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Design of Sensor Network for Home Automation System

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Abstract*— Design of sensor interface and relevant signal conditioning is essential to build sensor network for automation. Home automation is the need of the society in the fast changing and developing countries like India. In this work, sensor network is designed for home automation system using arduino microcontroller making use of the advanced features. Five sensors are used in the network namely RFID used for controlling the access of the 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 interconnects the sensor devices and equipment's in a home which includes domestic appliances and home entertainment systems. Suitable interfacing circuits are designed for networking the sensors and devices are connected to the microcontroller and computer to allow control via computer network.

***Index Terms* — automation, energy conservation, sensor, safety, microcontroller.**

I. 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 low cost, people look forward to install these sensors in their home. Automation plays an important role in the global economy and in daily life. 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 19th century and from industrial to services in 20th century.

II. 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 using sensor network. 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 measuring 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.

III. METHODOLGY

A sensor network is designed for home automation system consists of the following modules

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

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

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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 sensor network interface to microcontroller of home automation system is as shown in Fig. 1.

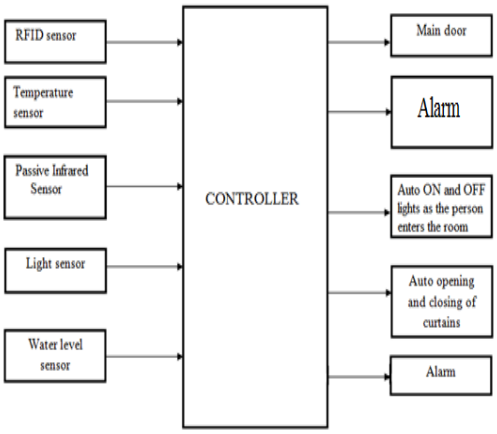

Fig. 1: Block diagram of sensor network interface to microcontroller in home automation system.

A. Door mechanism using RFID

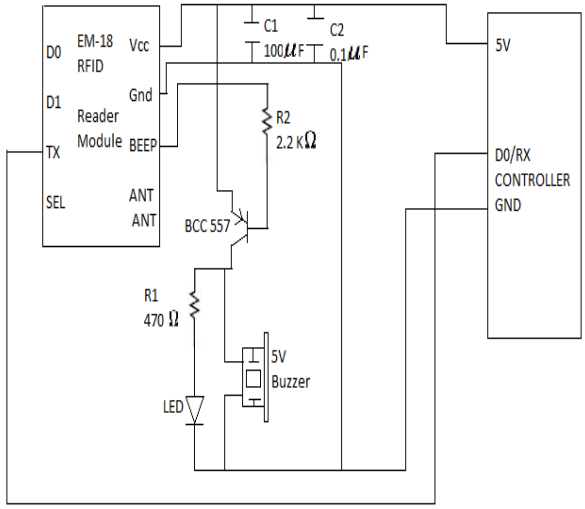

Fig 2: Interfacing EM-18RFID reader with Arduino.

The RFID module consists of a primary coil which radiates 125 KHz radio frequency radiations this acts as a reader, the EM 18 RFID reader module is used in our work. This is a 125 KHz module and comes with both serial and weigand interfaces. 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]. Most RFID readers provides with a serial interface for connecting to a microcontroller. The data transmission takes places through serial communication using Tx pin of the EM1402 and the Rx pin on the Arduino board. When the data read from the tag matches the data stored in the reader a high signal is given as the output which in turn energizes the DC motor which is connected to the rack and pinion arrangement which opens the door. Interfacing of EM-18 reader module to the Arduino board is shown in the Figure 2.

B. 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. The circuit for the selection of manual or automatic mode is connected to the channel 1 of ADC of the Arduino microcontroller. 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 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 voltage divider circuit is connect to the channel 2 of ADC of the Arduino microcontroller. 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 via rack and pinion arrangement.

The circuit diagram showing interface of LDR sensor for Automatic Curtain Controller is shown in the Figure 3.

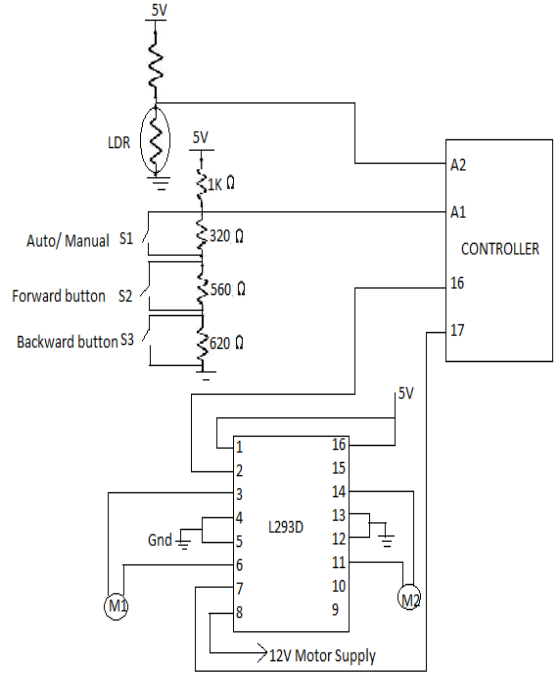

Fig 3: Circuit diagram of LDR interface in automatic curtain controller.

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C. *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.

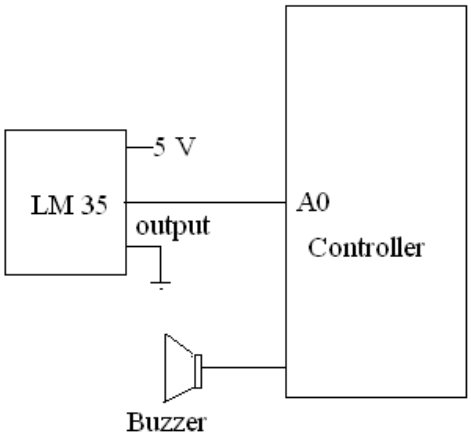

Fig 4: Interfacing of LM35 sensor with Arduino.

D. *Automatic lights*

PIR sensor is a pyro electric device that detects motion by measuring changes in the infrared levels emitted by the surrounding objects. It is used to detect the presence of human in a room. When a person enters the room the sensor detects the change in the 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.

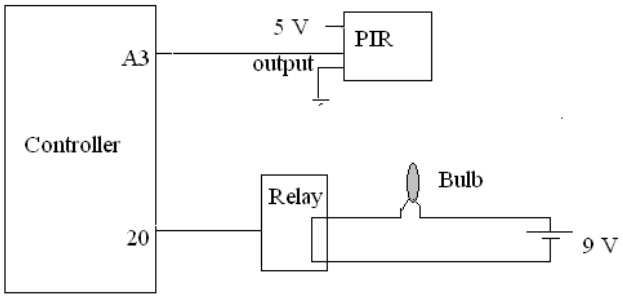

Fig 5: Circuit diagram of PIR Sensor interface.

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 output pin was directly interfaced with channel 3 of ADC of 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 turns ON the LED. The circuit diagram of PIR sensor is shown in the Figure 5.

E. 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)

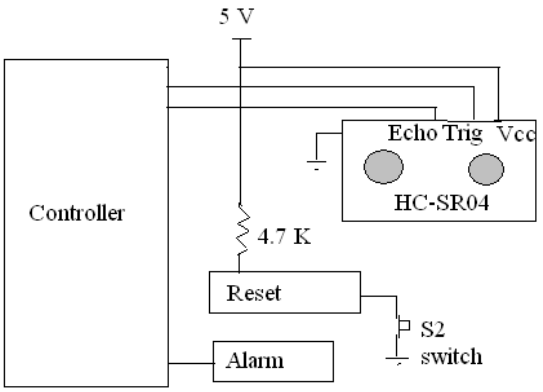

Fig 6: Circuit diagram showing interfacing of level sensor.

IV. RESULTS

The main aim of this project was to provide the safety and to minimize the human effort and electrical power by designing the sensor network. 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,

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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.

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

Table 3. Specifications of level sensor

Figure 7 shows the photograph of the developed home automation system using sensor network.

(a)

(b)

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

V. CONCLUSION

Sensor network for home automation system was successfully designed and was confirmed 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 network. 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 overhead 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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