A coplanar stripline fed compact UWB antenna

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Abstract

A novel compact coplanar stripline (CPS) fed antenna for ultra-wideband (UWB) application is investigated. The proposed antenna consists of a stair-case shaped radiator along with a shorted strip. The prototype is designed on a substrate of dielectric constant 4.4, with an overall dimension of 25mm x 7mm x 1.6mm. The antenna offers a 2:1 VSWR bandwidth from 3.1-11.4 GHz, with an average gain of 3dBi and average radiation efficiency of 75% throughout the band. Measured group delay and transmission characteristics show that the proposed antenna is a good candidate for UWB communication systems.

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Keywords: UWB; Coplanar stripline fed; Compact.

1. Introduction

UWB technology has been expanding rapidly as a promising technology for many applications such as ground penetrating radars, location tracking, data communication etc., since FCC had specified 3.1 – 10.6 GHz as the frequency band for UWB Radio systems. UWB is conventionally recognized as Impulse Radio (IR), which transmits data in short pulses and is devoted mainly to short range applications due to the limitations of the power spectral density of \(-41.3\) dBm/MHz within the UWB band\textsuperscript{1}. One of the biggest advantages of UWB is its immunity against fading effects. Modern era of communication are in need of small and miniaturized UWB antennas for many applications like Wireless Universal Serial Bus (WUSB), Wireless Body Area Networks (WBAN) etc.. Considerable research efforts towards the design of miniaturized UWB antennas\textsuperscript{2,3,4} have been made. A compact UWB antenna

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which consists of a microstrip fed monopole, printed on a 13mm x 22.5mm substrate, with a truncated ground plane loaded with a dielectric resonator was discussed in a previous paper. By making use of the advantages of coplanar fed antennas, a small coplanar UWB antenna was presented in a paper with a fairly compact dimension of 19mm x 16mm. The compactness of the antenna was achieved by exploiting a quasi-self-complementary structure along with a tapered radiating slot.

In this paper, we propose a compact coplanar stripline fed UWB antenna with a staircase-shaped radiating element along with a shorted strip. It achieved a 40% reduction in the overall area, compared to the one discussed in a paper and a 42% compared to another paper. Simulated and measured studies show that the proposed antenna offers a good reflection and radiation characteristics in the entire UWB band.

![Fig. 1. Geometry of the proposed antenna](image)

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2. Antenna design & geometry

Fig. 1 depicts the geometry of the proposed coplanar stripline fed UWB antenna. It comprises of a staircase-shaped radiator and a shorted strip running through the bottom of the antenna, which is symmetric around the +X-axis. The prototype is fabricated on a 25mm x 7mm x 1.6mm FR4 substrate with a relative permittivity ($\varepsilon_r$) of 4.4 and loss tangent ($\delta$) of 0.02. It is worth mentioning that the proposed UWB antenna meets the requirements of the
antenna for UWB radio systems, in spite of its small size. Hence, the antenna is well suited for various portable devices. The optimized dimensions of the proposed geometry are given in Table 1.

3. Results and discussion

All the measurements of the proposed antenna are monitored using PNA E8362B Network Analyzer and the farfield measurements are done in anechoic chamber. The photograph of the fabricated prototype is given in Fig. 2. A comparison of the measured and simulated reflection characteristics of the proposed antenna is depicted in Fig. 3. There is a good agreement between both the results. The slight discrepancies are due to the fabrication tolerance. From the figure, it is observed that the proposed antenna achieves a 2:1 VSWR bandwidth from 3.1-11.4 GHz, which makes the antenna suitable for UWB communication systems. The staircase-shaped radiator and the strip, running through the bottom of the antenna which is shorted to the staircase-shaped radiator, are responsible for the realization of UWB frequency band. The wide bandwidth is obtained by the combination of multiple resonances, predominantly due to the three resonances at 4.5, 8 and 10.5 GHz.

Fig. 2. Photograph of the fabricated UWB antenna.

Fig. 3. Simulated and measured reflection characteristics of proposed antenna.

Fig. 4 shows the measured radiation patterns at y-z plane (E-plane) and x-z plane (H-plane), respectively for three frequencies (4.5, 8, 10 GHz). The antenna provides omnidirectional coverage in the H-plane and bi-directional
coverage in the E-plane, with relatively stable radiation patterns in the UWB operating band. However, at the higher frequencies, from about 10 GHz onwards, the radiation patterns are less omnidirectional because of the higher-order resonant modes.

Fig. 4. Measured radiation pattern (a) E-Plane; (b) H-Plane.

Fig. 5. Measured gain and radiation efficiency.

A plot of the measured gain is depicted in Fig. 5. An average gain of 3dBi, with a peak gain of 3.5dBi at 10.5 GHz, within the 3.1-10.6 GHz UWB band is obtained for the proposed antenna. The radiation efficiency of the
antenna is measured using the Wheeler Cap method by Schantz\textsuperscript{7}. The antenna offers an average radiation efficiency of 75\% with a peak efficiency of 94\% at 3.5 GHz. Group delay and transmission characteristics were measured by using two identical prototypes of the antenna, kept at a distance of 15 cm. This measurement is important to have knowledge about the phase linearity of the transmitted signals. As observed from Fig. 6, the group delay remains constant throughout the UWB operating band with variation less than 1 ns, for both face-to-face and side-to-side orientations tested. Moreover, fairly good transmission characteristics were obtained within the band, as shown in Fig. 6. These indicate that the proposed antenna has a better pulse handling capability, which makes it a good candidate for UWB radio systems.

![Antenna Diagram](image)

**Fig. 6.** Measured group delay and transmission characteristics.

4. Conclusion

The design of a novel compact CPS fed antenna is proposed for UWB application. In spite of its small size, the antenna achieved a wide 2:1 VSWR bandwidth covering the entire UWB operating band, with an average gain of 3 dBi and average radiation efficiency of 75\%. The measured group delay and transmission characteristics of the proposed antenna projected its superior pulse handling capabilities and hence made it a good prospect for the modern UWB radio systems.

Acknowledgements

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References