



**Faculty of Electronics and Computer Engineering**

**DESIGN OF BROADBAND CIRCULARLY POLARISED PRINTED  
MONOPOLE ANTENNAS FOR INDOOR WIRELESS  
COMMUNICATION SYSTEMS**

اونيور سيتي تیکنیکل ملیسیا ملاک  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**Hussein Salameh Mahmoud Alsariera**

**Doctor of Philosophy**

**2021**

**DESIGN OF BROADBAND CIRCULARLY POLARISED PRINTED MONOPOLE  
ANTENNAS FOR INDOOR WIRELESS COMMUNICATION SYSTEMS**

**HUSSEIN SALAMEH MAHMOUD ALSARIERA**

**A thesis submitted  
in fulfilment of the requirements for the degree of Doctor of Philosophy**



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2021**

## DECLARATION

I declare that this thesis entitle “Design of Broadband Circularly Polarised Printed Monopole Antennas For Indoor Wireless Communication Systems” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

 Signature : .....  
Name : Hussein Salameh Mahmoud Alsariera  
Date : .....  
  
اونيورسيتي تيكنيكل مليسيا مالاک  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature .....  
Supervisor Name : Associate Professor Dr. Azmi Awang Md Isa  
Date : .....

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## DEDICATION

To my beloved mother and father, may Allah's mercy and forgiveness be upon them. I miss them so much.



## ABSTRACT

With the rapid changes in wireless communication systems, indoor wireless communication (IWC) technology has undergone tremendous development. Antennas are crucial components of IWC systems that transmit and receive signals within indoor environments. Thus, the development of indoor technology is highly dependent on the development of indoor antennas. However, indoor environments with a limited space require the fewest number of indoor antenna units and the smallest indoor antenna size. Hence, indoor antennas with a compact size and broad applications have become widely preferred. In an IWC system, the use of circularly polarised (CP) antennas is generally important, especially in dense indoor environments, because relative to linearly polarised (LP) antennas, CP antennas reduce polarisation mismatch and multipath losses. Conventional broadband CP antennas have been used for IWC systems. However, these antennas are bulky in size and feature a heavy profile. They are also expensive and difficult to design and fabricate. Thus, broadband CP printed monopole antennas (BCPPMAs) have received considerable attention in the field of wireless communication because of their compact size, low profile, low cost, simple structure and capability of providing broad impedance bandwidth (IBW) and axial ratio bandwidth (ARBW). However, these antennas have a difficulties in the trade-off between the antenna's bands (IBW and ARBW) with high overlapping percentage and their structure size which restricts their use in IWC systems. Therefore, this thesis aimed to design a new structure for BCPPMAs which should provide new functionality for indoor antennas. Two design topology approaches for BCPPMAs were introduced: the biplanar topology approach based on the microstrip feeding technique and the uniplanar topology approach based on coplanar waveguide feeding (CPW-fed) using low-cost FR4 materials. All presented antennas provided bidirectional radiation patterns with different CP senses and good gain with small variations over the majority of the achieved CP band. The main proposed CP antenna designs, namely, the P-shaped, L-shaped and modified rectangular-shaped BCPPMAs were simulated, fabricated and measured. The antennas provided broad IBW and ARBW greater than 100%. Moreover, the bandwidths showed a wide overlapping ratio between them of more than 89%. while the measured IBW and ARBW of the proposed modified rectangular CPW-fed BCPPMA are 108.5% (1.825–6.15 GHz) and 107.7% (1.8–6 GHz), respectively. This design retains a compact size of 35 mm × 35 mm and a wide overlapping percentage of 97%. The measurement results showed a good agreement with the simulation results. The benefits of the proposed antennas include broad IBW and ARBW, compact size and simple design. Hence, they are suitable candidates for IWC systems. The results of this work can facilitate improvements in broadband wireless communication systems and afford them with good tuning capabilities.

## **REKABENTUK ANTENA EKAKUTUB JALUR LEBAR TERKUTUB BULAT BERCETAK BAGI SISTEM KOMUNIKASI WAYARLES DALAMAN**

### **ABSTRAK**

Selaras dengan perubahan pesat pada sistem komunikasi wayarles, teknologi komunikasi wayarles dalaman (IWC) telah melalui pembangunan pesat. Antena sebagai komponen penting bagi sistem IWC di mana ia berfungsi memancar dan menerima isyarat-isyarat dalam lingkungan persekitaran dalaman. Oleh itu, pembangunan teknologi dalaman sangat bergantung kepada pembangunan antena-antena dalaman. Walau bagaimanapun, kekangan pada ruang persekitaran dalaman memerlukan unit antena dalam kuantiti dan saiz yang minimum. Maka, antena bersaiz kompak serta tawaran aplikasi pelbagai lebih menjadi pilihan utama. Dalam sistem IWC, penggunaan antena terkutub bulat (CP) adalah amat penting terutama sekali di lokasi persekitaran dalaman yang padat berikutan keupayaannya mengurangkan tak padanan galangan dan kehilangan pelbagai lorong berbanding dengan ciri terkutub lurus (CL). Antena CP jalur lebar konvensional telah diaplikasi pada sistem IWC, namun antena-antena ini berukuran besar dan mempunyai profil yang berat, malahan berkost tinggi dan rumit untuk direka serta difabrikasi. Oleh itu, antena-antena ekakutub jalur lebar terkutub bulat bercetak (BCPPMAs) lebih diutamakan dalam bidang komunikasi wayarles berikutan saiz yang kompak, profil rendah, kos pembuatan rendah, struktur sederhana, dan keupayaan mencapai galangan lebar jalur (IBW) dan nisbah paksi jalur lebar jalur (ARBW) yang lebih besar. Namun begitu, kerumitan pada pertukaran jalur-jalur IBW dan ARBW antena dengan peratus pertindihan tinggi serta saiz struktur dilihat mengehadkan penggunaannya pada sistem IWC. Justeru, tesis ini bertujuan menghasilkan rekabentuk struktur BCCPMAs yang berkeupayaan menyediakan fungsi baharu untuk antena dalaman. Dua pendekatan rekabentuk topologi telah diperkenalkan; topologi dwisatah berdasarkan teknik suapan mikrojalur dan topologi ekasatah berdasarkan teknik suapan pandu gelombang sesatah (CPW-fed) menggunakan bahan FR-4 berkost rendah. Hasil ukuran antena menampilkan radiasi dwiarah terkutub bulat yang pelbagai dengan variasi kecil pada dapatan antena berbanding jalur lebar terkutub bulat yang dicapai majoriti. Cadangan rekabentuk utama antenna CP, iaitu BCPPMA berbentuk-P, berbentuk-L dan berbentuk-segiempat tepat terubahsuai telah disimulasi, difabrikasi dan diukur. Keputusan menunjukkan keupayaan IBW yang lebar dan peratus ARBW melebihi skala 100%, malahan bacaan jalur lebar menunjukkan jurang nisbah pertindihan yang lebar, iaitu melebihi 89%. Bacaan IBW dan ARBW terhasil oleh rekabentuk terubahsuai segiempat CPW-fed BCCPMA, masing-masing mencapai peratus 108.5% (1.825–6.15 GHz) dan 107.7% (1.8–6 GHz). Rekabentuk ini mengekalkan saiz kompak berukuran 35 mm × 35 mm dan peratus pertindihan yang lebar iaitu 97%. Hasil eksperimen menunjukkan ianya selari dengan hasil simulasi, merangkumi IBW dan ARBW yang luas, saiz kompak, struktur rekabentuk mudah dan minimal, seterusnya menjadikan ia sebagai calon sesuai untuk aplikasi sistem IWC dan membantu proses pembaikan serta menawarkan keupayaan penalaan yang bagus pada sistem komunikasi wayarles.

## ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful Alhamdulillah. All praises to Allah for the strength and His blessing as I completed this thesis. My sincerest gratitude goes to my supportive supervisors Associate Professor Dr. Azmi Awang Md Isa and Professor Dr. Zahriladha Zakaria, for their invaluable supervision, guidance, kindness, encouragement and financial support throughout my study.

I would like to express my thanks to all lecturers and technicians from the Faculty of Electronics and Computer Engineering (FKEKK), Universiti Teknikal Malaysia Melaka (UTeM), for their time and effort that contributed to my achievement. I would also like to acknowledge the UTeM for the research grants and the Antenna Research Centre of Universiti Teknologi MARA for providing the measurement facility that enabled the completion of this research.

I also wish to thank my brilliant postgraduate colleagues in Makmal Pasca Siswazah Laboratory for their assistance and for providing an excellent research atmosphere and offering their genuine friendship during the course of my PhD candidature.

Last but not least, I am grateful for my beloved family for their unconditional support and unlimited encouragement. Special thanks go to my brothers Mohammad, Ahmad and Ibrahim and to my sisters for their generous support in my daily life and throughout my PhD study. They always make me happy. Thanks for your (du'aa') which I feel constantly. Thank you all so much for everything.



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