Electrical Power Project

Submitted for EPM 3171

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Introduction

In today’s dynamic world, electricity usage permeates every aspect of our lives, underlining the crucial role of power engineering. From generating electricity to distributing it through power grids to be able to supply the load demands and maintain a stable power network.

Hence this shows the need for accurate measurement of power consumption and energy usage Whether it was for designing robust power grids simply for calculating electricity bills, the ability to precisely measure energy consumption is a necessity.

So we decided to design a smart watthour meter, our report will be divided into three sections first section is for hardware, the second section is for simulation and the last section for software.

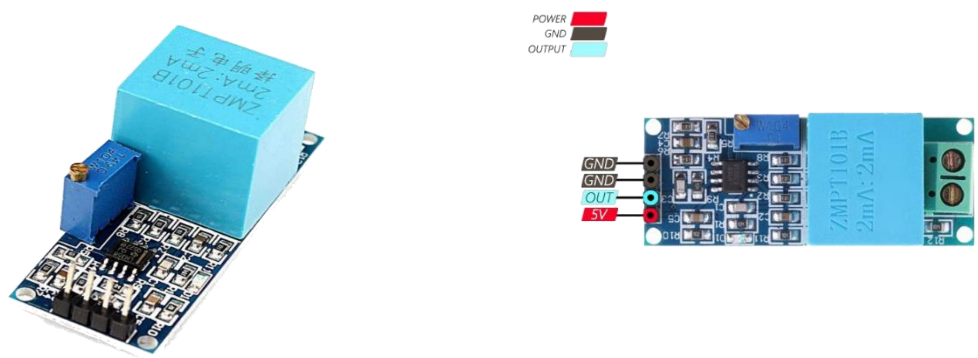
Note: There are bookmarks for easier navigation.

First section: Hardware.

1) The used components

1. AC Voltage sensor module (ZMPT101B)

This is the component responsible for measuring the voltage signal and translating it to a readable value that will be displayed on the LCD screen, it Measures AC voltage up to 250 volts and converts it to an analog voltage signal (0-5V).



Figure(1): ZMPT101B Voltage sensor.

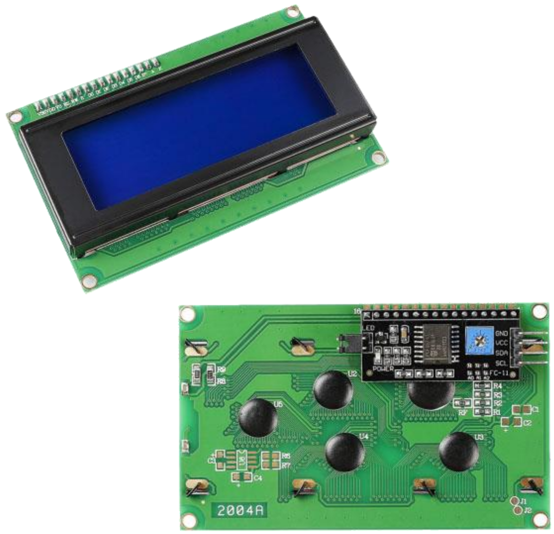
2. Non-invasive AC Current sensor (SCT-013-030)

This is the component is responsible for measuring the AC current signal passing through a wire and translating it to a readable value that will be displayed on the LCD screen, it Measures AC current up to 100 amps and converts it to an analog voltage signal, it’s used by clamping it around a wire rather than cutting a wire which makes it safer and more convenient.

Figure(2): SCT-013-030 AC Current sensor.

3. 20 x 4 LCD Display

This is the LCD display where the measurements coming from the sensors will be displayed, it consists of 4 Rows to be able to display instantaneous voltage, current, power and display the total Watthour energy consumed each on a single row.



Figure(3): 20*4 LCD.

4. Arduino UNO R3

That’s the microcontroller board used its based on ATmega328 AVR microcontroller.

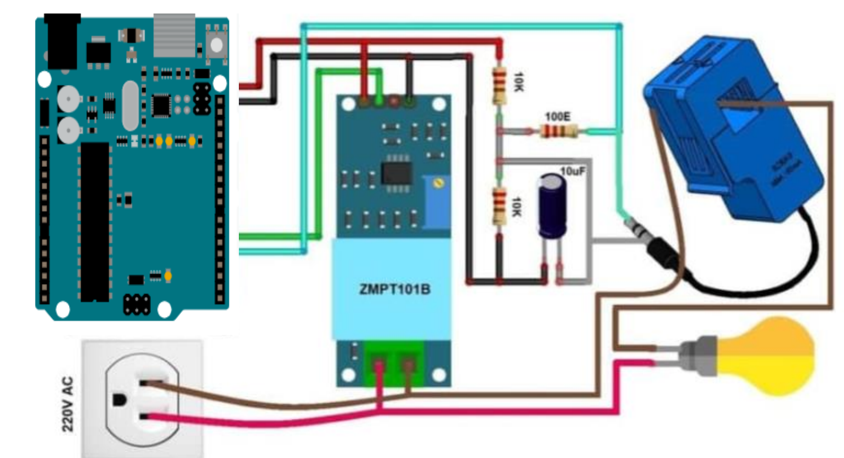
Figure(4): Arduino UNO R3 MCU.

5. Other components

Other components are used to interface LCD with sensors with Arduino processor like breadboard which is the platform on which the electronic circuit will be build, its perfect for easily placing and removing the components on it and makes it easier to connect nodes together, some jumper wires, resistors, capacitors, and potentiometer to control LCD brightness.

Figure(5): Other components used.

2) The Circuit Layout

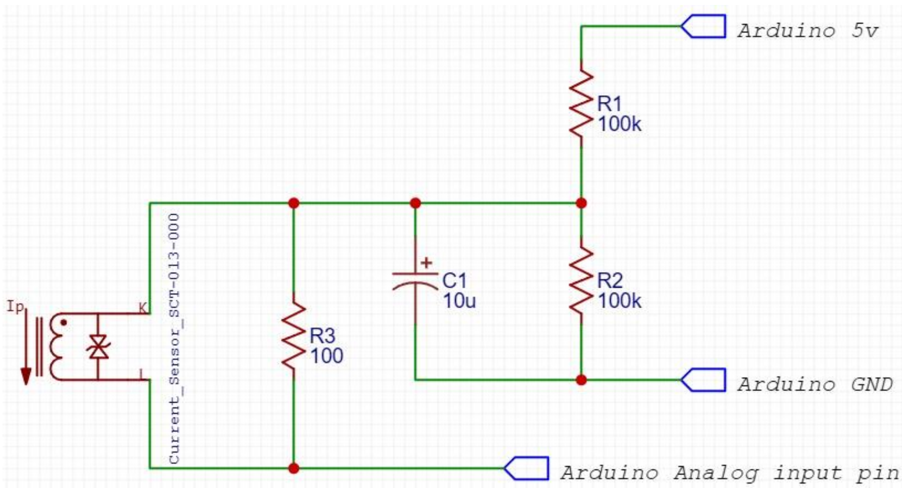


Figure(6): Circuit Diagram using fritzing.

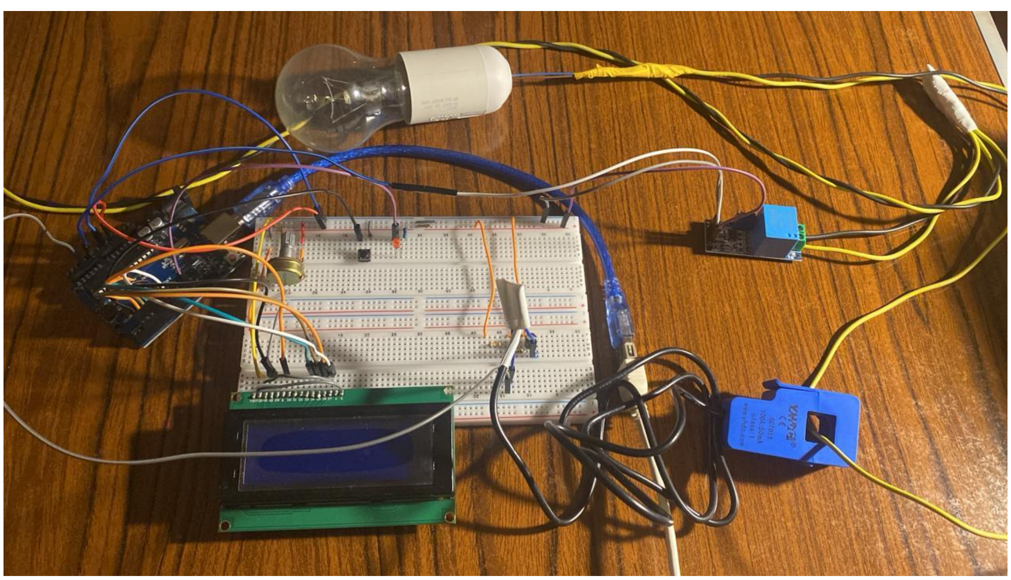
The connection diagram is simple. Both the Sensor, i.e. SCT-013 Current Sensor & ZMPT101B Voltage Sensor VCC is connected to Vin of Arduino which is a 5V Supply. The GND pin of both the modules is connected to the GND of Arduino. The output analog pin of the ZMPT101B Voltage Sensor is connected to pin14 of Arduino. Similarly, the output analog pin of SCT-013 Current Sensor is connected to pin16 of Arduino. You need a two resistor of 10K & a single resistor of 100 ohms connected along with a 10uF Capacitor.

Apart from the circuit part, the AC wires where the current and voltage needs to measured are connected to the input AC Terminal of Voltage Sensor. Similarly, the current sensor clip doesn't have any connection and a single live wire or neutral wire is inserted inside the clip part.

The current sensor connections diagram.



Figure(7): Current sensor connections.



Figure(8): The Actual Circuit.

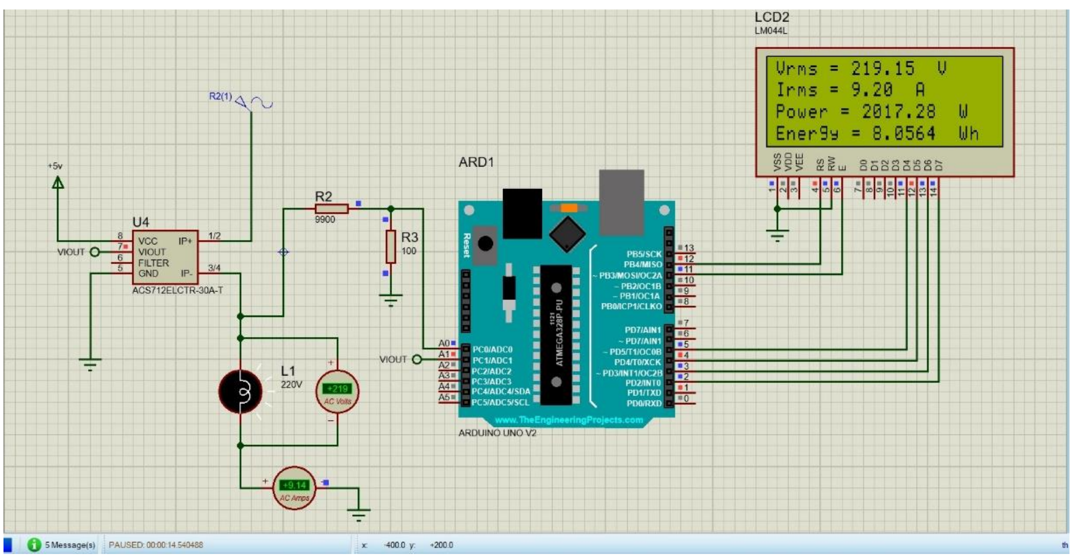
Second section: Simulation.

Using proteus software to simulate the circuit but there were some challenges:

- Arduino UNO Component wasn't in Proteus library, we searched on the internet for an Arduino UNO design and found one.
- The Voltage Sensor ZMPT wasn't in Proteus library, also there were no design for this component on the internet, so we used a voltage divider as a voltage sensor.
- The Current sensor SCT wasn't in Proteus library, but we found another one named ACS712 and we used it.

Then we used a 220V Lamp as a load (24 ohm), the input is sine wave with RMS Amplitude = 220V and Frequency = 50 Hz, Hence current should be nearly 9 amperes.
We also used AC Voltmeter and AC Ammeter to check that the reading values matches the real values.

Note: The Simulation code, proteus design and the Arduino code will be uploaded to the drive and we will attach the drive link at the end of the report.



Figure(9): Proteus Design.

Third section: Software.

In This section we will discuss the Arduino code used and the code drive link will be attached at the end.

- As discussed before the sensors will be connected to analog pins of Arduino board, which will be configured in the code to read the sensor values and calculate the apparent power using emon Arduino library the display the result on the LCD which will be connected to output pins of the board.
- Sensors read both voltage and current value and convert them to analog voltage signal in range [0,5] Volts, to be able to be passed to the microcontroller without damaging it, hence a calibration factor is needed to convert from high AC values to proper values.
- Both sensors aren't pre-calibrated, hence we need to calibrate the sensors to read the true value.
- Calibration factor depends on a lot of factors as phase shift of AC voltage signal and other factors related to the suppling voltage which change from an area to another.
- The calibration method is simply to use an AVOmeter to measure the values and change calibration factors till the reading matches the AVOmeter reading.
- Another method if no AVOmeter is available is to write Arduino code to iterate among calibration factors that are provided from those who used sensors before, and this is the method we used.
- Knowing that Egypt electricity is 220 v AC 50 Hz, and knowing lamp is 100 Watts, we made the code iterate till the difference between measured current and the actual current (error) in is less than 0.005 Amperes, and till the difference between measured voltage and actual voltage is less than 0.1 Volts.
- Our calibration function is called when pressing a push button.
- Another method used for calibration is to get the voltage sensor reading and draw the waveform using Arduino and knowing Egypt electricity values and supposed waveform you should calibrate till get a matched waveform, more details of this method is provided in the first reference.

  Note: the zmpt voltage sensor has a potentiometer used also to help in calibration.

Drive Link: Arduino code, proteus design and code are here.

References

[1] Interfacing ZMPT101B Voltage Sensor with Arduino.

[2] IoT Based Electricity Energy Meter using ESP32 & Blynk.