DESIGN AND ANALYSIS OF HIGH-QUALITY FACTOR MULTI-RESONATOR CHIPLESS RFID TAG

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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 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 Bachelor of Electronics Engineering with Honours.

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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

Nowadays, Chipless Radio Frequency Identification (RFID) tag has gained popularity due to lower-cost printing flexibility. Furthermore, chipless RFID tags also store information using electromagnetic features instead of memory chips. The technology comes through by focusing on a user-friendly RFID tag. According to the company's research into the technology, chipless tags have a significant bit of storage capacity. Therefore, the project presents a multi-resonator chipless RFID tag with a high-quality factor. The tags are designed and optimized using Computer Simulation Technology (CST) software and operated at 0-3 GHz with a high-quality factor with a high data capacity on a flexible substrate. This project also focuses on the performances of the chipless RFID tag such as radar cross-section in the response to the reflection from the environment. At the end of this project, the design is fabricated using a Fast Film substrate with permittivity, $\varepsilon r = 2.7$ and thickness, $h = 0.13$ mm chipless RFID tags. The chipless RFID tags have been analyzed and measured the performance of the tag running through Vector Network Analyzer.

ABSTRAK

Pada masa kini, tag Pengecaman Frekuensi Radio Tanpa Cip (RFID) telah mendapat populariti disebabkan fleksibiliti percetakan kos yang lebih rendah. Tambahan pula, tag RFID tanpa cip juga menyimpan maklumat menggunakan ciri elektromagnet dan bukannya cip memori. Teknologi ini datang melalui dengan memfokuskan pada tag RFID yang mesra pengguna. Menurut penyelidikan syarikat dalam teknologi, tag tanpa cip mempunyai kapasiti penyimpanan bit yang ketara. Oleh itu, projek ini membentangkan tag RFID tanpa cip berbilang resonator dengan faktor kualiti tinggi. Tag direka bentuk dan dioptimumkan menggunakan perisian Teknologi Simulasi Komputer (CST) dan dikendalikan pada 0-3 GHz dengan faktor kualiti tinggi yang mempunyai kapasiti data yang tinggi pada substrat yang fleksibel. Projek ini juga memberi tumpuan kepada prestasi tag pengecaman frekuensi radio tanpa cip seperti radar kutub silang dalam tindak balas kepada pantulan dari persekitaran. Pada akhir projek ini, reka bentuk direka menggunakan substrat Filem pantas dengan kebolehtelapan, $\varepsilon r = 2.7$ dan ketebalan, $h = 0.13$ mm tag RFID tanpa cip. Tag RFID tanpa cip telah dianalisis dan mengukur prestasi tag yang dijalankan melalui Penganalisis Rangkaian Vektor.

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First, I want to praise, and thank Allah almighty for blessing me, for giving me the courage to finish a study, and for providing me a chance. I would like to express my deepest gratitude and appreciation to my project supervisor Professor Madya Dr. Maisarah Binti Abu for their support and wise direction. My sincere appreciation for his attentive oversight, advice remarks as well as for taking the time to respond. This thesis would never have taken shape without his invaluable guidance and persistent help. Besides, I want to express my gratitude to my family for always being there for me to encourage me when the times got rough. I am overwhelmed to receive the kind words and all the assistance given. Next, to both panels of this project, Dr. Imran bin Mohd Ibrahim, and Mr. Azahari bin Salleh, always gave ideas and advanced during the presentation. Finally, I would like to thank all my fellow friends for their help and support. Their support was a great relief and comfort to push me to complete my project.

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LIST OF SYMBOLS AND ABBREVIATIONS

CST	:	Computer Simulation Technology
VNA	:	Vector Network Analyzer
VSWR	:	Voltage Standard Wave Ratio
RFID	:	Radio-Frequency Identification
RCS	:	Radar Cross Section
MRF	:	Multi-resonator filters
MCSRR	:	Modified Complementary Split Ring Resonator

CHAPTER 1

INTRODUCTION

1.1 Introduction

Since its debut, Radio Frequency Identification (RFID) usage has seen substantial growth. Radiofrequency identification device (RFID) technology offers many advantages over other methods like optical and radio frequency barcoding. They include non-line-of-sight reading, extended reading range, increased data capacity, and automation in item tracking, identification, and localization. Moreover, the next generation of bar code technology used for electronic product identification is radio frequency identification. RFID technology has demonstrated advantages over current bar code identification systems. Next, due to the existence of an application-specific integrated circuit (ASIC) chip, RFID tags with tiny chips cost more than barcode tags. The tag is used to encode product data in a variety of fieldsand can be programmed to operate in many different languages. The chipless tags use multiresonators to store and retrieve data fast. Without a data storage chip, chipless tags can be made. The method for creating a new type of tag includes RFID tags, middleware software, and a reader. The tag encodes information in the frequency spectrum, giving it its spectral signature. The RFID reader acquires the spectrum signature by interrogating the tag with a multi-frequency signal. The tag's spectral signature is encoded into the interrogation signal spectrum through a multi-resonator circuit. Moreover, multiresonators can be done by combining and matching resonator sizes and shapes. Multiresonators are structures that resonate at multiple frequencies over their operational range. Absence or presence can be used to encode data bits in their resonant peaks. The reader is connected to a host computer that performs additional signal processing and indicates the identity of the tag to interpret human readers. All RFID applications need to be inexpensive to compete with the cost of barcodes.

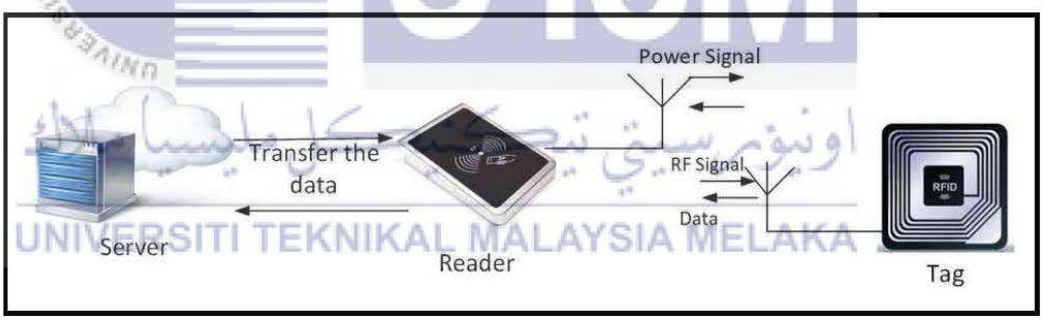

Figure 1.1 General RFID system [1]

1.2 Problem Statement

Chipless RFID has the potential to be a useful monitoring and identifying technology. However, there are two critical challenges in the chipless RFID tags' design level which is a sensitive response to the reflection from the environment. It can impact the dynamic environment and the object associated with the tags responses, which obstructs the tag ID measurement technique. Furthermore, the distance performance of tags has low data capacity. The tag is used to label things made of elevated and greater substances, such as metals and liquids with a water base. These days, chipless tags can easily be given while remaining incredibly affordable, small, and suited for manufacturing things. This is because chipless tags can be produced with waveguide technologies or using the appropriate copper inks, custom printed on a range of dielectric materials [2]. Therefore, to overcome these issues, this project aims to design and optimize the multi-resonator chipless RFIDtag with high-quality factors and increase the performance of the chipless RFID tags.

1.3 Objectives

1. To design and optimize the multi-resonator chipless RFID Tag.
2. To analyze the performance of the chipless RFID Tag.

1.4 Scope of Work

This project designed and analyzed the multi-resonator chipless RFID tag with high-quality factors. Other than that, the performance of the tag in terms of radar cross-section has been analyzed using Computer Simulation Technology (CST). The multi-resonator circuits will consist of a single element and a modest design. Additionally, it might be printed with semi-conductive ink on bendable plastic or paper substrates for extremely affordable but increased RFID systems. The chipless tags can simply be equipped with sensing capabilities while staying affordable, small,and portable. Other than that, this project will simulate parameters that will be studied such as insertion loss. This project was fabricated on a substrate such as a flexible substrate.

1.5 Importance / Significants

The printable passive RFID tags of chipless RFID systems have a few advantages over microchip RFID systems. This feature allows chipless RFID tags to be significantly less expensive than conventional RFID tags. Applications of chipless RFID tags can be the most promising technologies for the food business since they can meet all sensor and identification needs in food safety monitoring, package tracking, inventory control, early warning, and easy check-out. Other than that, this project of the chipless RFID tag with high-quality factor multi resonator is relevant to sustainability and environmentally friendly which can be used for potential impact and future revolution for a green project. This can be accomplished by creating a low-cost, durable, widely available, and simple-to-manufacture environmental sensor. Other than that, the concepts of chipless RFID tags appear to be promising for low- cost item tagging.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter contains the research results from a previous study that is relevant tothis project. These studies also serve as the primary source of information, with the theoretical, methodology, and interpretation of the studies assisting in the support of the project's material. The preferred journal objective was created by other people and related to the current project. The magazines or articles help the student to find new ideas and methods to fix a problem found in their project. A literature search is also helping students to find another way to solve the problem, even though they may have already done so and have a solution to a specific problem.

2.2 Multi-resonator chipless RFID tag

This research paper is about the design of chipless RFID tags based on multi-resonator filters. This project used a type of broadband chipless RFID tagging based on a slot-linked tapered slot antenna (TSA) loaded with a collection of resonators (MRF). Other than that, this project used 8 bits of the MRF circuit. The spectral and temporal domain responses of MRF circuits operating in the frequency range of 4 to 9 GHz are measured under short and open terminations in this research. The pulse fidelity factor is calculated after discovering the cross-correlation between the signals [2]. The result has been proposed as an open stub resonator with either short circuit loads, or long circuit loads to generate distinct RFID codes. Next, the researchpaper is about the design of chipless RFID by using the Modified Complementary Split Ring Resonator (MCSRR) to produce a high data capacity and miniaturized flexible chipless RFID tag. The 48 mm x 48 mm, 19-bit, chipless RFID tag uses a frequency shifting approach and is made up and shows an MCSRR with a Different Width (MCSRR with DW) structure composed of five overlapping slots. The flexible (Polyethylene Terephthalate) PET substrate employed in this study had a permittivity of 0.2 aside from that [3]. The main objective is to operate the frequency of a wideband tag antenna and a rising reader antenna utilized to assess the material structures using a chipless RFID tag technology with a range of frequencies of 0.9 and 2.7 GHz. As a result, a low-cost RFID tag-based CSRR material structure with a bendable, larger efficiency, and compact size has been developed. The potential 19 bits frequency signature was generated using 5 overlaying of MCSRR with DW structures with dimensions of 48 mm × 48 mm.

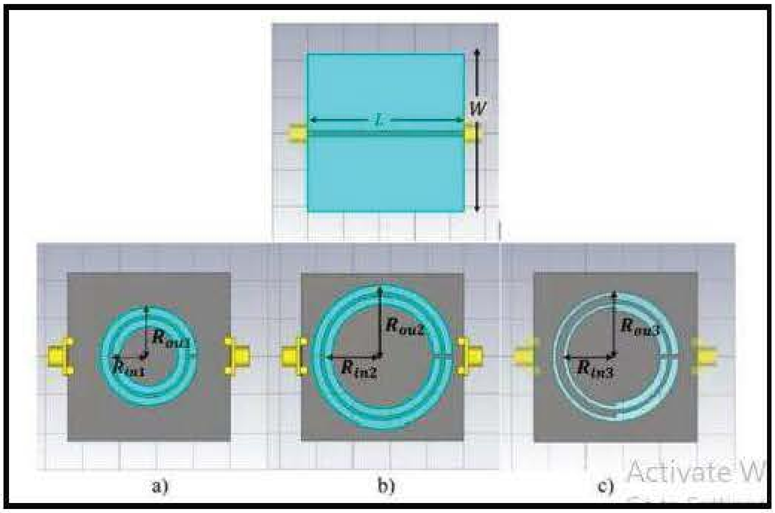

Figure 2.1 A proposed transmission line with resonator structure; a) CSRR structure, b) MCSRR structure c) MCSRR with DW [3].

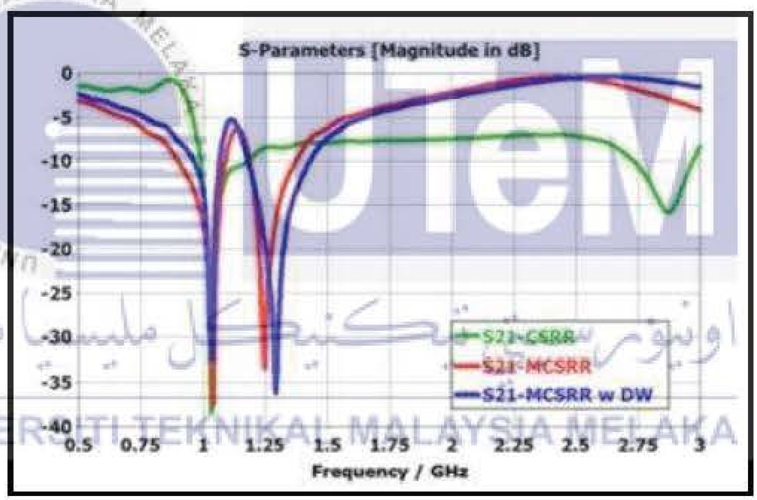

Figure 2.2 The simulated insertion loss for the proposed design; CSRR (green), MCSRR (red), and MCSRR with DW (blue) [3].

Next, the research paper is about the Dual band Modified Complementary Split Ring Resonator (MCSRR) Based Multi-resonator Circuit for Chipless RFID Tag. This project presented a small multi-resonator circuit that uses several modified complementary split-ring resonators (MCSRR) arranged along the transmission line as data bit encoding elements. Our suggested tag will increase the information density