

FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL ENGINEERING
FINAL YEAR PROJECT REPORT
DESIGN AND DEVELOPMENT OF AN INFORMATION MANAGEMENT SYSTEM
FOR ELECTRICITY PAYMENT IN UMEME YAKA METERS

BY

AGUTI AGNES STELLA

BU/UP/2020/1205

Email: agnesstellaaguti@gmail.com

SUPERVISORS

ENG. ANDREW RWENDEIRE

ASSOC PROF. TWAIBU SEMWOGERERE

A final year Project report submitted to the Department of Electrical Engineering in Partial fulfillment of the Requirement for the award of a Bachelor of Science degree in Electrical Engineering of Busitema University.

June, 2024

DECLARATION

I the undersigned, declare that this report is my original work except where due acknowledgement has been made. I declare that this work has never been submitted to this university or any other institute of learning for partial fulfillment for any award.

Name: AGUTI AGNES STELLA

Signature

Date/...../.....

APPROVAL

The project report was reviewed and approved by:

ENG. ANDREW RWENDEIRE

Signature.....

Date...../...../.....

ASSOC PROF. TWAIBU SEMWOGERERE

Signature.....

Date..... /...../.....

ACKNOWLEDGEMENT

I extend my sincere gratitude to Engineer Andrew Rwendeire and Associate Professor Twaibu Semwogerere, my project supervisors, for their invaluable guidance and support throughout this project. I also thank my lecturers and all the others who have supported me along the way. Special appreciation to my parents, siblings, and friends for their unwavering encouragement and assistance and above all, my sincere gratitude to the Almighty God who has given me life and has enabled me to reach this academic height.

DEDICATION

I dedicate this report to my beloved parents, siblings, and friends.

ABSTRACT

This project report seeks to address the challenges associated with manual electricity unit loading in UMEME Yaka meters by designing and developing an innovative information management system aligned with Uganda's development goals. The current system requires users to input a lengthy 20-digit token physically, leading to errors and inconvenience, especially during unit shortages. To mitigate these challenges, the proposed solution involves implementing GSM-based technology for automatic and remote activation, eliminating the need for physical interaction with the customer interface unit (CIU). Research methods like observation, interviews, and literature review were utilized to gather insights and identify technological solutions. A prototype was developed using Atmel ATMEGA328P-PU microcontroller advanced technology, interfaced with a SIM800L quad-band GSM modem. This prototype was able to automatically load the tokens when payment was made and the project objectives were met as indicated by the outcomes as demonstrated in the report. This project aligns with Uganda's objectives of promoting technological innovation, economic growth, and sustainable development, representing a significant step towards modernizing the country's electricity infrastructure and facilitating socio-economic progress.

LIST OF ACRONYMS

ASK:	Amplitude Shift Keying
BER:	Bit Error Rate
CPCA:	Carrier Present, Carrier Absent
CPU:	Central Processing Unit
DFD:	Data flow diagrams
DRAM:	Dynamic Random Access Memory
EEPROM:	Electrically-erasable programmable Read Only Memory
FCC:	Federal Communications Commission
GPS:	Global Positioning System
GSM:	Global System for Mobile communication.
I2C:	Inter Integrated Communication
LNA:	Low Noise Amplifier
OOK:	On Off Keying
PCB:	Printed Circuit Board
RAM:	Random Access Memory
RISC:	Reduced instruction Set Computer
RF:	Radio Frequency
ROM:	Read Only Memory
SPI:	Serial Peripheral Interface
SRAM:	Static Random Access Memory
TWI:	Two Wire Interface
UART:	Universal Asynchronous Receiver Transmitter

Table of contents

DECLARATION.....	ii
APPROVAL	iii
ACKNOWLEDGEMENT	iv
DEDICATION.....	v
ABSTRACT	vi
LIST OF ACRONYMS	vii
1 CHAPTER ONE	1
1.1 Introduction.....	1
1.2 Background.....	1
1.3 Problem Statement	3
1.4 Objectives	3
1.4.1 General Objective.....	3
1.4.2 Specific Objectives.....	3
1.5 Research questions.	3
1.6 Scope of the Study.....	4
1.7 Significance.....	4
1.8 Conceptual framework.....	5
2 CHAPTER TWO: LITERATURE REVIEW.....	6
2.1 Introduction.....	6
2.2 Related works.....	6
2.3 Current YAKA metering infrastructure	7
2.4 Developed system	7
3 CHAPTER THREE: METHODOLOGY	8
3.1 Requirements Gathering.....	8
3.2 Quality management, reliability and validity of data	8
3.3 Observation	8
3.4 Interview.....	9
3.5 Literature search	9
3.6 Requirement Analysis	9
3.7 System design.....	9
3.8 Testing and validation	9
4 CHAPTER FOUR: DESIGN	11
4.1 Introduction.....	11
4.2 System Requirements Specification	11
4.2.1 Functional Requirements	11

4.2.2	Nonfunctional Requirements	11
4.3	Components used and their specifications	11
4.3.1	ATMEGA328P-PU MCU	11
4.3.2	POWER SUPPLY DESIGN	14
4.3.3	7805 VOLTAGE REGULATOR	15
4.3.4	ZENER DIODES	16
4.3.5	SIM800L GSM MODEM	16
4.3.6	DC BUCK CONVERTER	19
4.3.7	INDICATORS LEDS	20
4.3.8	LCD (JHD162A)	21
4.3.9	CURRENT MEASUREMENT USING ACS712 CURRENT SENSOR	23
5	CHAPTER FIVE	25
5.1	Challenges	25
5.2	Recommendation	26
5.3	Conclusion	26
6	REFERENCES	27
7	Appendices	28
7.1	Appendix one: Project budget	28
7.2	Appendix Three: Pictures During Implementation	30
7.3	Appendix Four : Embedded Code	33

List of figures

Figure 3.1:circuit diagram.....	10
Figure 4.1: ATMEGA328P 28-DIP Top-view	12
Figure 4.2: AVR interfacing with crystal clock.....	12
Figure 4.3: Crystal Oscillator Connections.....	14
Figure 4.4: 240Vac to 9Vdc circuit. Source: practical electronics for invertors by Paul Scherz.....	14
Figure 4.5: 7805 TOP VIEW.....	16
Figure 4.6: Zener diode as a voltage regulator.....	16
Figure 4.7: SIM800L GSM modem. Source: www.simcom.com.....	17
Figure 4.8: DC buck converter.....	Error! Bookmark not defined.
Figure 4.9: LCD pin map. Source: HD44780 Character LCD datasheet	21
Figure 4.10: LCD interface circuit.....	22
Figure 4.11: current sensor	23
Figure 4.12: Sine curve show peak voltage	23
Figure 4.13: Output voltage Vs sensed current. Source: ACS712 datasheet	24
Figure 7.3: Final Developed Prototype	30
Figure 7.4: Design and Soldering of the Prototype.....	31
Figure 7.5: First Completed Design Before Testing	32

List of tables

Table 4.1: Device Clocking Options Select. Source: device datasheet.....	13
Table 4.2:Range of frequencies	14
Table 4.3: LED color PD definition.....	20
Table 7.1: Projected budget	28
Table 7.2: Project timeline.....	29

Equations

Equation 1	15
Equation 2	15
Equation 3	21
Equation 4.....	21

1 CHAPTER ONE

1.1 Introduction

This chapter covers the project's background, problem statement, general objectives, research questions, scope, significance, and conceptual framework. This report examines the design and physical modeling of a GSM-based Electricity Recharge System for prepaid metering in Uganda, commonly referred to as YAKA. Currently, users must enter a 20-digit token number provided after any payment, with a maximum of three attempts before the meter locks. If locked, customers must repeat the entire process they followed to obtain their electricity account. Given the length of the token, there is a high likelihood of incorrect input, making it challenging to get the sequence right. Additionally, entering the 20-digit token number is cumbersome, as it necessitates the user's physical presence at the customer interface unit. At present, there is no way to remotely input the token to activate purchased units.

The project's goal is to reduce errors by introducing a new method of loading the 20-digit token number without the need for physical interaction with the customer interface unit. This will allow users to recharge their electricity accounts remotely, without needing to be physically present at the customer interface unit.

1.2 Background

Smart meters have become essential components of modern utility systems worldwide, transforming how energy consumption is monitored, managed, and billed. Initially introduced in regions such as the United States, United Kingdom, Canada, and Europe, these devices replace traditional analog meters with advanced features, including digital displays and bi-directional communication capabilities. Analog meters presented challenges such as limited accuracy, manual reading requirements, and inability to detect energy theft or tampering. In contrast, smart meters offer numerous advantages, including remote monitoring, outage detection, and enhanced energy efficiency, empowering consumers to make informed decisions about their energy usage. As global adoption continues to grow, smart meters play a crucial role in advancing sustainability and efficiency in the energy sector through ongoing technological advancements and integration with renewable energy sources.

Recent advancements in smart meter technology, including the implementation of Secure Token Systems (STS) and Standard Transfer Specification (Smith, 2022) have played a pivotal role in the upgrading of meters. The globally adopted STS for prepayment metering protects

6 REFERENCES

- [1] J. Wire, 'Is UMEME's pre-paid Smart Metering a time bomb?', The New Vision, 2014. [Online]. Available: <http://newvision.com>. [Accessed: 11- Nov- 2017].
- [2] FBI, 'Smart Electric Energy meters altered to steal electricity', 2010. [Online]. Available: <http://fbi.gov/cybercrime>. [Accessed: 27- May- 2017].
- [3] Patriot & Paulies (Editors), '5 Hacks that render Smart Meters dumb', 2012. [Online]. Available: <http://patriotandpaulies.wordpress.com>. [Accessed: 16- Aug- 2017].
- [4] T. Leautier, 'Is Mandating "Smart Meters" Smart?', EJ, vol. 35, no. 4, 2014.
- [5] D. Baker, 'Malware based Smart meters' attack', Ioactive.com. Available: <http://www.ioactive.com/>. [Accessed: 08- Oct- 2017].
- [6] H. M. Zahid Igbal, M. Waseem and Dr. Tahir Mahmood, Automatic Energy Meter Reading using Smart Energy Meter.
- [7] S. Arun and Dr. Sidappa Naidu, 'Hybrid Automatic Meter Reading System', ISSN: 2277 128X, International Journal of Advanced Research in Computer Science and Software Engineering, vol. 2, no. 7, pp. 361-365, 2012.
- [8] Depuru, S. S, Wang, L., Devabhaktuni, V.: Electricity theft: Overview, issues, prevention and a smart meter-based approach to control theft. Energy Policy. 39, 1007–1015 (2011)
- [9] Kasita, I.: UMEME starts pre-paid power billing. The New Vision, Kampala (2011). <http://www.newvision.co.ug>
- [10] “The embedded C programming and Atmel AVR “, 2nd Edition by Barnett, Cox and O” Cull.
- [11] “The AVR microcontroller and embedded system using Assembly and C”, 2011 by Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi
- [12] “Practical electronics for inventors” Paul Scherz, 2000
- [13] Atmel 8-bit microcontroller with 4/8/16/32kbytes in-system programmable flash datasheet
- [14] “Atmel 8-bit and 32-bit Microcontrollers AVR127: Understanding ADC parameters “application note
- [15] “Understanding Electronics”, Third Edition by R. H. Warring and G. Randy Slone