KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY COLLEGE OF ENGINEERING



ENERSMART RECHARGE SYSTEM

A SMART WAY TO RECHARGE SMART METERS

A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/ELECTRONICS ENGINEERING, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FUFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF BSc. TELECOMMUNICATION ENGINEERING

November 22, 2015

Declaration

I hereby declare that this submission is our own work towards the award of the BSc. de- gree and that, to the best of my knowledge, it contains no material previously published by another person nor material which had been accepted for the award of any other degree of the university, except where due acknowledgment had been made in the text.

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Abstract

The following abstract gives a brief description of the purpose of this project.

The main aim of this project is to design and build an electronic payment platform to help users of the new ENERSMART Smart Prepaid Meters recharge their smart meters without having to go through the same unpleasantness that users of legacy postpaid and prepaid meters go through. This was achieved by setting up a high-performance comput- ing system which integrated the Electricity Company of Ghana’s meter payment system with existing electronic payment technologies such as the credit card system and mobile commerce services like Mobile Money.

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Chapter 1

INTRODUCTION

1.1 Background of Study

Meters are devices installed in customers’ premises to measure and record the amount of electricity used by the consumer over a period of time. There are generally two kinds of meters installed in customers’ premises: prepaid and postpaid meters. Customers pay an initial fee for installation and maintenance to acquire a meter.

The ECG has recently begun rolling out upgrades to all legacy meters(postpaid & pre- paid) and replacing them with new smart prepaid meters called ENERSMART prepay- ment meters. These meters are being deployed in hostels in and around the area under study (Kwame Nkrumah University of Science and Technology; Agyeduase and its envi- rons, Kumasi).

This move is to address the problem of illegal connections when using legacy meters.

An illegal connection is the drawing or tapping of power from the electrical mains without official approval from ECG authorities. It also includes the unauthorized reconnection of officially disconnected premises. It includes the following:

• Illegal Direct Connection - This occurs when the customer connects electricity supply to his premises without a meter.

• Illegal Meter Transfer - This occurs when a customer or applicant removes a legally installed meter from its original location to another location without the approval of ECG and/or payment of the necessary charges by the customer or ap- plicant.

• Meter Tampering - A customer is said to have tampered with ECG Meter

1. When the meter has had its original seals removed or damaged or replaced with another of the same or different kind.

2. When the terminal for the source voltage (incoming cables) are linked to the load cables (outgoing) in the meter.

3. When anything is done to slow down the meter reading or actions that cause the meter to be physically damaged.

• Meter Bypass - This is when a customer or applicant connects portions or all of his load (electrical or electronic appliances) without passing through the meter although a meter has been installed for the customer.

• Illegal Network Extensions - This is when a customer extends an existing ECG distribution/transmission network to his site without approval from ECG. Here the premises might have been conducted to the new construction or not yet connected. In some cases, the illegal construction is unearthed several months after a legal meter has been installed on the illegally constructed network.

• Illegal Distribution of Service Supply - This occurs when an applicant or cus- tomer who has acquired supply legally decides to extend the supply to his neighbours for some form of benefit or for no benefit without written authorization.

• Self-reconnection After Disconnection - A customer may be disconnected after some reasons such as violation of any of the above, owing a bill, safety reasons or defaulting on an agreed payment.

ENERSMART meters come equipped with an RF user card and a user interface unit (UIU). The method of recharging the meter works by induction. The interface displays a variety of information:

• Meter number

• Total consumption within the current month(kWh)

• Energy consumed for the previous month (kWh)

• Amount deposited or paid (GH¢)

• Amount used for the present month (GH¢)

• Amount used for the previous month (GH¢)

• Amount remaining or balance left for use (GH¢)

• Estimated number of days the credit could last if usage rate is constant.

The UIU reads the RF user card by induction. The ENERSMART meter features an inbuilt modem containing a SIM card which ECG uses to communicate with the meter via an Internet Service Provider (MTN).

1.2 Statement of the Problem

In the previous prepayment system, vendors could purchase recharge units in bulk and then sell the units at retail prices at ECG vending stations and vantage points to con- sumers.

However, unlike the old system where consumers could top up credit at these centres, the prepaid credit for ENERSMART meters can only be purchased at District and Regional Offices (Asokwa, Kentinkrono and Airport Roundabout) which are very long distances away from campus. This makes it difficult and very unpleasant for students in recharging their smart meters when they run out of credit, especially when they have lectures to attend during the day. Consumers(students) tend to spend significant amounts of money on transportation. Also the consumer has to hold the assigned RF user card to the UIU for some seconds to display ”READ” and then ”USED” before top-ups can be made. For instance, if a customer fails to induce the meter with the card before setting off for

Asokwa or Kentinkrono, he or she would have to return to the hostel to do that before going back to the office to top-up. All these increases the overall cost to the student and also wastes valuable time.

1.3 Justification of the Pro ject

The main aim of the ENERSMART Recharge System (abbreviated as ERS) is to design an electronic payment platform to allow users of the new ENERSMART Smart Prepaid Meters to recharge their smart meters without having to go through the unpleasantness that users of legacy postpaid and prepaid meters go through. This is achieved by setting up a high-performance computing system which integrates the Electricity Company of Ghana’s prepayment system with existing electronic payment technologies such as the credit card system and mobile commerce services like Mobile Money. It also has in place a system for provision of recharge cards of different amounts to increase the number of options available to consumers.

1.4 Ob jectives

The study has the following objectives.

1. To do a review of electronic recharge payment systems for smart meters globally.

2. To design and build an electronic payment platform for recharging smart prepaid meters.

3. To integrate remote control and monitoring of smart prepaid meters in the ENERS- MART Recharge System.

1.5 Scope and Limitations of the Pro ject

The entire project is focused on the designing and building of a secure and efficient electronic payment platform(web-based application, smartphone application and an sms-

based system)for recharging smart meters remotely.

1.6 Methodology

This project focuses on developing an easy way for consumers to recharge their smart meters remotely. It includes:

• Integration of the various modes of payment (e-commerce and credit/debit card platforms)

• Provision of remote shutdown of smart meters in situations where consumers would like to do so in order to save money.

• Providing a live feed of consumers’ usage at a particular time

1.7 Conclusion

The EnerSmart Recharge System will provide consumers an easier means to recharge their smart meters remotely through the current payment platforms.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews related works and presents an overview of smart meters, their mode of operation and also their recharge procedures.

2.2 Related works

Santhosh Raikar .M, Sushma S. Majigondar, Rithushree K., Rohith R. V., Venkatesh K.R. [1] in their work; ’Prepaid Power Billing Using Adaptive Meter’, designed an adaptive smart meter which included both metering of the power consumed and prepaid system. Their prepaid system was designed with a smart technology using ”renesas controller” and the recharging process was by some method of communication i.e. the GSM based recharging. Their mode of recharging could be done from any remote place without accessing the energy meter physically. Their concept of adaptive metering system is represented in Figure 2.1

Jubi.K, Mareena John [2] in their work; ’Prepaid Energy Meter with GSM Technology’ developed a system that adopts a totally new concept of ”Prepaid Electricity”. The GSM technology they used was aimed at alerting consumers to recharge when their credit is minimum. Also they implemented an automated billing system to keep track of the real time consumption of electricity by consumers.

A block diagram of their concept is shown in Figure 2.2

Azhar Fakharuddin in his thesis [3], ’A Smart Metering for Energy Management System

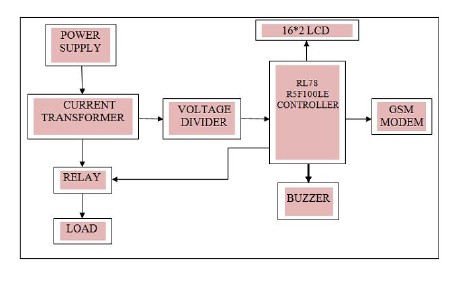


Figure 2.1: Power Billing Using Adaptive Meter

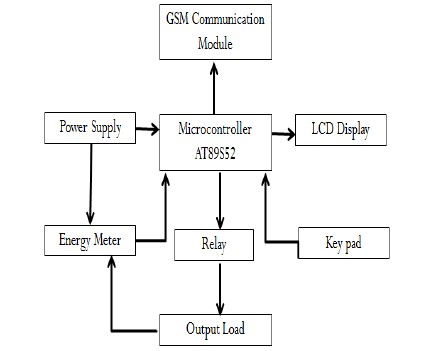


Figure 2.2: Prepaid Energy Meter with GSM Technology

via GSM-SMS Based Protocol’, designed a smart metering system aimed at the following objectives:

• Real time power monitor system

• Variable time pricing through GSM SMS protocol

• Periodic feedback to user about his electricity consumption details

Julius Quarshie Azasoo [4] in his Mphil Thesis,’Design of a GSM-Based Metering

System’, developed a smart meter system aid at the following:

1. Remotely Connect/Disconnect power supply through meter

2. Providing power utilities access through a network application

3. Providing SMS and internet access to customers

4. Maintain usage records of all meters

5. Configurable tarriffing

6. Loss of power notification

The smart meter system was capable of receiving instructions from a centralized database server, and sends meter readings and credit status information to the server. The Central Database Server then makes available to customers and the power companies the information it receives from the meter upon request or based on schedule.

Sapna Ganurkar and Pravesh Gour [5] in their paper, ’Prepaid Energy Meter for Billing System Using Microcontroller and Recharge Card’, presented a concept of smart metering system. This system according to their publication reduces the error made by humans while taking reading through a prepaid mechanism. The mode of recharge of

the smart meter was by a recharge card which varied in ranges (i.e. Rs. 50, Rs. 100, Rs.

200, etc). The recharge is done by using a keypad and the meter is charged with the

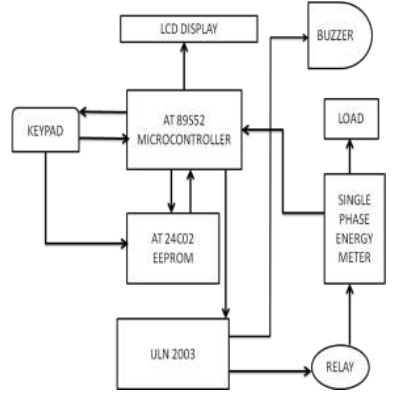


Figure 2.3: Prepaid Energy Meter for Billing System Using Microcontroller and Recharge

Card

Victor de la Guente Garcia [6], in his thesis, ’Evaluation of new Electricity Meters Communication Protocol’, focused on the new electricity meters and the potential of using their available functions(network sytem control) in combination with more active distribution networks. The network system control forms an active part in monitoring of smart meters.

Sharelynn More & David M. Hughes [7] in their paper, ’Advanced Metering Infrastructure’, focused on the Advanced Metering Infrastructure(AMI) networks. The emphasized the fact that the future of AMI will facilitate remote service shut-off and turn on in North America.

Antonio Liotta, Daniel Geelen, Gert van Kempen and Frans van Hoogstraten [8], analyzed the various network communication means or protocols for transmission in their paper, ’A Survey on networks for Smart-Metering System’. The means of communication of smart meters included PLC(Power Line Communication), Unlicensed RF Communication, Licensed RF Communication, Telephone(land) lines and also

GSM-based Communication.

Khalid Alfaheid [9] in his thesis,’A secure and Compromise-resilient Architecture for Advanced Metering Infrastructure’, analyzed the communication protocol of smart meters and developed an encryption algorithm for secure communication. His research was based on analyzing previous network encryption algorithms and designing a new algorithm to secure customer information or details across the network used by smart meters.

Therese Andresen [10] analyzed the different kinds of remote transmission ways for smart metering sytems in her thesis, ’Technical and Economic Aspects of Remote Data Tranmission Ways for Smart Metering’.

2.2.1 Prepaid Energy Solutions Providers

Conlog Solutions for utilites [11] is a world leader in the electricity prepayment industry. They provide consumers with a Conlog prepaid electricity meter and offer a web and smartphone application platform for customers to recharge their smart meters.

Electricity Billing Company is a prepaid and postpaid energy and water billing platfrom provided to over 200 utilities globally. They deploy smart meters with mobile-based

top-ups as well as web-based recharge integration.

Exceleron Software is the leading software developer of prepaid account management solutions for the utility industry. The company’s flagship product, MyUsageTM Prepaid, is a patented, web-based, hosted solution that allows utility service providers to offer prepaid accounts to customers, with no requirements for additional hardware or in-home devices.

Gentrack has an extensive history of developing, implementing and supporting its specialist software for energy utilities, water companies and airports. They provide a

billing engine for billing multiple utility types for customers on credit and prepayment plans. They also provide a complete flexibility of the metering and top-up technology.

HCL’s prepaid energy solutions integrates directly with AMI MDM and offers configurable balance thresholds, electronic payments and alerts using SMS and social media, making it user-friendly for today’s tech-savvy consumers.

Junifer Systems develop critical software applications to power the new ”Smart World”. The Junifer Prepay Module is designed for the automated handling of gas and electricity by utilities in the UK, and extends Junifer’s existing range of advanced billing and customer care solutions.

PayGo is a cloud based, fully integrated utility consumer engagement software provider enabling the rapid provisioning of smart grid applications. They enhance full meter to cash business processes through patent pending ”real time” pay-as-you-go (Prepay) energy programs, end-to-end postpaid bill payments and a related consumer messaging platform.

’Telco Prepay for Utilities’-Mobile4Energy is an elegant Meter to Cash solution allowing consumers to pay for energy using their mobile phones or other channels available through the existing telecoms ’Pay As You Go’ network. Mobile4Energy allows utilities to tap into the existing telecoms pre-pay infrastructure by way of an innovative

cross-sector mediation platform.

RedKnee provides real-time dynamic rating and billing as well as multi-channel

customer engagement for electricity and other smart home services. The Prepaid Energy proposition allows utility providers to offer a new pay-as-you-go model to their customers; one that allows for maximum flexibility while controlling financial risk. The system also supports various payment channels.

SmartGridCIS offers a powerful integrated platform that includes innovative web-based software, and complete integration to your smart grid infrastructure. They work in unison with existing MDM and AMI infrastructure and allows companies to provide

real-time pricing, interval reading, complex rating, pre-paid biling and remote control capabilities.

2.3 Overview of Smart Meters

A smart meter is usually an electrical meter that records consumption of electricity energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes. Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting. Smart Meters differ from traditional automatic meter reading(AMR) in that it enables two-way communication with the meter.

2.3.1 Global System for Mobile Communication (GSM)

The creation of GSM started as far back as 1982 where a high level communication expert at the European Conference of Postal and Telecommunication Administrations. The idea then was to address cellular infrastructure in Europe, but rapidly expanded to other countries. Finally, GSM became the standard set developed by the European Telecommunication Standards Institute (ETSI) to describe technologies for second generation(2G) digital cellular networks. Developed as a replacement for first generation analog cellular networks, the GSM standard originally described a digital,

circuit-switched network optimized for full duplex voice telephony. Data communications became part of GSM, first by circuit-switched transport, then packet switched through (General Packet Radio Services) and EDGE(Enhanced Data rates for

GSM Evolution or EGPRS).

2.3.2 AT Commands

AT commands are instructions used to control a modules. AT is the abbreviation of the ATtention. Every command line starts with ”AT” or ”at”. That’s why modem commands are called AT commands. Many of the commands that are used to control wired dial-up modems, such as ATD (Dail), ATA (Answer) etc, are also supported by GSM/GPRS modems and mobile phones. Mobile phones support and AT command set that is specific to the GSM technology, which includes SMS-related commands like AT+CMGS(Send SMS message). There are specific command set for various functionalities.

2.4 Software Applications

In information technology, an application is a computer program designed to help people perform an activity. Depending on the activity for which it was designed, an application can manipulate text, numbers, graphics, or a combination of these elements.

2.4.1 Software Programming Tools

These are tools or software applications known as software development tools that are used to create software applications. They can be used to debug, maintain an existing application. Some development tools are: Hypertext Preprocessor(PHP), Java, HyperText Markup Language(HTML) and Python.

Chapter 3

Methodology

Chapter 4

METHODOLOGY

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Appendix

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