

SMART ENERGY METER

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Abstract - Smart Energy Meter is an automated billing system that is far more efficient, faster, convenient, and reliable than the meter currently in use by Nepal Electricity Authority, Nepal's sole electricity provider. Because the units being consumed, as well as the amount of energy used (in currency), are displayed in the Dashboard/LCD, the Energy Meter we created requires minimal human effort. As a result, it is a very dependable method of electric billing.

To measure the input current and Voltage, this Energy Meter has a Current Sensor and a Voltage Divider Circuit. The Power Factor has been set to Constant because the meter is for residential use. We calculated power, energy, units consumed, and the amount of energy consumed in Nepalese currency using an Arduino (Micro-Controller). As a result, it eliminated errors because no manual calculations were required, and it also minimized the risk of data loss because the data were saved in Arduino. Also eliminated the risk of power theft because the user can't do any interference to the meter which is done in an electromechanical meter.

Key Words: Liquid Crystal Display (LCD), Micro-Controller, Arduino, Dashboard, and Energy Meter.

1. INTRODUCTION

The world is shifting toward automatic wireless systems, which not only lessen human effort but also aid in the automation and efficiency of systems. Whenever a system can determine what to do without being instructed what to do and can work automatically, it is said to be smart.

It is tough to believe life without electricity because it is a necessity. As a result, not only is there a high demand for efficient electricity generation and distribution, but also for how electricity has been used and evaluated at the point of billing. The primary duty of the Nepal Electricity Authority (NEA) is to generate and supply electricity, but it is also necessary to measure the power consumed by consumers, i.e. taking measurements and generating bills. To measure unit consumption, an electromechanical meter is currently available on the market. The person assigned by the Nepal Electricity Authority to take the reading must enter every residence in the area. Following the collection of data, the data is transformed to determine the exact amount of energy used in the metric of a kilowatt-hour (KWh), which is then converted to the equivalent amount in Nepalese rupees. All of these mathematics are done manually, and because the same process is used to calculate power consumption for

every house, many human errors are likely to occur. It necessitates a large amount of manpower. It takes a lot of time and perhaps one of Nepal's most serious issues is power theft.[1] The Smart Energy Meter presented in this paper solves all the issues as everything is done automatically.

1.1 Background

Some meters only measured the length of time that charge flowed, without an indication of voltage and current magnitude.[2] These were only suitable for applications with a constant load. Today, neither type is likely to have been used. Other types of metering are readily available for real-time monitoring depending on the quantity of energy consumption. Ampere-hour meters were used in the early days of electrification.[3] These were reliant on the supply voltage remaining constant for precise energy usage measurement, which was unlikely with most supplies. So, a Smart energy meter which we have presented in this paper works by instantaneously measuring voltage and current finally calculating the product to get instantaneous power, after it is integrated against time, and energy used is calculated. Smaller services (such as small residential users) can have their meters connected directly between the source and the customer.

1.2 Problem Description

The use of an electromechanical meter is common in our society, and the meter reading is frequently tampered with by the user.[4] Because the meter does not display the accurate amount of energy consumed, there is a risk of power theft. People use a magnetic device to tamper with the meter's reading. A lot of calculations are required, which takes a long time because they are done manually, which is also a major issue in the field of engineering because everything has moved to the automation world.

2. LITERATURE REVIEW

The ampere-hour meter is equivalent to the watt-hour meter, both of which are used to calculate total electricity usage in homes and businesses. The ampere-hour meter, on the other hand, accounts for ampere-hours and, like the watt-hour meter, is an integrating meter. It only measured the length of time that charge flowed, without an indication of voltage and current magnitude. These were only suitable

for applications with a constant load. [3] Today, however, no type is almost certain to be used. Other types of metering are available in addition to meter reading based on the amount of energy consumed. Ampere-hour meters, which evaluated the amount of charge (coulombs) used, were used in the early days. These were reliant on the supply voltage remaining constant for exact energy usage measurement, which was unlikely with most supplies.

An electromechanical induction meter counts the number of times a metal disk rotates. This disc's rotation is proportional to the amount of power flowing through the meter. As a result, the amount of energy used is proportional to the number of revolutions.[5] Electromechanical meters are notorious for their unreliability. Anything that lengthens the time between episodes can cause the meter to run heavily, resulting in lower bills. Consumption, humidity, dust, or damage caused by an accidental fall to the floor It has the potential to obstruct work and result in an electro-mechanical meter that does not fully exploit the reason for its creation.

A bidirectional energy meter is a type of energy meter that is used in net metering to add the power used from grid lines to the power produced by a solar plant installed in the house algebraically. This meter calculates the net power used by the consumer by subtracting the power sold to grid lines from the total power used by grid lines. The Nepal Electricity Authority plans to install bidirectional meters in solar-paneled homes so that they can sell the energy generated by their panels to the national grid lines (ranging from 230 volts to 11000 volts).[6]

3. METHODOLOGY

3.1 System Overview

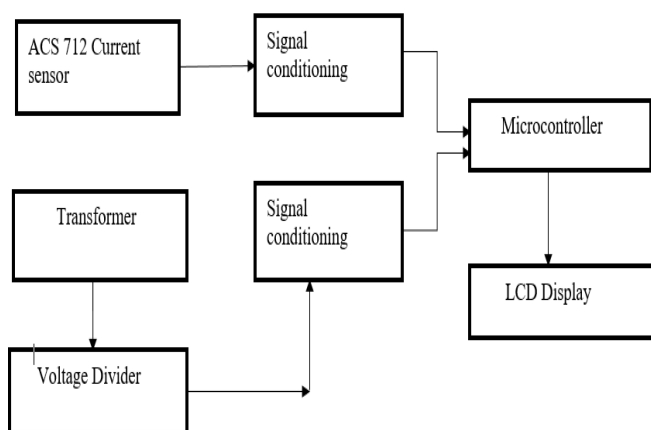


Figure 3.1 Overall System Block Diagram

Our requirement led to the selection of an AC current sensor and the creation of a voltage divider circuit. To keep the error to a minimum, the ac current sensor was meticulously calibrated. Here, a voltage divider circuit was built and

calibrated to obtain the voltage value, which was then fed to the microcontroller analog pin. Similarly, the ACS 712 was chosen and calibrated to obtain the current value, which was then fed to the microcontroller analog pin.

After that, the microcontroller was programmed with compilation and calculation code to determine the amount of power consumed by the user. To determine the amount of energy consumed, the power consumed is converted to a time domain. The electricity bill is then calculated using the tariff in hand[7]. These values are displayed on an LCD screen for the user to see. Materials that have been integrated into a microcontroller and tested using various parameters. An ACS712 is used to measure the AC current, and a voltage sensor is used to calculate the power consumed, rather than traditional electricity metering (which uses an aluminum coil to measure the electricity consumed). After that, the power consumed is measured in time to determine the amount of energy consumed, and the electricity bill is calculated using the given tariff. The outputs were monitored after the entire device was developed. This is done in a variety of settings, including the lab and the home. When various problems arose, they were all solved by using other components, a new design, and so on. All of the tests were carried out with varying loads.

In the system design a microcontroller was used. To estimate the power through the wire, this microcontroller is equipped with a voltage divider circuit and a current sensor. The estimated power is the amount of energy consumed by the user for the user to pay the specified amount. The microcontroller is used to collect these data.

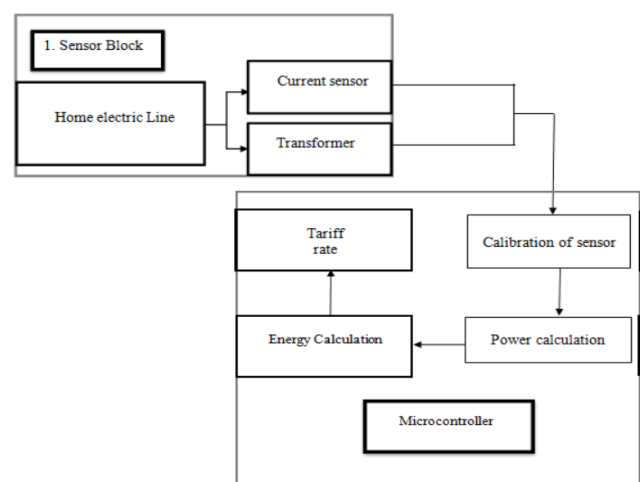


Figure 3.2 Detailed Block diagram of the System

Sensor Block

The system will be integrated with one sensor, which will be used to sense the current flowing through the electric lines, as shown in the block diagrams. A voltage divider circuit will be used to measure the voltage of AC 220 V and will be fed into the analog pin of the microcontroller. Similarly, current

sensor data is detected by the microcontroller in the form of voltage as the sensor output. To the microcontroller's analog pin the sensor output is connected.

Microcontroller Block

The microcontroller calibrates the data fed to the analog pins by first calculating the line's power factor, and then using these values to calculate the power consumed and energy through the line. The tariff rate is calculated after the energy has been calculated.

3.2 Circuit for the system

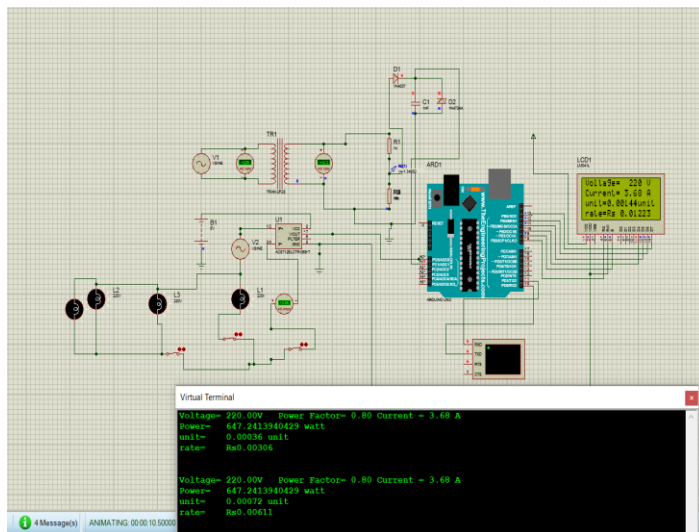


Figure 3.3 Simulation of the Model

The circuit is divided into two parts: current conversion and voltage conversion.

The output of the current sensor ACS 712 is voltage. It has a sensitivity of 185 mV/A and outputs 185 mV for a current flow of 1A in the circuit. The microcontroller uses this voltage to figure out how much current is being drawn through the main wire.

The voltage is shifted from the positive and negative half-cycles to just the positive cycle.

This is accomplished using the coding provided in the appendices for the microcontroller. The microcontroller then uses this to accurately measure the current.

3.2.1 Power and Energy Calculation

From Current Sensor to Analog Pin A0

$$\text{Current R.M.S} = (\text{Current}) * 0.707$$

From Voltage Divider Circuit to Analog Pin A1

$$\text{Voltage R.M.S} = (\text{Voltage}) * 0.707$$

$$\text{Power Factor} = 0.85$$

$$\text{Power} = \text{Current R.M.S} * \text{Voltage R.M.S} * \text{Power Factor}$$

$$\text{Energy} = \text{Power} * \text{Time}$$

3.2.2 Result and analysis

The output of the current sensor

The testing was carried out using filament lights and a heater to introduce a variable load. The motor accessible in the machine lab was used to test currents greater than 1 ampere. The outcomes are shown in the table below.

Table 3.1 Comparison of measured current to the actual

S. No.	Actual Current	Measured Current
1	193mA	195mA
2	250mA	252mA
3	400mA	402mA
4	812mA	815mA
5	930mA	932mA
6	1.56A	1.58A
7	2.89A	2.85A
8	4.32A	4.28A

The current sensor, as shown in the table, has good accuracy and can measure up to 100 Amps of current, which is plenty of to measure current used by a single house. As a result, the current sensor can be concluded to have good accuracy and be able to measure the current consumed by the house within a tolerance limit.

3.2.3 Testing Phase

Various tests were performed to test the system's performance after the assembly of each component in the breadboard was completed. Following the assembly, each component was individually tested. The entire system was put to the test several times. Most of the time, the system did not perform as expected, which was to regulate the input voltage to the discharge terminal on a regular basis. When the system had finally reached the desired level of performance, it was decided to fabricate.



Figure 3.4 Final Casing of Smart Energy Meter

4. CONCLUSION & FUTURE ENHANCEMENT

The project's main goal was to design and develop a working system that could provide accurate meter readings and displays of the user's electrical consumption in price units. The energy consumption has been monitored in this system, and the data has been stored in the Arduino, preventing data loss. The information is then used to calculate the exact amount of energy used in the unit of a kilowatt-hour (KWh) and then converted to Nepali rupees.

To make this device commercially viable, the device's case must be finished in a durable, dependable, and simple-to-install manner. A PCB of the developed circuit should be developed to make the device more durable. It is possible to integrate an SMS service to alert users to the presence of an offline grid. For complete system automation, the web service can be linked to the energy provider's server.

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