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Design and Development of a Radio Frequency Identification (RFID) Based Library Books Security System.

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ABSTRACT

This paper presents and discusses the design and development of a radio frequency identification based library books security system. This design is of two sections; one is the transmitter (tag) and the other one is the receiver (reader). These two sections enable the library personnel to know when a book is taken and when it is intact through the help of the alarm system connected to the system. In Terms of results obtained from the design, the Liquid Crystal Display (LCD) at the receiver module shows the status of the tagged books. The LCD shows the status of the tagged books on the shelf as either "TAKEN" or "INTACT" when a book is absent or present respectively. A light emitting diode (LED) corresponding to each sensory node on the receiver section that switches ON or OFF when a book is present or absent from the shelf. An alarm circuit integrated on the transmitter section sounds an alarm whenever any book is taken from the shelf. The system is applicable in libraries to secure reserved books, it is readily applicable in supermarkets to secure goods on display and it can be used to secure cars in public car parks.

Keywords*:* RFID, Security system, Library, Microcontroller, RFID Transmitter module, RFID receiver module.

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1. INTRODUCTION

Radio Frequency Identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. An RFID tag is an object that can be attached to or incorporated into a product, animal, or person for the purpose of identification using radio waves. Chip-based RFID tags contain silicon chips and antennae. Passive tags require no internal power source, whereas active tags require a power source

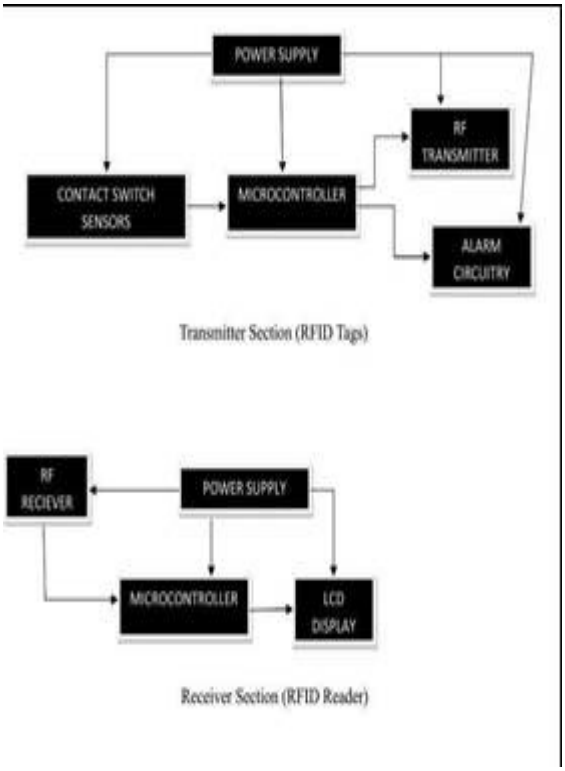

Figure 1: The Simplified Block Diagram of the System

2. LITERATURE REVIEW

Before time, library automation has been carried out by bar coding or manual inventory to monitor books and its movement within the library. A whole lot of man hours is wasted to carry out the running of the library. With the emergence of RFID technology, the whole library automation has become a lot easier as Library access, Inventory and total library can be interfaced with a PC (Personal Computer) [2,3]. According to Daniel McPherson and Vinod Chachra. (2003) who worked on "Personal privacy and use of RFID technology in libraries". His paper talked about RFID in libraries as a means privacy control while generating information off tagged objects within the libraries. The main shortcoming of the research work is the fact that upon theft, there was no interface that observes or keeps track of the tagged materials, only an alarm system was present [6].

More so, M.M.Ollivier (1995) "RFID a new solution technology for security problems". His paper addresses the use of RFID as a means of securing premises and materials for the first time. This now justifies the efforts geared towards the design and development of an RFID based library books security system to address the issue of theft involved [9].

3. DESIGN PROCEDURE / METHODOLOGY

The project in question is security system that monitors books on a shelf and wirelessly communicates the status of shelf to a liquid crystal display unit. The mode of communication is wireless using a radio frequency module, one to transmit the status of books on the shelf and a receiver that receives this status and interprets them to a display unit.

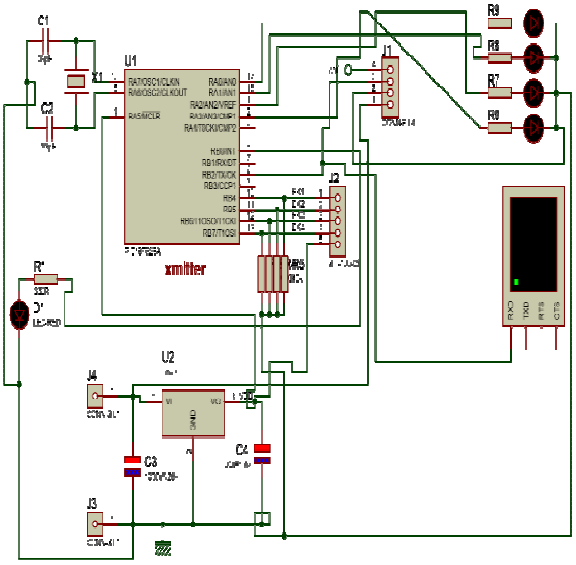

Figure 2a: Circuit diagram of RFID based Library book security system

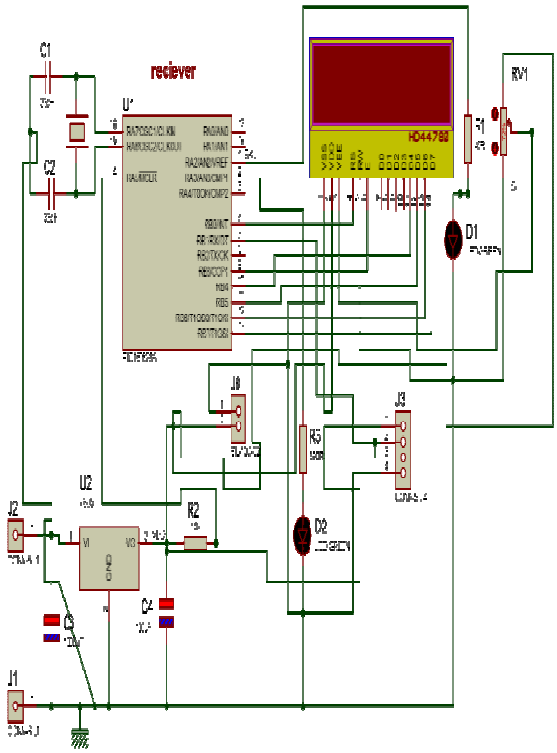

Figure 2b: Circuit diagram of RFID based Library book security system

Above is the circuit diagram of the transmitter unit (Tag) and receiver unit (Reader) ; it has a power section, a sensory unit, the controller, the RF transmitter module, LCD, RF receiver module and an alarm circuitry. Explaining each sector would give a comprehensive understanding of the system in whole.

3.1 Power Supply

Every electronic device and system requires power supply to perform whatever function they are to serve. But determining what supply is critical to this system, supply needed by each section of this system goes a long way to tell what supply the system would be needing, the contact sensor needs a DC full time supply at +5 volts so do the microcontroller and the RF transmitter but can require more than +5 volts to as high as +12 volts depending on how far one would like the transmission to travel to. The alarm circuitry also operates at +5 volts but for louder beep can also be operated to as high as 24 volts DC. The essence of this break down reveals that all section of the hardware requires only DC volts at a magnitude of between +5 volts to +9 volts. Therefore, attaching a battery to the system to construct the individual DC voltage ranges is in place.

3.2 Sensors
Its role is to monitor the presence of books on a shelf and the absence from the shelf, the sensor is not different from a contact switch, when it makes contact, it completes the circuit and when it doesn't the circuit becomes open.

3.3 Microcontroller
The controller used in both the transmitter and receiver section is an 18 pin IC named PIC16F628A; it stands central in the over-all workings of the system. The controller, like every other digital IC requires power (+5 volts DC VDD), ground or negative supply (VSS) and a clock oscillatory network.

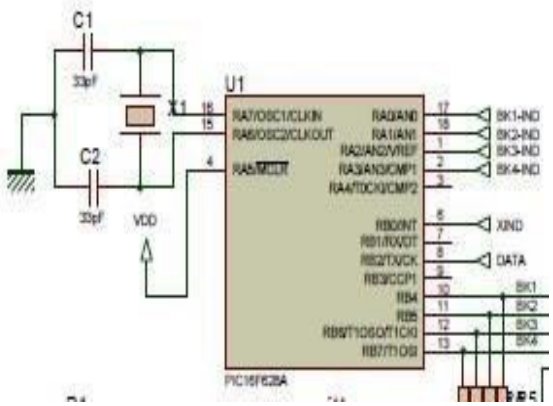

Figure 3: Circuit diagram of the microcontroller section

On the clock network is a crystal oscillatory capacitor and a ceramic capacitor connected together to ground. This network stands so important for the following reasons. The crystal first of all is the heart and generates the heartbeat to pulse the controller each step all the way, then power is applied to the controller. It waits to be pulsed to execute each instruction residing inside it. As each pulse is generated, each code is executed and on and on it goes until all codes are fully executed. Secondly, the microcontroller runs an internal frequency of ¼ of the external frequency obtained from the crystal oscillatory capacitor. As used in this design, a 4MHz crystal was connected externally, the controller would get ¼ of this which is 1MHz will then be used by the controller oscillates, an inverse of this is 1µsecond which is the total time taken to execute one cycle instruction of code. It is important to note that the crystal cannot start in its own without the help of the ceramic capacitors connected on each tag, on power up, the ceramic starts the crystal and in turn the crystal starts the controller all the way [5, 12, 14].

3.4 Microcontroller Software
The microcontroller is programmed using the C procedural language. The environment in which the program was written is the MPLAB which is a design tool for PIC microcontrollers. The software assisted in utilizing the management of the sensory unit for the transmitter section and also to control the output on the LCD on the receiver section [12].

3.5 Alarm
The alarm section is such that gives an audible indication when any or all books are lifted off the shelf.

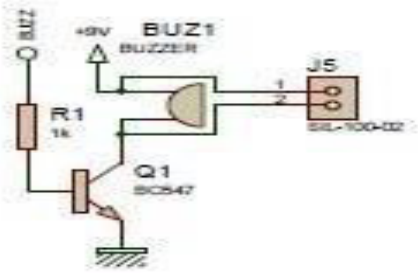

Figure 4: Circuit diagram of the alarm section

It is an arrangement of transistor as a switch and a buzzer, the buzzer requiring +9 volts DC cannot be connected directly to the controller. Transistor as a switch as used to connect ground supply to the negative terminal of the buzzer through the emitter of the transistor to ground. A network was adopted, a transistor as a switch, a resistor was connected from the microcontroller pin configures to control the pump to the base of an NPN transistor. The resistor is to reduce the voltage and current flowing into the base of the transistor, since it should be used as a switch very little amount of voltage is needed to activate the base, as little as 0.7 volts DC is enough.

3.5 RF Receiver Modules

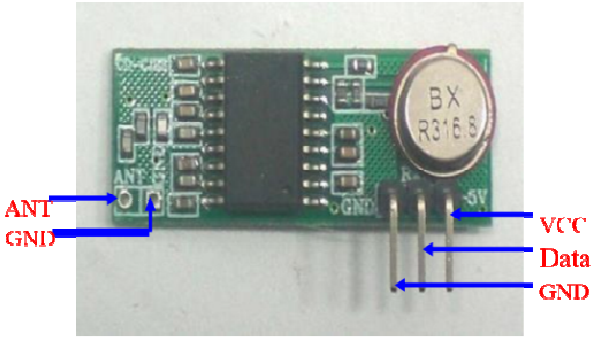

Figure 5: RF Receiver Module RF-RX-315

These RF receiver modules are very small in dimension. The low cost RF Receiver can be used to receive RF signal from transmitter at the specific frequency which determined by the product specifications. Super regeneration design ensure sensitive to weak signal.

The application includes:

1. Industrial remote control, telemetry and remote sensing.
2. Alarm systems and wireless reception for various types of low-rate digital signal.
3. Remote control for various types of household appliances and electronics projects **[11] [16].**

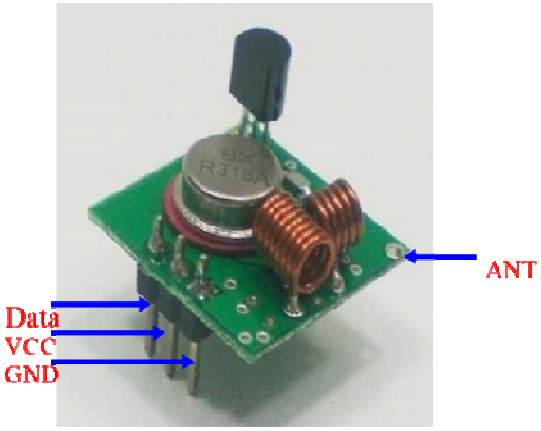

Fig 6: RF Transmitter Module RF TX 315MHz

These RF Transmitter Modules are very small in dimension and have a wide operating voltage range (3V-12V). The low cost RF Transmitter can be used to transmit signal up to 100 meters (the antenna design, working environment and supply voltage will seriously impact the effective distance). It is good for short distance, battery power device development.

The application includes:

- Industrial remote control, telemetry and remote sensing.
- Alarm systems and wireless transmission for various types of low-rate digital signal.
- Remote control for various types of household appliances and electronics projects.

Soldered the antenna to the RF Receiver Module, There are 2 GND on the module which are internally connected each other. Connect the 3pin header to your circuit so that the GND pin connects to ground of the circuit board, the VCC pin connects to VCC of the circuit board and the Data pin connects to your microcontroller's I/O pin [11].

3.6 Algorithm of the Design

Step 1: Start.
Step 3: Initialize Receiver with LCD.
Step 4: Initialize Transmitter with book sensors.
Step 5: Display Project Title on the LCD.
Step 6: Check whether Book sensor is active on the transmitter section.
Step 7: If Any Book sensor is active go to step-10
Step 8: Else if book sensor is inactive, go to step-12
Step 9: Else go to 6.
Step 10: Display the entries of EEPROM one by one on the LCD on the receiver section, containing the Item as INTACT.
Step 11: Go to step 6.
Step 12: Display the entries of EEPROM one by one on the LCD, containing the Item as TAKEN
Step 13: Go to step 6.
Step 14: Stop.

3.7. Flowchart of the Design

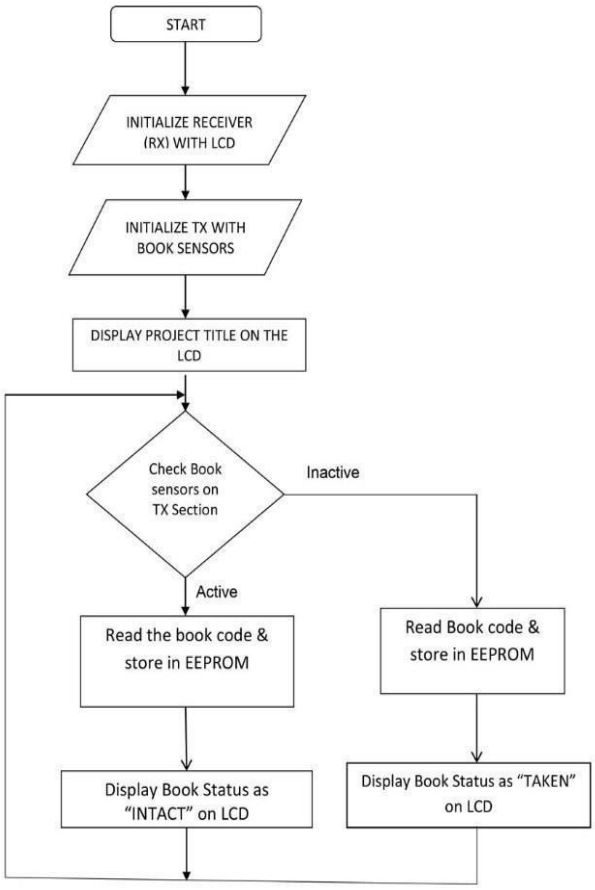

Figure 7: Flowchart of the Design

3.8. Construction

Construction was done in three stages, transmitter, receiver and the wooden shelf. For the transmitter and receiver, all the components are connected together on the board by soldering them according to the circuit layout. All the components are soldered together on the same board according to the schematic diagram for the transmitter and receiver circuit respectively.

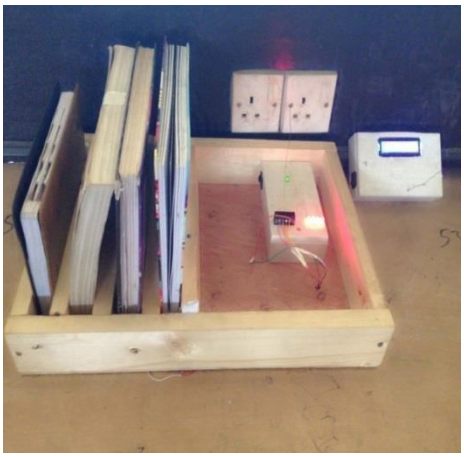

Figure 8: The Completed Project

4. TESTING AND EXPECTED RESULT

RFID Based Book Security System is able to identify tagged books on shelf display their status as either TAKEN or INTACT was successfully developed. The major contribution of this work is managing to write a functional code for the two Microcontrollers to communicate with each other. This system should be able to minimize the technical human error while securing important library materials. The table below shows all the results;

Table 1: Table of Results

BOOK CODE	BOOK SHELVE STATUS	RECEIVER LCD DISPLAY	TRANSMITTER LED INDICATORS	ALARM
ECE100	IN PLACE	"ECE100 INTACT"	ON	NO SOUND
ECE200	IN PLACE	"ECE200 INTACT"	ON	NO SOUND
ECE300	IN PLACE	"ECE300 INTACT"	ON	NO SOUND
ECE400	IN PLACE	"ECE400 INTACT"	ON	NO SOUND
ECE100	REMOVED	"ECE100 'TAKEN"	OFF	SOUND
ECE200	REMOVED	"ECE200 'TAKEN"	OFF	SOUND
ECE300	REMOVED	"ECE300 'TAKEN"	OFF	SOUND
ECE400	REMOVED	"ECE400 'TAKEN"	OFF	SOUND

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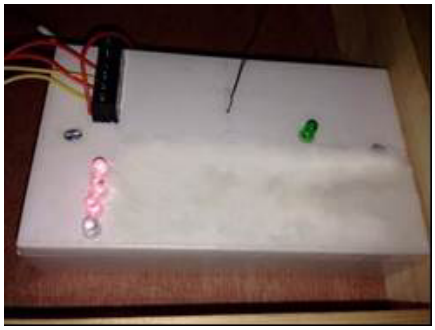

Transmitter Module LED Indicators

Receiver module LCD
Figure 9(a&b): Test result upon lifting book1 (ECE100)

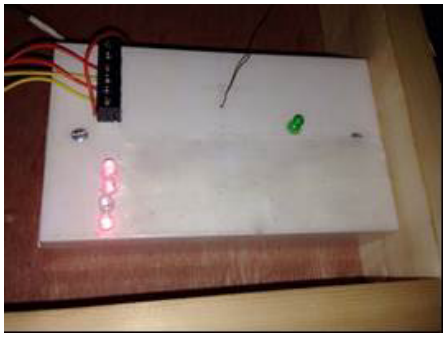

Figure 10: Test result upon lifting book2 (ECE200) from the book shelf

Figure 11: Test result upon lifting book3 (ECE300) from the book shelf

Figure 12: Test result upon lifting book4 (ECE400) from the book shelf

5. CONCLUSION

It is quite clear from the above discussion that an RFID system may be a comprehensive system that addresses book security needs of a library. RFID in the library is not a threat if best practices and guidelines are followed religiously. That is, it frees staff to do more user service tasks. The technology saves money too and quickly gives a return on investment. It is important to educate library staff and library users about RFID technology before implementing a program. Due to the high cost of RFID system tools and devices, this system can be implemented to secure important books in the library. A general implementation in the library can be done as the price of RFID modules lowers in the future [5].

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