RADIATION PATTERN RECONFIGURABLE ANTENNA FOR LTE APPLICATIONS

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To my parents, for their endless love and support

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ABSTRACT

This project proposes a radiation pattern reconfigurable antenna for LTE applications. Long Term Evolution (LTE) is an advanced system in the wireless telecommunication development. Compared to previous standards, LTE offers improved performance. The main advantage of this project is to steer the radiation pattern to a particular direction. The radiation pattern steering is achieved by applying progressive phase shifting. The transmission line model is used to obtain design parameters of the antenna. By using the progressive phase shift concept, three different configurations of patch array antennas are designed at 2.6GHz operating frequency. The three different directions had been formed at -15°, 0°, 15°. FR4 substrate is used for designing the reconfigurable antenna with thickness of 1.6mm. Measured and simulated results are well matched, but with some minor deviations. The gain of the antenna is 4.4dB with broadside direction and the gain is 4.6dB when the beam steers to either ±15°.

ABSTRAK

Projek ini mencadangkan antenna dengan corak radiasi beralih secara elektronik untuk aplikasi Evolusi Jangka Panjang (LTE). Evolusi Jangka Panjang (LTE) adalah sistem yang maju dalam pembangunan telekomunikasi. Berbanding dengan standard terdahulu, LTE menawarkan prestasi yang lebih baik. Kelebihan utama projek ini adalah untuk memandu corak radiasi ke arah yang ditentukan. Pemanduan corak radiasi dicapai dengan mengaplikasikan perubahan sudut secara progresif. Model talian penghantaran digunakan untuk menentukan parameter-parameter untuk antenna. Dengan menggunakan konsep perubahan sudut secara progresif, tiga konfigurasi yang berbeza untuk antenna patch array direka pada frekuensi operasi 2.6 GHz. Tiga arah berbeza dibentuk pada -15°, 0°, 15°. FR4 substrate digunakan untuk merekabentuk antenna yang boleh dikonfigurasi dengan ketebalan 1.6mm. keputusan pengukuran dan simulasi adalah berpadanan, tetapi dengan sedikit perbezaan. Gandaan antenna adalah 4.4dB dengan arah lebarsisi dan gandaan 4.6dB apabila pasak dipandu ke sudut ±15°.

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LIST OF ABBREVIATIONS

1G	-	First Generation
2G	-	Second Generation
3G	-	Third Generation
4G	-	Fourth generation
LTE	-	Long Term Evolution
CST	-	Computer Simulation Technology
MTS	-	Mobile Telephone Systems
AMTS	-	Advanced Mobile Telephone Systems
PTT	-	Push To Talk
IMTS	-	Improved Mobile Telephone Service
GPRS	-	General Packet Radio Service
WLAN	-	Wireless Local Access Network
FDMA	-	Frequency Division Multiple Access
CDMA	-	Code Division Multiple Access
GSM	-	Global System for Mobile Communication
EDGE	-	Enhanced Data Rates for GSM Evolution
UMTS	-	Universal Mobile Telecommunication Systems
HSDPA	-	High-Speed Downlink Packet Access
3GPP	-	3rd Generation Partnership Project
MIMO	-	Multiple Input Multiple Output
OFDM	-	Orthogonal Frequency Digital Multiplexing
MBWA	-	Mobile Broadband Wireless Access
WiMAX	-	Worldwide Interoperability for Microwave Access

LIST OF SYMBOLS

Z_0	-	Characteristics Impedance
Z_{in}	-	Input impedance
I	-	Current
V	-	Voltage
A	-	Ampere
W	-	Width
L	-	LengthEffective length
L_{eff}	-	Effective length
ΔL	-	Change in length
C	-	Speed of light
M	-	Micron
dB	-	Decibel
dB_i	-	Decibel reference to isotropic antenna
λ	-	wavelength
λ_0	-	Free space wavelength
λ_{eff}	-	Effective wavelength
Δ	-	conductivity
ϵ_r	-	relative permitivity
ϵ_{eff}	-	effective permitivity
Ω	-	Ohm

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

In wireless communications, four generations have been implemented until now. The 1st generation (1G), or analog, 2nd generation (2G), or digital, 3rd generation (3G), or broadband, 4th generation (4G), or digital broadband. Long Term Evolution (LTE) is the technology of 4G [1]. LTE is the advanced system in telecommunication and it offers improved performance.

There are different types of antennas, wire antenna, aperture antenna, reflector antenna and microstrip antenna. Microstrip antenna is easy and low cost to fabricate, low-profile, ease of installation, high-performance, less in size, light weight, and its exit in different shapes such as rectangular, square, circle and triangle are the most common shapes. However, the main drawback of microstrip antenna is that, it has narrow bandwidth [2].

The drawback of fixed radiation pattern is less coverage area, and to overcome this problem, pattern reconfigurable antennas are implemented. Pattern reconfigurable antennas, switch the radiation pattern towards a particular direction and provide more coverage area.

For some applications, single element antennas are unable to meet the gain or radiation pattern requirements. Combining several single antenna elements in an array can be a possible solution. Antenna arrays have the advantages of providing the capability of a steerable beam (radiation direction change) [3].

This chapter starts with an introduction, problem statement, objectives, and scope of the project.

1.2 Problem Statement

Microstrip patch antennas built on printed circuit board (PCB) substrate, are attractive due to their various features like light weight, low cost, easy to fabricate. Obviously, the microstrip element suffers from the inherent limitation of narrow impedance bandwidth and high substrate losses and low radiation efficiency. To relax the precision problem of conventional microstrip antenna, it is proposed to fabricate the antenna using lossless low permittivity substrates.

In general, an antenna design with very directive characteristics (very high gains) to meet the demands of long distance communication. Usually the radiation pattern of a single element microstrip radiator is relatively wide and each element provides the low value of directivity (gain). Enlarging the dimensions of the single elements offer high directivity, but this is not a practical solution. Another simple way is to form an assembly of radiating elements in an electrical and geometrical configuration. This multiple element is referred to as antenna array.

A conventional array antenna is capable of producing a single directional beam pattern, therefore it limited to a fixed direction of the main beam. This limitation can be overcome by using a beam reconfigurable antenna, which is upgrading the single antenna into a multifunctional antenna. Therefore, Beam reconfigurable, which capable to steer the main beam at three different places in the single antenna design was proposed in the present research. There only one beam can be steered at one time within the proposed design. Practically user's position is not stable, to maintain the connection, the antenna maximum radiation must always be pointing towards the base station. This requires a beam steerable antenna array.

1.3 Objective

The main objectives of this project as follows:

1. To model and design a microstrip antenna for LTE applications.
2. To steer the radiation pattern towards a particular direction.
3. To fabricate and measure the proposed antenna design.

1.4 Scope of the work

The scopes of this project starts with understanding the concept of radiation pattern and micro strip patch array antenna. The two element micro strip patch antenna operating at 2.6 GHz has been chosen and simulated by using a CST microwave studio. The measured return loss of the proposed antenna obtained below -10 dB and the gain of the antenna is almost similar, when steering the radiation pattern. Finally, the proposed antenna design has been fabricated and the simulated and measured results are compared.

1.5 Summary

This chapter presents the introduction of the project and an overview of the antennas, radiation pattern and array elements. The chapter also covers the problem statement, the objectives, scope of the work.

REFERENCES

1. Bhalla, M. R. and Bhalla, A. V. Generations of mobile wireless technology: A survey. *International Journal of Computer Applications*, 2010. 5(4).

2. Balanis, C. *Antenna Theory: Analysis and Design*. Wiley. 2015. ISBN 9781119178989. URL `https://books.google.com.my/books?id=PTFcCwAAQBAJ`.

3. Godara, L. C. Applications of antenna arrays to mobile communications. I. Performance improvement, feasibility, and system considerations. *Proceedings of the IEEE*, 1997. 85(7): 1031–1060.

4. Chen, H.-H., Guizani, M. and Mohr, W. Evolution toward 4G wireless networking [Guest Editorial]. *IEEE Network*, 2007. 21(1): 4–5.

5. Li, X., Gani, A., Salleh, R. and Zakaria, O. The future of mobile wireless communication networks. *Communication Software and Networks, 2009. ICCSN'09. International Conference on*. IEEE. 2009. 554–557.

6. Ruscelli, A. and Cecchetti, G. Toward the QoS support in 4G wireless systems. *Wireless Communications 2007 CNIT Thyrrenian Symposium*. Springer. 2007. 245–252.

7. Salleh, R., Li, X., Yang, L. and Li, Z. Radio Frequency Convergence Protocol for 4 G Networks. *WSEAS International Conference. Proceedings. Mathematics and Computers in Science and Engineering*. World Scientific and Engineering Academy and Society. 2008, 8.

8. Yiping, C. and Yuhang, Y. A new 4G architecture providing multimode terminals always best connected services. *IEEE Wireless Communications*, 2007. 14(2).

9. Mshvidobadze, T. Evolution mobile wireless communication and LTE networks. *Application of Information and Communication Technologies*

(AICT), 2012 6th International Conference on. IEEE. 2012. 1–7.

10. Khan, R. S. and Ishfaq, M. A Compact Microstrip Patch Antenna for LTE Applications, 2013.

11. Kulkarni, A. N. and Sharma, S. K. Frequency reconfigurable microstrip loop antenna covering LTE bands with MIMO implementation and wideband microstrip slot antenna all for portable wireless DTV media player. *IEEE Transactions on antennas and propagation*, 2013. 61(2): 964–968.

12. Pos, L. ETSI TS. 2016.

13. Hiew, Y. K., Aripin, N. M., Jayavalan, S. and Din, N. M. Spectrum band for smart grid implementation in Malaysia. *Research and Development (SCOReD), 2013 IEEE Student Conference on*. IEEE. 2013. 26–30.

14. Mohammed, A. H., Bilal, K. H. and Hassan, M. A. Voice over IP over LTE Network: A Review.

15. Ghosh, A., Ratasuk, R., Mondal, B., Mangalvedhe, N. and Thomas, T. LTE-advanced: next-generation wireless broadband technology. *IEEE wireless communications*, 2010. 17(3).

16. Pozar, D. *Microwave Engineering, Fourth Edition Wiley E-Text Reg Card*. John Wiley & Sons, Incorporated. 2013. ISBN 9781118631430. URL `https://books.google.com.my/books?id=N9W-kQEACAAJ`.

17. Agrawal, P. and Bailey, M. An analysis technique for microstrip antennas. *IEEE Transactions on antennas and propagation*, 1977. 25(6): 756–759.

18. Derneryd, A. A theoretical investigation of the rectangular microstrip antenna element. *IEEE Transactions on Antennas and Propagation*, 1978. 26(4): 532–535.

19. Derneryd, A. Analysis of the microstrip disk antenna element. *IEEE Transactions on Antennas and Propagation*, 1979. 27(5): 660–664.

20. Derneryd, A. and Lind, A. Extended analysis of rectangular microstrip resonator antennas. *IEEE transactions on antennas and propagation*, 1979. 27(6): 846–849.

21. Mohammadian, A. H., Martin, N. M. and Griffin, D. W. A theoretical and

experimental study of mutual coupling in microstrip antenna arrays. *IEEE Transactions on Antennas and Propagation*, 1989. 37(10): 1217–1223.

22. Kumar, P. P. and Rao, P. T. Dual staircase shaped microstrip patch antenna. *Pervasive Computing (ICPC), 2015 International Conference on*. IEEE. 2015. 1–5.

23. Wong, K.-L. *Compact and broadband microstrip antennas*. vol. 168. John Wiley & Sons. 2004.

24. Kumar, A., Kaur, J. and Singh, R. Performance analysis of different feeding techniques. *International journal of emerging technology and advanced engineering*, 2013. 3(3): 884–90.

25. Sharma, N., Jain, B., Singla, P. and Prasad, R. R. RECTANGULAR PATCH MICRO STRIP ANTENNA: A SURVEY. *International Advanced Research Journal in Science, Engineering and Technology*, 2014. 1(3): 144–147.

26. Mandal, A., Ghosal, A., Majumdar, A., Ghosh, A., Das, A. and Das, S. K. Analysis of feeding techniques of rectangular microstrip antenna. *Signal Processing, Communication and Computing (ICSPCC), 2012 IEEE International Conference on*. IEEE. 2012. 26–31.

27. Arora, A., Khemchandani, A., Rawat, Y., Singhai, S. and Chaitanya, G. Comparative study of different feeding techniques for rectangular microstrip patch antenna. *IJIREEICE*, 2015. 3(5): 32–5.

28. David, M. P. A Review of Aperture Coupled Microstrip Antennas: History, Operation, Development, and Applications by. 1996.

29. Obenchain, J. T. A Technical Assessment of Aperture-coupled Antenna Technology. 2014.

30. Bist, S., Saini, S., Prakash, V. and Nautiyal, B. Study The Various Feeding Techniques of Microstrip Antenna Using Design and Simulation Using CST Microwave Studio. *International Journal of Emerging Technology and Advanced Engineering*, 2014. 4(9).

31. Kaur, J. and Khanna, R. Co-axial fed rectangular microstrip patch antenna for 5.2 GHz WLAN application. *Universal Journal of Electrical and Electronic Engineering*, 2013. 1(3): 94–98.

32. Kumar, K. P., Rao, K. S., Sumanth, T., Rao, N. M., Kumar, R. A. and Harish, Y. Effect of feeding techniques on the radiation characteristics of patch antenna: design and analysis. *International Journal of Advanced Research in computer and communication Engineering*, 2013. 2(2): 1276–1281.

33. Bugaj, M., Przesmycki, R., Nowosielski, L. and Piwowarczyk, K. Analysis different methods of microstrip antennas feeding for their electrical parameters. *PIERS Proceedings, Kuala Lumpur, Malaysia*, 2012: 27–30.

34. Bisht, S., Singh, A., Chauhan, R. and Pant, G. Implementation and Applications of Various Feeding Techniques Using CST Microwave Studio. *International Journal on Recent and Innovation Trends in Computing and Communication ISSN*, 2014: 2321–8169.

35. Varshney, H. K., Kumar, M., Jaiswal, A., Saxena, R. and Jaiswal, K. A Survey on Different Feeding Techniques of Rectangular Microstrip Patch Antenna. *International Journal of Current Engineering and Technology*, 2014. 4(3): 1418–1423.

36. Nemati, M. H., Kazemi, R. and Tekin, I. Pattern reconfigurable patch array for 2.4 GHz WLAN systems. *Microwave and Optical Technology Letters*, 2014. 56(10): 2377–2381.

37. CAI, X.-t., WANG, A.-g., Ning, M. and Wen, L. Novel radiation pattern reconfigurable antenna with six beam choices. *The Journal of China Universities of Posts and Telecommunications*, 2012. 19(2): 123–128.

38. Donelli, M., Azaro, R., Fimognari, L. and Massa, A. A planar electronically reconfigurable Wi-Fi band antenna based on a parasitic microstrip structure. *IEEE Antennas and Wireless Propagation Letters*, 2007. 6: 623–626.

39. Sabapathy, T., Jamlos, M. F. B., Ahmad, R. B., Jusoh, M., Jais, M. I. and Kamarudin, M. R. Electronically reconfigurable beam steering antenna using embedded RF PIN based parasitic arrays (ERPPA). *Progress in Electromagnetics Research*, 2013. 140: 241–261.

40. Ha, S.-J. and Jung, C. W. Reconfigurable beam steering using a microstrip patch antenna with a U-slot for wearable fabric applications. *IEEE Antennas and Wireless Propagation Letters*, 2011. 10: 1228–1231.

41. Kamarudin, M. R., Hall, P. S., Colombel, F. and Himdi, M. Electronically switched beam disk-loaded monopole array antenna. *Progress In Electromagnetics Research*, 2010. 101: 339–347.

42. Nguyen, D.-T., Siragusa, R. and Tedjini, S. Beam steering patch antenna using reactive loading and Yagi-antenna concept. *Microwave and Optical Technology Letters*, 2015. 57(2): 417–421.

43. Pal, A., Mehta, A., Mirshekar-Syahkal, D. and Nakano, H. A Twelve-Beam Steering Low-Profile Patch Antenna With Shorting Vias for Vehicular Applications. *IEEE Transactions on Antennas and Propagation*, 2017. 65(8): 3905–3912.

44. Lotfi, P., Soltani, S. and Murch, R. D. Broadside Beam-Steerable Planar Parasitic Pixel Patch Antenna. *IEEE Trans Antenn Propag*, 2016. 64: 1–6.

45. Park, Z. and Lin, J. A beam-steering broadband microstrip antenna for noncontact vital sign detection. *IEEE Antennas and Wireless Propagation Letters*, 2011. 10: 235–238.

46. Carver, K. and Mink, J. Microstrip antenna technology. *IEEE transactions on antennas and propagation*, 1981. 29(1): 2–24.

47. James, J. R. *Handbook of microstrip antennas*. IET. 1989.

48. Paul, L. C. and Sultan, N. Design, simulation and performance analysis of a line feed rectangular micro-strip patch antenna. *International Journal of Engineering Sciences & Emerging Technologies*, 2013. 4(2): 117–126.

49. Casu, G., Moraru, C. and Kovacs, A. Design and implementation of microstrip patch antenna array. *Communications (COMM), 2014 10th International Conference on*. IEEE. 2014. 1–4.