# Ultra-Wideband Micro strip Antennas with notch Analysis

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*Abstract*—The advancement in personal mobile communication systems, led to increase of antennas that give ultra-wideband response. In this paper a ultra-wide band Microstrip antennas with their notch characteristics are discussed. First the ultra-wide band antennas realized by using combination of regular shaped radiators or by slots in radiator patch are discussed. Further, rectangular and U shaped structures are analyzed for notch characteristics using symmetrical E-shaped slots and stubs respectively. A detailed study to realize the ultra-wideband operation for notch characteristics is discussed. The proposed antennas yield operating bandwidth from less than 2 GHz to more than 10 GHz with notch to reject certain communication bands. Due to the realized bandwidth and gain, configurations can find applications in personal mobile communication and applications in 3 to 10 GHz frequency range.

Keywords—Ultra-wideband antenna, Planar monopole antenna, Rectangular planar monopole antenna, notch analysis

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## I. Introduction

The development in personal mobile communication systems having high data rate increased the demand for antennas which yield bandwidth (BW) in the range of few tens of GHz. For these monopole antennas are widely used [1]. The higher BW in monopole antennas is due to the large BW of individual resonant modes which in turn realizes BW of few GHz [2]. While designing planar monopole antenna, depending upon the substrate thickness, lower frequency of the operating bandwidth is calculated based upon resonance frequency equation for MSA or by using equation for quarter wavelength monopole antenna [3]. Microstrip antennas are widely used to design high frequency circuit for simple integration with the other microwave integrated circuit (MIC). Many printed planar monopole antenna using regular radiating shapes like, rectangular, circular, triangular have been reported which yields BW in the range of few tens of GHz. The ultra-wide band designs by cutting slots in the radiating patch or in the ground plane have also been reported [4 – 12]. Over the designated UWB spectrum (3 – 10 GHz), other narrowband services like, Wi-Max, C-band satellite communication (3.7 – 4.2 GHz), WLAN, IEEE 802.11a exist. To avoid interference with these communication systems notch is realized in the UWB response of the planar monopole antenna. In the literature many monopole designs with notch characteristics are reported. However in all the reported literature on printed monopole MSA's a detailed analysis of UWB response and its notch realization with respect to resonating modes is not available.

In this paper, a rectangular ring combined structure with dual wide-band characteristics and rectangular patch with modified ground plane are discussed. Further, rectangular patch with E-shaped slot is analyzed for WLAN notch frequency. Also, a U-shape structure with stubs in the feed-line and ground plane slot to realize dual band notch is discussed. The simulated and measured BW from less than 2 GHz to more than 10 GHz is obtained with notch bands. Due to the printed monopole design proposed antenna shows nearly Omni-directional radiation pattern over the entire BW with co-polar broadside gain of around 1 to 3 dBi. Due to the above impedance and pattern characteristics configurations can find applications in blue-tooth, Wi-fi and personal mobile communication system applications in 3 to 10 GHz frequency range. The antennas are first analyzed using simulation software followed by experimental verification. The impedance response till 8 GHz is measured using vector network analyzer whereas pattern and gain measurements till 8 GHz were carried out using RF source and spectrum analyzer inside the antenna lab wherein minimum reflection from surrounding object was ensured.

## II. PRINTED PLANAR MONOPOLE MSA

A novel structure is realized by combining rectangular ring and rectangle monopole patch to cover WLAN and Wi-Max applications respectively as shown in Figure. 1 (a). The dimensions of the same are as follows: L = 15 mm, $L_1$ = 18 mm, $L_2$ =11 mm, W = 12 mm, $W_1$ = 11.5 mm, $W_2$ = 4.5 mm, $W_3$ = 2 mm, $W_f$ = 3 mm, g = 0.5 mm, $S_1$ = 1.5 mm, $S_2$ = 3 mm. The return loss plot for the same is shown in Figure. 2(a). The resonant fundamental frequency of the rectangular ring is around 2.9 GHz and that of the rectangular monopole is around 4.4 GHz. The combined structure causes the fundamental resonant frequency of the rectangular monopole to increase to 5.2 GHz due to the reduced resonating length. The width of the rectangular structure affects the impedance bandwidth. The change in the width of the structure affects the surface current perturbations which in-turn affects its impedance bandwidth [4]. Another, rectangular structure is realized for UWB using slots and modified ground plane as shown in Figure. 3(a). The dimensions of the structure are as follows: $L_1$ = 1.5 mm, $W_1$ = 2.5 mm, $L_2$ = 5 mm, $W_2$ = 0.5 mm, $L_3$ = 2.5 mm, $W_3$ = 1 mm, $L_4$ = 19.5 mm, and $W_4$ = 15 mm. The return loss plot of the structure is shown in Figure. 3(b). With the increase in the length of the ground plane and width of the slot present in the ground plane the lower edge frequency decreases due to the reduced ground plane effect. The slot cuts present in the radiating patch improves the impedance bandwidth at the higher frequencies. This is due to the reduced induced currents of the ground plane at the higher frequencies [5].

## III. NOTCH ANALYSIS OF PRINTED MONOPOLE MSA

A novel structure with a pair of symmetric E-shaped slots UWB antenna with band-notched characteristic is shown in Figure 3(c). A symmetric E-shaped slot produces a notched frequency at the WLAN frequency band ($f_c$=5.2 GHz) as seen from the VSWR plot shown in Figure 4(c). The band-notched characteristic originates from the induced current flowing in the lower C-shaped rings of the patch, in way the E-shaped slot prevents the radiation element from radiating as seen in Figure 4(a, b). The resonant band-notched frequency is mainly determined by the length of the slot. The input impedance of the antenna at the band-notched frequency is greatly affected by the position of the proposed structure [6].

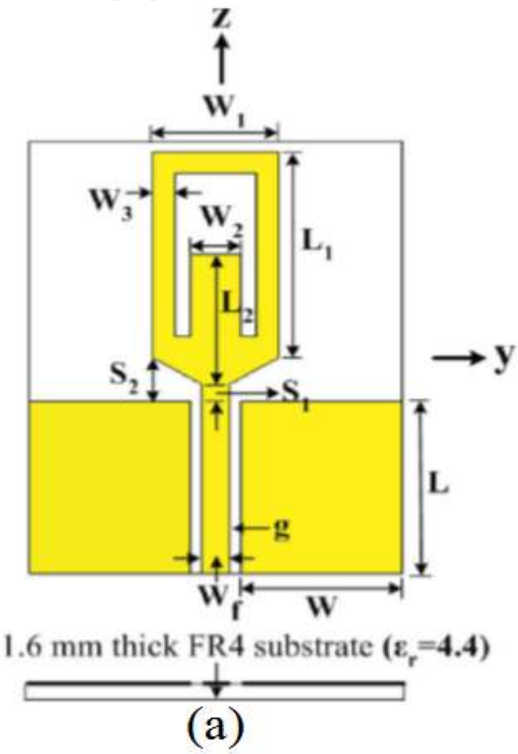


Fig. 1 (a) Geometry of Rectangular combined ring dual-wideband antenna [4]

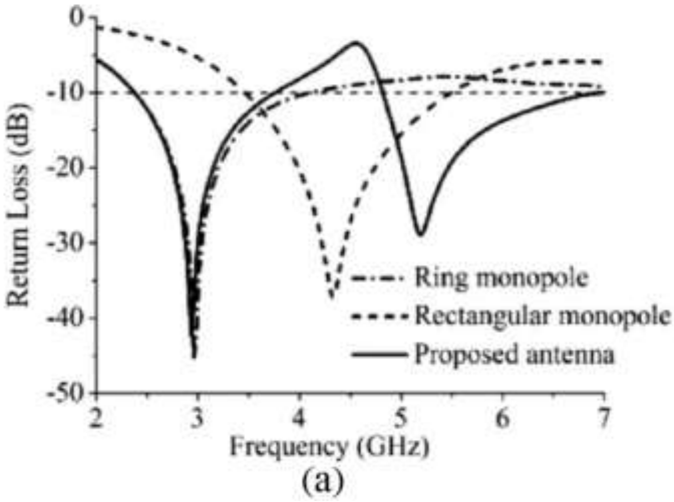


Fig. 2 (a) Return loss plot of the proposed Rectangular combined ring antenna [4]

A U-shaped UWB antenna is shown in Figure. 5(a). The proposed antenna has a large bandwidth over the frequency band from 2.75 GHz to 10.6 GHz except 3.27–4.26 GHz and 5.01–5.99 GHz frequency bands as seen in the VSWR curve shown in Figure. 5(b). The spiral stub in the radiating patch is used to reject the frequency band limited by Wi-Max and C-band systems while the symmetrical L-shaped slot on the ground plane is used to reject the frequency band limited by HIPERLAN/2 and WLAN systems. The dual band rejections are mutually uncorrelated due to the placement of structure in different places. At 3.8 GHz frequency the current mainly flows in the stub, which acts as short circuit resonator and there is little current in the radiating patch making it non-radiate. Similarly, at 5.6 GHz the surface current is concentrated around the L-shaped slots in the ground plane which causes the antenna to be non-responsive at that frequency. Thus, the impedance of the structure is not well matched and caused large reflections result in increased return loss and decrease radiation efficiency and gain in the stop bands. The band rejection frequency and bandwidth is tuned by changing the dimensions and position of spiral shaped open stub and L-shape slot respectively [7].

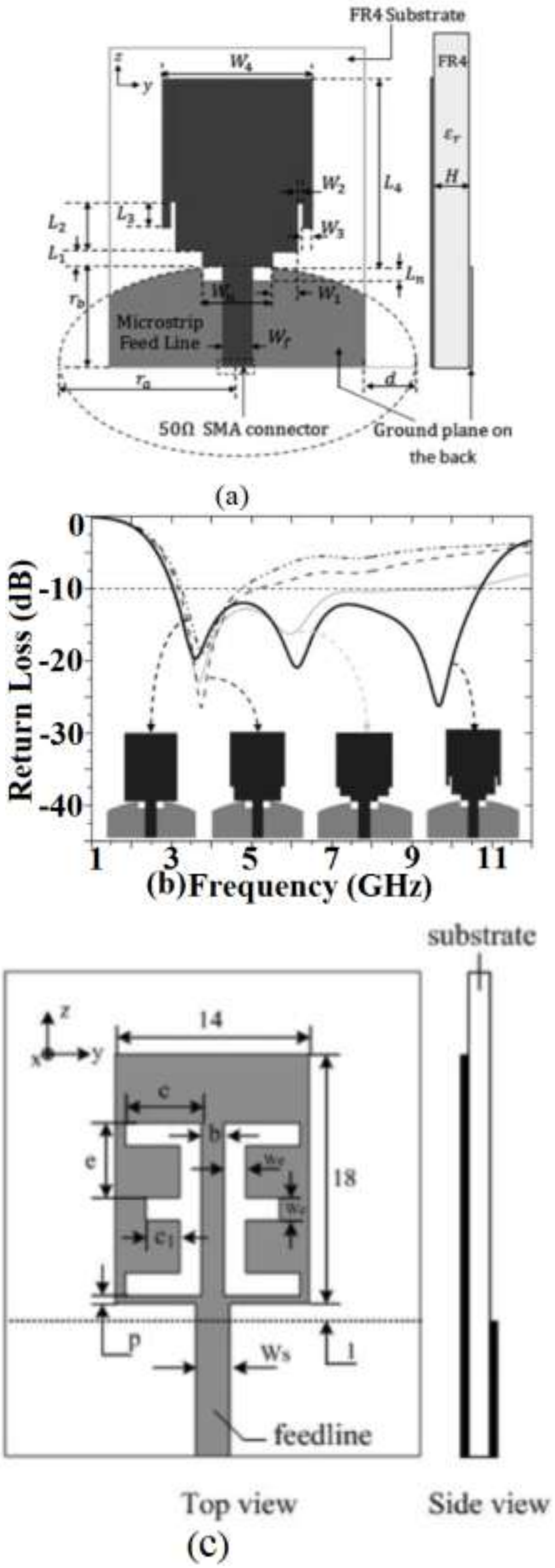


Fig. 3 (a) Geometry of compact ultra-wideband antenna, (b) return loss plots showing effects of various slots on the rectangular planar monopole antenna and (c) Symmetric E shape slot UWB antenna [5, 6]

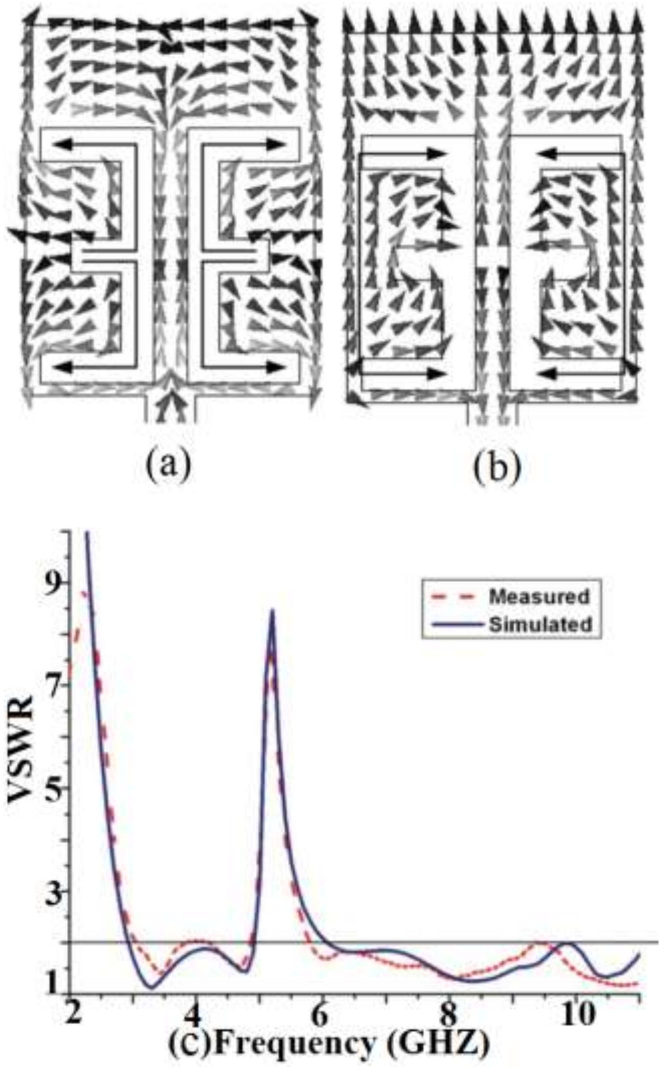


Fig. 4 Distributions of induced current in the Symmetric E-shape slot UWB antenna at the frequencies of (a) 5.2 GHz and (b) 7 GHz and (c) VSWR plots of the proposed planar monopole antenna [6]

It is observed from the study that notch frequencies can be analyzed by two ways either by cutting slots in the radiating in way that makes the patch non-responsive at the notch frequency and other by introducing stubs, which resonates at notch frequency, in the radiating structure and also by cutting slots in the ground plane notch frequency can be obtained at slot resonating mode. The notch frequency depends on slot and stub resonating length whereas, the notch band depends on the slot and stub position.

The radiation pattern plots in E and H-planes are omni-directional over the BW.

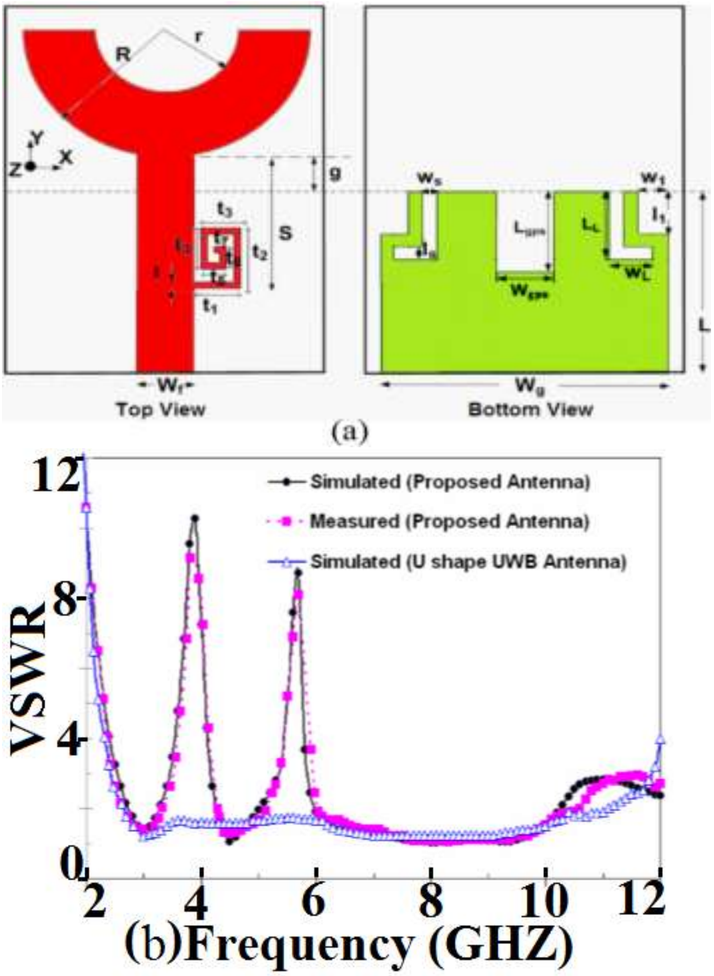


Fig. 5 (a) Compact printed dual band-notched U-Shape UWB antenna and (b) its VSWR curve [7]

The return loss is more than -10 dB around notch bands. The E-plane is aligned along √ = $90^0$. Due to monopole design the radiation pattern is nearly Omni-directional. Pattern shows higher cross-polarization over the BW due to orthogonal variations in surface currents at various higher order resonant modes. Due to this current variation, broadside gain over the BW varies from 1 dBi to around 3 dBi. Thus, the analyzed configuration can find applications in personal mobile communication like Wi-Fi, Bluetooth and in the Wi-Max applications in 3 to 10 GHz frequency band.

## IV. CONCLUSIONS

A novel Rectangular ring combined structure and rectangular structure with modified ground plane is analyzed for UWB response. E-shaped slot cut rectangular planar monopole antenna is analyzed for notch realization. The slot makes the radiating patch non-responsive at slot resonating frequency thereby realizing notch characteristics. Similarly, U shaped structure is analyzed. The stub introduced in the feed-line of the U-shape structure resonates at notch frequency making patch non-radiate. The slot and stub length and position affects the notch frequency and bands respectively. The antennas yield BW from around 2 GHz till more than 10 GHz with Omni-directional radiation pattern over the BW. Due to variation in cross polarization levels antenna gain varies from 1 dBi to around 3 dBi. The proposed configurations can find applications in Wi-fi, Wi-max, Bluetooth.

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