System Design of an Electric Meter with a Password Interface to Control Unauthorized Access

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Abstract

Disconnection is the deliberate and temporary curtailment of power supply to the premises of customers because of non-payment of bills illegal connection or unauthorized extension of supply. After the disconnection of meters at the customer's residence, some customers reconnect their meters after the electricity provider has disconnected their meters. This causes a loss in revenue to the electricity provider. In this paper, we propose an electric meter with a password interface. With such a meter, a password would be required to turn on or off the meter. This will prevent reconnection of electric meters by customers who owe the electricity company.

Introduction

Electric utilities utilize electric meters connected at customers' locations to quantify electric energy distributed to their customers for billing purposes (ECG, 2016). They are classically calibrated in billing units, the most widely recognized one being the kilowatt-hour (kWh) which is typically perused once each billing period. At the point when energy savings amid specific periods are wanted, some meters may gauge the demand, the most extreme utilization of energy in some interim. "Time of day" metering allows electric charges to be changed amid a day, to record energy usage amid peak high-cost periods and off-peak, lower-cost, periods. Likewise, in a few territories meters have

relays for demand response load shedding amid peak load periods.

As indicated by the Electricity Company of Ghana (ECG) (2016), an unlawful connection is tapping electrical power from the Electrical Mains which has not been endorsed authoritatively, or the reconnection of lawfully detached premises without authorization. The accompanying exercises go under illicit association characterization (ECG, 2016): unlawful direct interface, illicit meter exchange, meter altering, meter bypass, illegal network extensions, unlawful conveyance of service supply, and self-reconnection after disconnection. In literature, numerous examinations have been conducted in different nations on the unlawful utilization of electricity. For instance, Min and Golden (2013) examined the impact of illicit power use on an Indian state. Onat (2010) clarified that an electric energy system cannot give 100 percent output without losses. The author brought up that the cost of illicit power use was 14.4% which is 1.7 times Turkey's speculation on yearly transmission and distribution system. Gaur and Gupta investigated panel data collected from 2005 to 2009 of 28 Indian states by applying Feasible Generalised Least Squares and Ordinary Least Square regression models to identify the determinants of electricity thefts in Indian states and concluded that more than 20% of total electricity generated in India is lost to thefts. In addition, the authors concluded that socioeconomic and governance factors play a major role in this unfortunate incident.

In Ghana, on the other hand, such studies are rare, however, reports from ECG indicate that a high percentage of revenue losses can be attributed to unlawful connections (Kanarku, 2016). The following were some reports by ECG on unlawful connections and arrests:

- Electricity illegal connections: 52 offenders caught in Accra West (ECG, 2023)
- ECG discovers 130 illegal electricity connections in Ashaiman District (ModernGhana, 2024)
- The Electricity Company of Ghana (ECG), Ashanti West Region, uncovered 74 illegal connections during the first quarter of 2024. (CitiNewsRoom, 2024)

Disconnection is the deliberate and temporary curtailment of power supply to the premises of customers as a result of non-payment of bills unlawful connection or unapproved expansion of supply. However, after the disconnection of meters at the customer's residence especially post-paid meters, some customers reconnect their meters after the electricity provider has disconnected their meters due to accumulated unpaid bills. This causes further losses to the electricity provider. According to ECG, the following were recovered from illegal connections i.e. tempering with meters and bypassing of meters:

- Ghana: Over $600,000 lost in nine months through illegal power connections (Mbillah-Lawson, 2023)
- ECG loses $400m to illegal connections – Energy Minister (Amoah, 2022)

The Northern Electricity Distribution Company (NEDCo) also reported losing GH¢3.7 million to illegal power connections and recovered GH¢1.5 million. (Ghanaweb, 2024). There is a need to put an interface on the meter that will prevent reconnection of customers who owe the electricity company. Therefore, this study proposes an electric meter with a password interface to control unauthorized access to electric meters by users.

Concept of Electricity Meters

An electric meter is a device that quantifies the amount of electric energy used by a home, a business, or an electrically controlled device (García, 2012). Electricity Company of Ghana (ECG) utilizes energy meters installed at customers' premises to quantify electric energy conveyed to their customers for billing purposes. They are calibrated in billing units kWh. Meters of various precision classes are utilized for various purposes and applications (e.g. Private, Nonprivate, Industrial, and so forth.) in view of the exactness necessity. By and large, two broad kinds of meters are being used in ECG: whole current and transformer-operated

A. Whole Current Meters

These meters are associated directly with the residence (private and non-private) to be measured. They are used for Residential and Non-Residential clients with low energy requirements. Extensively, they are grouped by the technology used and are as per the following: Electromechanical and Electronic.

i. Electromechanical

The Electromechanical Meter functions by counting the revolutions of a non-magnetic, but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter. The quantity of revolutions is thus relative to the energy usage. The voltage coil devours a small and relatively persistent amount of power, usually around 2 watts which is not recorded on the meter. The current coil likewise devours a small total of power in proportion to the square of the current flowing through it, usually up to a couple of watts at full load, which is recorded on the meter. The electromechanical meters are all credit meters and are usually: A single-phase credit meter and Three three-phase credit meters.

ii. Electronic

Electronic meters show the energy utilized on an LCD or LED display, and some can also transmit readings to remote places. These meters work by counting impulses and therefore have ratings of impulses per kWh which vary from manufacturer to. Notwithstanding calculating the energy used, electronic meters can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor reactive power used, etc. They can likewise bolster time-of-day billing, for instance, recording the measure of energy used during on-peak and off-peak hours. These meters are manufactured as either credit or prepaid and may be supplied as follows: Single phase credit meter, Single phase prepayment meter, Three phase credit meter, and Three phase prepayment meter. Electronic meters are generally of accuracy class 1, i.e., ±1% variation of the nominal value.

B. Transformer Operated Meters

These are meters usually interposed (not connected directly) at the entry of the circuit to be quantified. Transformer-operated meters are usually of the three-phase grouping and are developed for demand above 70kVA (or 100A). Usual customers are SMEs and extensive non-residential customers such as hotels, restaurants, schools, hospitals, etc. The meters have exactness classes of 1.0, 0.5, and 0.2 reliant on the metering application. They may be either electromechanical or electronic.

Related Works

Veena et al. (2015) also developed a user-changeable password-based circuit breaker. The main component in the circuit is 8051 microcontrollers. The keypad was utilized to enter the password. The password, which is entered, is matched with the predefined password. On the off chance that the entered password is correct then the parallel electrical line is turned on or off. Raza and Naitam (2017) developed a password circuit breaker to safeguard the safety of the maintenance staff. The line could be turned off and on by a lineman. This system provides an avenue where a password is required to operate the circuit breaker. However, these works were not considered for electricity meter application.

Methodology

This section consists of the software design and hardware design.

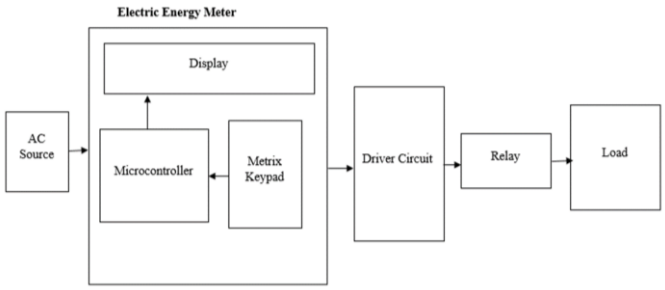


Figure 1. Block diagram of the electric meter

Software design

Proteus 8 Professional software was used to design and simulate the circuit diagram in Figure 1. The Keil µ was utilized to compose a program in assembly language in a text editor, amassing the written program in a compiler and finally producing a hex code from the compiled program. An Arduino Uno microcontroller connected to an LCD and Matrix keypad with a driver circuit connected to a relay that controls the meter (indicated as load). Other equipment parts required such as a lamp, tAT89C51, and an AC source were implemented to achieve the objective of the study.

Simulation and Results

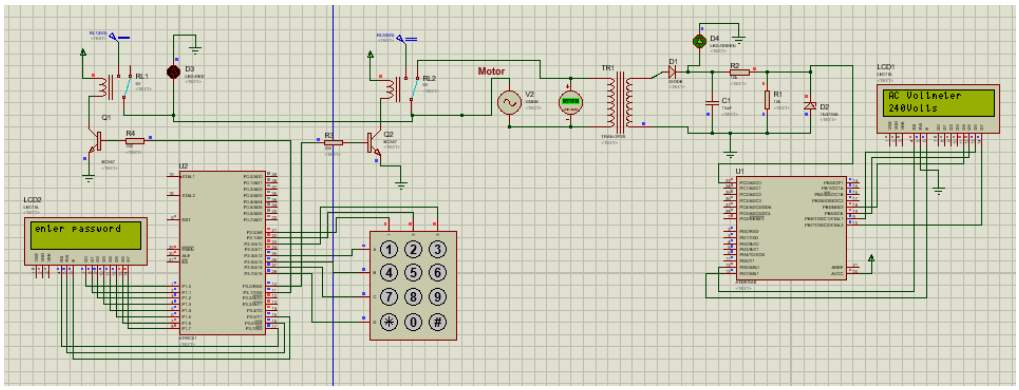


Figure 2. Active meter reading 240volts

Figure 2. Shows the electric meter in active mode with readings of 240 volts and the password interface ready to receive a password to switch off the meter. The green LED (D4) is always on or Blinking whenever the meter is active and the red LED (D3) comes on when the meter is deactivated.

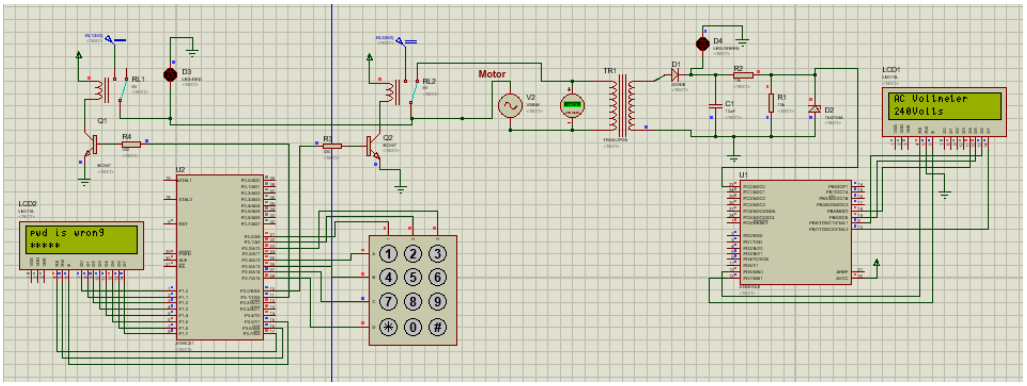


Figure 3. Wrong password entered with meter active

Figure 3. shows the electric meter in active mode with readings of 240 volts. A random password was entered but access to the

system was denied. This can be seen on the password interface as “pwd is Wrong”. No password can be allowed apart from the required password.

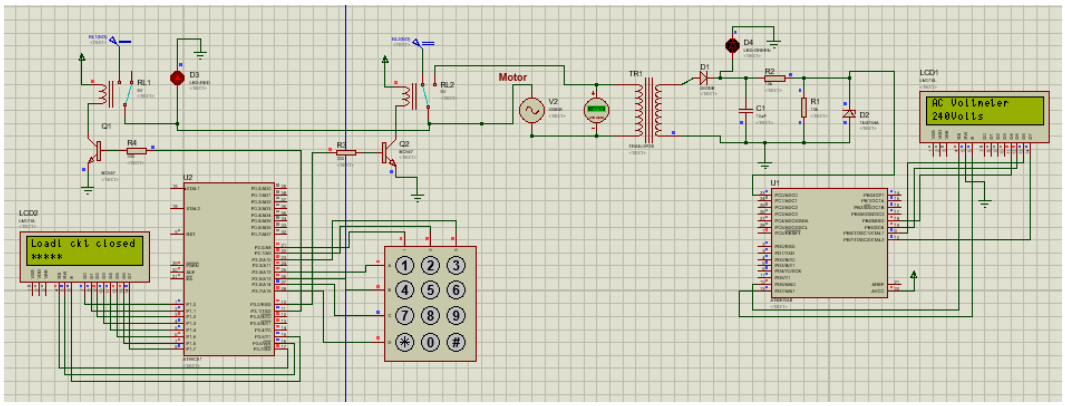


Figure 4. The correct password was entered with the meter preparing for deactivation

Figure 4. shows the correct password entered. This can be seen on the password interface as “load closed” which means the relay. The switch to the meter circuit has been turned off. As a result the green LED (D4) indicator goes off and the red LED (D3) is turned on.

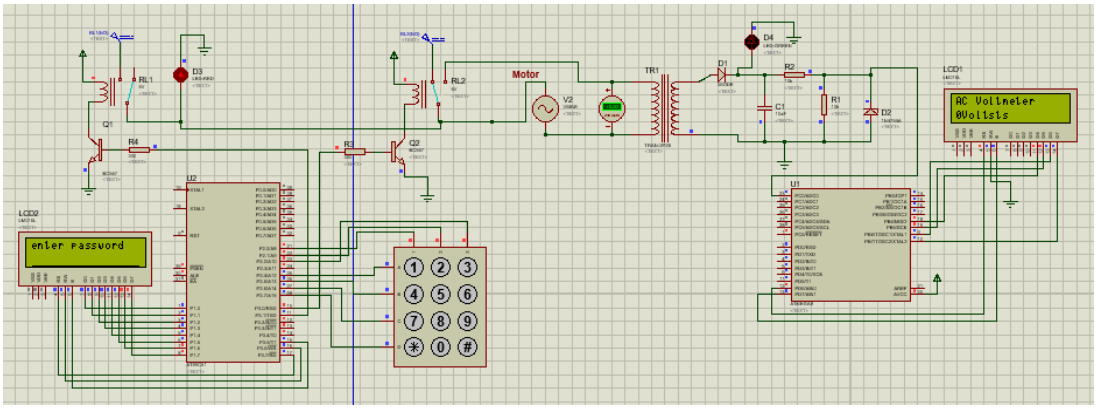


Figure 5. The meter was finally deactivated with a red LED indicator

Figure 5. shows the electric meter in deactivated mode with readings of 0 volts and LED (D3) turned on.

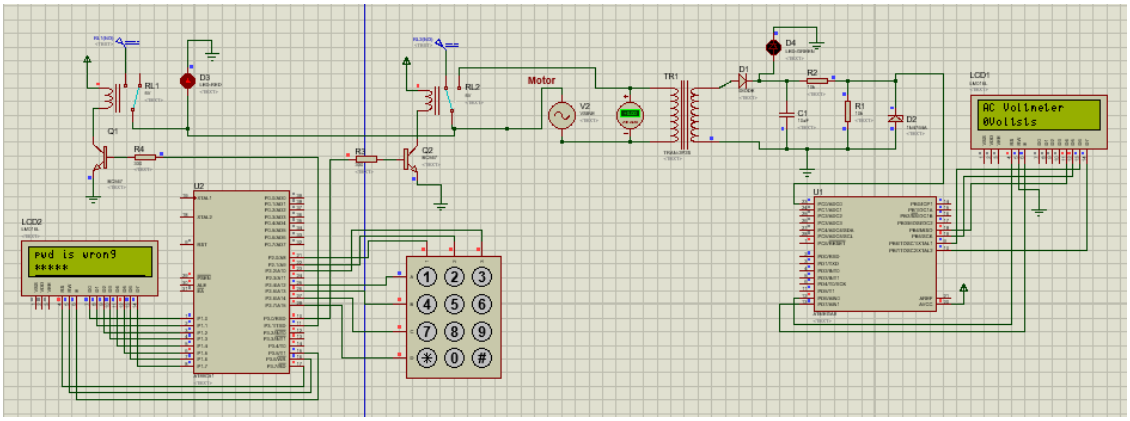


Figure 6. Wrong password entered with meter deactivated

Figure 6 shows the electric meter in deactivated mode with readings of 0 volts. A random password was entered but access to the system was denied. This can be seen on the password interface. As “pwd is wrong”. In the case, of putting the meter in an active mode no password can be allowed apart from the required password.

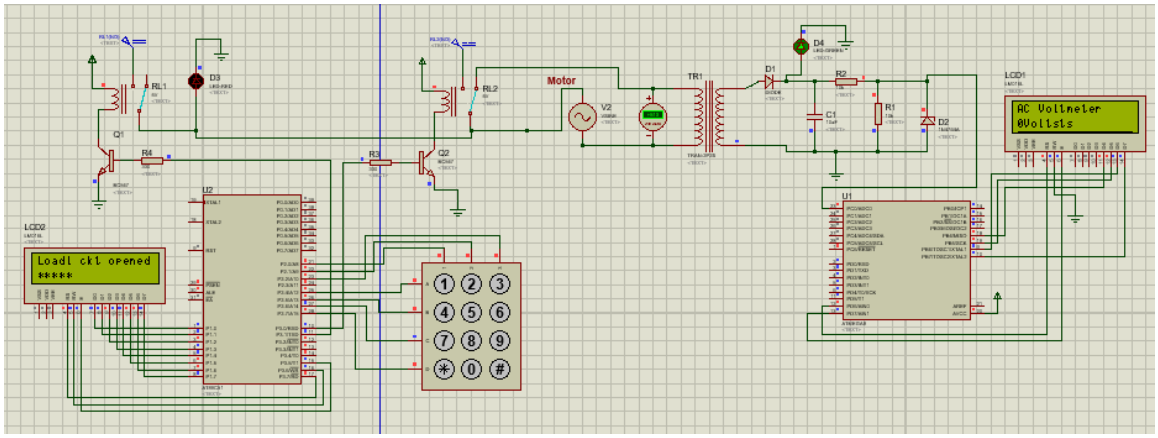


Figure 7. The correct password entered with the meter went active

Figure 7. shows the correct password entered to turn on the meter. This can be seen on the password interface as “load opened” which means the relay switch to the meter circuit has been turned on. As As a result the green LED (D4) indicator comes on and the red LED (D3) goes off.

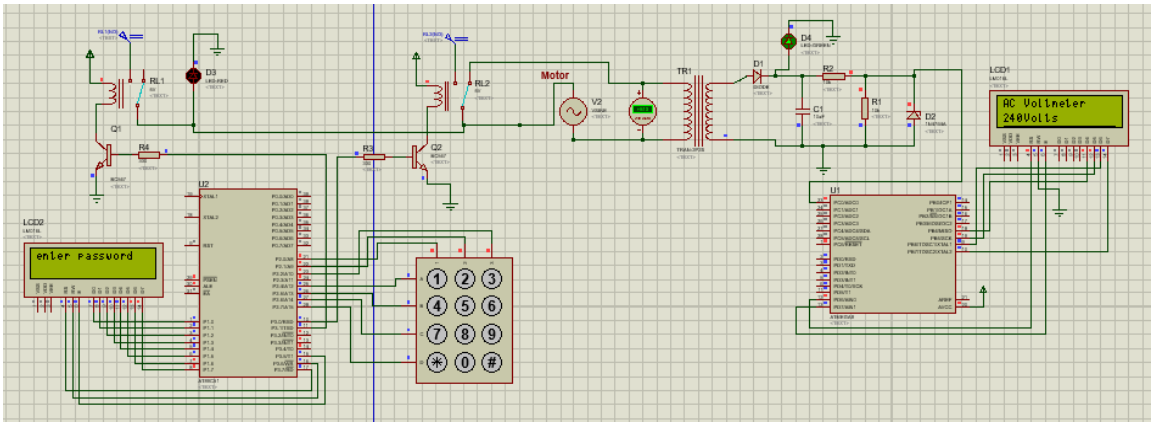


Figure 8. The meter finally active with a green LED indicator

Figure 8. shows the meter finally activated with a meter reading of 240 volts.

Conclusion

The study has demonstrated that when the system is implemented reconnection of electric meters by customers who owe the electricity company would be effectively controlled. The following future works are currently being considered;

- Hardware implementation of the system and controlling the system remotely.

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