Coplanar Printed-Circuit Antenna With Band-Rejection Elements For Ultra-Wideband Filtenna Applications

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Introduction

Filtennas consist of wideband antenna structures, which incorporate narrowband filter elements for band selection or interference reduction [1]. Especially with respect to ultra-wideband (UWB) technology in the 3.1 - 10.6 GHz range, it is essential that certain narrowband services be appropriately suppressed [2]. Recent activity focused on reducing the effect of IEEE 802.11a wireless local area network (WLAN) systems on UWB operation in the frequency range from 5.15 GHz to 5.85 GHz. Therefore, a number of so-called bandstop antennas (filtennas) in printed-circuit technology have been proposed, e.g. [3-7]. Since band-rejection elements are simple structures and easily integrated with printed-circuit technology, the entire filtenna concept offers low-cost fabrication and mass production. Moreover, the notched frequency range can be adjusted by changing the parameters of the band-rejection elements.

This paper presents three coplanar filtenna designs, which incorporate, first, a coplanar filter in the feed line, secondly, a u-shaped and, thirdly, an n-shaped slot in the center-conductor part of the coplanar UWB antenna.

Designs and Results

A recently introduced coplanar UWB antenna concept [8] is used as the base model for the filtenna applications. To verify the computational approach of the investigation, the antenna in [8] was simulated by three different EM-based software packages: CST Microwave Studio, Ansoft HFSS and MEFiSTo-3D. Very good agreement was achieved (not shown here for lack of space) and, therefore, the following results are based on CST computations only. The three different filtenna structures use FR4 substrates with 1.575mm thickness and a substrate area of W=30mm and L=40mm (c.f. Fig. 1a). All simulations include a 50Ω coaxial connector, which also serves to connect the two ground planes of the coplanar feed line.

Fig. 1 demonstrates the first filtenna concept in which a coplanar filter similar to that presented in [9] is incorporated into the feed line. Basic design guidelines in [9] are followed for the filter design whose stand-alone performance is shown in Fig. 2a. The two $|S_{11}|$ minima are due to the close proximity of the filter elements in Fig. 1b. The VSWR performance of the entire filtenna is shown in Fig. 2b and is compared with that of the original UWB antenna design (without the stopband

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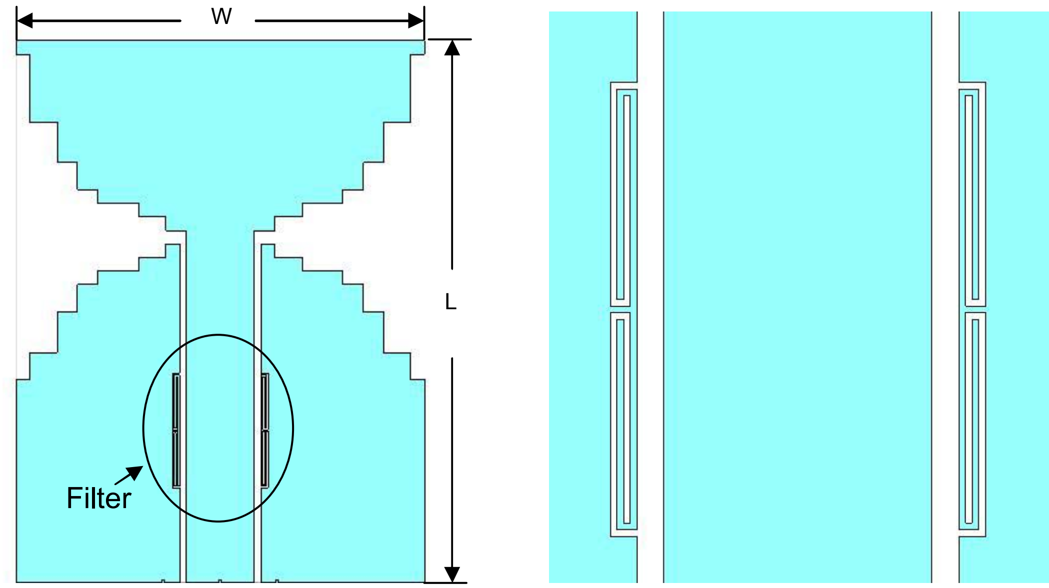
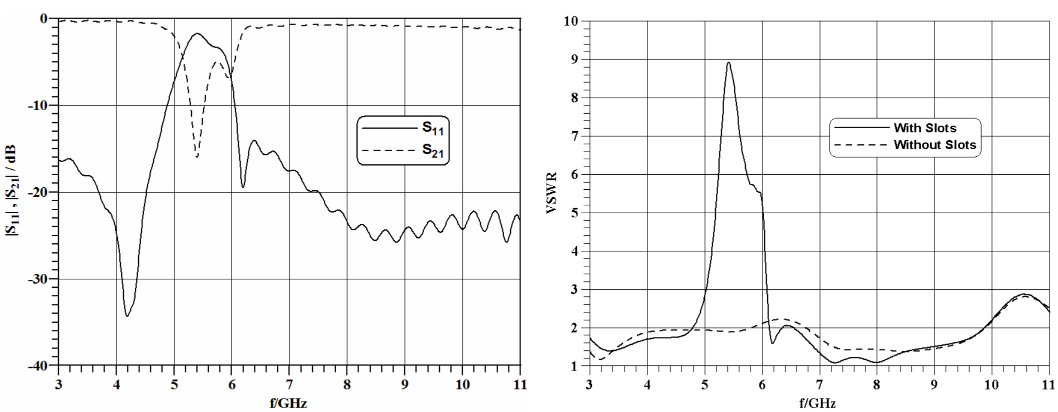
filter). The notched frequency band is from 4.8 GHz to 6.122 GHz, which covers the frequency range taken by WLAN. The maximum VSWR is 9 corresponding to $|S_{11}|$=-1.9 dB. Note that the VSWR exceeds a value of 2 above 9.9 GHz. This is attributed to the wide center-conductor feed line, which is used to separate the two filter parts.



(a) (b)

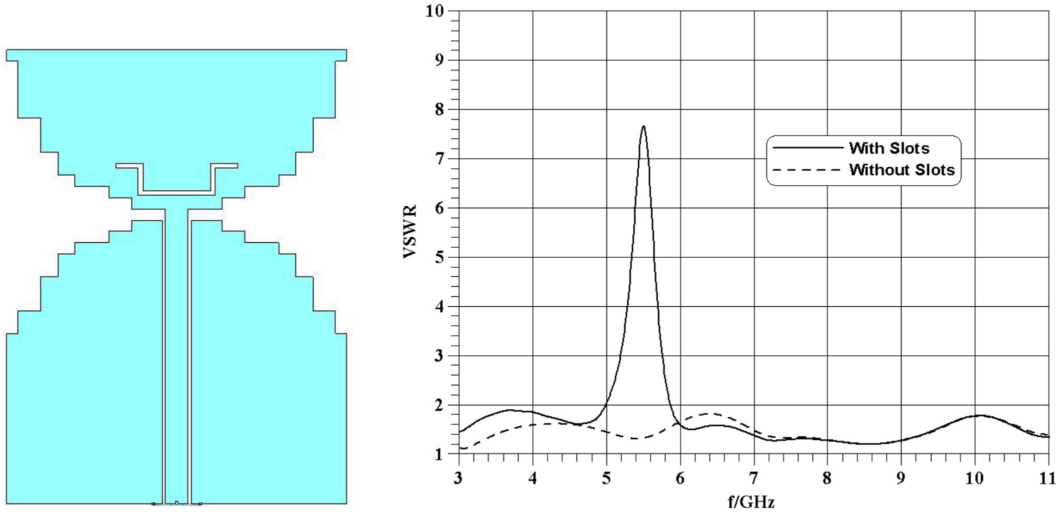
Fig. 1 Geometry of the first filtenna (a), and filter element (b).



(a) (b)

Fig. 2 Performance (a) of the bandstop filter in Fig. 1a (S_{11} - solid line, S_{21} - dashed line), and VSWR of the first filtenna (b).

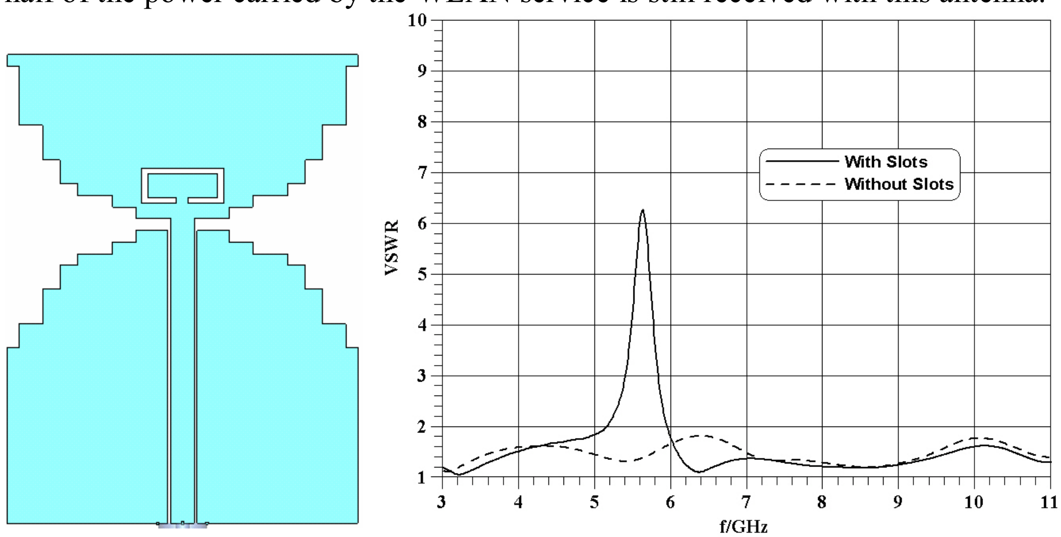
In our second filtenna design, the notched frequency range is adjusted by changing the length of a u-shaped slot [7] as shown in Fig. 3a. The total length of the slot is approximately λ/2 at midband frequency and creates a notched range between 4.99 GHz and 5.87 GHz, where the VSWR is significantly larger than 2 (c.f. Fig. 3b). The maximum VSWR is 7.6 corresponding to $|S_{11}|$=-2.3 dB. Note that due to the reduced width of the center feed line, the VSWR of the antenna without slot, as well as that of the slotted antenna in the respective frequency ranges, is now below 2.



(a) (b)

Fig. 3 Geometry (a) and VSWR of the filtenna with u-shaped slot (b).

Fig. 4 depicts the geometry and VSWR performance of a filtenna with an n-shaped slot. The slot length is again adjusted to be approximately $\lambda/2$ at midband notch frequency. The respective frequency range is from 5.15 GHz to 5.95 GHz and covers the WLAN frequency range. Compared to the UWB antenna without notch, the filtenna performs very well outside of the notched band. However, the peak VSWR is only 6.25 or $|S_{11}|$=-2.8 dB. That means that approximately one half of the power carried by the WLAN service is still received with this antenna.



(a) (b)

Fig. 4 Geometry (a) and VSWR of the filtenna with n-shaped slot (b).

Conclusion

In this paper, a coplanar printed-circuit UWB antenna with three different band-rejection elements for filtenna applications is proposed. The notched frequency bands of the proposed filtennas cover the WLAN frequency range for interference reduction between UWB and WLAN systems. The notched frequency bands of u-shaped and n-shaped slots can be easily adjusted by changing the total length of the slot. However, better stopband performance is achieved by using a bandstop filter in the coplanar feed line of the UWB antenna.

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