FREKUENSI RADIO IDENTIFIKASI
(RADIO FREQUENCY IDENTIFICATION DEVICE)

Oleh

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ABSTRAK

Frekuensi Radio Indentifikasi (RFID) ialah satu bidang yang baru yang sedang giat berkembang. Sistem ini banyak digunakan secara meluas dalam kehidupan seharian kita. Sebagai contohnya sistem ‘Smart Tag’ yang terdapat di lebuh raya – lebuh raya. Dengan menggunakan perkhidmatan ini kita hanya perlu memandu kenderaan menghampiri plaza tol tersebut. Secara automatik duit kita akan ditolak ketika melalui plaza tol tersebut. Satu lagi contoh ialah di pasar raya terdapat alat mencegah kecurian di pintu –pintu masuk. Di setiap produk dan barangan mereka terdapat pelekat keselamatan atau ‘tag’. Jika barang tersebut di bawa keluar maka sistem penggera akan berbunyi. Tujuan projek ini adalah untuk mereka aturcara untuk sistem RFID yang sedia ada untuk kegunaan peribadi. Walau bagaimanapun, disebabkan kesukaran untuk mendapatkan pemancar maka satu litar yang ringkas direka untuk menunjukkan secara asas bagaimana system ini berfungsi. Litar pembaca dan litar pemancar dikatakan berinteraksi atau ‘resonant’ pada frekuensi tertentu. Di dalam industri frekuensi yang biasa digunakan ialah 125 kHz atau 13.56 MHz. Namun demikian, di dalam projek ini, frekuensi 1MHz digunakan kerana alat {audia generator) yang digunakan hanya mampu menghasilkan 1MHz sahaja. Antara masalah utama yang dihadapi ketika membangunkan projek ini adalah untuk melaraskan antena untuk litar pemcar dan pembaca. Masalah ini diatasi dengan menggunakan alat Network Analyzer. Dengan menggunakan alat ini antena dapat diselaraskan dengan mudah. Di masa hadapan, pelajar-pelajar yang ingin menyambung projek ini boleh cuba membangunkan projek ini supaya teknologi RFID dapat ditingkatkan kesatu lagi tahap.

ABSTRACT

Radio Frequency Identification or RFID is a new technology and building its reputation rapidly. This system is widely use in our daily lives. For an example is ‘Smart Tag’ lane on high ways. The gate automatically opens during the entry of our vehicle. Another example of RFID system is security alarm at shops entrance. The entire product is label with tag and the alarm would be triggered if the product is stolen or brought out passing through the doors. The main objective of this project is to write a program for the microcontroller for the RFID reader so that it could be use for personal purpose, but because it is hard to purchase the tag a 1-bit RFID circuit is designed to give a basic overview on how RFID works. The reader circuit and the tag is said to be resonating at a specific frequency. In industry the frequency that is used is 125 kHz and 13.56 MHz. But in this project the frequency used is 1MHz because of the capability of the equipment (audio generator) used in this project. One of the main problems faced during the development of this project is tuning the antenna to resonant at 1MHz. This is solved easily by using Network Analyzer. For the future student who intent to continue this project could improve the memory of the tag and the reading distance of the tag so that the RFID technology could be improve to a whole new level.

CONTENTS

CHAPTER 4: INTRODUCTION of a 1-bit RFID SYSTEM

CHAPTER 5: CONCLUSION AND FUTURE WORK

DEDICATION

I would specifically like to thank and express deep appreciation to the following people who have help make this project successful.

First, my thanks go to Dr Othman Sidek, who is my project supervisor and also the Dean of School of Electrical & Electronic Engineering, Universiti Sains Malaysia for his insight and support.

My special thanks to Dr. Ansor bin Yusof for his invaluable experience, help, guidance and useful critiques of the material.

My special gratitude goes Mr. Abdul Latip bin Abdul Hamid technician of Communication Lab who was involved during the experiment and developmental period of the project.

Lastly, I thank my parents and my friends for their support and guidance through out the whole project period. Without them this project surely would not be successful.

I appreciate all of their effort – I could not have done the project without them.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF RADIO FREQUENCY IDENTIFICATION DEVICE

An identification system comprises an interrogator and a number of transponders. The interrogator includes a transmitter for transmitting an interrogation signal to the transponder, and a receiver for receiving a response signal from the transponder. A micro-processor identifies the transponder from data in the response signal. Each transponder comprises a receiving antenna for receiving the interrogation signal, a code generator, a transmitting antenna, and a modulator connected to the code generator. On receipt of the interrogation signal the transponder repeatedly transmits a response signal containing data which identifies the transponder. The interrogator detects successful identification of any transponder and briefly interrupts the interrogation signal to indicate the successful identification.

Each transponder includes a logic circuit responsive to a respective interruption in the interrogation signal to cease transmission of its own response signal. Interrogator/transponder systems have been used for identifying vehicles, animals, people and other objects. Such systems generally comprise an interrogator comprising a transmitter/receiver and a transponder attached to each object to be identified. The transponder carries a code which uniquely identifies the object in question. Systems of this kind can usually deal effectively with one transponder at a time.

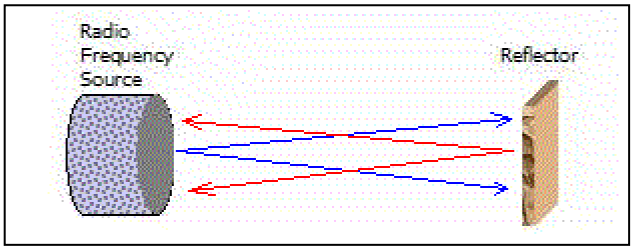


FIGURE 1.1: Basic diagram of RFID

Basically, the easiest way to understand RFID is to think of signal mirrors. For centuries it is known how to communicate messages with just a mirror by flashing the sun's reflection in the direction of the recipient. So, messages can be sent through the air simply by reflecting radiated sunlight. That is the basic idea behind RFID, except that instead of using radiated sunlight as our communication medium, we reflect radio waves.

1.2 PROJECT OVERVIEW

This report would give us an overview of an RFID system design that consists of two main components, a reader and a transponder or tag. Details on the antenna design, resonance tuning method for RLC series circuit and LC parallel circuit would also be included in this report.

The main tasks of this project are:

i. Write a program from an existing RFID circuit so that it can be use for personal purpose. Research and studies on the whole RFID system had to be done before any programming can be done.

ii. The layout for this circuit schematic is then created so that a printed circuit board (PCB) can be used.

The secondary tasks are:

i. Design a RFID 1- transponder that give us an overview of the whole RFID system.

ii. Antenna (coils) design for the reader and the transponder circuit.

iii. Communicating the reader circuit with the transponder circuit.

1.3 PROJECT DEVELOPMENT

In the early stage of this project a lot of reading and research had been done. Literature review are from books, internet and journal from IEEE. Books on RFID are very limited and most of the information is gathered from the internet.

Information on PIC programming is available easily on books in the library. Masters student are very helpful during the constructing to these program. To simplify the program development, flow chart is constructed.

Electronic engineering software such as Multisim 2001, Protel Dxp 2004, CODElite designer are used in the development o this project.

Knowledge on circuit theory is very important especially during the circuit design for the RFID 1-bit transponder.

1.4 Report Organization

This report is divided into 5 chapters. In chapter one the introduction, objective and the scope of the project is stated. This would help the readers to get an overall view of the report and the purpose of this project. The theory of RFID is discussed more detail in chapter two. Introduction to the main project, theory, programming and PCB layout is discuss more detailed in chapter three. Meanwhile in chapter four introduction and application to the secondary project- RFID 1-bit transponder is discussed. The antenna design and the programming are also included in this chapter. In the last chapter discussion and the conclusion for this project is discussed in this chapter. The problems faced during the development and suggestion to improve the project is also included in this section. Reference from books, journal and website will be included as well in this section.

CHAPTER 2
LITERATURE REVIEW

2.1 THEORY OF RFID SYSTEM

Radio Frequency Identification (RFID) tags has been in existence since the 1950's and two decades ago when they were introduced as the ultimate replacement for bar codes. RFID tags have the capability to read, write, transmit, store and update information. RFID tags can hold up to 64 mega bytes) of information making them more difficult to counterfeit than the bar codes. The biggest advantage of using an RFID tags is that data on existing tags can always be changed or updated.

These tags have proven to be very useful in the deliver of construction materials where a shakedown of a large quantity and variety of items can be read simultaneously without having to be separated and scanned individually. Information is communicated electronically via radio frequency waves and does not require contact or line-of-sight to transmit and stored data. Therefore, using RFID technology for the collection and transfer of information provides one with an inexpensive and non-labor intensive means of identifying and tracking products.

The smart chips (RFID tags) come in a large range of packaging options; they are reusable and can withstand harsh environments. In fact, RFID tags can operate effectively in temperatures ranging from $-40\ ^{o}C$ to $200\ ^{o}C$. The chips are also capable of performing under rugged conditions or when they are dirty, and not until recently were they capable of overcoming the interference of metal objects.

Over the past five years the information technology industry has seen a surge towards the development of an affordable RFID tag. Such developments have lead to larger reading ranges, greater memory capacity, and faster processing of radio frequency operating systems.

Unlike any other material management and material identification tag, RFID has a read – write capacity. A rewritable tag's ability to keep information up-to-date gives it the potential to strengthen national security and better inform people of maintenance and service records. Such a system could also alert automobile owners when an oil change or other routine maintenance is necessary. It also enhances the user's ability to locate objects when used in combination with GPS for real-time tracking.

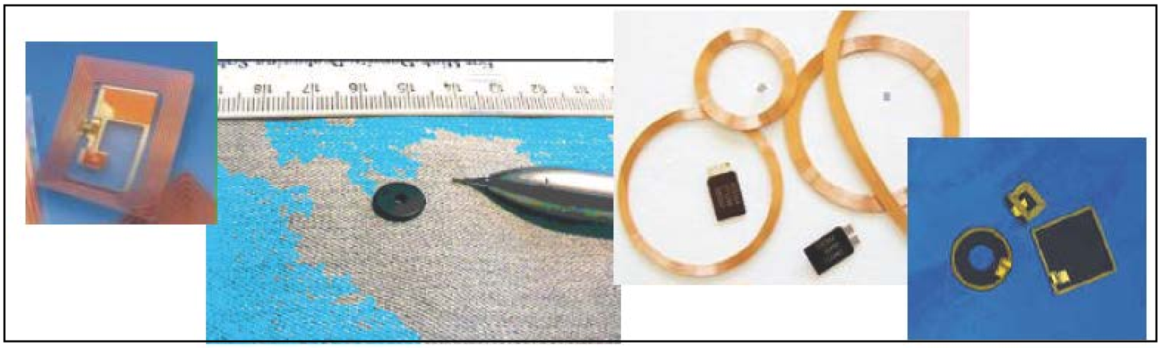


FIGURE 2.1: Types of RFID transponder

2.2 RFID Components

An RFID system is always made up of two main components:

- The transponder.
- The interrogator or reader.

The transponder or tags carry data in suitable transponders, and an RFID reader, which retrieves the data from the tags. Products that contain RFID tags embedded in them or fastened to them enable stored information to be transferred from an RFID tag to a remote reader through radio frequency waves.

There is no industry standard for frequency restriction, but the most common applications around the world uses frequency of 125 kHz and 13.56 MHz. Initially, data is written to the RFID tag enabling it to identify and characterize a product as a particular manufactured good with a determined application.

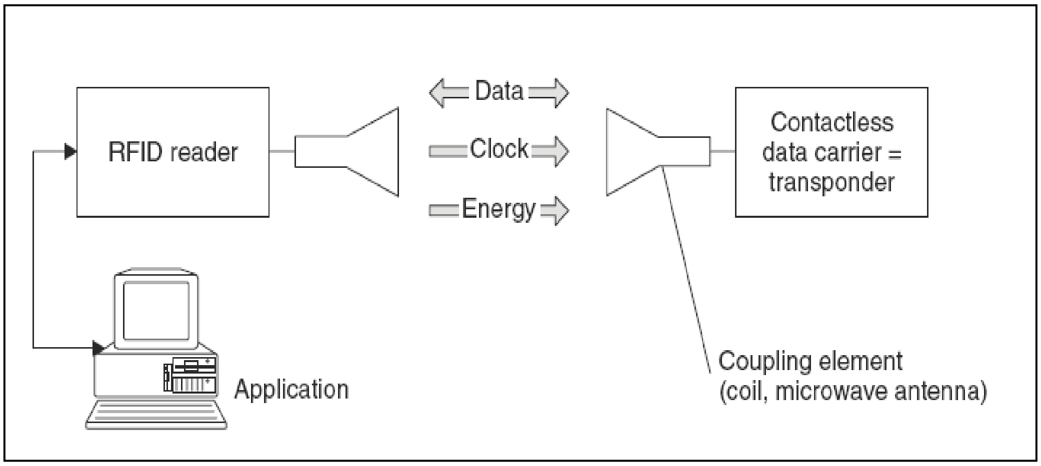


FIGURE 2.2: The reader and transponder are the main components of RFID system

2.3 RFID application

A reader typically contains a radio frequency module (transmitter and receiver), a control unit and a coupling element to the transponder. In addition, many readers are fitted with an additional interface (RS 232, RS 485, etc.) to enable them to forward the data received to another system (PC, robot control system, etc.).

The transponder, which represents the actual *data-carrying device* of an RFID system, normally consists of a *coupling element* and an electronic *microchip* (Figure 1.9).

FIGURE 2.3: RFID reader and contact less smart card in practical use

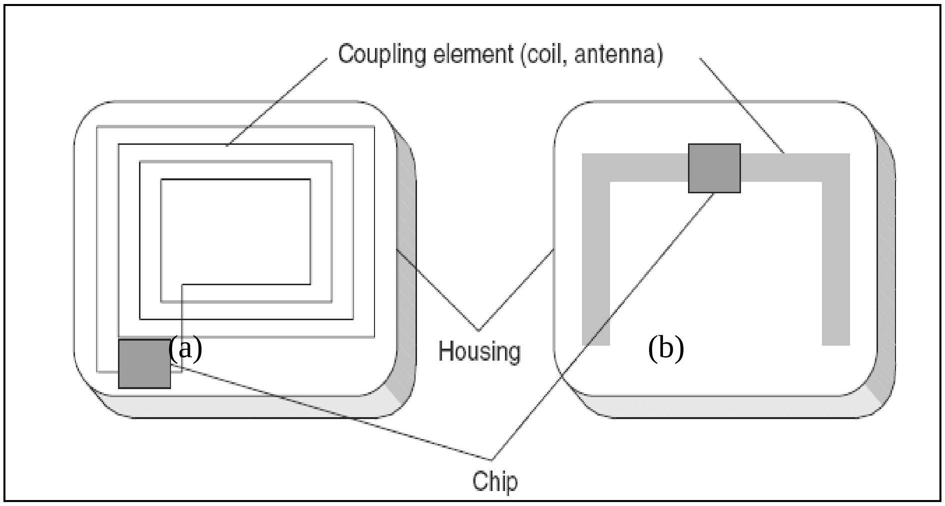


FIGURE 2.4: Basic layout of the RFID data-carrying device, the transponder.

(a) Left, inductively coupled transponder with antenna coil;

(b) right, microwave transponder with dipolar antenna

When the transponder, which does not usually possess its own voltage supply (battery), is not within the interrogation zone of a reader it is totally passive. The transponder is only activated when it is within the interrogation zone of a reader. The power required to activate the transponder is supplied to the transponder through the coupling unit (contact less), as are the timing pulse and data.

2.4 Security requirements

Security requirements to be imposed on a planned RFID application, i.e. *encryption* and *authentication*, should be assessed very precisely to rule out any nasty surprises in the implementation phase. For this purpose, the incentive that the system represents to a potential attacker as a means of procuring money or material goods by manipulation should be evaluated. In order to be able to assess this attraction, RFID applications are divided into two groups:

- Industrial or closed applications;
- Public applications connected with money and material goods.

This can be illustrated on the basis of two contrasting application examples. Let us once again consider an assembly line in the automotive industry as a typical example of an industrial or closed application. Only authorized persons have access to this RFID system, so the circle of potential attackers remains reasonably small.

A malicious *attack* on the system by the alteration or falsification of the data on a transponder could bring about a critical malfunction in the operating sequence, but the attacker would not gain any personal benefit. The probability of an attack can thus be set equal to zero, meaning that even a cheap low-end system without security logic can be used.

Our second example is a ticketing system for use in public transport. Such a system, primarily data carriers in the form of contact less smart cards, is accessible to anyone.

The circle of potential attackers is thus enormous. A successful attack on such a system could represent large-scale financial damage to the public transport company in question, for example in the event of the organized sale of falsified travel passes, to say nothing of the damage to the company’s image. For such applications a high end transponder with authentication and encryption procedures is indispensable. For applications with maximum security requirements, for example banking applications with an electronic purse, only transponders with microprocessors should be used.

2.5 Memory capacity

The chip size of the data carrier — and thus the price class — is primarily determined by its *memory capacity*. Therefore, permanently encoded read-only data carriers are used in price-sensitive mass applications with a low local information requirement.

However, only the identity of an object can be defined using such a data carrier.

Further data is stored in the central database of the controlling computer. If data is to be written back to the transponder, a transponder with EEPROM or RAM memory technology is required.

EEPROM memories are primarily found in inductively coupled systems. Memory capacities of 16 bytes to 8 Kbytes are available.

SRAM memory devices with a battery backup, on the other hand, are predominantly used in microwave systems. The memory capacities on offer range from 256 bytes to 64 Kbytes.

CHAPTER 3

RFID SYSTEM DESIGN

3.1 RFID System

System setup

A basic RFID system setup consists of three parts:

· A single or multiple identification labels (transponders or tags),

· A transceiver interface, to communicate between the microcontroller and the transponder,

· A data processing unit, such as a microcontroller.

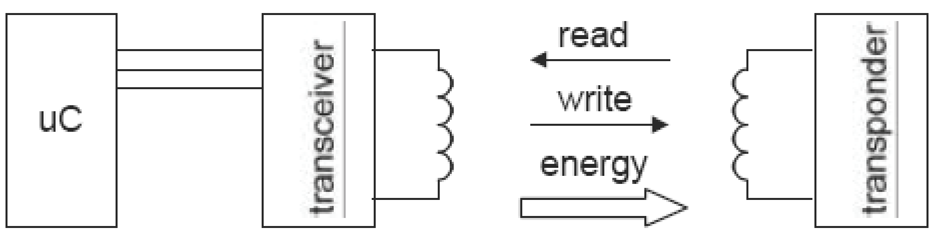


FIGURE 3.1: Basic RFID system setup

The reader (transceiver) is usually a fix mounted system, whereas the transponder is the moving part, e.g. in access control, or animal tagging. The reader and the transponder are working as a wireless, magnetic coupled communication system, each with a resonance circuit tuned to the frequency as close as possible. The reader provides energy to the transponder by an electromagnetic field. By modulating this field, the reader can transmit (write) data to the transponder. The transponder will power up and return its on-chip data to the reader.

3.2 RFID auto-theft immobilizer

3.2.1 READER CIRCUITS

The RFID reader consists of transmitting and receiving sections. It transmits a carrier signal, receives the backscattering signal, and performs data processing. The reader also communicates with an external host computer. A basic block diagram RFID reader is shown in **Figure 3.1.**

The RF field generated by a tag reader (the energy transmitter) has three purposes:

1. **Induce enough power into the tag coil to energize the tag.**

Passive tags have no battery or other power source; they must derive all power for operation from the reader field. 125 kHz and 13.56 MHz tag designs must operate over a vast dynamic range of carrier input, from the very near field (in the range of 200 VPP) to the maximum read distance (in the range of 5 VPP).

2. **Provide a synchronized clock source to the tag.**

Most RFID tags divide the carrier frequency down to generate an on-board clock for state machines, counters, etc., and to derive the data transmission bit rate for data returned to the reader. Some tags, however, employ on-board oscillators for clock generation.

3. **Act as a carrier for return data from the tag.**

Backscatter modulation requires the reader to peak-detect the tag's modulation of the reader's own carrier. See Section for additional information on backscatter modulation.

3.2.2 Transmitting Section

The transmitting section contains circuitry for a carrier signal (125 kHz), power amplifiers, and a tuned antenna coil. The 125 kHz carrier signal is typically generated by dividing a 4 MHz (4 MHz/32 = 125 kHz) crystal oscillator signal. The signal is amplified before it is fed into the antenna tuning circuit. A complementary power amplifier circuit is typically used to boost the transmitting signal level.

An antenna impedance tuning circuit consisting of capacitors is used to maximize the signal level at the carrier frequency. The tuning compensates the variations in the component values and the perturbation of coil inductance due to environment effect.

3.3 Receiving Section

The receiving section consists of an antenna coil, demodulator, filters, amplifiers, and microcontroller. In applications for close proximity read range, a single coil is often used for both transmitting and receiving. For long read-range applications, however, separated antennas may be used.

. The demodulation of the ASK signal is accomplished by detecting the envelope of the carrier signal. A half wave capacitor-filtered rectifier circuit is used for the demodulation process. The peak voltage of the back-scattering signal is detected by a diode, and this voltage is then fed into an RC charging/discharging circuit. The RC time constant must be small enough to allow the voltage across *C* to fall fast enough to keep in step with the envelope. However, the time constant must not be so small as to introduce excessive ripple.

The charging capacitor and load R has the following relationship for a full recovery of the data signal.

$$\frac{1}{\omega_s C} \geq R \geq \frac{1}{\omega_0 C} \tag{3.1}$$

Where ω_s and ω_o are the angular frequencies of the modulation (data) and carrier (125 kHz), respectively. *R* is the load (discharging) resistor. The demodulated signal must then pass through a filter and signal shaping circuit before it is fed to the microcontroller.

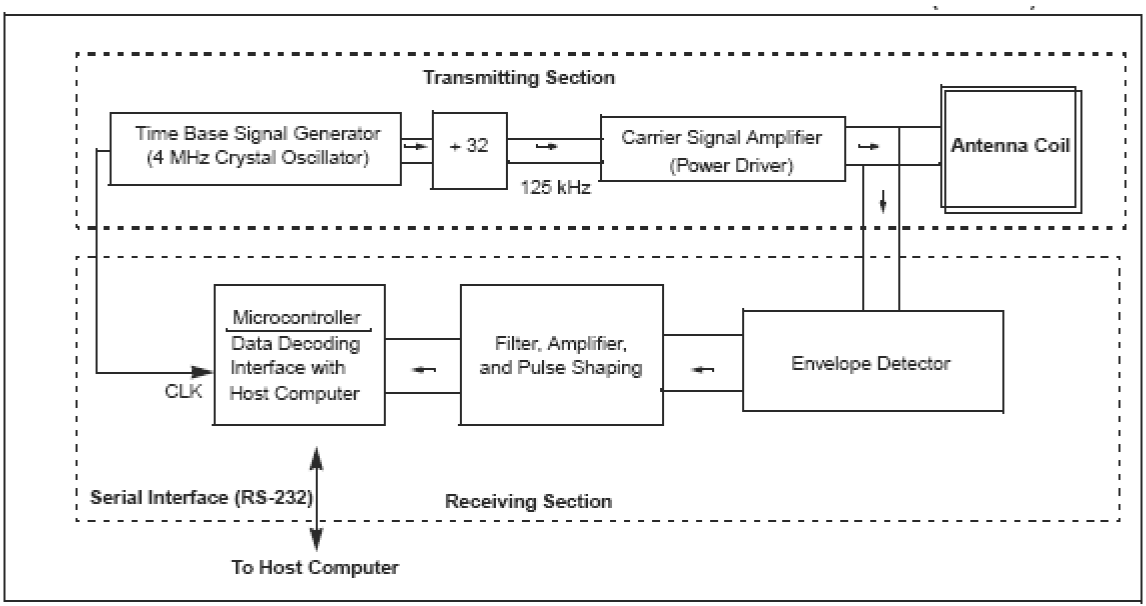


FIGURE 3.2: Block Diagram of RFID reader for 125 kHz signal.

3.4 Electronic Circuit Schematic reader

The electronic circuitry for an ASK reader is shown in FIGURE 3.3. The reader needs +9 VDC power supply. The 125 kHz carrier signal is generated by dividing the 4 MHz time base signal that is generated by a crystal oscillator. A 16-stage binary ripple counter (74HC4060) is used for this purpose. The 74HC4060 also provides a clock signal for the PIC16C84 microcontroller. The 125 kHz signal is passed to an RF choke (L1) and filter before it is fed into a power amplifier that is formed by a pair of complementary bipolar transistors (Q1 and Q2).

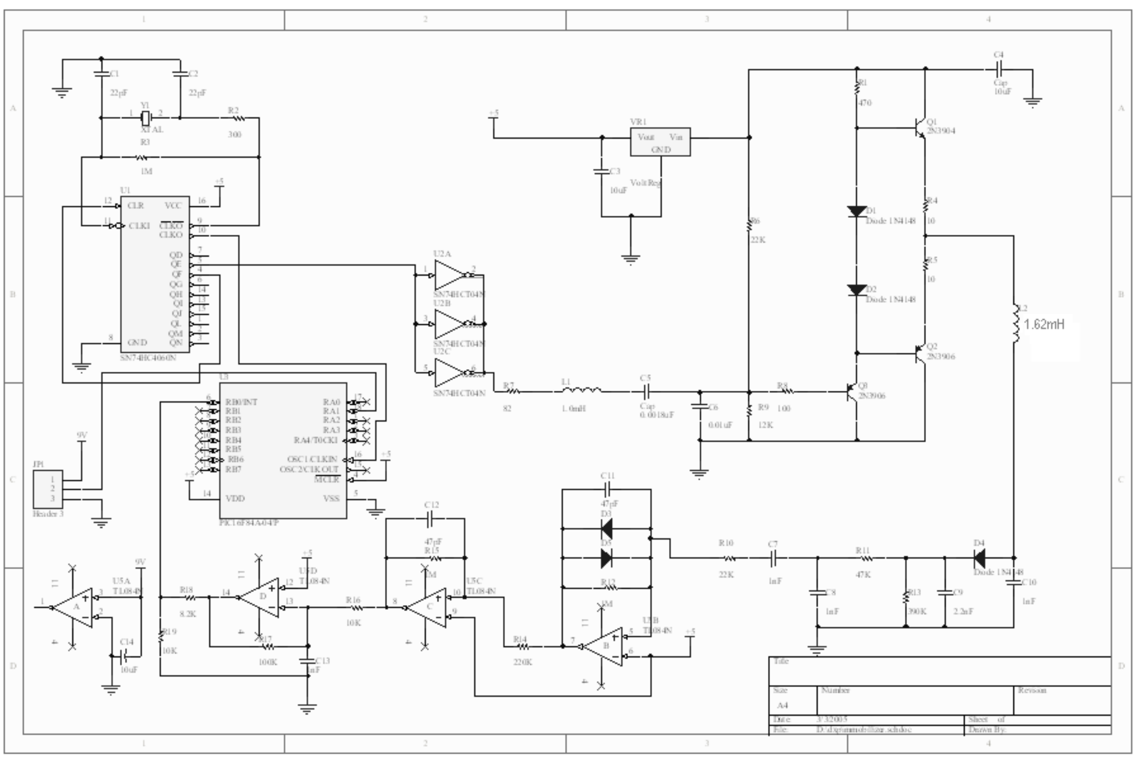


FIGURE 3.3: Circuit schematic of the RFID reader

For long read-range applications, this power amplifier circuit can be modified. Power MOSFETs may be used instead of the bipolar transistors (2N2222). These power MOSFETs can be driven by +24 VDC power supply. A push-pull predriver can be added at the front of the complementary circuit. This modification will enhance the signal level of the carrier signal and the read range of the ASK Reader. The reader circuit uses a single coil for both transmitting and receiving signals. An antenna coil (L2: 1.62 mH) and a resonant capacitor (C14: 1000 pF) forms a series resonant circuit for a 125 kHz resonance frequency.

Since the C10 is grounded, the carrier signal (125 kHz) is filtered out to ground after passing the antenna coil. The circuit provides minimum impedance at the resonance frequency. This result in maximizing the antenna current, and therefore, the magnetic field strength is maximized. L2, C10, D4, C9, R11, and the other components in the bottom part of the circuit forming a signal receiving section. D9 is a demodulator which detects the envelope of the backscattering signal. D4 and C9 form a half-wave capacitor-filtered rectifier.

The detected envelope signal is charged into C9. R13 provides a discharge path for the voltage charged in C9. This voltage passes active filters (U5: B and C) and the pulse shaping circuitry (U5: A) before it is fed into the PIC16C84 for data processing.

The PIC16C84 microcontroller performs data decoding to gain the original message signal.

3.5 Inductance of a Square Loop Coil with Multilayer

If N is the number of turns and a, is the side of the square measured to the center of the rectangular cross section that has length b and depth c as shown in Figure 3.4

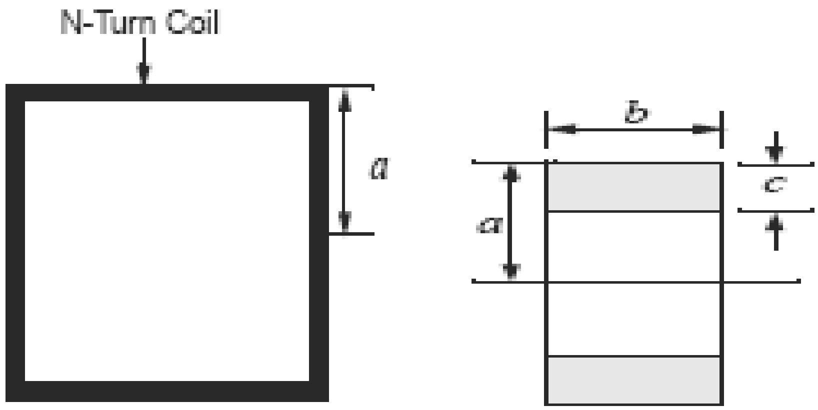


FIGURE 3.4: A Square Loop Antenna Coil with Multilayer

$$L = 0.008aN^2\left[2.303\log_{10}\left(\frac{a}{b+c}\right) + 0.2235\left(\frac{b+c}{a}\right) + 0.726\right] \quad (3.1)$$

The formulas for inductance are widely published and provide a reasonable approximation for the relationship between inductance and number of turns.

3.6 Calculation and Results

$$L = 0.008aN^2\left[2.303\log_{10}\left(\frac{a}{b+c}\right) + 0.2235\left(\frac{b+c}{a}\right) + 0.726\right]$$

a = 0.075m

b = 0.15m

c = 5mm

L = 1.62mH

$$1.62m = 0.008(0.075)N^2\left[2.303\log_{10}\left(\frac{0.075}{0.15+(5m)}\right) + 0.2235\left(\frac{0.15+(5m)}{0.075}\right) + 0.726\right]$$

$$1.62m = (0.6m)N^2\left[2.303\log_{10}(0.4839) + 0.2235(2.067) + 0.726\right]$$

$$1.62m = (0.6m)N^2\left[-0.726 + 0.4619 + 0.726\right]$$

$$1.62m = (0.6m)N^2\left[0.4619\right]$$

$$N^2 = \frac{1.62m}{0.27714m}$$

$$N = \sqrt{\frac{1.62m}{0.27714m}}$$

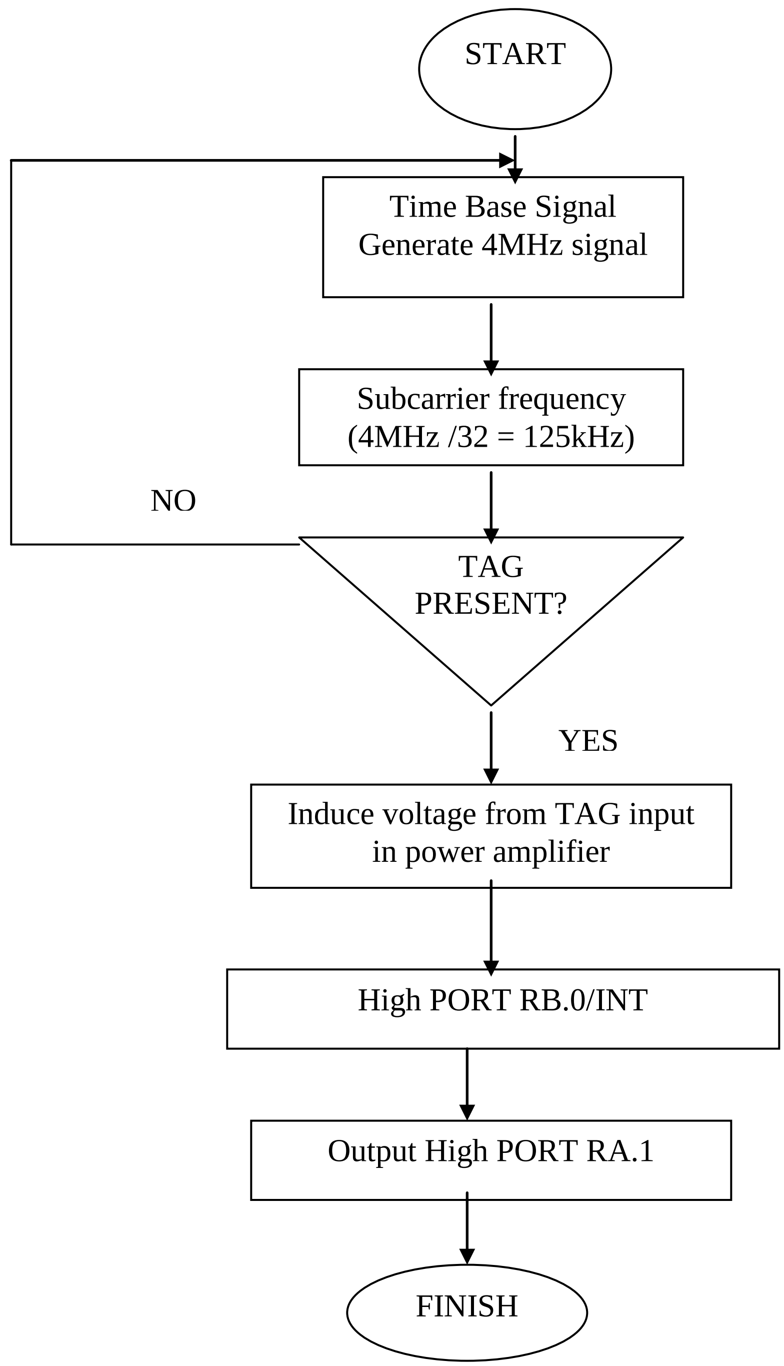
$$N = 2.42 \text{ Turns}$$

$\therefore$ 2 turn are required to achieve 1.62mH inductor value.

3.7 Programming RFID Microcontroller

The microcontroller of this RFID system is PIC (Programmable Intergrated Circuit) from Microchip Technology.

3.7.1 Flow Chart of the program



3.7.2 PIC programming

```
Symbol tag = PORTB.0
Input tag
Main:
Low PORTA.1
IF (tag = 1) Then led
 GoTo main
led:
        High PORTA.1
        Pause 1000
        Low PORTA.1
        GoTo main
End
```

3.8 PCB LAYOUT

Printed Circuit Board (PCB) Layout is design to using PROTEL DXP 2004. Due to the complexity of the circuit schematic, the PCB had to be fabricated on double layer of the copper board. These are the overview of the PCB.

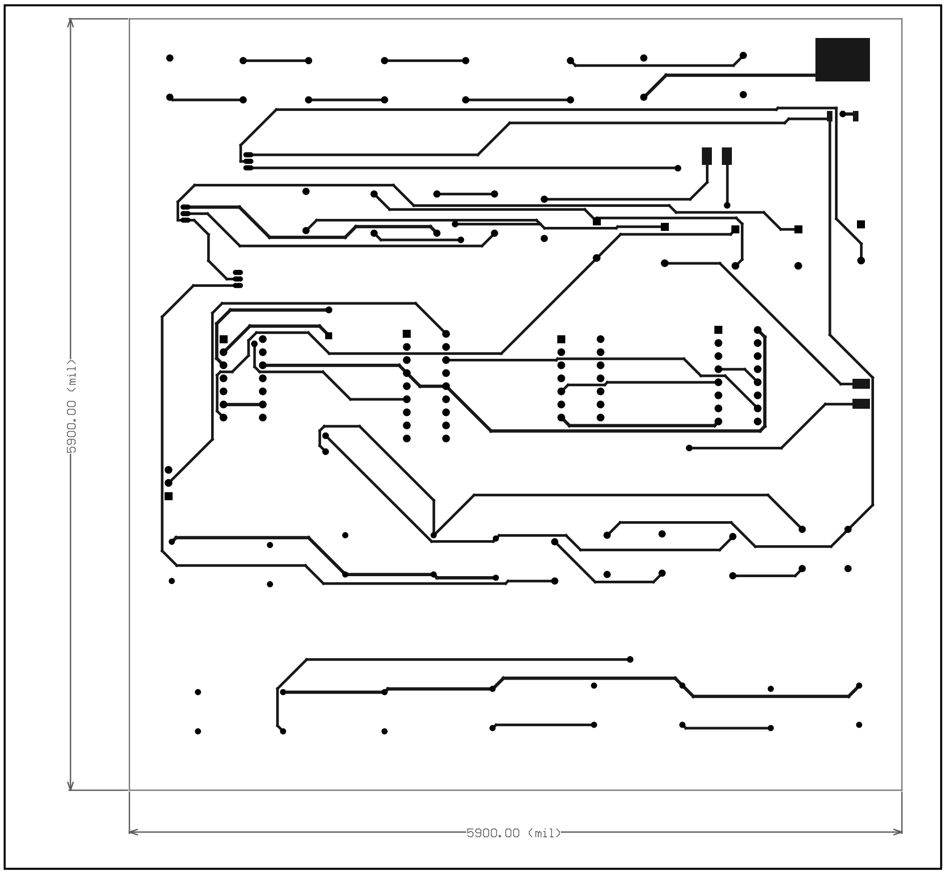


FIGURE 3.5: Top layer of the PCB.

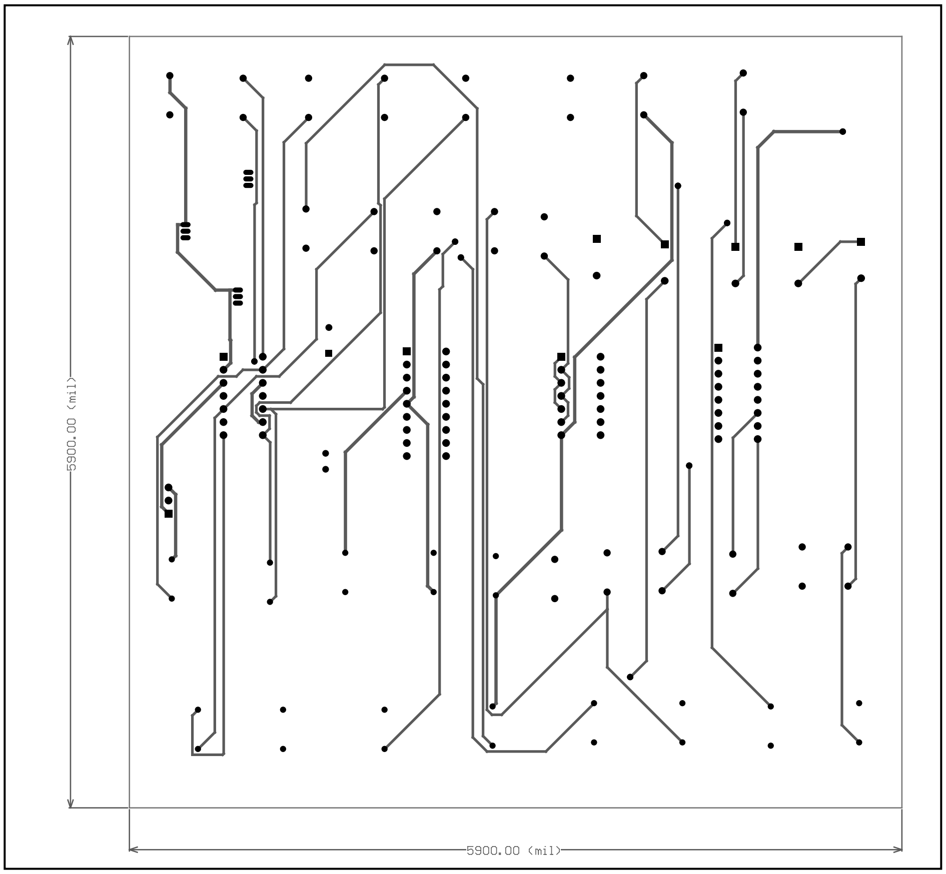


FIGURE 3.6: Overview of the Bottom Layer

4.1 Introduction of a 1-bit RFID system

1 bit Transponder

A bit is the smallest unit of information that can be represented and has only two states: 1 and 0. This means that only two states can be represented by systems based upon a *1-bit transponder*: ‘transponder in range’ and ‘transponder out of range’.

Despite this limitation, 1-bit transponders are widely use in daily lives. For example application using RFID 1-bit transponder:

- Electronic *anti-theft devices* in shops.
- On ship container and train container at warehouse.
- On luggage in airports.

4.2 RFID system design

The RFID device comprises of a reader and transponder circuit. The reader circuit is a series combination RLC circuit, and the tag as a parallel LC circuit adjusted to a defined resonant frequency fr in this case 1 MHz frequency.

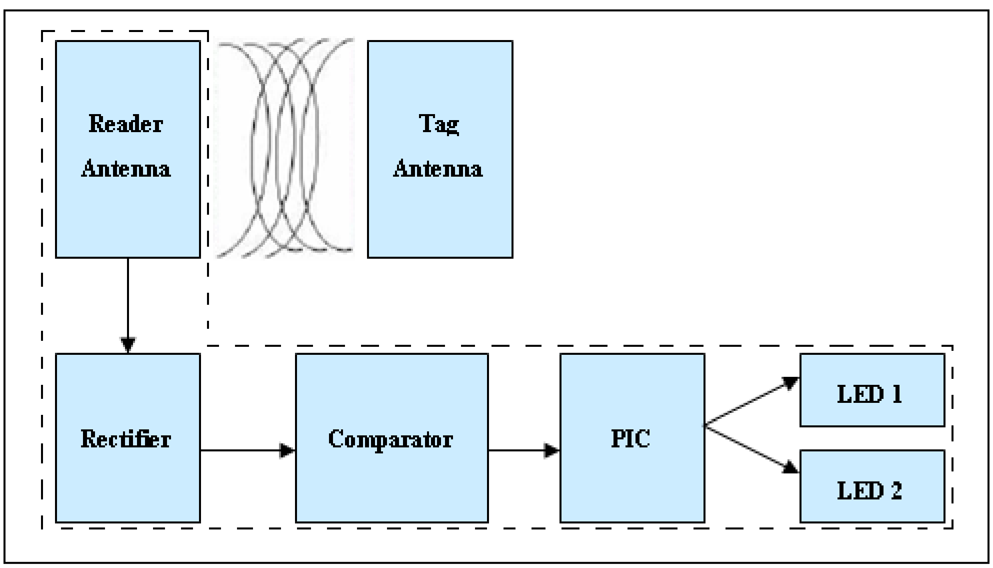


FIGURE 4.1: Block Diagram 1-bit RFID system.