PRINTED MONOPOLE ANTENNA FOR WIRELESS SENSOR NETWORK

UMAIMAH JAMALUDIN

UNIVERSITI TEKNOLOGI MALAYSIA

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UMAIMAH JAMALUDIN

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To

My dearest husband and family

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In the name of ALLAH, the Most Gracious and Most Merciful.

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ABSTRACT

Wireless sensor network (WSN) are networks that consist of spatially distribute device using sensors to monitor physiological conditions, agricultural environment and disaster rescue. One of the important components in WSN communication is antenna. However, WSN as an individual node faced a lot of constraints in terms of limited processing space, storage capacity and communication bandwidth. This is because; it has to be low in energy source. Thus compactness and small design are crucial for WSN antenna. The focus of this research is to design WSN antenna with reduced size. Based on modification from several research papers, three monopole antenna configurations are proposed C-shaped monopole antenna, loop monopole antenna and S-shaped monopole antenna. Parametric investigation is then carried out to achieve size reduction as well as desired frequency of operation of 2.45 GHz. This proposed design is then simulated and fabricated to obtain the properties of the antenna. C-shaped monopole and loop monopole antenna successfully achieved the desired frequency and size miniaturization and can be used for WSN application.

ABSTRAK

Rangkaian penderia tanpa wayar (WSN) adalah rangkaian yang merangkumi sekumpulan penderia yang diletakkan berasingan dalam jarak tertentu untuk mengawasi dan mengumpul data. Teknologi ini boleh diaplikasikan untuk pelbagai bidang contohnya dalam bidang pertanian untuk mengawasi keadaan tanah dengan mengumpul data mengenai suhu, kelembapan, dan komposisi kimia. Dalam bidang komunikasi, antenna memainkan peranan yang penting. Objektif penyelidikan ini ialah untuk mereka bentuk antenna dengan pengurangan saiz bagi aplikasi WSN. Tiga rekabentuk dicadangkan iaitu gelung ekakutub, bentuk C-ekautub dan bentuk S-ekakutub. Kesemua antenna ini disimulasi dan perubahan panjang antenna diubah untuk mencapai frekuensi 2.45 GHz dan pengurangann saiz. Prestasi antenna dibandingkan. Didapati antenna ekakutub dan C-ekakutub adalah mencapai prestasi yang memnuhi kehendak spesifikasi.

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LIST OF ABBREVIATIONS

WSN	–	Wireless Sensor Network
HPBW	–	Half Power Beamwidth
VSWR	–	Voltage Standing Wave Ratio
CPU	–	Central Processing Unit
UPS	–	Uninterruptible Power Supply
RF	–	Radio Frequency
QoS	–	Quality of Service
LAN	–	Local Area Network
WAN	–	Wide Area Network
TV	–	Television
RL	–	Return Loss
BW	–	Band Width
MMICs	–	Microwave Monolithic Integrated Circuits
OEICs	–	Optoelectronic Integrated Circuits
PC	–	Personal Computer
IEEE	–	Institute of Electrical and Electronics Engineers
ISM	–	Industrial Scientific and Medical
WiFi	–	Wireless Fidelity
SHR	–	Self Healing Ring
CM	–	C-shaped Monopole Antenna
LM	–	Loop Monopole Antenna
SM	–	S-shaped Monopole Antenna

LIST OF SYMBOLS

GHz	–	Giga Hertz
MHz	–	Mega Hertz
Hz	–	Hertz
Γ	–	reflection coefficient
Zin	–	input impedance
Zo	–	characteristic impedance
Zl	–	load impedance
dB	–	decibel
Ω	–	ohm
V_{max}	–	maximum voltage
V_{min}	–	minimum voltage
S_{11}	–	input reflection coefficient
f_h	–	high frequency
f_l	–	low frequency
f_c	–	center frequency
εr	–	dielectric constant of the substrate
εeff	–	effective dielectric constant
H	–	height of substrate
fr	–	resonance frequency
c	–	speed of light 3x 10^{-8} m/s

fo	–	operating frequency
C	–	Capacitance
R	–	Resistance
L	–	Inductance
tan δ	–	loss tangent
t	–	copper thickness
Wg	–	width of gap
La	–	length of center arm
Lg	–	Length of gap
mm	–	milimeter
d	–	diameter
λo	–	free-space wavelength

LIST OF APENDIX

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Wireless sensor networks (WSNs) are networks that consist of spatially distributed devices using sensors to monitor physiological conditions, agricultural environment and disaster rescue [1]. This new emerging technology can be applied to improve the quality of life such as in agricultural industries including monitoring of soil properties like temperature, humidity, and chemical composition. These can be measured in a collective way, thus providing essential data for the entire farm to start a new batch of crop.

Lots of other applications that can be benefitted from this technology are in environmental and habitat studies, military surveillance, and infrastructure for health monitoring. Hence, all WSN components need to be addressed. One important factor for consideration is communication. To monitor a collective network, each node has to communicate with central servers wirelessly under the constraint of low power consumption, low cost and added design flexibility. The necessary on-chip integrated transceivers are widely available.

However, WSN as an individual node faced a lot of constraints in terms of limited processing space, storage capacity and communication bandwidth. This is because; it has to be low in energy source. Thus compactness and small design are crucial for WSN antenna. The focus of this research is to design WSN antenna with reduced size. Based on modification from several research papers, three monopole antenna configurations are proposed C-shaped monopole antenna, loop monopole antenna and S-shaped monopole antenna. Parametric investigation is then carried out to achieve size reduction as well as desired frequency of operation of 2.45 GHz. This proposed design is then simulated and fabricated to obtain the properties of the antenna. C-shaped monopole and loop monopole antenna successfully achieved the desired frequency and size miniaturization and can be use for WSN application.

1.2 Problem Statement

WSN can be applied to various industries. Many applications are yet to be discovered that can be benefitted by WSN technologies. Antenna design for WSN faced the constraint in terms of small size and compact antennas as well as the need for better performance. This research addresses this problem by proposing suitable antenna configuration that operates in 2.45 GHz ISM band with focused on size miniaturization.

1.3 Objective

The objective of this project is to design reduced size antenna for WSN application. The chosen frequency of application is 2.45 GHz. The proposed design sets are then studied and analyzed to obtain the desired specification. The performances of these antennas are then compared. The optimum antenna is then fabricated and measured.

1.4 Scope of Work

The scope of work consists of several stages. Firstly, the WSN architecture is studied and the importance of WSN antenna is investigated through reported designs in the literature. Next, the antenna theory is studied whereby suitable WSN antennas can be proposed. Thirdly, three antenna configurations are proposed based on modifications done to the basic monopole antenna that is normally used in WSN application.

- Printed C-shaped monopole antenna
- Printed S-shaped monopole antenna
- Printed loop monopole antenna

These three configurations are then simulated and analyzed. Performance measures obtained are in terms of return loss, efficiency and radiation pattern. These are then analyzed and compared. Further fine tuning is done for optimization purposes. The optimum antenna is then fabricated and measured for verification with the simulated results.

1.5 Thesis Outline

This thesis consists of five chapters. The first chapter outlines the undertaken research briefly by presenting its background, and problem statement, followed by the objective, scope of study and thesis outline. Chapter two discusses relevant literature review on WSN, constraints in designing WSN antennas and several related WSN antenna designs that have been reported. In chapter three, brief theory on the antenna is presented, followed by the design methodology. Explanation on the fabrication and measurements are also given. The simulation and measurement results are presented next in chapter four. These are analyzed in depth and the findings highlighted. The final chapter concludes the thesis. Recommendation for future work is then given.

REFERENCES

[1] Yang Yu, Viktor K Prasanna, Bhaskar Krishnamachari, "Information Processing And Routing In Wireless Sensor Networks" 2nd^{t} Edition, Imperial College Press, London, 2010

[2] F.L Lewis, D.J Cook, S.K Das, "Wireless Sensor Network - Smart Environment: Technologies, Protocol and Application," 2st Edition, John Wiley & Sons, New York, 2004.

[3] Culler. D., Estrin. D. and Srivasta, M. "Guest Editors' Introduction: Overview of Sensor Networks" IEEE journal in Computers Society, Vol 37, pp 41- 49, August 2004.

[4] Liu.H, M.Zhijun, W.Maohua, "Wireless Sensor Network for Cropland Environment Monitoring" Networks Security, Wireless Communications and Trusted Computing Conference, August 2009.

[5] Constantine, A. Balanis, "Antenna Theory Analysis and Design," 3rd Edition, John Wiley &, Sons, Singapore, 2005.

[6] Junjun Wang and Xudong He, "Analysis and Design of a Novel Compact Multiband Printed Antenna" International Journal of Antennas and Propagation by Hindawi Publishing Corporation, 2013

[7] Li Zhang, Yong-Chang Jiao, Yang Ding, Bo Chen, and Zi-Bin Weng, "Cpw-Fed Broadband Circularly Polarized Planar Monopole Antenna With Improved Ground-Plane Structure" Ieee Transactions On Antennas And Propagation, Vol. 61, No. 9, Pp 4824- 4828, September 2013

[8] Ping Cao, Yi Huang, Jingwei Zhang and Rula Alrawashdeh, "A Compact Super Wideband Monopole Antenna" in Antennas and Propagation (EuCAP), Proceedings of 7th European on, pp 3107-3110, 2013.

[9] H. Chen, X. Yang, Y.-Z. Yin, J.-J. Wu And Y.-M. Cai, “Tri-Band Rectangle-Loaded Monopole Antenna With Inverted-L Slot For Wlan/ Wimax Applications” Electronics Letters 26th September 2013 Vol. 49 No. 20 Pp. 1261–1262

[10] Chenard, J.-S., Zilic, Z.; Chun Yiu Chu; Popovic, M., "Design Methodology For Wireless Nodes With Printed Antennas," Design Automation Conference, 2005. Proceedings. 42nd, Pp. 291- 296, 13-17 June 2005

[11] Li Zheng, “ZigBee Wireless Sensor Network in Industrial Applications,” SICE-ICASE, 2006. International Joint Conference 18-21 Oct. 2006, Page(s):1067 - 1070.

[12] K. Phaebua, and D. Torrungrueng,, “A Compact Antenna for server Node of Wireless Sensor network,” IEEE Antennas Wireless Propag. Lett., pp. 1-4, 2008.

[13] Panda, J.R.; Kshetrimayum, R.S.”A printed C-shaped dual-band monopole antenna for RFID applications “ in Applied Electromagnetics Conference (AEMC), pp1-3,2009

[14] Mallahzadeh, A.R.; Seyyedrezaei, S.F.; Ghahvehchian, N.; Nezhad, S.M.A.; Mallahzadeh, S, “Tri-band printed monopole antenna for WLAN and WiMAX MIMO system” in Antennas and Propagation (EUCAP), Proceedings of the 5th European Conference on 2011. Pp548-551

[15] Xian-Ling Liang, Shun-Shi Zhong and Li-Na Zhang “Printed S-Shaped Monopole Antenna for Tri-Band WLAN Application” Antennas, Propagation & EM Theory, 2006. ISAPE '06. 7th International Symposium on 26-29 Oct. 2006 pp1-3.

[16] Pulse Finland Oy “W3000 ceramic monopole antenna” in W3000 datasheets, copyright of 2009.

[17] Balanis, C. A. and Birtcher, C. R. (2007)” Antenna Measurements, in Modern AntennaHandbook (ed C. A. Balanis), John Wiley & Sons, Inc., Hoboken, NJ, USA