ISSN: 2395-1680 (ONLINE)
DOI: 10.21917/ijme.2018.0081

DESIGN AND ANALYSIS OF MICROSTRIP PATCH ARRAY ANTENNA FOR WLAN APPLICATIONS

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Abstract

In this paper, a rectangular slotted microstrip patch array antenna is proposed and designed for wireless local area network applications. A single patch, 1×2, 1×4 and 1×8 patch array antenna is designed and the impacts of functional characteristics such as return loss, VSWR, radiation pattern are investigated. The 1×4 array antenna provides the better results than other arrays. The dimension of the array antenna is 143 mm and 71 mm. The patch splits and slots are taken in this design in order to enhance the bandwidth. The proposed structure designed by FR4 substrate with the thickness of 0.8 mm. The proposed 1×4 array antenna resonates at 2.4 GHz with the return loss and VSWR of is -33.6878dB and 1.0233, respectively.

Keywords:

Microstrip Patch Array, WLAN, SLOT, FR4, 1×4 Array and Return Loss

1. INTRODUCTION

The whole generations are hooked to new technologies. One of the wireless communication technology is playing a main role, so every day they try to improve their status [1]. Even then microstrip patch antenna guarantees low profile, compact and affordable manufacturing for real time applications. An antenna array is a set of individual antennas used for transmitting and receiving radio waves, connected together in such a way that their individual currents are in specified amplitude and phase relationship. So comparing of these antennas, array antenna is highly used for improving gain and it does easily handle the more powers.

These antennas are widely used for wireless local area network (WLAN). A WLAN is a wireless computer network that links two or more devices using a wireless distribution method (often spread-spectrum or OFDM radio) within a limited area such as a home, school, computer laboratory, or office building. This gives the users to move around within a local coverage area and yet still be connected to the network. A WLAN can also provide a connection to the wider Internet. A cellular network is an example of WLAN [9].

In the literature, several array antennas are reported for WLAN application such as square, rectangular and circular patch antenna array [1], triangular antenna array [2], adaptive planar phased array [8], monopole antenna array [9], bi-Yagi and quad-Yagi antenna array [10], double sided printed dipole antenna array [12], reconfigurable bow tie antenna [13], C shaped monopole antenna array [14] and etc.

Various type of array structure used for improving, the performance of the antenna gain and directivity. Frequency selective surface used in array for improve the radiation parameters [2]. A triangular array antenna arranged in the form by using spectral domain technique [3].The radiating elements are formed in asymmetrically with the respect to the ground, this arrangement suppress the back lobe [4]. The array antenna is designed and implemented where the array consisted of two rectangular patch antenna with six parallel metal strips [5]. An L shaped array antenna is designed with the series fed meandered step impedance filter. An insertion loss method is applied on the design used for control the radiation aperture [6]. A dual band array antenna was designed which consists of 16 parallel feed rectangular patches and 64 hybrids fed double sided printed dipole. The side lobe level is suppressed by using amplitude weighting combining the quarter wavelength transformer [7].

A dual polarized adaptive planar phased array consist of feed network is designed to minimize the coupling between the ports [8]. Microstrip array consist of active monopole and two parasitic elements for compactness is reported [9] to enhance the antenna performance. Microstrip Yagi antenna array is employed and reported for achieve high gain [10]. The reconfiguration in array antenna design is reported which can be operated at right hand or left hand circular polarization. The reconfiguration is done by diodes [11]. A double side printed dipole element for array antenna is designed where the fed with balanced twin transmission line is reported [12]. E shaped patch array antenna is designed by particle swarm optimization and a genetic algorithm [14]. The linear array consists of half wave folded dipole elements is employed [15]. Two C shaped monopole with shorting line antenna array. Two RF switches were integrated for control the antennas [16]. Through there are several array antenna is reported, it is essential to enhance the antenna performance. Hence, 1×4 array antenna is proposed and designed.

In this paper, a tri-cell combination of rectangular slotted microstrip patch 1×4 array antenna is proposed and designed for WLAN application at 2.4GHz. This antenna is designed with FR4 substrate with 0.8mm thickness, 1mm feed width and the width and length of the substrate dimensions are 143mm and 71mm, respectively. The length and width of the patch are 38mm and 29.6mm, respectively. The antenna parameters are investigated for the proposed antenna.

This paper is organized as follows. Section 2 presents the proposed antenna design. Section 3 describes results and discussion of proposed array antenna. The impact of return loss with respect to the frequency while varying the number of array element in an antenna is presented in section 4. Finally, section 5 presented the conclusion.

2. ANTENNA DESCRIPTION

The Fig.1 shows the schematic representation of proposed tri-cell combination rectangular slotted microstrip patch 1×4 array antenna and Fig.2(a)-Fig.2(d) depicts the formation of proposed structure, patch formation and patch dimension. Each patches having the similar dimensions. The FR4 substrate is used with the dimension of 143mm width and 71mm length. The dimension of patch is 29.6mm width and 38mm length which is derived from [18]. And the microstrip feeding techniques with 1mm feed width is employed. The thickness of the substrate is 0.8mm and a dielectric loss tangent is 0.02. The proposed structure is composed of microstrip patch, rectangular split and rectangular slot. The splits and slots are used for enhancing the antenna performance. The detailed structural parameters of the proposed tri-cell combination rectangular slotted 1×4 microstrip patch array antenna are listed in Table.1.

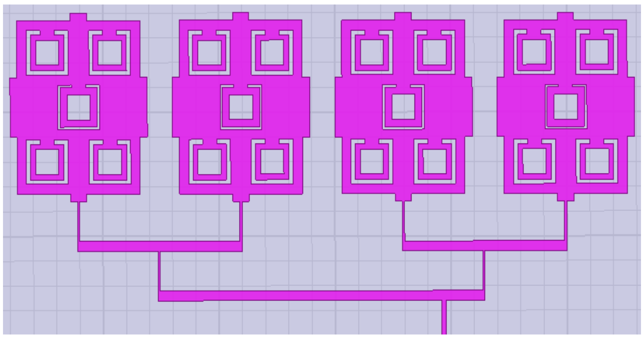
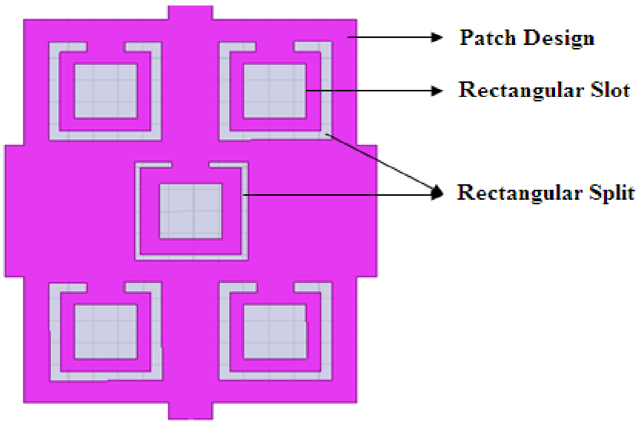
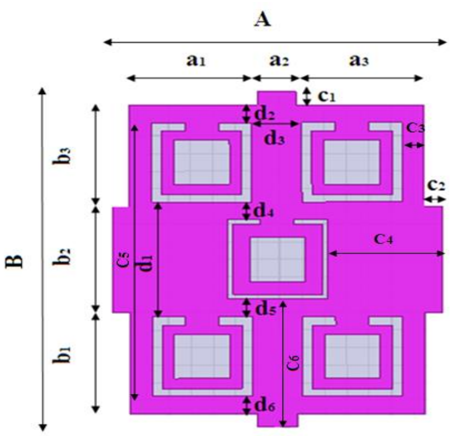


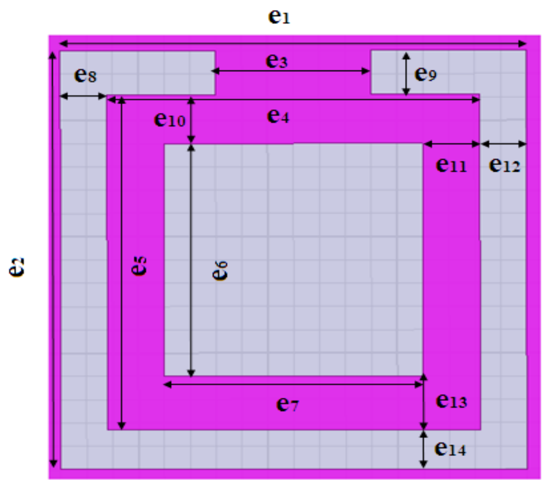
Fig.1. Schematic representation of proposed tri-cell combination rectangular slotted 1×4 microstrip patch array antenna



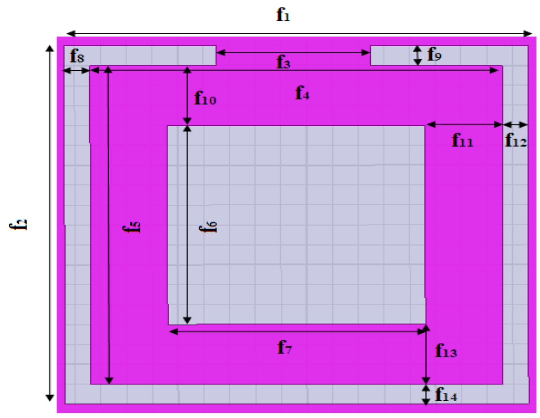
(a) Patch formation with up configuration



(b) Patch dimension



(c) Corner rectangle



(d) Center rectangle

Fig.2. Proposed Structure (a) patch formation with up configuration (b) patch dimension (c) corner rectangle and (d) center rectangle

Table.1. Structural details of tri-cell combination rectangular slotted 1×4 microstrip patch array antenna

Parameter	A	B	a_1	a_2	a_3	b_1	b_2	b_3	c_1	c_2	c_3	c_4
Values (mm)	29.6	38	11.5	3.5	11.5	11.5	12	11.5	1.5	1.6	2	10.3
Parameter	c_5	c_6	d_1	d_2	d_3	d_4	d_5	d_6	e_1	e_2	e_3	e_4
Values (mm)	31	14.5	13	2	4.5	2	2	2	9	9	3	7.2
Parameter	e_5	e_6	e_7	e_8	e_9	e_{10}	e_{11}	e_{12}	e_{13}	e_{14}	f_1	f_2
Values (mm)	7.5	5	5	0.25	0.25	1.05	1.1	0.9	1.15	0.85	9	9
Parameter	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}
Values (mm)	3	8	8	5	5	0.5	0.5	1.5	1.5	0.5	1.5	0.5

3. SIMULATION RESULTS AND DISCUSSION

The Fig.3 shows the return loss of Tri-Cell combination of 1×4 Microstrip patch array antenna. The return loss of the proposed antenna is -33.6878dB at 2.4GHz. In addition, the return loss of the proposed antenna other than resonant frequency is less than -10dB which provides better signal strength to transmit the signal form the feed point.

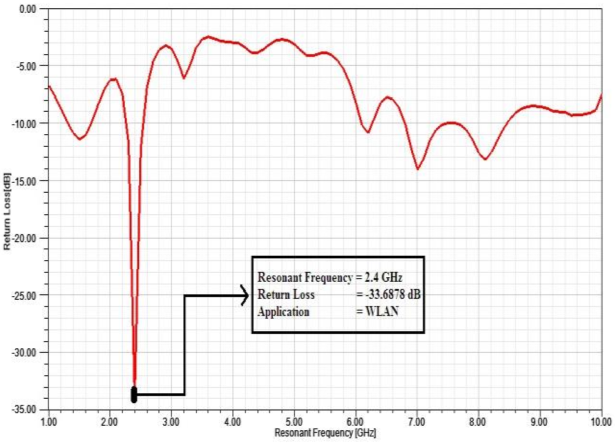


Fig.3. Return loss of the proposed antenna

The Fig.4 depicts the response of the VSWR for proposed Tri-Cell Combination 1×4 microstrip patch array antenna. The VSWR of proposed antenna is 1.0233. The Fig.5 shows the simulated radiation pattern of proposed antenna at 2.4GHz. The representation of the 2D radiation pattern of simulated result is unidirectional. The gain of the antenna is -27.8576dB. The directivity of the proposed antenna is low and the directivity is -26.1848. From the above reported results it is clearly noticed that the proposed antenna will be suitable for real time applications.

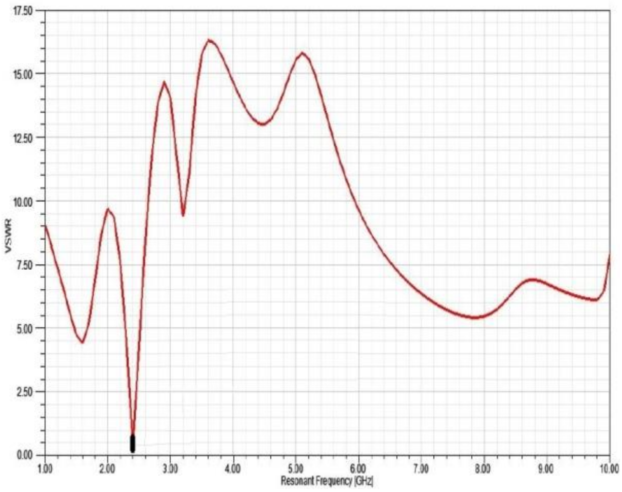


Fig.4. VSWR of the proposed antenna

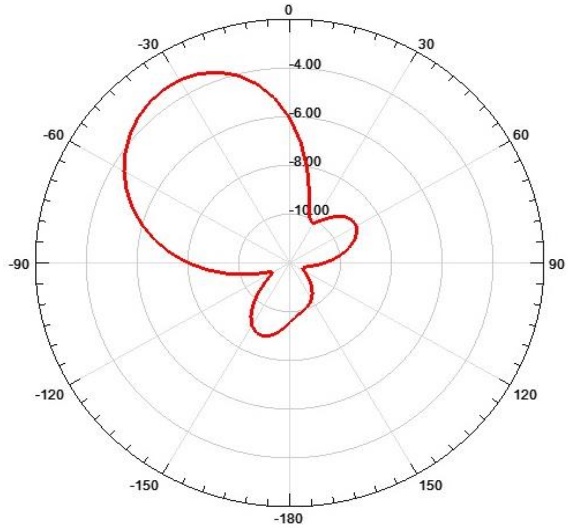


Fig.5. Radiation pattern of the proposed antenna

4. PARAMETRIC ANALYSIS

In this section, the impact of return loss is analyzed while changing the following parameters in the proposed tri-cell rectangular slotted antenna.

i. Substrate thickness as 0.8mm, 1.6mm and 3.2mm
ii. Single element antenna with right, left, up and down rectangular slotted antennas
iii. 1×2 array with all four configurations
iv. 1×4 array antenna with all four configuration

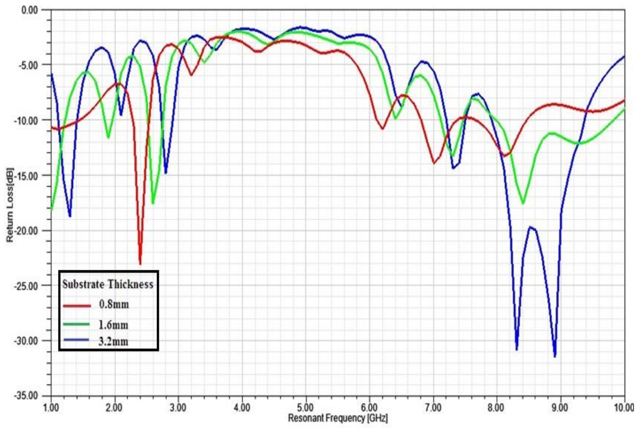


Fig.6. Impact of return loss vs. Substrate Thickness

The impact of return loss while varying the substrate thickness is analysed and it is shown in Fig.6. From Fig.6, it is noticed that the resonant frequency is shifted to higher frequency and the return loss is increased while increasing the size of the substrate. If the substrate thickness is increased, the cumulative dielectric strength of the antenna is increased which shifts the resonant frequency. Here substrate thickness of 0.8mm is used and it produces the better return loss when compared with other substrate thickness. Hence, 0.8mm of substrate thickness is accounted to increase array elements.

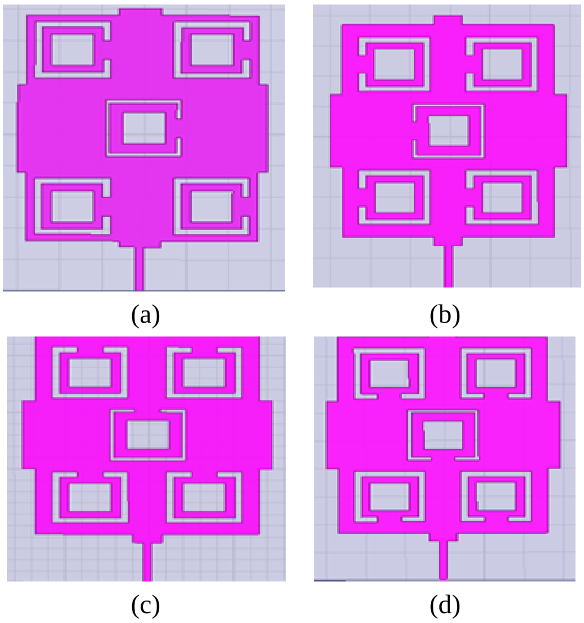


Fig.7. Comparison of Single patch with different slot directions (a) right (b) left (c) up and (d) down

The Fig.7(a)-Fig.7(d) show the single element of tri-cell rectangular slotted microstrip patch antenna in up, down, left and right direction. The feed width of single element is 1mm. The position of the rectangular slot is varied and the impact of the return loss is analysed. The Fig.8 shows the return loss performance of a single element tri-cell rectangular slotted microstrip patch array antenna. The rectangular slot with up direction is provided better performance than others and also resonates at 2.4GHz.

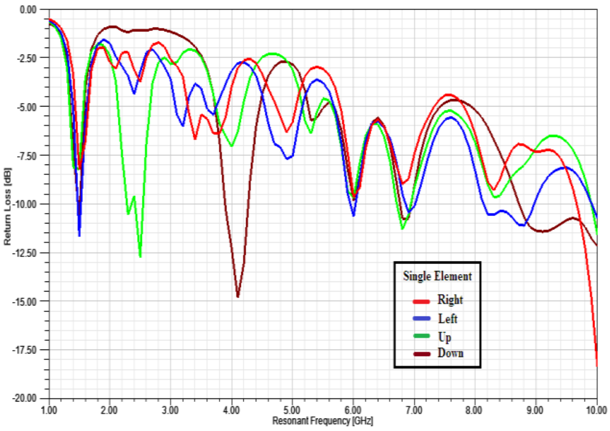


Fig.8. Comparison analysis of return loss vs. resonant frequency of a single element tri-cell rectangular slotted microstrip patch array antenna

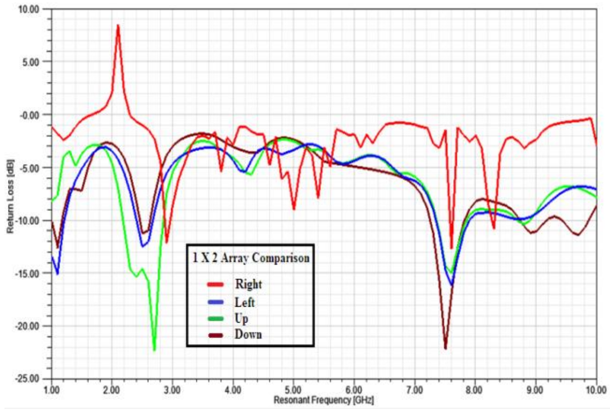


Fig.9. Comparison analysis of return loss vs. resonant frequency of 1×2 tri-cell rectangular slotted microstrip patch array antenna

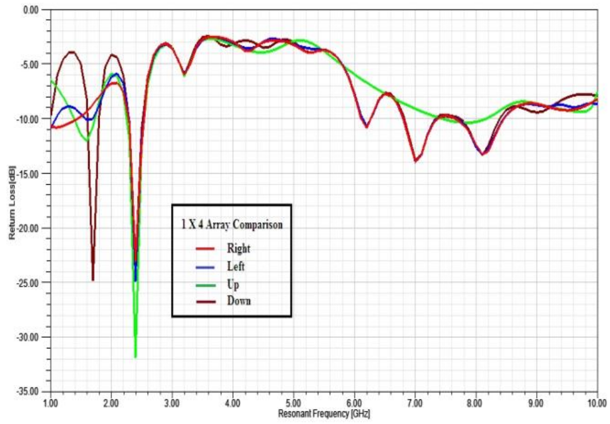


Fig.10. Comparison analysis of return loss vs. resonant frequency of 1×8 tri-cell rectangular slotted microstrip patch array antenna

The Fig.9 depicts the return loss performance of 1×2 array antenna. The 1×2 configuration is not performing well for all the configuration. The Fig.10 shows the comparison analysis of return loss with respect to resonant frequency of a 1×4 Tri-Cell combination of rectangular slotted microstrip patch array antenna. It is clearly noticed that the return loss is changed, when the direction of rectangular split is changed. It shows there is minor variation in resonant frequency and return loss is observed. From Fig.10, it is clearly observed that the resonant frequency for left, right, up and down configurations are remaining same. However, the return loss is increased for up configurations, hence, it is considered in this attempt. Typically, the antenna is radiated the power from bottom to top once it is received the signal form the input port. The array configuration namely right, left and down configurations is having the slot in its respective directions which could not radiate the entire input signal owing to its directions. However, the up configuration is having the slot in the up direction which directly radiates the power. Hence, maximum amount return loss is arrived for up configurations.

5. CONCLUSION

In this attempt, a tri-cell combination rectangular slotted 1×4 microstrip patch array antenna is proposed and designed for WLAN applications. The functional characteristics of the proposed array antenna namely return loss; VSWR, gain and directivity are investigated. The proposed 1×4 array antenna is resonating at 2.4GHz, and the return loss and VSWR about -33.6878dB and 1.0233, respectively. The overall size of the proposed array antenna is 143mm×71mm. Hence it could be consolidated for WLAN applications.

REFERENCES

[1] Zaakari Saf, Zenkour Lahbib and Bri Seddik, "The Square, Rectangular, circular Patch was Designed with Corner Fed Arrangement", *Journal of Microwaves, Optoelectronics and Electromagnetic Application*, Vol. 12, No. 1, pp. 23-36, 2013.

[2] Valdez. A. Almeida Filho and Antonio Luiz P.S. Campos, "Performance Optimization of Microstrip Antenna Array using Frequency Selective Surfaces", *Journal of Microwaves, Optoelectronics and Electromagnetic Application*, Vol. 13, No. 1, pp. 31-46, 2014.

[3] C. Aissaoui and A. Benghalia, "Rigorous Analysis of a Compact Triangular Antenna Array using Spectral Domain Method", *Journal of Microwaves, Optoelectronics and Electromagnetic Application*, Vol. 16, No. 1, pp. 16-24, 2017.

[4] Eduardo S. Silveira, Denial C. Nascimento, Alexis F. Tinnoco and Marcus V.P. Pina, "Design of Microstrip Antenna Array with Suppressed Back Lobe", *Journal of Microwaves, Optoelectronics and Electromagnetic Applications*, Vol. 16, No. 2, pp. 460-470, 2017.

[5] Xu Bao Sun and Mao Yong Cao, "Low Mutual Coupling Antenna Array for WLAN Application", *IEEE in Electronics Letters*, Vol. 53, No. 6, pp. 368-370, 2017.

[6] Wee Kian Toh, Xianming Qing and Zhi Ning Chen, "A Planar Dual Band Array", *IEEE Transactions on Antennas and Propagation*, Vol. 59, No. 3, pp. 833-838, 2010.

[7] Shantwng He and Jidong Xie, "Analysis and Novel Design of a Novel Dual Band Array Antenna with a Low Profile for 2400/5800 MHz WLAN Systems", *IEEE Transactions on Antennas and Propagation*, Vol. 58, No. 2, pp. 391-396, 2010.

[8] C.T.P. Song, Angus Mak, Bill Wong, D. George and R.D. Mruch, "Compact Low Cost Dual Polarized Adaptive Planar Phased Array for WLAN", *IEEE Transactions on Antennas and Propagation*, Vol. 53, No. 8, pp. 2406-2416, 2005.

[9] M. Farran, D. Modotto, S. Boscolo, A. Locatelli, A.D. Capobianco, M. Midrio and V. Ferrari, "Compact Printed Parasitic Array for WLAN Application", *Electronics Letters*, Vol. 15, pp. 918-921, 2015.

[10] Gerald R. Dejean, Trang T.Thai, Symeon Nikolauo and Manos M. Tentzeris, "Design and Analysis of Microstrip Bi-Yagi and Quad-Yagi Antenna Arrays for WLAN Application", *IEEE Antennas and Wireless Propagation Letters*, Vol. 6, pp. 244-248, 2007.

[11] C.H. Weng, H.W. Liu, C.H. Ku and C.F. Yang, "Dual Circular Polarization microstrip Array Antenna for WLAN/WiMAX Applications", *Electronics Letters*, Vol. 46, No. 9, pp. 609-611. 2010.

[12] J. Zhang, X.M. Zhang, J.S. Liu, Q.F. Wu, T. Ying and H. Jin, "Dual Band Bidirectional High Gain Antenna for WLAN 2.4/5.8GHz Applications", *Electronics Letters*, Vol. 45, No. 1, pp. 6-7, 2009.

[13] Tong Li, Huiqing Zhai and Chang Hong Liang, "Frequency Reconfigurable Bow-Tie Antenna Array", *Electronics Letters*, Vol. 50, No. 8, pp. 1264-1266, 2014.

[14] Zhongkan Ma, Viadimir Volski and Guy A.E.Vandenbosch, "Optimal Design of a Highly Compact Low Cost and Strongly Coupled Four Elements Array for WLAN", *IEEE Transactions on Antennas and Propagation*, Vol. 59, No. 3, pp. 1061-1065, 2011.

[15] Chia-Ching Lin, Chih Ming Su, Fu Ren Hsiao and Kin Lu Wong, "Printed Folded Dipole Array Antenna with Directional Radiation for 2.4/5GHz WLAN Operation", *Electronics Letters*, Vol. 39, No. 24, pp. 1698-1699, 2003.

[16] Q. Luo, J.R. Pereira and H.M. Salgado, "Reconfigurable Dual Band C Shaped Monopole Antenna Array with High Isolation", *Electronics Letters*, Vol. 46, No. 13, pp. 888-889, 2010.

[17] Jaume Anguera, Aurora Andujar, Minh-Chau Huynh, Charlie Orlenius, Cristina Picher and Carles Puente, "Advances in Antenna Technology for Wireless Handheld Devices", *International Journal of Antennas and Propagation*, Vol. 2013, pp. 1-25, 2012.

[18] Shantwng He and Jidong Xie, "Analysis and Novel Design of a Novel Dual Band Array Antenna with a Low Profile for 2400/5800 MHz WLAN Systems", *IEEE Transactions on Antennas and Propagation*, Vol. 58, No. 2, pp. 391-396, 2010.