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FACULTY OF ENGINEERING SCIENCES AND TECHNOLOGY

SCHOOL OF ELCTRICAL AND ELECTRONIC ENGINEERING

DEPARTMENT OF ELECTRICAL AND POWER ENGINEERING

COURSE NAME: BACHELOR OF TECHNOLOGY (ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY)

FINAL PROJECT PROPOSAL

TITLE: WIRELESS POWER THEFT DETECTION AND INTIMATION SYSTEM USING GSM

BY: BILL OJANGO ANDALIA

EEEI/00970/2015

NOVEMBER 25TH, 2019

DECLARATION

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I, **MRS NGAIRA**, do certify that this project report has been submitted to the School of Electrical and Electronic Engineering, Technical University of Kenya, with my approval as the Designated Project Supervisor.

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Signature Date

ACKNOWLEDGEMENT

For the past few months, we have devoted ourselves to this work, the progression of which would never have been possible on our own and for that, we have found ourselves indebted to many. First and foremost, I would like to acknowledge the Almighty God for his care and protection in my education journey. To my supervisor **Mrs. Ngaira** l also owe her much whose continuous positive support, guidance and help has indispensably led to the completion of this work. Using her perspective, I was able to focus on the most convenient in terms of my research interests. *Thank you Madam.*

I am deeply thankful to my family for the strong support they have given me throughout the past few months. I would also like to acknowledge the Technical University of Kenya for giving me infrastructural support to undertake this project.

ABSTRACT

This proposal presents a detection of power theft in every houses and in industry for different methods of theft. Electrical energy is very important for everyday life and spine for the industry.
Power Theft is a non –ignorable crime that is highly prevented, and at the same time it directly affected the economy of a nation. Electricity theft is a social evil, so it has to be completely eliminated. Power consumption and losses have to be closely monitored so that the generated power is utilized in a most efficient manner.

Electrical power theft detection system is used to detect an unauthorized tapping on transmission lines. Existing system is not able to identify the exact location of tapping. We have designed a system which can detect the theft of electric power in a line and inform the nearest substation with the location of line in which theft has occurred. This is a real time system. Wireless data transmission and receiving technique is used.

This project will automatically collect the reading and using that data, we define the load shedding technique through controlled automation and also detect the theft and will also reduce manual manipulation work and try to achieve theft control. This will protect distribution network from power theft done by tapping, meter tampering etc.

DEDICATION

First and foremost, I wish to thank God for guiding me and being on my side throughout my studies. I would like to dedicate this final project to my parents and friends for their moral and financial support in completion of this project.

I would also like to dedicate to my brother Bonface Andalia for his continuous encouragement and my supervisor Mrs. Ngaira for her assistance in writing this report.

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1.0 INTRODUCTION

1.1 BACKGROUND

Electricity has become one of the most necessary elements of our daily life. Nowadays, it is something that people cannot live without. It has become a necessary element for the survival of maximum human beings. The Kenyan electric power supply system is a very complex grid system. So efficiency and reliability of power grid system is the main factor of the supply system. The losses which occur in our country transmission and distribution system is very large. This happens due to lack of safety, inefficient monitoring and control devices present in a grid system. There is also an uneven distribution of power which is mainly in rural areas. Also, there is power theft which occurs that goes unnoticed. About one-third of total 174 Gigawatts generated by grid system annually is either stolen or wasted due to dissipation in the conductor.

Most popularly of power theft detection mostly on distribution line is done by manual manipulation of the distribution line to customers.

1.2 PROBLEM STATEMENT

This manual manipulation of the distribution line is tiresome and wastes a lot of time and the reading of electricity billing is also not precise. Also, not all theft will be detected since the electrical technician will not always be available hence most electrical theft will occur undetected and a lot of money is used in paying the technician. With the increasing need of the electricity, the electricity theft is also increasing and it will keep on continuing until some measures are taken to detect and control it. Power theft through illegal connections as well as vandalism and meter tampering costs the country around Ksh500 million annually. This waste is too costly and a solution for this problem needs to be identified.

1.3 PROPOSED SOLUTION

The study proposes the use of GSM technique to transmit signals to the main control station. The GSM module provides an efficient way to convey this information to the authorized official. The cryptographic method is used to secure the communication channel. This project deals about one of the efficient methods to intimate theft of Electrical power. The fundamental process in this method is obtaining theft intimation using current sensors, LCD for display, microcontroller for data processing and transmitting the data via GSM network to the central control unit and information analysis and to take appropriate decision.

This method is divided in to two parts. One part is called the “Slave system” and the other part is called the “Master system”. In the actual system there will be many slave systems in a particular area with its identity numbers (it may be consisting any words) but a single Master system that will control all the slaves (having its own identity number also). All the systems will be mounted on each of the electricity distribution pole. The master stem will be located at the central pole and slaves will be on the surrounding poles

The purpose of the slave is to monitor the current flow on the transmission line for that particular pole, the system uses the current sensors for this. It will measure the current flow on the transmission line in two parts, one is incoming current to the pole and the other is outgoing current from the pole. Both the currents values may be different as there may be an authorized electrical connection going to a consumer from that pole. Another task of the slave is to transmit those current values to the Master system over a wireless RF link. For this purpose the system is going to use trans-receiver modules.

The master system will also measure the incoming and outgoing current on the master pole. It will also collect the current values coming from all the slaves over the RF links. The master system will arrange all those current values in a sequence in which the actually current flows through each of the current sensors. The main task of the master is to find out difference between outgoing current of each pole and the incoming current consecutively next pole. Like this it will detect the leakage/theft of the power in the transmission line. A GSM modem can be used to send the message to the area supervisor of that particular area using the SMS system. Another message can be sent to the higher authority to avoid corruption at lower levels also.

1.4 SYSTEM AIMS

1.4.1 System Aims

- ❖ The complete system should be able to detect an electrical power theft without any human interface.

1.4.2 System Objectives

The complete proposed system should be able to;

i. Indicate exact zone and distribution line on which unauthorized taping is done in real time.
ii. Measure and find out the difference between outgoing current of each pole and the incoming current consecutively next pole.
iii. Transmit signals to the main control station using GSM technique.
iv. Provide a digital record in case of any judicial dispute.
v. Maximize the profit margin of power utility company.
vi. Save time if distribution company personnel take reading by this wireless technique.
vii. Determine transmission line faults.

1.5 BLOCK DIAGRAM

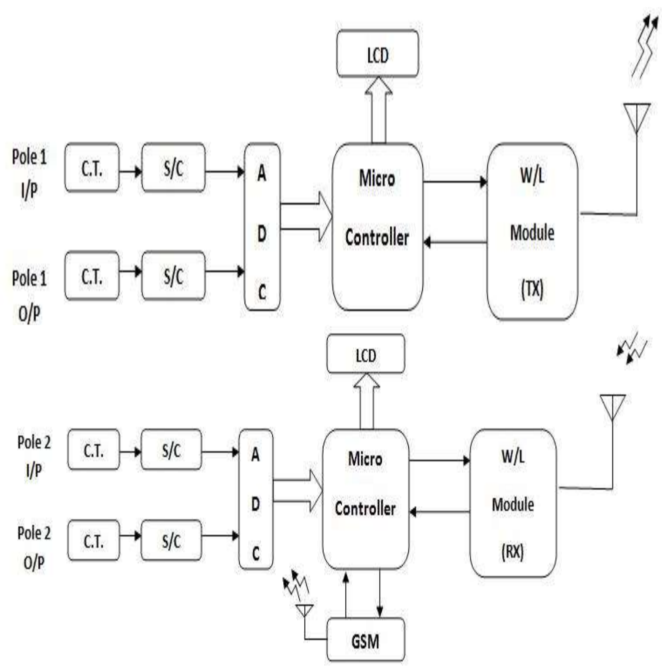


Fig 1. 1 Block diagram of the proposed system

Current Sensor (C.T)

Current sensor is used to measure the current in distribution line and convert it into measurable value. And this current sends to signal conditioner.

Signal Conditioner (S.C)

Signal conditioner is used to convert the current into necessary form, which means it converts current into voltage by using resistor.

Analog to Digital Converter (ADC)

ADC is used to convert analog data to the digital, because microcontroller requires digital input. It sends the voltage in digital form to the microcontroller.

Tx-Rx module

In slave circuit, Tx-Rx module acts as transmitter. It transmits the signal through the antenna to the Tx-Rx module of the master circuit. Tx-Rx module acts as receiver in the master circuit. It sends output to the microcontroller.

Microcontroller

Microcontroller is heart of the proposed system. It performs many operations.
In slave circuit, microcontroller acquires the input from ADC and sends to Tx-Rx module also the output sends to the LCD display.

In master circuit, microcontroller acquires the input from ADC as well as Tx-Rx module. It compares the current between slave and master circuit. If the difference between these two values of current is predefined value of tolerance, then it sends the signal to the GSM module.

GSM Module

GSM stands for global system communication for mobile. If microcontroller sends the output to GSM, then it sends to the corresponding computer or mobile.

LCD Display

In proposed system it is used to display the current in corresponding transmission line.

1.6 SYSTEM SPECIFICATIONS

- Line voltage = 230V
- Pole span = 50m
- Line frequency = 50Hz
- Current tolerance = 5%
- Reference current value =13A
- Maximum load = 14A
- System sensitivity = 30s

2.0 SYSTEM ANALYSIS AND LITERATURE REVIEW

2.1 EXISTING SOLUTIONS

The following are some of the existing solutions trying to detect power theft in distribution systems in Kenya;

- Automatic meter reading (AMRs), prepaid metering, and use of dry type transformers in the most vulnerable areas or setting the transformers high up and above the high voltage lines especially in the informal settlement areas to prevent direct connections (hooking up).

- Direct connection is being reduced through prompt installation of meters immediately the service lines are constructed. Exceptional reports are now' regularly availed to help evaluate the levels of non-technical electricity' losses in efforts to reduce them and eventually put an end to electricity theft completely in the future.

- Massive slum and rural electrification is embarked on to reduce the illegal tapping of power from already legitimately' connected lines. I here is also the intensive sensitization of the community on the effects of electricity theft and the need to immediately report any cases on the same.

2.2 CURRENT SENSORS

Definition

A current sensor is a device that detects electric current in a wire, and generates a signal proportional to that current. The generated signal could be analog voltage or current or even a digital output. The generated signal can be then used to display the measured current in an ammeter, or can be stored for further analysis in a data acquisition system, or can be used for the purpose of control.

The various types of current sensing techniques are;

2.2.1 Hall Effect Current Sensor Sensing Method.

Hall Effect sensor produces an output voltage depending on the magnetic field. The ratio of the output voltage is proportional to the magnetic field. During the current sensing process, the current is measured by measuring the magnetic field.

Working principle

This type of sensor have a hall element that is fit inside a gap in the core that surrounds the current bus. This hall element detects the magnetic field generated by the target current (I) and converts it into a voltage. The output voltage is very low and needs to be amplified to a useful value by using a high gain amplifier with very low noise. Apart from amplifier circuit Hall Effect sensor requires additional circuitry as it is a linear transducer.

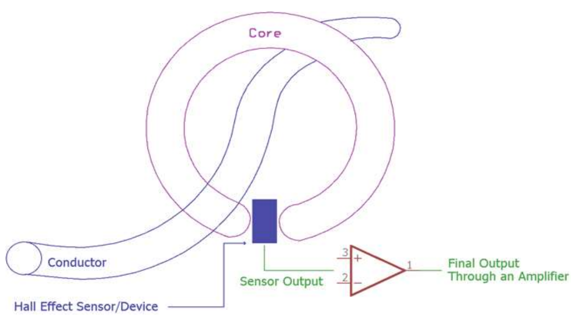


Fig 2. 0 Hall Effect current sensor

Pros:

1. Can be used in higher frequency.
2. Can be used in both AC and DC accurately.
3. Noncontact based method.
4. Can be used in a rough environment.
5. It is reliable.

Cons:

1. The sensor drifts and requires compensation.
2. Additional circuit requires for useful output.
3. Costly than shunt based technique.

An example current sensor that uses this principle is ACS712.

- **Hall effect current sensor(ACS712)**

The ACS712 is a bi-directional hall-effect current sensor. That means that it will detect positive and negative flowing currents. Since the module runs on 5V, the output of the ACS712 is set to 1/2Vcc or approximately 2.5V to represent zero current flow. So a negative current flow will go from 2.5V down and a positive current will go from 2.5V up. Allegro ACS712 device which provides an economical and precise way of sensing AC and DC currents based on Hall Effect. We use ACS712 Hall Effect current sensor to measure the current flowing from power line. As shown in figure below ACS712 is connected in series to power line. And corresponding voltage is given through output pin. The sensitivity of the current is 185 mV/A. i.e. if 1 amp current flows through ACS712 then 185 mV will be the corresponding voltage through output pin.

The ADC value change corresponding to V_{OUT}. Therefore relationship between V_{OUT} and ADC count is;

$V_{OUT} = (count/1023) \times V_{CC}$ ………………………………………………………………………………………………….. (2.1)

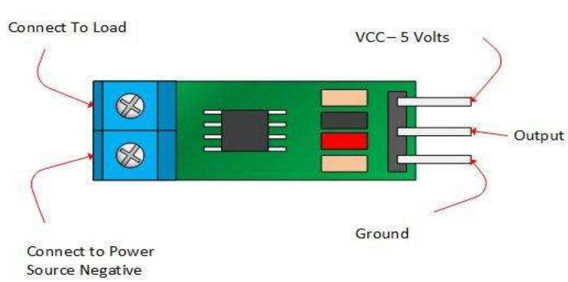


Fig 2. 1 *ACS712 current sensor block diagram*

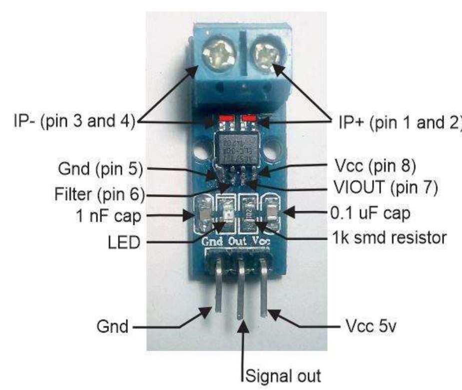


Fig 2. 2 *ACS712 pinout*

Output voltage vs sensed current of ACS712-05B at 5.0 V power supply for 5A sensor

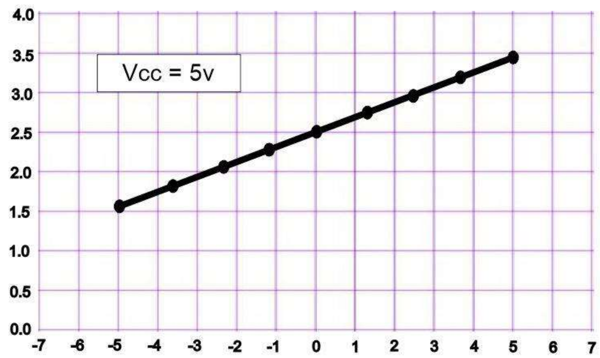


*Fig 2. 3*A graph of output voltage vs sensed current of ACS712-05B at 5.0 V power supply for 5A sensor

2.2.2 Flux Gate Sensor Current Sensing Method

A saturable inductor is the main component for the Fluxgate sensing technique. Due to this, Fluxgate sensor is called as Saturable Inductor Current Sensor. The inductor core which is used for the fluxgate sensor works in the saturation region. The saturation level of this inductor is highly sensitive and any internal or external flux density changes the saturation level of the inductor. The permeability of the core is directly proportional to the saturation level, hence the inductance also changes. This change in inductor value is analyzed by the flux gate sensor to sense the current. If the current is high, the inductance become lower, if the current is low, the inductance become high.

The Hall Effect sensor works similarly to the fluxgate sensor, but there is one difference between them. The difference is in the core material. Flux Gate sensor uses a saturable inductor but the Hall Effect sensor uses air core.

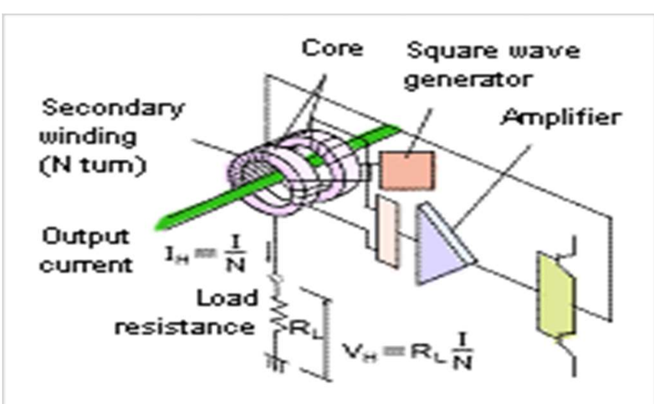


*Fig 2. 4*Flux gate current sensor

2.2.3 Shunt Resistor Current Sensing Method

This technique is based on Ohms law. A low-value resistor in series is used to sense the current. When the current flow through a low-value resistor, it produces a voltage difference across the resistor.

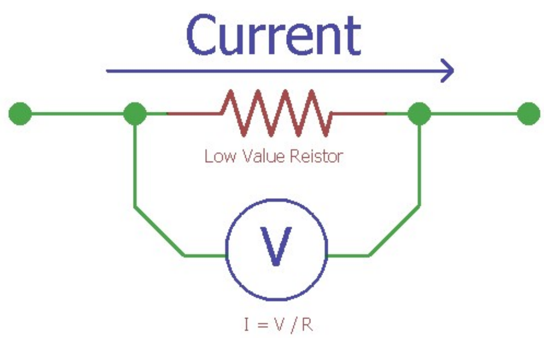


Fig 2. 5 shunt resistor current sensor

(Palak Kalra, 2015).

2.3 TRANS-RECEIVER (TX-RX) MODULE

Definition

A *transceiver* is a device comprising both a transmitter and a receiver which are combined and share common circuitry or a single housing.

It's an integrated technology embedded in devices such as network cards. In a network environment, a transceiver gets its name from being both a transmitter and a receiver of signals, such as analog or digital.

Technically, on a LAN the transceiver is responsible to place signals onto the network media and also detecting incoming signals traveling through the same cable. Transceivers can ship as a module or chip type. *Chip transceivers* are small and are inserted into a system board or wired directly on a circuit board. *Module transceivers* are external to the network and are installed and function similarly to other computer peripherals, or they may function as standalone devices.

There are many types of transceivers:

- *RF transceivers,*
- *WIFI transceivers,*
- *Bluetooth transceivers,*
- *GSM transceivers*,

2.3.1 RF Transceivers

An RF transceiver module (radio frequency module) is a small electronic device used to transmit and/or receive radio signals between two devices.

The main application of RF module is an embedded system to communicate with another device wirelessly. This communication may be accomplished through radio frequency communication.

The applications of RF modules mainly involve in low volume and medium volume products for consumer applications like *wireless alarm systems, garage door openers, smart sensor applications, wireless home automation systems and industrial remote controls.*

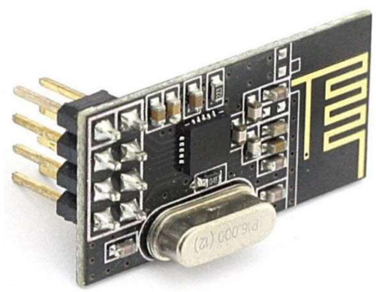


Fig 2. 8 RF Transceiver Module

In a radio transceiver, the receiver is silenced while transmitting. An electronic switch permits the transmitter and receiver to be allied to the same antenna and stops the o/p of the transmitter from injuring the receiver. With this kind of a transceiver, it is difficult to get signals while transmitting and this mode is named as half duplex.

Some kind of transceivers is designed to let reception of signals through transmission periods. This mode is called as full duplex, and needs that the transmitter (TX) and receiver (RX) work on considerably different frequencies so the signal which is transmitted doesn't interfere with reception.

RF Transceiver module design is made up of amplifiers, RF Mixers, pads & other RF components using micro strip technology. The transmitter and Receiver parts in the RF transceivers called as RF Up converter and RF Down converter.

Block Diagram of RF Transceivers

In the design of the wireless systems, there are normally two overriding limitations: *it must work over a convinced distance and transfer a convinced amount of information within a data rate.*
The size of the RF modules is very small and have an extensive range of operating voltage that is 3V to 12V.

Basically, these modules are 433 MHz RF TX and RX modules. The transmitter (TX) draws no power when transferring logic zero while fully destroying the carrier frequency, thus consume considerable low power in battery operation. When logic1 is sent carrier is fully on to about 4.5mA with a 3V power supply. The information is sent serially from the transmitter (TX) which is received by the receiver. Transmitter (TX) and the receiver (RX) are duly interfaced to two
Microcontrollers for transferring the data.

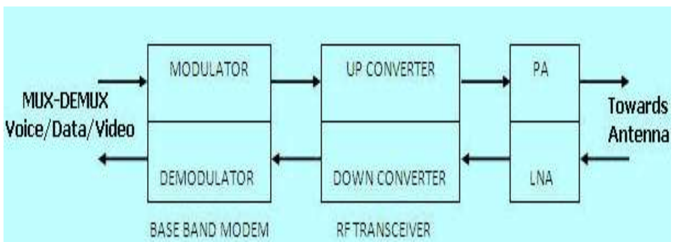
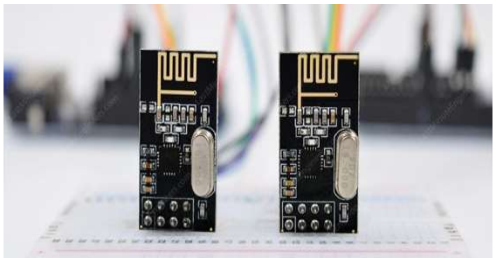


Fig 2. 6 RF Transceiver Block Diagram

RF modules can be applied for various types, sizes and shapes of electronic circuit boards. It can also be useful for modules across a vast variety of capacity and functionality. These modules typically include a PCB, TX circuit or RX circuit, antenna and serial interface for communication to the main processor.
The types of RF modules mainly include *RF transmitter module, RF receiver module RF transceiver module and SOC module.*
There are 3-types of signal modulation techniques commonly used in RF transmitter and RF receiver modules such as ASK-amplitude shift keying, OOK-On-Off Keying and FSK-frequency shift keying.
An example of RF transceiver is NRF24L01

- **nRF24L01+ Wireless Module**

The nRF24L01+ transceiver module is designed to operate in 2.4 GHz worldwide ISM frequency band and uses GFSK modulation for data transmission. The data transfer rate can be one of 250kbps, 1Mbps and 2Mbps.

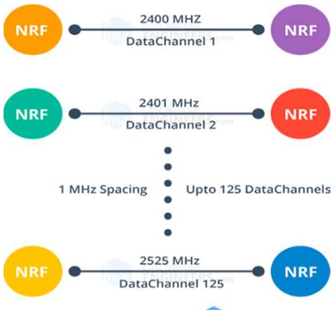


The operating voltage of the module is from 1.9 to 3.6V**,** but the logic pins are 5-volt tolerant. The module supports programmable output power viz. 0 dBm, -6 dBm, -12 dBm or -18 dBm and consumes around 12 mA during transmission at 0 dBm, which is even lower than a single LED.

- **RF Channel Frequency**

The nRF24L01+ transceiver module transmits and receives data on a certain frequency called Channel. Also in order for two or more transceiver modules to communicate with each other, they need to be on the same channel. This channel could be any frequency in the 2.4 GHz ISM band or to be more precise, it could be between 2.400 to 2.525 GHz (2400 to 2525 MHz).

Each channel occupies a bandwidth of less than 1MHz. This gives us 125 possible channels with 1MHz spacing. So, the module can use 125 different channels which give a possibility to have a network of 125 independently working modems in one place.



RF channel frequency of your selected channel is set according to the following formula:

$Freq_{(Selected)} = 2400 + CH_{(Selected)}$

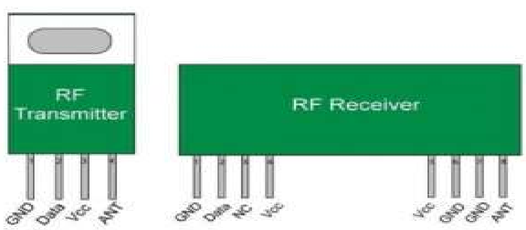
For example, if you select 108 as your channel for data transmission, the RF channel frequency of your channel would be 2508MHz (2400 + 108)

- ***RF Transmitter***

An RF transmitter module is a small size PCB capable of transferring a radio wave and modulating radio wave to carry data. RF transmitter modules are usually applied along with a micro controller, which will offer data to the module which can be transmitted. These transmitters are usually subject to controlling requirements which command the maximum acceptable transmitter power o/p, band edge and harmonics requirements.

- ***RF Receiver***

An RF receiver module takes the modulated RF signal to demodulate it. There are two kinds of RF receiver modules, namely the super-regenerative receivers and super-heterodyne receivers. Usually, super-regenerative modules are low power designs and low cost using a series of amplifiers to remove modulated data from a carrier wave. These modules vary, generally inaccurate as their operation of frequency significantly with power supply voltage and temperature.



The main advantage of Superheterodyne receiver modules is a high performance over super-regenerative. They offer increased stability and accuracy over a large temperature and voltage range. This stability comes from a stable crystal design which in turn leads to a relatively more expensive product.

- ***System on Chip (SOC) module***

A SoC module is the same as a transceiver module, but it is often made with an onboard micro controller (MCU).

The MCU is typically used to handle radio data packetisation or managing a protocol such as an IEEE 802.15.4-compliant module. This type of module is typically used for designs that require additional processing for compliance with a protocol when the designer does not wish to incorporate this processing into the host MCU.

Technical Specifications of RF Transceiver

There are so many parameters related to RF Transceiver

- The parameters in the RF transmitter part include gain flatness, I/p and o/p frequency range, gain adjustment, conversion gain, compression point, 1dBm frequency stability, spurious & harmonic o/p.
- The parameters on the receiver part include input & an output frequency range, gain flatness, gain adjustment, spurious output, noise figure, Image rejection, adjacent channel, on adjacent channel and rejection frequency stability.

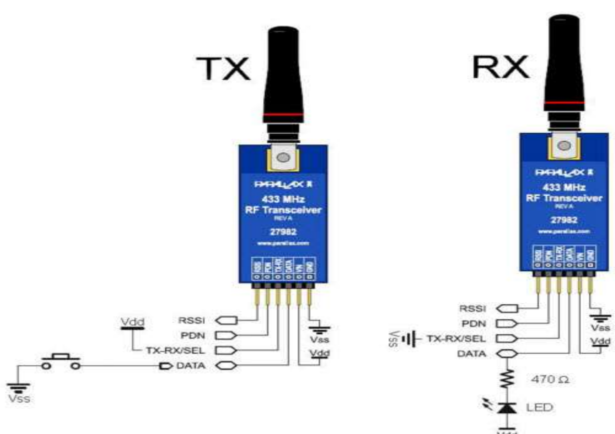


Fig 2. 7 *Technical Specifications of RF Transceiver*

2.3.2 Wi-Fi Transceiver Module

The Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network.

It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor.

Besides, a WI-FI module has powerful on-board processing and storage capabilities that allow it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area.

The pin diagram is as shown below;

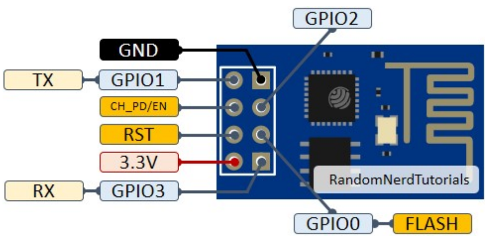


Fig 2. 8 *wifi transceiver module*

2.3.3 Bluetooth Transreceiver.

Bluetooth module can easily achieve serial wireless data transmission. Its operating frequency is among the most popular 2.4GHz ISM frequency band. In Bluetooth 2.0, signal transmit time of different devices stands at a 0.5 seconds interval so that the workload of Bluetooth chip can be reduced substantially and more sleeping time can be saved for Bluetooth. This module is set with serial interface, which is easy to use and simplifies the overall design/development cycle.

2.3.4 Fiber-optic transceiver

A fiber optic transceiver is a device that uses fiber optical technology to send and receive data.

The transceiver has electronic components to condition and encode/decode data into light pulses and then send them to the other end as electrical signals. To send data as light, it makes use of a light source, which is controlled by the electronic parts, and to receive light pulses, it makes use of a photodiode semiconductor.

Data can usually travel only one way in a fiber optic cable, so most transceivers have two ports for bidirectional communication: one for sending and the other for receiving signals. Alternatively, a single cable can be used, but it can only send or receive data at a time but not both.

(Mr.Ashutosh Kumar, Mr.A.V.Athalekar,2014)

2.3.5 GSM/GPRS MODULE

Definition

GSM/GPRS module is used to establish communication between a computer and a GSM-GPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries.

GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates.

Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB, etc.) for computer. GSM/GPRS MODEM is a class of wireless MODEM devices that are designed for communication of a computer with the GSM and GPRS network. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network.

Also they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification. A GSM/GPRS MODEM can perform the following operations:

- *Receive, send or delete SMS messages in a SIM.*
- *Read, add, search phonebook entries of the SIM.*
- *Make, Receive, or reject a voice call.*

GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.

The MODEM needs AT commands, for interacting with processor or controller, which are communicated through serial communication. These commands are sent by the controller/processor.

The MODEM sends back a result after it receives a command. Different AT commands supported by the MODEM can be sent by the processor/controller/computer to interact with the GSM and GPRS cellular network.

GSM FREQUENCIES

FREQUENCY	RANGE
GSM900	880-915 MHz paired with 925-960MHz
GSM1800	1710-1785MHz paired with 1805-1880MHz
GSM1900	1850-1910MHz paired with 1930-1990MHz

GSM-900 uses 890 - 915 MHz to send information from the Mobile Station to the Base Transceiver Station (uplink) and 935 - 960 MHz for the other direction (downlink), providing 124 RF channels (channel numbers 1 to 124) spaced at 200 kHz. Duplex spacing of 45 MHz is used

GSM-1800 uses 1710 - 1785 MHz to send information from the Mobile Station to the Base Transceiver Station (uplink) and 1805 - 1880 MHz for the other direction (downlink), providing 374 channels (channel numbers 512 to 885). Duplex spacing is 95 MHz

GSM-850 uses 824 - 849 MHz to send information from the Mobile Station to the Base Transceiver Station (uplink) and 869 - 894 MHz for the other direction (downlink). Channel numbers 128 to 251.

Applications for GSM:

-Digital Communication such GPS, Cell Phones, Laptops.

(Thomas B Smith, wireless communication: 2009)

2.4 LIQUID CRYSTAL DISPLAY

Definition

A Liquid Crystal Display (LCD) is a thin, flat panel display device used for electronically displaying information such as text, images and moving picture. LCD is used in Computer monitors, Televisions, Instrument panels, gaming devices etc. Polarization of lights is used here to display objects.

2.4.1 Liquid crystals

Liquid crystals are liquid chemicals in a state that has properties between those conventional liquid and solid crystals. That is a liquid crystal may flow like a liquid, but its molecules may be oriented in a crystal like way.

Liquid crystals molecules can be aligned precisely when subjected to electric fields, as like as in the way metal shavings line up in the field of a magnet. When properly aligned, the liquid crystals allow light to pass through.

2.4.2 Working principle of LCDs

Liquid crystals can adopt a twisted up structure and when we apply electricity to them, they straighten out again. This is the key how LCD displays turn pixels on and off. The polarization property of light is used in LCD screen to switch its colored pixels on or off. At the back of the screen, there is a bright light that shines out towards the viewer. In front of this, there are the millions of pixels, each one made up of smaller areas called sub-pixels that are colored Red, Green, or Blue.

Each pixel has a polarizing glass filter behind it and another in front of it at 90 degrees. Normally the pixels looks dark. In between the two polarizing filters there is a tiny twisted, nematic liquid crystal that can be switched on or off electronically. When it is switched on, it rotates the light passing through it through 90 degrees, effectively not allowing light to flow through the two polarizing filters and making the pixel look dark. Each pixel is controlled by a separate transistor that can switch it on or off many times each second.

Reasons for using LCD

- Smaller size —LCDs occupy approximately 60 percent less space than CRT displays an important feature when office space is limited.
- Lower power consumption—LCDs typically consume about half the power and emit much less heat than CRT displays.
- Lighter weight —LCDs weigh approximately 70 percent less than CRT displays of comparable size.
- No electromagnetic fields —LCDs do not emit electromagnetic fields and are not susceptible to them. Thus, they are suitable for use in areas where CRTs cannot be used.
- Longer life —LCDs have a longer useful life than CRTs.

2.4.3 Types of LCD

I. Direct Address Display
II. Passive Matrix Display
III. Active Matrix Display

- **Direct Address Display**

When the display include limited variable components such as

- ✓ Watches
- ✓ Calculators

Simple electronics is used to control the components.

- **Passive Matrix Display**

Passive matrix display has;

- ✓ Rows of electrodes on one piece of glass.
- ✓ Columns of electrodes on the opposing piece of glass.
- ✓ Complex electrical waveform control the voltage differential at the intersection of the electrodes.

- **Active Matrix Display**

Allow very high resolution. Each sub-pixel is individually controlled by an isolated thin-film transistor (TFT). It allows the electrical signal for each sub-pixel to avoid influencing adjacent elements. The TFT is patterned into the glass layer.

- **Twisted Nematic (TN) Display**

Is the most common LCD Display. The two alignments layer for the liquid crystal material are orthogonal. The light entering the polarize panel rotates by the twist in the liquid crystal and allowing it to pass through the second polarize.

16×2 LCD DISPLAY

A 16x2 LCD shown in the image below can display 32 characters with 16 characters in each row. It is capable to display any character with ASCII values ranging from 0 to 255.

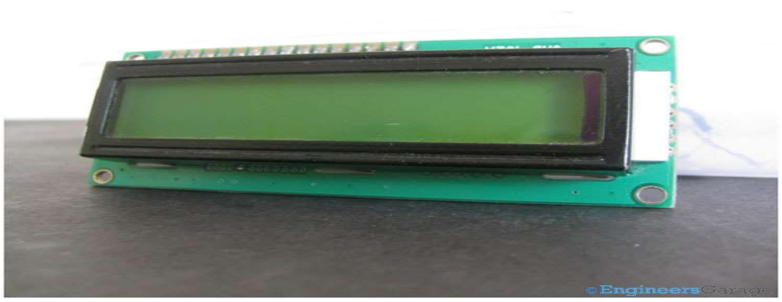


Fig 2. 9 16×2 LCD display

Different layers of the LCD glass are shown in the following figure.

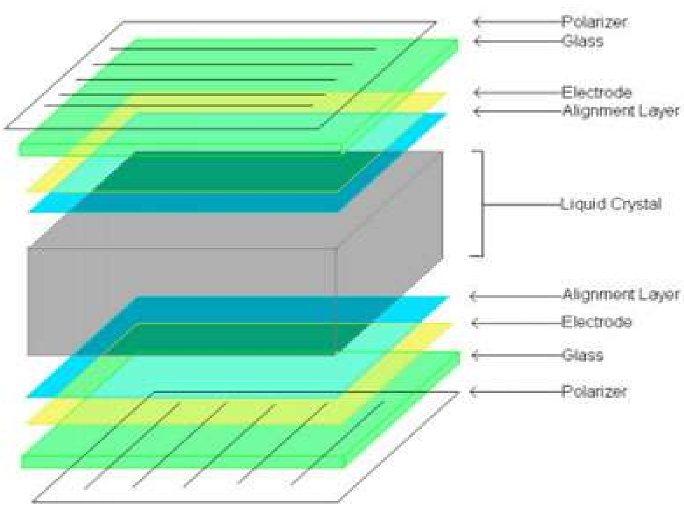


Fig 2. 10 LCD layers

Working

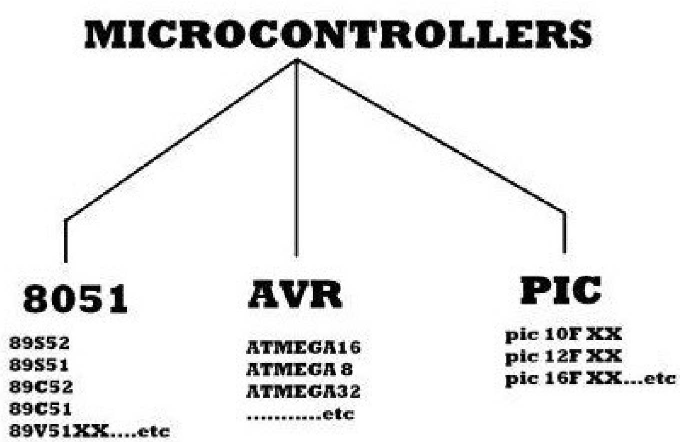
The liquid crystals used in the LCD are Twisted Nemantic (TN), a type of liquid crystals that are twisted at 90^o with the surface. In this state, crystals allow the light to pass through the polarizer but on applying a voltage, they get untwisted and block the light to passing through the polarizer.

The LCD controller in the form of COB IC sends the electric signals to the electrodes which are sandwiched in between the glasses. Electrodes apply the voltage to the corresponding crystals as per the signals received from the ICs. These crystals are then untwisted and blocks the light (from LED strip) making those area darker on the glass. By applying voltage to specific crystals, a desired shape is formed on the LCD.

2.5 MICROCONTROLLER

A microcontroller is an integrated circuit (IC) that can be programmed to perform a set of functions to control a collection of electronic devices. Also is a self-contained system in which a processor, support, memory, and input/output (I/O) are all contained in a single package. Being programmable is what makes the microcontroller unique.

The microcontrollers are characterized regarding bus-width, instruction set, and memory structure as shown below;



2.5.1 Types of Microcontrollers

2.5.1.1 Microcontroller 8051

It is a 40pin microcontroller with Vcc of 5V connected to pin 40 and Vss at pin 20 which is kept 0V. And there are input and output ports from P1.0 – P1.7 and which having open drain feature. Port3 has got extra features. Pin36 has open drain condition and pin17 has internally pulled up transistor inside the microcontroller.

When we apply logic 1 at port1 then we get logic 1 at port21 and vice versa. The programming of microcontroller is dead complicate. Basically we write a program in C-language which is next converted to machine language understand by the microcontroller.

A RESET pin is connected to pin9, connected with a capacitor. When the switch is ON, the capacitor starts charging and RST is high. Applying a high to the reset pin resets the microcontroller. If we apply logic zero to this pin, the program starts execution from the beginning.

2.5.1.2 AVR Microcontrollers

AVR microcontroller is developed by Alf-Egil Bogen and Vegard Wollan from Atmel Corporation. The AVR microcontrollers are modified Harvard RISC architecture with separate memories for data and program and speed of AVR is high when compare to 8051 and PIC. The AVR is stands for **A**lf-Egil Bogen and **V**egard Wollan's **R**ISC processor.

Classification of AVR Controllers:

AVR Microcontrollers are classified into three types:

- *TinyAVR* – Less memory, small size, suitable only for simpler applications
- *MegaAVR* – These are the most popular ones having good amount of memory (up to 256 KB), higher number of inbuilt peripherals and suitable for moderate to complex applications
- *XmegaAVR* – Used commercially for complex applications, which require large program memory and high speed

There are many AVR family microcontrollers, such as ATmega8, ATmega16 and so on. Arduino uses ATmega chip.

ARDUINO UNO MICROCONTROLLER

It’s a great tool for developing interactive objects which takes input from various sensors, actuators, switches and controls the output for obtaining desired result. Arduino is a tool for making computer that can sense and control more physical world than your desktop computer. It’s an open source physical computing platform based on simple microcontroller board and a development environment for writing software for board.

Specifications

- The Arduino Uno is a microcontroller board, based on the ATmega328.
- It has 14 digital input/output pins which 6 can be used as PWM outputs,
- It has 6 analog inputs,
- Is a 16 MHz crystal oscillator,
- Has a USB connection, a power jack, an ICSP header, and a reset button.
- It can operate at a wide range of power-supply voltages, from 1.8V to 5.5V. Thus it can be used for battery-powered applications.
- Arduino board has six ADC channels.
- The **Arduino Uno ADC** is of 10 bit resolution (so the integer values from (0-(2^10) 1023)). This means that it will map input voltages between 0 and 5 volts into integer values between 0 and 1023. So for every (5/1024= 4.9mV) per unit.
- ATmega328 can operate up to 20MHz frequency.

Working

The Arduino UNO can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery.

The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the Power connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

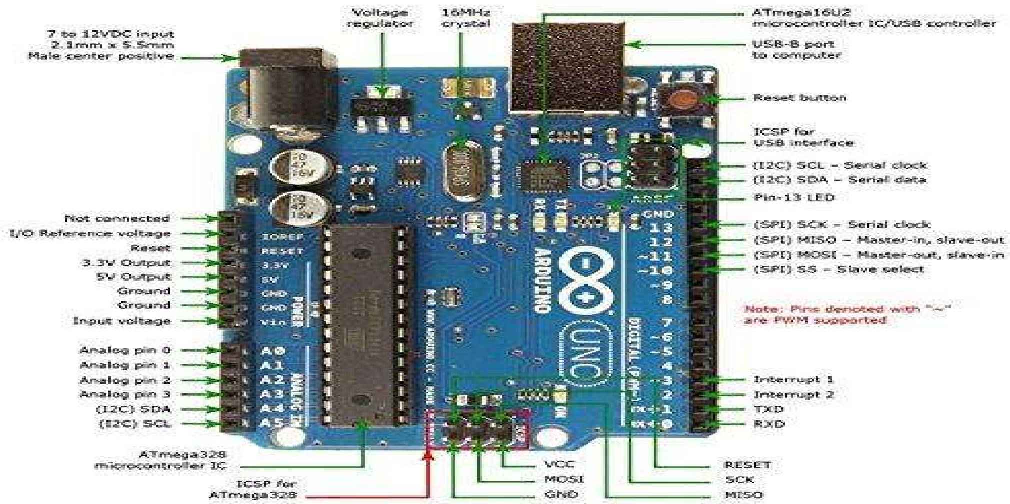


Fig 2. 11 *Arduino Uno pinout*

Advantages of using Arduino

- *It is open-source hardware. The Arduino software is also open-source accessible to all without prior permission to use.*
- *One of the greatest advantage of using Arduino is that it can be runned on any operating system such as windows, Macintosh, Linux unlike other micro controllers which are limited to windows.*
- *As Arduino is open-source software platform so you can get lots of source code available on online forum & communities related to Arduino.*

2.5.1.3 PIC Microcontroller

The term PIC stands for "Peripheral Interface Controller". PICs use an instruction set that varies in length from about 35 instructions for the low-end PICs to more than 70 for the high-end devices. PIC microcontrollers are finding their way into new applications like smart phones, audio accessories, video gaming peripherals and advanced medical devices.

Fig 2. 12 *PIC microcontroller*

Pros of PIC microcontroller

- Small Instruction Set to learn
- RISC architecture
- Built in oscillator with selectable speeds
- Programmable Comparators
- Easy in-circuit programming

Cons of PIC microcontroller

- One accumulator
- Operations and registers are not orthogonal
- Register-bank switching is required to access the entire RAM of many devices

There are many PICs, started with PIC16F84 and PIC16C84

(Dr. Jongeun Jongeun Choi, Microcontrollers design, 2015)

3.0 SYSTEM DESIGN

In the system design, in the prototype we shall use two 2.5mm^2 electric cable carrying between two poles.

Also will use two 100Watts bulbs, one for the legal customer and the other for the illegal customer.

Current drawn by each bulb will be;

P = IV …………………………….. (1)

Therefore current will be

I=P/V

=100/230

=0.435A

Therefore for a normal supply without theft occurring, the total current in each pole will be;

$I_T = I_L$ ………………………..... (2)

Where I_L is the load current

= 0.435A

If theft occurs i.e. bulb two switched the total current in the circuit will be;

= 0.435+0.435

= 0.87A

N/B: *All design shall be with respect to the prototype specifications.*

3.1 CURRENT SENSOR

Given that the prototype specification is; line voltage of 230V, a current of 0.435A for a legal customer and 0.87A for an illegal customer or if theft occurs as shown in equation 2, our typical current sensor will give an output of;

i. ***For normal/legal load***

Voltage at 0A = 2.5Vdc

Sensitivity of the sensor = 185mV/A

Therefore the output will be;

V_{OUT} = 2.5 + (sensitivity*current)

= 2.5 + (185*0.435)

= 2.585V

ii. ***For illegal/theft load***

V_{OUT} = 2.5 + (sensitivity*current)

= 2.5 + (185*0.87)

= 2.661V

The chip to be used will be ACS712ELC-05A

The diagram below shows how ACS712ELC-05A is interfaced with microcontroller.

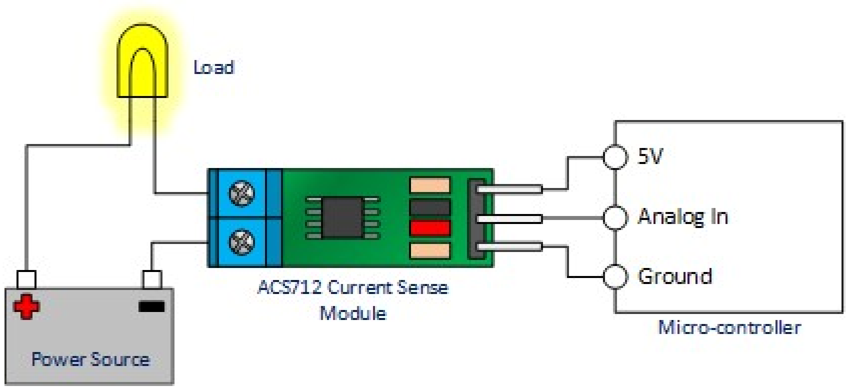


Fig 3. 0 *ACS712ELC-05A interfacing with microcontroller.*

We have selected to use the Hall Effect current sensor specifically ACS712, as evident in the design.

3.2 MICROCONTROLLER SYSTEM

From the literature review, the proposed microcontroller to be used is Arduino Uno which uses AT mega 328 from the AVR family of microcontroller.

Power supply = 1.8V – 5.5V

The Program code for the system is written using Arduino software and uploaded onto the processor using the computer via USB port. The board can operate on an external supply of 6 to 20 volts. Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms.

The UNO ADC channels has a default reference value of 5V. This means we can give a maximum input voltage of 5V for ADC conversion at any input channel. Since our input from the current sensor is between 2.585V and 2.661V and the reference voltage is 5V, the accuracy will be less. So we have to change this reference value to around 2.5V using the following instruction; *("analog Reference (2.5) ;")*

3.2.1 Slave Arduino Uno microcontroller

Analog Input voltage (ADC value) = the output voltage from current sensor

= 2.585V

This value is converted to a digital value using the ADC converter in Arduino. Therefore the voltage measured is found by;

Voltage = (ADC value ÷ ADC resolution) × reference voltage

= (2.585 ÷ 1024) × 2.5

= 6311.03mV

In case of theft the measured voltage will be;

= (2.661 ÷ 1024) × 2.5

= 6496.58mV

Therefore the slave value will be 6311mV for normal load and *6496.58mV* in case of theft which will be displayed on the LCD and also send to the Master controller for comparing using the transmitter module.

3.2.2 Master Arduino Uno microcontroller

In the master microcontroller, the Analog Input voltage (ADC value) will also be 2.585V and the measured voltage *6311.03mV* since the circuits are identical with that of slave so the reading will be same.

From the receiver, the input voltage from the slave microcontroller is *6311.03mV* for normal load and *6496.58mV* in case of theft. In actual implementation the slaves will be many so the master will compare all incoming voltages each pole with the predefined value.

Let the Current in the master circuit is I_1 and current in the slave circuit is I_2. In microcontroller of master circuit, these two current I_1 and I_2 are compared.

If,

i. I_1-I_2 > Predefined value of tolerance. Then this signal is send to corresponding computer through GSM module.

ii. I_1-I_2 <= Predefined value of tolerance. Then CT starts to take new reading.

Therefore $I_1 = 6311.03mV$

$I_2 = 6311.03mV$

If $I_1 <= I_2$ Then CT starts to take new reading.

$I_1 > I_2$ Then this signal is send to corresponding computer through GSM module.

3.3 TRANSRECEIVER MODULE

We have selected the use of nRF24L01 transceiver module as evident from the literature analysis.
The nRF24L01 integrates a complete 2.4GHz RF transceiver, RF synthesizer, and baseband logic including the Enhanced Shock Burs hardware protocol accelerator supporting a high-speed SPI interface for the application controller.

nRF24L01 specifications

- Uses 2.4 GHz
- Can operate at a baud rate of 250Kbps – 2Mbps
- If used in open space it's coverage ranges up to 100m
- Can use 125 different channels to communicate
- Each unit can communicate with up to six other units at the same time
- Max power consumption is 12mA
- Operating/input voltage: 1.9-3.6V
- Other pins tolerates 5V logic

Interfacing with Arduino

GND of Arduino is connected to GND of nRF24L01, VCC of Arduino is connected to VCC of nRF24L01, CE of nRF24L01 is connected to pin 7 of Arduino, CSN of nRF24L01 is connected to pin 8 of Arduino, CSK of nRF24L01 is connected to pin 13 of Arduino, MOSI of nRF24L01 is connected to pin 12 of Arduino.

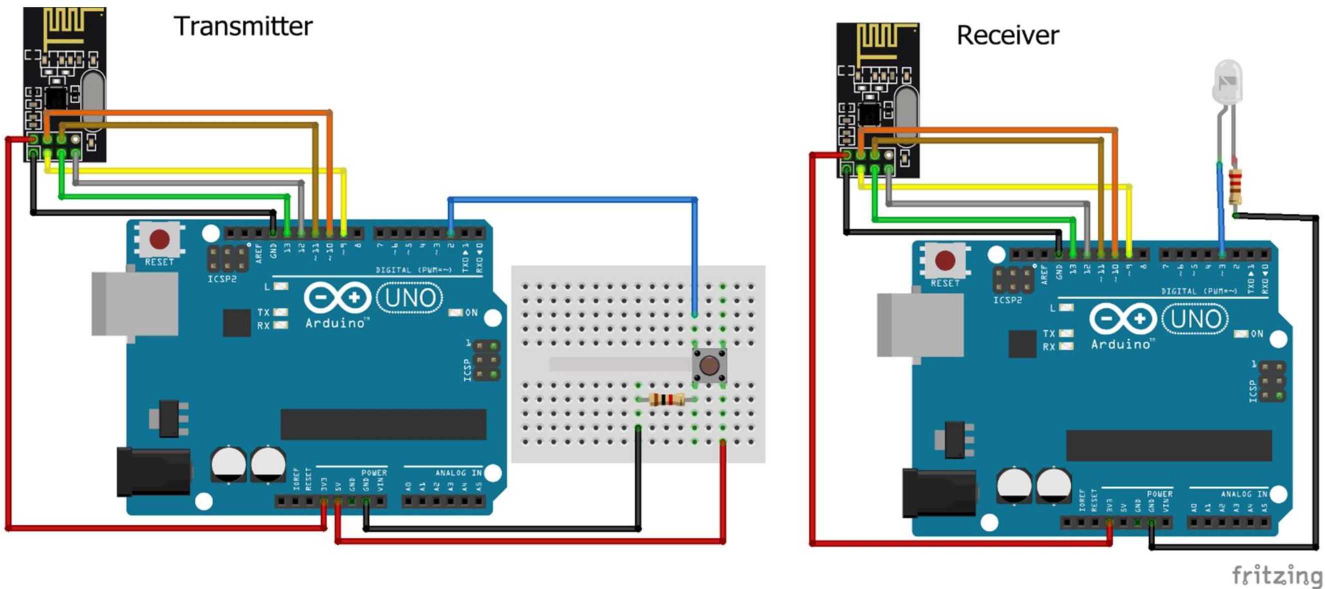


Fig 3. 1 *NRF24L01 transmitter and receiver interfacing with Arduino*

3.4 GSM MODULE

The module will receive instructions from the controller after doing necessary comparison and the kind of message to send to the relevant person.

The SIM900A is a complete Dual-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications. Featuring an industry-standard interface, the SIM900A delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption.

The module is controlled by using AT commands. AT is the abbreviation of ATtention. In this project the AT command will be used to; *Send (AT+CMGS, AT+CMSS), read (AT+CMGR, AT+CMGL), write (AT+CMGW) or delete (AT+CMGD) SMS messages and obtain notifications of newly received SMS messages (AT+CNMI).*

Selecting Antenna

An antenna is required to use the module for any kind of voice or data communications as well as some SIM commands. So, selecting an antenna could be a crucial thing. There are two ways you can add an antenna to your SIM800L module.

A Helical GSM antenna which usually comes with the module and solders directly to NET pin on PCB. This antenna is very useful for projects that need to save space but struggles in getting connectivity especially if your project is indoors.

Supplying Power for SIM800L module

Depending on which state it's in, the SIM800L can be a relatively power-hungry device. The maximum current draw of the module is around 2A during transmission burst. It usually won't pull that much, but may require around 216mA during phone calls or 80mA during network transmissions.

Wiring – Connecting SIM800L GSM module to Arduino UNO

Start by soldering/connecting the antenna, insert fully activated Micro SIM card in the socket. We cannot directly connect Rx pin on module to Arduino's digital pin as Arduino Uno uses 5V GPIO whereas the SIM800L module uses 3.3V level logic and is NOT 5V tolerant**.** Tx signal coming from the Arduino Uno must be stepped down to 3.3V using resistor divider.

Current = 0.17mA

V_M = 5V

V_{OUT} = $V_M \times \frac{R2}{R1+R2}$, where Vm=transmitter pin Voltage

R2 = V/I

= 3.3÷0.00017

= 19411Ω

V1= V_M - V_{OUT}

$= 5 - 3.3 = 1.7V$

$R1 = V_1/I$

$= 1.7V/0.00017$

$= 10000\Omega$

Therefore, from the above design, A 10K resistor between SIM800L Rx and Arduino Tx, and 20K between SIM800L Rx and GND is used so as to step down the voltage.

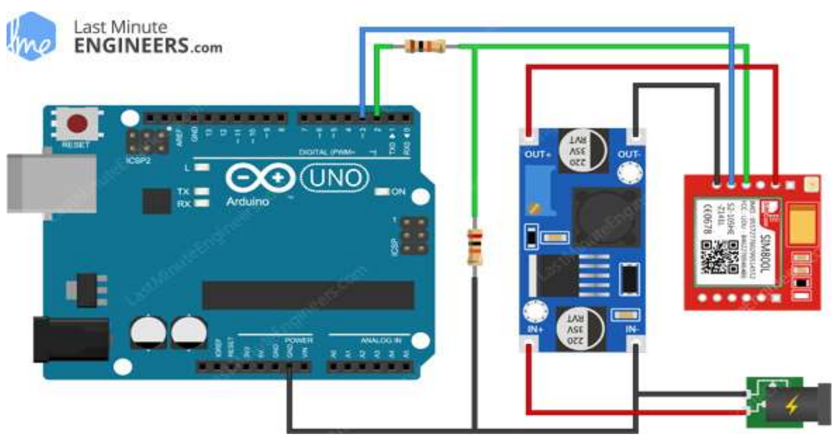


Fig 3. 2 *GSM interfacing with Arduino*

We will use the instruction **Serial. Available ( )** – to check for any data coming through serial port of Arduino. The SIM800 GSM/GPRS shield uses UART protocol to communicate with an Arduino. The chip supports baud rate from 1200bps to 115200bps with Auto-Baud detection.

In this project we proposed to use GSM-800L for conveying information to the relevant authorities as seen from the design above.

3.5 LIQUID DISPLAY CRYSTAL

In this project the LCD used is LM016L as evident from the literature analysis. The functions of different pins in this display are;

VSS: For ground for LCD.

VDD: For giving Vcc (+5 volt).

VEE: For adjusting brightness of LCD screen. We can use rheostat to give variable voltage to change the brightness.

RS: RS stands for resister select. If RS is HIGH then data at data bus treat as a data or if RS is LOW data at data bus treat as a command.

E: E stand for led enable pin.

D0-D7: D0-D7 are data pin.

Some important Arduino commands to display our data at LCD are;

Begin (): this begin () command is used for initializes the LCD screen, and specifies the dimensions of the display. Syntax is: lcd.begin (cols, rows)

Print (): This print () command is used to prints text to the LCD. Syntax is; lcd.print(data)

clear() : Clear() command is used to clears the LCD screen and set the cursor positions in the upper-left corner. Syntax: lcd.clear()

write() : write() command is used to write a character to the LCD. Syntax: lcd.write(data)

setCursor() : this command used for set the position the LCD cursor. Syntax: lcd.setCursor(col, row)

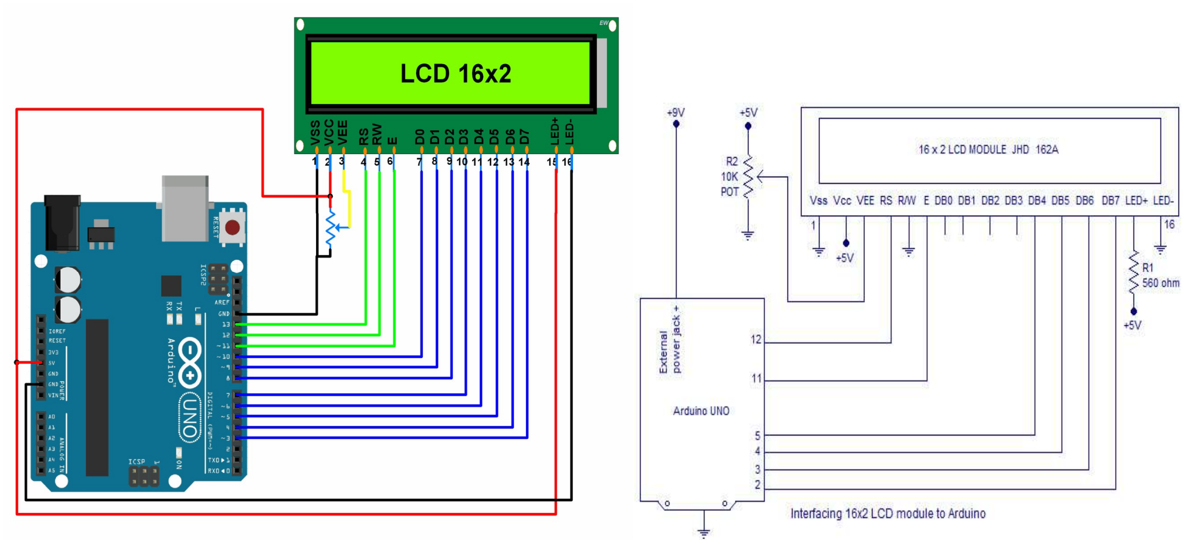


Fig 3. 3 *LCD pinout with Arduino*

From the circuit diagram, the RS pin of the LCD is connected to the pin 12 of the Arduino. The LCD of R/W pin is connected to the ground. The pin 11 of the Arduino is connected to the enable signal pin of LCD module. The LCD module & Arduino module are interfaced with the 4-bit mode in this project. Hence there are four input lines which are DB4 to DB7 of the LCD.

The digital input lines (DB4-DB7) are interfaced with the Arduino pins from 5-2. To adjust the contrast of the display here we are using a 10K potentiometer. The current through the back LED light is from the 560-ohm resistor. The external power jack is provided by the board to the Arduino. Using the PC through the USB port the Arduino can power.

The flow chart of the whole proposed project is as shown below;

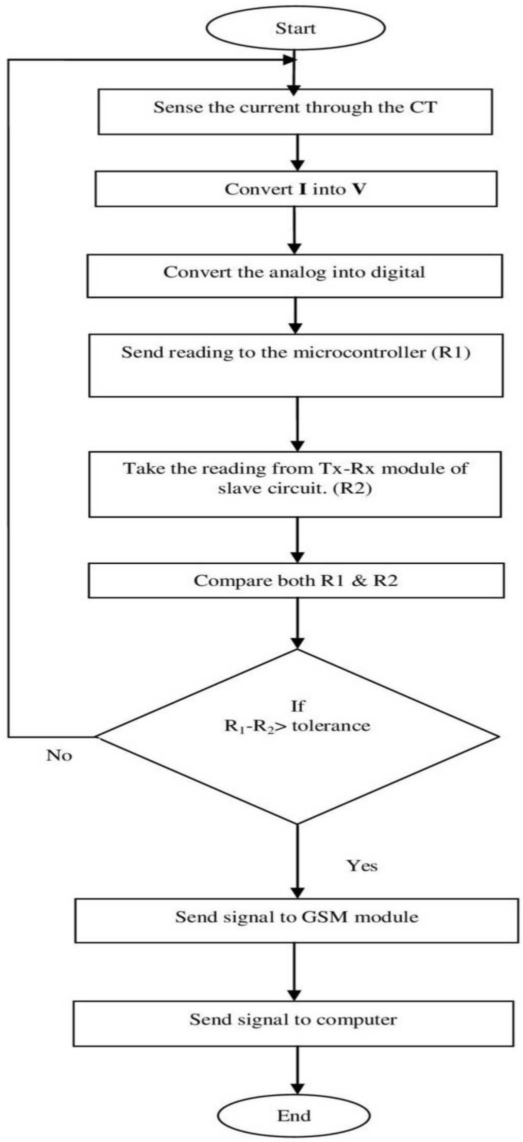


Fig 3. 4 *System flow chart*

3.6 SYSTEM CIRCUIT DIAGRAM

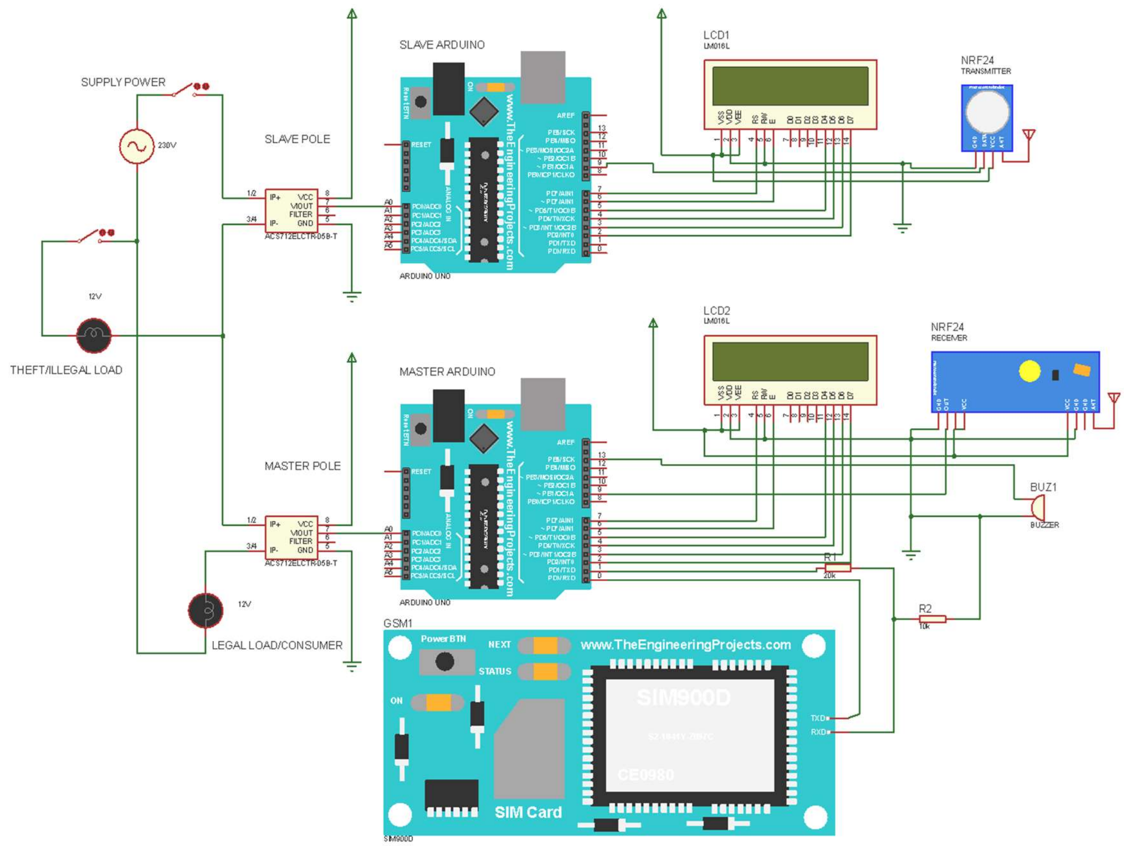


Fig 3. 5 Proposed system circuit diagram

4.0 SYSTEM CONSTRUCTION AND TESTING

4.1 System Construction and Testing

This chapter discusses the design implementation of the wireless power theft and intimation system using gsm. It gives a detailed account of the process of attaining an operational hard-wired system.

4.2 Hardware Requirement

- Two hall-effect acs712 current sensor
- Two nrfl01 trans-receiver
- Two atmega 328P
- Two 16×2 LCD display
- Sim 800L GSM module
- Power supply (5V and 3.3V)
- Resistors
- Potentiometers
- Jumper wires
- Copper board
- Sim card
- Two leds
- 9V battery

4.3 Implementation

The construction process involved three important stages i.e. simulation, bread-boarding and soldering onto the copper board. All the three steps are discussed below;

4.3.1 Simulation

The first stage of the construction process was simulation using proteus software. Proteus- is software for PCB designing, drawing schematics and simulating circuits in real time. The simulation allows human access during run time, thus providing real time simulation. The circuit ran successfully. However, it was not possible to use nrf24 trans-receiver for simulation. Instead a single chip with two analog inputs was used; one for the transmitter and the other one for the receiver.

4.3.2 Bread-boarding

The second stage of construction was putting up all the components on a breadboard according to the circuit diagram above. Setting up the circuit on the bread-board was essentially. It was easy to identify faulty components and make the necessary changes where necessary. The changing and re-arranging of the circuit could have been too hard when the circuit is already fixed onto the copper board. The circuit perfectly worked on the breadboard and all that remained was to solder on a copper board. Unlike at the simulation stage, nrf2401 trans-receivers were used.

4.3.3 Component Fixing and Soldering onto a copper board

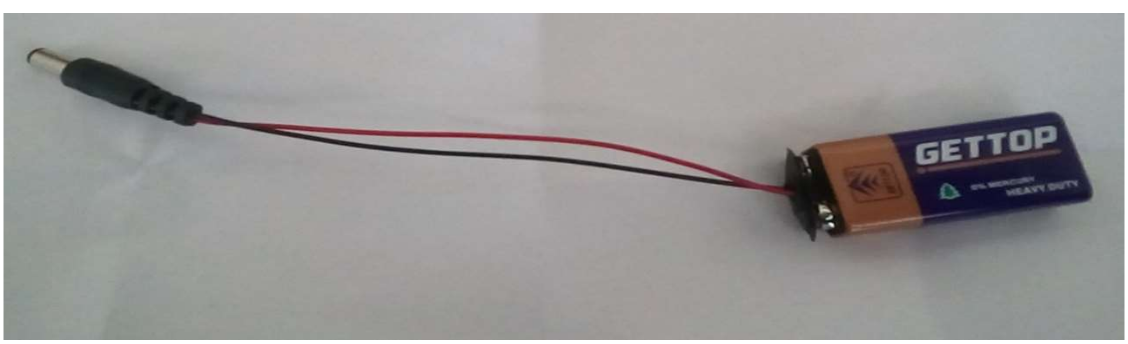
The functioning circuit was then shifted on the copper board. This process involved screwing of the various components to the board and making electrical connections by soldering. Not all components were directly fixed onto the board however. Some like the LCD displays and gsm module were just left free.

4.4 System Units

The system is divided into several units as discussed below.

4.4.1 Power Supply Unit

It is necessary to design a Power Supply that would provide sufficient power to the system. The Power Supply Unit (PSU) will be used to supply the whole system with a constant 9V DC supply. It is composed of a high density 9V battery. This high voltage will be fed through the power supply which supports 6-12V so as to be converted to a 5V and 3.3V to supply voltage throughout the remainder of the Circuit. Atmega328P requires 5V and the nrf24 3.3V so the power supply is adequate for them. The battery is shown in the diagram below together with the connector.



4.4.2 Controller Unit

As discussed in Chapter III, the on-board processor will serve as the main processing unit for the device. It is composed of Atmega 328P microcontroller chip.

4.4.3 Sensory Unit

The sensory unit consists of two current sensors to sense current and two nrf24 transcievers which transmits the sensed current from slave pole to master for compairing.

4.4.4 Display Unit

It consists of two 16×2 liquid crystal display which displays current values. Pin 3 is grounded through a 1K resistor to set the contrast of the display. Pin 15 and 16 are used for backlight.

4.4.5 System Testing

It is important to test performance of the system. The testing of the prototype was done by first connecting the system to a normal load and noting down the current on the distribution side and on the consumer side. Also the reading is taken a theft load is switched and noting how the current changes in the distribution. It's also important to test whether GSM sends message when a theft load is switched on. The results of the testing are as discussed in the next chapter.

5.0 RESULTS AND DISCUSSION

The functioning of the system was tested. The testing was done by having two loads, one for the normal load and the other one to act as the theft load. For normal electricity distribution, the current on the distribution side should be equal to the current on the consumers. But, the moment theft load is switched on, current on the distribution side increases and the system sends a notification text through gsm to the necessary authority for appropriate action to be taken.

STATUS	**OBSERVATIONS**			
	DISTRIBUTION CURRENT(AMPS)	CONSUMER CURRENT(AMPS)	CONSUMER LCD	GSM TEXT
At NO Load	0.00	0.00		__
Normal Load ON	0.03	0.03		__
Theft Load ON	0.07	0.03	Theft Detected SMS send	Power Fault at Pole Number 1 check out!!!

The system has two current sensors one for measuring the distribution current and the other one for measuring consumers current. When load current the current on the line is zero. Current value rises to 0.03A when normal load is connected to line. The moment a theft load is connected in the line, the current on the distribution side increases to 0.07A. The load used include 75W bulb for normal and 100W bulb for theft load

Current on the distribution side increases because current is divided when a theft load is connected so more current is drawn from the distribution side to meet the demand and this may cause the system to be unstable causing blackouts. The GSM module sends text notification to distribution station for appropriate action to be taken to prevent theft cases to increase.

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

In conclusion, this project is used for low transmission line. From this project monitoring of the transmission line is done. If power theft is done between the transmission lines then GSM module sends the signal to mobile of corresponding person.

From the project the aim of the project was achieved i.e. the complete system was able to detect an electrical power theft without any human interface. Also the objective of the project was met. The values of current was fluctuating since its A.C hence causing some errors in the calculation on the current. This project if implemented will help in improving the efficiency of power distribution to consumers since there will be no interferences in the line.

The project was successful despite the current errors that was there.

6.2 RECOMMENDATION

The system, as designed and constructed in this work, is applicable and critical in realizing its objectives. Nevertheless, further study needs to be done on certain areas to improve the efficiency of the system. This study puts across three recommendations for future research within the scope of this work:

- The future work will be to modify the same proposed system to facilitate the detection of fault in the power system along with the power theft.
- Modify the system to be able to cut the supply to the person stealing electricity.
- Modify the system to be able to re-adjust if the number of consumer's increases as current will also increase.

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APPENDIX I 1

Receiver Code

```
#include <SPI.h>
#include "nRF24L01.h"
#include "RF24.h"
#include <SoftwareSerial.h>
#include <LiquidCrystal.h>
SoftwareSerial mySerial(3, 5);
LiquidCrystal lcd(7,6,A5,A4,A3,A2);
RF24 radio(9,10);
byte address[][6] = {"0"};//set addresses of the 2 pipes for read and write
float sensorIn = A0;
int mVperAmp = 185; // use 100 for 20A Module and 66 for 30A Module
double Voltage = 0;
double VRMS = 0;
double VRMS1 = 0;
double AmpsRMS = 0;
int led_pin = 13;

struct package
{
float AmpsRMS = 0;
};

typedef struct package Package;
Package data;

void setup(){
mySerial.begin(9600);   // Setting the baud rate of GSM Module
Serial.begin(9600);
pinMode (led_pin,OUTPUT);

lcd.begin (16,2);
lcd.print ("THEFT DETECTOR");
lcd.setCursor(0,1);
lcd.println (" WITH ARDUINO  ");
delay (1000);
lcd.clear();
lcd.setCursor (0,0);
lcd.print("  CONSUMER  ");
lcd.setCursor (0,1);
lcd.print ("   SIDE  ");
delay (1000);

radio.begin ();
```

```
radio.openReadingPipe(1, address[0]);
radio.setPALevel(RF24_PA_MIN);
radio.setDataRate(RF24_2MBPS);
radio.setChannel(123);
radio.startListening();

}

void loop(){
Voltage=getVPP();
VRMS=(Voltage/2.0)*0.707;
AmpsRMS = (VRMS*1000)/mVperAmp-.05;
Serial.print(AmpsRMS);
Serial.println(" Amps");

if (radio.available()){

radio.read(&data, sizeof(data));
Serial.print(data.AmpsRMS);
Serial.println(" Amps RMS");
lcd.clear();
lcd.setCursor (0,0);
lcd.print("Distri:");
lcd.print(data.AmpsRMS);
lcd.print("Amps");
delay(0);

lcd.setCursor (0,1);
lcd.print("Consum:");
lcd.print(AmpsRMS);
lcd.print("Amps");
delay(0);

if (data.AmpsRMS>AmpsRMS+.03){
Serial.println("Initializing...");
delay(1000);
mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
delay(1000);  // Delay of 1000 milli seconds or 1 second
mySerial.println("AT+CMGS=\"+254713713837\"\r"); // Replace x with mobile number
delay(1000);
mySerial.println("POWER FAULT AT POLE NUMBER 1, CHECK OUT!!!");// The SMS text
you want to send
delay(100);
mySerial.println((char)26) ;// ASCII code of CTRL+Z
delay(1000);
```

```
digitalWrite(led_pin,HIGH);
Serial.print("theft detect alarm");
lcd.clear();
lcd.setCursor(0,0);
lcd.print("THEFT DETECTED");
lcd.setCursor(0,1);
lcd.print("SMS Sent");
delay(1000);


}
else{
digitalWrite (led_pin,LOW);

}

}
}

float getVPP()
{
float result;
int readValue;
int maxValue=0;
int minValue=4095;
uint32_t start_time=millis();

while((millis()-start_time)<1000) //sample for 1 sec
{
readValue=analogRead(sensorIn);
if(readValue>maxValue)
{
maxValue=readValue;
}
if(readValue<minValue)
{
minValue=readValue;
}
}
//maxValue = 4095-maxValue;
//minValue=4095-minValue;
result=((maxValue-minValue)*3.3)/4095.0;
Serial.println(maxValue);
Serial.println(minValue);
return result;
}
```

APPENDIX I 2

ACS712

Fully Integrated, Hall Effect-Based Linear Current Sensor with 2.1 kVRMS Voltage Isolation and a Low-Resistance Current Conductor

COMMON OPERATING CHARACTERISTICS[1] over full range of T_{OP}, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

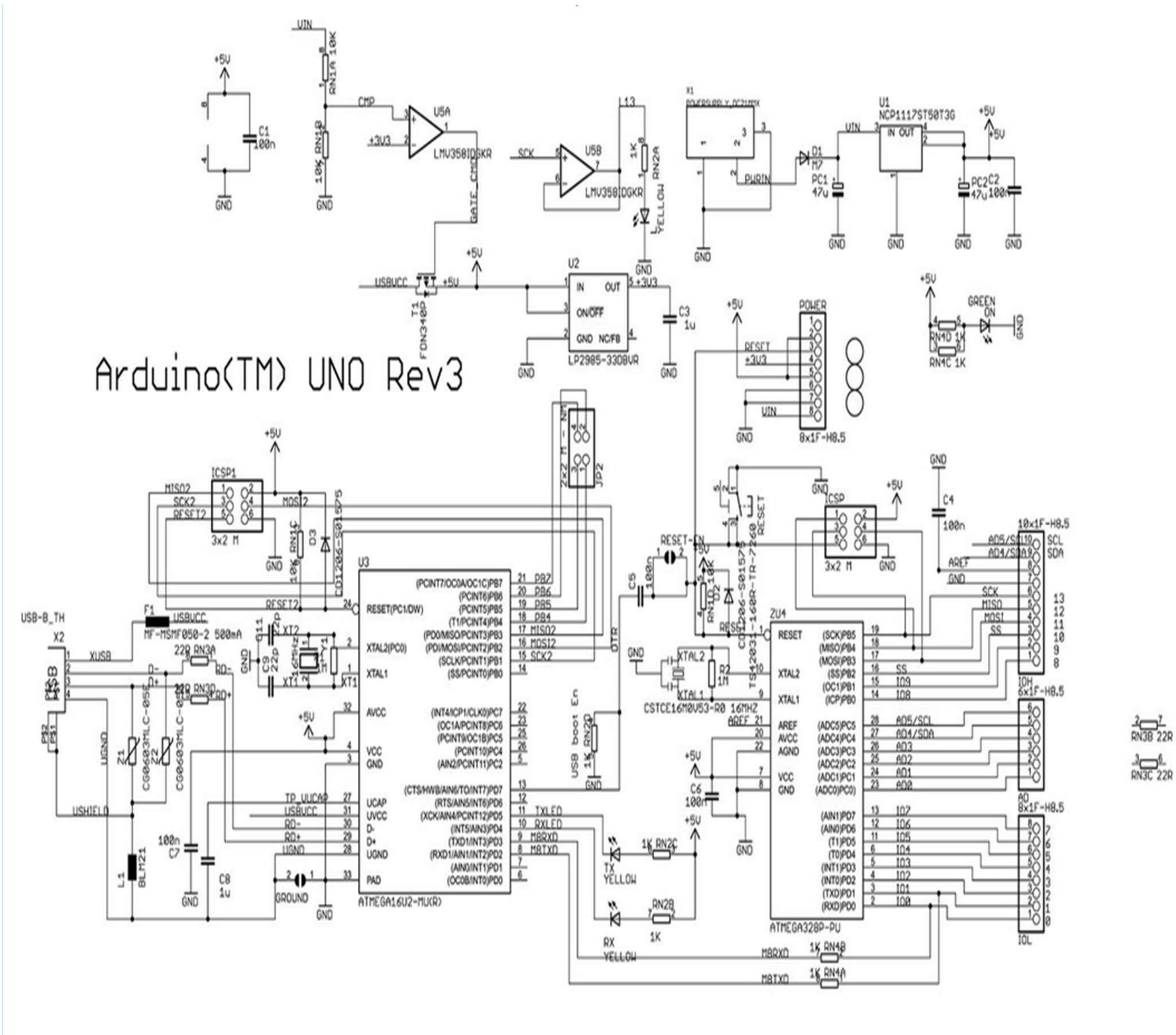
Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	V_{CC} = 5.0 V, output open	6	8	11	mA
Output Zener Clamp Voltage	V_Z	I_{CC} = 11 mA, T_A = 25°C	6	8.3	–	V
Output Resistance	R_{IOUT}	I_{IOUT} = 1.2 mA, T_A=25°C	–	1	2	Ω
Output Capacitance Load	C_{LOAD}	VIOUT to GND	–	–	10	nF
Output Resistive Load	R_{LOAD}	VIOUT to GND	4.7	–	–	kΩ
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	1.2	–	mΩ
RMS Isolation Voltage	V_{ISORMS}	Pins 1-4 and 5-8; 60 Hz, 1 minute, T_A=25°C	2100	–	–	V
DC Isolation Voltage	V_{ISODC}	Pins 1-4 and 5-8; 1 minute, T_A=25°C	–	5000	–	V
Propagation Time	t_{PROP}	$I_P = I_P$(max), T_A = 25°C, C_{OUT} = open	–	3	–	μs
Response Time	$t_{RESPONSE}$	$I_P = I_P$(max), T_A = 25°C, C_{OUT} = open	–	7	–	μs
Rise Time	t_r	$I_P = I_P$(max), T_A = 25°C, C_{OUT} = open	–	5	–	μs
Frequency Bandwidth	f	–3 dB, T_A = 25°C; I_P is 10 A peak-to-peak	50	–	–	kHz
Nonlinearity	E_{LIN}	Over full range of I_P	–	±1	±1.5	%
Symmetry	E_{SYM}	Over full range of I_P	98	100	102	%
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A, T_A = 25°C	–	V_{CC} × 0.5	–	V
Magnetic Offset Error	V_{ERROM}	I_P = 0 A, after excursion of 5 A	–	0	–	mV
Clamping Voltage	V_{CH}		Typ. –110	V_{CC} × 0.9375	Typ. +110	mV
	V_{CL}		Typ. –110	V_{CC} × 0.0625	Typ. +110	mV
Power-On Time	t_{PO}	Output reaches 90% of steady-state level, T_J = 25°C, 20 A present on leadframe	–	35	–	μs
Magnetic Coupling[2]			–	12	–	G/A
Internal Filter Resistance[3]	$R_{F(INT)}$			1.7		kΩ

[1]Device may be operated at higher primary current levels, I_P, and ambient, T_A, and internal leadframe temperatures, T_{OP}, provided that the Maximum Junction Temperature, T_J(max), is not exceeded.

[2]1G = 0.1 mT.

[3]$R_{F(INT)}$ forms an RC circuit via the FILTER pin.

APPENDIX I 3



APPENDIX I 4

BILL OF QUANTITIES

S/N	ITEM	PRICE (KSH)	QUANTITY	AMOUNT(KSH
1.	Current sensor	400	2	800
3.	Atmega 328 chip	350	2	700
4.	16×2 LCD	450	2	900
5.	nRF24L01 module	600	2	1,200
6.	GSM 800L module	800	1	800
7.	Jumper Wires (40 wires)	150	1	150
8.	Breadboard	250	1	250
9.	2.5mm^2 cable	120	2	240
10.	Bulb	50	2	100
11.	Switch	100	2	200
12.	Copper Board	300	1	300
13.	Simcard	50	1	50
14.	9V battery	50	2	100
15.	Power Supply	200	1	200
16.	Resistors	50		50
	TOTAL			6,040

Table 4. 1 Project Proposed Budget