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Design And Implementation Of A Microcontroller-Based Keycard

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ABSTRACT:
The advent of Information and Communication Technology (ICT) has improved organizations' approach to achieving security. In this paper, a microcontroller-based security door system is proposed to automate and computerize keycard for access control in both private and public offices in an organisation. The system is designed to serve the purpose of security. To operate this door, a welcome screen is shown on the microcomputer which serves as the visual interface. The user is required to insert a smart card which serves the purpose of a key into the card reader on the door. The controller holds the codes which drives the card reader. On validating the smart card, it loads and shows another screen on the monitor asking for user password. This is used to ensure that the user is actually an authenticated user of the card. A buzzer is also added to the system to alert the security personnel in the security unit if an unauthorized user attempts to gain access to the room three times.

KEYWORDS: *microcontroller, microcomputer, card reader, keycard, security, security door system, visual interface*

I. INTRODUCTION:

Inderpreet Kaur (2010) opined that " with advancement of technology things are becoming simpler and easier for us. Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization." According to Oke et al(2009) , "most doors used in some organisations are controlled manually especially by security personel employed by these organisations, through the use of handles and locks with key to operate the locks. Examples are banks, hotels, motels and so on; some are controlled by switches while others are controlled by the biometrics technique."

The thrust of this work, is to develop a Micro-controller based keycard and interactive lock that provides access permission into restricted area(s) in an organization to only authorized persons who possess valid keycard and also have a correct pass code which has been legalized by the Administrator's computer which has a software program interfaced with the project circuitry. This program handles the validation of the card and the authentication of the password. The program also triggers the door to automatically lock after 30 seconds of opening.

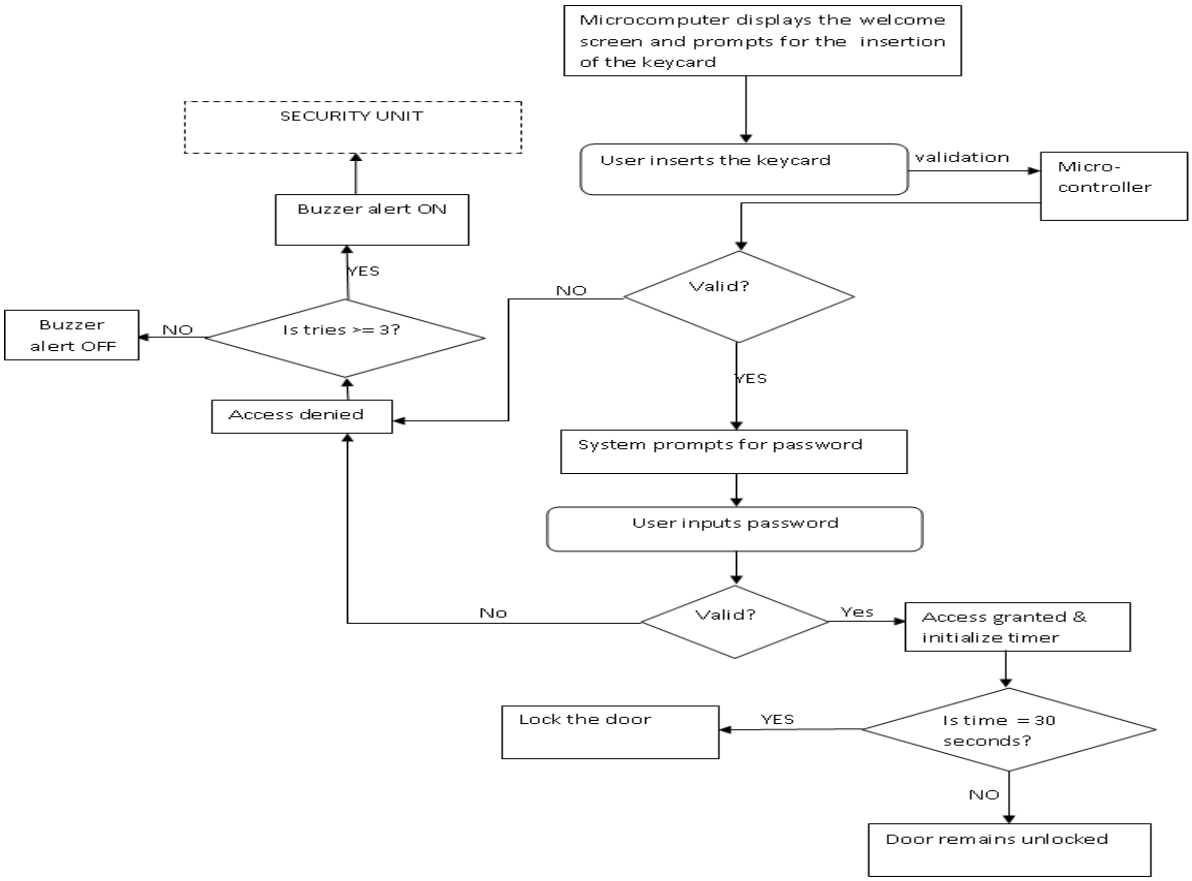

Fig1: The process flow diagram of the system

To gain access to the restricted area, a smart card (keycard) should be inserted into the card bay incorporated in the door. The microcontroller validates this card by ensuring that it conforms to the requirement. If the card is valid, the user is prompted for a password which is keyed in from the keypad also incorporated on the door. The microcontroller again validates this password and if correct, unlocks the door for access. The controller times down to 30 seconds and relocks the door. Once access has been gained, door can be mechanically opened from inside without any form of security. A buzzer is also added to the system to alert the security personnel in the security unit of an unauthorized attempt to gain access to the room. The process flow diagram illustrating the operation of the system is presented in Fig. 1.

The whole operation is designed to serve the purpose of security. To gain access to the room;

- Firstly, for any system to function, it needs power supply. The power source is the AC from the wall socket which is been stepped down to 12V DC and then regulated to 5V DC which most of the system components requires. Components like relays and motor that need 12V tap power before the voltage regulator.

- To operate this door, a welcome screen is shown on the microcomputer which serves as the visual interface. It is required to insert a smart card which serves the purpose of a key. The card is of resistive type having a 6.6KΩ resistor embedded into it thus any smart card that does not provide this value is seen as invalid and this is what I used to differentiate between the card keys. It has just two pins heads/eyes which the reader uses to identify the card.

- Next is to insert the card into the card reader on the door. The card reader is designed using a 555 timer configured in its monostable mode where the card acts as the R2 of the 555 timer circuit. It compares the resistance of the card inserted into it with the internal resistance which has been set to be 1KΩ and if equal sends a signal to the microcontroller for validity. The reader is designed to be installed on the door and reads the card. The 555 Timer or card reader unit is connected to the microcomputer.

- The microcontroller is an AT89C51 controller which is made up of 40 pins which has four ports of eight pins each thus 32 I/O pins. The controller holds the codes which drives the card reader. On validating the smart card, it loads and shows another screen on the monitor asking for user password. This is used to ensure that the user is actually an authenticated user of the card.

Block Diagram

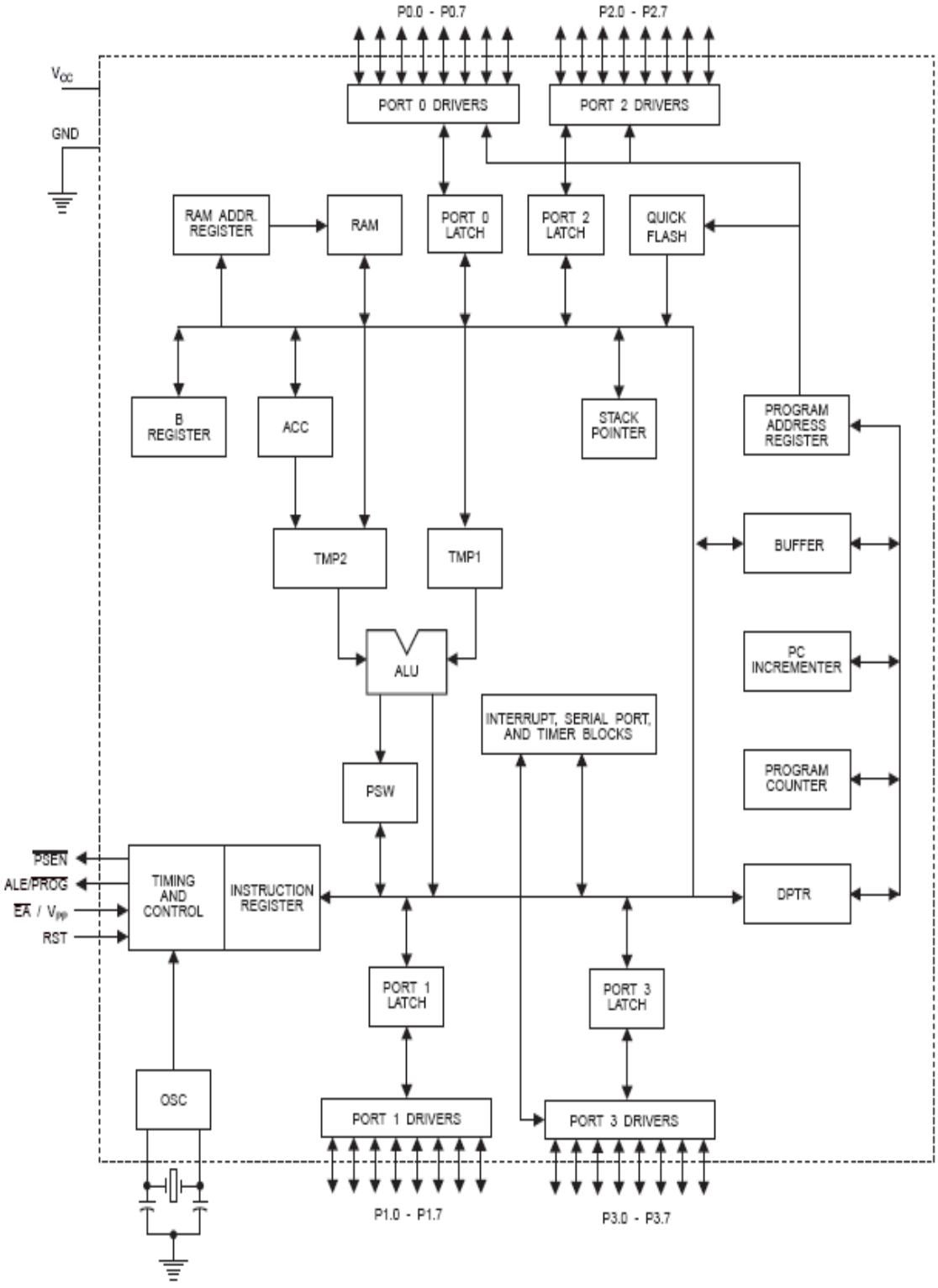

Fig 2: Block Diagram of AT89C51 Microcontroller

- The next step is to key in the password using a 12key keyboard designed for this purpose. The keyboard is of dot matrix configuration. It is made of 12 switches arranged in a 3 x 4 matrix format. The rows elements are connected to port 1 of the controller while the column elements to port 3. For the controller to detect a depressed key, it places a Logic 0 on the first row and Logic 1 on all other rows. It places a logic 1 on all the columns thus if any switch on the first row is depressed, the logic state of that row/column intersect is altered the numeric value for that intersect is registered. This is applicable to other intersects.

- If the password is valid, the microcontroller sends a Logic 1 to forward bias transistor1 which in turn causes relay1 to force the door's motor to move in the forward direction (by electromagnetism) thus opening the door. The controller also after 30 seconds sends Logic 0 to transistor1 to reverse bias it while forward biasing transistor2 to cause relay2 to force the motor to move in the opposite direction thus closing the door.

- The controller is connected to the microcomputer through a DB 25 LTP cable for visual interface using two data lines and one status line; D0, D1, S3. The controller also is connected to a buzzer through a transistor. It sends a Logic 1 to this transistor which on forward biasing, triggers off the buzzer if an invalid smart card is tried three consecutive times or if an invalid code is used three consecutive times within a space of 5 minutes. This is to alert security of intrusion.

II. SYSTEM DESIGN APPROACH

The design of this system incorporates both the top-down and bottom up design approach. In the top-down design category the designer starts from the input and achieves the objective section by section down to the output of the work Inyiama(2007). This category of design deals with designing from the output of the system down or back to the input of the system Inyiama(2007). The two were deployed since some sections of the system that operate with the output result in reference to the input require the bottom up design approach while other sections that depend on the input for their output are designed using the top down approach.

2.1 System sub-system

The design of the microcontroller based keycard is modularized into Sub-systems:

- Hardware Sub-system
- Software Sub-system

Hardware Sub-System

This describes the sequence involved in the step by step unit design of the system, the detail of the components fixtures and soldering of the sub units as well as the block schematics design of each unit starting from the power supply to the door latch and computer interface, taking each of the steps sequentially. The block diagram showing the system hardware sub-systems is shown in fig.2.

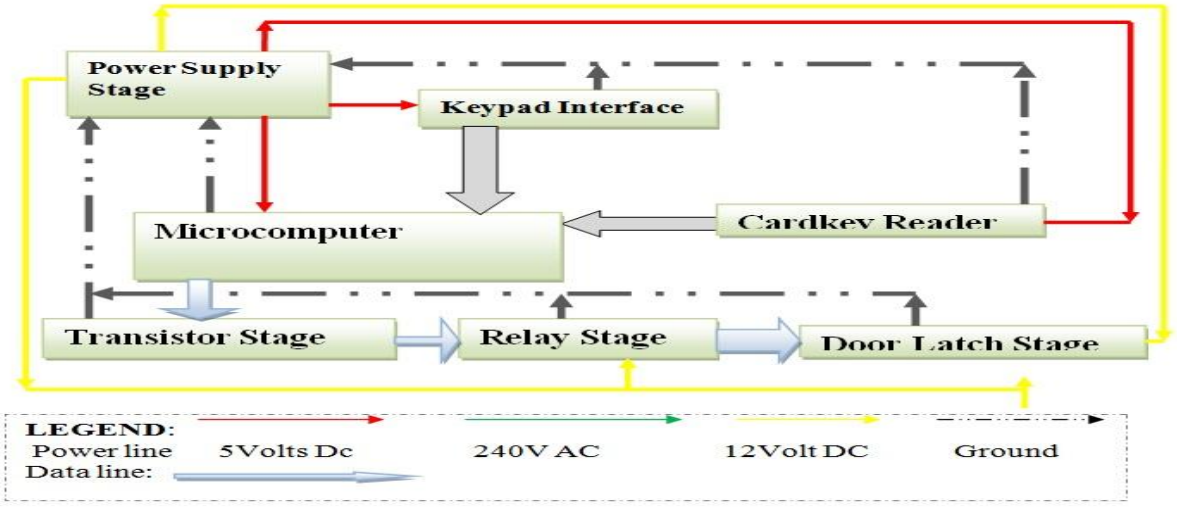

Fig.2: Block diagram showing the system hardware sub-components

- **Card Reader Module**

This module is divided into two main sub unit which are the card key, a resistive circuit embedded into a card which when installed into the reader, instructs or identify a specific operation to the reader and the reader circuit. 555 Timer is a timer chip/integrated circuit which is universally used in IC timing circuitries.

The resistive voltage divider is used to set the voltage comparator threshold. All resistors are of equal value thus the upper comparator has a reference of ⅔Vcc and lower comparator has a reference of ⅓Vcc. The comparator output controls the state of the flip-flop. When the trigger voltage goes below ⅓Vcc, the flip-flop is set and the output jumps to its HIGH level. The threshold input is normally connected to an external RC timing network. In this work, the timer in monostable mode was used.

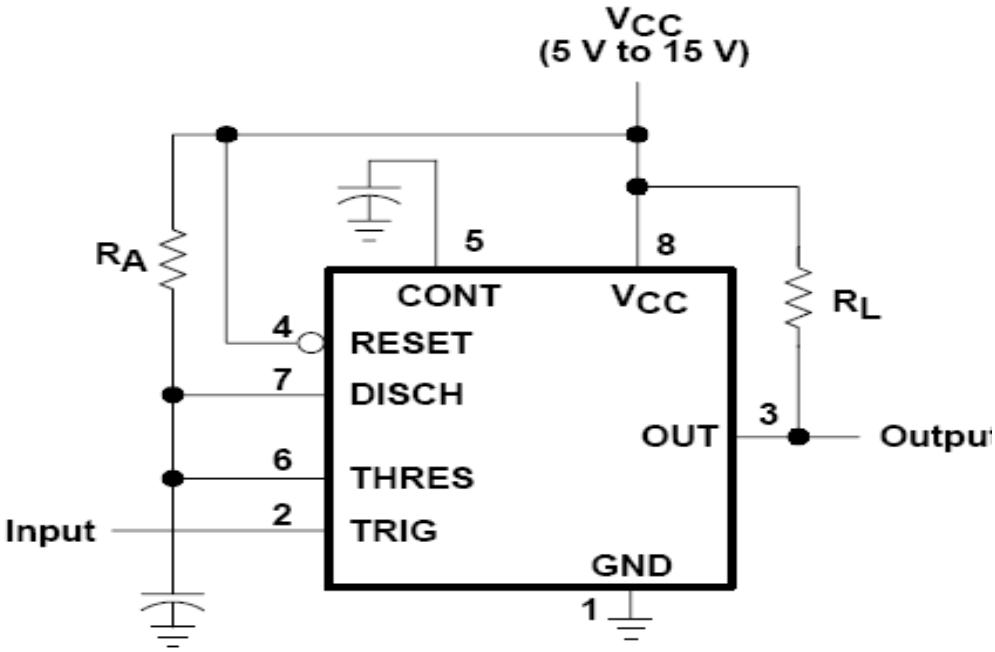

Fig 3: Circuit for a Monostable Configuration of 555 Timer Chip

- **Interface Module:**

This is the connection of the hardware and the computer system using a DB25 printer cable through a parallel port. The DB25 cable has the following specifications; 25 pins, pin 2 to 9 are labeled Do through D7; Pins 10, 11, 12, 13 and 15 are used for acknowledgement and handshakes labeled Š3, S4, S5, Š6, S7 respectively. They are very important pin sets used in printer to system communications.

Fig 4 Photo OF A LTP Db25 Printer Parallel Port Head Device

Another set of pins used for control and state changes are pins 1, 14, 16 and 17 labeled Č3 C2 Č1 and Č0 respectively. They are hence used for basic controls of the interface. The remaining pins are ground pins; they are pins 18, 19, 20, 21, 22, 23, 24, and 25. Each of these pins are labeled or identified with different and unique cable colours. Hence the colour of each cable of each pin is not exactly the same with the neighboring pin, in practical this unique colour identification is used in installing the port. Bit to Pin Mapping for the Standard Parallel Port (SPP):

Table 1: Tabulated Presentations of the Types of Port on the Cable

Address		**MSB**							**LSB**
	Bit:	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Base (Data port)	**Pin:**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
Base+1 (Status port)	**Pin:**	**11**	**10**	**12**	**13**	**15**			
Base+2 (Control port)	**Pin:**					**~17**	**16**	**~14**	**~1**

Generally, the port is divided into three major sections; the data interface section, the control and the common connection interface. The Data interface contains the parallel Data connection (D0 to D7), the control section has two main sub section, the status and the control section, the status common contains the S3 to S7 and the control section contains the Co to C3 pins .

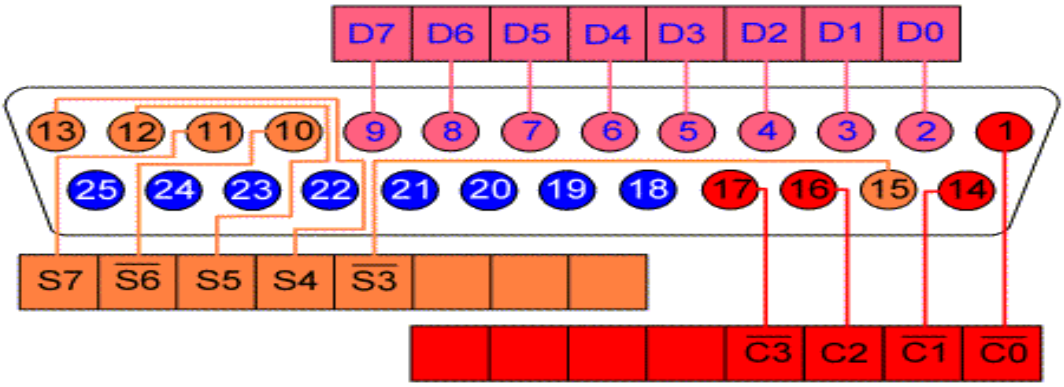

Fig 5: Photo of the Connection Db25 Pin Assignment

The common is used to ground all the bytes addressed pins. Again it is noticed that the two main sections (Data and Control) are all 1 bytes in size rating.

Table 2: Table Showing Db Pin Assignment and Comparison

Pin No (DB25)	**Pin No (36 pin)**	**Signal name**	**Direction**	**Register – bit**	**Inverted**
1	1	nStrobe	Out	Control-0	Yes
2	2	Data0	In/Out	Data-0	No
3	3	Data1	In/Out	Data-1	No
4	4	Data2	In/Out	Data-2	No
5	5	Data3	In/Out	Data-3	No
6	6	Data4	In/Out	Data-4	No
7	7	Data5	In/Out	Data-5	No

8	8	Data6	In/Out	Data-6	No
9	9	Data7	In/Out	Data-7	No
10	10	nAck	In	Status-6	No
11	11	Busy	In	Status-7	Yes
12	12	Paper-Out	In	Status-5	No
13	13	Select	In	Status-4	No
14	14	Linefeed	Out	Control-1	Yes
15	32	nError	In	Status-3	No
16	31	nInitialize	Out	Control-2	No
17	36	nSelect-Printer	Out	Control-3	Yes
18-25	19-30,33,17,16	Ground	-	-	-

In the design interface, only pins 2, 3 are used for data and 12 for status. The rest of the pins were not used (not connected). Resistors were used at the base of this connection to prevent surge from damaging the port of the computer.

- **The Cardkey Reader and the LTP Interface Connection**:

This is the connection of 555 timer reader circuits which is configured in the monostable mode and the LTP cable to the controller chip through the basic parallel printer ports as described by the diagram below.

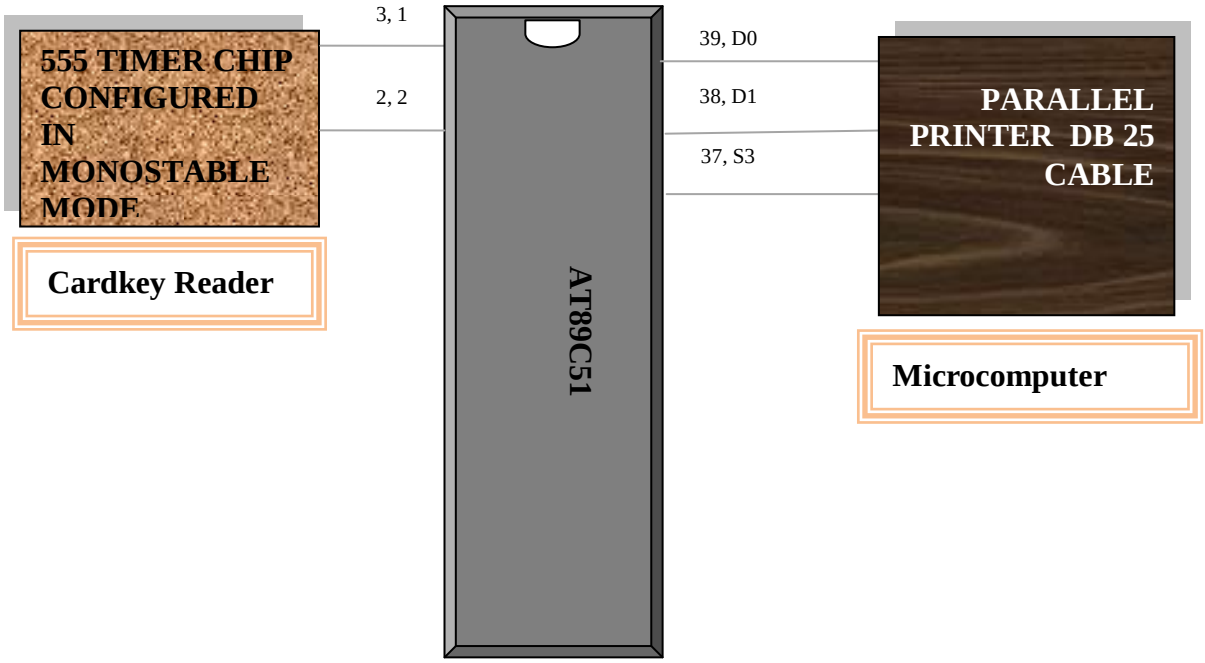

Fig 6: The Cardkey Reader and the LTP Interface Connection

The circuits described with the aid of diagrams and circuit components above are the basic connections made with the microcontroller chip and other circuit components. From a summary of the circuits it can be seen that very small size of the memory will be running hence the controller will be very smart and have free calculations of its operation.

- **The Keyboard Interface**:

This is the interface to the dot matrix keyboard. The 3 x 4 dot matrix keyboard is designed to connect to the microcontroller through port 1 and port 3. The row elements of the keyboard are connected to port 1; P1.4, P1.5, P1.6 while the column elements are connected to port 3; P3.0, P3.1, P3.2, P3.3.

Software Sub-System

- **C Programming Design for the Atmel AT89C51 Controller**

The software was designed using CRIMSON EDITOR C compiler and SDCC (small device C compiler) which contains the header file of the Microcontroller (AT89C51). It used virtual conventional C programming language keywords and syntax. The program environment is where the codes are written, compiled and debugged .It will generate an Intel hex file which is transferred into the microcontroller via a computer interfaced programming device. The codes are written to send a Logic 1 to forward bias transistors and Logic 0 for reverse; for the timer to ensure that door closes after 30 seconds of opening; to accept only a 6.6KΩ smart card and accept only a correct password.

- **Designing the Visual Basic Interface**

The visual basic interface was designed in a way that it can be easily and securely used to validate the cardkey and password. There are various steps taken in the course of this design which are;

- Securing the form from unauthorized access
- Outlining the aim of the interface for simple usage
- Arranging forms, labels and textbox for the VB form or window design
- Writing the VB basic codes for the form which accepts card and validates it.
- Writing the VB basic codes for user password authentication.

Taking the above in turns would probably result to the interface form that will be used for card validations.

When the start button is clicked, user can now insert card and key in password which if valid the controller displays “ACCESS GRANTED” on the label and opens the door.

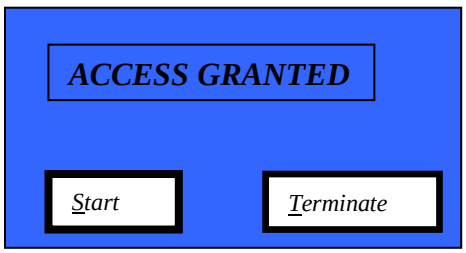

Fig 7. VB Interface

CONCLUSION

The thrust of this work is the design and implementation of a microcontroller-based keycard tailored to improve security in both private and public offices in an organization. In this work, the mode of operation of the system has been explicitly presented. The system sub-systems; both hardware and software have been presented and details of their designs also discussed. To improve the security of the organization, a buzzer is added to the system in order to alert the security personnel if three wrong consecutive tries are made on the system.

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