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UWB MIMO Antenna with Band-Notched Characteristic

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***Abstract*—** A multiple-input-multiple-output (MIMO) band-notched antenna with a compact size of only 22 × 36 mm^2 is proposed for ultra wideband (UWB) applications. The antenna consists of two square monopole-antenna elements, a T-shaped ground stub, a vertical slot cut on the T-shaped ground stub to reduce mutual coupling, and two strips on the ground plane and to create a notched frequency band. Simulation are used to study the antenna performance in terms of impedance matching, isolation between the two input ports, radiation pattern and peak gain. Results show that the antenna can operate from 3.1 to more than 11 GHz with a notched band in 5.15–5.85 GHz. The mutual coupling is less than −15 dB. Results show that the proposed MIMO antenna is a good candidate for portable UWB applications.

Keywords- *Band notch, multiple-input-multiple-output (MIMO), small antenna, ultra wideband (UWB).*

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I. INTRODUCTION

Multiple-input-multiple-output (MIMO) technology, with the potential of increasing channel capacity with-out requiring additional frequency spectrum or power, has been drawing much attention. An MIMO communication sys-tem requires using multiple antennas installed in the transmitter and/or receiver with low coupling between them. However, for portable devices where the space is very limited, installing MIMO antennas with low coupling is always a great challenge for antenna designers. Various MIMO antennas have been studied for uses in portable devices in different wireless systems such as the WLAN. In studies showed that MIMO technology used in ultra wideband (UWB) system would provide superior channel capacity over that used in narrowband systems. Following this, studies were carried out to reduce coupling between antenna elements in MIMO UWB antennas.

The UWB from 3.1 to 10.6 GHz, assigned by the FCC for unlicensed use, overlaps with the WLAN frequency band from 5.15 to 5.85 GHz; thus, the UWB system and WLAN systems could interfere with each other. One of the possible solutions to this problem is to design the UWB antenna with band-notched characteristic. MIMO antennas with notched characteristics were studied to suppress interference from the WLAN systems. The UWB MIMO antenna was designed on a flexible film. Two heptagonal monopole elements were orthogonally and symmetrically placed on the substrate for good isolation between the two input ports. A slot was cut on each of the antenna elements to create a notch in the WLAN band. However, the two monopole elements did not have a common ground plane, making the MIMO antenna difficult to use in practice. The MIMO antenna employed two-folded monopole elements, each coupled with a parasitic inverted-L element, to achieve UWB operation. Two meander lines, a connection line and a short parasitic line, were used to enhance isolation between the two input ports. The band-notched characteristic was created using an open stub on the radiator. The antenna structure was a little complicated and required high fabrication accuracy. Slot antennas were designed for UWB MIMO applications with a strip to ensure high isolation. The slots were etched on the feeding structure to create a band notch. However, this kind of structure had a relatively large size.

A dual band notch was designed for an UWB MIMO antenna using parasitic strips and slots on the radiator. To the best of the authors' knowledge, it is the smallest one among all the UWB MIMO antennas with and without notches found in literature. The antenna had a compact size of 27 × 30 mm^2 .

In this paper, we propose an UWB MIMO band-notched antenna even smaller than the design of previous papers . It has a compact size of only 22 × 36 mm^2 . A strip on the ground plane is used to create the band notch. The simulated results show that the proposed MIMO antenna has good impedance matching and high isolation performance throughout the UWB with a band-notched characteristic in 5.15–5.85GHz.

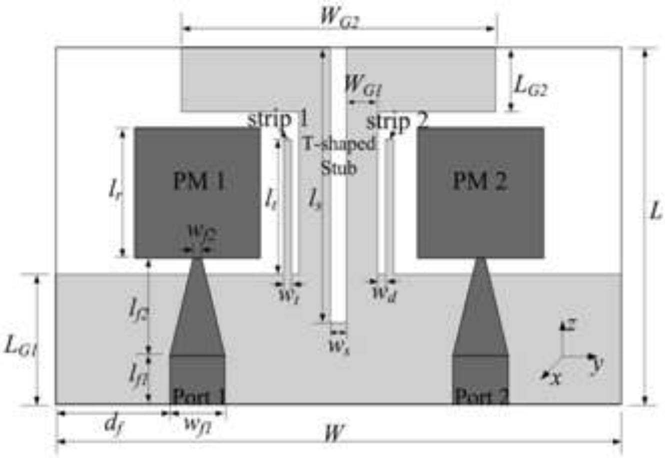

Fig. 1 Design of proposed antenna

II. ANTENNA DESIGN

The design of the proposed MIMO antenna, as shown in Fig. 1, has two planar monopole elements, denoted as PM 1

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and PM 2, with a very compact area of only 22 × 36 mm^2. The radiator of an UWB monopole antenna could be of many shapes such as rectangular, elliptical, and circular-ring shaped. In general, do not give significant differences in performance. However, the size of the radiator must be large enough to allow a long current path to generate a low resonance for achieving a low-cut off frequency of lower than 3.1 GHz for the UWB. Thus, size has been one of the major challenges in the design of UWB antennas. Designing the ultra-wide bandwidth for an UWB antenna is not such a problem and can be achieved through matching using etching a ground slot under the feed line, adjusting the gap between the ground and the radiator, and the feed line, as used in our MIMO antenna. In our MIMO antenna shown in Fig. 1, for simplicity, we use square-shaped radiators for the planar monopole elements.

TABLE I. DIMENSIONS OF PROPOSED ANTENNA (UNIT :mm)

w	W_{G1}	W_{G2}	W_{F1}	W_{F2}	W_S	W_t	W_d	d_f
36	2	20	3.5	0.5	1	0.5	0.5	5
L	L_{G1}	L_{G2}	L_{F1}	L_{F2}	L_S	L_t	L_r	
22	8	4	3	6	17	8.3	8	

In Fig. 1, the T-shaped ground stub protruding vertically between the monopole elements is used to improve matching of the antenna. A long ground slot is cut vertically on the T-shaped ground for better isolation between the two input ports. To create a notch in the 5.5–GHz band to suppress interference in the WLAN band, two strips, denoted as strips 1 and 2, are added between the monopole elements and the T-shaped ground stub. They form two open-end slots, which serve as $\lambda/3$-resonators at the notch frequency. The antenna has a symmetrical structure, so the two input ports have identical impedance. This makes
the design procedure significantly easier because the antenna can be designed with either port excited. The MIMO antenna is designed using the EM simulation tool HFSS on a Rogers R4350B substrate with a dielectric constant ε_r of 3.5, a loss tangent of 0.004, and a thickness of 1.6 mm. The dimensions for the final design are listed in Table I.

III. STUDY OF MIMO ANTENNA

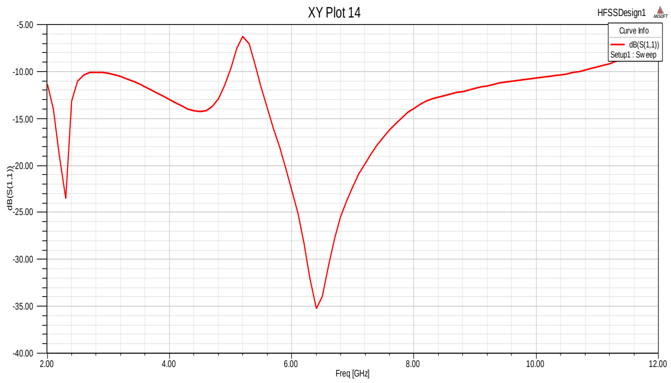
Here, the effects of the T-shaped ground stub, ground slot, and strips are studied.

A. Effects of T-Shaped Ground Stub

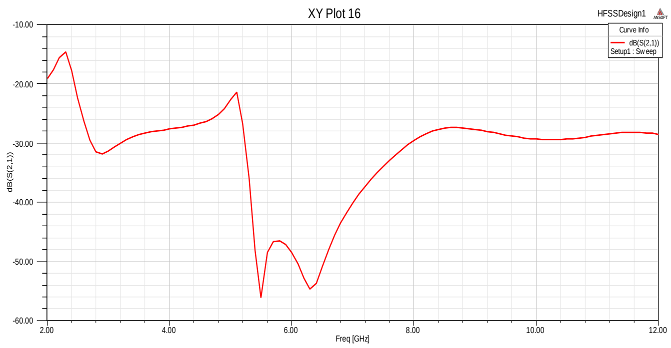
The T-shaped ground stub in the MIMO antenna shown in Fig. 1 has two main functions: providing better matching for the antenna and enhancing isolation by reflecting radiation from the radiators. A T-shape is used because the size of the antenna can remain compact and the T-shaped ground stub can also serve as reflector. Simulation on the S parameters of the MIMO antenna with and without the T-shaped stub. It can be seen that without using the T-shaped stub, the antenna has a low-cut off frequency (for S11 < −10 dB) of about 4 GHz (which is higher than 3.1 GHz required for the UWB). Mutual coupling (indicated as S21) between the two input ports is almost above −15 dB. However, with the T-shaped stub used, a resonance is generated at about 5 GHz, which lowers down the low-cut off frequency to about 2.8 GHz. Mutual coupling S21 is also significantly suppressed at high frequencies.

B. Effect of Ground Slot

In Fig. 1, the ground slot cut on the T-shaped ground stub plays an important role in enhancing isolation. Note that due to the symmetrical structure of the antenna, S22 and S12 are same as S11 and S21, respectively, so we only show S11 and S21 in Fig. 2 It can be seen that the simulated impedance bandwidths (for S11 < −10 dB) of the antenna with and without the ground slot do not vary much and are from 2.8 GHz to more than 11 GHz. However, without using the ground slot, the mutual coupling between the two input ports of the antenna is larger than −15 dB (i.e., S21 > −15 dB) in the frequency below 5 GHz, which is not low enough for good performance. With the use of the ground slot, a resonance at about 2.6 GHz is generated, lowering S21 down to below −15 dB.



(a)



(b)

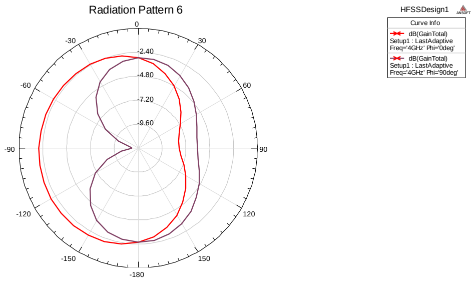
Fig. 2 Simulated S parameters of antenna (a) S_{11}
(b) S21

C. Effect of strips

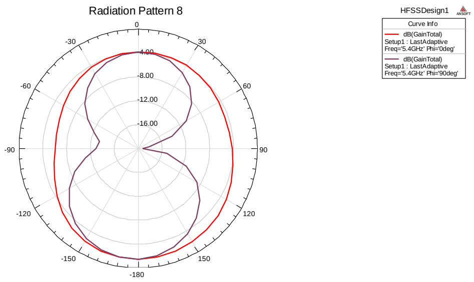
The simulated S parameters with and without using the strip. Without using the strips, the MIMO antenna has good impedance matching (i.e., S11 < −10 dB) and low mutual coupling (i.e., S21 < −15 dB) throughout the UWB from 3.1 to 10.6 GHz. As mentioned before, the two thin strips, strips 1 and 2, as shown in Fig. 1, are used to provide a band-notched characteristic for the antenna. In study, l_t = 8.3 and w_t = 0.5 mm are used to set the notched band in the 5.15– 5.85 GHz to suppress interference for the WLAN band.

IV. RESULTS AND DISCUSSION

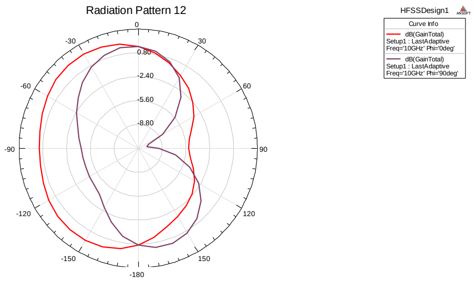
The simulated and measured S11 and S21 are shown in Fig. 2 for comparison. Fig. 2 (a) shows that the antenna has a simulated impedance bandwidth (for S11 < −10 dB) from 2.6 GHz to more than 11 GHz with mutual coupling (in terms of S21) below −15 dB from 3.1 GHz to more than 11 GHz. This indicates that the antenna is suit-able for MIMO operation throughout the FCC UWB. A notched band from 5.15 to 5.85 GHz is created to suppress interference in the WLAN band.



(a) At 4 GHz



(b) At 5.4 GHz



(C) At 10 GHz

Fig. 3 2D Radiation Pattern

The simulated 2-D radiation patterns at 4, 5.4 and 10 GHz have good agreements as indicated in Fig. 3. That the patterns are slightly directional at about θ= 0 - 90^0. Red colour indicates the Electric field. That means transmitting of information. Remaining colour indicates no Electric field.

B. Radiation Performance

2D Radiation pattern

The radiation patterns of the realized gain for the MIMO antenna have been simulated the simulated 3-D radiation patterns with the same colour scale at the low frequency of 4 GHz, the notch frequency of 5.4 GHz, and the high frequency of 10 GHz are shown in Fig. 3. The simulated and measured 2-D radiation patterns at 4, 5.4, and 10 GHz have good agreements as indicated in Fig. 3. In the rest of UWB, the peak gain ranges from 1 to 5 dB.

3D Radiation Pattern

Fig. 4 3D Radiation Pattern

3D Radiation pattern shows the gain of the designed antenna. Red colour indicates the gain. This antenna gain shows the two in db's. The above figures shows the radiation patterns of 2D & 3D.

VSWR result

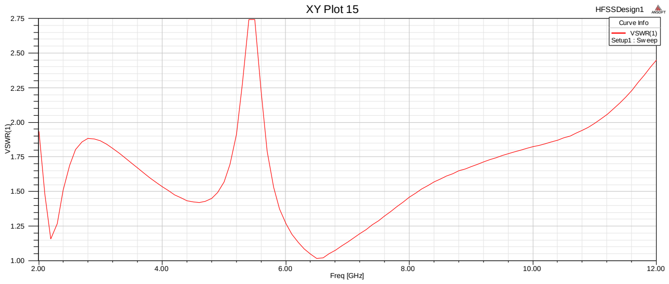


Fig. 5 VSWR result

From the above figure VSWR is less than two (<2). This value indicates antenna performance is good. But certain frequencies VSWR is >2, at that frequencies antenna is not working because that frequency belongs to other technology. These are all antenna parameters.

VI. CONCLUSION

MIMO antenna with a very compact size of 22 *36 mm^2 has been designed for portable UWB applications. Two square monopole elements are used to provide UWB operation from 3.1 to 10.6 GHz. A T-shaped ground stub with a slot is used between the monopole elements to reduce mutual coupling to below −15 dB. Two ground strips are used to create a deep band notch from 5.15 to 5.85 GHz to suppress interference in the WLAN band. Results indicate that the MIMO antenna is suitable for portable UWB MIMO applications.

REFERENCES

[1] L. Zheng and N. C. Tse, "Diversity and multiplexing: A fundamental trade off in multiple-antenna channels," *IEEE Trans. Inf. Theory*, vol. 49, no. 5, pp. 1073–1096, May 2003.

[2] Y. Cheon, J. Lee, and J. Lee, "Quad-band monopole antenna including LTE 700 MHz with magneto-dielectric material," *IEEE Antennas Wireless Propag. Lett.*, vol. 11, pp. 137–140, Jan. 2012.

[3] Z. Li, Z. Du, M. Takahashi, K. Saito, and K. Ito, " Reducing mutual coupling of MIMO antennas with Parasitic elements for mobile ter-minals," *IEEE Trans. Antennas Propag.*, vol. 60, no. 2, pp. 473–481, Feb. 2012.

ISSN: 2321-8169
244 – 247

[4] S. W. Su, C. T. Lee, and F. S. Chang, "Printed MIMO-antenna system using neutralization-line technique for wireless USB-dongle applications," *IEEE Trans. Antennas Propag.*, vol. 60, no. 2, pp. 456–463, Feb. 2012.
[5] V. P. Tran and A. Sibille, " Spatial multiplexing in UWB MIMO communications," *Electron. Lett.*, vol. 42, no. 16, pp. 931–932, Aug. 3, 2006.
[6] S. Zhang, Z. Ying, J. Xiong, and S. He, "Ultra wideband MIMO/diversity antennas with a tree-like structure to enhance wideband isolation," *IEEE Antennas Wireless Propag. Lett.*, vol. 8, pp. 1279–1282, Nov. 2009.
[7] M. Gallo *et al.*, "A broadband pattern diversity annular slot antenna," *IEEE Trans. Antennas Propag.*, vol. 60, no. 3, pp. 1596–1600, Mar. 2012.
[8] L. Liu, S. W. Cheung, and T. I. Yuk, "Compact MIMO antenna for portable devices in UWB applications," *IEEE Trans. Antennas Propag.*, vol. 61, no. 8, pp. 4257–4264, Aug. 2013.
[9] Y. F. Weng, S. W. Cheung, and T. I. Yuk, " Compact UWB antennas with single band-notched characteristic using simple ground stubs," *Microw. Opt. Technol. Lett.*, vol. 53, no. 3, pp. 523–529, Jan. 2011.
[10] L. Liu, S. W. Cheung, and T. I. Yuk, "Deep band-notched UWB planar monopole antenna using meander lines," *Microw. Opt. Technol. Lett.*, vol. 55, no. 5, pp. 1085–1091, May 2013.
[11] Y. F. Weng, S. W. Cheung, T. I. Yuk, and L. Liu "Creating band-notched characteristics for compact UWB monopole antennas," in *Ultra Wideband-Current Status and Future Trends*, M. Matin, Ed. Rijecka, Croatia: Intech, Oct. 2012, ISBN 978-953-51-0781-1.
[12] H. K. Yoon, Y. J. Yoon, H. Kim, and C. H. Lee, " Flexible ultra-wideband polarization diversity antenna with band-notch function," *IET Microw. Antennas Propag.*, vol. 5, no. 12, pp. 1463–1470, Sep. 2011.
[13] J. M. Lee, K. B. Kim, H. K. Ryu, and J. M. Woo, "A compact ultra wideband MIMO antenna with WLAN band-rejected operation for mobile devices," *IEEE Antennas Wireless Propag. Lett.*, vol. 11, pp. 990–993, Aug. 2012.
[14] J. F. Li, Q. X. Chu, Z. H. Li, and X. X. Xia, "Compact dual band-notched UWB MIMO antenna with high isolation," *IEEE Trans. Antennas Propag.*, vol. 61, no. 9, pp. 4759–4766, Sep. 2013.
[15] P. Gao *et al.*, "Compact printed UWB diversity slot antenna with 5.5-GHz band-notched characteristics," *IEEE Antennas Wireless Propag. Lett.*, vol. 13, pp. 376–379, Feb. 2014.
[16] B. P. Chacko, G. Augustin, and T. A. Denidni, " Uniplanar polarization diversity antenna for wideband systems," *IET Microw. Antennas Propag.*, vol. 7, no. 10, pp. 851–857, Jul. 2013.
[17] L. Liu, S. W. Cheung, and T. I. Yuk, "Bandwidth improvements using ground slots for compact UWB micro strip-fed antennas," in *Proc. Prog. Electromagn. Res. Symp. (PIERS)*, Suzhou, China, Sep. 2011, pp. 1420– 1423.
[18] L. Liu, S. W. Cheung, R. Azim, and M. T. Islam, "A compact circular-ring antenna for ultra-wideband applications," *Microw. Opt. Technol. Lett.*, vol. 53, pp. 2283–2288, Oct. 2011.
[19] K. G. Thomas and M. Sreenivasan, " A simple ultra wideband planar rectangular printed antenna with band dispensation," *IEEE Trans. Antennas Propag.*, vol. 58, no. 1, pp. 27–34, Jan. 2010.
[20] L. Liu, S. W. Cheung, Y. F. Weng, and T. I. Yuk, " Cable effects on measuring small planar UWB monopole antennas," in *Ultra Wideband–Current Status and Future Trends*, M. Matin, Ed. Rijecka, Croatia: Intech, Oct. 2012.
[21] T. W. C. Brown, " Antenna diversity of mobile terminals," Ph.D. dissertation, Dept. Electron. Phys. Sci., Univ. of Surrey, Guildford, Surrey, U.K., 2002.