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Miniaturized Dual-Band Monopole Antenna Design for Wireless Communications

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Abstract— This work carries a dual band monopole antenna design specially meant for wireless applications like Wireless Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (WiMax). The antenna proposed consists of a rectangular patch monopole in which a slot is cut inorder to obtain a dual band operation and size reduction. The antenna operates in two frequency bands which are 2.4 GHz and 5.1 GHz. These two bands are now widely used in wireless communications. The directivity of the antenna when operating at 2.4 GHz range is about 6.5779 dBi and at 5.1 GHz it showed a directivity of about 5.7191 dBi. Also, the VSWR of the proposed antenna is less than 1.5. The proposed antenna has a bandwidth of 245 MHz at 2.4 GHz and 685 MHz at 5.1 GHz. This miniaturized dual band monopole antenna proves to be an effective option for wireless devices to communicate with the outside world.

***Index Terms*—Dual Band, Directivity, Monopole Antenna, Size Reduction, WLAN.**

I. INTRODUCTION

The explosive growth in the demand for wireless communication and information transfer using handsets and personal communication system (PCS) devices has created the need for major advancements of antenna design as a fundamental part of any wireless systems. At the same time, the system must radiate low power and provide reliable communication of voice and possibly data. Added to the operational requirements, the user and service providers demand wireless units with antennas that are small and compact, cost effective for manufacturability, low profile and easy to integrate with the wireless communication system. The antenna designer must also consider the following electrical characteristics of the antenna which include Antenna tuning (Operating Frequency), VSWR, Return Loss(Input Impedance), Bandwidth, Gain Directivity, and Radiation Pattern.

These design considerations have led antenna designers to consider a wide variety of antenna structures to meet the often conflicting needs for wireless systems as: Operation frequency, return loss (VSWR), bandwidth, gain and directivity, location and orientation of the antenna, radiation pattern. The increasing popularity of indoor wireless LAN capable of high-speed transfer rate is prompting the development of efficient broadband antennas. Due to increased usage in residential and office areas, these systems are required to be low profile, aesthetically pleasing and low cost as well as highly effective and efficient. A key requirement of a WLAN and WiMax systems are that it should be low profile, where it is almost invisible to the user. For this reason the monopole antennas are the only choice available for use due to their small real estate area and the ability to be designed to blend into the surroundings. However the technologies for wireless communication still need to be improved further to satisfy the higher resolution and data requirements. Another important thing to look to is the cost and in this sense also monopole antenna is the only option. Monopole is a type of the radio antenna formed by replacing one half of a dipole antenna with a ground plane at right angles to the remaining half. This paper contains such a monopole antenna design that effectively covers two bands that is used now-a-days for wireless applications.

II. RELATED WORK

Dual and multi-frequency band operation of antennas has increasingly become common, mainly because of the tremendous growth in modern wireless communication systems. Many antennas are available for wireless applications. Dual band monopole antennas have been reported [1]-[5] but these however offer a narrow impedance bandwidth characteristic. Wideband Printed Monopole Antenna [6] was introduced by Chien-Yuan Pan, Tzyy-Sheng Horng, Wen-Shan Chen, and Chien-Hsiang Huang for WLAN/WiMAX Applications in 2007. The proposed monopole wideband antenna operating in dual band satisfied not only the wireless local area network (WLAN) applications; also accomplish the worldwide interoperability for microwave access applications (WiMax). The antenna structure is comprised of a rectangular monopole with a 50Ω micro strip feed line for excitation and a trapezoid conductor-backed plane for band broadening. The use of trapezoid conductor-backed plane has increased impedance bandwidth very remarkably.

Hisamatsu Nakano, Mitsutoshi Fukasawa, and Junji Yamauchi proposed Discrete Multiloop, Modified Multiloop, and Plate-Loop Antennas [7] in March 2002. The VSWR characteristic has been analyzed over multi-frequency and wideband for discrete Multiloop (ML), modified ML, and plate-loop (PL) antennas. The analysis of the discrete ML antenna shows that one of the loops resonates when its circumference is approximately one wavelength. It follows that the discrete ML antenna has N minima in the frequency response curve of the VSWR. Further analysis reveals that the PL antenna has a VSWR bandwidth similar to that of the modified ML antenna. Small Low-Profile Loop Wideband Antennas with Unidirectional Radiation Characteristics [8] were presented by Do-Hoon Kwon, and Yongjin Kim. Directive radiation characteristic is achieved by proper

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combination of fields radiated by symmetric and anti-symmetric current components supported by any loop antenna. The reasonable forward gain over UWB frequency band is observed except for the backward gain over 6-10 GHz range, where the gain response has been dropped sharply. The gain of this antenna in the desired direction of maximum radiation exceeds the maximum achievable practical gain for omni directional antennas of the same dimensions over wide frequency band. Without increasing the size of the antenna, unidirectional radiation pattern can be obtained by selecting the proper combinations of the TM (electric dipole) and the TE (magnetic dipole) spherical modes.

Gyoo-Soo Chae and Young-Ki Cho explained about PIFA for Dual-Band WLAN operations [9] in 2004. The proposed antenna design is based on the folded quarter-wave antennas, which have a conductor plate having two arms. This extremely thin prototype antenna can perform in IEEE 802.11a, b (2.4-2.484 GHz and 5.15-5.35 GHz) and be adopted for laptop applications. However, for the 5 GHz band, the bandwidth is only 430 MHz (4.9-5.3 GHz), which is not enough to cover the entire 5 GHz band in WLAN system. In order to expand the bandwidth in 5 GHz band (5.15-5.85 GHz), improved design is required. Anyhow the proposed antenna has good characteristics in the 2.4 GHz and 5 GHz bands, manufacturing and installation in the fixtures are very simple and easy. Finally, it has been very easy to tune the antenna in lower and higher bands by controlling the two arms.

Soon-Ho Hwang et. Al [10] proposed an antenna that covers dual bands which are the ISM (2400-2483MHz and 5150-5350MHz/5725-5875MHz) and satellite DMB (2535-2655MHz) bands. This novel structure is the folded printed dipole type antenna with a small ground plane while retaining the similar antenna performances with the conventional PIFA. This folded dipole arms are designed to operate at two resonant modes, 2GHz and 5GHz bands. But the measured gain of the antenna is lower.

This paper focuses on miniaturized monopole antenna design for wireless applications. In Section III, a detailed design procedure for designing the miniaturized monopole antenna is given. Followed by Section IV describing the experimental results and their discussion. Later on, Section V holds some concluding remarks of the results obtained.

III. DESIGN PROCEDURE AND SIMULATION RESULTS OF THE MINIATURIZED MONOPOLE ANTENNA

A. Design Procedure

One of the most popular antennas for wireless communication is the monopole antenna. In communication systems the most important things to look for are the cost and low power of the device used. In case of the antenna this two things can be satisfied by means of using the monopole antenna. Monopole is an antenna with just the radiating element where the ground of the transmitter is connected to an electrical ground which serves as an Image ground to the radiating element. Thus the name "mono" pole. Fig. 1 shows the geometry of the proposed monopole antenna for the dual band wireless applications.

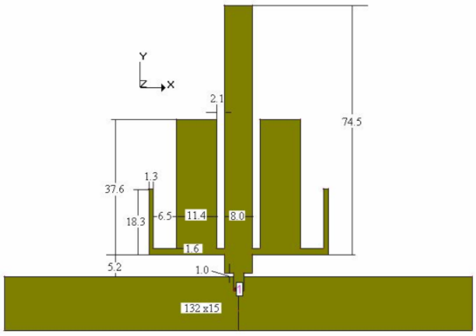

Fig. 1 Geometry of the Proposed Dual Band Monopole Antenna

The proposed monopole consists of a radiation patch along with the ground plane and slots in order to achieve dual band operation and size reduction. The antenna is designed and developed purely in Advanced Design Systems (ADS) environment. It is built by using the FR4 substrate with a specific relative dielectric constant 'ξ_r' of 4.4 and thickness 'h' of about 1.59mm and a loss tangent value of about 0.02 is also included so as to remove any losses. Ground plane is printed on the bottom side of the substrate. Fig 2 shows the configuration of the proposed capacitor loaded monopole antenna. The dimensions of the proposed antenna are all taken in millimeters. The proposed monopole antenna designed in ADS is given in fig. 2.

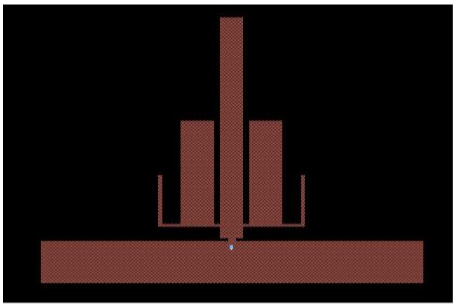

Fig. 2 Proposed Dual Band Monopole Antenna Designed in ADS

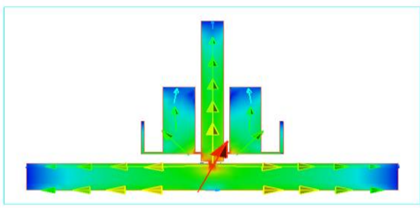

Fig. 3 Current Distribution of the Proposed Dual Band Monopole Antenna Designed In ADS

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B. Simulation Results and Discussions

The current distribution of the antenna is shown in fig. 3. When the monopole element is very thin and not too long, its current distribution is approximately sinusoidal and independent of the radius of the ground plane. Consequently, the element's current distribution can be initially specified and wended only determine the ground plane's current distribution. The return loss of proposed dual-band antenna is shown in fig. 4. This dual-band antenna has the return loss of -30.358 dB at the frequency of 2.434 GHz which is the center frequency of first band. At 5.1 GHz, centre of second band, the return loss is -35.295 dB. Fig. 4 also shows that the measured impedance matching is better than 15 dB across the frequency bands from 2.32 GHz to 2.56GHz and 4.8 GHz to 5.524 GHz, which cover and exceed both of wireless local area network (WLAN) bands, except 802.11a upper band 5.725-5.825 GHz.

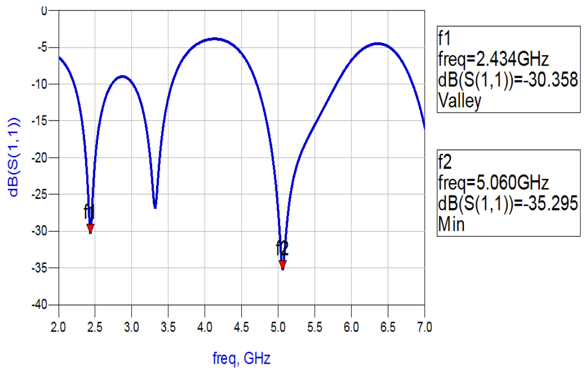

Fig. 4 Return Loss of the Proposed Dual Band Monopole Antenna Designed In ADS

For a radio (transmitter or receiver) to deliver power to an antenna, the impedance of the radio and transmission line must be well matched to the antenna's impedance. The parameter VSWR is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to. VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR).

The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this case, no power is reflected from the antenna, which is ideal. Often antennas must satisfy a bandwidth requirement that is given in terms of VSWR. The proposed antenna for dual-band operation provides the required VSWR≤1. 5 matching band, from 2.434 GHz and 5.060 GHz, Assuming the input impedance of feed is 50Ω. It is evident that required bands have been achieved with desired VSWR values. Fig. 5 shows VSWR Vs frequency plot. It shows the double minima obtained for dual-band antenna. The important parameters that measure the performance of any antenna are the gain, directivity and radiation pattern. The term Antenna Gain describes how much power is transmitted in the direction of peak radiation to that of an isotropic source.

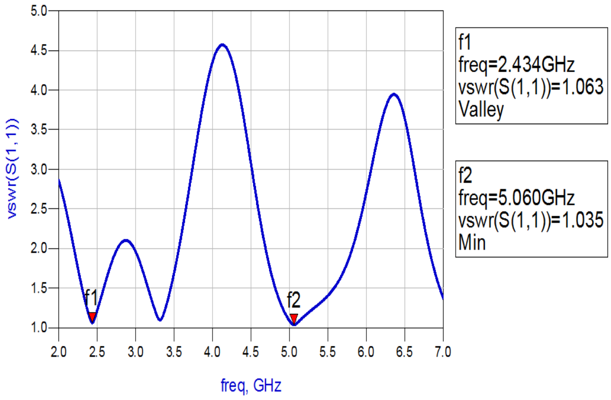

Fig. 5 The Simulated VSWR of The Proposed Dual Band Monopole Antenna Designed In ADS

Antenna gain is more commonly quoted in a real antenna's specification sheet because it takes into account the actual losses that occur. It is measured in terms of dB. The simulated gain for the dual-band antenna is shown in fig 6. It shows that the reasonable gain is achieved over bands from 2.434 GHz and 5.060 GHz.

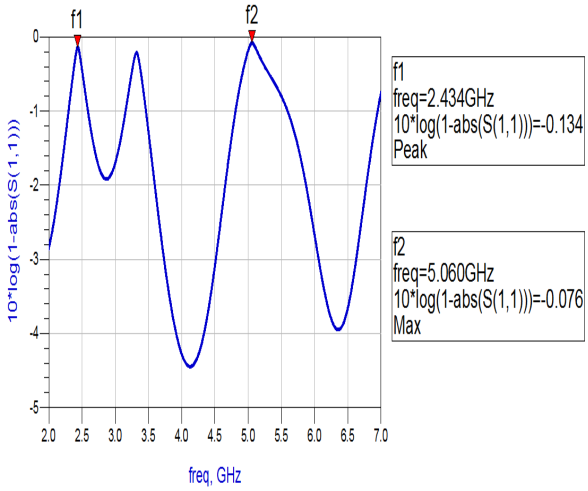

Fig. 6 The Simulated Gain of The Proposed Dual Band Monopole Antenna Designed in ADS

Directivity is the ability of an antenna to focus energy in a particular direction when transmitting, or to receive energy better from a particular direction when receiving. In a static situation, it is possible to use the antenna directivity to concentrate the radiation beam in the wanted direction. However in a dynamic system where the transceiver is not fixed, the antenna should radiate equally in all directions, and this is known as an omni-directional antenna. Fig 7 (a), fig 7 (b), and fig 7 (c) show the simulated 2-dimensional radiation patterns for the dual-band antenna operating at 2.4 GHz in the x-y, x-z, and y-z planes respectively. And the directivity of 6.5779 dBi is obtained at 2.4 GHz.

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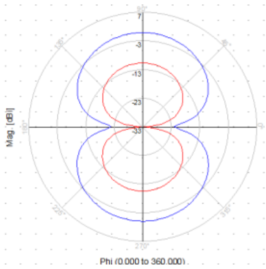
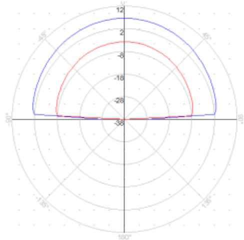
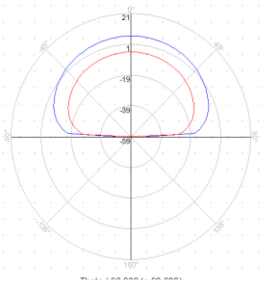


(a)



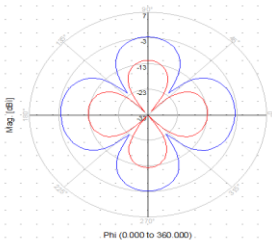
(b)



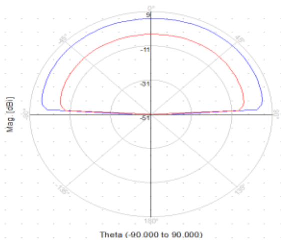
(c)

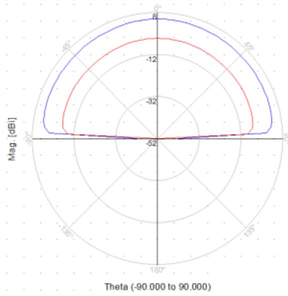
Fig. 7 2-D Radiation Patterns of the Dual-band monopole antenna at 2.4 GHz (a) x-y plane, (b) x-z plane, and (c) y-z plane.

The simulated directivity of the dual-band antenna at the frequency of 5.1 GHz is 5.7191 dBi. Fig 7 (a), fig 7 (b), and fig 7 (c) show the simulated 2-dimensional radiation patterns for the dual-band antenna operating at 5.1 GHz in the x-y, x-z, and y-z planes respectively.



(a)

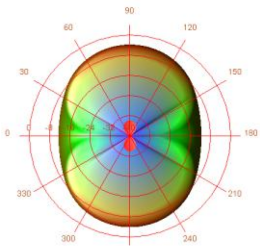




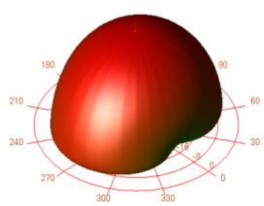
(c)

Fig. 8 2-D Radiation Patterns of the Dual-band monopole antenna at 5.1 GHz (a) x-y plane, (b) x-z plane, and (c) y-z plane.

Next performance measure is the radiation pattern. An antenna radiation pattern or antenna pattern is defined as "a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. In most cases, the radiation pattern is determined in the far-field region and is represented as a function of the directional coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity, phase and polarization. A trace of the received electric (magnetic) field at a constant radius is called the amplitude field pattern. On the other hand, a graph of the spatial variation of the power density along a constant radius is called an amplitude power pattern. Fig 9 shows the radiation pattern of the proposed dual-band antenna at 2.4 GHz.

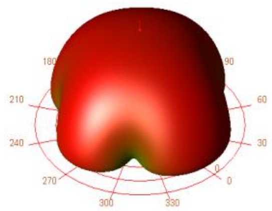


(a)

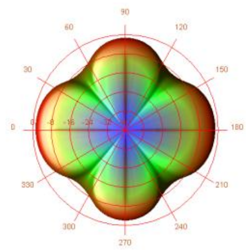


(b)

Fig. 9 3-D Radiation Pattern of the Dual-Band Antenna at 2.4 Ghz (a) Bottom View and, (b) Isometric View



(a)



(b)

Fig. 10 3-D Radiation Pattern of the Dual-band antenna at 5.1 GHz (a) Bottom View and, (b)

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IV. CONCLUSION

A dual band monopole antenna specially meant for wireless applications like Wireless Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (WiMax) was proposed. The antenna proposed operates in dual band operation and it was also size reduced. The antenna operates in two frequency bands which are at 2.4 GHz and 5.1 GHz. The directivity of the antenna when operating at 2.4 GHz range is about 6.5779 dBi and at 5.1 GHz it showed a directivity of about 5.7191 dBi. Also, the VSWR of the proposed antenna is less than 1.5. The proposed antenna has a bandwidth of 245 MHz at 2.4 GHz and 685 MHz at 5.1 GHz. This miniaturized dual band monopole antenna proves to be an effective option for wireless devices to communicate with the world.

REFERENCES

[1] Tae-Hyun Kim and Dong-Chul Park, “Compact Dual-Band Antenna with Doub; e L-Slits for WLAN Operation”, IEEE Antennas and Wireless Propagation Letters, Vol. 4, 2005.

[2] D. Nashaat, H.A.Elsadek and H Ghali, “Dual- band reduced size PIFA antenna with U-slot for Bluetooth and WLAN applications”, IEEE Proc. on Antennas and Propagation Society Int. Symp, vol 2, pp 962-965, 2003.

[3] C.C.Lin, G.Y.Lee and K.Y.Wong, “Surface mount dual-loop antenna for 2.4/5 GHz WLAN operations”, Electron. Lett. , vol 39, pp. 1302-1304, Sept. 2003.

[4] Y.L.Kuo and K.L.Wong, “Printed double-T monopole antenna for 2.4/5.2 GHz dual band WLAN operations”, IEEE Transaction Antennas and Propagation, vol. 51, no 9, pp 2187-2192, Sept. 2003.

[5] Y.H.Suh and K.Chang, Low cost microstripfed dual frequency printed dipole antenna for wireless communications, Electron. Lett. vol. 36, pp. 1177-1179, Jul 6 2000.

[6] C-Y Pan, T-S Horng,, W-S Chen,C-H Huang, “Dual Wideband Printed Monopole Antenna for WLAN/WiMAX Applications”, IEEE Trans. Antennas and Wireless Propagation Letters, Vol. 6, 2007.

[7] H. Nakano, M. Fukazawa, and J. Yamauchi, “Discrete multiloop, modified multiloop, and plate-loop antennas—multifrequency and wideband VSWR characteristics,” IEEE Trans. Antennas Propag., vol.50, pp. 371–378, Mar. 2002.

[8] D.-H. Kwon and Y. Kim, “Small low-profile loop wideband antennas with unidirectional radiation characteristics,” IEEE Trans.Antennas Propag., vol. 55, pp. 72–77, Jan. 2007.

[9] Gyoo-Soo Chae- Young-Ki Cho, “Printed Folded Antenna for Dual-Band WLAN operations”, JKEES, vol 4, No.3.sep. 2004.

[10] Soon-Ho Hwang, Young-Jun Cho, and Seong-Ook Park, “A Printed Multi-Band Antenna for 2.4/5GHz WLAN and Satellite DMB Applications”, Proceedings of ISAP2005, SEOUL, Korea.