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Design and Implementation of a sitting Room Control and Monitoring System Using Arduino Micro Controller on Android Phone

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ABSTRACT : Home and office appliances like light and fan are controlled manually, which leads to power wastage. This is because they are left **on** even when not in use and even when the appliances are in use their operation is not controlled by environment conditions like temperature variations and daylight. By making a smart automated controlling system for appliances the study will save the power by some amount. This study provides solution for preventing the wastage of power in an adequate and cost effective way. The system switches the appliances in the room when there is someone there; regulates the intensity of lights in the room based on the amount of natural light (sunlight), the speed of fan and turns ON/OFF the air conditioner based on the temperature of the room. This system also allows the state of these appliances to be remotely monitored and controlled via the internet through an android phone application.
Keywords: [Appliances, Arduino Micro Controller, Sitting room, Android phone app]

I. INTRODUCTION

The technologies of today were not developed yesterday but over a period of time. The introduction of electricity into homes in the first quarter of the 20th century marked the beginning of change in homes (Harper, 2003). As noted by (Forty, 1986) the decline of domestic servants in the first half of the century can be directly linked to the introduction of electricity into homes.

The introduction of electricity in homes brought with it the electrically powered machines such as food-processors, sewing machines, fans, vacuum cleaners, radiators, cookers; some of which were hand-operated mechanical tools (sewing machines, food-processors, vacuum cleaners) (Joseph, 1999). It has been argued that the advent of electrically powered machines in homes can be said to be the beginning of automating and easing the burdens of domestic work (Joseph, 1999). The 1980s and 1990s saw the explosion of appliances in households. According to (Bowden et al, 1994) almost three quarters of households in England had color television in the early 1980s and video recorders in the late 1980s.

It can be deduced from the above paragraph that the explosion of electrical home appliances in the 1980s and 1990s lead to houses consuming more electricity; this therein lead to higher electricity bills.

Home automation has been a feature of science fiction movies for many years; it only became practical and a feature in privileged homes in the early 20th Century following the widespread introduction of electricity into the home, and the rapid advancement of information technology (Harper, 2003). Practical implementation of full blown home automation system started emerging in the 1990s even though home automation systems have existed before then; like the ECHO IV designed in 1966. The home automation technology might not be a necessity today but it helps to get daily task done easily; providing convenience to the elderly, disabled, children, and comfort to other users of this technology (Harper, 2003).

The need to stop wastage of power and the emergence of home automation technologies has led to various proposed solutions to power management in households one of which is "Energy Conservation in a Smart Home" (Al-Kuwari et al, 2011) this system and most other similar systems proposed a low cost system that reduced power wastage to a certain degree (18.7% according to (Al-Kuwari et al, 2011) but lack flexibility of use.

This project will attempt to design and implement a sitting room control and monitoring system to reduce power wastage in a typical household.

Waste has always been a major problem of the typical household. Lights turned on, running fans, television sets switched on, and other plugged appliances plugged in and left running and without anyone using them are common examples of how electrical power is wasted in typical households. The waste of electric power increases electricity bills and general cost of living for families. Also, when electrical/electronic appliances are left unattended to, there is always the question of safety as appliances left in this state (turned on but not used) have been known to cause fire outbreaks and damage of properties.

This work seeks to reduce the waste of electrical power in homes by designing a system that will control and monitor home appliances. 1.4 Significance of the problem

This work will reduce waste of electric power in homes; this will reduce the cost of power and cost of living for average households. In the long run, this home automation system will also reduce the carbon footprint of homes.

II. REVIEW OF SMART HOUSE DEVELOPMENT

The past decade has seen significant advancement in the field of consumer electronics. Various 'intelligent' appliances such as cellular phones, air conditioners, home security devices, home theatres, etc. are set to realize the concept of a smart home. They have given rise to a Personal Area Network (PAN) in home environment, where all these appliances can be interconnected and monitored using a single controller. Busy families and individuals with physical limitation represent an attractive market for home automation and networking. This system will also assist and provide support in order to fulfill the needs of elderly and disabled in home. A wireless home network that does not incur additional costs of wiring would be desirable.

Several works have been done in the field of Home automation and some of this works have been channeled towards not just automating particular home appliances but also towards linking separate home appliances together forming a system. The aim of this is to have a "Standard Smart Home", one that will serve as a reference point for home automation and also a complete system for control and monitoring of home appliances. Over the years a tangible amount of success has been achieved in this field and more is still anticipated as technology improves.

(Liang et al 2002) argued that because of the advanced development in computer technology, the microprocessors are not only on the desktop but also exist everywhere. It is obvious that microprocessors are embedded in electronic appliances (EAs) in our home today. In the past, the EAs are working stand-alone and cannot cooperate with one another. But in the recent years, these appliances can be monitored and controlled by embedded microprocessors and be displayed on terminals, but they are still in lack of integration. Since the present home automation (HA) system is not equipped with efficient integration mechanism, it cannot fully manifest the worth of these developments. In order to achieve this goal of integration, many appliance manufacturers focus on the development of intelligent (or information) appliances to be integrated into a complete HA system for monitoring and controlling. Due to the advent of advanced computer and wide-band network, the personal computer-based environment seems to be a very suitable platform for system integration. The personal computers can be linked by the network and are capable of powerful computation and easy display. We can take advantage of such abilities to develop an integration system.

2.1 Smart home security

Smart Home can be also known as Automated Home or intelligent home which indicates the automation of daily tasks with electrical appliances used in homes. This could be the control of lights, fans, viewing of the house interiors for surveillance purposes or giving the alarm alteration or indication in case of gas leakage.

Home security has changed a lot from the last century and will be changing in coming years. Security is an important aspect or feature in the smart home applications. The new and emerging concept of smart homes offers a comfortable, convenient, and safe environment for occupants. Conventional security systems keep homeowners, and their property, safe from intruders by giving the indication in terms of alarm. However, a smart home security system offers many more benefits.

Focusing on the security of the home when the owner is not around; two systems were proposed, one was based on GSM technology and other used web camera to detect the intruder.

The first security system uses a web camera, installed in house premises, which is operated by software installed on the PC and it uses Internet for communication. The camera detects motion of any intruder in front of the camera dimensions or camera range. The software communicates to the intended user via Internet network and at the same time it gives sound alert.

The second security system is SMS based and uses GSM technology to send the SMS to the owner. The proposed system was aimed at the security of Home against Intruders and Fire.

In any of the above cases happens while the owners are out of their home then the device sends SMS to the emergency number which is provided to the system. The system was made up of five components: sensors, GSM-GPS Module (sim548c), Atmega644p microcontroller, relays to control the device and buzzers to give security alert signal in terms of sound.

The major downside of this work was the fact that the system depends a lot on networks to perform most of its functions. Considering the risks involved in the transmission of data over a network and that the focus of the system is security makes the system not as efficient as required for this technology. Home security over a network might increase risk and not improve security.

2.2 Smart home-control and monitoring.

The Internet of Things (IoTs) can be described as connecting everyday objects like smart-phones, Internet TVs, sensors and actuators to the Internet where the devices are intelligently linked together enabling new forms of communication between things and people, and between things themselves (Kortuem et al, 2010). Now anyone, from anytime and anywhere can have connectivity for anything and it is expected that these connections will extend and create an entirely advanced dynamic network of IoTs. IoTs technology can also be applied to create a new concept and wide development space for smart homes to provide intelligence, comfort and to improve the quality of life.

This project present a low cost and flexible home control and monitoring system using an embedded micro-web server, with IP connectivity for accessing and controlling devices and appliances remotely using Android based Smart phone app. The proposed system does not require a dedicated server PC with respect to similar systems and offers a novel communication protocol to monitor and control the home environment with more than just the switching functionality. It utilized Restful based Web services as an interoperable application layer that can be directly integrated into other application domains like e-health care services, utility, distribution, or even vehicular area networks (VAN).

Home automation or smart homes (also known as domotic) can be described as introduction of technology within the home environment to provide convenience, comfort, security and energy efficiency to its occupants (Piyare et al, 2013)

Lately few researchers have also presented use of Web services, simple object access protocol (SOAP) and representational state transfer (REST) as an interoperable application layer to remotely access home automation systems.

(Ling- Shiang, 2007) presented architecture for home automation where the system is based on a dedicated network. This system depicted how to solve home automation problems at the software level and no hardware aspects were included. (Yavuz et al, 2002) presented a telephone and PICbased remote control system. Other studies such as those presented in (Sriskanthan et al, 2002) give examples of web based home automation system. Another PC based home automation system for appliances control was proposed by (Sriskanthan, 2002). However, the system cannot be controlled by a mobile/cell phone. (Piyare, 2011) proposed a Bluetooth based home automation system using cell phone. Due to the advancement of wireless technology, there are several different connections are introduced such as GSM, WIFI, ZIGBEE, and Bluetooth

2.3 Implementing smart homes with open source solutions

A Smart home provides living environment with comfortable, convenient, energy saving, safety place for people to live in. From technology viewpoint, its core is information system with physical manipulation capability which is referred as cyber physical system. Most of such systems available currently are proprietary products which put end users at risk of some issues such as long term support, system compatibility and cost. To address such issues, an approach with emerging open source solutions was discussed. The core of the proposed open source system is Arduino platform. A module for performing functions to implement smart homes also proposed in this paper. It is a typical cyber physical system and consists of input, output and energy monitoring functions.

People enjoy comfortable, convenient, energy saving, safety and health care life in smart homes. To provide such residential place some automatic interactions with the parameters in that environment should be performed. Having temperature, humidity and/or brightness information and conducting start or stop operation on some lamps or switches are examples. The above mentioned operations can be performed with various ways, such as manual, electronic or computerized. Computerized approach is superior to other ones.

A computerized system can perform interactions with objects in the physical world, this is called cyber physical systems (CPS) which are integrations of computation and physical processes (Lee, 2008). No matter what approach is used to constructing smart homes; the key point is human – centric that is serving human being. Therefore, a smart home is an application of human-centric sensing because some sensors are deployed in. The human-centric sensing can be classified into one of following category in terms of the extent and human participation: 1) human as target of sensing, 2) human as sensor operators, 3) human as data sources (Srivastava et al, 2013).

They noted that to implement a smart home some issues should be taken into consideration. The life expectancy of a house is at least several decades, or even centuries, in contrast life expectancy of CPS is much shorter. The future maintenance and development of the CPS is the first issue. If cost is not the problem, most people prefer to live in a smart home. The major cost of constructing a smart home is CPS systems. If a smart home can be built with less expensive CPS systems, more people can afford to have it. Therefore cost is another issue. Cloud computing offers users many kind of services. Integrating with cloud computing is third issue. Open source solution is one of feasible approaches to address these issues. An approach to build smart homes with emerging open source solutions was proposed in this paper. The core of the proposed open source system is Arduino platform.

Open source is a concept that the detailed information of a product, such as software and hardware, is disclosed to the public under certain conditions. To help students develop interactive projects with lower cost, staff of a university in Italy developed a system called Arduino which is based on Atmel AVR micro controller. Arduino is not a standalone device but a platform which includes Arduino board and IDE development environment. In addition, Arduino itself was not a brand new design but based and derived from various early systems. Following the same trend, a number of systems exist are also from Arduino. Arduino board itself is open source hardware. The hardware information is open to public with open source license. These sources include Bill of Material (BOM), schematics, layout, device drivers, and application program interface (API), and development platform.

2.4 Power saving system for home automation

For the next decades, the two major problems concerning energy are the greenhouse effect and the depletion of petrol resources especially the energy provided by oil and gas. Therefore, by conscience or by necessity, the resort to renewable resources of energy such as wind or solar radiations arrives in the buildings knowing that the building represents 47% of the energy consumption and it is responsible for 25% of the greenhouse effect (Fontaine, 2003). Moreover, undoubtedly, the user will be confronted by variable tariffs of energy according to the hour and the days and to the energy producers. It is in this varied and dynamic context of production and consumption of energy that a building, equipped with a Home Automation system to control the energy, takes its importance.

The role of a Home Automation system dedicated to power management is to adapt the power consumption to the available power resources taking into account user comfort criteria: it permits to limit the use of supplementary resources which require additional investment and to avoid the expensive need of storage. A Home Automation system has to reach a compromise between the priorities of the user in term of comfort and in term of cost while satisfying technological constraints of equipment and user's comfort constraints.

Power saving system using home automation involves the use of home automation technology such aszigbee to save power by making electrical/electronic appliances to respond to environmental variables such as temperature or light intensity to determine whether they will go on or off. Some work presented in the field include "ARM Based Smart Power Saving System For Home Automation" (Madhu et al, 2014) where they presented a very low cost power saving system with a door lock. The system saves power by powering up appliances only when one has gained access to the house through the finger print door lock. The strength of this system is that it not only saves power to the system but also gives it added security. The system's weakness is the inflexibility of the system. The does not allow the user to independently control his appliances when he feels like it. Tejani et al, 2011) presented a comparison of power consumption in different parts to the home with smart control and without smart control; they noted that a house with smart control system does consume less power than a system without smart home control.

2.5 Components

ARDUINO: Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

ARDUINO UNO: The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

Technical Specifications :Microcontroller: ATmega328
Operating Voltage: 5V
Supply Voltage (recommended): 7-12V
Maximum supply voltage (not recommended): 20V
Digital I/O Pins: 14 (of which 6 provide PWM output)
Analog Input Pins: 6
DC Current per I/O Pin: 40 mA
DC Current for 3.3V Pin: 50 mA
Flash Memory: 32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM: 2 KB (ATmega328)
EEPROM: 1 KB (ATmega328)
Clock Speed: 16 MHz

Programming: The Uno can be programmed with the Arduino Software (IDE). The ATmega328 on the Uno comes preprogrammed with a boot-loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

You can also bypass the boot-loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar.

ANDROID: Android is a Linux-based, open-source operating system designed for use on cell phones, e-readers, tablet PCs, and other mobile devices. For users of smart phones, Android provides easy access to social networking sites like Facebook, Twitter, and YouTube and smooth integration with Google products like Gmail, Google Maps, and Google Calendar. Android has been adopted by a number of manufacturers, including Motorola, Samsung, HTC, and Sony Ericsson. The expanding assortment of applications available on this platform suggests that Android-based phones will continue to be strong competitors in the smart-phone market. As a mobile platform, Android has grown in popularity among hardware manufacturers and the general public alike in recent years. Its open market model allows registered software developers to create applications for Android mobile devices in Java and list them in Android Market without undergoing review and waiting for approval. Users can download from a growing store of smart-phone applications at Google Market, many of which connect with existing Google services. They can also download compatible Android apps from other locations. Flexible and adaptable, Android's facility in supporting screen-based interfaces has also made it the OS of choice for many industrial and consumer electronics, including navigation devices, set-top boxes, kiosks, medical equipment, netbooks, tablets, and e-readers.

Android OS is the open source technology stack that runs on over 400 million devices worldwide. This technology stack consists of various components that allow developers and device manufacturers to work independently. This can be broken into five primary pieces—applications, application frameworks, native librar Applications: The applications exist at the highest level. These are the tools that everyone who uses Android is most familiar with. Android comes with various robust applications that support everyday phone needs, such as messaging, e-mail, Internet browsing, and various third-party applications. These applications are primarily written in the Java programming language.

Application Frameworks: Android provides developers the ability and tools to create extensive, interactive, rich graphical applications to users, and is targeted to deploy these applications to the Google Play Store. Developers have access to the same APIs that are used inside of core applications, as well as access to almost all existing Java libraries.

Native Libraries: The next level is where the road diverges. The native libraries and the Android runtime exist in roughly the same space. The native libraries are compiled and preinstalled C/C++ binaries that the Android system depends on. These include all of the libraries in the green section of Figure 2.1. The following sections contain descriptions of some of the more prominent native libraries and their functions inside of Android.

Surface Manager: This is often referred to as Android’s Window Manager. Surface Manager is used for composing what any individual screen will look like. It also does some more subtle things that help Android run smoothly, such as off-screen buffering and transitions.

SQLite: This is a database used to store and share information across sessions of an Android device. On Android, the SQLite database is stored inside of the device’s internal memory so SD cards can be interchanged without losing device-specific information.

WebKit: WebKit allows for HTML to be rendered and displayed to Android very quickly and efficiently. This is the default browser engine in the Android system and is available to system and third-party applications.

OpenGL/ES: The OpenGL engine processes graphics in Android. OpenGL can render both 2D and 3D objects on Android. This also supports hardware acceleration on devices with dedicated graphic chips.

Android Runtime: Inside of the Android runtime are two primary components: the core Java libraries that Android provides, and the Dalvik virtual machine. The Dalvik virtual machine is Google’s implementation of Java that is optimized to be used on mobile devices.

Linux Kernel: The last of the layers is the Linux kernel. Android was initially based on the Linux 2.6 kernel, with some optimizations for mobile use. Current versions of Android are based on the Linux 3.1 kernel. The Linux kernel provides access as close to the hardware as possible. As a result, drivers are written in the kernel space to operate as fast and as possible. These include things like controlling the internal radios, turning on the stereo and camera, dealing with power and battery charging, and operating the physical keyboard or buttons on the device. The Linux kernel, like Android, is an open source project and is used widely, particularly on servers in enterprise environments.

III. METHODOLOGY

The approach that was applied to this problem will be shown with a block diagram as shown in the diagram below this system is made up of several subsystems put together.

The first step in building this is to design and simulate the circuits required; the circuits will be designed using eagle cad and simulations using proteus vsm. After all the circuits have been designed and tested, they will then be implemented to achieve the various subsystems. Communication between the arduino and android device is another major aspect of system; this is achieved by ensuring that both devices are all connected to the PUBNUB network to ensure communication which will give room for control and monitoring.

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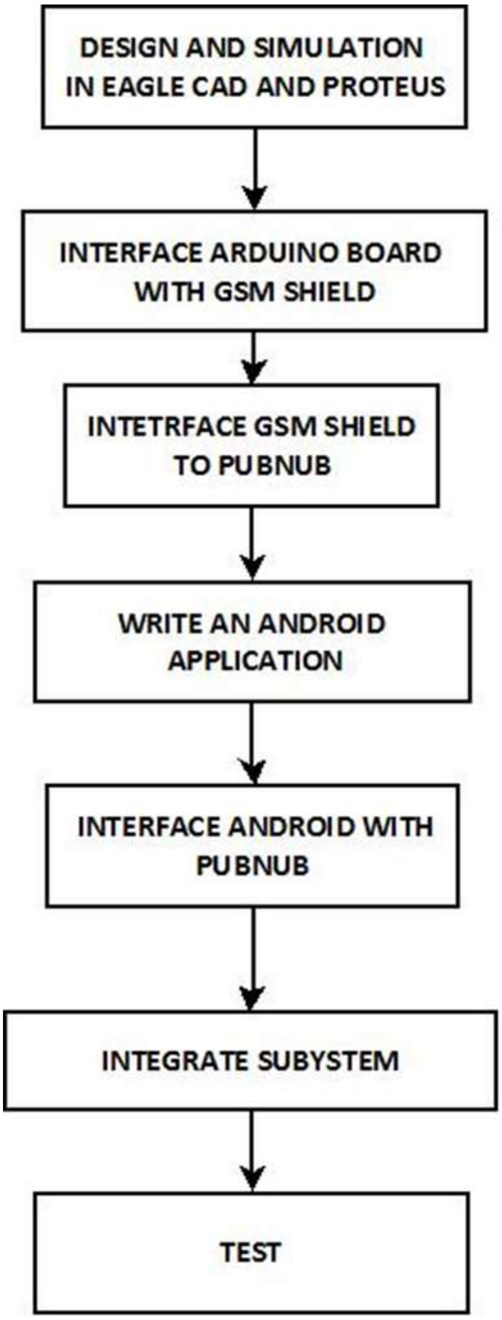

3.2: Methodology Block Diagram

A modular approach was used in designing the system. This approach was used to simplify the system design process. The project was carried out in three phases;
Phases one Circuit Schematic Design followed by phases two which is circuit simulation, breadboard implementation and testing the third phase is Vero board implementation

3.3 Project Description
The system operates in two modes: Automatic Mode and Manual Mode

3.4 Automatic Mode
When the system is powered up, all sensors are initialized and there output values read by the arduino development board. The system waits for motion to be recorded by the motion sensor. Once it is recorded that there is someone in the room all room appliances (heater, fan, lights

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and A.C) are switched ON or OFF based on the values read in by the microcontroller platform.

The room heater is switched ON when the room temperature read from the temperature sensor is below 18oC and switched OFF if the read value is above 18oC. The fan and air conditioner are also turned ON or OFF at particular set room temperatures.

The lights have their brightness adjusted according to the amount of light that falls on the LDRs. If the room is dark, the lights in the room become very bright and if the room is bright, the lights in the room become dim or are switched OFF completely.

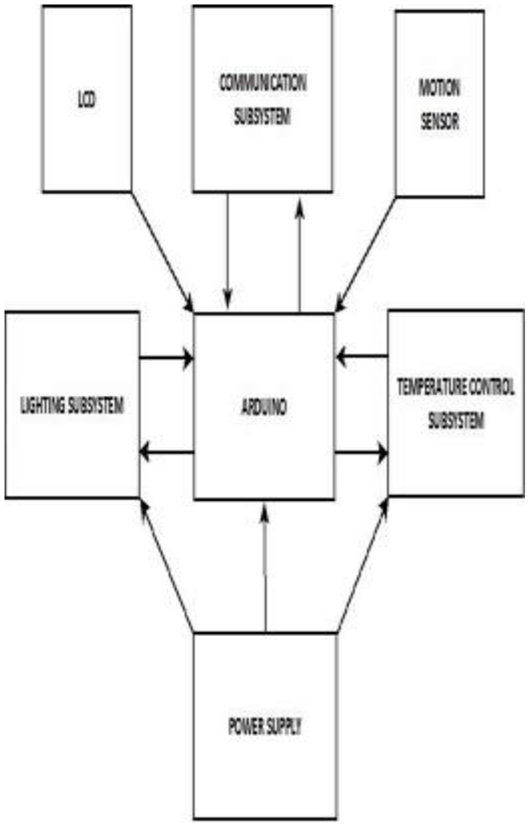
Switching ON or OFF an appliance in this mode does not require any human intervention at all as long as the system is powered. Also, in this mode, everything is dependent on whether there is someone in the room or not in the room. If motion is not recorded by the motion sensor after a preset time (one hour in this case) all appliances are turned OFF but once motion is recorded again the system starts again.

3.5 Manual Mode

This mode allows a user to turn ON or OFF an appliance from an android device. This can be done from anywhere there is GPRS network.

As the system is powered ON, it starts in automatic mode but not before it connects to a GPRS network and a particular channel on pubnub. As soon as a user sends a command from the android application and the command is received, the system stops working in automatic mode and goes to manual mode and executes the command sent by the user. The board also sends an acknowledgement back to the user. This mode is entirely based on inputs from the user and not based on environment variables. This allows for complete control of the system by user at any time.

The system is also broken down into three subsystems; namely Lighting Subsystem, temperature Control Subsystem and Communication Subsystem



3.0: System Block Diagram (Subsystem Setup)

3.6 Design and simulation of lighting subsystem
3.7 Design Overview

This lighting subsystem will determine how bright or dim a room is depending on the amount of natural light (sunlight) going into a room. This subsystem will make sure that no unnecessary amount of electric power will be used to power the light bulbs in a room when there is sufficient natural light in the room. The amount of natural light reaching a room will be measured and relayed to a control unit; the control unit will generate an appropriate signal to power the light bulbs.

Two light dependent resistors (LDR) were used in measuring the amount of natural light going into a room; the measured values (LDR analog value range from 0 – 1023) are then relayed to a microcontroller where the average of the values is calculated. The microcontroller sends out a signal value (microcontroller signal range from 0 - 255). The signal that is sent out by the microcontroller by using a technique called pulse width modulation (PWM).

Pulse width modulation is a technique for getting analog results with digital means. Digital control is used to create a square wave, a signal switched between ON and OFF (Arduino, 2016).

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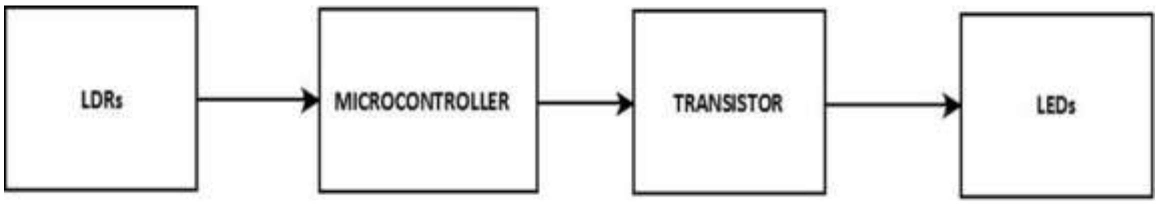


3.1: Block Diagram of Lighting Subsystem

The subsystem is made up of: Light Dependent Resistor (LDR), Microcontroller, Transistor and Light Emitting Diode (LED)

Light Dependent Resistor: Light dependent resistors also known as photo-resistors are light controlled variable resistors. In terms of operation, a light dependent resistor is usually very resistive (in the megaohms) when placed in the dark. However, when it is illuminated, its resistance decreases significantly; it may drop as low as a few hundred ohms, depending on the light intensity (Scherz et al, 2013). The LDR was used to develop this subsystem because of its availability and low cost even though it has the drawback of been slow to respond to changes in light intensity.

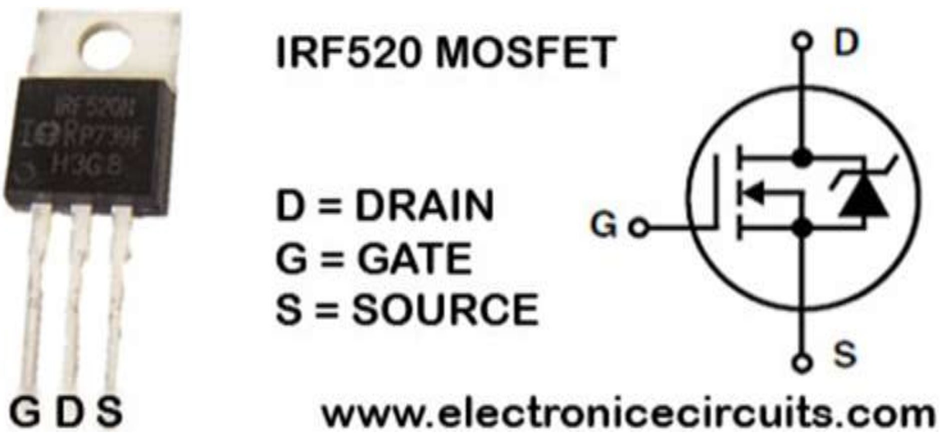
3.2(a): Schematic Symbol of A LDR

3.2(a): Schematic Symbol of A LDR

Microcontroller: The arduino development board was used as the microcontroller platform for the design. (See page 13 for more details).

Transistor: A MOSFET (Metal Oxide Semiconductor Field Effect Transistor) operates in such a way that when a small voltage is applied at its gate lead, the current flow through its drain-source channel will be altered Scherz et al, (2013).

An N-Channel enhancement MOSFET (IRF 520) was the transistor of choice because of its low on state resistance, larger current handling, draw very little gate current and very low threshold voltage for the IRF 520 (Scherz et al, 2013).



3.3: IRF 520 MOSFET

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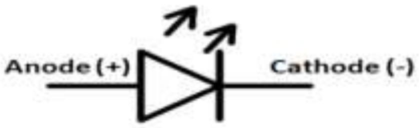
Light Emitting Diode: Light-emitting diodes (LEDs) are two-lead devices that are similar to pn-junction diodes, except that they are designed to emit visible or infrared light. When LED's anode lead is made more positive in voltage than its cathode lead (by at least 0.6 to 2.2 V), current flows through the device and light is emitted. However, if the polarities are reversed (anode is made more negative than the cathode), the LED will not conduct, and hence it will not emit light (Scherz et al, 2013).

Owing to the fact that there are many electric lighting or lighting devices (incandescent light bulbs, LED lamps, gas discharge lamps (fluorescent lamps, compact fluorescent lamps)), only two were looked at (LED lamps and compact fluorescent)closely for the choice of serving as a light source for the subsystem due to their power saving capabilities and cost efficiency.

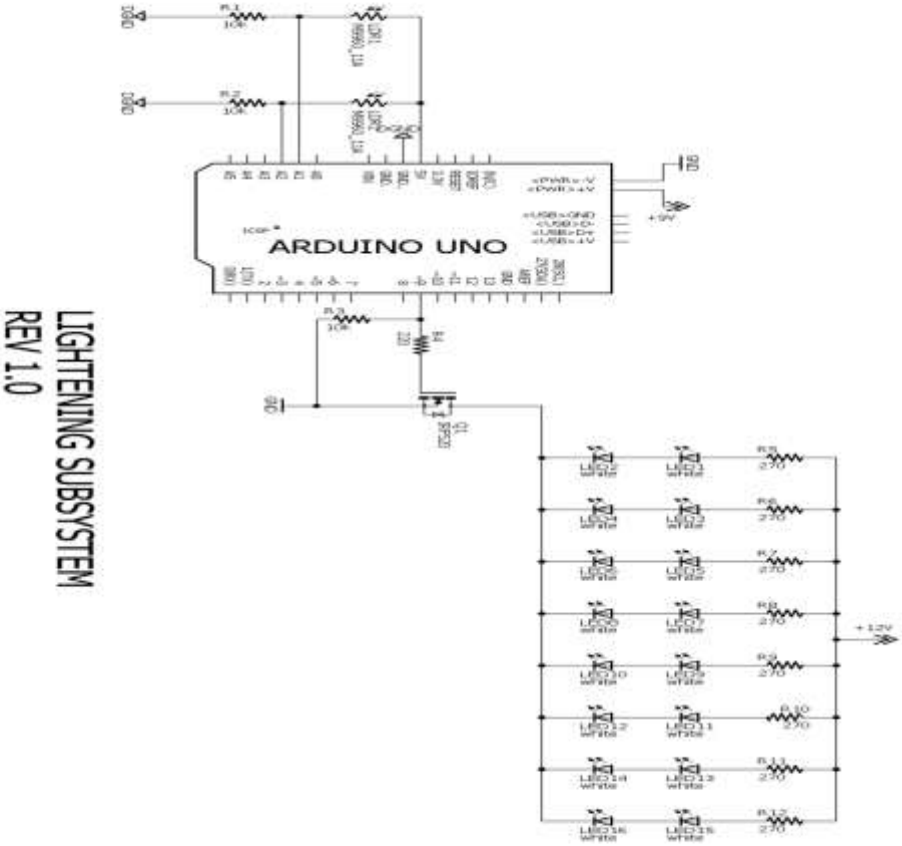
The LED became the component of choice at the end due to the fact that they are more durable, long lasting, mercury free, cost effective and their intensity can be easily controlled using pulse width modulation (Haitz et al, 2002)



(a): Schematic Symbol of A LED FIGURE 3.4(b): A LED

3.8 Subsystem Power Supply

The subsystem is powered from a 12V, 2A direct current (D.C) voltage adapter with 12V directly supplied to the LEDs while the arduino is supplied with a stepped down voltage of 9V. The LDRs are powered directly from the arduino board by a 5V supply line.



3.5: Schematic Diagram of Lighting Subsystem with Eagle CadSoft

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The LDRs are connected to the analogue pins A1 and A2 of the arduino. The LDRs are connected in series with a 10k resistor and then to ground to form a light sensitive voltage where inputs to A1 and A2 is given by

$$\frac{R_1}{R_1 + R_2} \times Vin$$

Where R_1 = 10k, = LDR resistance and = 5V

As the intensity of light increases, the resistance of the LDR decreases and A1, A2 increases. The transistor's (IRF 520) gate lead is connected to pin 9 of the arduino board. The arduino sends out a PWM signal which turns the transistor ON and OFF at a frequency of Hz. The gate of the transistor is connected in series with a 220 ohms resistor to limit the amount of current sourced from the arduino pin to about 23mA; also the arduino pin is pulled to ground with a 10k resistor to reduce the action of the MOSFET as a capacitor during the change of state of the pin from OFF to ON and make the MOSFET stay OFF when the arduino is starting up. The source pin of the MOSFET is connected to ground and its drain pin is connected to the LEDs.

The LEDs are connected in a series parallel arrangement to get a moderate current stability. A resistor limits the current flow in a circuit. The series resistor to the LEDs is given by

$$Rs = \frac{Vin - (V_{D1} + V_{D2})}{I_{,D\max}}$$

$$V_{D1} = V_{D2} = V_D$$

$$V_{D1} + V_{D2} = V_D + V_D = 2V_D$$

$$V_D = 3.6, I_D = 20mA, Vin = 12V$$

$$Rs = \frac{12 - (2 \times 3.6)}{20 \times 10^{-3}}$$

$$= \frac{12 - 7.2}{0.02}$$

$$Rs = 240\Omega$$

Where = Series resistor value.

Using standard design principles a 270Ω resistor is used as a current limiting resistor for the LEDs during implementation.

3.9 Subsystem Simulation

A simulation of the subsystem was carried out in proteus design suite with code written in the arduino IDE (Integrated Development Environment) to check the functionality of the subsystem and rectify any errors. No errors were found at the time of simulation as the subsystem behaved as it was supposed to.

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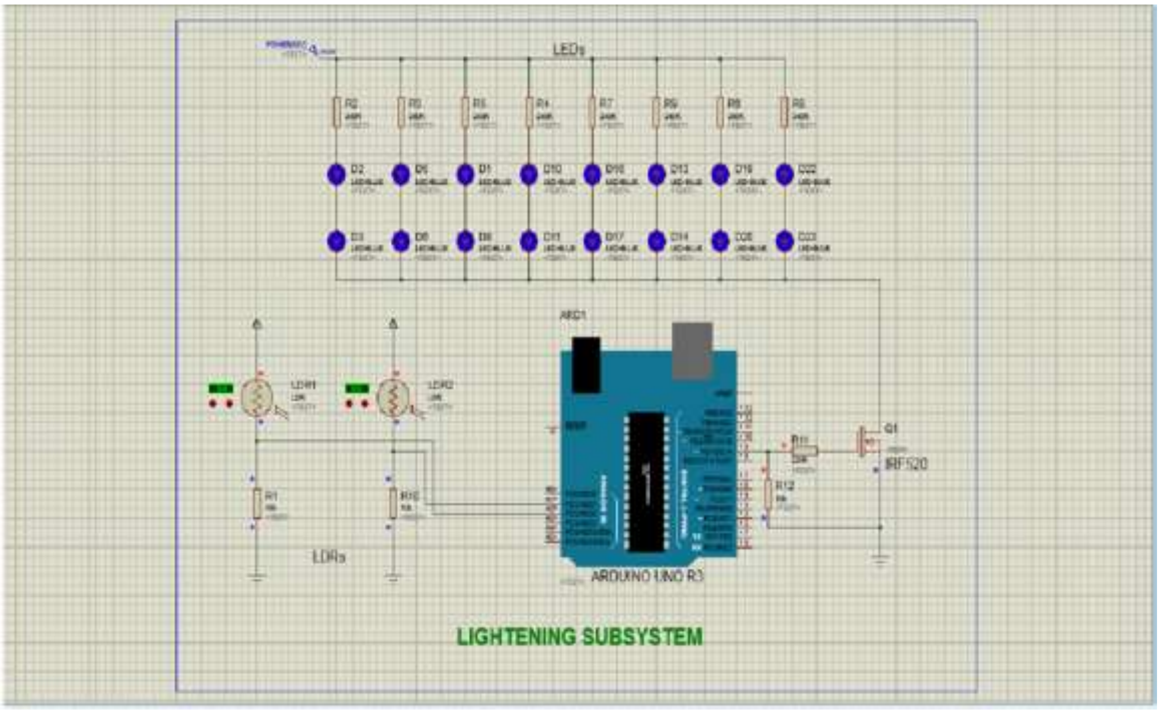

3.6: Simulation in Proteus Design Suite

3.9.1Design and simulation of temperature control subsystem

3.9.2Design Overview

The temperature of a room will determine the behavior of a fan, air-condition and heater i.e. the temperature of a room will determine when these appliances come ON or go OFF. This subsystem will also help in reducing power consumption in a household by switching OFF appliances that are not needed at certain temperatures (e.g. air-condition is turned off when room temperature is 5oC) and switch them ON when needed.

The temperature of the room will be read into a control unit; the control unit will switch ON or OFF an appliance(s) depending on the temperature read. A temperature sensor (TMP36) is used to measure the room temperature (value range from 0 - 1023), the temperature value is feed into a microcontroller which then converts the value into temperature in degree centigrade. The microcontroller then sends out an appropriate signal based on the value of the temperature to either switch ON or OFF an appliance. Also, the speed of the fan will be controlled via pulse width modulation.

The appliances to be controlled are represented in this work by an LED for air-condition, incandescent light bulb for the heater and a PC fan for a regular room fan. The heater will be turned ON when the room temperature is below 18oC otherwise it stays OFF. The fan is turned ON with a duty cycle of 50% when the room temperature is 27oC or less than 30oC; at a temperature of 30oC or less than 33oC the duty cycle is of the fan is increased to 75% while at of 33oC or more the fan’s duty cycle is increased to 100% and also the air-condition is turned ON at this temperature (> 33oC). When the room temperature is between 21o C and 27oC all appliances are switched OFF.

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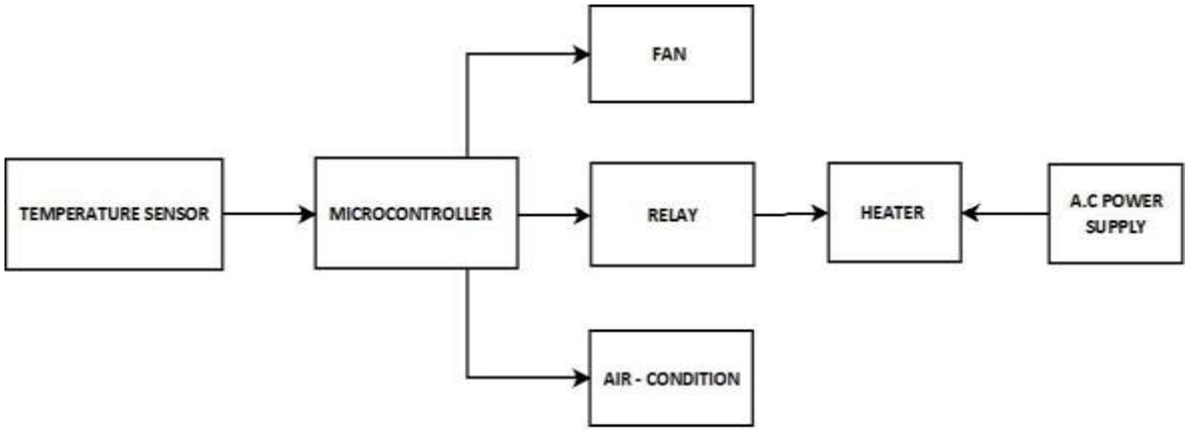

3.7: Block Diagram of Temperature Control Subsystem

The subsystem is made up of: Temperature Sensor (TMP36), Subminiature Relay, Air-Condition (LED), Fan (4 wire PC fan) and Heater (Incandescent light bulb)

Temperature Sensor: A sensor is a device that measures a physical property such as temperature or weight and converts such measurements into electrical signals Scherz and Monk, (2013).

The TMP36 is a 3-pin analogue temperature sensor which has an output voltage of 10mV/oC that is linearly proportional to the Celsius temperature. The sensor does not require any external calibration and is accurate up to ±2oC for a temperature range of -40oC to +125oC (Analog Devices, 2010). The TMP36 was used because it is very easy to configure with a microcontroller. The temperature in oC is calculated from the output of the sensor using the formula

ToC = (100Vout) – 50 where the constant 50 is specified in the TMP36 datasheet.

3.8: TMP36

Subminiature Relay: A 12V, 10mA d.c actuated relay is connected to the bulb. A relay is an electrically controlled switch. There three basics types of relays, there are; mechanical relays, reed relays and solid-state relays. A subminiature mechanical relay is used to connect with the bulb. This particular relay was used because it can isolate the two kinds of voltages used in the system (A.C and D.C).

Microcontroller: The arduino development board was used as the microcontroller platform for the design. (See page 13 for more details on microcontroller). The microcontroller computes the temperature value in Celsius using the formula ToC = (100Vout) – 50 but because we have a 10bit ADC using a 5V reference voltage we have

Air-Condition: A light emitting diode (LED) was used to represent air-condition in this work. See page 27 for more information on LED.

Fan: A 12V direct current (D.C) fan is used to represent a regular room fan in this project. A 4 wire PC fan is used because its speed can be controlled via pulse width pulse width modulation.

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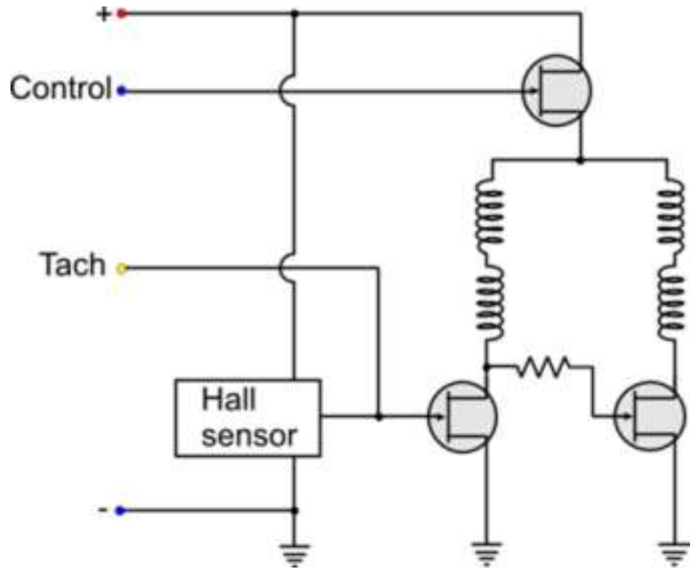

3.9: Schematic of a Four Wire PC Fan

3.9.1: Four Wire PC Fan

Heater: A 240V, 60W incandescent lamp light bulb was used as a heater in this system. An incandescent light bulb lights up when current passes through a tungsten wire filament that is placed inside an evacuated glass bulb filled with an inert gas e.g. argon Scherz and Monk, (2013). This process of generates a lot of heat as current passes through the filament; this heat generation by the incandescent light bulb is the reason why it is used in this work as a heater.

3.10 Subsystem Power Supply

The subsystem is powered from a 12V, 2A direct current (D.C) voltage adapter with 12V directly supplied to the fan while the arduino is supplied with a stepped down voltage of 9V (. The temperature sensor and air-condition (LED) are powered directly from the arduino board bya 5V supply line. The heater (incandescent light bulb) is powered by a 240V alternating current (A.C) power supply line.

3.11:Schematic Diagram of Temperature Subsystem with Eagle CadSoft

The temperature sensor (TMP36) connects to the arduino via analogue pin A0. A 0.1µF ceramic is connected in parallel to the sensor to filter out noise getting to the sensor. The air-condition (LED) connects to the arduino via digital pin 12. A 150Ω resistor is connected to the LED to limit the amount of current reaching it.

Where Vin = 5V, VLED = 2.1V, ILED = 20mA and Where = Series resistor value. Using standard resistor values Rs = 150Ω.

The fans pulse width modulation control pin is connected to digital pin 10 of the arduino. A diode is connected is in series with a resistor to stem the flow of any reverse current from the fan and also limit the current sourced from the arduino pin to about 20mA.

The heater (incandescent light bulb) is connected to arduino through a relay and transistor to pin 5 of the arduino. The connection to the transistor can be seen in the lighting subsystem. A diode is connected between the power source and transistor to prevent current surges from reaching the transistor or arduino when switching the relay ON or OFF.

3.12 Subsystem Simulation

A simulation of the subsystem was carried out in proteus design suite with code written in the arduino IDE (Integrated Development Environment) to check the functionality of the subsystem and rectify any errors. No errors were found at the time of simulation as the subsystem behaved as it was supposed to. Components other than the ones specified in the design schematic were used in the simulation. LM50 was used as a temperature sensor in simulation because it has characteristics that are similar to the TMP36 and a two wire fan was used instead of a four fan. These substitutions were done because proteus design suite did not the required components in its library.

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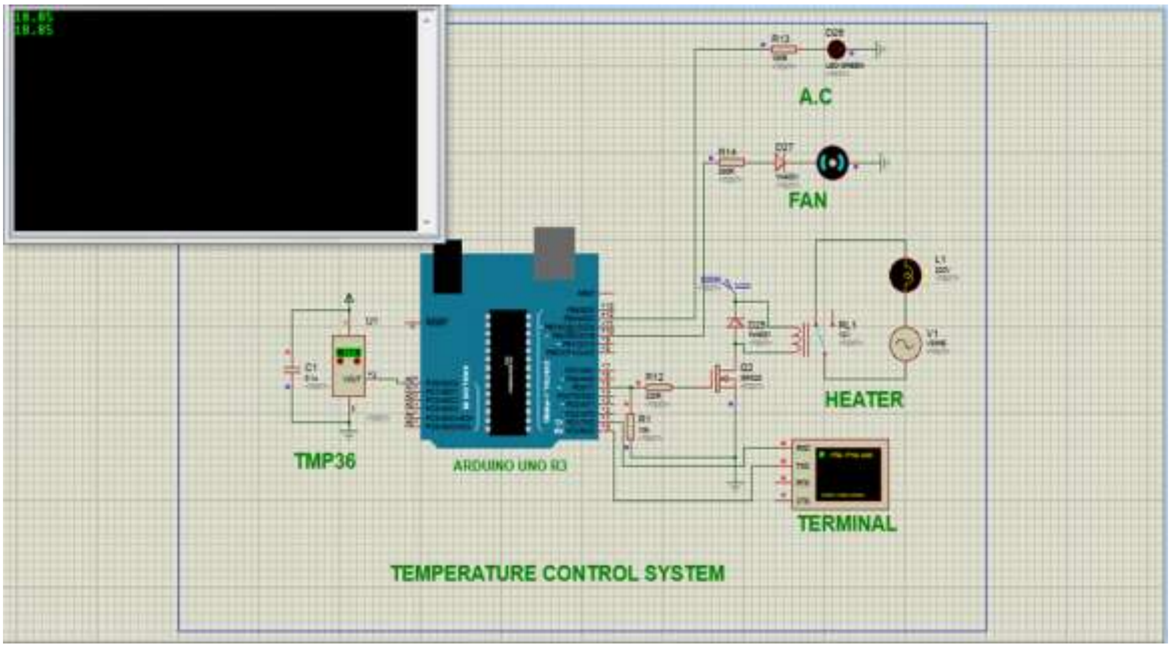
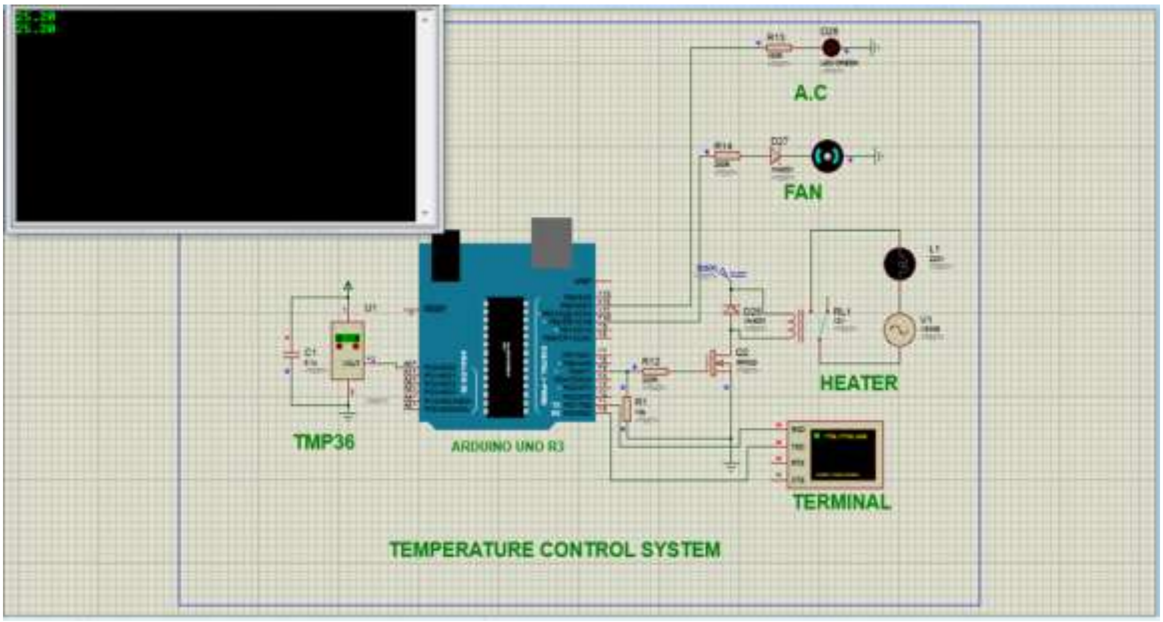
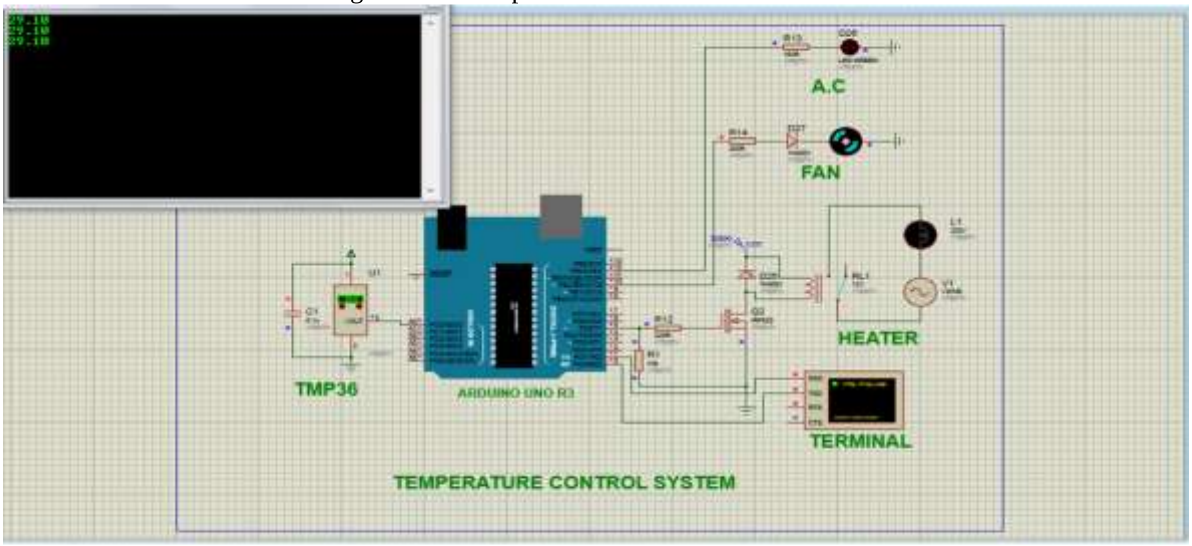


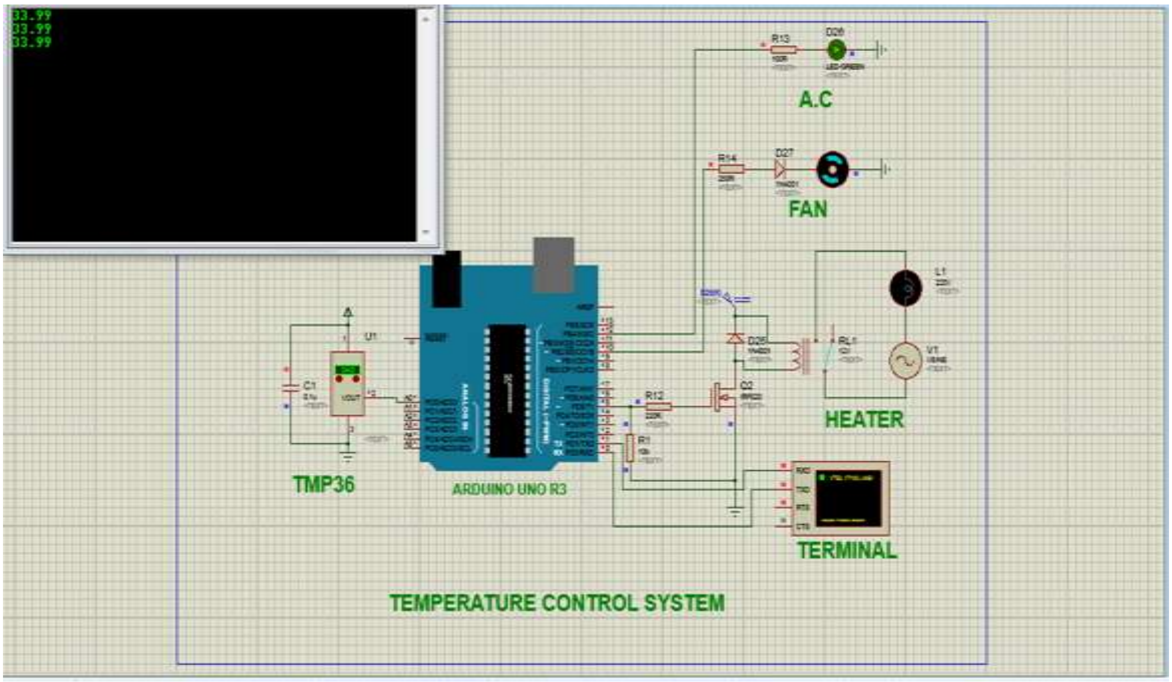
3.13: Simulation in Proteus Design Suite At temperature = 19oC



3.14: Simulation in Proteus Design SuiteAt temperature = 29oC



3.15: Simulation in Proteus Design Suite At temperature = 30oC



3.16: Simulation in Proteus Design Suite At temperature = 34oC

3.16.1 Design overview

One of the key components of this work is the communication subsystem. It enables a user to control lighting and temperature subsystem from an android device.

A command to turn ON or OFF a device is sent from an android device to the arduino development board over the internet using GPRS (General Packet Radio Service). This command first goes from the android device to an internet data stream network (PubNub), the arduino GSM(Global System for Mobile Communication) shield then picks up the command from PubNub and then sends it to arduino development board which then executes the command. The command sent and executed is either to turn ON or OFF a device.

After executing the command, the arduino development board sends a response to the android device via the GSM shield over the internet. The

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response reaches PubNub from where the android device picks up the response command, notifying the user that the command sent has been executed.

3.17:Block Diagram of Communication Subsystem

The subsystem is made up of: Arduino GSM Shield, Microcontroller, PUBNUBand Android Device / Application

3.18Gsm shield

The arduino GSM shield connects the arduino development board to the internet using the GPRS network. It also allows the making / receiving of calls and also sending/ receiving sms. The shield enables communication between an android device and the arduino board.

The arduino GSM shield was chosen as a communication medium in this work because it very easy to use and has a very large library which makes it easy to program.

3.18.1 Pubnub

PUBNUB is a global Data Stream Network (DSN) and realtime infrastructure-as-a-service (IaaS) company based in San Francisco, California. The company makes products for software and hardware developers to build real time web, mobile, and Internet of Things (IoT) applications. PUBNUB's primary product is a real time publish/subscribe messaging API built on their global data stream network which is made up of a replicated network of at least 14 data centers located in North America, South America, Europe, and Asia. The network currently serves over 300 million devices and streams more than 750 billion messages per month. PUBNUB utilizes a Publish/Subscribe model for real time data streaming and device signaling and supports all of the capabilities of WebSockets, Socket.IO, SignalR, WebRTC Data Channel and other streaming protocols. PUBNUB provides SDKs for over 70 different programming languages and environments including JavaScript, iOS, and Android, as well as JavaScript frameworks such as AngularJS, Ember js, and Backbone.js. PUBNUB also provides client libraries for board platforms including Raspberry Pi, Arduino, Texas Instruments, and Microchip.

In this work PUBNUB serves as an interface between the arduino and the android phone. The platform is used to create a reserve known as a channel where both devices can send and receive commands to and from each other. Given that the devices cannot communicate with each other directly, communication is achieved via PUBNUB since both devices can communicate directly with it. Commands are sent to and from each of the devices via PUBNUB and as such an android phone is used to control appliance through the arduino via the internet.

3.19 Android Device

The android application is used to control the appliances and monitor the state of each appliance as its state changes. The application receives data via the PUBNUB network as sent from the arduino GSM shield. An application is written to receive and respond to certain commands and also to send commands to the arduino via the PUBNUB network and GSM shield. The application is used to remotely switch the appliances on/off. The application can be installed on any android device either phone or tablet and when properly configured, it can be used to switch the appliances on/off.

Android was chosen as the preferred platform because of its open source nature making it widely available and cost effective. The application was written using the android software development kit (SDK) and java programming language based on the android API. It uses the android internet access feature in the android API to receive and send data to and from the arduino via the PUBNUB network. The application was designed to serve as a handy means of controlling electric appliances.

3.20 Liquid Crystal Display (lcd)

A 16x2 LCD is used as a display for this work. LCDs are low power display device that mostly use external light source (others use backlights) to display characters. LCDs come in various sizes and are a cheap way of displaying an array of characters. Even though LCDs have very slow switching speeds they are a cheap alternative to other displays e.g. organic LEDs Horowitz and (Hill, 2015).

The LCD used is a 16-pin LCD with backlights. It has three power lines (VSS, VDD and VEE) where VSS (pin 1)and VDD (pin 2)are negative and positive power supply while VEE (pin 3) is used to control display contrast usually with a potentiometer. There are also three control lines (RS, R/W and E) where RS (pin 4) is register select, RW (pin 5) is read/write and E (pin 6) is the enable pin. D0 – D7 (pin 7 - 14) are data bus lines. Data can be transferred to and from the display either as a single 8-bit byte or a two 4-bit nibble. A two 4-bit nibble transfer (D4 – D7) is used in this work. The last two pins are used for the backlight Scherz and Monk(201

3.21 Motion sensor

The motion sensor used in this work is a 3-pin passive infrared sensor (PIR sensor). The PIR is made up of a pyro-electric sensor and some supporting circuitry. The ability of a material to generate a temporary voltage when there is a change in temperature in its environment is known as pyro-electricity; this means that the PIR can detect infrared radiation. The PIR was used because it is very easy to interface with a microcontroller, cheap and has a digital output (Fried, 2014).

3.21.1 System power supply

There are two types of currents used in the system. A direct current (D.C) power supply and an alternating current (A.C) supply. A direct current is one that flows in only one direction. An alternating current is one that changes its direction of flow with time.

A 12V, 2A D.C adapter is used to power most components of the system. The arduinouno development board is powered by 9V which is gotten from the 12V supply. The 12V supply is stepped down to 9V using the LM7809 voltage regulator. The LM7809 is a three terminal fixed voltage regulator that can output currents of up to 1A (Scherz , 2013).

12V D.C is supplied to the lightening subsystem to power the LEDs. The LDRs are powered by the 5V pin of the arduinouno development board. The arduino pin powers the transistor for the heating subsystem.

The temperature control subsystem is powered via two different power supplies; D.C and A.C supply. 12V D.C is used to power the fan and the relay. The LED representing the air condition is powered by the digital pin of the arduino. The incandescent light bulb rated 60W representing the heater is powered by the A.C supply. The incandescent light bulb draws around 0.42A. The temperature sensor is powered by the 5V pin of the arduino development board. The arduino pin powers the transistor for the heating subsystem.

3.21.2 System simulation

A simulation of the system was carried out in proteus design suite with code written in the arduino IDE (Integrated Development Environment) to check the functionality of the system and rectify any errors. No errors were found at the time of simulation as the subsystem behaved as it was supposed to. Components other than the ones specified in the design schematic were used in the simulation.

IV. TEST RESULT AND DISCUSSION

The work done was tested for functionality, correctness and reliability. Test was carried out on individual subsystems before being integrated into the main system. Test was also carried out on individual components that made up these subsystems. The tools used to carry out this test are: Breadboard, Digital Multimeter, Arduino Serial Monitor, Android Simulator, PUBNUB Debug Platform

4.1Lighting Subsystem Test and Result

Test was carried out on this system by implementing the subsystem schematic on a breadboard. The system worked well on the breadboard with current drawn by the system measured by the multimeter to be around 90mA after the system worked for 30 minutes. The arduino serial monitor was used as a debugging to here to display the light intensity falling on the LDRs

4.2 temperature control subsystem test and result

Test was carried out on this system by implementing the subsystem schematic on a breadboard. The system worked well to a certain extent on the breadboard. The main problem encountered during the test was that of electrical noise affecting the temperature sensor, this makes the sensor to give wrong outputs from time to time. The arduino serial monitor was used as a debugging to here to display the output of the temperature sensor.

V. CONCLUSION

In this paper we considered Home and office appliances like light and fan which usually are controlled manually, which leads to power wastage. This is because they are left **on** even when not in use and even when the appliances are in use their operation is not controlled by environment conditions like temperature variations and daylight. This paper proposed a smart automated controlling system for appliances. The study provided ways to save power by some amount. This study provides solution for preventing the wastage of power in an adequate and cost effective way. The system switches the appliances in the room when there is someone there; regulates the intensity of lights in the room based on the amount of natural light (sunlight), the speed of fan and turns ON/OFF the air conditioner based on the temperature of the room. This system also allows the state of these appliances to be remotely monitored and controlled via the internet through an android phone application.

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