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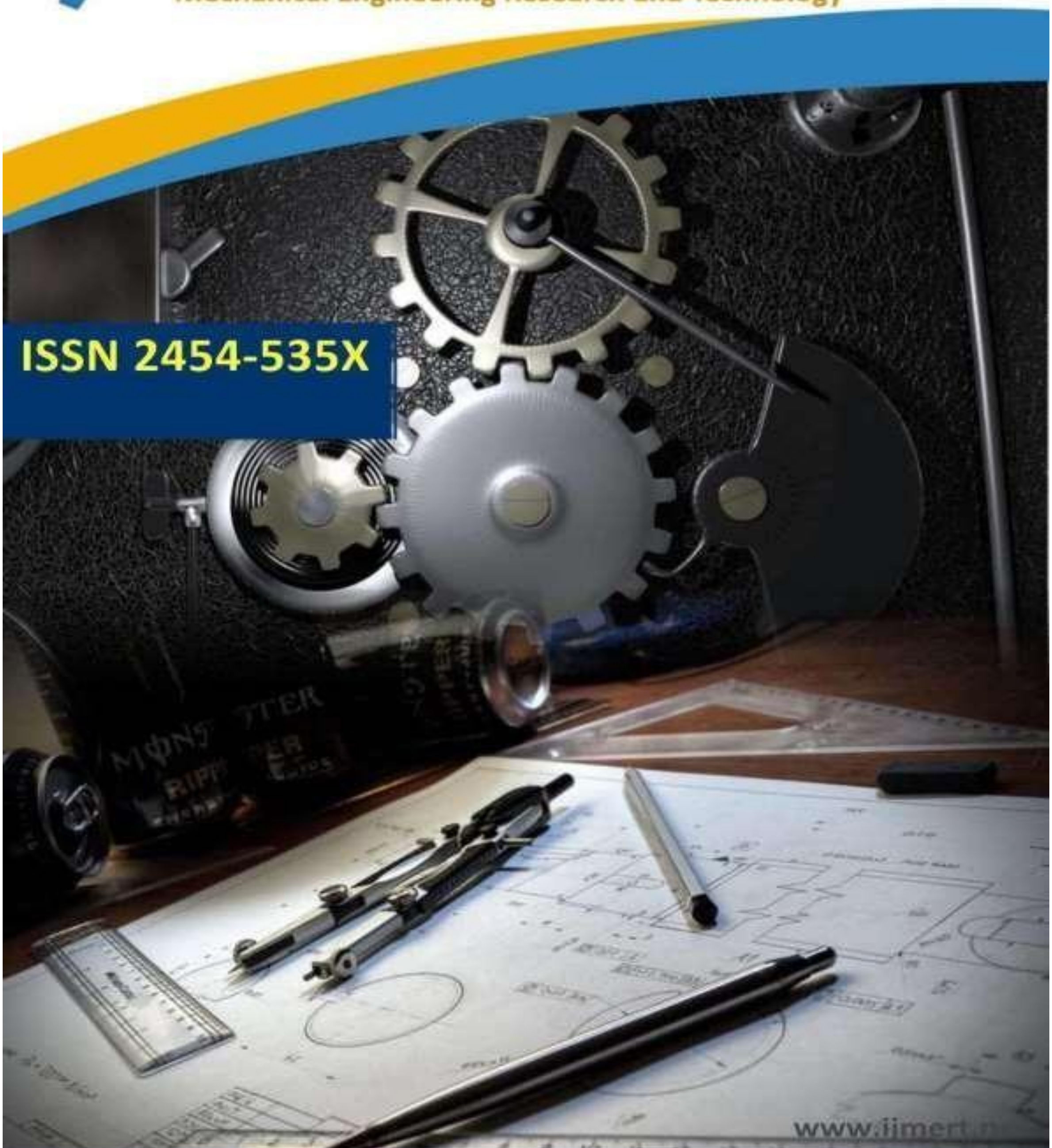

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A U SLOT LOADED PLANAR UWB ANTENNA WITH SIGNAL REJECTION CAPABILITY IN THE 5.2 – 5.8 GHz BAND.

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Abstract— This paper presents the construction of a small planar antenna that can simultaneously reject signals in the 4-6 GHz range—the band that is designated to IEEE802.11a and HIPERLAN/2—and has ultra wideband performance. This design is shown on a 0.64 mm thick RT6010LM substrate with a relative dielectric constant of 10.2. According to the data shown, the 27 mm x 20 mm antenna can withstand frequencies between 2.7 GHz and beyond 10 GHz (not including the rejection band). The antenna has excellent radiation efficiency and * almost omnidirectional properties. These terms are used in the index: ultra wideband (UWB) antenna, slot antenna, and linear antenna.

Introduction

Antennas for ultra wideband (UWB) frequencies have become more popular in recent years, ever since the U.S. FCC approved UWB technology in 2002 [1]. Concurrent with this upsurge in interest in ultra-wideband antennas, studies have concentrated on designing front end modules using multilayer dielectric substrates in an effort to shrink wireless transceivers [2]. A planar UWB antenna is ideal for integrating the radiating structure with the radio frequency (RF) front end circuits. A number of planar UWB antenna designs that might fulfill these criteria were detailed in the literature [3]–[7].

Designing UWB systems to operate well with current standards like IEEE802.11a and HIPERLAN/2A necessitates the rejection of a specific sub-band within the 4.0-6.0 GHz spectrum. Using a filter to remove unwanted frequencies is one way to satisfy the new requirement. Using a UWB antenna that can reject sub-band signals is a better option, however, as shown in [8]. The design in [8] doesn't meet the criterion for integration with a multilayer dielectric RF front end circuitry since it is nonplanar, which is one of the problems with it. This article describes a totally planar ultra- wideband antenna that can narrowly reject signals in the 4-6 GHz range. To achieve this objective, a straightforward design method is shown.

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Section II of this letter describes the proposed antenna design. Computer simulations and measurements concerning voltage standing wave ratio (VSWR), radiation pattern, and gain of the proposed antenna are shown in Section III. Section IV concludes the article.

The configuration of a planar UWB antenna with the capa- bility of rejecting frequencies within the 4.0–6.0 GHz band is illustrated in Fig. 1.

The antenna structure is assumed to be in the -plane with its higher dimension extending along the -axis. The radiating slot is the result of intersecting of two circles in a conductive layeron top of the substrate. The antenna is fed with a coplanar wave- guide (CPW). The observed transition from CPW to a coaxial probe can be regarded as via in a multilayer front end module. A tuning slot to reject a signal within the 4–6 GHz band is in- troduced in the second circle. Steps used to design this antenna are summarized as follows.

xy

x

1) Depending on the lowest frequency of operation (f_1), thickness of the substrate (h) and its dielectric constant (ε_r), width (w), and length (l) of the antenna structure arecalculated from [9] as

$$w = \frac{c}{2f_1}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$l = \frac{c}{2f_1\sqrt{\varepsilon_{re}}} - 2\Delta l$$

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}$$

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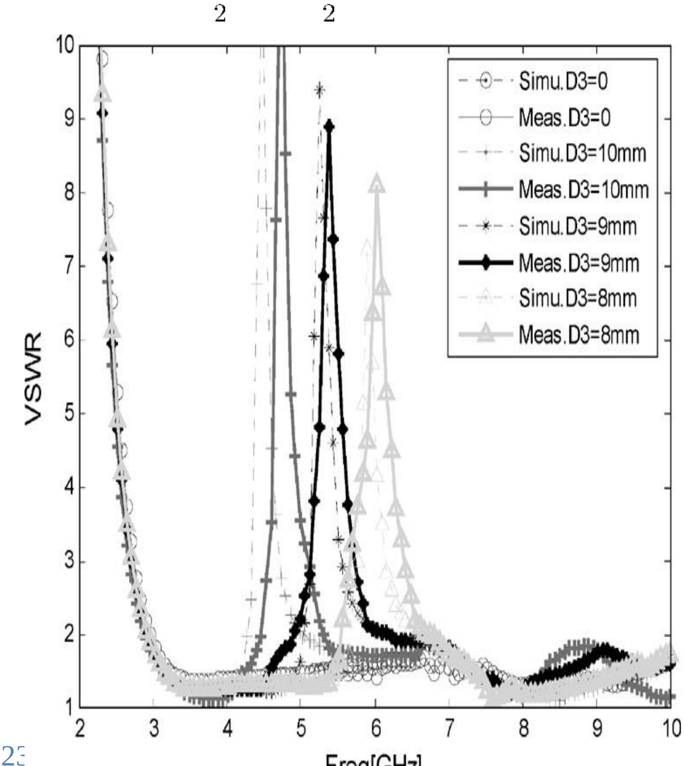
TABLE I
VALUES OF DESIGN PARAMETERS FOR UWB ANTENNA

Design Parameters	Designed value (mm)	Optimized value (mm)
w	25	27
l	18.5	20
D_1	25	25
D_2	12.5	12.6
D_3	8.9	9
y_1	--------	3
y_2	--------	6.8

$$\Delta l = 0.412h\frac{(\varepsilon_{re} + 0.3)\left(0.264 + \frac{w}{h}\right)}{(\varepsilon_{re} - 0.258)\left(0.8 + \frac{w}{h}\right)} \quad (4)$$



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where c is the speed of light in free space and ε_{re} is the effective dielectric constant. In the undertaken approach, the parameter Δl is neglected as it usually takes a small value in comparison with b.

2) The radiating slot is formed by cutting a circle (Circle1) from the ground plane designed above and adding a second circle (Circle2) to the ground plane in the manner shown in Fig. 1. Diameters of Circle1 and Circle2 (D_1 and D_2),in the preliminary stage of the design are equal to

$$D_1 \quad D_2 \quad = w; \quad = \frac{w}{2}. \quad (5)$$

Usually, D_1 is taken to be lower than the value mentionedin (5) to allow some space for the ground plane around theradiating slot.

3) Centers of the two circles are shifted by y_1 and y_2 fromcentre of the ground plane. Parts of the two circles that ex- tend outside the ground plane from one direction are cut toform the CPW needed to feed the antenna. Values of y_1 y_2 and are chosen in order to maintain the required impedance bandwidth.

4) In order to tune out the undesired band a tuning slot is made in the second circle. The slot is in the shape of half circle with diameter D_3 chosen according to the followingequation:

$$D_3 = \frac{c}{2 f_u \sqrt{\varepsilon_{re}}} \quad (6)$$

where f_u is centre of the undesired band. Position of theslot and its width are selected to control the rejected band. Design parameters (D_1,D_2,D_3, y_1, $y_2$and) for the UWB slot antenna obtained using this method are optimized with AnsoftHFSSv2 and an in-house developed program written in Mi-crosoft-Perl 5.6 [10]. The initial and optimized values assuming f_1 of 2.5 GHz and f_u of 5.4 GHz are given in Table I. The opti-mization was performed for the best impedance bandwidth ex- cluding the undesired band. The optimized values differ by lessthan 10% from the original ones. This result gives a lot of con- fidence in the presented design formulas.

Results and Discussion

The scientists used a widely accessible RT6010LM substrate with a dielectric constant of 10.2, tangent loss of 0.0023, and a thickness of 0.64 mm to develop the UWB antenna with signal rejection capabilities in the 4-6 GHz range. Figure 2 displays the experimental and computational findings for the voltage-state-of- resonance (VSWR) as a function of frequency for the antenna design (using the dimensions given in Table I), both with and without the tuning slot. A comparison of the calculated and observed VSWR characteristics for the antenna without the tuning slot shows that it exhibits UWB behavior throughout a bandwidth of over 10 GHz, taking VSWR 2 as a reference. Including the tuning slot causes the worst VSWR to happen across a small sub-band between 4 and 6 GHz. The tuning slot length determines the decision. The original UWB antenna's VSWR characteristics are hardly marginally impacted by the tuning slot in the pass band. This demonstrates the effect of employing tuning slots of varying sizes. The location of the rejected band may be easily changed by modifying the slot diameter. By a design-compatible proportion, the rejected band is shifted to a lower value as the tuning slot diameter increases (6). We found that if you want your antenna to stay in the intended band, you need to make sure that the center of the tuning slot is precisely equal to the center of Circle 2. By expanding the tuning slot, the rejected bandwidth may be raised. Results from both simulations and measurements corroborate this, revealing negligible differences. From the perspective of ultra-wideband (UWB) applications, the antenna must radiate in all directions. The developed antenna satisfies this requirement, as seen by the simulation results in Figure 3.

Figure 4 displays the measured gain of the planned antenna. Gain (in dB) ranges from 0.4 to 4.6 dB for both the original antenna (without the tuning slot) and the modified antennas (with the tuning slot) outside of the rejected band, as shown in the figure, which is essentially linear with frequency from 3 GHz to 10 GHz. The gain in the band that was rejected.

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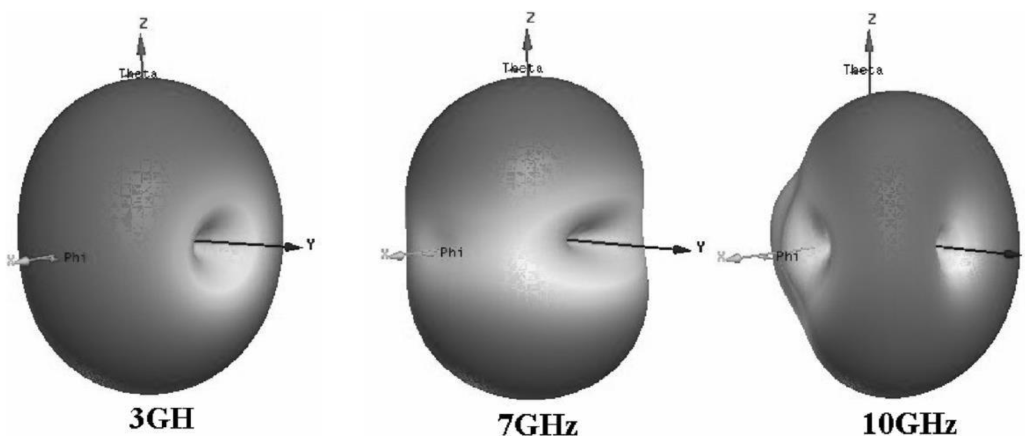

Fig. 3. Three-dimensional radiation pattern for the UWB antenna (without the tuning slot) at different frequencies.

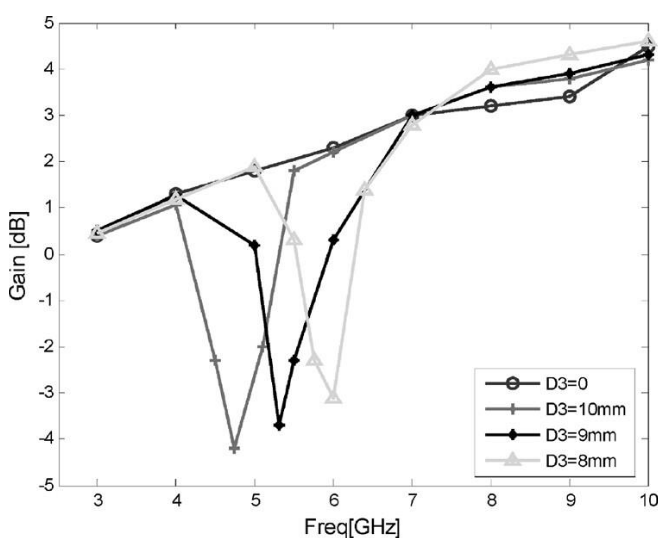

Fig. 4. Measured gain against frequency for the UWB antenna.

to be as low as-4.5 dB. The HFSS simulations have shown that this antenna features more than 90% radiation efficiency in thepass-band.

CONCLUSION

In this letter, we have shared a straightforward approach to designing a planar UWB antenna that can reject signals in the 4-6 GHz wavelength range. Two intersecting circles, which furthermore include, shape the intended radiating element, which is a slot.

in order to feed the CPW. The sub-band rejection is accomplished by means of a tuning slot. Measurements and computational modeling have validated basic design equations. The developed ultra-wideband antenna has an efficient radiation pattern and can radiate in all directions. Designers of ultra-wideband front ends using multilayer substrates should find the given antenna layout and its design process quite interesting.

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