DESIGN AND DEVELOPMENT OF A WIRELESS RADIO FREQUENCY IDENTIFICATION READER COMMUNICATION SYSTEM AT UHF BAND

By

MOHAMMAD SHAHRAZEL BIN RAZALLI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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DEDICATION

In the name of Allah, Most Gracious and Most Merciful

For the Sake of Islam

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Associate Professor Mohd Adzir Mahdi, PhD
Faculty: Engineering

Radio Frequency Identification (RFID) system has been widely used recently to replace a bar code system. The purpose of the RFID device is the same as a bar code device that provides a unique identifier data for an object. In the bar code device, the identifier data is printed on the object, while in the RFID device the identifier data can be stored and updated from time to time because it has a small size of memory chip or microprocessor located in its tag. Besides that, the RFID device does not need a line of sight to retrieve the data from the tag since it uses a magnetic wave or radio frequency wave at 134.2 KHz or 13.56 MHz to communicate between the reader and tag.

The common RFID reader in the market nowadays is using a wire communication between the reader and the host computer. This limits the reader performance

since it is not portable. To make it portable, the device can be connected to the Personal Digital Assistant (PDA) or Bluetooth wireless device, but the solutions are costly.

In this thesis, the research is concentrated on the design and development of the communication system between the reader and the host computer. The communication between the RFID reader and the computer host is by using wireless and the communication is set to RS232 protocol. The system is operated at UHF 370 MHz band and it uses an amplitude shift keyed (ASK) modulation technique The system is established by modulating the amplitude of the high bit or bit '1' of the signal at radio frequency wave at the UHF carrier wave. For the low bit or bit '0' there is no radio frequency (RF) modulation taken place at the transmitter circuit, therefore the receiver does not receive any RF modulation wave from the RF transmitter reader and this is defined as low bit or bit '0' at the receiver.

This RFID wireless reader communication system can provide a good communication range in between 20 to 30 meters for line of sight or without line of sight. It is very useful for the outdoor such as tree tagging and electronic gardening applications. Furthermore, the designed RF transceiver is cost effective as compared to other RF transceiver modules available off the shelf and also from other wireless communication technologies such as Bluetooth or Wireless Fidelity (Wifi).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

REKABENTUK DAN PEMBANGUNAN SISTEM PERHUBUNGAN PEMBACA RADIO FREKUENSI IDENTITI TANPA WAYAR PADA JALUR UHF

Oleh

MOHAMMAD SHAHRAZEL BIN RAZALLI

Jun 2006

Pengerusi: **Profesor Madya Mohd Adzir Mahdi, PhD**
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Sistem pengenalan identiti menggunakan frekuensi gelombang radio (RFID) telah digunakan dengan meluas dewasa ini bagi menggantikan sistem pengenalan identiti menggunakan kod garisan. Tujuan kegunaan sistem pengenalan identiti menggunakan frekuensi gelombang radio adalah sama sahaja seperti pengunaan sistem kod garis, iaitu untuk menyediakan pengenalan unik untuk objek. Bagi sistem pengenalan identiti menggunakan frekuensi gelombang radio, data maklumat boleh disimpan dan dikemas kini dari masa ke semasa kerana sistem ini mempunyai cip storan ingatan yang bersaiz kecil didalam penanda. Dengan sistem ini, penguna tidak perlu mengesan objek secara garisan lurus (kaedah mengesan

objek seperti didalam sistem kod garis), kerana ianya mengunakan gelombang radio untuk tujuan pembacaan atau pengesanan objek. Frekuensi pembaca RFID yang popular digunakan sekarang adalah pada 134.2 kHz dan 13.56 MHz. Secara amnya, kebanyakan pembaca sistem pengenalan identiti frekuensi gelombang radio ini direkacipta dengan menggunakan talian wayar untuk berkomunikasi diantara pembaca dan terminal komputer. Ini menyebabkan ianya tidak begitu mudah alih untuk kegunaan diluar bangunan. Untuk menjadikannya mudah alih, pengguna perlu menyambungkan sistem ini dengan pembantu digital persendirian (PDA) atau *Bluetooth*.

Dalam tesis ini, kajian tertumpu kepada sistem perhubungan diantara pembaca RFID dengan terminal komputer. Alat sistem perhubungan ini direkacipta supaya menjadikan pembaca RFID ini tanpa wayar dan mudah alih. Frekuensi gelombang radio yang di pilih adalah pada 370 Mhz dan menggunakan protokol RS232. Teknik modulatan gelombang radio ini berdasarkan pada teknik amplitud modulatan (ASK). Apabila pembaca membaca penanda, maklumat bit '1' didalam penanda, ia mengaktifkan gelombang radio pemancar atau memodulatkan gelombang radio pada 370 MHz. Ini akan menyebabkan penerima pada terminal komputer mentakrifkan sebagai maklumat bit '1'. Apabila maklumat bit adalah '0', ia tidak memodulatkan gelombang radio pemancar dan penerima pada terminal komputer akan mentakrifkan ini sebagai maklumat bit'0'.

Pembaca sistem pengenalan identiti tanpa wayar ini bekerja baik didalam lingkungan 30 meter dengan adanya halangan atau tanpa halangan. Ianya amat

sesuai sekali bagi penggunaan di luar bangunan seperti, penandaan pokok didalam hutan dan bercucuk tanam secara elektronik. Selain daripada itu, kos rekacipta dan pembangunan sistem ini jauh lebih murah jika dibandingkan dengan sistem komunikasi dengan seperti Bluetooth dan fidelity tanpa wayar (WIFI).

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Thank you so much.

I certify that an Examination Committee has met on 2nd June 2006 to conduct the final examination of Mohammad Shahrazel bin Razalli on his Master of Science thesis entitled "Design and Development of a Wireless Radio Frequency Identification Reader Communication System at UHF Band" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my own work except for the quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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MOHAMMAD SHAHRAZEL BIN RAZALLI

Date:

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LIST OF ABBREVIATIONS

AC - Alternating Current

AM - Amplitude Modulation

ASCII - American Standard Code II

ASK	**-**	**Amplitude Shift Keyed**
AWG	**-**	**American Wire Gauge**
BJT	**-**	**Bipolar Junction Transistor**
BPF	**-**	**Band Pass Filter**
CH1	**-**	**Channel 1**
CH2	**-**	**Channel 2**
C_{tuned}	**-**	**Tuning Capacitor**
CW	**-**	**Continuous Wave**
DC	**-**	**Direct Current**
EM	**-**	**Electromagnetic**
FCC	**-**	**Federal Communications Commission**
FM	**-**	**Frequency Modulation**
fo	**-**	**First Spectrum Frequency**
2fo	**-**	**Second Spectrum Frequency**
3fo	**-**	**Third Spectrum Frequency**
FSK	**-**	**Frequency Shift Keyed**
HCL	**-**	**Hydrochloric**
IC	**-**	**Integrated Circuit**
IR	**-**	**Infra Red**
ISM	**-**	**Industrial, Scientific and Medical**
IW	**-**	**Instantaneous Wave**
LC	**-**	**Inductor, Capacitor**
LF	**-**	**Low Frequency**

LOS	**-**	**Line Of Sight**
LPF	**-**	**Low Pass Filter**
LSI	**-**	**Large Scale Integrated NLOS**
NLOS	**-**	**Non Line Of Sight**
OEM	**-**	**Original Engineering Module**
PCB	**-**	**Printed Circuit Board**
PSK	**-**	**Phase Shift Keyed**
R	**-**	**Resistance loss**
RF	**-**	**Radio Frequency**
RFC	**-**	**Radio Frequency Choke**
RFID	**-**	**Radio Frequency Identification**
RLoss	**-**	**PCB Copper Loss Resistance**
RM	**-**	**Ringgit Malaysia**
RMS	**-**	**Root Mean Square**
Rrad	**-**	**Radiation Resistance**
RS232	**-**	**Recommended Standard 232**
SHF	**-**	**Super High Frequency**
SW1	**-**	**Switch 1**
TI	**-**	**Texas Instrument**
TTL	**-**	**Transistor-Transistor Logic Level**
UHF	**-**	**Ultra High Frequency**
USB	**-**	**Universal Serial Bus**
USD	**-**	**United State Dollar**

LIST OF NOTATIONS

A	-	**Area of the coil loop in** m^2
$B.W$	-	**Bandwidth in** $rads^{-1}$
C	-	**Reactance of the Capacitor in H**

f	-	**Frequency in hertz**
Ic	-	**Collector Current in A**
Ib	-	**Base Current in A**
l	-	**perimeter of the coil in m.**
L	-	**Reactance of the Inductor in H**
L_M	-	**Mutual Inductance in H**
N	-	**Coil turns**
P_{rad}	-	**Radiation Power in W.**
P_{Loss}	-	**Loss Power in W**
P_{Total}	-	**Total Power in W**
Q_{Series}	-	**Series Quality Factor of the inductance**
r	-	**Coil radius in mm**
R	-	**Resistor in Ω**
Rf	-	**Feedback Resistor in Ω**
T	-	**Time**
μ	-	**Non Magnetic Material permeability in H/m**
V	-	**Voltage in V**
Vbe	-	**Voltage Across base emitter junction in V**
Vc	-	**Collector Voltage in V**
VDz	-	**Voltage zener diode in V**
Vin	-	**Input Voltage in V**
Vout	-	**Output Voltage in V**

W	-	**Energy Storage in J**
ω_r	-	**Resonance Frequency in** $rads^{-1}$
w	-	**Width of the PCB copper track in m**
X_M	-	**Inductance reactance linkage between primary and secondary coil in** Ω
σ	-	**Conductivity in S/m of the pcb track**
ε_r	-	**relative dielectric constant**
k	-	**coupling coefficient**
β	-	**Forward Current Gain**