International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Index Copernicus Value (2015): 62.86 | Impact Factor (2015): 3.791

Sensors and its Smart Applications

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Abstract: ***Today's day to days life is rising with new and smart technologies, where the sensors plays a vital and major role. In early days everything used to be manual where human work was mandatory. But now a day's manual had become automatic with increase in the sensor terminology. History has shown that advancements in materials*** **science** ***and engineering have been*** **important** ***drivers in the development of*** **sensor technologies*****. This paper mainly focuses on the sensor terminology and its applications which are commonly used in our day to day life. Generally with the emerging trends in the microcontroller like Arduino the effect of the application had became easy for sensor measurement. Here different sensor applications like ultrasonic sensor, Biometric sensor, motion sensor had been presented.***

Keywords: Arduino, Sensor, Relay, Servomotor, IR receiver

1. Introduction

A sensor is an object whose purpose is to detect events or changes in its environment, and then provide a corresponding output. A sensor is a type of transducer; sensors may provide various types of output, but typically use electrical or optical signals [1][2]. For example, a thermocouple generates a known voltage (the output) in response to its temperature (the environment). A mercury-in-glass thermometer, similarly, converts measured temperature into expansion and contraction of a liquid, which can be read on a calibrated glass tube. Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micro machinery and easy-to-use micro controller platforms, the uses of sensors have expanded beyond the most traditional fields of temperature, pressure or flow measurement, for example into MARG sensors. Moreover, analog sensors such as potentiometers and force-sensing resistors are still widely used. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine, robotics and many other aspects of our day-to-day life. Arduino plays a vital role for the smooth operation. This is an user friendly environment where the practical application of sensor is made easy[2]. A sensor's sensitivity indicates how much the sensor's output changes when the input quantity being measured changes. For instance, if the mercury in a thermometer moves 1 cm when the temperature changes by 1 °C, the sensitivity is 1 cm/°C. Some sensors can also affect what they measure; for instance, a room temperature thermometer inserted into a hot cup of liquid cools the liquid while the liquid heats the thermometer [4]. Sensors need to be designed to have a small effect on what is measured; making the sensor smaller often improves this and may introduce other advantages. Technological progress allows more and more sensors to be manufactured on a microscopic scale as micro sensors using MEMS technology [5]. In most cases, a micro sensor reaches a significantly higher speed and sensitivity compared with macroscopic approaches [6]. The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring. Often in a digital display, [7] the least significant digit will fluctuate, indicating that changes of that magnitude are only just resolved. The resolution is related to the precision with which the measurement is made.

2. Basic Terminology

- **Range**

Every sensor is designed to work over a specified range. The design ranges are usually fixed, and if exceeded, result in permanent damage to or destruction of a sensor. It is customary to use transducing elements over only the part of their range where they provide predictable performance and often enhanced linearity.

- **Zero**

When making a measurement it is necessary to start at a known datum, and it is often convenient to adjust the output of the instrument to zero at the datum.

- **Zero Drift**

The signal level may vary from its set zero value when the sensor works. This introduces an error into the measurement equal to the amount of variation, or drift as it is usually termed. Zero drift may result from changes of temperature, electronics stabilizing, or aging of the transducer or electronic components.

- **Sensitivity**

Sensitivity of a sensor is defined as the change in output of the sensor per unit change in the parameter being measured. The factor may be constant over the range of the sensor (linear), or it may vary (nonlinear).

- **Resolution**

Resolution is defined as the smallest change that can be detected by a sensor.

- **Response**

The time taken by a sensor to approach its true output when subjected to a step input is sometimes referred to as its response time. It is more usual, however, to quote a sensor as having a flat response between specified limits of frequency. This is known as the frequency response, and it indicates that if the sensor is subjected to sinusoidally oscillating input of constant amplitude, the output will faithfully reproduce a signal proportional to the input.

- **Linearity**

The most convenient sensor to use is one with a linear transfer function. That is an output that is directly proportional to input over its entire range, so that the slope of a graph of output versus input describes a straight line.

- **Hysteresis**

Refers to the characteristic that a transducer has being unable to repeat faithfully, in the opposite direction of operation, the data that have been recorded in one direction.

- **Calibration**

If a meaningful measurement is to be made, it is necessary to measure the output of a sensor in response to an accurately known input. This process is known as calibration, and the devices that produce the input are described as calibration standards.

- **Span (input)**

A dynamic range of stimuli which may be converted by a sensor id called a span or an input full scale (FS). It represents the highest possible input value which can be applied to the sensor without causing unacceptably large inaccuracy.

3. Ease of Study

3.1 Piezo

A piezo is an electronic device that generates a voltage when it's physically deformed by a vibration, sound wave, or mechanical strain. Similarly, when you put a voltage across a piezo, it vibrates and creates a tone. Piezos can be used both to play tones and to detect tones.

3.2 Motion Sensor

PIR or passive infrared is a common method of motion detection that measure changes in heat to signal the change. Power it up and wait 1-2 sec for the sensor to sense as shown in Figure.1

Figure 1: Motion Sensor

3.3 Finger Print Sensor

The Finger Print Sensor as shown in Figure.2 is one optical fingerprint sensor which will make fingerprint detection and verification adding super simple. There's a high powered DSP chip AS601 that does the image rendering, calculation, feature-finding and searching.

Figure 2: Motion Sensor

3.4 555 Timer

The 555 timer IC as shown in Figure.3 is an integrated circuit used in a variety of timer, pulse generation and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. Derivatives provide up to four timing circuits in one package. Depending on the manufacturer, the standard 555 package includes 25 transistors, 2 diodes and 15resistors on a silicon chip installed in an 8-pin minidual-in-line package (DIP-8). Variants available include the 556 (a 14-pin DIP combining two 555s on one chip), and the two 558 & 559s (both a 16-pin DIP combining four slightly modified 555s with DIS & THR connected internally, and TR is falling edge sensitive instead of level sensitive).

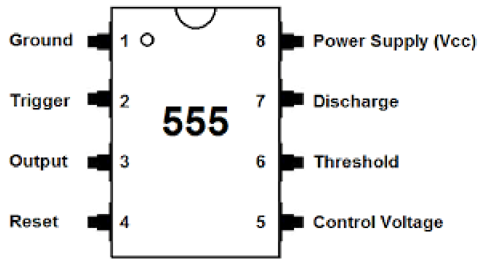


Figure 3: 555 Timer

3.5 IR Sensor

Two IR sensor modules as shown in Figure.4 contain IR diodes, potentiometer, Comparator (Op-Amp) and LED's. Potentiometer is used for setting reference voltage at comparator's one terminal and IR sensors sense the object or person and provide a change in voltage at comparator's second terminal. Then comparator compares both voltages and generates a digital signal at output. Here in this circuit we have used two comparators for two sensors. LM358 is used as comparator. LM358 has inbuilt two low noise Op-amp.

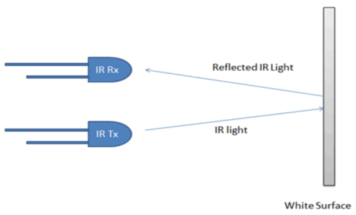


Figure 4: IR Sensor

An infrared receiver, or IR receiver, as shown in Figure.5 is hardware that sends information from an infrared remote control to another device by receiving and decoding signals. In general, the receiver outputs a code to uniquely identify the infrared signal that it receives. This code is then used in order to convert signals from the remote control into a format that can be understood by the other device. It is the part of a device that receives infrared commands from a remote control. Because infrared is light, it requires line-of-sight visibility for the best possible operation, but can however still be reflected by items such as glass and walls. Poorly placed IR receivers can result in what is called "tunnel vision", where the operational range of a remote control is reduced because they are set so far back into the chassis of a device.

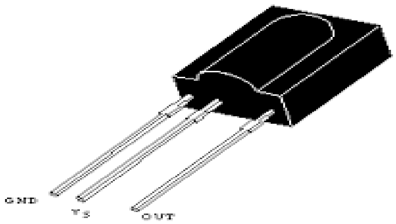
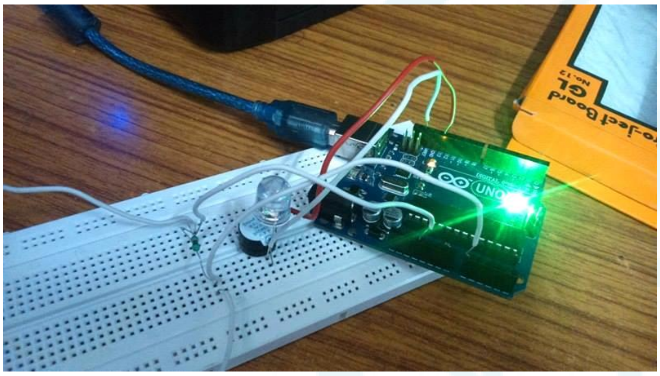


Figure 5: IR Receive

TV remote suitable for IR Receiver in this project TSOP 31230 IR receiver has been used.



3.6 Relay Module

A relay is an electrically operated switch as shown in Figure.6 allows to turn on or off a circuit using voltage and/or current much higher than the Arduino could handle. There is no connection between the low voltage circuit operated by Arduino and the high power circuit. The relay protects each circuit from each other. The module provides three connections labeled COM, NC and NO. NC stands for “NORMALLY CLOSED”. This means that when the relay has no signal (LOW or 0V from an Arduino), the connected circuit will be active; conversely, if 5V applied or pulled the pin HIGH, it will turn the connected circuit off. “NO” stands for “NORMALLY OPEN”**,** and functions in the opposite way; when applied 5V the circuit turns on, and at 0V the circuit turns off. Relays can replace a manual switch. Remove the switch and connect its wires to COM and NO**.** When the relay is activated the circuit is closed and current can flow to the device and circuit is controlled.

Figure 6: Relay Module

4. Case Studies

4.1 Knock Sensor using Arduino

A **piezo** is an electronic device is shown in Figure.7 generates a voltage when it's physically deformed by a vibration, sound wave, or mechanical strain. Similarly, when voltage is applied across a piezo, it vibrates and creates a tone. Piezos can be used both to play tones and to detect tones. The sketch reads the piezo output using the analog Read() command, encoding the voltage range from 0 to 5 volts to a numerical range from 0 to 1023 in a process referred to as analog-to-digital conversion, or ADC. If the sensors output is stronger than a certain threshold, your board will send the string "Knock!" to the computer over the serial port. Open the serial monitor to see text.

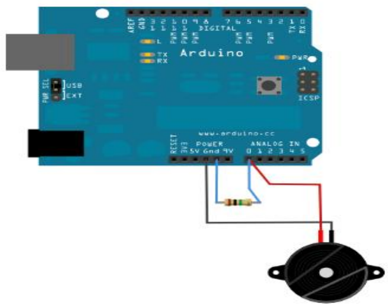


Figure 7: Knock Sensor using Arduino

Piezos are polarized, meaning that voltage passes through them (or out of them) in a specific direction.

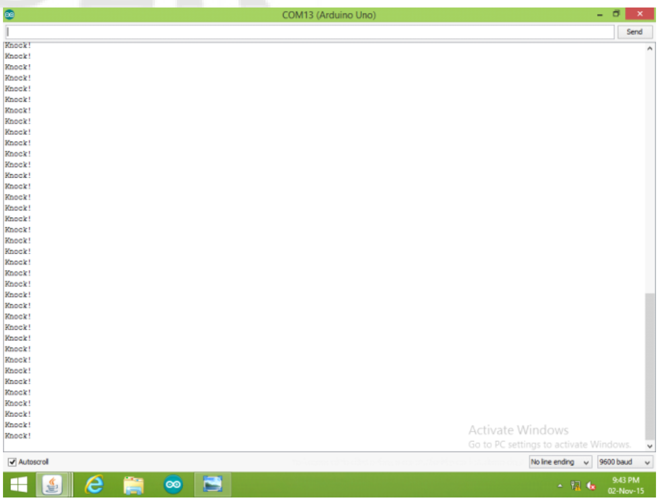


Figure 8: Hardware setup for Knock Sensor using Arduino

Connect the lower voltage to ground and the higher voltage to analog pin 0 as shown in Figure.8. Additionally, connect a

1-megohm resistor in parallel to the Piezo element to limit the voltage and current produced by the piezo and to protect the analog input

Figure 9: Output of Knock Sensor on serial monitor

It is possible to acquire piezo elements without a plastic housing. These will look like a metallic disc, and are easier to use as input sensors. Piezo sensors work best when firmly pressed against, taped, or glued their sensing surface as shown in Figure 9.

4.2 Motion activated Automatic sensorised dustbin

The basic model is that motion sensor takes IR images different times, when they differ, they know some thing has changed as shown in Figure 10. Hooking up to arduino is pretty simple. The red wire is V+ as the brown wire is ground and the black wire is signal wire.

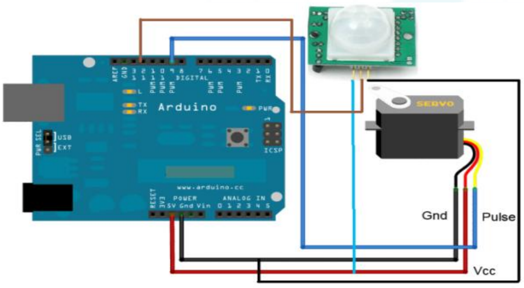


Figure10: Motion activated automatic sensorised dustbin

Figure 11: Hardware setup for Motion activated automatic sensorised dustbin

PIR sensor is connected to the arduino for the supply of 5v, servometer is connected in parallel with the PIR sensor using pcb board is shown in Figure.11. PIR sensor has three pins namely Vin, Ground and the Output pin. Servomotor has three pins namely Vin, Ground and Input digital pin. The connections are made as per the circuit diagram. Ground pin of servomotor and PIR sensor is connected to the ground pin of arduino using pcb board and the digital pin 11 in the arduino is the input to the PIR sensor.

4.3 Finger Print sensor

New fingerprints are enrolled directly - up to 162 are stored in the onboard FLASH memory. There's a red LED in the lens which will light up during taking photos so that its working conditions are known.

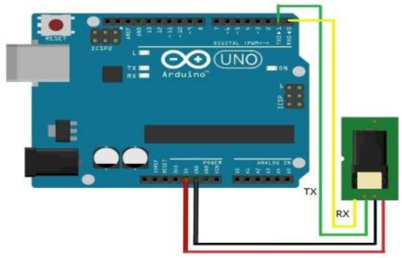


Figure 12: Fingerprint sensor

Specification:

- Supply voltage: 3.6~6.0 V
- Operating current(Max) : 120 mA
- Fingerprint imaging time: 1.0 S
- Baud rate : 9600, 19200, 28800, 38400, 57600bps

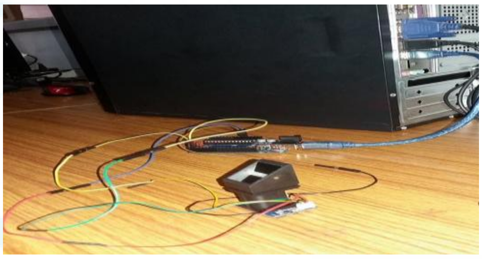


Figure 13: Hardware setup for Fingerprint sensor

Connect the sensor with Arduino UNO is shown in Figure.13 circuit diagram. Open Arduino Software and Type the blank, enroll, fingerprint and delete programs sequentially. Enroll your finger print and check the output in the Serial monitor.

4.4 Speed Control of DC Motor

The 24 V dc motor is rotating with a speed of 1000 rpm, by using pot of 10k ohm by varying voltage as Resistance changes voltage and current varies is shown in Figure.14. By using this principle POT can be varied automatically using Servo motor with the help of arduino uno board and arduino software thus the servo motor rotates a particular angle as instructed by user using a Bluetooth device thus the person can control the speed of motor using mobile and the speed of the DC motor is noted by using Proximity sensor.

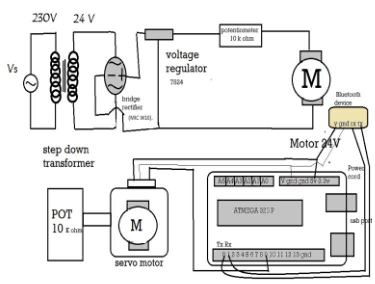


Figure 14: Speed Control of DC Motor

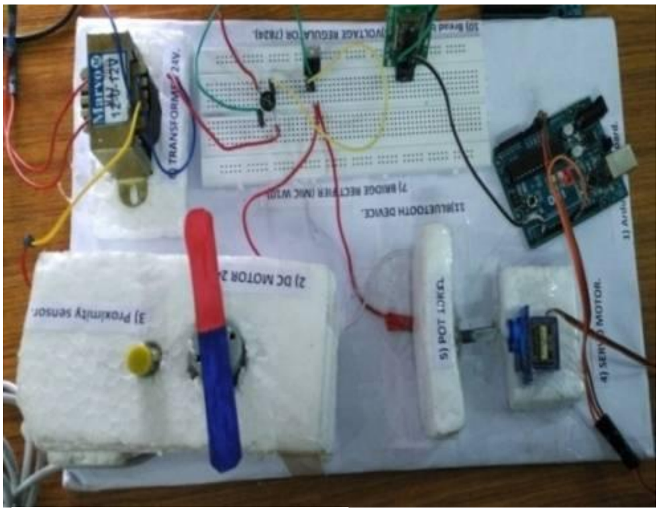


Figure 15: Hardware setup for Speed Control of DC Motor

The input to the motor 24 volts DC is supplied using 24 V transformers. By converting 24 V AC to DC Using a bridge rectifier (MIC W10) and voltage regulator. The input to the Motor i.e, 24V DC is given by using a 24V transformer. As the output of transformer is 24 V AC so a Bridge Rectifier and Voltage Regulator are used to convert the 24 V AC to 24 V DC. This 24 V DC supply is varied from 0 to 24 V by using a POT of value 10k ohm, as the resistance varies the input voltage also varies as shown in Figure.15.

The Pot resistance from 0 to 10 k ohm is varied automatically using a Servo Motor. The input to the Servo Motor is 5Vwhich is given from arduino.(Red=5V, Brown=gnd, orange=9 digital pin).The Servo motor is made to be rotate at particular angles required by using Bluetooth device from a mobile.

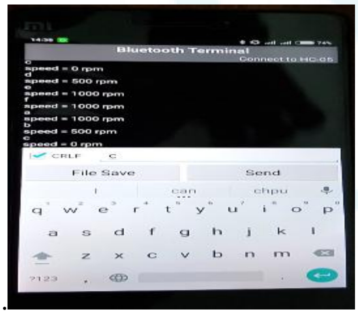


Figure 16: Display in Mobile Phone Speed Control of DC Motor

Thus the resultant speed of the dc motor is displayed and controlled from Mobile.

4.5 Automatic Room Light controller with Bi-Directional visitors counter

The project, "Bidirectional Digital Visitor Counter" is based on the interfacing of some components such as sensors, motors etc. with arduino microcontroller is shown in Figure 17. This counter can count people in both directions. This circuit can be used to count the number of persons entering a hall/mall/home/office in the entrance gate and it can count the number of persons leaving the hall by decrementing the count at same gate or exit gate and it depends upon sensor placement in mall/hall. It can also be used at gates of parking areas and other public places.

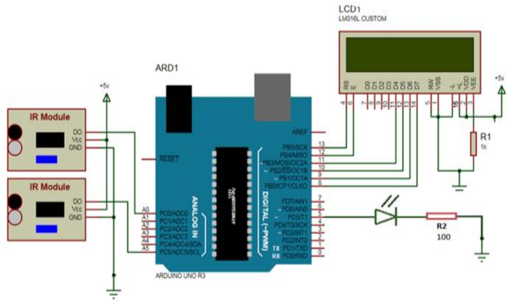


Figure 17: Automatic Room Light Controller with Bidirectional Visitors Counter

This project is divided in three parts: sensors, controller and counter display. The sensor would observe an interruption and provide an input to the controller which would run the counter increment or decrement depending on entering or exiting of the person. And counting is displayed on a 16x2 LCD through the controller.

When any one enters in the room, IR sensor will get interrupted by the object then other sensor will not work because we have added a delay for a while.

The outputs of IR Sensor Modules are directly connected to arduino digital pin number 14(A0) and 19(A5). LCD is connected in 4 bit mode.

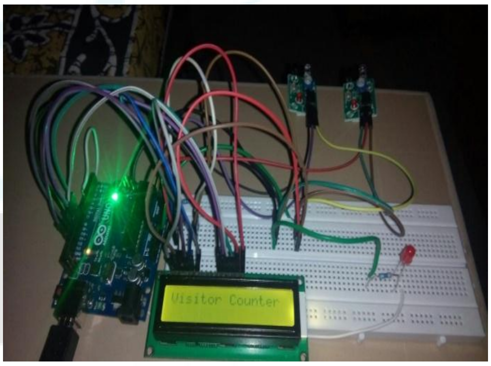


Figure 18: Automatic Room Light Controller with Bidirectional Visitors Counter

RS and EN pin of LCD is directly connected at 13 and 12. Data pin of LCD D4-D7 is also directly connected to arduino at D11-D8 respectively.LED is connected to digital pin 5 of the arduino. Display section contains a 16x2 LCD. This section will display the counted number of people and light status when no one will in the room.

4.6 Electrical Home Appliances Control using IR

The project is designed to operate electrical loads using an IR-based TV remote. The TV remote transmits coded infrared data which is then received by a sensor that is interfaced to the control is shown in Figure 19.

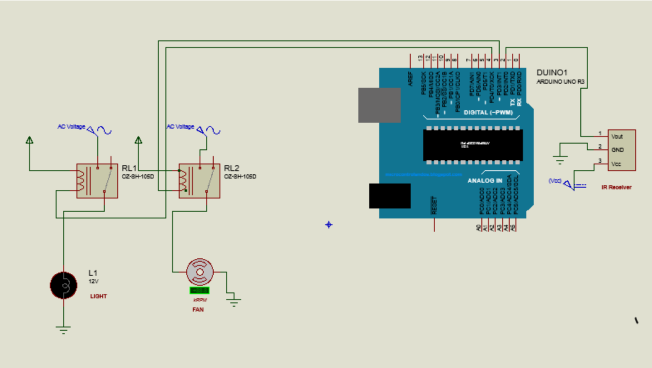


Figure 19: Electrical Home appliances control using IR

The system operates electrical loads depending on the data transmitted from the TV remote. Operating conventional wall switches is difficult for elderly or physically handicapped people. This proposed system solves the problem by integrating house hold appliances to a control unit that can be operated by a TV remote. Coded data sent from the TV remote is received by an IR receiver interfaced to an Arduino board. The program on the Arduino refers to the code to generate respective output based on the input data to operate a set of relays is shown in Figure 20 and Figure 21.

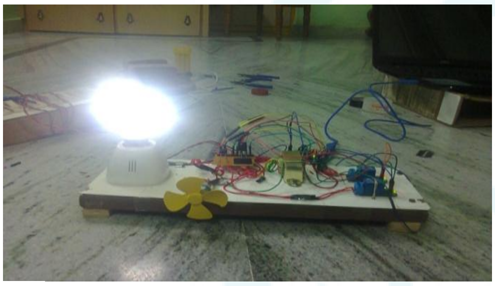


Figure 20: Load 2 (i.e. bulb) is in on position and load 1 (i.e. fan) is in off position

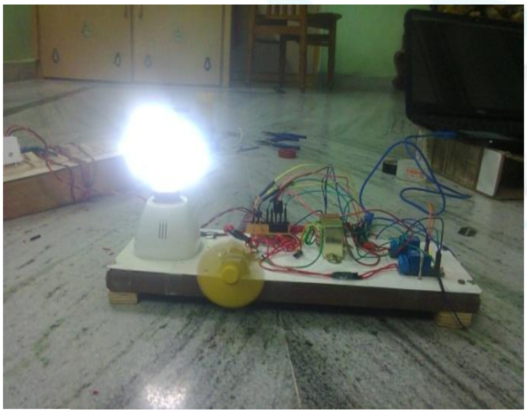


Figure 21: Both load 2(i.e. bulb) and load 1 (i.e. fan) are in on position

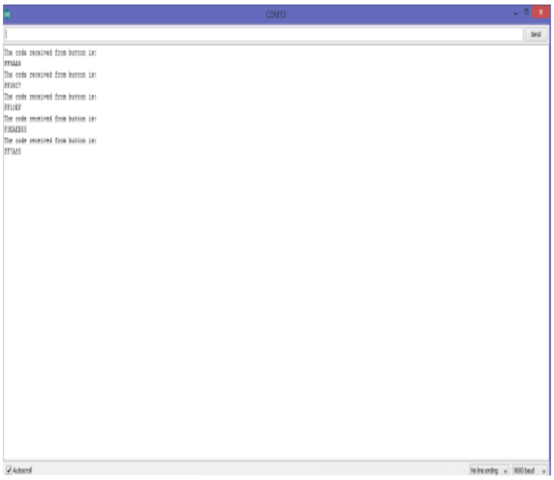


Figure 22: Output of Electrical Home Appliances Control using IR on serial monitor

IR Receiver and Transmitter are used for Environmental control systems, Emergency response systems and Augmentative communication devices.

5. Conclusions

Here different applications based on sensors had been presented. These applications had been demonstrated to the students for the change in education. Now, they can able know the sensors involved in every electrical aspect point with regard to practical application. In future, introducing the sensor application to the engineering curriculum is mandatory to meet the Smart Technology.

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