WIDEBAND CPW-FED MONOPOLE ANTENNA FOR CUSTOMER PREMISES EQUIPMENT (CPE) OF LTE APPLICATIONS

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To my beloved Mostafa

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ABSTRACT

Design of a Wideband CPW-fed Monopole Antenna with low volume is of practical interest for the ever growing wireless communication industry. In this regard, the design of a wideband monopole antenna for Customer premises equipment (CPE) for Global System for Mobile Communications (GSM, 900 MHz and 1.5 GHz), Wireless Fidelity(WiFi, 2.4 GHz (2.4-2.484GHz)) , Long-Term Evolution(LTE, 0.9GHz - 2.6 GHz) applications by using Co-Planar Waveguide fed is proposed. Bandwidth enhancement is obtained by modifying the patch of antenna by cutting the corners like steps. The parametric study is performed to understand the characteristics of the proposed antenna. The antenna operates in wide frequency bands from 0.9 GHz to 2.6 GHz covering LTE bands. Also good antenna performances such as radiation patterns and antenna gain over the operating band have been observed and simulated peak gain of the antenna is 4.3 dBi at resonant frequency of 2.6 GHz

ABSTRAK

Reka bentuk Monopole Antena Wideband CPW-makan dengan jumlah yang rendah adalah kepentingan praktikal bagi industri komunikasi wayarles yang sentiasa berkembang. Dalam hal ini, reka bentuk antena Wideband Monopole bagi premis Pelanggan peralatan (CPE) bagi Sistem Global untuk Komunikasi Mudah Alih (GSM, 900 MHz dan 1.5 GHz), Wireless Fidelity (WiFi, 2.4 GHz (2.4-2.484GHz)), Long -Term Evolution (LTE, 0.9GHz - 2.6 GHz) permohonan dengan menggunakan Co-Planar Waveguide makan adalah dicadangkan. Peningkatan Bandwidth diperolehi dengan mengubah patch antena dengan mengurangkan sudut-sudut seperti langkah. Kajian parametrik dijalankan untuk memahami ciri-ciri antena yang dicadangkan. Antena beroperasi dalam jalur frekuensi luas daripada 0.9 GHz kepada 2.6 GHz meliputi band LTE. Persembahan antena juga baik seperti corak sinaran dan gandaan antena lebih band operasi telah diperhatikan dan simulasi keuntungan puncak antena ialah 4.3 dBi pada frekuensi salunan 2.6 GHz.

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INTRODUCTION

1.1 Introduction

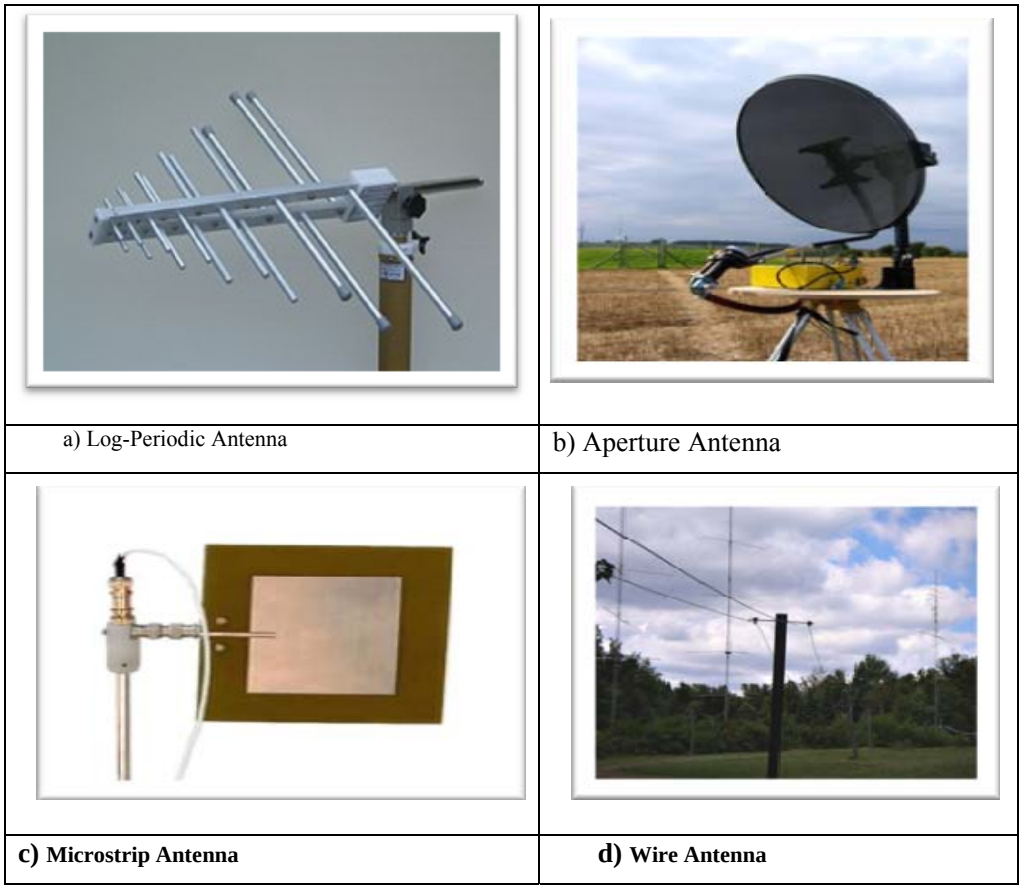
Antennas are the backbone and almost everything in the wireless communication without which the world could have not reached at this age of technology.

Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, broadcast television, two-way radio, communications receivers, radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, Bluetooth enabled devices, wireless computer networks, baby monitors, and RFID tags on merchandise.

A basic classification for antenna types:

- Wire antennas: dipoles, monopoles, helical antennas and Yagi-Uda antennas, commonly used in lower frequency
- Aperture antennas: waveguide horn, slot in waveguide, cavity or ground plane, generally used in microwave frequency.
- Printed antennas: microstrip antennas, used in microwave frequency and MMIC Applications.

- Reflector antennas: parabolic reflector antenna and Cassegrain antenna operating at microwave frequencies [1].



a) Log-Periodic Antenna

b) Aperture Antenna

c) Microstrip Antenna

d) Wire Antenna

Figure 1.1 Types of antenna

Antennas have so many applications:

- Automatic Vehicle Location (AVL)
- Broadcast: Television and Radio
- Cable Television, Wireless (MMDS)
- Cellular Radio
- Cordless Telephones
- Direction Finding
- Global Positioning System (GPS)

- Local and Wide Area Networks, Wireless (LAN/WAN)
- Low Power Wireless Devices (FCC Part 15)
- Marine Communications and Navigation
- Military Communications and SATCOM
- Mobile Radio
- Pagers and Paging Transmitters
- Personal Communications Systems (PCS)
- Portable Wireless Products
- Radio Frequency Identification (RFID)
- Supervisory Control And Data Acquisition (SCADA)
- Trunked Radio, SMR, LMR
- Spread Spectrum Devices
- Transportation Systems (IVHS, Automatic Toll Systems, etc.)

Each type of antenna has some advantages and disadvantages. Among all types of antenna such as Aperture Antennas, Microstrip Antennas, Wire Antennas, and Log-Periodic Antennas, Microstrip Antennas get more and more important in today's world of wireless communication systems. Compared with conventional antennas, microstrip patch antennas have more advantages. They have very light weight and low profile and they are smaller in their dimension, they are low cost, and their fabrication is so much easier than other antennas. Because such antennas have a very low profile, are mechanically rugged and can be adaptable, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

In this thesis the antenna works in the frequency range of Customer premises equipment (CPE) for Long Term Evolution (LTE) networks, from 900MHz to 2600MHz.

A customer premises equipment device (CPE device) refers to a telecommunications hardware device located on the telecommunication customer's

premises. This equipment might include cable or satellite television set-top boxes, DSL or other broadband Internet routers, VoIP base stations, telephone handsets, or other customized hardware. CPE equipment can be owned by the customer or leased from the telecommunications company. CPE also includes the interior wiring at the customer's location that is connected to a communication service. CPE devices facilitate the delivery of services provided by the telecommunications company. These devices are frequently modems or routers owned and provided by an Internet service provider (ISP). This arrangement shields the customer from the cost of the technology upgrades while providing the ISP with more control over the delivery of the services.

Figure 1.2 Customer Premises Equipment (CPE)

Long Term Evolution (LTE) is a wireless broadband technology designed to support roaming Internet access via cell phones and handheld devices. Because LTE offers significant improvements over older cellular communication standards, some refer to it as a 4G (fourth generation) technology along with WiMax.

With its architecture based on Internet Protocol (IP) unlike many other cellular Internet protocols, Long Term Evolution supports browsing Web sites, VoIP and other IP-based services well. LTE can theoretically support downloads at 300 Megabits per second (Mbps) or more based on experimental trials. However, the actual network bandwidth available to an individual LTE subscriber sharing the

service provider's network with other customers is significantly less. LTE is used for 4G wireless networks to deliver high-speed wireless service.

Typically, 4G wireless is supposed to be anywhere from four to ten times faster than 3G networks. Long Term Evolution service is only available in limited geographic areas, but telecommunications providers have been actively expanding their LTE services.

Figure 1.3 LTE frequencies

Mobile communication standard	Wavebands needed for "global" terminal
GSM (including GPRS)	4 bands (850MHz, 900MHz, 1.8GHz, 1.9GHz)
W-CDMA (including HSPA)	3–5 bands (800MHz, 1.9GHz, 2.1GHz, etc.)
LTE	7–9 bands (780MHz, 860MHz, 880MHz, 1.5GHz, 1.7GHz, 1.8GHz, 1.9GHz, 2.1GHz, 2.5GHz, etc.)

Figure 1.4 Quantity of wavebands needed for "Global" Terminal

1.2 Statement of the Problem

Even though these Microstrip antennas are compared with conventional antennas they have some number of disadvantages such as Low impedance bandwidth, Low gain, Low power handling capacity and etc.

Due to some applications such as: Mobile systems, Broadband services and Ground base direction finding system, demands for high bandwidth antennas have been increased. This research investigated the design and the fabrication of a wideband CPW microstrip patch antenna and increase its bandwidth with some bandwidth enhancement techniques that will mention later.

1.3 Objective of the study

This project focuses on design of wideband CPW microstrip patch antenna in the frequency range of 900 MHz to 2600 MHz for CPE usage in LTE network. The objectives of project are as follow:

1) To design a wideband CPW microstrip patch antenna for customer premises equipment (CPE) of LTE applications.
2) To investigate the suitability of this antenna in the frequency range of 900 MHz to 2600 MHz with optimum bandwidth.
3) To fabricate this microstrip patch antenna.

1.4 Scope of the Study

The scope of study is listed as below:

1) CST software for simulation of microstrip patch antenna will be used to investigate the suitability of this antenna in the frequency range of 900 MHz to 2600 MHz
2) Broadband antennas design techniques will also be used.
3) CPW feed technique and the transmission line model will be considered for this design.

1.5 Significance of the study

Mobile systems, Broadband services and Ground base direction finding systems increased demands for high bandwidth antennas. By increasing the bandwidth in the antenna we can improve the performance of those systems.

REFRENCES

[1] B. Gs, "Investigations On Slot-Loaded Square Microstrip Patch Antennas For Compact Dual Frequency Dual Polarized Operations," Cochin University Of Science And Technology, 2002.

[2] R. Garg, *Microstrip Antenna Design Handbook*. Boston, Ma: Artech House, 2001.

[3] J. Jen-Yea, K. Jui-Chang, C. Yuan-Tung, C. Wen-Shyang, And C. Hua-Ming, "Cpw-Fed Wideband Printed Planar Monopole Antenna For Ultra-Wideband Operation," In *Antennas And Propagation Society International Symposium 2006, Ieee*, 2006, Pp. 1697-1700.

[4] D. Chao, X. Yong-Jun, And L. Ping, "Cpw-Fed Planar Printed Monopole Antenna With Impedance Bandwidth Enhanced," *Antennas And Wireless Propagation Letters, Ieee,* Vol. 8, Pp. 1394-1397, 2009.

[5] M. E. De Cos And F. Las-Heras, "Polypropylene-Based Dual-Band Cpw-Fed Monopole Antenna [Antenna Applications Corner]," *Antennas And Propagation Magazine, Ieee,* Vol. 55, Pp. 264-273, 2013.

[6] H. V. Nikolaos "Investigation Of Loaded Monopole Antenna," Master Of Science, Department Of Electronic & Electrical Engineering, The University Of Leeds, 2000.

[7] N. B. A. Ghafar, "Design Of A Compact Microstrip Antenna At 2.4 Ghz," Department Of Electrical-Electronics & Telecommunications, Faculty Of Electrical Engineering, Universiti Teknologi Malaysia, 2005.

[8] D. M. Pozar, "Microstrip Antennas," *Proceedings Of The Ieee,* Vol. 80, Pp. 79-91, 1992.

[9] P. S. Nakar, "Design Of A Compact Microstrip Patch Antenna For Use In Wireless/Cellular Devices," Msc. In Electrical Engineering, Department Of Electrical And Computer Engineering, The Florida State University, 2004.

[10] Z. I. Dafalla, W. T. Y. Kuan, A. M. A. Rahman, And S. C. Shudakar, "Design Of A Rectangular Microstrip Patch Antenna At 1 Ghz," In *Rf And Microwave Conference, 2004. Rfm 2004. Proceedings*, 2004, Pp. 145-149.

[11] K. T. Ahmed, M. B. Hossain, And M. J. Hossain, "Designing A High Bandwidth Patch Antenna And Comparison With The Former Patch Antennas," *Canadian Journal On Multimedia And Wireless Networks,* Vol. 2, 2011.

[12] S. Behera, "Novel Tuned Rectangular Patch Antenna As A Load For Phase Power Combining," 2007.

[13] D. M. Pozar, D. Schaubert, I. Antennas, And P. Society, *Microstrip Antennas: The Analysis And Design Of Microstrip Antennas And Arrays*: Institute Of Electrical And Electronics Engineers, 1995.

[14] N. I. Dib, *Theoretical Characterization Of Coplanar Waveguide Transmission Lines And Discontinuities*: University Of Michigan., 1992.

[15] A. Aslam And F. A. Bhatti, "Novel Inset Feed Design Technique For Microstrip Patch Antenna," In *Applications Of Electromagnetism And Student Innovation Competition Awards (Aem2c), 2010 International Conference On*, 2010, Pp. 215-219.

[16] W. Chai, X. Zhang, And J. Liu, "Characteristics Study Of Four Coplanar Waveguide Feeding Devices," *Piers Online,* Vol. 3, Pp. 48-51, 2007.

[17] M. A. Saed, "Reconfigurable Broadband Microstrip Antenna Fed By A Coplanar Waveguide," *Progress In Electromagnetics Research,* Vol. 55, Pp. 227-239, 2005.

[18] A. S. R. Saladi, J. R. Panda, And R. S. Kshetrimayum, "An E-Shaped Cpw-Fed Folded-Slot Antenna For The 2.45 Ghz Rfid Applications," In *Communications And Signal Processing (Iccsp), 2011 International Conference On*, 2011, Pp. 363-366.

[19] K. Li, C. H. Cheng, T. Matsui, And M. Izutsu, "Simulation And Experimental Study On Coplanar Patch And Array Antennas," In *Microwave Conference, 2000 Asia-Pacific*, 2000, P. 1411.

[20] S. Costanzo, "Synthesis Of Multi-Step Coplanar Waveguide-To-Microstrip Transition," *Progress In Electromagnetics Research,* Vol. 113, Pp. 111-126, 2011.

[21] J. Kraus, "Antellllgs: Our Electronic Eyes & Years," *Microwave Journal,* Pp. 77-92, 1989.

[22] L. Lewin, "Radiation From Discontinuities In Strip-Line," *Proceedings Of The Iee-Part C: Monographs,* Vol. 107, Pp. 163-170, 1960.

[23] V. L. Subrahmanya, "Pattern Analysis Of "The Rectangular Microstrip Patch Antenna"," Msc. Electrical Engineering, School Of Engineering, University College Of Boras, 2009.

[24] R. Staraj, E. Cambiaggio, And A. Papiernik, "Infinite Phased Arrays Of Microstrip Antennas With Parasitic Elements: Application To Bandwidth Enhancement," *Antennas And Propagation, Ieee Transactions On,* Vol. 42, Pp. 742-746, 1994.

[25] P. B. Parmar, B. J. Makwana, And M. A. Jajal, "Bandwidth Enhancement Of Microstrip Patch Antenna Using Parasitic Patch Configuration," In *Communication Systems And Network Technologies (Csnt), 2012 International Conference On*, 2012, Pp. 53-57.

[26] R. A. Abd-Alhameed, K. Khalil, P. S. Excell, And C. H. See, "Simulation And Measurement Of Broadband Microstrip Patch Antenna For 3g Wireless Communications," In *Antennas And Propagation, 2003. (Icap 2003). Twelfth International Conference On (Conf. Publ. No. 491)*, 2003, Pp. 477-480 Vol.2.

[27] S. Srivastava And P. K. Goswami, "A New Design Improvement Of Microstrip U-Shape Antenna For Bandwidth Enhancement Using Ebg Structure Deformation," *International Journal Of Engineering Science,* Vol. 4, 2012.

[28] Y. Chen, S. Yang, And Z. Nie, "Bandwidth Enhancement Method For Low Profile E-Shaped Microstrip Patch Antennas," *Antennas And Propagation, Ieee Transactions On,* Vol. 58, Pp. 2442-2447, 2010.

[29] S. D. Gupta And M. Srivastava, "Multilayer Microstrip Antenna Quality Factor Optimization For Bandwidth Enhancement," *Journal Of Engineering Science And Technology,* Vol. 7, Pp. 756-773, 2012.

[30] A. M. A. T. A. Rahman, "Broadband Modified Rectangular Microstrip Patch Antenna Using Stepped Cut At Four Corners Method," *Progress In Electromagnetics Research,* Vol. 137, Pp. 599-619, 2013.