Proposed Geometric Printed Patch Shapes for Microstrip Ultra-Wideband Antennas

Rashid A. Fayadh, F. Malek, Hilal A. Fadhil, Norshafinash Saudin

***Abstract*—**In this paper, a design of ultra wideband (UWB) printed microstrip antennas that fed by microstrip transmission line were presented and printed on a substrate Taconic TLY-5 material with relative dielectric constant of 2.2. The proposed antennas were designed to cover the frequency range of 3.5 to 12 GHz. The antennas of printed patch shapes are rectangular, triangle/rectangular, hexagonal, and circular with the same dimensions of feeder and ground plane. The proposed antennas were simulated using a package of CST microwave studio in the 2 to 12 GHz operating frequency range. Simulation results and comparison for return loss (S_{11}), radiation patterns, and voltage standing wave ratio (VSWR) were presented and discussed over the UWB frequency.

***Keywords*—**Microstrip patch antenna, ultra-wideband frequency, wireless communication systems, return loss and radiation patterns.

I. Introduction

AS the acceptance of using UWB technology was reported in [1] by the FCC in the USA of frequency range between 3.1 and 10.6 GHz, the small size and low cost are the main research goals in military and commercial applications. The UWB technology for wireless systems makes the users free from wires and enables the wireless connections of multiple devices and several users in transmission and reception. Now a day, the requirement of using wireless system is increasing with high bit rate transfer at low power consumption. The size of these systems was reduced for reliability usage, so, small UWB antenna should be designed to be comfortable with the wireless devices. A small T-slotted patch UWB antenna was designed by Yusnita Rahayu [2] to improve the evaluation of antenna performance. A circular disc of one and two microstrip lines in the feeder part was produced by [3] for three bands from 1.8 GHz to 8.12 GHz of the third generation mobile and UWB systems. Rectangular shaped patch antenna with two concave and convex circulated corners at the bottom part of the radiator was designed in [4] to cover the UWB operation dynamic range and the results cleared the effect of these corners on the impedance matching of the feeder and radiator. The number of dielectric layers and the stacked radiator dimensions for each layer was studied in [5] at different locations of the feed line. A narrow cavity backed antenna was described in [6] to optimize the impedance matching through these cavities and compare their effective with conventional proximity coupled antenna. A small microstrip planar antenna design was deployed in [7] with integrated E-shaped slots in the ground plane and in [8] with wide slot on the microstrip-line feeder. Geometry diamond-shape of patch antenna was designed in [9] with several notches on each side of the patch to perform the parameters of the microstrip antenna, such as return loss (S_{11}), voltage standing wave ratio (VSWR), and radiation pattern. In this paper, we proposed four small size geometrical patch-shaped antennas and they are rectangular, triangle /rectangular, hexagonal, and circular patch forms to cover the UWB frequency. The comparison between these proposed antennas is illustrated in return loss, VSWR, and radiation patterns configurations.

Rashid A. Fayadh is with the Universiti Malaysia Perlis (UniMAP), School of Computer and Communication Engineering, Arau, Parlis, Malaysia (phone: 010-371-7864; e-mail: r_rashid47@yahoo.com).

F. Malek is with the Universiti Malaysia Perlis (UniMAP), School of Electrical System Engineering, Arau, Parlis, Malaysia (phone: 019-4718-111; e-mail: mfareq@unimap.edu.my).

Hilal A. Fadhil is with the Universiti Malaysia Perlis (UniMAP), School of Computer and Communication Engineering, Arau, Parlis, Malaysia (phone: 016-4923-211; e-mail: hilaladnan@unimap.edu.my).

Norshafinash Saudin is with the Universiti Malaysia Perlis (UniMAP), School of Electrical System Engineering, Arau, Parlis, Malaysia (e-mail: norshafinash@unimap.edu.my).

II. Antenna Design Shapes

All the proposed antennas are printed on Taconic TLY-5 substrate of thickness 1.4mm and relative dielectric constant (ε_r) of 2.2. The dimensions of the patch are excited using a 50 input impedance of the microstrip line. The printed patches are made of copper of 0.035mm thickness (t) and the dimensions of the ground plane are same for the proposed geometrical designs as shown in Fig. 1. The gap between ground plane and radiating patch is 1mm for all simulated antennas. The rectangular patch antenna of Fig. 2 was designed having dimensions of 16x14mm^2 and it is fed by a feeder of 4.8 x 12mm^2 in dimension. The patch and feeder are printed on substrate of 30x28mm^2 in dimension. The triangle/rectangular-shaped antenna is shown in Fig. 3 as radiator geometry of the planer PCB antenna and its dimensions. The patch area is reduced by removing two parts of 8mm length and $\theta = 45^o$ from the both top sides of the patch as a modification in the first rectangular-shape antenna to change the center frequency. The third geometry of the proposed antenna is shown in Fig. 4 which consists of hexagonal-shape patch of 4mm arc and $\theta = 45^o$ with the same dimensions for transmission line feeder as those for previous designs. The idea of this design approach is to increase the antenna activity in cellular area communications and single-chip radar transceiver. Fig. 5 shows the forth geometry circular form antenna with radius of 8mm. The circular-shape is designed to obtain the best return loss (S_{11}) at lower frequency band that makes the antenna useful for mobile phones and remote sensing devices applications.

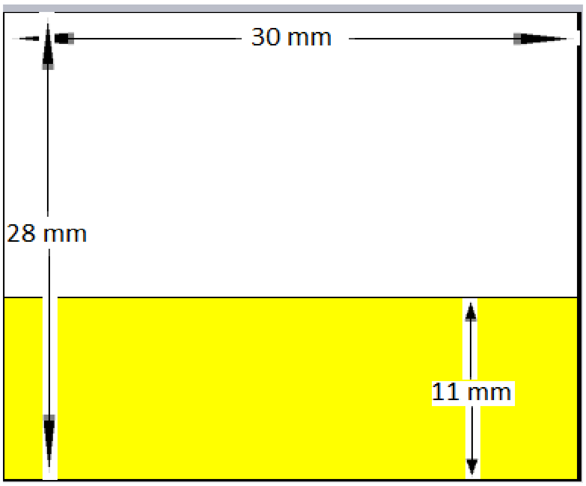


Fig. 1 The same back view for all proposed shapes of UWB antennas

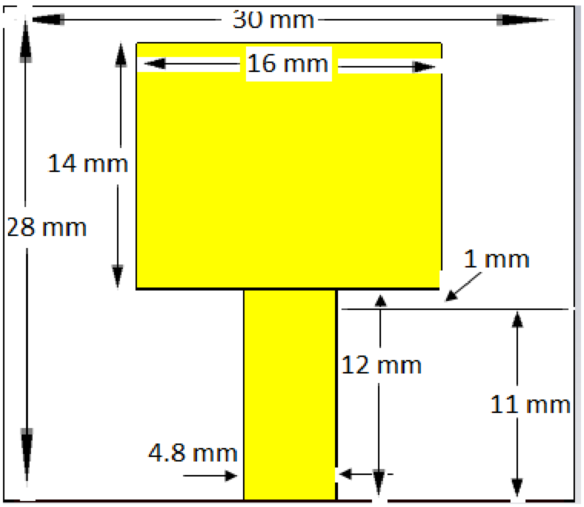


Fig. 2 Front view of rectangular-shaped antenna

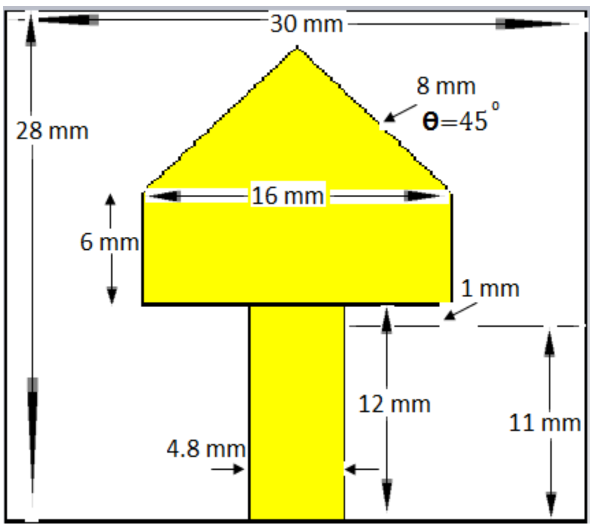


Fig. 3 Front view of triangle/rectangular-shaped antenna

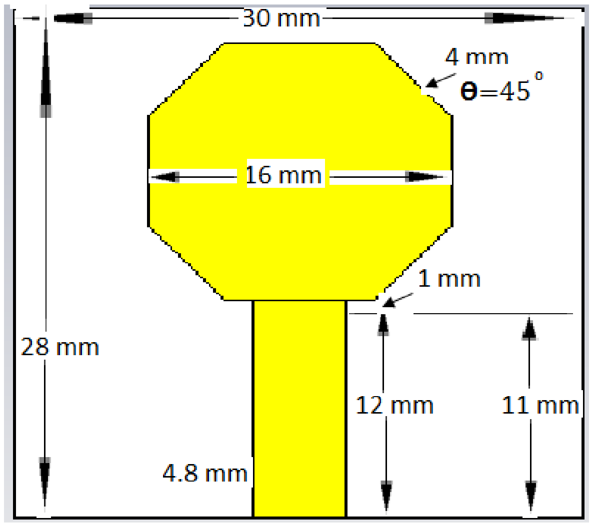


Fig. 4 Front view of hexagonal-shaped antenna

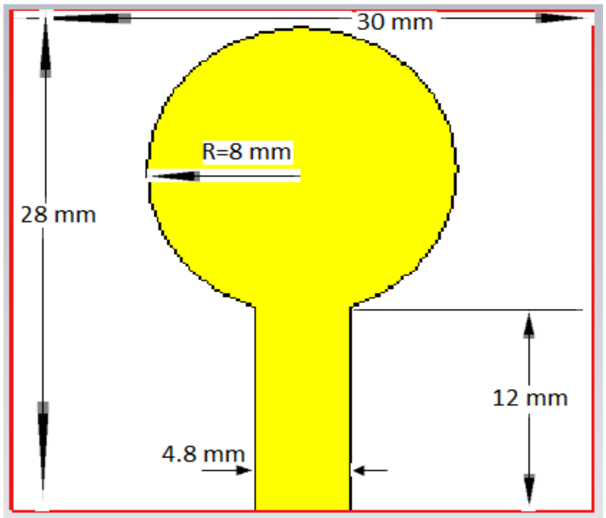


Fig. 5 Front view of circular-shaped antenna

III. Simulated Results and Discussions

The CST microwave studio software was used in simulation run to calculate the results of return loss (S_{11}, VSWR, and radiation patterns in frequency domain. Fig. 6 shows the simulated S_{11} less than -10 dB in the whole UWB bandwidth and the best radiation for rectangular-shaped antenna at frequencies of 4.3 GHz and 8.5 GHz when S_{11} is less than -20 dB. For triangle/rectangular-shaped antenna, the starting frequency at nearly 4 GHz and the best value of S_{11} below -25 dB at 6 GHz as a resonance frequency. In hexagonal-shaped antenna, the S_{11} below -10dB is up to 8 GHz and the best radiation at frequency of 4.2 GHz when S_{11} is less than -25 dB. So this antenna can be used for 3.5 to 8 GHz UWB wireless system applications. In circular-shaped antenna, the S_{11} less than -10 dB characteristics are the same as that for hexagonal antenna. Figs. 7 and 8 show the simulated VSWR of the Taconic TLY-5 material proposed antennas that less than 2 for whole the UWB bandwidth. For the proposed geometrical printed monopole antennas of different shape, the simulation results for radiation patterns are shown in Figs. 9 and 10 which have been performed at 2 GHz to 12 GHz. These radiation patterns were simulated at frequency of 8.5 GHz, elevation angle (Phi = 45^o, 90^o) and azimuth angle (Theta = 45^o, 90^o) which depict antenna's omni-directional patterns along the UWB frequency range. When the phi and theta are equal to 45^o, the radiation patterns are slightly better than those when phi and theta are equal to 90^o in covering omni-directional area.

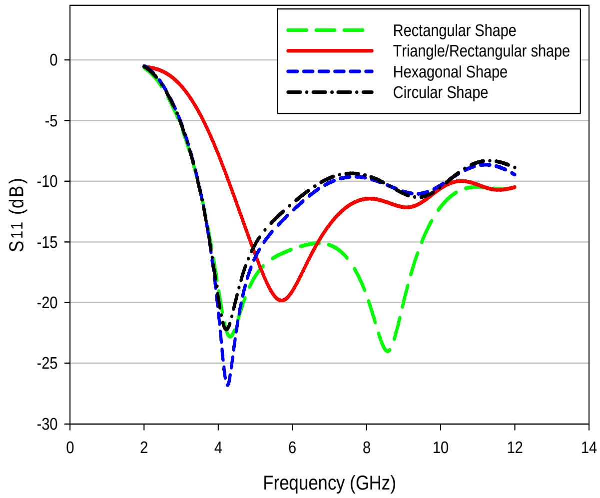


Fig. 6 The simulated return loss for four geometrical forms antennas

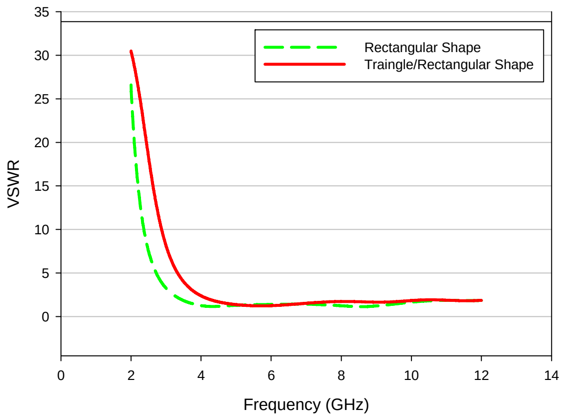


Fig. 7 Simulated rectangular-shaped and triangle/rectangular-shaped antennas VSWR

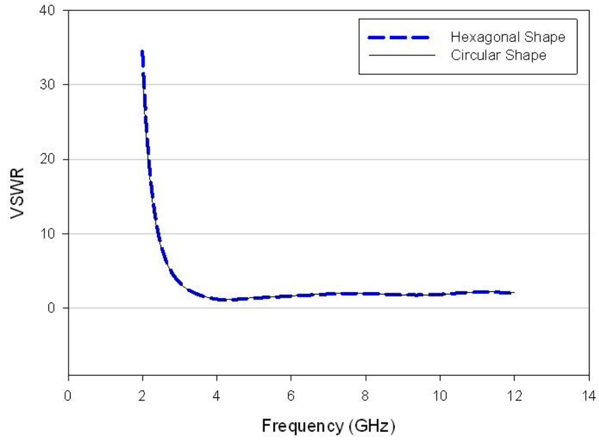
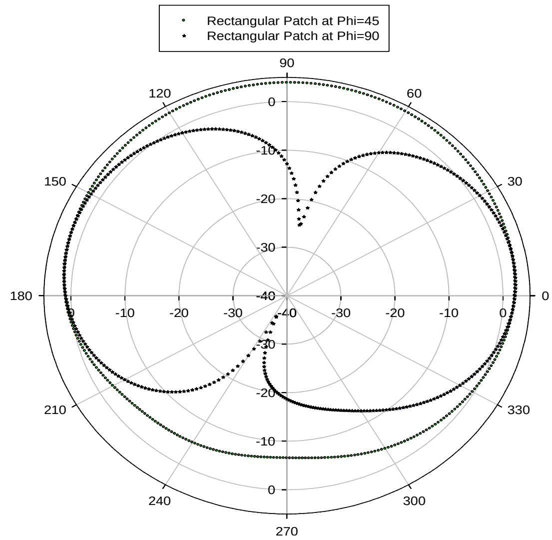
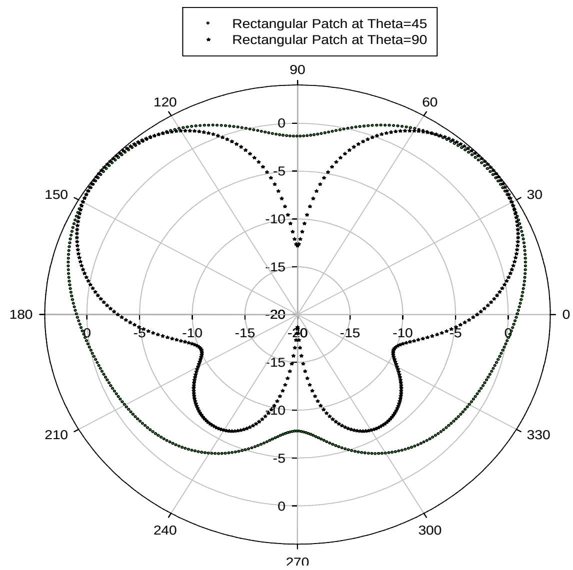


Fig. 8 Simulated hexagonal-shaped and circular-shaped antennas VSWR



(a)



(b)

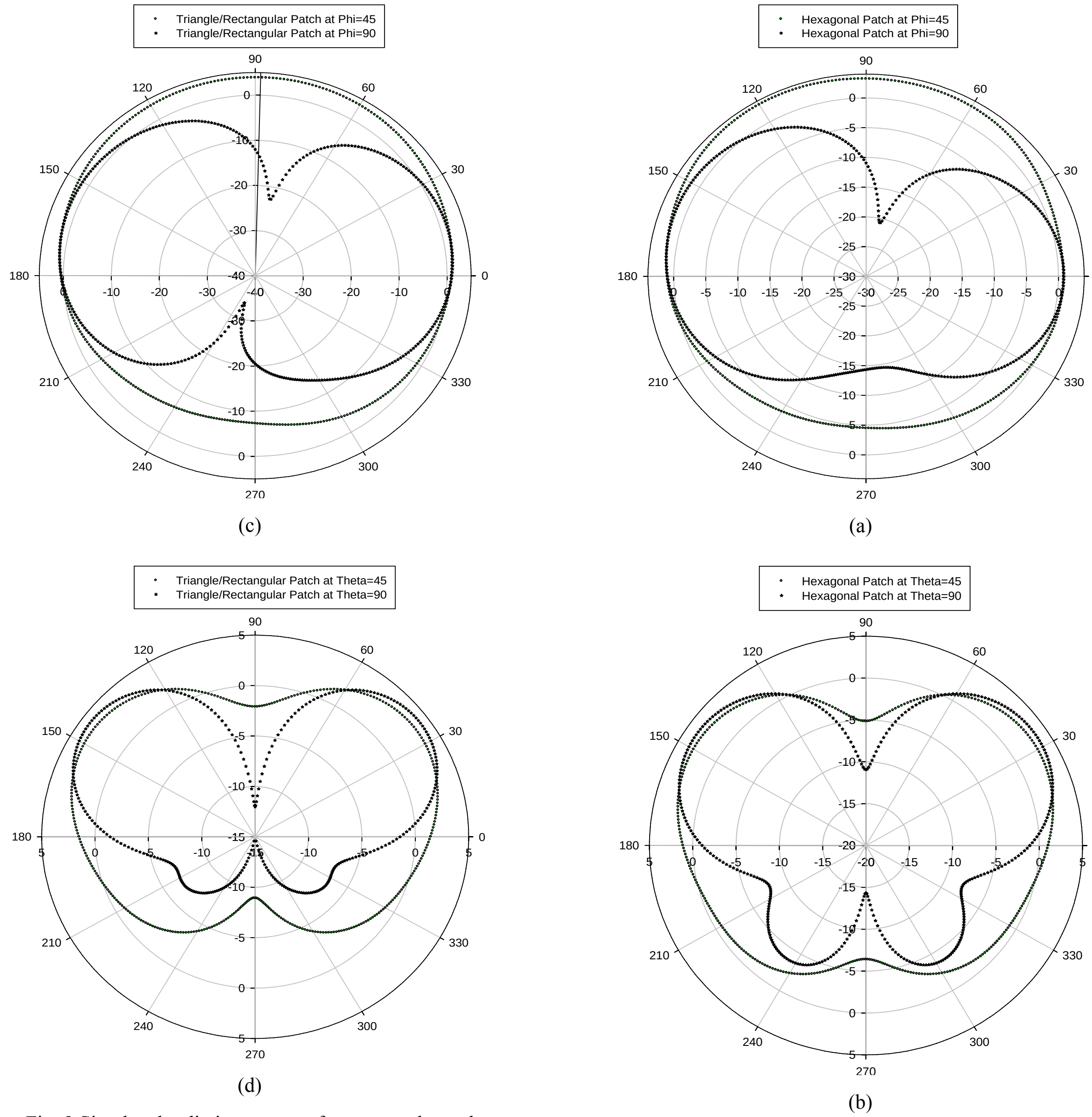
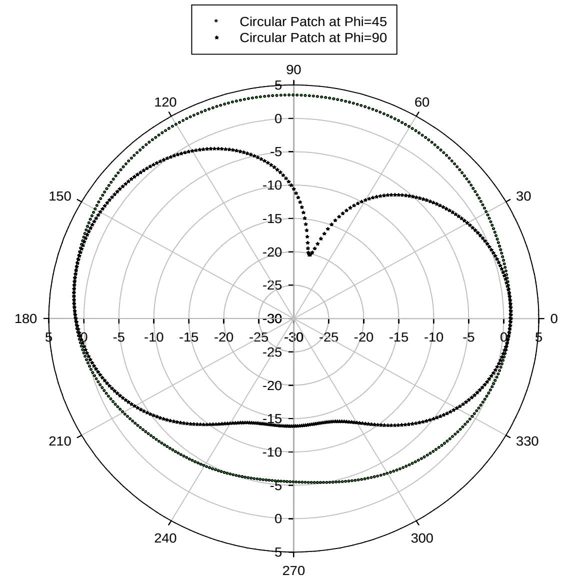
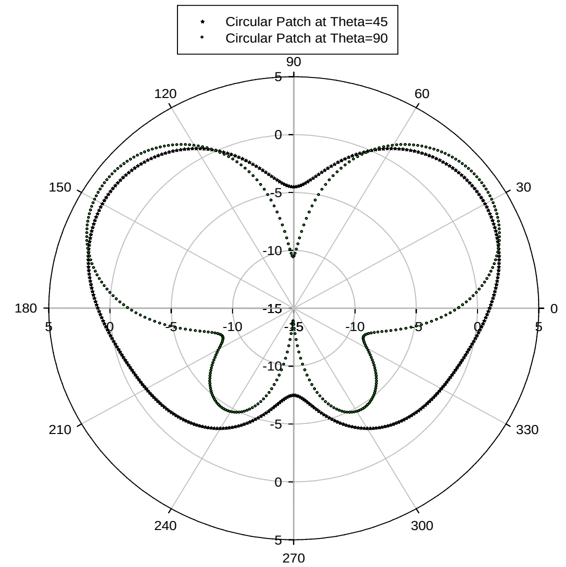


Fig. 9 Simulated radiation patterns for rectangular and triangle/rectangular patch shapes at 8.5 GHz (a), (b) E-plane (c), (d) H-plane



(c)



(d)

Fig. 10 Simulated radiation patterns for hexagonal and circular patch forms at 8.5 GHz (a) and (b) E-plane (c) and (d) H-plane

IV. Conclusions

This paper presents four different patch shapes of UWB antennas with the same substrate, feed transmission line, and ground plane dimensions. These antennas are suitable for small size of wireless UWB and narrow band systems because of their attractive characteristics, such as, small size, low cost, impedance bandwidth, omni-directional radiation, easy fabrication, and low weight. The rectangular and triangle/rectangular patch shapes antennas have a good performance compared with hexagonal and circular patch shapes antennas by covering most of the UWB frequency. So, they are more suitable in operation for multiband systems through the wideband applications.

References

[1] Federal Communications Commission (FCC), "Revision of part 15 of the commission's Rules Regarding Ultra-Wideband Transmission Systems," First Report and order, FCC, pp. 02-48, 2002.

[2] Yusnita Rahayu Razali Ngah, and Tharek Abd. Rahman, "*A Small Novel Ultra Wideband Antenna with Slotted ground plan*e, chapter 18, Ultra-Wideband," Boris Lemberikov, pp. 427-444, Aug. 2010.

[3] M. N. Srifi, "*Ultra-Wideband Printted Antennas Design*, Chapter 10, Ultra Wideband Communications," Shanghai, China, pp. 195-214, Aug. 2011.

[4] M. Hayouni, A. El-Oualkadi, F. Choubani, T. H. Vuong, and J. David, "Antenna Ultra Wideband Enhancement by Non-Uniform Matching," *Progress In Electromegnatic Research Letters*, Vol. 31, pp. 121-129, 2012.

[5] Wagnes, S. T. Rowe, and R. B. Waterhouse, "Investigation in to the Performance of Proximity Coupled Stacked Patches," *IEEE Transactions on Antennas and Propagation*, pp. 1693-1698, Jun. 2006.

[6] Sun, D. L. You, "A Broad-Band Impedance Matching Method for Proximity-Coupled Microstrip Antenna," *IEEE Transaction on Antennas and propagation*, pp. 1392-1397, Apr. 2010.

[7] Dastranj, A. and H. Abiri, "Bandwidth Enhancement of Printed E-shaped Slot Antennas Fed by CPW and Microstripline," *IEEE Transaction on Antennas and Propagation,* pp. 1402-1407, Apr. 2010.

[8] Sze, J. Y. and K. L. Wong, "Bandwidth Enhancement of a Microstripline-Fed Printed Wide-Slot Antenna," *IEEE Transaction on Antennas and propagation*, pp. 1020-1024, Jul. 2011.

[9] Ziani Kerarti Djalal and Meriah Sidi Mouhamed, "New Diamond Antenna for Ultra-Wideband Applications," *International Journal of Computer Science Issues,* Vol. 9, Issue 4, No. 1, pp. 387-390, Jul. 2012.

Rashid Ali Fayadh received his B.Sc. degree from Middlesex University /Engineering College / UK, in 1986 and worked as an electronic warfare engineer in Iraqi air force up to 1998. He received the M.Sc. degree from University of Technology/ Al-Rasheed College / Baghdad-Iraq in 2000. He was a lecturer from 2001 to 2012 in the Electrical and Electronic Technical College, Foundation of Technical Education, Baghdad, Iraq. He is currently working towards the Ph.D. degree in wireless communications at school of computer and communication engineering, University Malaysia Perlis, Malaysia. He is doing research on the antennas design and performance analysis of wireless communication systems, with specific focus on ultra-wideband (UWB) technologies. He has published some reviewed journal and conference papers.

Dr. Mohd. Fareq Abd. Malek received his B. Eng (Hons) in Electronic and Communication Engineering from The University of Birmingham in 1997. He then worked in Siemens Malaysia in the Information and Communications Mobile (ICM) group. He developed the mobile strategy for the Malaysia market, provided network strategy solutions, sales competency in mobile core network and intelligent network product lines. In 2000, he joined Alcatel Malaysia at its regional center of competence, in charge of all aspects of mobile radio network design, planning, solutions, technical sales and trainings. He had provided solutions and trained customer personals from more than 30 telecommunication companies in the Asia Pacific region. He received his MSc (Eng) in Microelectronic Systems and Telecommunications with Distinction from The University of Liverpool, and was also awarded the Sir Robin Saxby Award for the best MSc (Eng) student in 2004. His MSc (Eng) project, "Adaptive Channel Estimation for Multiple-Input Multiple-Output (MIMO) Frequency Domain Equalization (FDE)" was also awarded the best MSc (Eng) project. He received his PhD in Radio Frequency and Microwave in 2008, also from The University of Liverpool. He is now an Associate Professor and Dean (School of Electrical System Engineering) at Universiti Malaysia Perlis. His research interests include antennas and propagation, mobile wireless communications, digital signal processing and microwave engineering. He teaches 'mobile and satellite communications', 'digital communication', 'microwave engineering' and 'antennas and propagation' at university.

Dr. Hilal Adnan Fadhil was born in Paris, France 1981; he received the B.Sc. degree in Electronic and Communication engineering from Al-Nahrain University in 2002, M. Sc. Degree in communications engineering from Al-Nahrain University in 2004, Baghdad, and Ph.D. degree in Optical Communication Engineering from Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia. His research interests include optical CDMA, FDMA technologies and wavelength division multiplexing for Optical Access Networks. He holds several copyright patents in UK and Malaysia and published more than 60 reviewed conference papers and indexed journals articles. Owing to his many research and product achievements and contributions, Hilal A. Fadhil was awarded many Awards and Medals in UK, Europe, and Malaysia; He is a senior member of IEEE Communications Magazine, Optical Engineering Society, IET Optoelectronics and the founding Reviewer of the IEEE Communication Letter.