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GSM Based Smart Energy Meter using Arduino

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Abstract: Existing energy meters are not consumer friendly because the consumer cannot be able to know about their energy consumption and it always needs periodic checking's from utility to inform about their monthly tariff, this process requires more man power.

This proposed project reduces this over burden and it makes real time observation of energy consumption by the consumer and it also sends SMS on daily/monthly basis and helps in implementing off peak loading concept with load control, over and under voltage intimations.

This project involves ARDUINO UNO as main microcontroller, GSM for communication, voltage and current sensors for measurement, LCD display for monitoring, ARDUINOIDE software for programming ARDUINO.

Keywords: ARDUINO UNO, GSM (Global System for Mobile communication), Voltage & Current Sensors , LCD display 4-channel relay, loads.

I. INTRODUCTION

Digital meters that replace the old analog meters used in homes to record electrical usage . Digital meters can transmit energy consumption information back to the utility on a much more frequent schedule than analog meters, which require a meter reader to transmit information.

Electrical energy use will be recorded every hour or less at your homes . Smart meters will enable you to monitor your consumption more precisely so you can make more informed energy choices . Depending on the feature set, the meter may also notify the customer about the overvoltage, under voltage and peak load hours .

By having the knowledge about such information a customer can take the actions like remotely switching off loads , to protect the loads from damaging during overvoltage conditions and also can implement off peak loading concept in order to save their electricity bill.

The household energy consumption can be reduced by providing real-time feedback to homeowners so they can change their energy use.

A. Understanding AC Power

Power in an electric circuit is the rate of flow of energy passed a given point of the circuit. In alternating current circuits ,energy storage elements such as inductors and capacitors may result in periodic intervals of the direction of energy flow.

The portion of power that, averaged over a complete cycle of the AC waveform, results in net transfer of energy in one direction is known as Active power(sometimes also called as real power). The portion of power due to stored energy, which returns to source in each cycle , is known as Reactive power.

II. EQUIPMENT USED IN THIS PROJECT:

We have used Arduino UNO as main microcontroller, half wave bridge rectifier circuit for measuring AC voltage, ACS712 20A current sensor to measure AC current ,GSM (Global S ystem for Mobile Communication) for communication between meter and the customer, relay is used as a switch for remotely turning ON/OFF the loads ,and an LCD display for monitoring voltage,current and energy consumption.

A. Arduino Uno

Arduino is an open -source electronics platform based on easy -to- use hardware and software .Arduino boards are able to read inputs -lights on a sensor,a finger on a button ,or a twitter message - and turn it into an output- activating a motor ,turning on an



Fig. 1 Arduino microcontroller

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.

Thanks to its simple and accessible user experience, Arduino has been used in thousands of different projects and applications. The arduino software is easy-to-use for beginners, yet flexible enough for advanced users. It runs on Mac, windows, and Linux. Teachers and students use it to build low cost scientific instruments, to prove chemistry and physics principles, or to get started with programming and robotics. Designers and architects build interactive prototypes, musicians and artists use it for installations and to experiment with new musical instruments.

B. ACS712 CT Interfacing Arduino

As we mentioned before, this CT is for educational purpose. It's cheap, low accuracy, harmonic source cannot handle more than 10A load current although its data sheet says its current capacity is 20A.

20A Range Current Sensor Module (ACS712)



Description:
 1, the current sensor chips: ACS712ELC-20A;
 2, pin 5V power supply, on-board power indicator;
 3, the module can measure the positive and negative 20 amps, corresponding to the analog output 100mV / A;
 4, no test current through the output voltage is $V_{CC} / 2$;
 5, PCB board size: 31 (mm) x13 (mm);
 Note: ACS712 is based on the principle of the Hall test, please use this field to avoid impact

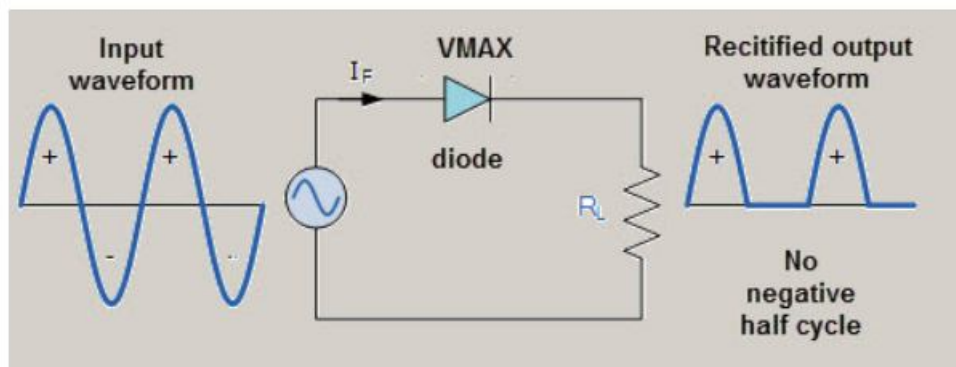
Package:
 1 PCS 20A range Current Sensor ACS712 Module

Fig. 1 ACS712 20A current sensor

So for an industrial version of our we have to use one of CT types which we mentioned before.To connect a CT sensor to an ARDUINO, the output signal from the CT sensor needs to be conditioned, it meets the input requirements of the Arduino analog inputs , i.e. a positive voltage between 0V and the ADC reference voltage.

C. AC Voltage Measurement

A rectifier is an electronic device that converts AC voltage into DC voltage. In other words, it converts alternating current to direct current. A rectifier is used in almost all the electronic devices. Mostly it is used to convert the main voltage into DC voltage in the power supply section. By using DC voltage supply electronic devices work. According to the period of conduction, rectifiers are classified into two categories: Half Wave Rectifier and Full Wave Rectifier.



Half wave Rectifier Working

Fig. 3 voltage sensor circuit

In this project, we have used a step down transformer to reduce the 230v AC voltage to 9v AC voltage and then reduced it to 5v using voltage divider circuit and then used a half wave bridge rectifier circuit to convert it into dc supply and its analog value is given as input to Arduino to measure respective AC voltage at the output side we have connected a capacitor and the zener diode in order to filter ac ripples and to limit the dc output to 5v, as we cannot give more than 5V as input to Arduino.

D. GSM(Global System For Mobile Communication) Module

This GSM Modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily.

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.

- 1) Read, add, search phonebook entries of the SIM.
- 2) Make, Receive, or reject a voice call.



Fig. 4 GSM (Global System for Mobile communication) Module

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.

Specification:-

Design for Industrial Application:-

- a) High-powered industrial cellular module.
- b) Housing: iron, providing IP30 protection.
- c) Power range: DC 5~35V

E. Liquid Crystal Display

A liquid crystal display or LCD draws its definition from its name itself. It is combination of two states of matter, the solid and the liquid. LCD uses a liquid crystal to produce a visible image. Liquid crystal displays are super-thin technology display screen that are generally used in laptop computer screen, TVs, cell phones and portable video games. LCD's technologies allow displays to be much thinner when compared to cathode ray tube (CRT) technology.

Liquid crystal display is composed of several layers which include two polarized panel filters and electrodes. LCD technology is used for displaying the image in notebook or some other electronic devices like mini computers. Light is projected from a lens on a layer of liquid crystal. This combination of colored light with the grayscale image of the crystal (formed as electric current flows through the crystal) forms the colored image. This image is then displayed on the screen.

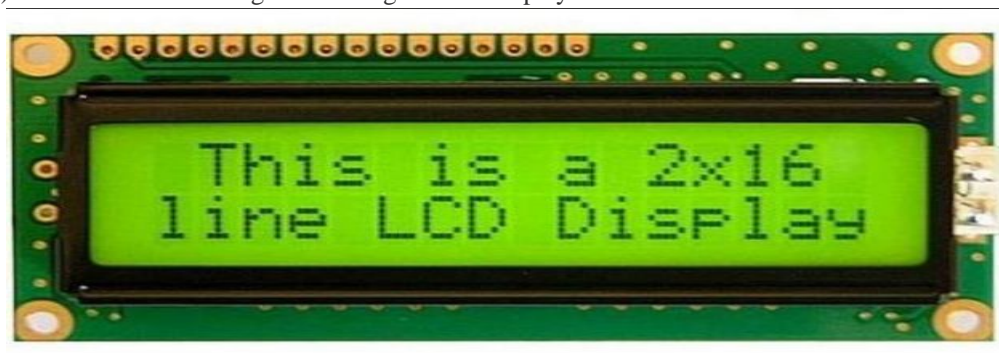


Fig. 5 Liquid Crystal Display (LCD)

1) Advantages of an LCD's

- a) LCD's consumes less amount of power compared to CRT and LED
- b) LCD's are consist of some microwatts for display in comparison to some mill watts for LED's
- c) LCDs are of low cost
- d) Provides excellent contrast
- e) LCD's are thinner and lighter when compared to cathode ray tube and LED

F. 4-Channel Relay

This is a 5V 4-channel relay interface board, and each channel needs a 15-20mA driver current. It can be used to control various appliances and equipment with large current. It is equipped with high-current relays that work under AC250V 10A or DC30V 10A. It has a standard interface that can be controlled directly by microcontroller.

1) Features

- a) Size: 75mm (Length) * 55mm (Width) * 19.3mm (Height)
- b) Weight: 61g
- c) PCB Color: Blue
- d) There are four fixed screw holes at each corner of the board, easy for install and fix. The diameter of the hole is 3.1mm
- e) High quality Songle relay is used with single pole double throw, a common terminal, a normally open terminal, and a normally closed terminal
- f) Optical coupling isolation, good anti-interference.
- g) Closed at low level with indicator on, released at high level with indicator off
- h) VCC is system power source, and JD_VCC is relay power source. Ship 5V relay by default. Plug jumper cap to use
- i) The maximum output of the relay: DC 30V/10A, AC 250V/10A

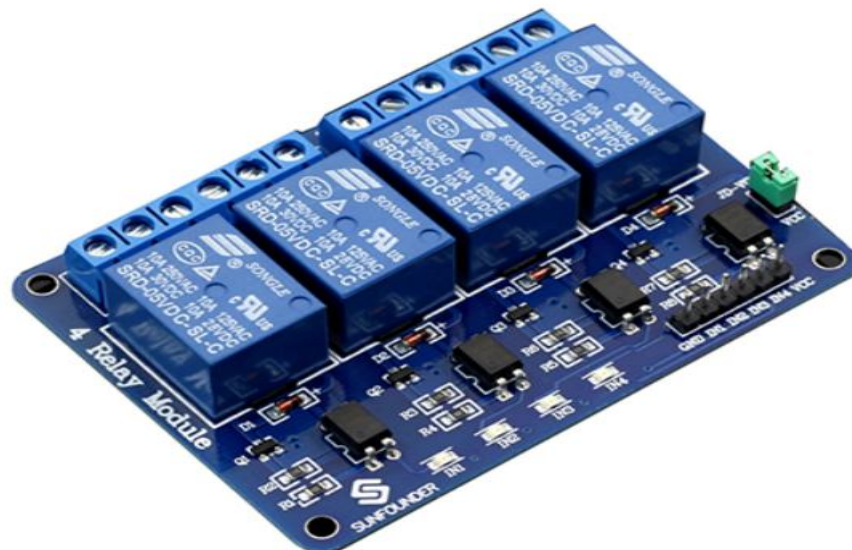


Fig. 5 4-channel Relay

III.BLOCK DIAGRAM

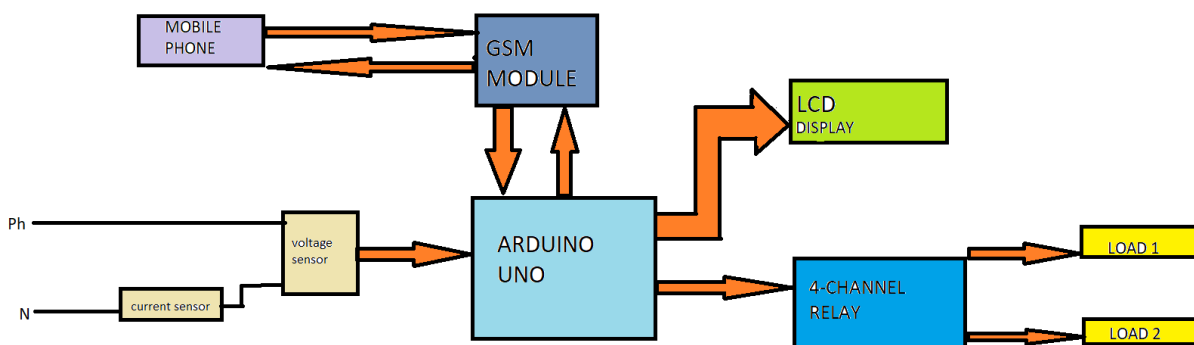


Fig. 6 Block Diagram Of Project

IV.EXPLANATION

From the above block diagram we can easily conclude the use of each and every equipment.

Voltage sensor, current sensor measures the voltage and current values and then send the measured values to the microcontroller(Arduino).GSM module is used to act as interface between the user and the meter . i. e..information can be sent from microcontroller to the gsm module from which data can be transmitted to user using gsm module

Similarly the data sent by the user can be received by microcontroller using gsm module.

Lcd display here is used to display the actions taken by the microcontroller can be displayed here (just like measured voltage, current, messaging actions can be displayed here.

The 4-channel relay here used is to perform the action of a switch whenever a 5v signal is received from microcontroller it can be turned-ON and when this signal is removed it can be turned-OFF.

V. WORKING

In this project,we are going to measure the ac voltage using half wave bridge rectifier circuit, and the AC current is measured using ACS712 20A current sensor, hence these acts as inputs to the microcontroller(Arduino UNO). The output of the entire system can be observed in the LCD screen. Since the main aim of this project is to intimate the overvoltage and under voltage conditions are arised during working conditions .hence whenever the measured AC voltage is greater than the predefined value then it sends an sms to the mobile number that is present in the program. On arrival of the message ,it waits for the response from the user .

This response can be a message that indicating the microcontroller to trip the CB. Such that all the loads are turned -OFF at a time protecting the equipment from the damage ,Similarly during under-voltage conditions there will be same action taken by the meter to protect the equipment.

Not only these ,by using this meter we are able to implement the off –peak loading concept i.e ..,whenever all the loads present on the meter are turned–ON at a time then an intimation message will be sent by the microcontroller to the user mobile indicating that “turn-OFF your loads to save your bill” and then waits for a reply from the user .

The reply consists of the loads that are need to be turned OFF (unnecessary loads) when this message is received by microcontroller then it sends a signal to the relay to which the loads are connected.

Hence by using this type of meters in industries can make the owners to obtain the profit of off-peak loading that is utility offers some discount rates to the industries that implement off peak loading concept.

VI. OUTPUTS

A. Under Normal Working Conditions

1. Ac voltage, Current and Power Measurement



Fig. 7(a) Lcd Output

2. Relay status Will Be

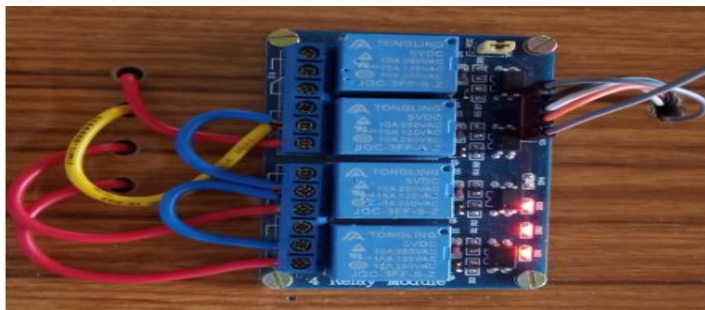


Fig. 7(b) Relay Output

3. All Loads are ON

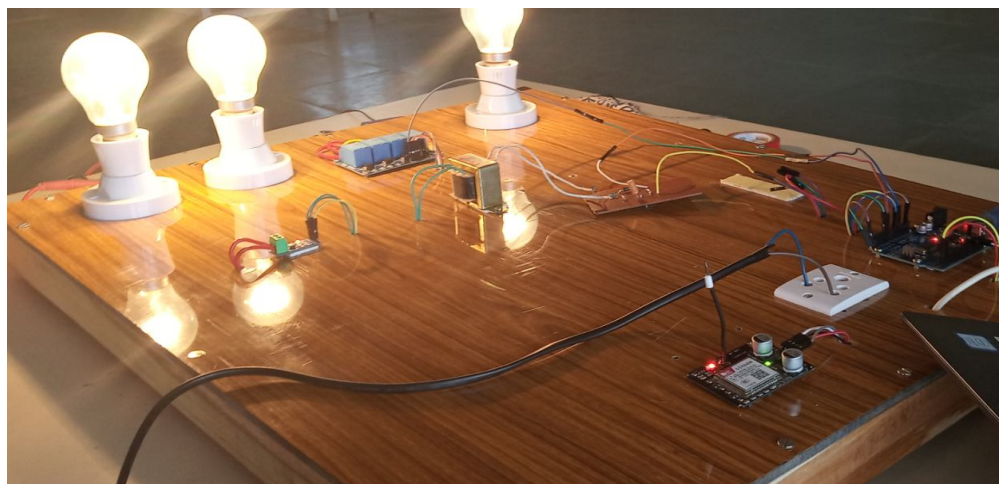


Fig. 7(c) Project View

4. When An Undervoltage Is Raised Message Sent By Meter Indicating Undervoltage Is Arised

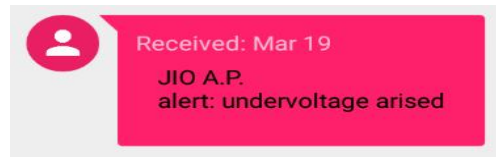


Fig. 7(d) Message sent to User

5. If We Sent A Reverse Message To Turn Off Relay Then It Will Turn Off All The Loads

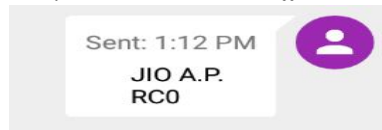


Fig. 7(e) Message sent to Arduino



Fig. 7(f) Relay status after sending Message

B. Similarly if an OVERVOLTAGE is arised then

1) Message Sent By Meter To The Registered Mobile Number

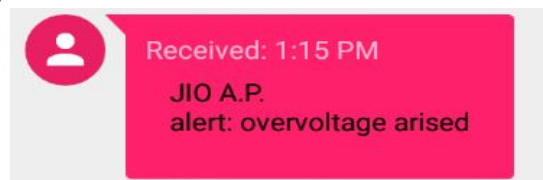


Fig. 7(g) Message sent to User

2) If We Sent A Reverse Message To Turn Off Relay Then It Will Turn Off All The Loads

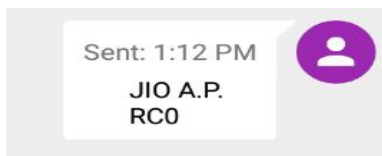


Fig. 7(h) Message sent to Arduino

3) Relay Status After Turning Off All The Loads



Fig. 7(i) Relay status after receiving Message

C. Under Peak Load Conditions

If all the loads are turned ON at a time then the current value will be greater than the predefined limit, in this case also it sends us a message to turn OFF the unnecessary loads.

1) When all loads are ON at a time then relay status will be

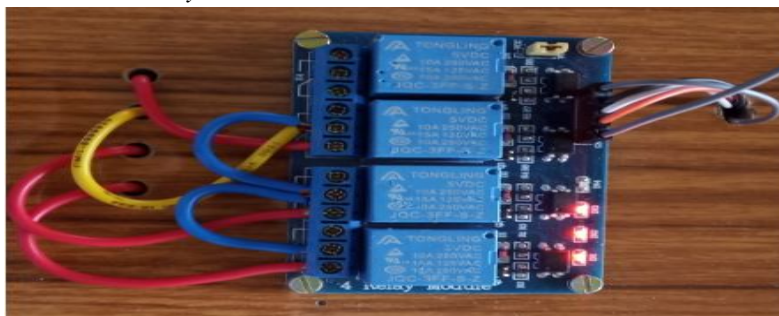


Fig. 7(j) Relay status when peakload Arised

2) Message Sent By Meter To The User Will Be

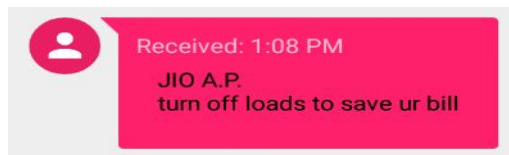


Fig. 7(k) Message sent to User

3) The Reverse Message Sent By The User To Turn Off The First Relay Will Be

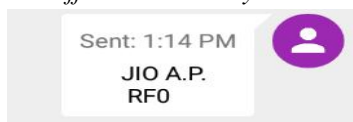


Fig. 7(l) Message sent to Arduino

4) Then the first relay will be turned OFF by the meter

5) The relay status will be

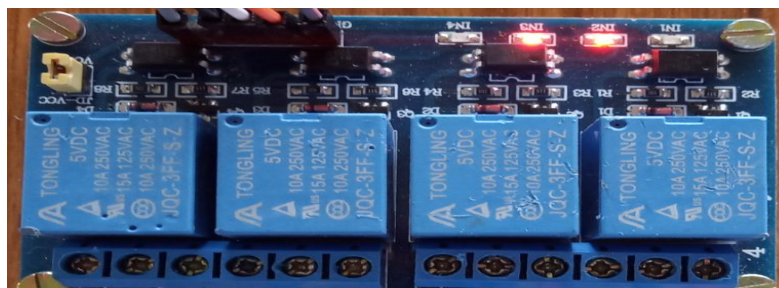


Fig. 7(M) Relay status after receiving Message

VII. CONCLUSION

Hence in this way when this type of smart meter is connected to a Residential load/commercial load/industrial load then it will help us in monitoring the electrical supply as well as helps in protecting the loads from OVERVOLTAGE and UNDER-VOLTAGE. It also helps in implementing the OFF-PEAKLOADING concept in real time. And helps the customer in saving their electricity bills and increases the life expectancy of the equipment, it is user friendly also.

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