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A Compact Printed Extremely Wideband Microstrip Patch Antenna with Stacked Configuration

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Abstract— A common technique to realize wideband microstrip antenna is by introducing slots at an appropriate position inside the patch. In this communication a stacked configurated microstrip patch antenna with slots similar to ISI shape introduced on a square radiating patch with a microstrip line feed is presented. The slots introduced in the radiating patch of the proposed antenna increase the fringing fields which enhances the bandwidth. In order to achieve wider bandwidth an air gap is used between the driven and the parasitic patches. The results were validated by measurements in the laboratory. The impedance bandwidths determined at -10 dB return loss for the proposed antenna is about 90.65% (1.088 to 2.892 GHz). The effects of key design parameters such as air gap, length of microstrip line, dimensions of the parasitic patch are studied to optimize for the better performance of the designed antenna.

Keywords— Microstrip antenna, Wideband, impedance bandwidth, stacked, microstrip line, driven, parasitic.

I. INTRODUCTION

The microstrip antennas have several advantages such as low profile, low cost, light weight, ease of fabrication and compatibility with printed circuits. However, despite these advantages the microstrip antennas have some disadvantages such as low bandwidth and low efficiency. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, slotted patch antennas, the use of various impedance matching and feeding techniques etc. [1]. In the past years, many techniques have been presented to enhance the bandwidth of microstrip antennas. An H-shaped microstrip antenna with U-slot and capacitive feed is presented for bandwidth enhancement up to 45% [2]. A modified E-shaped proximity fed microstrip patch antenna with 47% bandwidth has been demonstrated [3]. A bow tie patch antenna is investigated for 66.67% bandwidth [4]. Again a stacked configurated patch antenna with aperture coupling is presented for 27% bandwidth enhancement [5]. Two printed wide slot antennas with E-shaped patch are demonstrated for extremely wide bandwidth [6]. Two inverted antennas with E-H and LEE-H shaped patches are investigated for 30% and 21.15% bandwidths respectively [7-8]. To achieve wide bandwidth antenna with tuning stub, planar antenna with a dipole and LHM unit cells, a planar antenna array with a butler matrix have been implemented, AR bandwidths of single-fed truncated-corner microstrip patch antennas with different thickness have been studied [9-12]. A compact dual band slot antenna for WLAN applications, a frequency reconfigurable patch with U-slot, stacked patches with U-shaped parasitic element and multiple slots, E-shaped patch for high speed WLAN, have been presented [13-23].

Wireless communication systems, such as universal mobile telecommunications service (UMTS) and wireless local-area networks (WLANs), have rapidly attracted attention, often requiring the allocation of new frequency bands. For instance, committees have recently assigned the frequency band from 2500 to 2690 MHz to mobile UMTS services as an expansion band of the 1920–2170 MHz UMTS band. Consequently, wide-band or multiband radiating elements must be constantly upgraded and improved. Actual antennas providing multiband operability for GSM and UMTS networks are characterized by an impedance bandwidth up to 25%, while an impedance bandwidth of more than 33% is required for systems operating in the UMTS (1920–2170 MHz), WLAN (2400–2484 MHz), and UMTS II (2500–2690 MHz) frequency bands. In this communication a new compact slotted microstrip patch antenna is proposed for enhancement in bandwidth. The broader bandwidth is realized by cutting slots on the square patch. The slots of ISI shape are cut from the patch and air gap is introduced between the driven and the parasitic patch. The design employs 50 Ω microstrip line feeding. The impedance bandwidth of the proposed antenna at -10 dB return loss is about 90.65% which can easily cover the frequency bands of UMTS (1.92-2.17 GHz), WLAN (2.40–2.48GHz), and UMTS II (2.50–2.69GHz). Numerical sensitivity analysis has been done to understand the effects of various dimensional parameters and to optimize the performance of the designed antenna. The antenna is simulated using IE3D, 12.32 version of Zealand. Good agreement is obtained between the simulated and experimental results.

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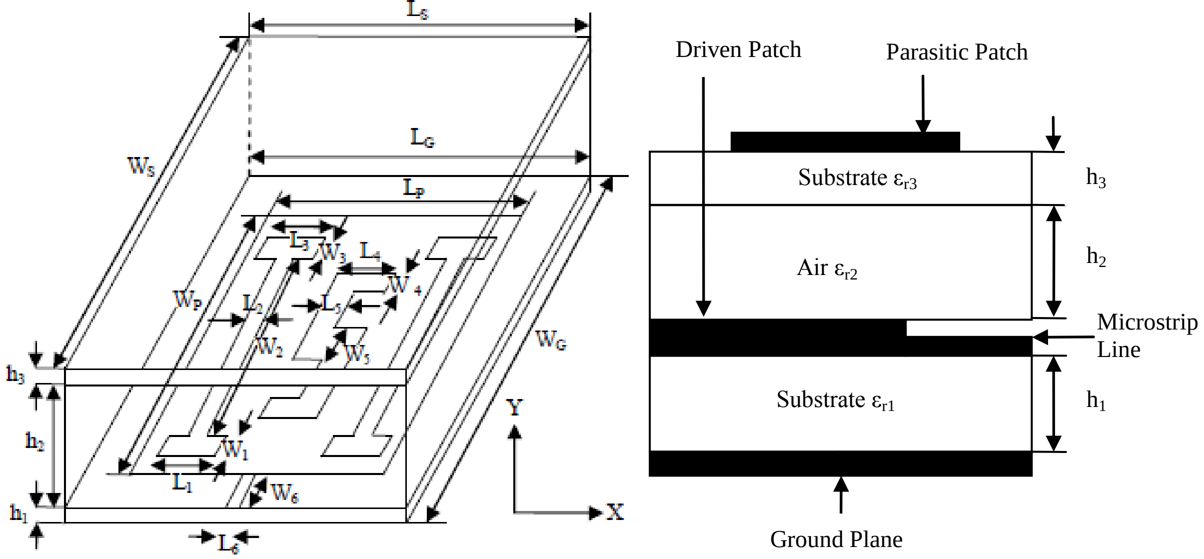
II. ANTENNA DESIGN

The dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna. Low dielectric constant of the substrate produces larger bandwidth, while the high dielectric constant of the substrate results in smaller size of antenna. A trade-off relationship exists between antenna size and bandwidth [20].



(a) Top view of the antenna. (b) Side view of the antenna.

Fig.1. Top and side view of the proposed antenna.

The top and side view of the proposed antenna is shown in figure 1. The proposed antenna consists of a finite ground plane with dimensions of 50 mm x 50 mm. The three slots in ISI shape are etched on a square substrate which acts as a driven patch for the proposed antenna and with a size of 40 mm x 40 mm, substrate thickness of lower patch h_1 = 1.6 mm and relative dielectric constant ε_{r1} = 4.2. A substrate of low dielectric constant is selected to obtain a compact radiating structure that meets the demanding bandwidth specification. For the given design the slotted patch and the feeding line are printed on the same side of the dielectric substrate. To enhance the bandwidth an air filled substrate with ε_{r2} = 1 and thickness h_2 = 15 mm is used between the driven and the parasitic patch. The square shaped parasitic patch is of size 50 mm x 50 mm, with substrate thickness h_3 = 1.6 mm and relative dielectric constant ε_{r3} = 4.2. The patch is fed by a 50 Ω microstrip line. Table 1 shows the optimized design parameters for the proposed antenna. The two I-slots are symmetrical in shape and size and therefore have same dimensions

.

TABLE I. The proposed patch antenna design parameters.

Parameter	Value [mm]	Parameter	Value [mm]
W_G	50	L_3	7.5
L_G	50	W_4	2.5
W_P	40	L_4	7.5
L_P	40	W_5	2.5
W_S	50	L_5	2.5
L_S	50	W_6	5
W_1	2.5	L_6	5
L_1	7.5	h_1	1.6
W_2	15	h_2	15
L_2	2.5	h_3	1.6
W_3	2.5		

III. RESULTS AND DISCUSSIONS

The proposed antenna was first simulated and optimized by IE3D software and was then fabricated and measured. In this section, experimental and simulation results are presented. The pictures of the proposed fabricated antenna fed by a Microstrip line are shown in figure 2. The simulated and measured return loss of the proposed antenna is shown in the figure 3. The results show that the simulated and measured impedance bandwidths at -10 dB return loss are about 90.65% (1.088 to 2.892 GHz) and 81.63% (1.16 to 2.76 GHz) respectively. This large enhancement in bandwidth is obtained by selecting suitable slot shape, proper feeding technique and adding air filled substrate between the driven and the parasitic patch. There is a good agreement between the simulated and the experimental results. The simulated radiation patterns of the elevation and azimuth of the proposed antenna are shown in figure 4.

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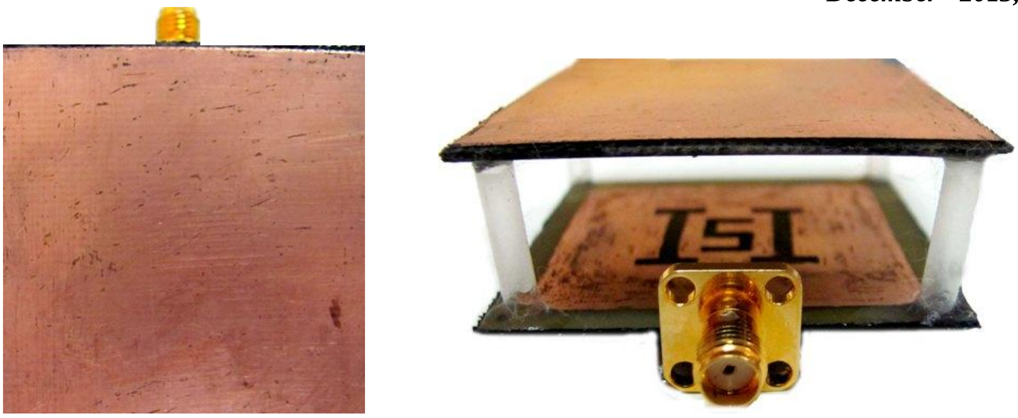


(a) (b)

Fig. 2. Picture of the fabricated antenna. (a) Top view. (b) Front view.

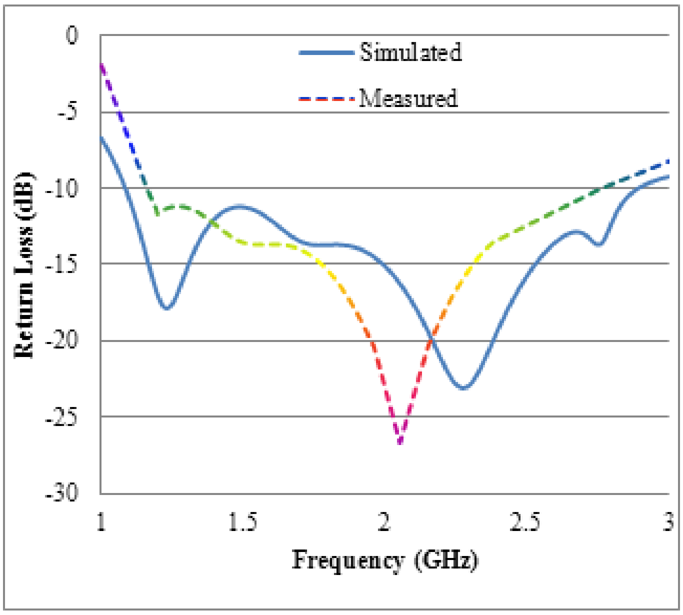
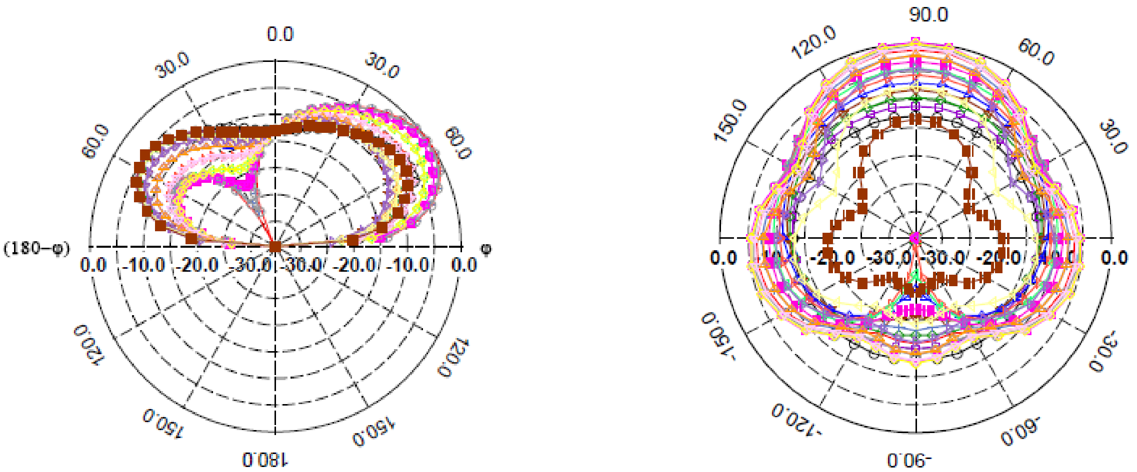


Fig. 3. Simulated and measured return loss of the proposed antenna.



(a) (b)

Fig. 4. Simulated radiation pattern of the proposed antenna. (a) Elevation pattern. (b) Azimuth pattern.

IV. SENSITIVITY ANALYSIS

A comprehensive numerical sensitivity analysis has been done in order to understand the effects of various dimensional parameters and to optimize the performance of the designed antenna. The results show that the enhancement in bandwidth largely depends on L_6, L_S x W_S, h_2 and h_3. The effect of these parameters on impedance bandwidth is studied after varying and optimizing them one by one for achieving higher bandwidth.

The comparison of the simulated return loss for different lengths L_6, of the microstrip line feed is shown in figure 5. The impedance bandwidths versus L_6 are summarized in table II. The optimum value of L_6 is 5 mm.

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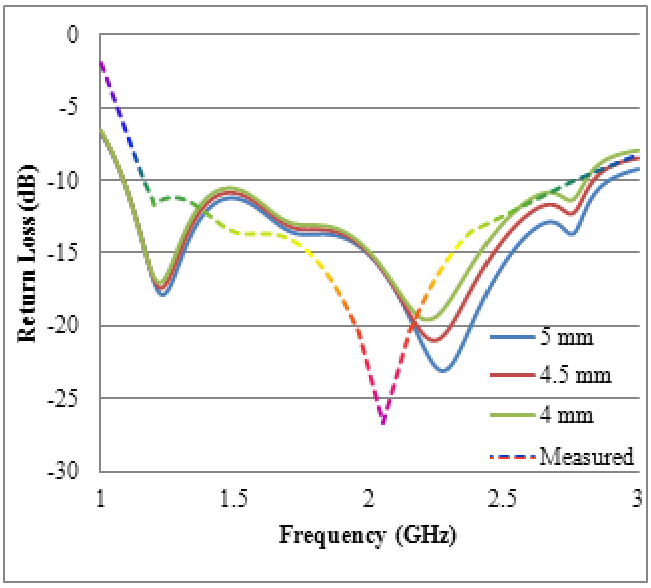

Fig.5. Simulated return loss of the proposed antenna with different lengths L_6 of the microstrip line feed.

Table II. The simulated bandwidths for various L_6.

L_6 [mm]	f_l [GHz]	f_h [GHz]	IMPEDANCE BANDWIDTH
5	1.088	2.892	90.65%
4.5	1.088	2.832	88.9%
4	1.088	2.804	88.18%

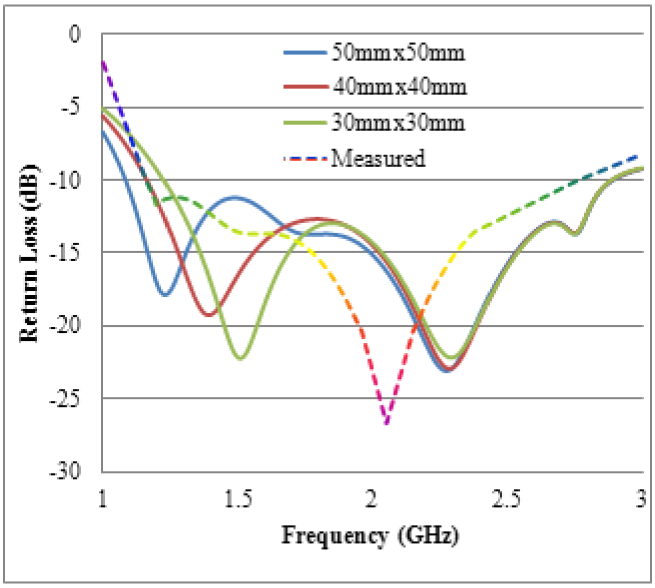

Fig.6. Simulated return loss of the proposed antenna with different dimensions L_S x W_S of the parasitic patch.

The simulated return loss versus the bandwidth for different dimensions of the parasitic patch is shown in figure 6. It is observed that this parameter affects the performance of the antenna. The optimum value of this parameter is 50 mm x 50 mm. The impedance bandwidths for different dimensions of this parameter are summarized in table III.

Table III. The simulated bandwidths for different L_S x W_S.

L_S x W_S [mm]	f_l [GHz]	f_h [GHz]	IMPEDANCE BANDWIDTH
50 x 50	1.088	2.892	90.65%
40 x 40	1.166	2.885	84.86%
30 x 30	1.228	2.884	80.54%

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The simulated return loss versus the bandwidth for different values of air gap is shown in figure 7. It can be observed that this parameter plays a very vital role in enhancing the bandwidth and the performance of the antenna. The optimum value of this parameter is 15 mm. The impedance bandwidths for different values of this parameter are summarized in table IV.

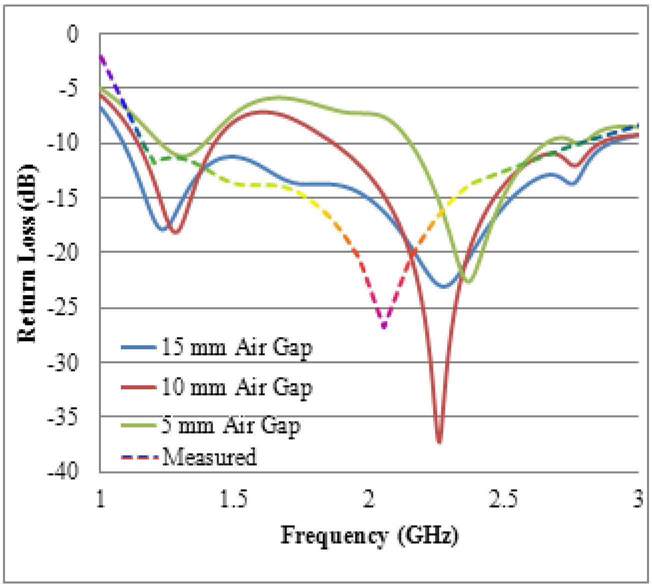

Fig.7. Simulated return loss of the proposed antenna with different values of air gap h_2.

Table IV. The simulated bandwidths for different h_2.

h_2 [mm]	f_l [GHz]	f_h [GHz]	IMPEDANCE BANDWIDTH
15	1.088	2.892	90.65%
10	1.87	2.852	41.59%
5	2.154	2.651	20.7%

The comparison of the simulated return loss for different heights h_3 of the parasitic patch is shown in figure 8. The impedance bandwidths versus h_3 are summarized in table V. The optimum value of h_3 is 1.6 mm.

Table IV. The simulated bandwidths for different h_3.

h_3 [mm]	f_l [GHz]	f_h [GHz]	IMPEDANCE BANDWIDTH
1.6	1.088	2.892	90.65%
1.0	1.128	2.886	87.59%
0.8	1.136	2.884	86.9%

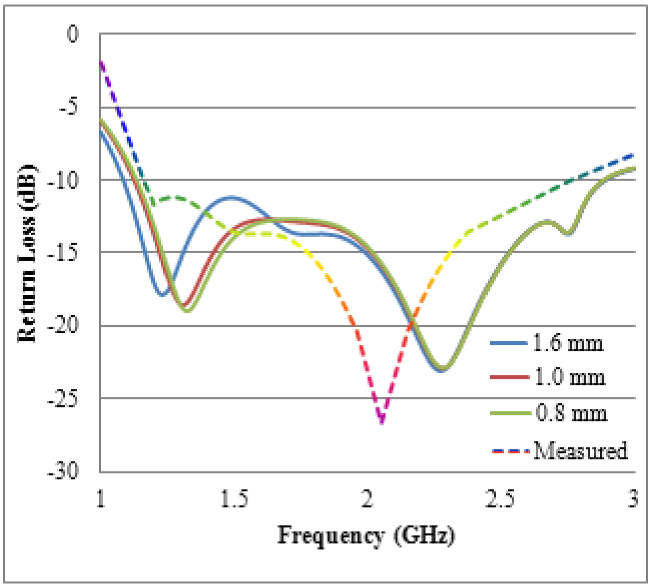

Fig.8. Simulated return loss of the proposed antenna for different substrate thickness h_3 of the parasitic patch.

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V. CONCLUSION

A novel compact and stacked microstrip patch antenna with large impedance bandwidth has been proposed and implemented. The proposed antenna exhibits a large operating bandwidth of about 90.65% (from 1.088 to 2.892 GHz). This bandwidth is achieved by introducing slots similar to ISI shape on the square radiating patch. The impedance bandwidth of the proposed antenna can easily cover the frequency bands of UMTS (1.92-2.17 GHz), WLAN (2.40–2.48GHz), and UMTS II (2.50–2.69GHz).

REFERENCES

[1] Ramadan, A., K. Y. Kabalan, A. El-Hajj, S. Khoury, and M. Al- usseini, "A reconfigurable U-Koch microstrip antenna for wireless applications," *Progress In Electromagnetics Research, PIER* 93, pp. 355-367, 2009.

[2] Vaibhav Tarange, Tushar Gite, Piyush Musale and sanjay V. Khobragade, "A U-Slotted H-Shaped Microstrip Antenna with Capacitive feed for Broadband Application," *Proc. IEEE*, Vol. 978-1, pp. 182-184, 2011.

[3] Amit A. Deshmukh, Ameya Kadam and K. P. Ray, "Broadband Proximity Fed Modified E-shaped Microstrip Antenna," *Proc. IEEE*, Vol. 978-1, 2011.

[4] Tommi Hariyadi, Achmad Munir and Antonius Darma Setiawan, "Unidirectional Broadband Microstrip Antenna for Through Walls Radar Application," *Proc. IEEE*, Vol. 978-1, 2011.

[5] Fan Zhang, Fu-Shun Zhang, Chen Lin and Gang Zhao, "Broadband Microstrip Patch Antenna Array Using Stacked Structure," *Proc. IEEE*, Vol. 978-1, pp. 388-391, 2011.

[6] Aliakbar Dastranj and Habibollah Abiri, "Bandwidth Enhancement of Printed E-Shaped Slot Antennas Fed by CPW and Microstrip Line," *IEEE Transactions On Antennas And Propagation*," Vol. 58, No. 4, pp. 1402-1407, 2010.

[7] M. T. Islam, M. N. Shakib and N. Misran, "Broadband E-H shaped microstrip patch antenna for wireless systems," *Progress In Electromagnetics Research, PIER* 98, pp. 163-173, 2009.

[8] M. T. Islam, M. N. Shakib and N. Misran, "Design Analysis Of High Gain Wideband L-Probe Fed Microstrip Patch Antenna," *Progress In Electromagnetics Research, PIER 95*, pp. 397-407, 2009.

[9] Z. S. Duan, S. B. Qu and J. Q. Zhang, "Wide Bandwidth and Broad Beamwidth microstrip Patch Antenna," *Electronics Letters*, Vol. 45 No. 5, pp. 2009.

[10] Merih Palandoken, Aandre Grede and Heino Henke, " Broadband Microstrip Antenna With Left Handed Metamaterials," *IEEE Transactions On Antennas And Propagation*," Vol. 57, No. 2, pp. 331-338, 2009

[11] Mohamed Elhefnawy and Widad Ismail, "A Microstrip Antenna Array for Indoor Wireless Dynamic Environments," *IEEE Transactions on Antennas And Propagation*," Vol. 57, No. 12, pp. 3998-4002, 2009.

[12] S. L. S. Yang, K. F. Lee, and A. A. Kishk, "Design and Study of Wideband Single Feed Circularly Polarized Microstrip Antennas," *Progress In Electromagnetics Research, PIER* 80, pp. 45–61, 2008.

[13] Ahmed Khidre, Kai-Fong Lee, Fan Yang, and Atef Z. Elsherbeni, "Circular Polarization Reconfigurable Wideband E-Shaped Patch Antenna for Wireless Applications," *IEEE Transactions on Antennas and Propagation*, VOL. 61, NO. 2, pp. 960-964, Feb. 2013.

[14] W. Ren, "Compact dual-band slot antenna for 2.4/5 GHz WLAN applications," *Progress In Electromagnetics Research*, B, Vol. 8, 319-327, 2008.

[15] Shing-Lung Steven Yang, Ahmed A. Kishk, and Kai-Fong Lee, "Frequency Reconfigurable U-Slot Microstrip Patch Antenna," *IEEE Antennas and Wireless Propagation Letters*, Vol. 7, pp. 127-129, 2008.

[16] Jiawei Dong, Anguo Wang, Peng Wang and Yonghong Hou, "A Novel Stacked Wideband Microstrip Patch Antenna with U-Shaped Parasitic Elements," *Proc. IEEE*, Vol. 978-1, 185-188, 2008.

[17] Wen-Chung Liu, Yung-Lun Chen, and Chao-Ming Wu, "A Compact Wideband Strip Antenna for Wireless USB Dongle Application," *Microwave and Optical Technology Letters*, Vol. 55, No. 2 pp. 302-304, Feb. 2013.

[18] B. K. Ang and B. K. Chung, "A Wideband E-Shaped Microstrip Patch Antenna For 5–6 GHz Wireless Communications," *Progress In Electromagnetics Research, PIER* 75, pp. 397–407, 2007.

[19] Emre Erdil, Kagan Topalli, Mehmet Unlu, Ozlem Aydin Civi, and Tayfun Akin, "Frequency Tunable Microstrip Patch Antenna Using RF MEMS Technology," *IEEE Transactions on Antennas And Propagation*," Vol. 55, No. 4, pp. 1193-1196, 2007.

[20] Halim Boutayeb, and Tayeb A. Denidni, "Gain Enhancement of a Microstrip Patch Antenna Using a Cylindrical Electromagnetic Crystal Substrate," *IEEE Transactions on Antennas And Propagation*," Vol. 55, No. 11, pp. 3140-3145, 2007.

[21] Joshua A. Fladie and Jennifer T. Bernhard, " On the Radiation Characteristics of Right- and Left-Handed Microstrip Patch Antenna Designs," *IEEE Antennas and Wireless Propagation Letters*, Vol. 5, pp. 563-565, 2006.

[22] Jaume Anguera, Lluís Boada, Carles Puente, Carmen Borja, and Jordi Soler, "Stacked H-Shaped Microstrip Patch Antenna," *IEEE Transactions on Antennas And Propagation*," Vol. 52, No. 4, pp. 983-993, 2004.

[23] Jongkuk Park, Hyung-gi Na, and Seung-hun Baik, "Design of a Modified L-Probe Fed Microstrip Patch Antenna," *IEEE Antennas and Wireless Propagation Letters*, Vol. 3, pp. 117-119, 2004.

[24] Yang Luo, Ying-zeng Yin, Yuan-yuan Guo, and Yang Zhao, "A Dual-Wideband Antenna With An Open L-Slot For WLAN/WIMAX Applications," *Microwave and Optical Technology Letters*, Vol. 54, No. 6, pp. 1499-1502, Jun. 2012.

[25] Y. Sung, "Bandwidth Enhancement of a Microstrip Line-Fed Printed Wide-Slot Antenna With a Parasitic Center Patch," *IEEE Transactions on Antennas and Propagation*, VOL. 60, NO. 4, pp. 1712-1716, Apr. 2012.

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[26] Yang Gao, Zhenghe Feng, and Li Zhang, "Compact Asymmetrical T-Shaped Dielectric Resonator Antenna for Broadband Applications," *IEEE Transactions on Antennas and Propagation*, VOL. 60, NO. 3, pp. 1611-1615, Mar. 2012.
[27] Sasan Ahdi Rezaeieh, Serkan Simsek and Javad Pourahmadazar, "Design Of A Compact Broadband Circularly-Polarized Slot Antenna for Wireless Applications," *Microwave and Optical Technology Letters,* Vol. 55, No. 2 pp. 413-418, Feb. 2013.

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