Faculty of Electronic and Computer Engineering

DESIGN OF NEW INVERTED SUSPENDED CIRCULAR POLARIZED ANTENNA WITH METASURFACE

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DECLARATION

I declare that this thesis entitled “Design of New Inverted Suspended Circular Polarized Antenna with Metasurface” is the result of my research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : .....

Name : Hamizan bin Abu Bakar

Date : .....

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 Master of Science in Electronic Engineering.

Signature : …….

Supervisor Name : Assoc. Prof. Dr. Mohamad Zoinol Abidin bin Abd. Aziz

Date : …….

DEDICATION

Dedicated to Allah S.W.T. Almighty, my loving mother, Awah binti Sait, my beloved father, Abu Bakar bin Abd. Rahman and to all my siblings for the infinite and unfading love, sacrifice, patient and encouragement.

ABSTRACT

Nowadays, with the fast development in wireless devices, a wireless communication system such as Wireless Local Area Network (WLAN) application has been widely developed to pave the way for the so-called anywhere, anytime communication. In recent years, an antenna with a small size and large bandwidth has received much attention. As mobile devices are using ever-bigger portions of available bandwidth; wireless providers are in search of new and better ways to boost capacity on their system. Thus, a circularly polarized antenna with small size and wide bandwidth that can operate at WLAN application operating frequency was demanded. Circularly polarized antennas can reduce the unavoided multipath interference, provide better mobility, weather penetration and flexibility in orientation angle. However, the conventional circularly polarized microstrip antenna has narrowband characteristics and more significant in size. Due to this deficiency, L-probe technique and integration of metasurface structure technique was introduced to provide miniaturization requirement and enhancement in antenna parameter performance such as bandwidth and gain. Therefore, the objective of this project was to design, simulate, fabricate and measure the design of new inverted suspended circular polarized antenna with metasurface for WLAN application at 2.4 GHz. In this project, the antennas were designed by using an inverted suspended L-probe technique with separation of air gap layer. Modified L-probe fed was used for the antenna design where the feed line was printed either at the upper or at the bottom side of the FR4 substrate. First, circular polarized rectangular patch antenna Design A (90 x 90 mm) was designed. Then, the circular polarized circular patch antenna (Design B_1, B_2, B_3, and B_4) with miniaturization up to 20.91 % (80 x 80 mm) by comparing to Design A were designed. Lastly, the most suitable of optimized metasurface structure design (Design C_1) was chosen to be combined with antenna Design B_4. The optimized metasurface antenna (Design BC_{1d}) provides miniaturization, better reflection coefficient, larger bandwidth and maintaining a circular polarization property. The fabrication process is carried out using a low-cost 4.4 permittivity FR-4 substrate. Based on the simulation and measurement result, the designed metasurface antenna Design BC_{1d} covered a frequency of 2.4 GHz with more than 450 MHz bandwidth. Other than that, the proposed metasurface antenna has the advantages of reduction in patch size up to 45.24 % and miniaturization of the antenna substrate up to 23.44 % (70 x 70 mm). Moreover, the axial ratio bandwidth (ARBW) of the metasurface antenna is up to 18.6 %. Overall, another antenna parameter such as total efficiency, directivity and realized gain of the metasurface antenna also showed good responses. Therefore, this miniaturized metasurface antenna is capable of performing circular polarization and offer wide bandwidth which is a suitable candidate to be applied for WLAN application.

ABSTRAK

Pada masa kini, dengan perkembangan pesat dalam peranti tanpa wayar, sistem komunikasi tanpa wayar seperti aplikasi Rangkaian Kawasan Setempat Tanpa Wayar (WLAN) telah banyak digunakan dalam membuka jalan untuk apa yang dipanggil di mana-mana sahaja, komunikasi bila-bila masa. Dalam beberapa tahun kebelakangan ini, antena yang mempunyai saiz kecil dan jalur lebar yang besar telah mendapat banyak perhatian. Memandangkan peranti mudah alih menggunakan lebih besar bahagian jalur lebar yang boleh didapati; pembekal tanpa wayar mencari cara baru dan lebih baik untuk menaikkan kapasiti sistem mereka. Oleh itu, antena polarisasi bulat dengan saiz kecil dan jalur lebar luas yang boleh beroperasi di frekuensi operasi aplikasi WLAN dituntut. Antena polarisasi bulat boleh mengurangkan gangguan pelbagai arah yang tidak dapat dihindari, menyediakan mobiliti yang lebih baik, penembusan cuaca dan fleksibiliti dalam sudut orientasi. Walau bagaimanapun, antena jalur mikro polarisasi bulat konvensional mempunyai ciri-ciri jalur sempit dan saiz yang lebih besar. Disebabkan kekurangan ini, teknik L-probe dan integrasi teknik struktur metasurface diperkenalkan untuk menyediakan keperluan pengecilan dan peningkatan dalam prestasi parameter antena seperti jalur lebar dan dapatan. Oleh itu, objektif projek ini adalah untuk mereka bentuk, mensimulasi, menfabrikasi dan mengukur reka bentuk baru antena polarisasi bulat digantung terbalik dengan metasurface untuk aplikasi WLAN pada 2.4 GHz. Dalam projek ini, antena direka bentuk dengan menggunakan teknik tergantung terbalik L-probe dengan pemisahan lapisan jurang udara. Suapan L-probe yang telah diubahsuai digunakan untuk reka bentuk antena di mana garisan suapan dicetak sama ada di bahagian atas atau di bahagian bawah substrat FR4. Mula-mulanya, polarisasi bulat antena tampalan segi empat Reka Bentuk A (90 x 90 mm) direka bentuk. Kemudian, polarisasi bulat antena tampalan bundar (Reka Bentuk B_1, B_2, B_3, dan B_4) dengan pengecilan sehingga 20.91 % (80 x 80 mm) dengan membandingkan dengan Design A telah direka bentuk. Akhir sekali, reka bentuk struktur metasurface optimum yang paling sesuai (Reka Bentuk C_1) telah dipilih untuk digabungkan dengan antena Reka Bentuk B_4. Antena metasurface optimum (Reka Bentuk BC_{1d}) menyediakan pengecilan, koefision pantulan yang lebih baik, jalur lebar yang lebih besar dan mengekalkan sifat polarisasi bulat. Proses fabrikasi dijalankan menggunakan FR-4 substrat kos rendah dengan 4.4 ketelusan. Berdasarkan keputusan simulasi dan pengukuran, antena metasurface Reka Bentuk BC_{1d} yang direka bentuk meliputi frekuensi 2.4 GHz dengan lebih daripada 450 MHz jalur lebar. Selain itu, antena metasurface yang dicadangkan mempunyai kelebihan pengurangan saiz tampalan sehingga 45.24 % dan pengecilan substrat antena sehingga 23.44 % (70 x 70 mm). Lebih lagi, nisbah paksian jalur lebar (ARBW) antena metasurface adalah sehingga 18.6 %. Secara keseluruhannya, parameter antena lain seperti jumlah efisiensi, pengarahan dan dapatan sebenar daripada antena metasurface juga menunjukkan hasil yang baik. Oleh itu, antena metasurface miniatur ini mampu melaksanakan polarisasi bulat dan menawarkan jalur lebar luas dimana ianya merupakan calon yang sesuai untuk digunakan dalam aplikasi WLAN.

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