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Design and Implementation of RFID-Based Document Management System

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Abstract :
It is a challenge for companies to keep up with the heavy demands of locating stored documents as they churn and store thousands of papers each day. Companies are increasingly in need of a system that eases the process of searching and locating important files. This paper aims to describe the implementation of an RFID-based technology designed to aid the search for files and documents in corporate organisations. The RFID-based Document Management System hastens the location of documents by using a Reader, a short-range 125kHz tag inserted into each folder and an embedded firmware code in PIC16F877A that matches each tag to the list and names of documents the folder contains. The primary drive behind the development of this system is to bring to light the feasibility of an RFID-based document management system in corporate organisations.

Keywords –*Microcontroller, PCB, Proteus, RFID*

I. INTRODUCTION

The average worker uses 10,000 sheets of copy paper each year [1]. It is startling when we multiply this figure by the average number of employees in large corporate bodies. Offices and Institutions around the world use and store important documentations of their work everyday and employees constantly need to retrieve this information from stored files. The crux of the issue is developing a system that will enable members of these kinds of bodies search and find filed reports in the least possible time. It is important to note that the speed at which this can be achieved is dependent on the type of search system used.

II. LITERATURE REVIEW AND RELEVANCE

The implementation of RFID-based solutions in various units of organizations is slowly gaining ground in our modern day world. The following case studies expantiate on current happenings and mirrors the implementation of RFID solutions as described in this paper.

A. RFID in Law Firms

LHERMET LABIGNE & REMY (LLR) is a French Law firm that specializes in patent law and intellectual property for individuals and companies alike. The firm, founded in 2000, is directed by Guillaume de La Bigne and Vincent Remy (founders) with a current head count of 40 [2]. The successful firm manages over 30,000 archived files and adds between 5,000 and 6,000 new files every year. For a company with that number of employees who frequently used client files, file-searching was a cumbersome task. As a result, locating a single file could take several days, leading to ineffectiveness in employee's work and client dissatisfaction. To improve productivity, LLR decided to implement a reliable and efficient RFID system to quickly locate client files within the firm. The company implemented an RFID system using paper-thin, adhesive tags affixed to client files, a programming station, and a portable hand-held reader, all of which were integrated seamlessly with the existing file management software.

B. RFID in Waste Management

RFID technology is even needed in managing the trash bins. In Nigeria today and indeed most parts of the world, waste collection practices are far from efficient. Waste bins are emptied at regular intervals, irrespective of the level of waste in the bin. Therefore, collection truck routes are longer than necessary or may drive through neighborhoods where collection is not needed at a particular point in time. Optimisation of collection routes is of special importance, considering the fact that waste collection vehicles (RCVs) are among the least efficient vehicles on the road (One Plus Corp., 2011).

Pay-as-you-throw (PAYT) is an RFID-based solid waste disposal system. This means that the service is charged precisely, according to the user's actual waste generation, measured by weight or by volume. PAYT systems have already been implemented in many countries. PAYT users' waste collection service is charged for according to actual waste generation measured by weight or volume [3].

C. RFID-Based Document Management System For Large Outfits

RFID technology, when combined with mobile computing, provides a way for organizations to identify and manage their assets. Mobile computers, with integrated RFID readers, can now deliver a complete set of tools that eliminate paperwork, give proof of identification and attendance [1]. Proper document Management also ensures safe-keeping of assets and could prevent important documents from getting misplaced or stolen. Organizations are already using RFID tags combined with a mobile asset management solution to record and monitor the location of their assets, their current status, and whether they have been maintained [2]. Some of the world's biggest banks such as Wells Fargo and Bank of America are using Passive RFIDs to track their assets. The Financial Services Technology Consortium (FSTC) set a technical standard for tagging IT assets and other industries have followed suit [3].

III. DESIGN METHODOLOGY

This RFID system consists of 4 major building blocks which are:

1. A Power Supply Unit
2. A Microcontroller unit that performs CPU functions
3. An RFID reader module in which the antenna is embedded
4. An Input/Output system which consists Input keys and a LCD display to display output information

The internetwork of these building blocks is well depicted in the Fig. 1 blow

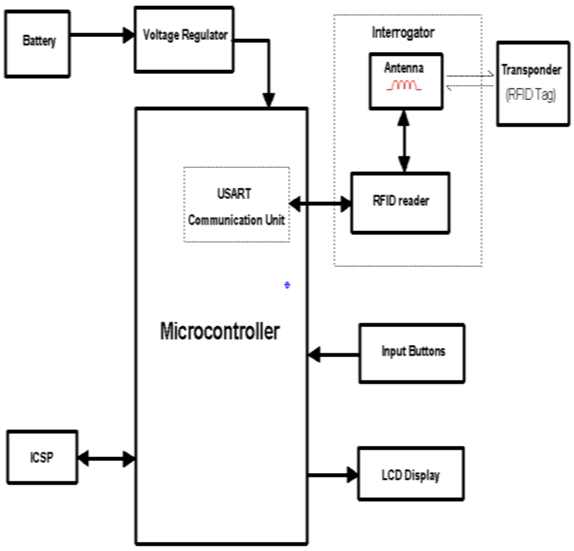

Fig. 1: Block Diagram of the Document Management RFID System

The operation of each of these building blocks is well explained in the following sections

A. Power Supply

A 9V battery used to supply stable DC voltage to the circuit for which a 5V regulator will be suitable. However, the voltage regulator has to have a voltage input higher than its required output (at least 2 volts higher). I use a 9V supply because it is conveniently above 5V and is locally available. Microcontrollers, like the one used in this device, require very precise, stable current which a resistor fixed at the end of the battery cannot sufficiently provide. Hence, we need a voltage regulator. An LM7805 Voltage regulator is used to regulate the 9V battery input to 5V

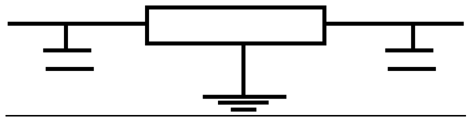

Fig. 2: LM7805 Voltage Regulator

The LM7805 has 3 pins; Input, Ground and Output. A 0.1µF capacitor is placed at the input of the regulator to filter any noise in form of AC current coming from the battery. This capacitor acts as a Bypass capacitor; shorting out AC and passing only DC. The capacitor fixed at the output also serves as a bypass capacitor, filtering the unwanted components.

B. RFID Reader

The reader consists of three main parts as listed below

1. The Digital/control section.
2. The RF section.
3. The Antenna.

The digital section of the RFID reader processes the signals received from the RFID transponder. This section usually consists of a microprocessor, a memory block, analogue-to-digital converters (ADCs) and the software application in communication block.

The RF section is used for RF signal transmission and reception and consists of two separate signal paths to correspond with the bi-directional flow of data. The 125KHz waveform is emitted by the Inductor and Capacitor in the RF section.

The electromagnetic wave is received by the tag through it's own transponder. It is very similar to the coupling effect between two inductors as in Transformers. To send a logic '0' to the reader, the tag puts a 'load' to its power supply line to request more power from the reader. That will make a small voltage drop on the RFID reader's side. That voltage level is logic '0'as shown in the picture as the dips in the line. As the reader transmits the 125 kHz signal, it reads the voltage of the transmitted signal through the Inductor and Capacitor filters. When the Tag doesn't require any additional power, it doesn't make a voltage drop. That is logic '1' as shown as the rises in the diagram.

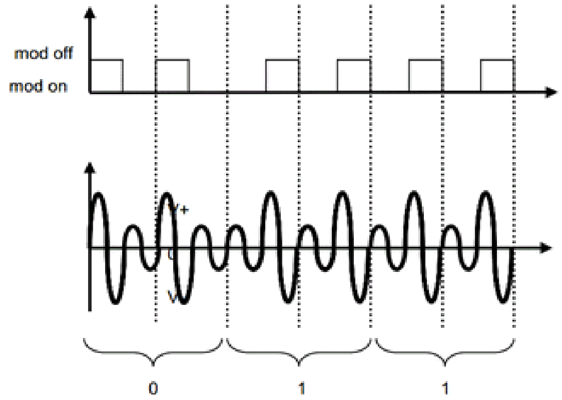

Fig. 4: Wave Diagram of the Logic 1's and 0's [4]

The read distance between the Tag and the reader's coil is dependent on the number of turns of the coil. When you place an RFID tag in the read distance of the reader, the reader will read the 10-digit unique ID of the Tag and transmit it as ASCII characters trough the serial output.

The RFID reader can be designed by varying the antenna's resonating frequency, gain, directivity and radiation pattern.

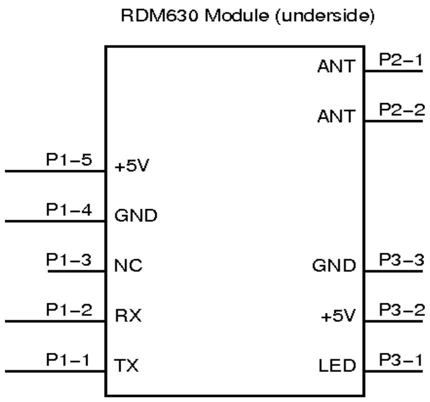

Fig 5: Schematic of the Reader Module [5]

The RDM630 reader module is an RFID module with 10 pins. The schematic above shows each pin and the function of each. However, in our circuit, pins 2, 3 and 5 are not connected. The pins 1, 2 at the upper right are connected to the antenna. The pins at the lower right serve primarily to connect the LED bulb to indicate that there is power in the chip. The pins in use at the lower left are for ground and Transmitter. The pin, Tx is used to send signals to the PIC16F877A.

The Reader module transmits at 125kHz, has a Baud rate of 9600, operates at a voltage level of 5V.

C. Microcontroller Unit

The microcontroller used is the PIC16F877A is A 40-pin microcontroller that can be used in many applications.

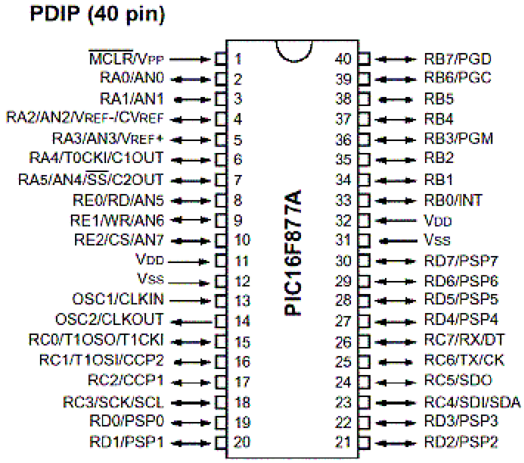

Fig. 6: Schematic of the 40-pin [6] PIC16F877A

The Microchip operate on RISC Architecture which has 35 Instructions, relatively easy to learn; Enhanced USART module which Supports RS-485, RS-232 and LIN2.0 and In-Circuit Serial Programming (ICSP) Option amongst other features. This is another major component in this device. A 4MHz crystal is connected to pins 13 and 14. It literally serves as the heartbeat of the microcontroller without which it would be unable to execute instructions. The frequency of the crystal can provide the rate at which instructions will be executed. For example, the microcontroller with execute instructions at a rate, 0.25µ per second. The Figure 7 below shows the internal diagram of the microcontroller used.

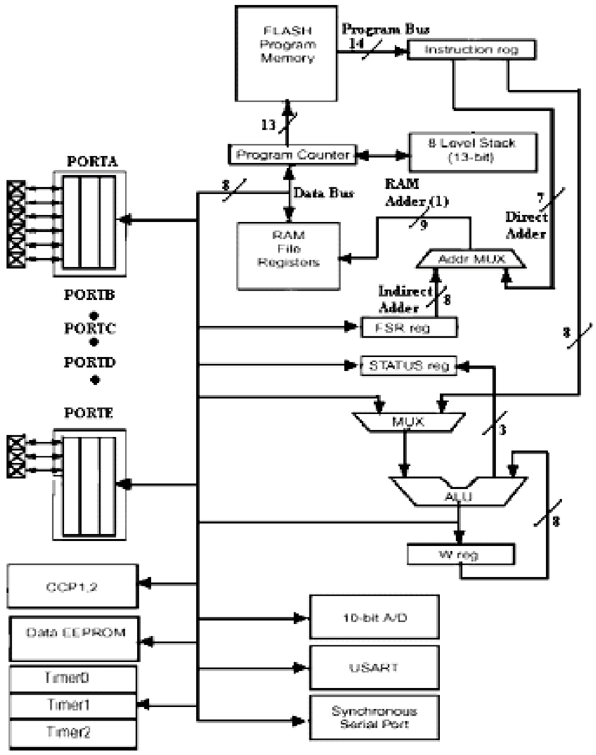

Fig. 7: Internal Diagram of PIC16F877A

The PIC16F877 has a 13-bit program counter (PC) capable of addressing an 8K word of program memory space. A port has 8 pins and each pin can work either as an input or output. Each pin's assignment as input or output is determined by a bit assignment of a corresponding direction assignment file register.

The section below shows an excerpt of the firmware codes

Code 1: Excerpt of the Firmware Code for the RFID System

```
'declarations
dim txt as string [20]
dim txts as char [12]
dim A as char [12]
dim B as char [12]
dim CC as char [12]
dim DD as char [12]
dim delim as char[1]
dim n,i,temp,value as byte
dim Card as byte
main:
 Usart_Init(9600)
'Call LCD declearations and welcome message
 welcome
delim = (" ")
while true
  while Usart_Data_Ready = 0 wend
   'delay_ms(100)
   Usart_Read_Text(txt, delim)
   Lcd_Cmd(LCD_CLEAR)       ' This sends a command to the LCD to clear it's display
   Lcd_Cmd(LCD_CURSOR_OFF)       'This command prevents the cursor from appearing on the screen
   GetID
   GetData
wend
end.
sub procedure GetID
'A = 7F9FF82 B = 79D2039  C = 80726AA D = 79C1109
  A =  "030087F9FF82"
  B =  "0300879D2039"
  CC = "0300880726AA"
  DD = "0300879C1109"
  n = 0
  for i = 0 to 11
  txts [n] = txt [n+3]
  inc(n)
  next i
  temp = 1
  temp = Strcmp(txts,A)
  if temp = 0 then
  temp = 1
  Card = 1
  end if

  temp = Strcmp(txts,B)
  if temp = 0 then
  temp = 1
  Card = 2
  end if

  temp = Strcmp(txts,CC)
  if temp = 0 then
  temp = 1
  Card = 3
  end if
```

```
  temp = Strcmp(txts,DD)
  if temp = 0 then
  temp = 1
  Card = 4
  end if
end sub
```

The Sub function: 'GetData' instrcuts the microcontroller to display particular messages associated with each unique tag.

The completed code is written into the micronctroller through an ICSP. This technology enables easy re-writing and improvement of the source code during the Testing phase.

D. I/O System:

The system is primarily made up of Input buttons and the LCD Display as its core I/O components. The input buttons are few to ensure the end product is compact and really meets its mandate; a light-weight, handheld system. To this end, the user will have three options: Turn the device on, scroll to find what is being searched for and turn it off. The decive will automatically sense tags in close proximity once it is turned on, so there is no need to type in excessive commands. Once it is not being used, it is turned off and it stops intercepting the RF energy being emitted by the tags.

On the other hand, the LCD display which is a 16 by 4 LCD display to ensure the device is user friendly. LCD display with smaller specifications will increase the time to scroll through file options on display. The 9V battery supplies power to the circuit, the Voltage Regulator varies the input voltage to 5V. The current enters the first LED and lights it to indicate that there is power supply. The RFID Reader module is connected to the 5V power from the regulator through its Pin 2. The second LED connected to its Pin 1 lights up to show that the Reader is powered. Once the Reader is on, Oscillating movement occurs between its Inductor and Capacitor, in this case, 125000 times a second. Hence, it emits 125KHz Low Frequency energy into its surroundings and creates an magnetic field by doing so. The Tag when brought in close proximity (not less than 5cm) is affected by this field due to a phenomenon called Inductive coupling.

The Tag consists of a silicon device and an antenna which consists of a LC resonant circuit. It is this resonant circuit that induces the RF energy from the reader and sends a modulated RF signal.

When the Reader receives the modulated backscatter signal, it decodes the signal and through its transmitter on Pin 10, the decoded signal is sent to the Serial communication port of the Microcontroller. The Microcontroller uses the 4MHz crystal to skip to each instruction in its memory. It responds to the user's input and sends the output to be displayed by the LCD Display.

Using MicroBasic, the source code that provides the blueprint by which the microcontroller functions is written. First declarations are made so that the microcontroller stores variables in its memory which will be called during the execution of the program:

IV. IMPLEMENTATION

When the power button is pressed at implementation, both indicating LED's come on and the LCD displays the introductory message. The "Help" Button can be used to get directives on how to use the device.

In summary, when the user places the device close to a folder with the corresponding embedded 125kHz tag, it displays the following

1. Date of creation of file
2. List of Files in the folder

Fig. 9: Device Displaying the Welcome Message

Fig. 10: Device Showing Usage Instruction

When the user places the reader close to the first folder with an embedded 125Khz tag, it displays the message:

Fig. 11: Device Displaying Folder Content

V. CONCLUSION

It is now obvious that RFID technology proffers many solutions to people in the workplace. It is also relatively easy to implement and is not costly. Many RFID applications gain a fast-paced Return On Investment because users have the flexibility to choose technology and tailor solutions to solve their specific business problems; be it an issue with finding documents needed for work in a Law firm to using RFID to avoid human errors in medical environments that could cost lives. Enterprises in all sectors can benefit from RFID technology as it currently does not operate on networks. In conclusion, an RFID reader promises to be a faithful, helpful machine, very essential for smooth operations in corporate organizations the world over.

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