Novel Compact T-Slot Microstrip Patch Antenna for Wideband Application

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Abstract
Design of Compact inverted T-slot Microstrip patch antenna for wideband application is proposed in this communication. The novel design is achieved by simply cutting two notches in the bottom portion of the rectangular patch introduces multiple resonances. The proposed microstrip patch antenna is designed to operate from 2.8163 to 26.7050 GHz. The antenna complies with the return loss of S11 < -10 dB and Voltage Standing Wave Ratio (VSWR) < 2 throughout the impedance bandwidth. Impedance bandwidth of 161.84% could be achieved with the aid of simple microstrip line feeding technique. Therefore the proposed design is suitable particular for wireless communication application such as WLANs, Wi-Fi, ISM band, and WiMax. The proposed antenna design has an overall size of only 28 x 24 x 0.8 mm^3.

1. Introduction

In the recent years, the development in communication system requires low cost and easy of fabrication, compact size, low power handling capability that are capable of maintaining high performance over a wide spectrum of frequencies. This type of trend has focused much effort into the design of a Microstrip patch antenna. It consists of a radiating patch on one side of a dielectric substrate with a continuous metal layer bonded to the opposite side of the substrate which forms the ground plane. For this reason, Microstrip patch antennas are most commonly used in aircraft, spacecraft, satellite, mobile communications and missile applications due to their many attractive features such as simple structure, low cost of production, light weight and robustness.

Microstrip antenna designers often face challenges such as meeting space constraints, achieving wide impedance bandwidth and wide radiation pattern. Wireless communication is fundamentally different from all other communication techniques because it employs extremely narrow RF pulses to communicate between transmitters and receivers. Wideband technology can be widely used in ground penetrating radars, high data rate short wireless local area communications, Bluetooth technology and other military applications.

In this paper we have presented the use of a patch antenna with T-shaped slot to achieve wideband application with compact size and very low return loss. The VSWR parameter was found to be less than 2 within the operating frequency range. It may be used for Wireless Local Area Network application in the frequency range from 5.2 to 5.8 GHz. By properly selecting dimensions of the notches as well as the embedded slots, wide impedance bandwidth and suitable radiation characteristics for application in the WLAN system can be achieved. Efforts of cutting notches and embedding slots to the original patch on resonance were studied. Also, measurement of the proposed antenna working across the operating frequencies was implemented for verifying the simulation results.

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2. Antenna Design and Discussions

Fig.1 illustrates the geometry of the synthesized wideband microstrip-fed slotted patch antenna. A rectangular patch as a radiator was etched on the top portion of one side of an FR4 substrate with initial dimensions of 28(L) x 24(W) mm^2, whereas the ground plane with a size of Lg x W was printed on the other side of the substrate. The specified characteristics of this substrate are 0.8 mm in thickness and 4.4 in relative permittivity. A 50Ω microstrip line of width (Ws) and length (Ls) was then adopted for feeding the patch. For improving the matching condition and then effectively extending the impedance bandwidth, dual triangular notches, each with dimensions of Ln x Wn, were cut at the two lower corners of the patch. Thereafter, to further enhance the bandwidth T-slot were embedded into the notched patch.

3. Antenna Design and Discussions

The antenna parameter for the microstrip patch antenna can be calculated by the transmission line method.

(1) Width of the patch can be determined by,

$$W = \frac{1}{2f_r}\frac{c}{\sqrt{\frac{2}{\xi_r+1}}}$$

(2) The effective dielectric constant for the antenna design can be obtained by,

$$\xi_{reff} = \frac{\xi_r+1}{2} + \frac{\xi_r-1}{2}\left[1+12\frac{h}{W}\right]^{1/2}$$

Where,

ε_{reff} = Effective dielectric constant
εr = Dielectric constant of substrate
h = Height of dielectric substrate
W = Width of the patch.

The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given by,

$$\Delta L = 0.412h \frac{(\xi_r + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\xi_r - 0.3)\left(\frac{W}{h} + 0.8\right)}$$

(3) The actual length *L* of the patch is given as,

$$L = \frac{c}{2 f_r \sqrt{\xi_{reff}}} - 2\Delta L$$

(4) The length and width of the ground plane can be determined by,

$$W_g = 6h + W$$

$$L_g = 6h + L$$

Where,

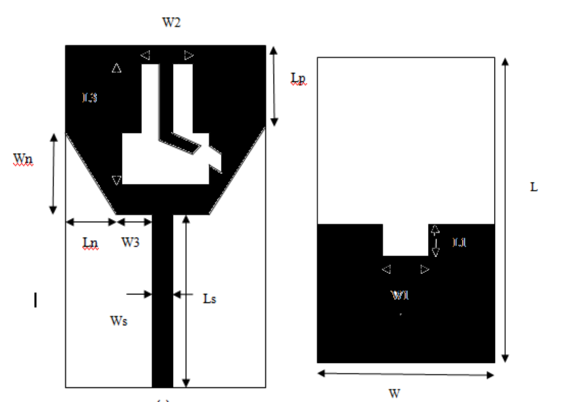
l = Length of the Patch
h = Height of the Substrate
W = Width of the Patch
fr = Resonant Frequency.

Optimal geometrical parameters of the proposed wideband antenna are shown in table 1. Here, width of 1mm was selected for the T-slot.

Table: 1: Optimal Geometrical Parameters Of The Proposed Wideband Antenna

Parameter	L	W	Lg	L1	W1	Ln	n	Ls	Ws
Mm	8	24	11.5	.5	1.5	9.75	8	12	3.5

This is because the slot has been found to be effective way to excite additional resonances and produces a continuous wide bandwidth of about 23.8887 GHz (defined for 10- dB return loss) and covering the range from 2.8163 to 26.7050 GHz. The obtained band sufficiently covers WLAN, Wi-Fi, WiMax and ISM standard applications.



(a) (b)

Fig: 1. Configuration of the proposed compact slotted patch antenna for wideband application: (a) top view; (b) bottom view

4. Simulation Results

Design evolution of the proposed wideband antenna on simulated frequency response of return loss is shown in figure 2. It begins with the design of an antenna with a rectangular patch of 8 (Lp) x 24 (W) mm^2, with respect to the center frequency of the desired Wireless band. When cutting a triangular notch of 9.75 (Ln) x 8 (Wn) mm^2 in size at each of the two lower-side corners and embedded with T-slot to increase the mode excitation as well as extend the whole bandwidth. Obviously, once the T-slot was simultaneously embedded into the notched patch multiple resonances are excited and accordingly provide an wide impedance bandwidth of about 23.8887 GHz (defined for 10-dB return loss), covering the range from 2.8163-26.7050 GHz. The obtained operating band effectively covers the wideband wireless applications.

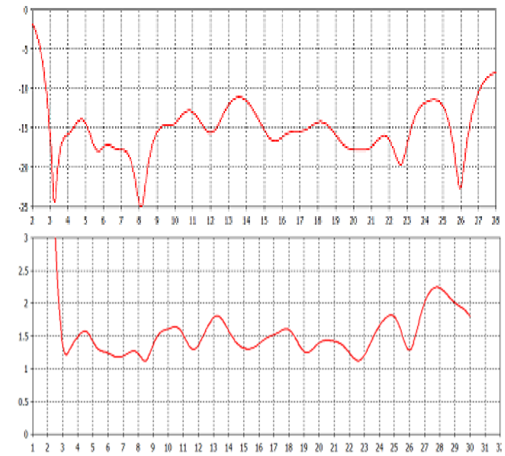


Fig: 2. Simulated Return loss and VSWR against frequency for the proposed wideband patch antenna with T-slot embedment

Farfield 'farfield [f=3.1857] [1]' Directivity_ Abs[Theta]; phi = 90^0 and phi = 0^0

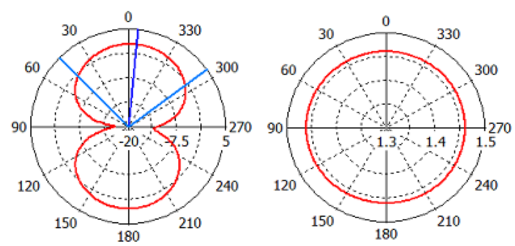


Fig: 3. Simulated far-field radiation pattern for the proposed wideband patch antenna at the operating resonance of 3.1857 GHz with phi=90^0 and phi=0^0

This back-lobe radiation is an added advantage for using this antenna in a cellular phone, since it reduces the amount of electromagnetic radiation which travels towards the users head, it is noticed that the beam-width in both plane is wide enough.

The impedance bandwidth of about 161.84% was obtained from the proposed wideband microstrip patch antenna by using the FDTD simulator tool.

Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for phi = 0^0 (H-plane) and phi = 90^0 (E-plane) degrees would be important. Fig.4 shows the radiation field pattern of the antenna under consideration in the (x-z) plane (phi = 0^0) and the (y-z) plane (phi = 90^0) at the operating resonance of 3.1857 GHz.

It is found that at the operating resonance of maximum radiation is obtained in the broadside direction for both plan.

5. Conclusion

In this paper, a miniaturized microstrip patch antenna is designed for wideband operation has been presented with the fractional bandwidth of 2.8163 to 26.7050 GHz using the FDTD simulator tool. It has been shown that this design of the patch antenna produces a impedance bandwidth of approximately 161.84% with a stable radiation pattern within the frequency range. The proposed antenna design exhibits a good impedance matching of approximately 50ohm at the center frequency. The simple feeding technique used for the design of this antenna make this antenna a good choice in many communication systems. The proposed antenna design has additional advantage of smaller in size and produces the wide radiation pattern. In future, the proposed antenna structure will be fabricated and testing for measuring return loss and radiation pattern by using Network Analyzer and Patch Test Bench.

References

[1] S. Nikolaou, K. Boyon, Y.S. Kim, J. Papapolymerou, M. M. Tentzeris, CPW- fed ultra wideband (UWB) monopoles with band rejection characteristics on ultra thin organic substrate, in Asia-Pacific Microwave Conference (APMC), 2006, 2010-2013.

[2] E. Pancera, D. Modotta, A. Locatelli, F. M. Pigozzo, C. De Angles, Novel Design of UWB Antenna with Band – Notch Capability, in European Conference on Wireless Technologies, 2007, 48-50.

[3] J. -B. Jiang, Z. -H. Yan, C. Wang, A novel compact UWB notch-filter antenna with a dual-y-shaped slot, Progress In Electromagnetic Research Letters, 14, 2010, 165-170

[4] X. L. Bao, M. J. Ammann, Printed Band-Rejection UWB Antenna with H-shaped Slot, in International Workshop on Antenna Technology: Small and Smart Antennas Metamaterials and Applications (IWAT), 2007, 319-322.

[5] Y. F. Weng, S. W. Cheung, T. I. Yuk, Ultra wideband antenna using CPW resonators for dual-band notched characteristic, in International Conference on Wireless Communications & Signal Processing (WCSP), 2009, 1-4

[6] Y. F. Weng, W. J. Lu, S. W. Cheung, T. I. Yuk, UWB antenna with single or dual band-notched characteristic for WLAN band using meandered ground stubs, in Loughborough Antennas & Propagation Conference (LAPC), 2009, 757-760.

[7] S. Barbarino, F. Consoli, UWB circular slot antenna provided with an inverted-L notch filter for the 5 GHz WLAN band, Progress In Electromagnetic Research, 104, 2010, 1-13