Design and Development of Energy Conservative Home Automation System

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ABSTRACT
Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. Home automation is one of the most exciting developments in technology from the past decade. In this work, home automation system is developed using arduino microcontroller. There are five sensors used in this system namely RFID used for controlling the access of main door, light dependent resistor (LDR) for automatic control of curtains, LM35 for fire detection system, Passive infrared (PIR) for lighting system and ultrasonic level sensor for continuous monitoring of water level in tank. A home automation system integrates electrical devices in a house with each including domestic appliances and home entertainment systems. These devices are connected to microcontroller and computer to allow control via computer network.

General Terms
Automation, Instrumentation system, home safety system

Keywords
Automation, energy conservation, sensor, microcontroller

1. INTRODUCTION
Home Automation can be used for a wide variety of purposes, from turning lights on and off to programming appliances within a home and use of timers for these various devices. Home Automation is often used as a luxury convenience within a home and as these devices become cheaper, people look forward to install in their home. Automation plays an increasingly important role in the global economy and in daily experience. The automated devices with mathematical and organizational tools are used to create complex systems for a wide range of applications and human activities. Human-level pattern recognition, language recognition, and language production ability are well beyond the capabilities of modern mechanical and computer systems. Tasks requiring subjective assessment or synthesis of complex sensory data, such as scents and sounds, as well as high-level tasks such as strategic planning, require human expertise [1]. Automation has a notable impact on many industries in manufacturing process. In medical field automation is used in screening application such as electrocardiograph, radiography and in laboratory analysis of human genes, blood plasmas, cells, and tissues for more speed and accuracy. Automated teller machines (ATMs) have reduced the need for bank visits to obtain cash and carry out transactions. In general, automation has been responsible for the shift in the world economy from agrarian to industrial in the 19th century and from industrial to services in the 20th century.

2. EARLIER WORK
Home Automation can be is used to control variety of appliances such as lighting system, water level controlling, automation of doors and window curtains. These devices when available at low cost become more fascinating to people to install them at their homes. Paolo Carner [2] attempted to design a smart home and his work was limited to only three parameters namely light, temperature and motion. Kushal Shakya et al [3] attempted a remote control home automation mainly concentrating on security and power consumption, but they have not experimented with any physical parameter in their work. Sajidullah S. Khan et al [4] worked on light and temperature. Bilal Ghazal et al [5] in their work designed a home automation for senior citizen and physically disabled but the physical parameters were not sensed or measured. Therefore there is a need of sensing and measurement of physical parameters and design of a complete home automation system. Based on the review of the earlier work on home automation, a system is designed with the following features

- Opening and closing of the door based on RFID system.
- Opening and closing of the curtain based on the light sensing.
- Switching ON/OFF the lights based on presence of human using PIR sensor
- Detection of fire using temperature sensor
- Water consumption management using ultrasonic level sensor

3. METHODOLGY
The energy conservative home automation system consists of the following modules

- Door mechanism using RFID
- Automatic curtain controller
- Temperature sensor
- Automatic lights
- Ultrasonic Level Sensor
- Door mechanism using RFID

RFID (radio frequency identification) is used to access the main door lock system. The sensor reads the tag and transmits the code to the arduino for data matching. If matched the door opens using a DC motor and rack and pinion arrangement [6]. LDR is used to automatically control the opening and closing of the curtains depending on the intensity of light falling on the sensor. It is featured with both automatic mode and manual mode. PIR is used to turn on the lights as the person

enters the room and off as the person moves out. Temperature sensor, LM35 senses the change in temperature in the surrounding, if there is a fire accident an alarm is set on. Ultrasonic level sensor is used continuous monitoring of water level in the overhead tank and switches on an alarm when the level goes below a preset low data.Block diagram of energy conservative home automation system is as shown in Figure 1.

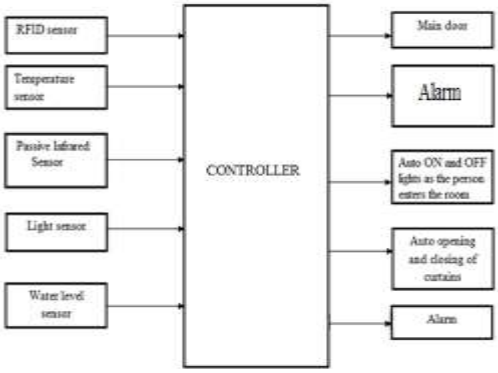

Fig 1: Block diagram of energy conservative home automation system.

3.1 Door mechanism using RFID

The RFID module consists of a primary coil which radiates 125 KHz radio frequency radiations this acts as a reader. When a tag which consists of a 125 KHz radiating secondary coil is brought near the reader electromagnetic energy is produced hence the reader reads the identity information stored in the tag. If the read data matches with the stored data in the reader the door gets activated [7]. The data transmission takes places through serial communication using Tx pin of the EM1402 and the Rx pin on the arduino board. Interfacing of EM-18 reader module to the arduino board is shown in the Figure 2.

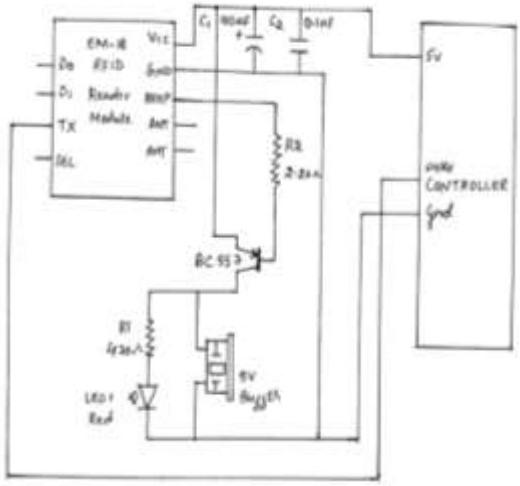

Fig 2: Interfacing EM-18RFID reader with arduino.

3.2 Automatic curtain control

The Automatic control of window curtain takes place depending on the intensity of light in the room. It features both automatic mode and manual override mode. In the manual override mode the user is free to choose the open and close of the curtains. Whereas in the automatic mode, the preferred intensity level in the room is preset using a potentiometer and the control system operates the motor and adjust the curtains suitably depending upon the intensity of light falling on the LDR. When there is increase an increase in light intensity from the preset level the curtains will open else the curtains are closed. A voltage divider circuit is rigged up with LDR value 5 KΩ and resistance 3.3 KΩ and output is measured across the LDR [8]. The circuit Diagram of Automatic Curtain Controller is shown in the Figure 3.

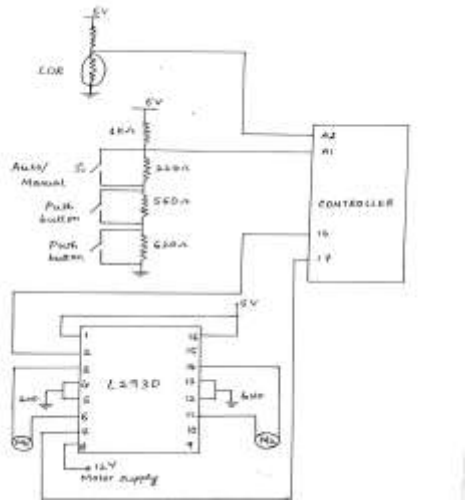

Fig 3: Circuit diagram of an automatic curtain controller.

When the LDR receives no light the ADC outputs a zero, else outputs a digital value in the range 338 to 350. The formula to obtain the output voltage is given by

Output voltage = (digital value/1023)*5V (1)

The output of the microcontroller is given to the DC motor to operate the curtains.

3.3 Temperature Sensor

Temperature sensor is used to measure the rise in temperature inside the house. When there is a rise in temperature in the surrounding due to a fire accident, the temperature which is sensed by LM 35, checks if the sensed temperature is above a preset level, and if so, triggers an alarm through the arduino[9]. The output of the sensor is connected to the channel 0 of ADC. The digital output of ADC is converted to temperature units using the formula

Temperature = (5*digital value)*100/1024 (2)

Where, 5V was the supply voltage. 1024 is 10 bits representation for the analog value. The circuit diagram of temperature sensor is shown in Figure 4.

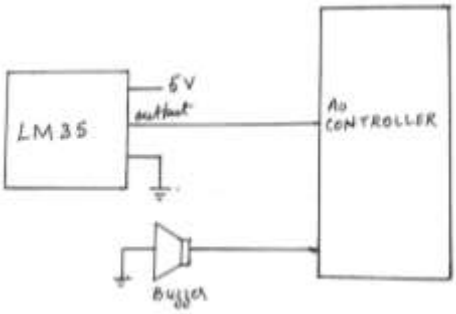

Fig 4: Interfacing of LM35 with arduino.

3.4 Automatic Lights

PIR sensor is a pyroelectric device that detects motion by measuring changes in the infrared levels emitted by surrounding objects. It is used to detect the presence of human in a room. When a person enters the room the sensor detects IR radiation emitted by human and triggers the lighting system through arduino microcontroller. The sensor gives a high signal when a human is detected and as the ambient infrared signals change rapidly, the on-board amplifier trips the output to indicate motion. The sensor is designed to adjust for slow variations in the environment that would normally happens as the day progresses, and respond by making the output high when sudden changes occur, like a detection of motion due to human movement. PIR was directly interfaced with arduino with no signal conditioning and switches on the LED. The sensor gives the output voltage of 3.28V whenever there is human movement within the range of 2 meters and

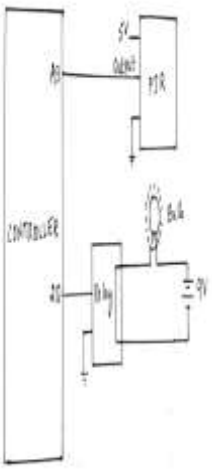

Fig 5: Circuit diagram of PIR Sensor

turns ON the LED. The circuit diagram of PIR sensor is shown in the Figure 5.

3.5 Ultrasonic Level Sensor

Ultrasonic level sensor, which is mounted on the top of the overhead tank continuously measures and monitors the water level in the tank. The sensor is non-contact type, and the principle of operation is similar to sonar. The sensor, evaluates the distance of the target by interpreting the echoes from the ultrasonic sound waves. The sensor transmits an ultrasonic wave and produces an output pulse that corresponds to the time required for the burst echo to return to the sensor. By measuring the echo pulse width, the target distance can be calculated. The module is interfaced to arduino using two pins, one for measurement and the other for triggering. The circuit diagram of level sensor is shown in the Figure 6.The water level is monitored by measuring the distance and the distance is converted into volume. The distance and volume are continuously monitored in computer using serial communication. The sensor was experimented and found working accurately in the range of 0 to 240 centimeters.

The formula used to calculate the distance is given as

Test distance = (high level time x velocity of sound (340m/s)/2 (3)

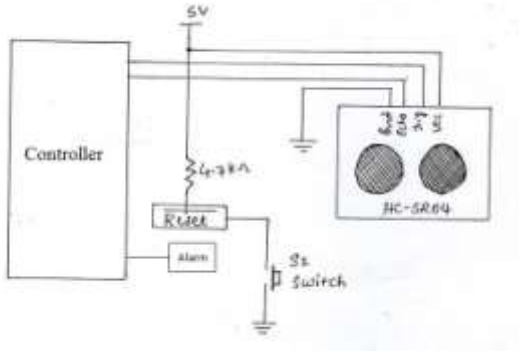

Fig 6: Circuit diagram of level sensor.

4. Results

The main aim of this project was to provide the safety and to minimize the human effort and electrical power. The system worked satisfactorily and produced desired outputs and results. The function of RFID system was to open the door which was successfully done; using a DC motor and rack and pinion arrangement, when the data in the tag and the stored data of the arduino matched. The temperature sensor output was, connected to channel zero of the ADC. The digital output for every five degree rise in temperature was measured and the results are shown in Table 1. When the temperature increased above 50^{o} C an alarm was set ON to indicated a fire accident.

Table 1. LM35 output range

TEMP.(^{O}C)	ADC OUTPUT	OUTPUT VOLTAGE(V)
28	58	0.2832
30	62	0.3027
35	72	0.3515
40	82	0.4003
45	92	0.4492
50	103	0.5029
55	113	0.5517
60	123	0.6005
65	133	0.6494
70	144	0.7031

PIR was interfaced directly with the arduino and programmed to switch on the LED. The sensor gives the output voltage of 3.28V whenever there is human movement within the range of 2 meters and turns ON the LED. The voltage values of PIR at different pins are as shown in the Table 2.

Table 2. LM35 output range

In the presence of human in the range of PIR		Without the presence of human in the range of human	
Pin number	Voltage	Pin number	Voltage
1(gnd)	Ground	1(gnd)	Ground
2(out)	3.27636V	2(out)	0V
3(5V)	5V	3(5V)	5V

The LDR used for automatic light control which is a part of a voltage divider circuit gives digital value zero when there is darkness in the room and a digital value ranging from 338 to 350 when the curtain is open, depending on the light changing outside the house. The water level is monitored by measuring the distance which in turn is converted to volume. The distance and volume were continuously monitored with a computer using serial communication. The sensor worked accurately in the range of 0 to 240 centimeters. The working details of ultrasonic sensor are shown in the Table 3.

Table 3. Specifications of level sensor

Working voltage	DC5V
Working current	15ma
Working frequency	40hz
Range	2m - 4m
Measuring angle	15 degree
Trigger input signal	10 microseconds TTL pulse
Echo output signal	Input TTL lever signal and the range in proportion

Figure 7 shows the photograph of the developed home automation system.

(a)

(b)

Fig 7: Prototype model of designed home automation system (a) front view (b) side view.

5. CONCLUTION

Energy conservative home automation system was successfully designed and checked for its working. By automation of the home a stress free living environment can be created with the available advanced mechanism and integrating the entire system into one unit. The home is completely safe from fire accidents and theft as it has restricted the asses with card holder only. The automation of the curtains is an added feature along with level control of over head tank. The PIR based circuit conserves energy by switching on the lights only during the presence of a person in the room.

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