Control Area Network Based SecuritySystem

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Abstract*—A security and protection system encompasses various means and devices designed to safeguard individuals and property from hazards such as crime, fire, accidents, espionage, and sabotage, with a focus on specific threats. The Control Area Network (CAN) is a communication protocol that enables multiple controllers to interact directly without a host PC, allowing for interdependent tasks where inputs from one controller can trigger outputs from another. This protocol is commonly used in large industrial automation systems. In our project, we have developed a CAN-based security system utilizing three microcontrollers, each designated a specific task, to enhance overall security through collaborative communication.

Keywords - Control Area Network (CAN); Communication Protocol; Host PC; Microcontrollers

I. INTRODUCTION

We are living in a hi-tech era where crime is increasing day by day. Due to increase in numbers of threats and intrusions in society, everyone needs a security system which can keep their belongings secure and at the same time we also want to protect our home assets from any kind of hazard. Security and protection system, any of various means or devices designed to guard persons and property against a broad range of hazards, including crime, fire, accidents, espionage, sabotage, subversion, and attack. Most security and protection systems emphasize certain hazards more than others. Home protection and family safety are the primary purposes of a home security system. While this includes detecting burglary, a security system also detects a number of other threats, including smoke, fire, carbon monoxide poisoning, and water damage. The main purpose of a home security system is to keep your property and the people inside it safer. Harm may come in the form of a burglary, home invasion, fire, flood, or other environmental disaster. Most home security systems can monitor for all of these.

In this project that is CAN based security also we have tried to design the same communication protocol where there is three microcontrollers each having its one specific task. The first control will be interfaced with the keypad to check the password.The second controller will be interface with buzzer and the gate opening circuit. The third controller will be interfaced with the 16x2 LCD. If the password entered is correct there will be no alarm and the gate will be opened with proper display of encrypted password on the LCD and the notifications also else vice versa will happen. A microcontroller based Door locker is an access control system that allows only authorized persons to access a restricted area. The system has a Keypad by which the password can be entered through it. When the entered password equals with the password stored in the memory then the gate gets open. In today's high-tech era, the rising incidence of crime and various threats necessitates the implementation of robust security systems to safeguard personal belongings and home assets. Security and protection systems comprise a variety of means and devices designed to protect individuals and properties from a wide array of hazards, including crime, fire, accidents, espionage, sabotage, subversion, and attacks. While many systems focus on specific threats, the overarching goal remains the same: to ensure home protection and family safety. Home security systems are primarily designed to detect burglaries, but they also play a critical role in identifying other dangers such as smoke, fire, carbon monoxide poisoning, and water damage. The fundamental purpose of these systems is to enhance the safety of both property and the people residing within, as potential harm can arise from various sources, including burglary, home invasions, fires, floods, or other environmental disasters. Most modern home security systems are equipped to monitor and respond to these diverse threats effectively.

In our project, we have developed a CAN-based security system that employs a communication protocol involving three microcontrollers, each designated to perform a specific task. The first microcontroller is interfaced with a keypad, which allows users to enter a password for access control. The second microcontroller is connected to a buzzer and the gate-opening circuit, providing immediate feedback and control over the physical entry point. The third microcontroller interfaces with a 16x2 LCD

display, which provides visual feedback to the user. When the correct password is entered, the system will not trigger an alarm, and the gate will open while displaying the encrypted password on the LCD screen. Conversely, if the password is incorrect, the system will activate the alarm and prevent access. This microcontroller-based door locking system serves as an effective access control mechanism, allowing only authorized individuals to enter restricted areas. By integrating these components, our CAN-based security system aims to deliver a comprehensive solution that enhances home security while ensuring user convenience and safety.

II. HARDWARE COMPONENTS

1. 4X4 KEYBOARD:

This 16-button keypad provides a useful human interface component for microcontroller projects. Convenient adhesive backing provides a simple way to mount the keypad in a variety of applications. Security systems, menu selection data entry for embedded systems are some applications. The 4x4 matrix keypad is a simple mechanism that resembles the numeric input on your computer keyboard, except that it has an additional '*,' '#' and 4 other auxiliary buttons that can be used for various functions in the application.

The keypad is usually made of plastic materials and is relatively cheap compared to touchscreen displays. A 4x4 matrix keypad can be implemented separately or within the physical product itself, such as a security access controller, where it is used for PIN identifications. Either way, the mechanism of the mechanical keypad remains the same when hardware and firmware designers are concerned.

If you've never designed with a 4x4 mechanical keypad, the best way to visualize the internal mechanism is a matrix of push- button switches. A 4x4 keypad has a total of 8 connections, where 4 of them are connected to the column and the remaining rows of the matrix of switches. When an individual button is pressed, a connection is established between one of the rows and columns. The microcontroller then deciphers the physical button based on the index of the row and column that is activated.

Fig.1. 4X4 Keyboard

2. ATMEGA 168 MICROCONTROLLER:

This unit is the brain of the system. This is responsible for the full control of the system. The AVR is a modified Harvard architecture 8-bit RISC single chip controller which wasdeveloped by Atmel in 1996. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage, as opposed to one-time programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time. This family of microcontrollers can be directly used for digital and analog input and outputs. These microcontrollers have in-built ADC's and output PWM channels. AVR is a series of microcontroller in which architecture design is same with the different series controllers having certain advance features and different memory mappings for different memory elements. The ATMEGA-8 is the basic controller of this series. It consists of ATMEGA-16, ATMEGA-32, ATMEGA-168 and many more controllers.

The ATMEGA168 is a CMOS 8-bit microcontroller with low power consumption based on the AVR® enhanced RISC architecture that is available in three packages: PDIP, MLF, and TQFP. The devices achieve CPU throughput approaching one million instructions per second (MIPS) per megahertz by executing instructions in a single clock cycle, allowing the system designer to optimize power consumption versus processing performance. The first two have 28 pins on each module, while the third has a 32-pin interface.

The program memory is 16K and is based on Flash, while the other two memories, RAM and EEPROM, each comprise 1K and 512 Bytes and have a data retention capacity of roughly 20 years.The device has a 10-bit ADC module, which is critical for sensor interface and has a total of 8 channels, adequate to give analog todigital conversion to a number of pins. Only a few controllers, including the ATmega168, support all three communication protocols: SPI, I2C,

and USART. These protocols are commonly used when communicating with external devices .Other features of this module include a watchdog timer, power-up timer, oscillator start-up timer, Brown out Detection, and In-Circuit Serial Programming, in addition to giving a sufficient pace for executing a number of instructions.

The instruction set distinguishes this AVR module from PIC Microcontrollers. AVR microcontrollers perform most instructions in a single clock cycle, but PIC microcontrollers take a number of clock cycles per instruction. In addition, the PIC has a 'W' register, but the AVR has 32 general-purpose registers, three pairs of which can be used as pointers.

The Atmel AVR core combines a rich instruction set with 32general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The Power down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next Interruptor Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption.

FEATURES:

The Atmega168 provides the following features: 16 Kbytes of In- System Programmable Flash with Read-While-Write capabilities, 512 bytes of EEPROM, 1 Kbyte of SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two wire Serial Interface, a 6-channel ADC (eight channels in TQFP and QFN/MLF packages) with 10-bit accuracy, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM; Timer/Counters, SPI port, and interrupt system to continue functioning.

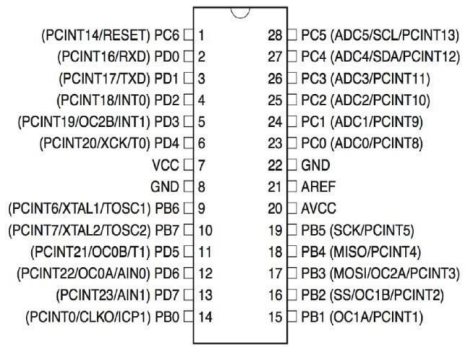


Fig.2. ATMEGA 168 MICROCONTROLLER

3. LIQUID CRYSTAL DISPLAY:

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD displayis very basic module and is very commonly used in various devicesand circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The datais the ASCII value of the character to be displayed on the LCD.

PIN DESCRIPTION:

PIN NO.	SYMBOL	FUNCTION
1	Vss	GND
2	Vdd	+5V
3	Vo	Contrast Adjustment
4	RS	H/L Register Select Signal
5	R/W	H/L Read/Write Signal
6	E	H/L Enable Signal
7	DB0	H/L Data Bus Line
8	DB1	H/L Data Bus Line

9	DB2	H/L Data Bus Line
10	DB3	H/L Data Bus Line
11	DB4	H/L Data Bus Line
12	DB5	H/L Data Bus Line
13	DB6	H/L Data Bus Line
14	DB7	H/L Data Bus Line
15	A/Vee	+5V
16	K	GND

LCD Interface Diagram:

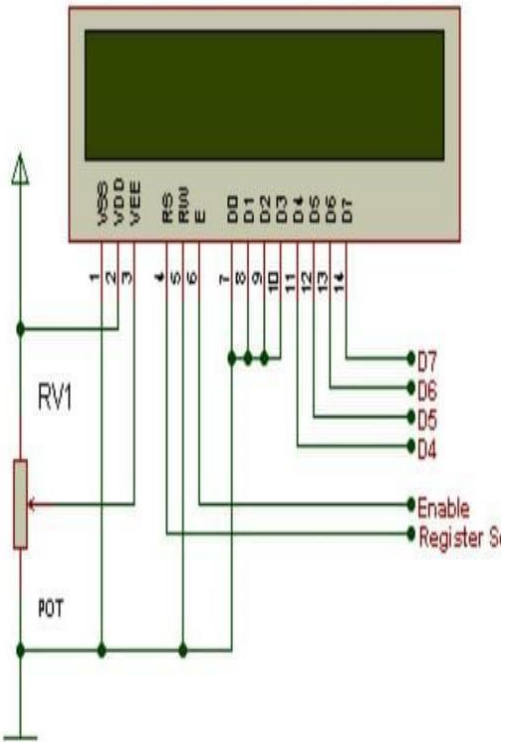


Fig.3.LCD Interface Diagram

Above is the connection diagram of LCD in 4-bit mode, where we only need 6 pins to interface an LCD. D4-D7 is the data pins connection and Enable and Register select are for LCD control pins. We are not using Read/Write (RW) Pin of the LCD, as we areonly writing on the LCD so we have made it grounded permanently. If you want to use it, then you may connect it on yourcontroller but that will only increase another pin and does not make any big difference. Potentiometer RV1 is used to control the LCD contrast. The unwanted data pins of LCD i.e. D0-D3 are connected to ground.

4. MOTOR:

A DC motor is an electrical motor that uses direct current (DC) to produce mechanical force. The most common types rely on magnetic forces produced by currents in the coils. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

Motor drive is used to drive the DC motors as directed by the microcontroller. This is the OUTPUT block. Here we used L293D to drive the motors .whatever signals it receives from the microcontroller on the basis of that it will drive the motors. An H- bridge is an electronic circuit which enables a voltage to be appliedacross a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwardsand backwards. H-bridges are available as integrated circuits, or can be built from discrete components.

Fig.4.Motor

5. BUZZER:

The buzzer used is a piezo-buzzer. It will sound to ensure alarming. In simplest terms, a piezo buzzer is a type of electronic device that's used to produce a tone, alarm or sound. It's lightweight with a simple construction, and it's typically a low-cost product. Yet at the same time, depending on the piezo ceramic buzzer specifications, it's also reliable and can be constructed in a wide range of sizes that work across varying frequencies to produce different sound outputs.

Fig.5.Buzzer

6. POWER SUPPLY BLOCK:Transformer:

The power supply consists of a step down transformer 230/12V, which steps down the voltage to 12V AC. This is converted to DC using a Bridge rectifier. The ripplesare removed using a capacitive filter and it is then regulated to +5V using a voltage regulator 7805 which is required for the operation of the

microcontroller and other components. Transformer is a static electrical device that transfers energy by inductive coupling between its winding circuits. A varying current in the primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic flux through the secondary winding. This varying magnetic flux induces a varying electromotive force (EMF), or "voltage", in the secondary winding.

Adapter:

The adapters are the device that has inbuilt circuitry forconverting the 230V AC in to desired DC like +5V adapter,
+12V adapter, +9V adapter and many more. This consists ofinbuilt circuit for HIGH AC to low voltage DC conversion.

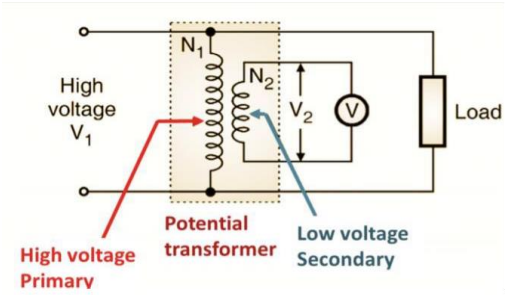


Fig.6.Adapter

III. SOFTWARE PART

➢ ARDUINO COMPILER:

Programming or burning a microcontroller means to transferthe program from the compiler to the memory of the microcontroller. A compiler is software which provides an environment to write, test and debug a program for the microcontroller. The program for a microcontroller is generally written in C or assembly language. Finally the compiler generates a hex file which contains the machine language instruction understandable by a microcontroller. It is the content of this hex file which is transferred to the memory of the microcontroller. Once a program is transferred or written in the memory of the microcontroller, it then works in accordance with the program.

To program a microcontroller, we need a device called a burner/programmer. A programmer is a hardware device with dedicated software which reads the content of the hex file stored on the PC or the laptop and transfers it to the microcontroller to be burned. It reads the data of the hex fileby connecting itself to the PC via a serial or USB cable and transfers the data to the memory of the microcontroller to be programmed in accordance with the protocols as described by the manufacturer in the datasheet.

The Arduino IDE is a cross-platform application written in Java, and is derived from the IDE for the Processing programming language and the Wiring project. It is designedto introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. There is typically no need to edit make files or run programs on a command-line interface. Although building on command-line is possible if required with some third-party tools such as Ino.

The Arduino IDE comes with a C/C++ library called "Wiring"(from the project of the same name), which makes many common input/output operations much easier. Arduino programs are written in C/C++.

IV. TESTING

1) Connect the black terminal of the Digital Multimeter to the ground of the supply source and turn the knob to 20V DC voltage.
2) Make sure the notch of all the IC's including microcontroller is same as given above.
   PIN 15
   PIN 01
   PIN 28
   PIN 14
3) Check the continuity and short circuit of the PCB's.
4) Provide supply of 12V to motor driver board from mainboard.
5) Check the voltages at pin o (output) of both 7805 and itshould be +5 volts on the boards.
6) Check the voltage at pin 7 and 20 of the all threemicrocontrollers it should be +5 volts.
7) Check pin number 1 & 9 of L293D it should be +5V andpin number 8 & 16 it should be +12V.
8) Check the voltage at pin 2 and pin 15 of the

LCD, Itshould be +5V.

9) LCD should display all these data.
10) If all the above parameters are met, then the testing part is complete and we can run our Project.
11) Ensure that all ground connections on the PCB areproperly connected and have continuity.
12) Use an oscilloscope to check for any noise on the powerlines that could affect performance.
13) Use Multimeter for any unintended short circuits on thePCB.
14) Monitor the power supply while the system is running to ensure it remains stable under load.
15) Perform a final visual inspection of the PCB for any soldering defects, loose connections, or physical damage.

Caution: Check the orientation of LCD, and all IC.

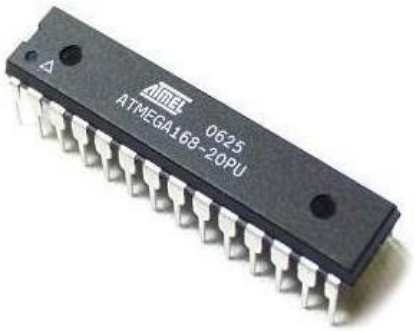


Fig.7.ATMEGA 168

V. WORKING

The input is 230V AC which is step down using the transformer (12-0-12) .The 12V ac input is fed to the bridge diode to gives 12V pulsating DC. This DC voltage is filtered through the capacitor to remove the ripples. The filtered DC is fed to 7805 regulator to fetch +5v regulated output. This regulated voltage is given to all the components to function properly.

The serial solution was preferred and a lot of serial buses and protocols were developed optimizing different parameters of the communication. The microcontrollers ATMEGA 168(AVR family) are programmed in arduino compiler to check for the proper input and generate proper output as per the interfacing. Each individual controller executes its input output task and conveys the message to next controller. The output in the project is LCD interface, buzzer and motor driving unit. There is 16x2 LCD interface also to display the operation and other activities. The LCD is interfaced to the microcontroller through its 6 pins .Proper display on LCD is managed through programming (refer programming section). The motor is interfaced to the microcontroller by a motor driver IC. The signal is generated through the programming. This signal is fed to a motor driver IC L293D. The function of this is to provide proper current and voltage to the motor as well as control the direction of the motor and generate proper output. A CD tray is used as door prototype.

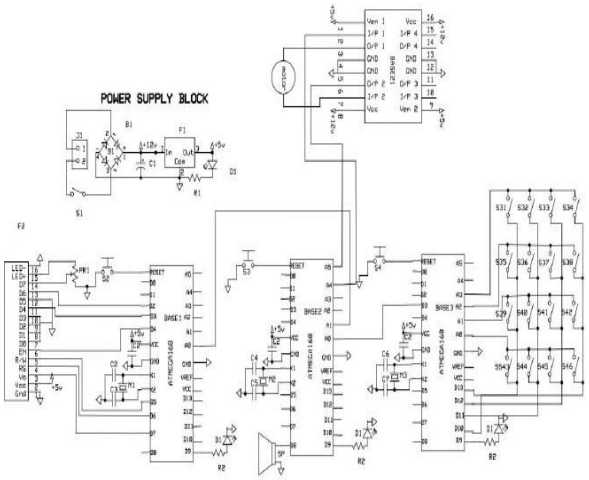
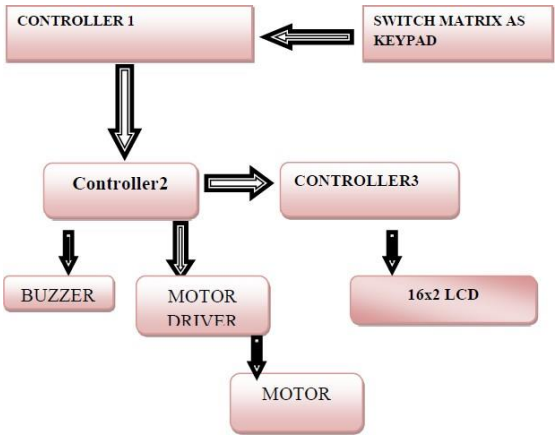


Fig.8. Power Supply Block

Block Diagram:



SECTION DESCRIPTION:

1) 4x4 Keypad block: This consists of switches for entering the password.
2) Controller 1 block: This is used to read the keypad as per programming means it checks for the password.
3) Controller 2 blocks: This block is used to generate the alarm if password entered is wrong and control the gate when password entered is correct.
4) Buzzer block: Used to generate alarm.
5) Motor driver block: Used to control the motor of

the doorin our case represented by CD tray.

6) Controller 3 blocks: This block is used to control the LCDdisplays and the notifications.
7) LCD block: This block is used for display of required setof data.

VI. ADVANTAGES & DISADVANTAGES

ADVANTAGES

1) Constant Protection: Appointing security guards or personally being there to protect the property 24/7 is practically not possible. These security systems provide round-the-clock protection against burglars and break-ins.
2) Strong Deterrent: Homes and commercial propertiesthat have burglar alarm systems installed are at a lesser risk of being targeted by intruders and burglars. When infiltrators find out that you have an alarm system installed, they are persuaded to move away from your property. Even if they are not aware of its presence, the alarming sound will scare them off.
3) Uninterrupted Functionality: There are two types of alarm systems. Wireless alarm systems work on batteries and not electricity. Which means they are effective during power-cuts as well. Hardwired systems do not use batteries and consume electricity from the source. So, there is no need of regular battery charging or replacement.
4) Can Relocate: The alarm system devices can be disconnected and installed at different places. It is easy to relocate both, wireless as well has wired alarm security systems.
5) Special Alarm Systems: Modern alarm security systems provide the ability to monitor the activities happening on your property when you are away. There are security systems that have an add-on feature of detecting fire or smoke. These systems will instantly notify you during emergencies like a fire breakout, gas leak, or a flood emergency.

DISADVANTAGES:

1) False Alarm: These security systems are prone to falsealarms that involve the alarm ringing when anyone fromyour family enters the restricted area. Or there are instances when the alarm is triggered by itself without any reason
2) Expensive: Both, wireless and hardwired alarmsystems are expensive to install. They require an initial investment, which includes equipment cost, installation, and subscription of security monitoring service.
3) Can be Stolen: Irrespective of the type of burglaralarm you have, it can be stolen from the site where it is installed. Wireless systems are comparatively easier to disconnect. Some burglars can easily disconnect the wired alarm systems.

VII. CONCLUSION

Through this project we have provided very sophisticated CAN based security system using hardware as well as software components to achieve ultimate security of homes, offices, and various important places which needs security. In this project that is CAN based security also we have tried to design the same communication protocol where there is three microcontrollers each having its one specific task.

It introduces a sophisticated CAN-based security system that seamlessly integrates hardware and software components to provide robust security solutions for homes, offices, and other critical environments. Utilizing the Controller Area Network (CAN) protocol, we enhance communication efficiency and ensure data integrity across the system.

The architecture comprises three dedicated microcontrollers, each assigned specific roles: the first focuses on real-time surveillance using various sensors and cameras; the second acts as the alarm and notification hub, triggering immediate alerts through multiple channels; and the third provides an intuitive control interface, allowing users to manage settings and monitor system status via mobile apps and web portals.

Our custom communication protocol features message prioritization, error detection, and scalability, ensuring adaptability to evolving security needs. Additionally, the system incorporates encryption and tamper detection to safeguard against cyber threats and physical tampering.

This CAN-based security system is versatile, suitable for residential, commercial, and critical infrastructure applications. As urban areas transition into smart cities, such advanced security solutions will be vital in enhancing public safety.

Ultimately, our project demonstrates the feasibility and importance of innovative security technologies. By leveraging modern advancements, we aim to create a safer future, empowering individuals and organizations to operate with confidence. We look forward to further enhancements that will continue to

meet the dynamic security needs of our communities.

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