Smart House Control using LabVIEW

To cite this article: S Angalaeswari *et al* 2020 *J. Phys.: Conf. Ser.* **1716** 012004

View the article online for updates and enhancements.

Smart House Control using LabVIEW

Angalaeswari S[1], Deepa T[1, *], Subbulekshmi D[1], Krithiga S.[1], Machupalli Narsimha Reddy[1], Kuntumalla Siddartha[1] and Chaitanya C[1]

[1]School of Electrical Engineering, Vellore Institute of Technology Chennai Campus-600127, Tamilnadu, India

deepa.t@vit.ac.in

Abstract. This project is solely based on the IOT application of Smart house. This is the day and age of smart devices. Companies are looking to transform the way humans interact with the environment. So digital technologies such as IOT is gaining popularity across the globe. So, trying to implement an IOT model which can function with the help of LabView and Arduino. The main objective of this project is to implement 5 subsystems which are frequently used in a smart house namely: Internal lighting system, External lighting system, Burglar alarm, Temperature and Smoke detector. The other main objective is to monitor the sensor data on the front panel of LabVIEW. The project is successfully completed and the original goals are met. The sensor data is continuously monitored and this data can be viewed on the front panel of LabVIEW. And with the help of LabVIEW, various loads can be controlled such as lights and fan**s.**

1. Introduction

This is the day and age of digital technologies where technology is evolving at a rapid rate. Technology is transforming the way of live. Different technologies and various technological tools are gaining popularity and companies and organizations are coming forward to incorporate these technologies to transform the way of interacting with our surroundings. IOT is one such technology which can be implemented anywhere. This project is based on Smart house. A smart house automation is developed to carry out regular tasks in a comfortable way without consuming much time. In a smart house, the data is monitored continuously and various operations can be performed without human intervention.

This project is solely based on the idea of Smart house which can be operated using LabVIEW and a microcontroller. Arduino is the microcontroller used in this scenario. LabVIEW is a graphical programming language which can be used to implement control systems in real time. It gives accurate and precise desired values which is of utmost importance in today's world. The other main advantage of incorporating LabVIEW is the lack of usage of code blocks. LabVIEW is a software where you program the control systems in graphical blocks which is easy to implement and understand.

The Smart house technology is gaining importance because of the increase in the number of theft cases. An unguarded house is very likely to be robbed. Even those who can afford a personal security personnel often have their homes robbed because of human negligence and human error. This can be nullified by a smart house. You can implement complex security systems with simple technologies and at a much lower capital cost. A simple sensor such as a PIR motion sensor can be incorporated at doors and windows and whenever there is an intruder, the alarm goes off and the owner of the house can be alerted. Thanks to the ever-increasing popularity of technology, these electronic components are

inexpensive and are affordable.

The sensor data being recorded can be graphically represented using the Data acquisition module in LabVIEW. This data can be graphically represented on the front panel of LabVIEW. The same task can be carried out using MATLAB but the results and representations are more accurate using LabVIEW [1]. LabVIEW can be incorporated not only for monitoring and representation of sensor data. It can also be used to control a few of the electrical appliances such as light and fans. This can be implemented by inserting a comment section box wherein a comment can be used as a switch to turn on or off these appliances [2].The LED driver with LabVIEW for the detection of multiple parameters such as voltage, current, efficiency, THD (Total Harmonic Distortion) and the peak factor is proposed in [3] and it is implemented in hardware consisting of data acquisition card, a computer with test cables and the signal devices.

The authors have designed the simulation for the actuator control based on the motion controllers using LabVIEW with PID control method [4]. The vibration characteristics of transformer have been analyzed using LabVIEW for various working nature [5] by comparing the standard deviation of the signal with the regular operating condition. The position of a spring has been measured by attached a mass using data acquisition and control devices of LabVIEW in an experimental setup in [6] with curve fitting method.

The design of a pneumatic injector with the automation concept for analyzing the geometric quality is obtained with LabVIEW software in [7] and the design consists of the thermal and mechanical components, piston along with the resistors. For monitoring the solar panel behavior in real platform with Arduino board, the virtual instrument-based LabVIEW system is simulated in [8] and the current-voltage, power voltage curves are plotted in LabVIEW.

A smart aquaculture system is created to facilitate and manage the fish ponds for the detection and the quality of water in [9], in which the water level, oxygen level is monitored and displayed in LabVIEW screen with the warning set up. The authors [10] developed a monitoring system for analyzing the ECG of patient using LabVIEW with amplifier circuit, data acquisition system and filters techniques are used for the process of the measured data.

The remote monitoring of the brushless DC motor is designed in [11] to measure the current, voltage, speed and temperature using LabVIEW and Zigbee method. To find the speed, frequency and rotation of a DC motor, the PID control-based LabVIEW system is developed in [12] using sensors. The hexapod model is modeled in [13] for understanding its motion design with CAD/CAE system integrated with LabVIEW system in 3D view. The automated process of data acquiring and the processing is presented in [14] in LabVIEW for the repeatedly performed test reports. The actuator design and its control is modeled in [15] using LabVIEW by defining its movement path.

The main goal of this work is to make a sustainable and an affordable smart house model which can be easily accessible to even those below the poverty line. To achieve this goal of ours by incorporating technology using inexpensive electronic components. Section 1 gives a brief introduction to the smart house technology in general and about this work. It introduces and elaborates scope and objectives of this work.

1.1 Motivation

The objective of this work is to implement a smart house technology which incorporates the applications of IOT and provide the necessary security features to tackle the theft issues face by major households. What really motivated us to implement this project is to provide a smart house interface which can be easily understood and implemented and make a few changes, if necessary. The LabVIEW is programmed graphically, which can be easily understood and interpreted. The number of code blocks used to program the various electronic devices is reduced in this work. The other main objective of this project is to implement the smart house technology with minimum capital cost. The cost is also reduced by incorporating LabVIEW and inexpensive microcontrollers such as Arduino. A smart house is implemented using various computer system and electronic systems. All these devices are interconnected. A smart house can do regular things in a comfortable way without consuming much

time with the help of IOT, which makes the regular tasks as easier.

1.2 Objectives

The main objective of this project is to implement a five-subsystem based smart house namely:

      1.) Internal Lighting System 2.) External Lighting System. 3.) Burglar Alarm

      4.) Temperature. 5.) Smoke Detector

   The other main objective of this project is to monitor the sensor data on the front panel of LabVIEW. LabVIEW monitors the senor data regularly and this is displayed in the form of a graph on the front panel. LabVIEW is also used to control the working of various electrical loads such as fans and lights.

   This project deals with the implementation of a smart house with five subsystems along with LabVIEW software. A demo model of the smart house could have been made but due to time constraints, the demo house model couldn't be done. The five subsystems have been implemented on a cardboard platform and the LabVIEW software has been installed on a laptop. The data is received to and sent from the laptop using the ZigBee transmitter and receiver modules. These modules can work in the range of up to 10 meters.

2. Overview

This project basically consists of two sides: Home side and Control side. The home side comprises of all the five subsystems and the microcontroller in the center. These subsystems comprise of sensors and their subsequent connections of loads. For example, the PIR motion sensor is connected to the buzzer. So, when this sensor detects a motion, a high to low signal is sent to this buzzer and it rings thereby indicating that there is an intruder. On the control side, the LabVIEW software installed onto a laptop and this is connected to the receiver module of ZigBee. When a sensor detects some data, this is directed towards the microcontroller. And the Arduino has been fed with code corresponding to each subsystem with a set of instructions.

   And the Arduino revisits all the available conditions to check whether the sensor value is less than or greater than the threshold value and appropriate action is taken (for example, ringing the buzzer). Each sensor is connected to a load such as light bulb or a fan. For example, the smoke sensor is connected to an exhaust fan to expel out the smoke in case of fire. The data collected by the sensor is transferred to the ZigBee receiver module via the ZigBee transmitter module. And this data is displayed on the front panel of LabVIEW in graphical representation. Electrical loads can also be controlled via LabVIEW. The switch can be on or off for the light bulb using LabVIEW by means of command signal. This is achieved through the transmitter and receiver modules of ZigBee. The block diagram of the system is depicted in figure 1.
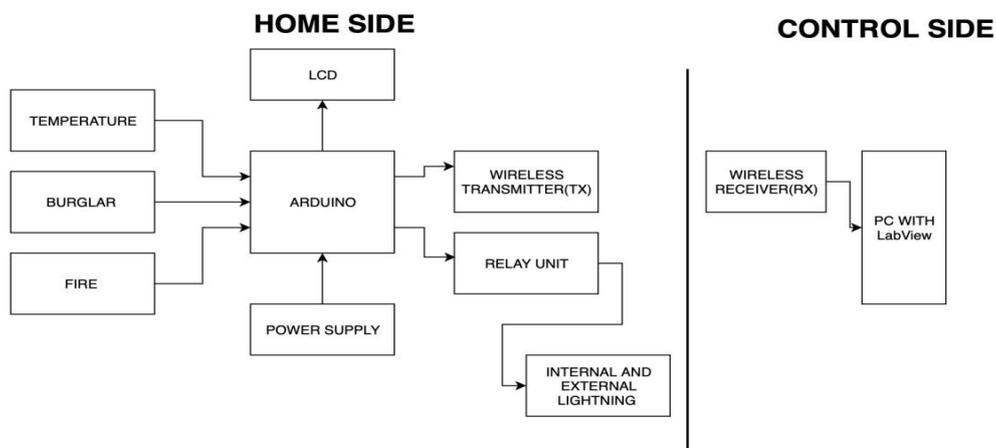

Figure 1. Block Diagram

2.1 Modules of the work

The project mainly comprises of all the five subsystems namely External lighting system, Internal lighting system, Burglar alarm, Temperature and Smoke detector. All these subsystems are internally connected to the loads and the Arduino. So, let us look at these five subsystems in detail.

2.1.1. Module 1 – External and Internal lighting subsystem

This internal lighting subsystem comprises of PIR motion sensor along with light bulb load and LabVIEW software. This subsystem corresponds to the automatic lighting inside the house when the motion sensor detects any movement. This sensor can be placed anywhere in the house such as bedrooms or hall. Whenever the PIR motion sensor detects movement within its range, then it sends a signal to the Arduino and the Arduino is pre-equipped with the Arduino ide code corresponding to the sensor. It checks for all the if cases to see whether the data value generated by the motion sensor is greater than the threshold value. If it is greater, then the Arduino sends a high to a low signal to the light bulb. This data is continuously monitored by the LabVIEW. So, this sensor data is sent to the LabVIEW side via the transmitter and receiver modules of ZigBee. This data is graphically represented on the front panel of the LabVIEW.

The following are the major tasks which are involved in the design and the implementation of the Smart house:

1. **Designing and modelling**: This is of utmost importance. Before connections part, the clear picture of the work is defined. It involves designing the house and deciding upon the placement of various sensors and electronic devices.

2. **Design Specification**: Once the design part is ready, then the electronic components to be used are decided. The specification of each component such as input voltage, output voltage, resistance and so on and so forth are selected and also the raw materials to be used for the house is chosen.

3. **Connections:** After the specification part, the connections are given with the gathered components using wires and cables in a cardboard to ensure the longevity of the model.

4. **LabVIEW:** The LabVIEW simulation models are designed simultaneously. By referring the LabVIEW manuals, the design the logic of the virtual instrument is done. Both the front panel as well as the back panel were designed and once the connections were made, the interfacing of the Arduino with LabVIEW is done.

5. **Testing:** Once the hardware implementation was complete, the testing of the model is done for each and every subsystem and made sure that the connections are intact and that the output results are accurate.

3. Design approach

A smart house is equipped with special structured wiring which allows occupants to program an array of automated home electronic devices by entering a single command. Implementation of the smart home is based on the Lab VIEW software. The objective of this project is to map the processes that optimize the use of smart home technology to ensure that as many users as possible have access to the technology as possible. LabVIEW controls the Indoor lighting, outside lighting, temperature, fire In-house security and burglary security. LabView comes with different inputs. The sensors are linked and processed according to the specified program, and then logical output to the whole power system in the house. Its add-on characteristics is that it has power security mechanism even, if there is a fault within the building defense device traps the key force instantly Source.

Table 1. Codes and standards

IEEE Standard	Description
IEEE 1451	1451 defines Transducer Interface standards that permit systems to automatically identify sensors and obtain their calibration and operating parameters.
IEEE NESC	**NESC** stands for National Electrical Safety Code

3. 1 Realistic constraint

- In practical conditions, voltage is too high; so, parameters change for every sensors and loads.
- In practical conditions, range of detection will be more. So, suitable wireless transmission technology is required.
- Cost of the process in reality increases, but it can be reduced by decreasing number of controllers used.

3.2 Technical specifications

It reads associate analog input, maps the result to a spread from zero to 255 associated uses the result to line the pulse width modulation (PWM) of an output pin. Also prints the results to the serial monitor. The potentiometer is connected to analog pin zero. The middle pin of the potentiometer goes to the analog pin. facet pins of the potentiometer move to +5V and ground. Semiconductor diode is connected from digital pin nine to ground.

Table 2 Technical Specifications

Components used	Operational specifications	Units
Motion sensor	Motion detected = 2.8V Motion not detected = 0.1mV	Volts
LDR sensor	In light voltage=2.9mV Resistance =5kohm In dark voltage=0.658mV Resistance=1mohm	Volts, ohm
Temperature sensor	Output voltage =305mV Room temperature=30.5C	Volts, Celsius
MQ2 sensor	Input voltage=5V Analog output voltage=0- 5V	Volts
Relay unit	5V (2)	Volts
Arduino Uno board(modified)	Input voltage 0-5V	Volts
LabVIEW software	Input voltage 220V	Volts
Step down transformer	Input voltage 220V; Output voltage 24V	

3.3 Components used

The following components are used in the hardware prototype model in this work.

3.3.1 Motion sensor (PIR)

Pyro electrical Infrared (PIR) sensing element is a compact and complete sensing element that is employed for body detection. For top sensitivity and low noise, a lens and motion detection circuit are incorporated within the sensing element. Output of a sensing element could be a commonplace 5V active low output. The sensing element will observe motion up to six meters and might be utilized in theft cases. It is inexpensive and ideal for alarm systems, motion activated lighting and AI applications.

3.3.2 LDR sensor

The output value of this light-weight detector is outlined by the brightness of sunshine that falls on that. Greenockite is a semiconductor that is employed to form lightweight dependent resistors. The amount of sunlight falling on material changes its resistance. Photoelectric impact plays a crucial role in this process where the amount of sunlight falling on the sensor determines the value of the output. The change in resistance plays a very crucial role. This light-weight detector incorporates a resistance 1mega ohm. In a bright environment, its resistance increases to 5k ohms.

The sensitivity of a photodetector is that the relationship between the amount of sunlight falling on the device and also the ensuing output signal. Like the human eye, the relative sensitivity of a transducer depends on the wavelength (color) of the incident sunlight. Each and every photoconductor material type has its own distinctive spectral response curve or plot of the relative response of the detector versus wavelength of the amount of sunlight.

3.3.3 Temperature sensor (LM35)

The LM35 series are integrated-circuit temperature sensors, whose output voltage is linearly proportional to the temperature value in degrees Centigrade. The LM35 doesn't need any external standardization or trimming to produce typical accuracies of $\pm 1/4°C$ at temperatures which lie in the range of -15 degrees Centigrade to +150 degrees Centigrade.

3.3.4 MQ2 sensor

Sensitive material of MQ-2 gas detector is SnO_2. As a result, its conduction is very low in clean air without the presence of gases. Once the concentration of the target flammable gas increases in the air, the conduction of the sensor also increases. This significant change in the conduction of the sensor is converted into output digital signal. MQ-2 gas detector has high sensitivity to LPG, fuel and H, conjointly may well be accustomed to methane series and different flammable steam.

3.4 Zigbee Technology

3.4.1 Wireless communication

Wireless communications comprise of transmitters, receivers and antennas. Path between the transmitter and also the receiver is brief. The transmitter feeds an indication of encoded information modulated into RF waves into the antenna. The antenna radiates the signal through the air wherever it's picked up by the antenna of the receiver. The receiver demodulates the RF waves into the encoded information stream sent by the transmitter.

3.4.2 Zigbee specifications

The frequency bandwidth of the ZigBee transmitter is in the range of 2.4Ghz and it Verilog architecture. Physical layer and Medium access control (MAC) layer are the most used layers in a ZigBee transmitter. ZigBee transmitter operates in three frequency bands namely: 2.4GHz with 16 channels, 915MHz with 10 channels and 868 MHz with 1 channel. A 2.4GHz band with 16 channels is used for the spread wide and easy to transmit data over long distances. It has a spacing of 5MHz and data rate of 250Kbps.

Table 3. ZigBee Specifications

Parameter	Specification
Data rate	250kbps
No of channels	16
Operating frequency	5.4GHz
Channel spacing	5MH
Chip rate	2 mega chips for

Section 3 mainly deals with the design approach of the project. It deals with codes and standards, realistic constraints and alternative tradeoffs of the project. It mainly focusses on the design specifications of the various components used in the project.

3.5 Arduino Uno

Arduino Uno is the most extensively used microcontroller and it is inexpensive. It is based on the ATmega328. It comprises of 14 digital input/output pins, 6 analog inputs, a 16MHz ceramic resonator, a USB connection, a power jack for the external power source, an ICSP header and a reset button. All these are embedded inside the microcontroller and to operate it, just connect it to the laptop and load the code corresponding to the five subsystems. "Uno" suggest one in Italian and is known as to mark the future unleash of Arduino 1.0. The Uno and version 1.0 are the reference versions of Arduino, moving forward. The Uno is the latest one in the series of microcontroller boards. These microcontrollers are inexpensive and can be extensively used for the electronic purposes.

3.6 Step down Transformer

Step down transformers are generally used for stepping down the supply voltage without changing the current rating. This transformer has 230V primary windings and 12V secondary voltage. As a result, all the devices and components can be operated at lower voltage. This transformer is capable of supplying power for all kinds of loads used in a project. So, the main purpose of this transformer is to step-down the AC voltage from 230V on the primary side to 12V on the secondary side with a maximum current rating of 1A. Step down transformer works on the principle of electromagnetic induction.

3.7 Channel 5V 10A Relay Module

A relay turns on or off a circuit which is operating at a much higher voltage. Relay is generally used for protecting the circuit against the flow of high voltage and current. The relay protects each and every circuit by acting as a switch or a barrier between them. Whenever there is a flow of high value current or voltage, then the connection is cut-off by the relay.

4. PROJECT DEMONSTRATION

4.1 Description

Post completion of hardware part, it is tested for the correct functionality of the components. Graphical code is developed in the LabVIEW software and both software and hardware are interfaced through ZigBee technology which is used for wireless transmission. There are some accuracy problems regarding the functionality of sensors when interfaced with the software which can be resolved by using better quality sensors. So, the results can be divided into Simulation results and Hardware results. In Simulation results, it mainly deals with the front and the back-panel results. Hardware results comprise of the hardware components.

Section 4 mainly deals with the demonstration of the project in terms of results. It focusses on

analytical, simulation and hardware results. It includes the screenshots of all these results including graphs.

4.2 Simulation results

 Figure 2 shows the back panel of LabVIEW where one design the graphical code which is suitable and interfaceable with the Zigbee software. When the design of the graphical code in the black panel, then automatically subsequent control functions which can be monitored are created in control panel or front panel.
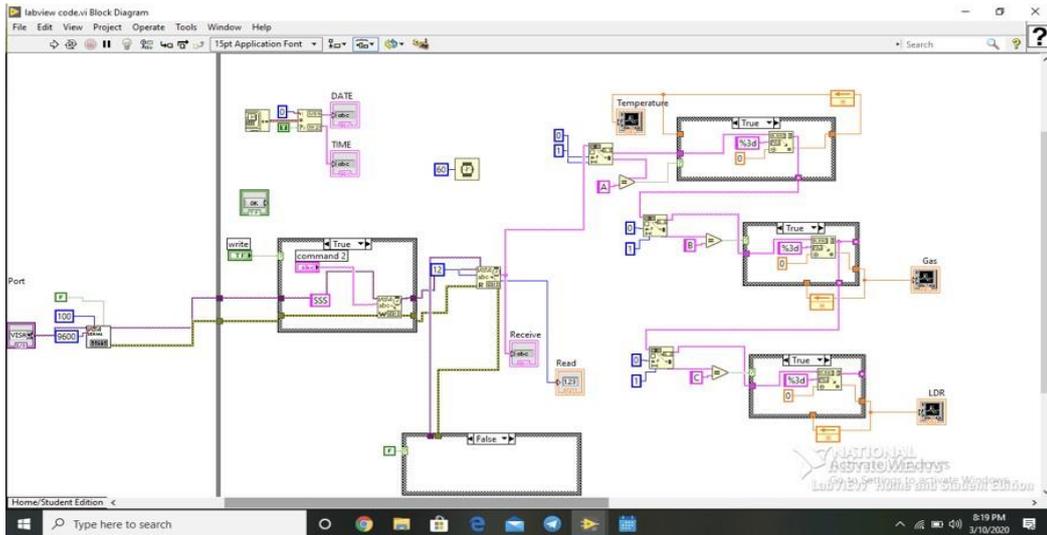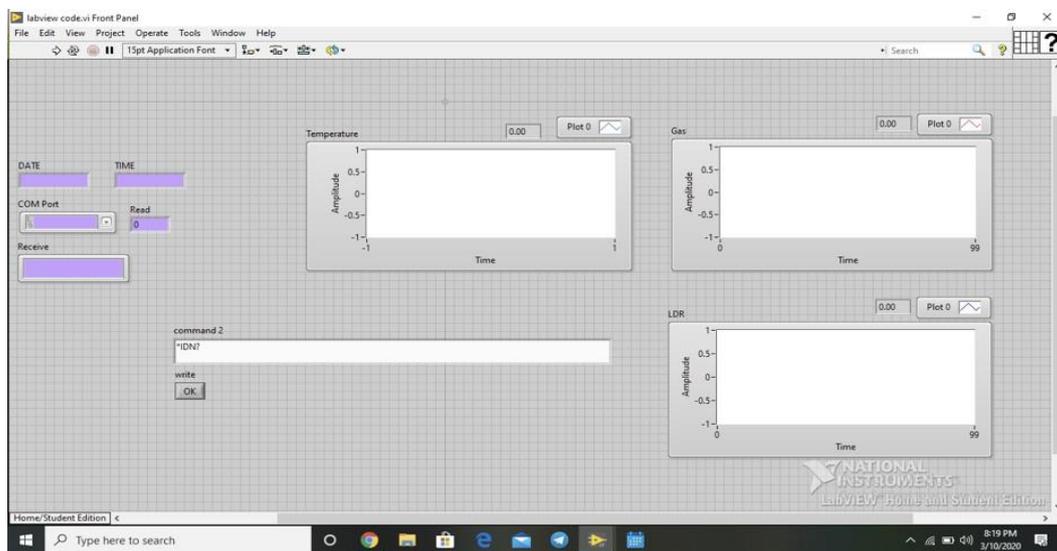

Figure 2. Back panel

Figure 3. Front panel (Idle Condition)

When to switch ON/OFF the loads by using LabVIEW, alternate code will be given to LabVIEW control panel which controls some of the electrical loads such as fans and lights. To continuously monitor the sensor data and visualized graphically on the front panel, the front panel is used. In this way, real time monitoring can be done with the help of LabVIEW.

Figure 4. Front panel (Working Condition)

The threshold values of every sensor are mentioned clearly in the code. So, using those values, one can monitor the functionality of the sensor. Separate block is created for each and every sensor and load so that it is easy to observe the monitored data. Simulation is successfully tested against the hardware setup.

4.3 Hardware Implementation

Figure 5. Hardware model

As you can observe from the above Figure 4 Arduino is the central connecting block of the model. All
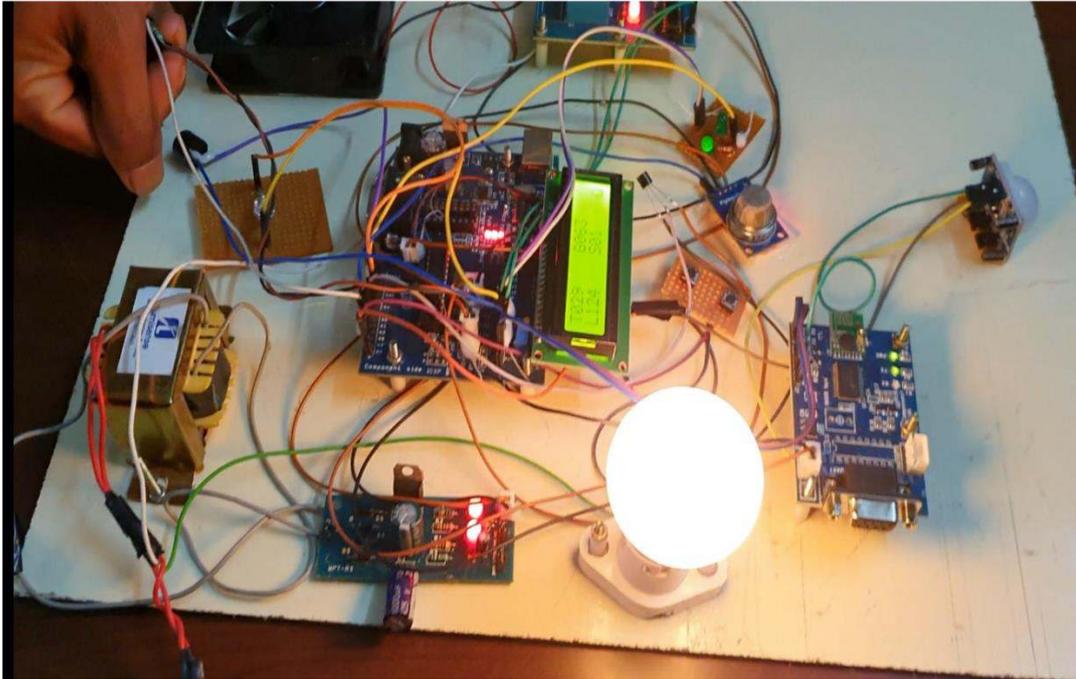
the five subsystems are connected to the Arduino. The different types of electrical loads including fans and lights are used with ZigBee transmitter and receiver modules as well. The battery as well as the transformer are used in this work for the power supply.

Figure 6. Working of Loads

As can be observed from the above Figure 5 the working of the hardware model has been successfully verified wherein the data from the different sensors is displayed on the LCD display. As it is observed from figure 6, the sensor data is continuously monitored and graphically represented on the front panel of LabView.

5.Conclusion

The main purpose of this work is to increase the accessibility of Smart houses to those who wish to live in one, but could not afford it. This is the main reason as to why Arduino is used in place of raspberry pi and replaced the functionality of MATLAB with that of LabVIEW. Cost factor plays a very important role in the design of this work. It is designed such a way that the capital costs can be reduced to the fullest. A smart house working with raspberry pi costs more at the ground level. The cost of raspberry pi alone amounts up to Rs.4000. So, the cost is reduced in this work.

Table 4. Cost of the prototype

S.No	Item/Description	Rate/Item (Rs.)	Quantity	Item Cost (Rs.)
1.	Arduino UNO	400	1	400
2.	PIR sensor	200	1	200
3.	MQ2 sensor	214	1	214
4.	LM35	220	1	220

5.	ZigBee (Tx and Rx)	1500	1	1500
6.	Relay junction	276	1	276
7.	Transformer	149	1	149
8.	LCD display	175	1	175
9.	Miscellaneous (Wires, Batteries,etc)	300	1	300
10.	Shipping charges	200	1	200
			Total	3634

6. Scope of Work

- The project leaves scope for some more improvisation. As mentioned earlier, this project can be extended further.
- A GSM module can be used for sending alert SMSs to the owner as well as the firefighter's office.
- A further extension can be made by including a solenoid valve which cuts the supply of the gas during a leakage or a fire outbreak.
- The mode of control and operation can be extended beyond the boundaries of the house. One can use the internet features of Arduino and LabVIEW and let the owner control all the appliances using his/her mobile phone. This is one of the main applications of IOT.
- One can even try to implement a SCADA system which can be used to obtain important specifications of the various systems involved.
- Various modifications can be made to the internal design of the smart house by installing sensors all around the place. The project is very easy to understand and implement. It doesn't involve a lot of code blocks. It is feasible enough to implement further extensions and modifications.

7. Summary

In a short and brief summary, implementation of a smart house which can be operated and controlled using LabVIEW is performed. It is used five subsystems and installed them inside the house walls. These five subsystems include Internal and External lighting, Burglar, Smoke Detector and Temperature. The Arduino as the microcontroller and LabVIEW in place of MATLAB for data visualization is used. The main reason for using LabVIEW is that its usage significantly reduces the usage of code blocks you usually encounter with the usage of MATLAB. And the DAQ system works better with LabVIEW. These five subsystems carry out their operations and their work are coordinated by the microcontroller. This sensor data is sent to the receiver module of ZigBee via the transmitter module. And this data is continuously monitored by visualizing it graphically on the front panel of LabVIEW. LabVIEW also controls the switch on and off of certain electrical loads such as fans and lights. The project leaves scope for further extensions such as the usage of GSM module. With the help of this module, one can send alert SMSs to the owner as well as the firefighter's office. One can also install a solenoid valve to cut off the supply of gas and smoke during a fire outbreak. One can also use long distance transmission technique to control the operations of this smart house via a smart phone. The last section deals with practical implementation of the project. It focusses on cost analysis, scope and the overall summary of the project. It also offers recommendations for improvements to the project.

References

[1]   Sleman A; Alafandi and M Moeller 2009 Integration of Wireless Fieldbus and Wired Fieldbus for Health Monitoring, *Consumer Electronics*, ICCE '**09**. Digest of Technical Papers International Conference, 1-2

[2]   Van Nguyen T, Jin Gook Kim and Deokjai Choi, 2009 ISS: The Interactive Smart home Simulator," Advanced Communication Technology, *ICACT,11th International Conference*,**03**, 1828- 1833

[3]   Yue Hua, Tianhu Wang, Tianyu Chen, Naiping Song, Keming Yao and Yinsheng Luo,2020 Design and implementation of testing system of LED driver power based on LabVIEW *Optik - International Journal for Light and Electron Optics* ,**163411**, 1-8

[4]   Bhagyashree M Yaragal, Abilash Desai, Deepak Dhadoti and Vijay Prabhu, 2016 Profile based motion generation for actuators using LabVIEW software *IOP Conf. Series: Materials Science and Engineering* **149,**1-9

[5]   Zhanlong Zhang, Yongye Wu1, Sigong Zhang, Peiyu Jiang and Huarui Ye, 2019 Online monitoring research of transformer vibration based on Labview *IOP Conf. Series: Journal of Physics: Conf. Series,* **1168(2)**, 1-9

[6]   Anusorn Tong-on, Parinya Saphet and Meechai Thepnurat, 2017 Simple Harmonics Motion experiment based on LabVIEW interface for Arduino *IOP Conf. Series: Journal of Physics: Conf. Series,* **901**, 012114

[7]   Rincón-Quintero A D, L A Del Portillo-Valdés, A Meneses-Jacomé, C G, Cárdenas-Arias, C L Sandoval-Rodriguez, J G Ascanio-Villabona, B E, Tarazona-Romero, J A Sandoval-Baldión, J C Ortiz-Ríos and R A Mantilla- Olejua, 2020 Manufacture of hybrid pieces using recycled R-PET, polypropylene PP and cocoa pod husks ash CPHA, by pneumatic injection controlled with LabVIEW Software and Arduino Hardware *IOP Conf. Series: Materials Science and Engineering* , **844**, 012054

[8]   El Hammoumi A, S Motahhir, A Chalh, A El Ghzizal and A Derouich, 2018 Real-time virtual instrumentation of Arduino and LabVIEW based PV panel characteristics *IOP Conf. Series: Earth and Environmental Science,* **161** ,012019

[9]   Huang Shufen and Cheng Wei, Xu Shuiyin,2020 LabView-based Smart Aquaculture system *Journal of Physics: Conference Series,* **1550,** 042037

[10] Om Prakash Singh, DawitMekonnen and M. B.Malarvili, 2015 Labview Based ECG Patient Monitoring System for Cardiovascular Patient Using SMTP Technology *Hindawi Publishing Corporation, Journal of Medical Engineering*, **701520,** 1-9

[11] Vaishakh J K and V Vanitha, 2019 Remote monitoring of BLDC motor using LabVIEW and zigbee" *IOP Conf. Series: Materials Science and Engineering,* **561,**012118

[12] Gengcheng Chen and Yaping Lu, 2018 Research and Design of Motor Control System Based on Labview PCI *IOP Conf. Series: Materials Science and Engineering,* **423,**012058

[13] Herbuś K and P Ociepka, 2015 Analysis of the Hexapod Work Space using integration of a CAD/CAE system and the LabVIEW software *IOP Conf. Series: Materials Science and Engineering,* **95,**012096

[14] Andrey Korgin , Valentine Ermakov and Laith Zeyd Kilani, 2019 Automation and Processing Test Data with LabVIEW Software *IOP Conf. Series: Materials Science and Engineering,* **661,**012073

[15] Bhagyashree M Yaragal, Abilash Desai, Deepak Dhadoti and Vijay Prabhu, 2016 Profile based motion generation for actuators using LabVIEW software *IOP Conf. Series: Materials Science and Engineering*, **149,**012159