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Band-Notched Ultra-Wideband Antenna with Asymmetric Coupled-Line for WLAN and X-Band Military Satellite

Jun-Hyuk Lee · Young-Je Sung

Abstract

This paper presents a novel ultra-wideband (UWB) antenna that rejects narrow and broad bands and is suitable for wireless communications. The base of the proposed antenna has a circular patch that can cover the UWB frequency range (3.1～10.6 GHz). The interference issues caused by co-existence within the UWB operation frequency are overcome by a design that uses a parallel-coupled asymmetric dual-line with a circular monopole antenna. The proposed antenna showed a stable radiation pattern, realized gain and reflection coefficient lower than －10 dB across the UWB operation bandwidth except for 5.15～5.85 GHz and 7.25～8.4 GHz. The fabrication, simulation, and measurement results obtained for the proposed antenna were in good agreement with the expected values.

Key words: Parallel Coupled Line, Notch-Bands, Patch Antenna, Ultra-Wideband (UWB).

Ⅰ. Introduction

The allocation by the Federal Communication Commission (FCC) of the unlicensed band at frequencies between 3.1～10.6 GHz [1] for commercial purposes has resulted in rapid development of ultra-wideband (UWB) wireless communication systems. This frequency band is now in great demand in microwave components such as indoor and hand-held wireless devices, owing to its merits, particularly its good impedance matching, large bandwidth, low signal distortion and high speed of more than 100 Mbps within the operation frequency bands [2]. However, a problem arises that affects and interrupted UWB operation. For example, UWB systems will experience interference from the wireless communication bands of Wireless Local Area Network (WLAN) (5.15～5.35 GHz & 5.725～5.825 GHz) and X-band military satellite (7.25～7.75 GHz & 7.9～8.4 GHz). Therefore, the bands used fort WLAN and X-bands military satellite must be rejected. UWB researchers have attempted to suppress this interference by studying and investigating various band stop methods that reject the typical WLAN band or large part of it [3]～[6]. One of the methods used to suppress some interference frequencies adapt a parallel coupled line and this can demonstrate notch characteristics [7], [8].

This paper describes a UWB monopole antenna with band-stop characteristics that uses a parallel-coupled dual-line. The asymmetric dual-line is suggested. The proposed antenna can suppress interference from strong narrow and broad by controlling the asymmetric dual-line. However, this solution can only reject planned interference bands. The operation characteristics in UWB, which eliminates influences related to WLAN and X-band military satellite, are advanced by determining and optimizing the proposed antenna by a parasitic line in a parallel-coupled line. Additionally, to achieve the good impedance matching, the bottom GND of the proposed antenna is modified by cutting rectangular slot on the center edge and symmetrical rectangular slots on the right and left edge [9]. These adaptations allowed the optimal design, fabrication, and measurement of a UWB notch antenna with an asymmetric dual-line.

Ⅱ. Antenna Geometry

The configuration of the UWB printed antenna for band-notch characteristics is proposed in Fig. 1(a) and (b). The proposed antenna consists of a circular patch radiator and a parallel-coupled asymmetric dual-line on a Taconic substrate with a size of 53 mm×40 mm, thickness of 1.14 mm, and relative permittivity 2.2. The

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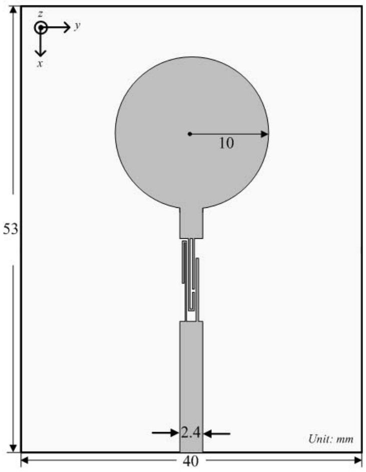
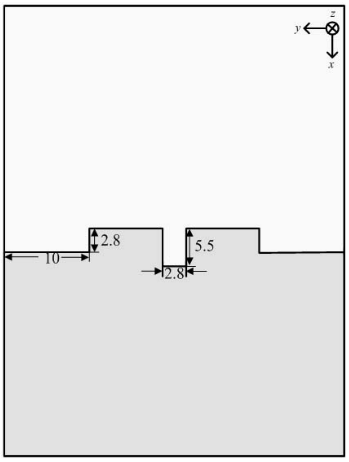
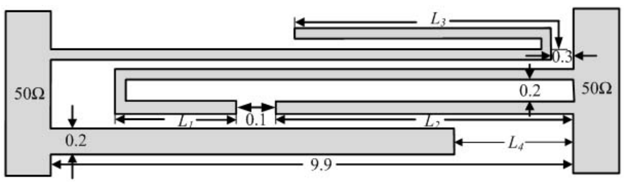
Dept. of Electronic Engineering, Kyonggi University, Suwon, Korea.
Corresponding Author : Young-Je Sung (e-mail : yjsung@kgu.ac.kr)



(a)



(b)



(c)

Fig. 1. (a) Top layer, (b) bottom layer, (c) topogoly of the proposed asymmetric notch design.

adopted circular patch is operated as a radiating function and the microstrip feed line is fixed at 2.4 mm to activate 50-Ω characteristic impedance at 3.1~10.6 GHz. The detailed parallel-coupled asymmetric dual-line of the proposed antenna is shown in Fig. 1(c). Based on these points, the parameters are as follows: the parameters follow as: L_1=2.2 mm, L_2=6.3 mm, L_3=5 mm, L_4=2.3 mm. The gap between the strips in the parallel-coupled strips in parallel-coupled line is 0.1 mm except for the 0.2 mm previously mentioned. This interdigital coupled-line structure generates a higher current density and phase transit so that it can activate a notched band under the operation

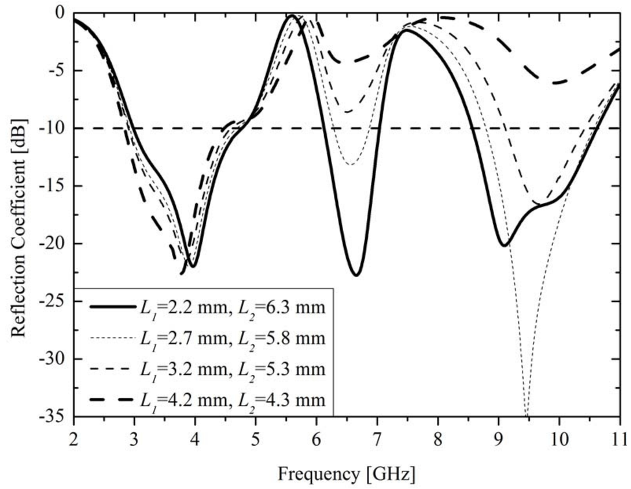
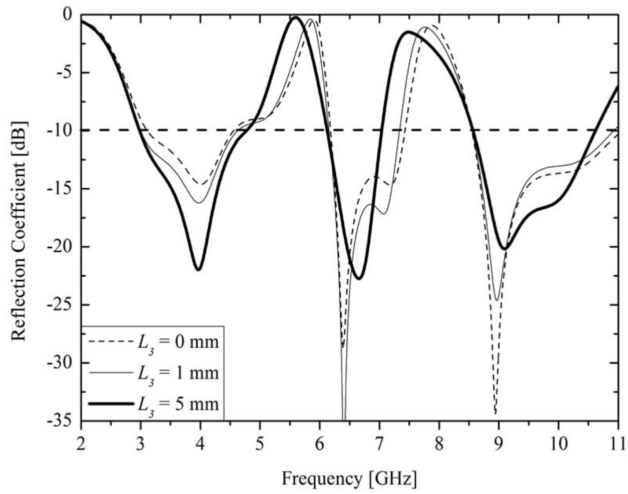
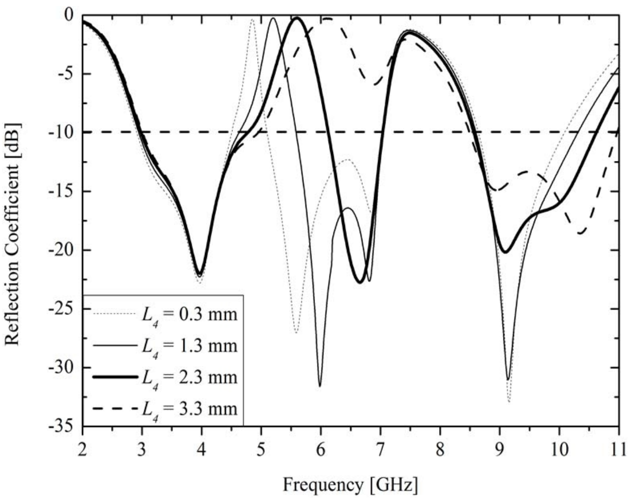


Fig. 2. Comparisons of simulated reflection coefficient for various lengths L_1 and L_2 in asymmetric coupled-line.



(a) L_3



(b) L_4

Fig. 3. Comparisons of simulated reflection coefficients for various lengths

passband [10]. The reason for forming a cut-off frequency is so that the parallel coupled-line structure can achieve high tight coupling [11]. The band-notch bandwidths can be controlled by parameter analysis with the length L_1 and L_2 in a parallel-coupled dual-line. When the values of L_1 and L_2 differ, this can be used as a cut-off characteristic for the two different frequency bands. In contrast, when the values of L_1 and L_2 is are identical, the band-notched effect occurs at one frequency band. As shown in Fig. 2, the asymmetric dual-line is also available to reject the two band-notches by controlling L_1 and L_2. The proposed antenna also takes into consideration that parasitic line L_3 and L_4 are suitable for shifting to suppress the specified frequency WLAN and X-band military satellite bands independently. The simulated frequency responses of the parametric analysis with L_3 and L_4 are depicted in Fig. 3(a) and (b). Consequently, the higher band (X-band military satellite band) shifts to low when L_3 is increased. Conversely, the lower band (WLAN) moves to high when L_4 is increased.

Ⅲ. Simulated and Measured Results

The proposed UWB antenna is simulated using electro-magnetic simulation tools HFSS and measured using Wiltron 3605B network analyzer at the frequency from 2 GHz to 11 GHz. By adopting the methods of a different length for L_1 and L_2 and tuning the parasitic length L_3 and L_4, the WLAN and X-band military satellite bands are bypassed. Fig. 4 shows the simulated and measured reflection coefficient (dB) with and without the asymmetric dual-line ($S_{11}<-10$ dB). The result is somewhat different between the simulated and measured value, which shifts to and upper frequency about 20 MHz. These results satisfy the planned bandwidth with only a slight error in measurement. The simulated and measured radiation patterns are shown as E-plane and H-

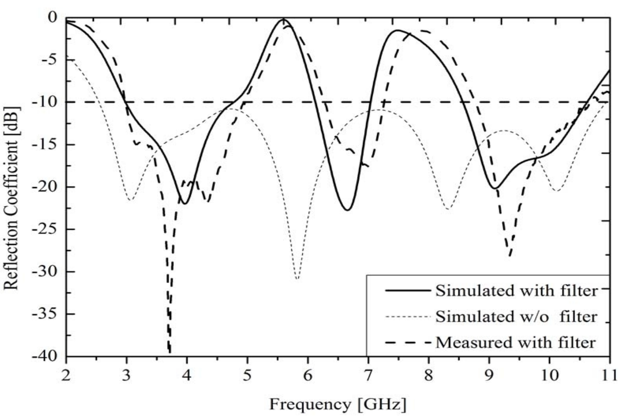
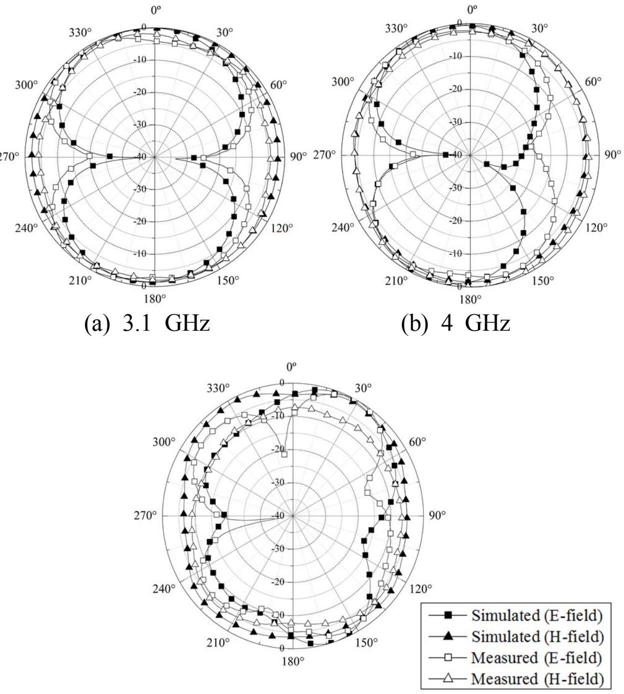


Fig. 4. Simulated and measured reflection coefficient (dB) with and without a notch coupled-line.



(a) 3.1 GHz (b) 4 GHz

(c) 9 GHz

Fig. 5. Simulated and measured 2D radiation patterns of proposed antenna.

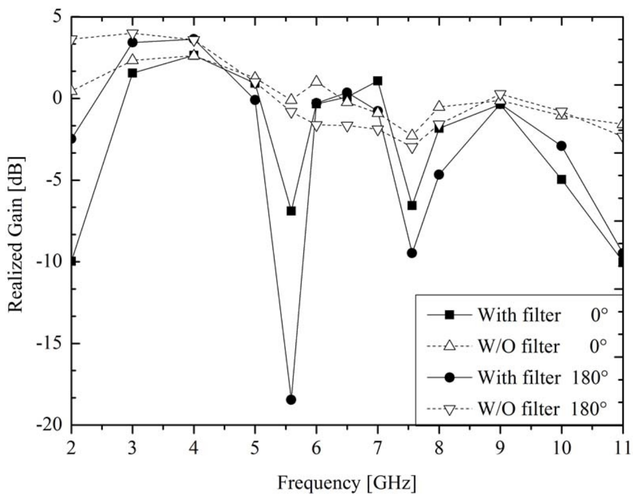


Fig. 6. Realized gain (dB) of the proposed antenna.

plane in Fig. 5(b) and (c). The proposed fabrication has dipole-like stable and omnidirectional radiation patterns across all the operation bands. Finally, the realized gain is shown for the simulated result at two angles 0° and 180° in Fig. 6. Consequently, a rapid decrease occurs at notch frequencies when the band-notched dual-line is added at 0° and 180°.

Ⅳ. Conclusion

This work proposes a shorted monopole antenna with a coupled UWB antenna with asymmetric dual-line for notch characteristics has been proposed. We adapted an asymmetric dual-line and confirmed the rejection of narrow and broad bands (5.15～5.85 GHz & 7.25～8.4 GHz). The band-notch frequencies are tuned by adjusting reasonable values through parameter analysis. The results obtained using the proposed antenna have been promising, and hence, this antenna appears to be suitable for use in UWB communication systems.

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Jun-Hyuk Lee

was born in Seoul, Korea, in 1986. He received the B.S. in 2012. Since 2011, he has studied and researched RF subject at Microwave Lab., Kyonggi University, Suwon, Korea. His research interests include reconfigurable antennas, cellphone antennas, wideband and compact UWB antenna.

Young-Je Sung

was born in Incheon, Korea, in 1975. He received the B.S., M.S., and Ph.D. degrees from Korea University, Seoul, Korea, in 2001, 2002, and 2005, respectively. From 2005 to 2008, he was a Senior Engineer with the Antenna R&D Laboratory, Samsung Electronics, Korea. In 2008, he joined the Department of Electronic Engineering, Kyonggi University, Suwon, Korea, where he is currently an Associate Professor. His research interests include reconfigurable antennas, cellphone antennas, wideband slot antennas, multifunction devices, compact circular polarized antennas, and compact dual-mode filters. Prof. Sung is serving as a reviewer for the IEEE Transactions on Microwave Theory and Techniques, IEEE Microwave and Wireless Components Letters, IEEE Antennas And Wireless Propagation Letters, Progress in Electromagnetic Research, IET Electronics Letters, IET Microwaves, Antennas and Propagation, and the ETRI Journal of the Electronics and Telecommunications Research Institute, Korea.