PRINTED WI-FI RADIATING ELEMENT INTEGRATING WITH LIGHT EMITTING DIODE (LED)

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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I declare that this report entitled "Printed Wi-Fi Radiating Element Integrating with Light Emitting Diode (LED)" is the result of my work except for quotes as cited in the references.

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APPROVAL

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DEDICATION

This work is dedicated to my beloved family and those people who have guided and inspired me throughout my journey of education, I have also dedicated this work to my supervisor, Prof. Madya Dr. Maisarah Binti Abu who has been a constant source of knowledge and inspiration. Thank you for supporting me and for all the encouragement.

ABSTRACT

This project presents the Printed Wi-Fi Radiating Element Integrating with Light Emitting Diode (LED). The purpose of this project is to design and optimize the radiating element integrated with Light Emitting Diode (LED) to have dual functionality in one device which is illumination and wireless communication. The other purpose is to verify the performance of the fabricated printed radiating element with LED in terms of return loss, Voltage Standard Wave Ratio (VSWR), bandwidth, and directivity. The radiating element is designed using Computer Simulation Technology (CST) and operated at 2.4 GHz. The placement of LEDs is located on the slotted area between the radiating elements. The design is fabricated using Rogers RT 5880 substrate with permittivity, εr = 2.2, and thickness, h = 1.575 mm. The performance parameter was verified through Vector Network Analyzer and Anechoic Chamber room. The result between simulation and measurement shows the radiating element performance with and without the integration of LED.

ABSTRAK

Projek ini memperkenalkan "Printed Wi-Fi Radiating Element Integrating with Light Emitting Diode (LED)". Tujuan projek ini adalah untuk mereka bentuk dan mengoptimumkan elemen penyinaran yang disepadukan dengan Diod Pemancar Cahaya (LED) untuk mempunyai dwi fungsi dalam satu peranti iaitu pencahayaan dan komunikasi tanpa wayar. Tujuan lain adalah untuk mengesahkan prestasi elemen penyinaran bercetak yang direka dengan LED dari segi kehilangan balikan, Nisbah Gelombang Piawai Voltan (VSWR), jalur lebar dan kearahan. Elemen penyinaran direka menggunakan Teknologi Simulasi Komputer (CST) dan dikendalikan pada 2.4 GHz. Penempatan LED terletak pada kawasan berlubang antara elemen penyinaran. Reka bentuk ini direka menggunakan substrat Rogers RT 5880 dengan kebolehtelapan, εr = 2.2, dan ketebalan, h = 1.575 mm. Parameter prestasi telah disahkan melalui "Vector Network Analyzer" dan bilik "Anechoic Chamber". Keputusan antara simulasi dan pengukuran menunjukkan prestasi elemen penyinaran dengan dan tanpa penyepaduan LED.

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LIST OF SYMBOLS AND ABBREVIATIONS

LED	:	Light Emitting Diode
CST	:	Computer Simulation Technology
VNA	:	Vector Network Analyzer
RL	:	Return Loss
ML	:	Mismatch Loss
dB	:	Decibel
Wi-Fi	:	Wireless Fidelity
VSWR	:	Voltage Standard Wave Ratio
FR-4	:	Flame Retardant 4
SMA	:	Subminiature version A
BW	:	Bandwidth
PCB	:	Printed Circuit Board
WLAN	:	Wireless Local Area Network
V	:	Volt
HFSS	:	High-Frequency Structure Simulator

CHAPTER 1

INTRODUCTION

1.1 Background of project

Nowadays, due to the high demand to use the integration of antenna, a new antenna concept is introduced to support wireless communication such as plasma antenna. However, the current issue with the plasma antenna is not environmentally friendly because it is known as an antenna with ionized gas enclosed in a tube that could harm the environment. Therefore, the project presents the Integration of Light Emitting Diode (LED) with the Printed WI-FI Radiating Element. The purpose of this project is to design the dual functionality of the device which is for wireless communication and illumination. This project also focused on the performance of the radiating element that can resonate at 2.4 GHz with the integration of the LED.

The design is simulated in the Computer Simulation Technology software for testing out the performance of the radiating element that integrates with LED. At the end of this project, the fabricated design is measured its parameter in terms of the return loss, VSWR, bandwidth, and directivity during the condition LED is turned ON and OFF for both measurement and simulation results to analyze its overall performance of the design.

1.2 Problem statement

The growth of wireless communication systems is increasing at an amazing speed. The demand from the user and service provider is required to use especially the antenna that has high gain performance for wireless communication. The current issue that has been proposed for a long time is the matter of the performance of the antenna to achieve better bandwidth and directivity. The inconsistency of the antenna's performance would be unable to support especially for Wi-Fi applications. Even though the new concept of the antenna introduced was the plasma antenna which can support the wireless communication system, the limitation of the plasma antenna could bring harm to environmental uses. It was because inside the fluorescent tube that acts as a plasma element contains the mercury substance which is harmful to the surroundings if did not manage properly. The use of plasma antennas is not environmentally friendly. Therefore, the proposed solution is to develop a printed radiating element that can support Wi-Fi functionality.

The project design is also integrated with the Light Emitting Diode (LED) to enhance the antenna's performance. The project is designed through Computer Simulation Software (CST) and fabricated in the laboratory.

1.3 Objectives

The research is focused on the design of the radiating element integrated with the Light Emitting Diode at 2.4 GHz. The main objectives of this project:

1. To design and optimize the radiating element integrated with Light Emitting Diode (LED) to have dual functionality in one device which is the illumination and wireless communication.
2. To verify the performance of the fabricated printed radiating element with LED in terms of Return Loss (S11), VSWR, bandwidth, and directivity.

1.4 Scope of project

The project scope is covered software, hardware, and equipment. The design of radiating elements is developed in the CST Microwave Studio. The parameters were verified in the simulation. The hardware components consist of material Rogers RT/Duroid 5880 substrate, Subminiature version A (SMA) Connecter, Battery AA of 3V, and Surface Mount Device (SMD) 5050 LED. Then, the design is fabricated using the wet etching technique. The design outcome is measured in the laboratory and the equipment used is Vector Network Analyzer and Anechoic Chamber room. The measurement is conducted during the condition of LED ON and OFF state. The operating frequency of 2.4 GHz is set as a benchmark for this project.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

This section is explaining about the background study of the research which is the significance of the previous project taken to review and support this project's research regarding the radiating element. The project design needed to be an experiment so that it can support wireless communication and the addition of LED into the radiating element.

2.2 Microstrip patch antenna

A low-profile radio antenna that can be installed on a low surface is called a microstrip patch antenna. It is made by etching the antenna element pattern on the metal trace that is adhered to the dielectric to create a narrow band, wide beam-fed antenna. a substrate, like a printed circuit board, that has a continuous metal layer adhered to the side that faces the ground plane. In their conventional form, microstrip patch antennas are narrow-band devices. “The range of their impedance is typically 1% to 2%. This can be attributed to its resonant form, which allows it to transmit effectively only across a limited range of frequencies” [1]. “Even though microstrip antenna typically has a small bandwidth, it is widely believed to be ideal for many wireless applications. A ground plane is located on the opposite side of a dielectric substrate that has a radiating patch on one side” [2].

Over many years, a microstrip patch antenna has been developed into many shapes and patterns used for many applications demanded by people. One of the applications of microstrip antenna was commonly used for wireless communication. “It became widely useful among the antenna users because of its advantages such as lightweight, compact design and ease of fabrication” [3].

Because of how simple the microstrip patch structures are to make, microstrip analysis has become a significant research issue. In the twenty-first century, research on microstrip antennas focused on reducing size, improving gain, wide bandwidth, various functionality, and system-level integration. “Higher dielectric constants, which are less effective and lead to a narrower bandwidth, must be used to produce a small Microstrip patch antenna. Therefore, a balance between antenna size and performance is required” [4]. Figure 2.1 shows the structure of the microstrip patch.

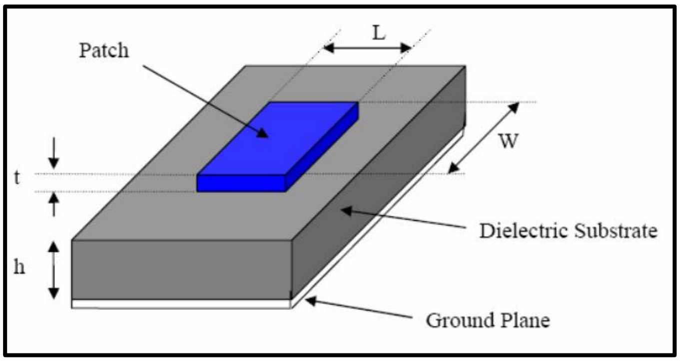

Figure 2.1 Structure of microstrip patch antenna

2.3 Feeding technique for microstrip patch antenna

The feeding technique is one of the methods used to enhance the gain of the patch antenna. “To optimize the antenna input impedance matching and ensure the effective operation of the antenna, feeding plays an important role” [5]. The most basic feeding technique is microstrip line feeding. A microstrip line with a 50 Ohm impedance is joined to the patch, and the port is connected to the opposite end of the added microstrip line. This extra microstrip line serves as a feeder for the rectangular microstrip patch antennas. The length of the feeding line is unaffected by other factors, whereas the width is computed using older formulas for the same frequency and impedance of 50 ohms. In the previous findings mentioned case study works “the width of the microstrip feed line out to be around 3 mm and the feed line is measured in 10 mm” [6]. Figure 2.2 shows a rectangular patch with a microstrip feed line.

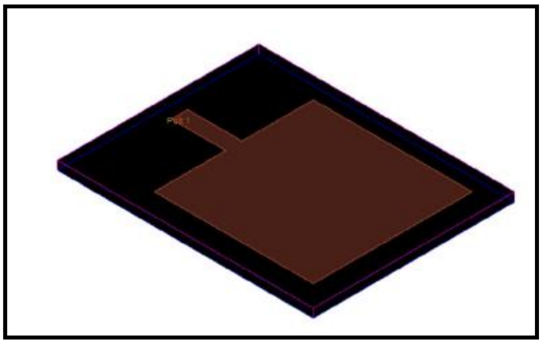

Figure 2.2 Rectangular patch antenna with the microstrip feed line

“The benefit of this type of feed arrangement is that the feed can be etched on the same substrate to create a planar structure” [7]. Although the findings have improved, it still not meets the criterion of an acceptable antenna response. As a result, the method is switched to the Microstrip inset feed technique.

Microstrip inset feed is a step forward from the microstrip feed line that was previously introduced. It is a form of microstrip line feeding technique that has the benefit of enabling a planar structure through the narrow width of the conducting strip relative to the patch. “The inset cut in the patch is designed to match the input impedance of the patch to the feed line without the use of any extra matching elements” [8] [9]. By correctly setting the inset cut position and dimensions, this can be accomplished. In these findings, a feed point is measured someplace on the surface of the rectangular patch where the patch's impedance equals the microstrip feed line's impedance of 50 ohms in this feeding approach. The feed cable is then connected to that specific antenna position. In general, the feed point where the rectangular patch's impedance is 50 ohms is at around one-third of the width and the length's center. Figure 2.3 show the microstrip inset-fed patch antenna design

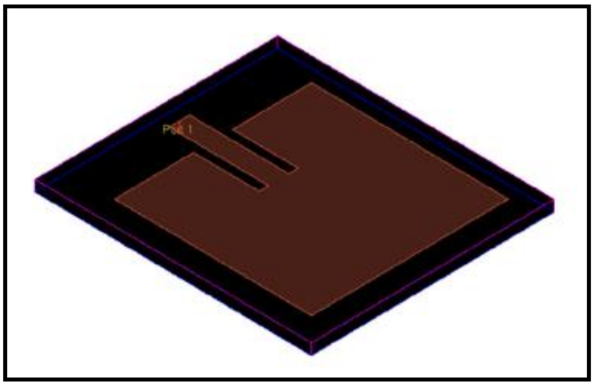

Figure 2.3 Microstrip inset-fed patch antenna design