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# Design and Implementation of an Improved Prepaid Meter Anti-Tampering System with Mains-On and Mains-Off Detection Capability and Short-Message Service Via GSM Modem

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***Abstract***— *The information on the degree of power energy theft was gleaned from a variety of annual reports published by several utility firms in Uganda, particularly UMEME Limited, the country's largest electricity distributor. This paper was inspired by the incessant cries of electricity utilities who are losing billions of dollars due to power losses and, in particular, power theft. A visit to the UMEME lab found that meter manipulation was stealing considerable quantities of energy. While the meters in use at the time were fitted with an anti-tampering system, the customer was intended to be disconnected if the meter was tampered with. In the event that one wished to tamper, this did not always work. In this paper, a system that ensure continuous monitoring of users' energy consumption, identifying any attempts to tamper with the meter, and send reports about the current status of the metering system to the power company was designed and implemented.*

**Keywords—** Umeme, Prepaid meter, anti-tampering, GSM module, Utility, Energy theft

## 1. Introduction

Energy is a necessary component of a country's economic success. It is necessary for improving the general population's quality of life as well as industrial and agricultural development. As a result, the electrical grid has become a must in modern civilization. Tens of millions of people's everyday lives will be disrupted without a secure and reliable electrical grid. Energy theft is a frequent activity all around the world, according to reports [1] and it is causing utility companies to lose money. This is exacerbated by rising electricity costs, making it a major source of concern for government agencies. Consumers have been caught tampering with their energy meters, causing them to stop, under register, or even circumvent the meter, effectively utilizing electricity without paying for it [2]. The resulting losses cause power utilities to raise electricity prices in order to recoup distribution and operation costs, which hinder economic growth. Breaking the seals on the meter and the terminal cover opening either to bypass the meter at the terminal or tamper with the meter circuitry, and illegal tapping from the distribution lines are some of the most common energy theft techniques. The high cost of installation, maintenance, and consumption, as well as corrupt technicians in the sector, are all factors in power theft. illegal connections can result in death, as well as deprive the economy of much-needed electricity to power companies and illuminate neighborhoods. UMEME limited, Uganda's main power distributor, implemented prepaid meters as part of a drive to reduce theft losses, and by the end of 2020, 97% of her customers had been connected to prepaid meters [3]. UMEME has been successful in reducing losses from around 40% when it first joined the distribution company in 2005 to 17.5 percent by the end of 2020 [2]. Despite the fact that this is a great achievement, it is still above the statutory objective of 14%, and more work needs to be done to lower it. On that note, this paper focuses on reducing losses incurred due to various tamper techniques currently used in electrical domestic prepaid meters in Uganda.

2. Design of the Project

The flow diagram below was used for this paper.

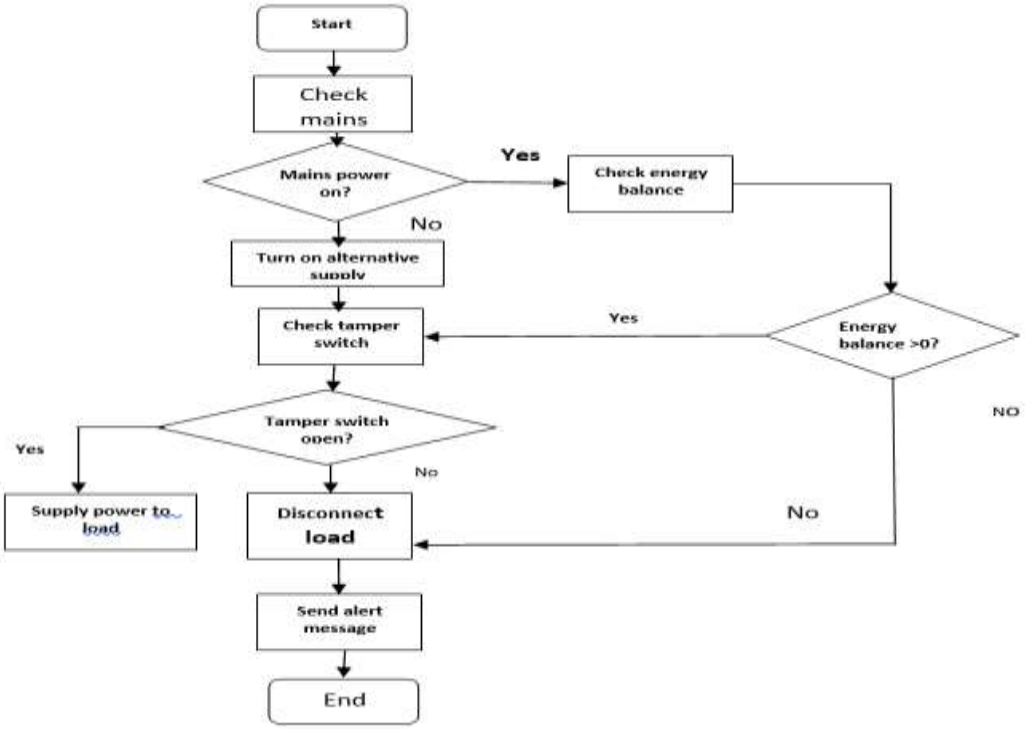


Figure 1: Flow diagram for the IPM MOMO DC

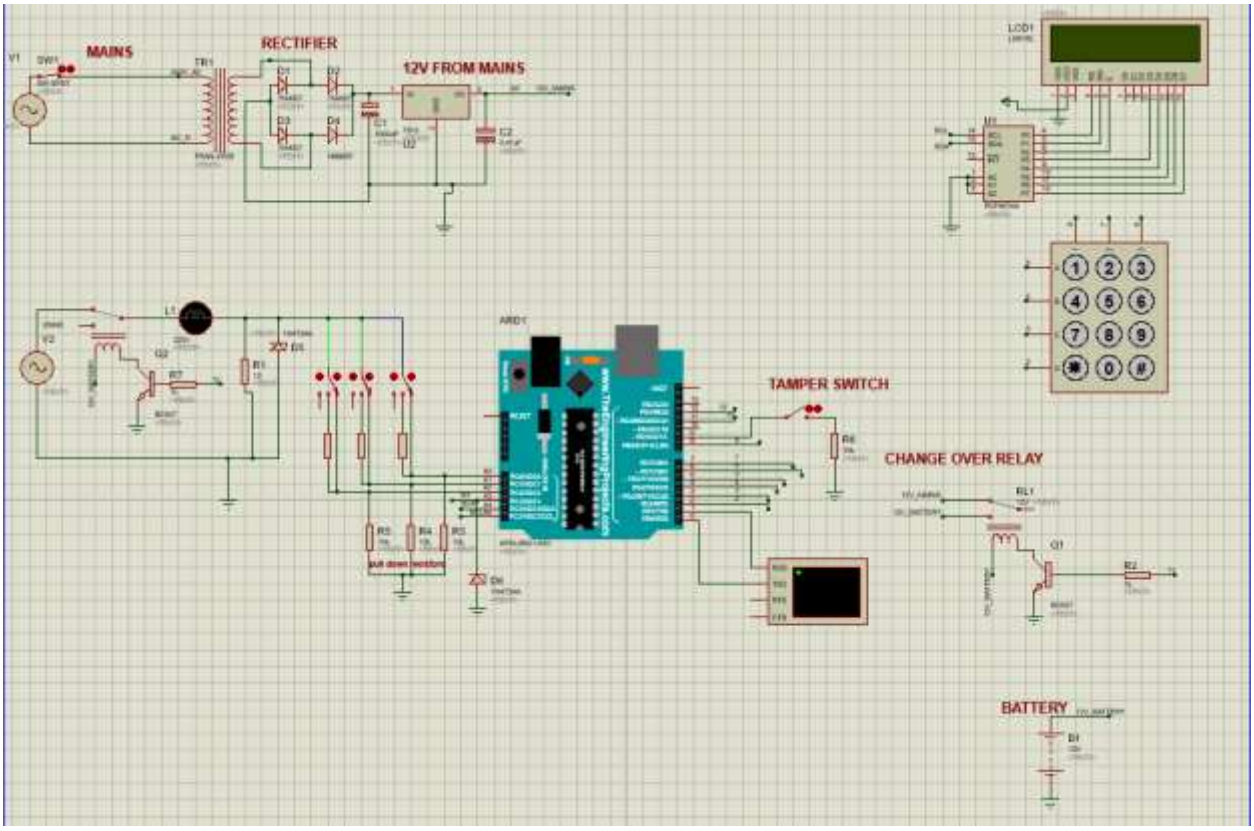


Figure 2: Schematic Circuit IPM-MOMO DC with messaging services via GSM modem.

The energy meter was created by programming an Arduino Uno microcontroller to track, measure, and record the amount of energy used by the load. When a tampering attempt is detected, it is also programmed to disconnect the customer load and issue an alarm message [4][5][6].

3. Operation of the Project

**Power supply:** A 12VDC battery and a 12V two-way relay have been included to ensure that the meter continues to function even when the mains power is turned off. When the mains supply is turned on, the meter receives 12 volts from the mains via a transformer and rectifier unit. When the power goes out, the relay switches to a 12VDC battery built into the circuit to provide power. This keeps the meter powered up at all times, ready to detect and report any tampering.

**Measurement Limiting resistors:** Three parallel signal wires from the load feed bar to the microcontroller's pins PC0/ADC0, PC1/ADC1 and PC2/ADC2 have been added to the simulation circuit to demonstrate how the IPM-MOMO-DC system operates when resistors are connected for tampering intentions.

The microprocessor calculates the difference between the current flowing through the pins and the current flowing through the wires. Under normal circumstances, there should be no difference between any two of the three wires. If a thief inserts a resistor into one of the wires, the readings will differ, leading the microcontroller to set the meter to tamper status. Until the utility's vending system is instructed to generate a clear tamper token, which must be placed into the meter to clear the tamper status and reconnect the customer load, the meter will remain disconnected [6].

The three resistors wired in parallel to each of the signal cables, as well as the changeover switches, are merely there to show what happens when a thief connects a Measuring Limitation Resistor(MLR).

**Tamper detection and messaging:** The tamper switch connected to one of the pins of the microcontroller, is the first line of defense in the meter terminal compartment, designed to close when the terminal cover screw is opened, sending a logic 1 message to the microcontroller as a meter tamper message. This will result in the disconnection of the customer's load and the transmission of a tamper alert message through SMS via the GSM module to the meter inspector's phone [4].

**Tamper detection in case of battery failure**: The crook can open the meter and successfully install a measurement limiting resistor in the confusing signal wires from the load wire to the microcontroller if the battery fails for some reason and the microcontroller fails to be powered when the mains goes off, the tamper switch cannot operate to cause customer load disconnection. When mains power is restored, the microcontroller will detect a difference in currents reaching the microcontroller's pins, and the customer load will be disconnected immediately, and a tamper message will be sent.

## 4. Conclusion

The developed improved prepaid meter with mains-off and mains-on detection capability with SMS messaging via GSM modem will act as a deterrent to potential power thieves. Real time messaging will aid the utility to take appropriate action before significant amount of energy is stolen assuring it that no meter tampering will be done without being noticed regardless of the availability of mains supply. Hence energy theft through meter tampering will be reduced to a minimum. The remote connection and disconnection capability when implemented will reduce the labor of physical disconnection and routine inspections. This will also help in the disconnection of hostile erring customers. It is therefore pertinent that stake holders in the electricity metering subsector should incorporate this technology into their meters in Uganda to maximize the benefits of reduced meter tampering.

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