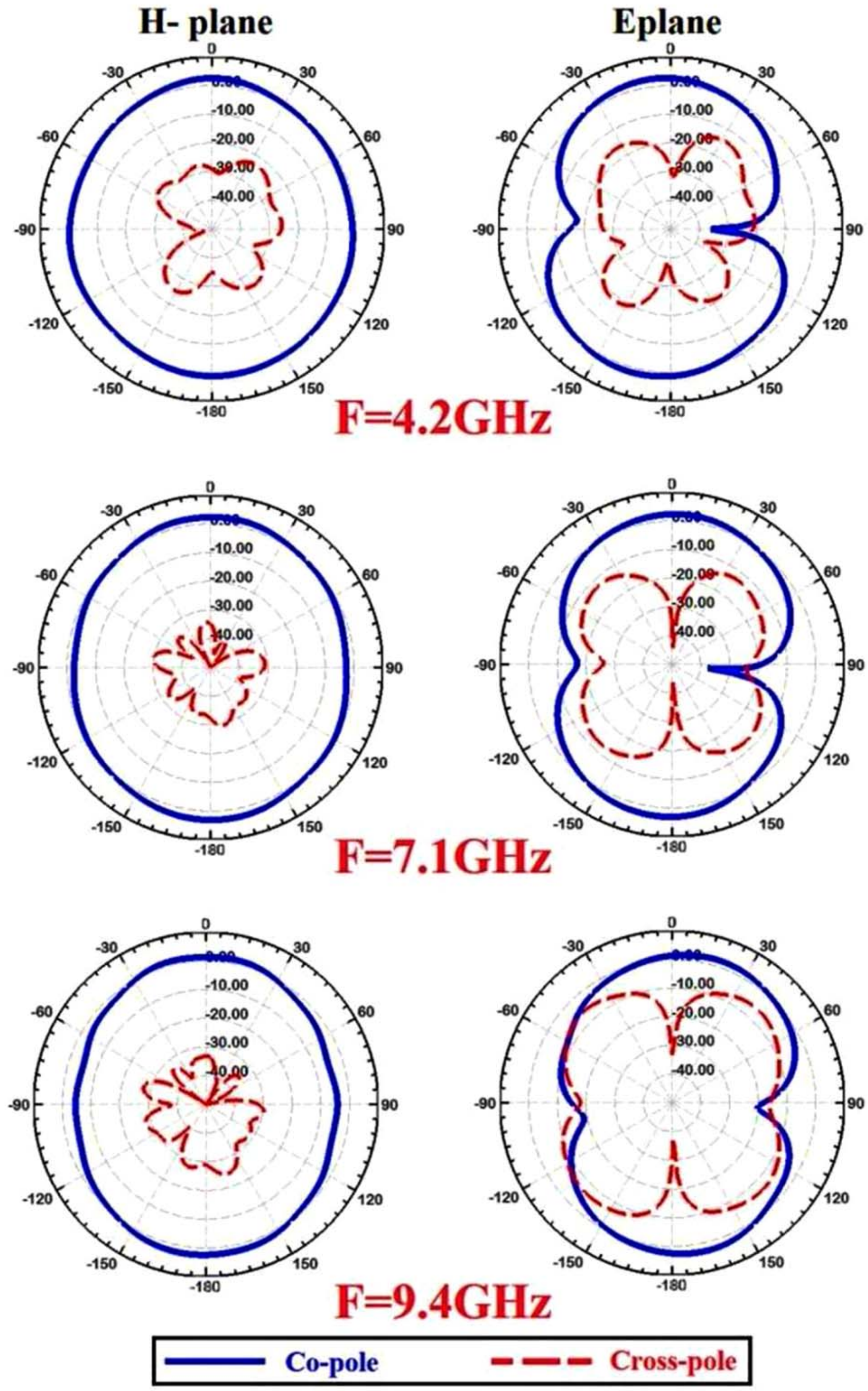

Figure 7 Radiation pattern of antenna at different frequencies. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

Unfortunately, there is another narrowband at the defined bandwidth that severely interfere with it. One of them is wireless local area networks (WLAN) with bandwidth of (5.15–5.35 GHz and 5.725–5.825 GHz). For deal with this interference bandwidth we must use special equipment or circuits which they added to the system and inhibit from the interference. These methods have some disadvantages like unwanted increasing the size or the cost of communication system. Then for reducing the cost and dimensions of communication systems, the design of wideband antennas by filtering characteristics (filtering band 5.15–5.825 GHz) as a method introduced. Till now various PMA wideband with eliminating properties produced. Some of them are: Using proximity coupled resonator [2], Inverted U-shaped slot added in the hexagonal patch [3], segmenting a circular patch [4], Inverted-L-shaped slots on the ground plane[5], mushroom-type electromagnetic-band gap[6], cutting slot with

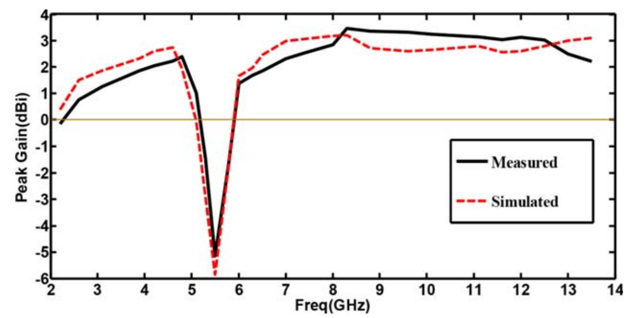

Figure 8 Measured and simulated gain versus frequency in the $\pm z$ direction of the proposed antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

semi rectangular shaped and π-shaped in [7] and [8] respectively, using resonators in [9] and [10], Embedding a tuning stub within a slot on the patch [11] and employing U-shaped filter in radiating element [9].

In this article, a new design of microstrip-fed slot antenna is presented. By adjusting the aperture of the ground, a wide measured impedance bandwidth (IBW) of (3.05–13.12 GHz) is achieved. In this design, by embedding a pair of T-shaped stubs (PTSS), which they are in opposite side with respect together, in the ground structure and construction of omni-directional currents in the mentioned stubs, we neutralized far fields of antenna in bandwidth of 4.98–5.96 GHz. The simulated and measured results are close together that causes designed antenna be a suitable option for wideband systems. In the following sections, characteristics of the antenna and its application will be represented and its properties will compared with the same designs.

2. ANTENNA STRUCTURE

This structure applied on a cheap FR4 substrate with relative permeability 4.4, loss tangent 0.02 and 1.6 mm thickness. At a one side of substrate a microstrip type fed line is connected to a U-shaped patch as a radiating element and on the opposite side, ground structure is located. The shape of the ground structure is same as a rectangle that two semi-oval slotted from the up and down side of it and formed a slot exactly behind of the radiation element of patch (Figure 1). The bandwidth of the antenna is severely dependent to the shape and dimensions of the ground slot and play an important role to introduce and expanding of the IBW. The two T-shaped stubs that located in contrary position with respect together, act as a filtering element that eliminate the WLAN band. In this frequency band by introducing the opposite fields, the return loss of the antenna rises then it do not

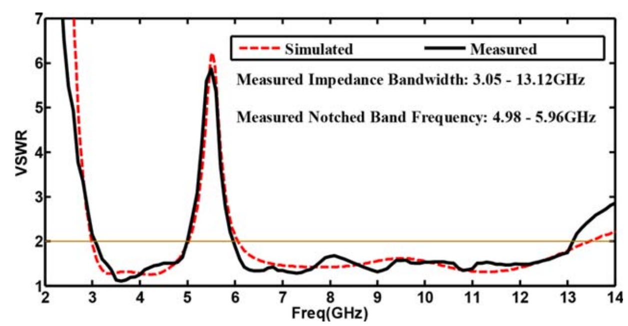

Figure 9 Measured and simulation VSWR results for purposed antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

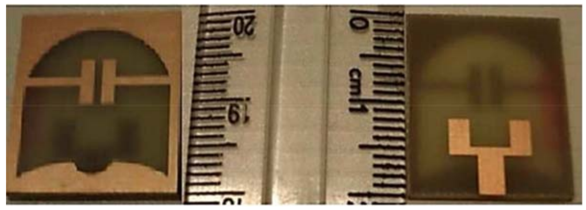

Figure 10 Fabricated antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

have suitable radiation. In Figure 2 the evolution of antenna designing in four steps is depicted and in Figure 3 the simulated VSWR curves for these steps is shown. The first step includes the radiating patch and ground slot in the form of a rectangle. In the second step, the shape of ground slot changed to dome shape. By etching the patch from the top and center of it as a rectangle shape and applying a semi-circular notch located in the vicinity of the radiating element, the third step is realized. These modifications widen the IBW of the antenna, as shown in Figure 3. Finally, in step 4 by embedding two T-shaped stubs on the ground slot, the final structure of the antenna is accomplished and then the WLAN band is rejected successfully. With respect to Figure 3 that simulated and analyzed with high frequency structural simulator (HFSS) version 13 the bandwidth of 10.49 GHz (2.95–13.44 GHz) and eradicated bandwidth of 1.03 GHz (5.02–6.05) GHz for designed antenna are reported.

3. ANTENNA PERFORMANCE

The parameters of this proposed antenna are studied by changing the salient parameters one at a time while keeping all other parameters fixed. Among all parameters, varying the length of L_s has greatest effects on focal point and eliminated bandwidth of antenna. Figure 4 clearly shows that by increasing the L_s from 8.5 mm to 11.3 mm, the center frequency of notch moves from 5.2 GHz to 6 GHz, while rejected bandwidth decreased tangibly. The surface current distribution at the notch's center frequency of 5.45 GHz depicts in Figure 5.

It shows the extremely focused surface currents on T-shaped stubs, but the antenna do not radiate at mentioned frequency band because of opposite direction of currents. Smith charts are plotted in Figure 6. It shows deeper understanding from eliminated bandwidth. In fact, by forming T-shaped stubs in the inner part of the slot that causes to produce capacitance property in antenna and finally the field stored at this capacitance and do not radiate.

4. RADIATION PATTERN AND GAIN OF PURPOSED ANTENNA

Figure 7 shows far fields' radiation pattern of purposed antenna in frequencies 4.2, 7.1 and 9.4 GHz. H-plane pattern (X-Y plane) almost is omni-directional and E-plane (Y-Z plane) shape is mono-pole like. In the Figure 8, the gain curves of the

TABLE 1 Comparison of Purposed Antenna with Some Printed Monopole Antennas (PMA) With Suppressing Bandwidth Property

References	Antenna Dimensions (mm^3)	Published Year
[2]	42 × 44 × 1.6=2975	2010
[3]	52 × 32 × 1.59=2645	2012
[4]	47 × 37 × 1.5=2608	2010
[5]	32 × 28 × 1.6=1433	2013
Purposed antenna	20 × 18 × 1.6=576	2014

antenna that obtained from simulation and measurements of fabricated purposed antenna are shown. It shows an acceptable and almost flat gain on the frequency bandwidth of antenna. In the frequency about 5.5 GHz, the gain of the antenna drastically drops that causes the antenna do not radiate in this frequency bandwidth.

5. MEASURED RESULTS OF ANTENNA AND COMPARISONS

Figure 9 shows VSWR results from measurement and simulation of purposed antenna. With respect to the result, it is obvious there is a good agreement between measurement and simulation values. The negligible mismatches between these values are normal because of human, fabrication, measurement, soldering errors and existence of the noise. The measurements of VSWR curve is done by Agilent 8722EES Analyzer apparatus. The photograph of the fabricated slot antenna is shown in Figure 10. In the Table 1 physical dimensions of purposed antenna with some prototype of PMA with suppressing bandwidth property that discussed in reputable publications recently are compared. As we can see in the table, the smallest antenna is [5] that approximately is 248% larger than our purposed antenna.

4. CONCLUSION

In this article, steps of antenna design evolution, analysis and fabrication of a miniaturized planar UWB slot antenna with an interference suppressing capability is shown. This antenna has a microstrip fed line which with printing and fabrication technology that fabricated and tested on substrate. The results of this miniaturized antenna for IBW 3.05–13.12 GHz and eliminated unwanted bandwidth 4.98-5.96 GHz are measured. Finally, designed antenna with dimensions of $20 \times 18 \times 1.6$ mm^3 in contrast with antennas that have same characteristics is more smaller, efficient and suitable option to wideband systems without worn about the interference bandwidth.

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DESIGN AND INITIAL MEASUREMENTS OF K-BAND FMCW RAIN RADAR WITH HIGH RESOLUTION

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ABSTRACT:: *This paper presents an FMCW K-band rain radar with the property of high resolution. The radar system was designed for measurement of localized torrential rain. Using DDS and FPGA control, heterodyne modulation was used to generate the FMCW down-chirp signal with 50 MHz bandwidth, and emitted a K-band signal with nominal power of 125 mW in the vertical direction. To obtain high resolution for the Doppler spectrum, the radar system used a coherent signal processing method. Several experiments were conducted and the results were compared with data from the meteorological administration.* © 2016 Wiley Periodicals, Inc. Microwave Opt Technol Lett 58:817–822, 2016; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.29677

Key words: *rain radar; FMCW; 24 GHz; long range radar; high resolution*

1. INTRODUCTION

The frequency-modulated continuous wave (FMCW) technique is widely used for weather radar systems [1–4]. Recently, FMCW compact rain radar has designed to measure the localized heavy rain [5,6]. It is important to improve the high resolution in order to archive good quality of precipitation measurement [1]. In this paper, we designed a 24 GHz rainfall radar system that radiates electromagnetic waves in the vertical direction, and analyzes the distribution of reflectivity resolved into a 1024 range gate with a vertical rage resolution of 3 m. FMCW radar uses less expensive and lower power RF components than those of pulse radar. On the other hand, because FMCW radar systems continuously emit electrical signals, leakage of transmitter signals occurs. Thus high isolation between the transmitter and the receiver is required to improve sensitivity. In order to improve the isolation property, a separation wall with a serration edge structure between the transmitter and the receiver antennas was used [7]. To obtain the Doppler information with high resolution frequency, coherent operation was used to combine the consecutive range spectra of 1024 numbers. As a result, the frequency resolution is increased and the radar is able to detect relatively slow moving target. The radar system