

**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

RANGA JOEL

BU/UP/2020/1238

[joelranga000@gmail.com](mailto:joelranga000@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 hereby declare that, to the best of my knowledge and belief, this report represents my original work and has not been submitted to any other educational institution. It is a genuine and authentic account of our research and findings. Where references or secondary data have been utilized, appropriate acknowledgments have been duly made.

Name: RANGA JOEL

Signature.....

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

**APPROVAL**

The project report was reviewed and approved by:

ENG. ANDREW RWENDEIRE

Signature.....

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

ASSOC PROF. TWAIBU SEMWOGERERE

Signature.....

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

## **ACKNOWLEDGEMENT**

I am deeply grateful to a number of people who have supported and guided me throughout this project. Their contributions have been invaluable in the successful completion of this report.

First and foremost, I would like to express my sincere gratitude to my supervisors, Professor Twaibu Ssemwogere and Engineer Andrew Rwendeire whose guidance, insightful feedback, and unwavering support have been instrumental in steering this project to fruition. Their expertise and patience were critical in overcoming numerous challenges and refining the scope and execution of the work.

I extend my heartfelt thanks to my project partner, Aguti Agnes Stella, for her dedication, hard work, and collaborative spirit. Your contributions, innovative ideas, and commitment have been crucial to the success of this project. Working with you has been both a pleasure and a learning experience.

I am profoundly thankful to my parents for their endless encouragement and support. Your unwavering belief in my abilities and continuous moral and financial backing have been a cornerstone throughout this journey. Your love and sacrifices have provided me with the strength and motivation to persevere.

I would also like to acknowledge the contributions of Engineer Patrick Ssonko, without whom, this project might not have come to be. He has imparted his knowledge and wisdom, shaping my understanding and approach as regards this project. His teachings and expert advice have enriched my academic experience and provided a solid foundation for this project.

Thank you all for your unwavering support and contributions, which have made this achievement possible.

.

## **DEDICATION**

I dedicate this report to my beloved parents, siblings, and friends and all those who have contributed to it in one way or another, I may not mention names but know this, I appreciate you all entirely.

## **ABSTRACT**

This project report addresses the inefficiencies in manual electricity unit loading in UMEME's Yaka metering system by developing an advanced information management system aligned with Uganda's development goals. The existing method requires users to manually input a 20-digit token into the Customer Interface Unit (CIU), which is prone to errors and inconvenience, especially during periods of unit shortage. To resolve these issues, we proposed a GSM-based system for automatic and remote activation of electricity units, thereby eliminating the need for physical interaction with the CIU. This solution utilizes an 8-bit RISC Atmel ATMEGA328P-PU microcontroller interfaced with a SIM800L quad-band GSM modem. The system employs current and voltage sensors to continuously monitor energy usage and automatically updates the meter balance based on cellular messages received upon payment. Research methods including observation, interviews, and literature review were employed to gather relevant insights and inform the design of the technological solution. A functional prototype was developed and tested, demonstrating the capability to automatically load tokens and meet the project's objectives. This innovative approach supports Uganda's strategic goals of technological advancement, economic growth, and sustainable development. By modernizing the electricity metering infrastructure, this project significantly contributes to the enhancement of operational efficiency and the facilitation of socio-economic progress in Uganda.

## **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
UEDCL:	Uganda Electricity Distribution Company Limited
UETCL:	Uganda Electricity Transmission Company Limited

## Table of contents

DECLARATION.....	ii
APPROVAL .....	iii
ACKNOWLEDGEMENT .....	iv
DEDICATION.....	v
ABSTRACT .....	vi
LIST OF ACRONYMS .....	vii
<b>1 CHAPTER ONE .....</b>	<b>1</b>
<b>1.1 Introduction.....</b>	<b>1</b>
<b>1.2 Background.....</b>	<b>1</b>
<b>1.3 Problem Statement .....</b>	<b>3</b>
<b>1.4 Objectives .....</b>	<b>3</b>
<b>1.4.1 General Objective.....</b>	<b>3</b>
<b>1.4.2 Specific Objectives.....</b>	<b>3</b>
<b>1.5 Research Questions.....</b>	<b>4</b>
<b>1.6 Scope of the Study.....</b>	<b>4</b>
<b>1.7 Significance.....</b>	<b>4</b>
<b>1.8 Conceptual framework.....</b>	<b>5</b>
<b>2 CHAPTER TWO: LITERATURE REVIEW.....</b>	<b>6</b>
<b>2.1 Introduction.....</b>	<b>6</b>
<b>2.2 Related works.....</b>	<b>6</b>
<b>2.3 Current YAKA Metering Infrastructure.....</b>	<b>7</b>
<b>2.4 Developed System.....</b>	<b>7</b>
<b>3 CHAPTER THREE: METHODOLOGY .....</b>	<b>8</b>
<b>3.1 Requirements Gathering.....</b>	<b>8</b>
<b>3.2 Quality Management, Reliability and Validity of Data .....</b>	<b>8</b>
<b>3.2.1 Quality Management .....</b>	<b>8</b>
<b>3.2.2 Reliability .....</b>	<b>8</b>
<b>3.2.3 Validity.....</b>	<b>9</b>
<b>3.3 Field Visits:.....</b>	<b>9</b>
<b>3.4 Observation .....</b>	<b>9</b>
<b>3.5 Interview.....</b>	<b>9</b>
<b>3.6 Literature search .....</b>	<b>10</b>
<b>3.7 Requirement Analysis .....</b>	<b>10</b>
<b>3.8 System design.....</b>	<b>10</b>
<b>3.9 Testing and validation .....</b>	<b>10</b>



3.9.1	Unit Testing: .....	10
3.9.2	Integration Testing: .....	11
3.9.3	Functional Testing: .....	11
3.9.4	System Testing:.....	11
3.9.5	Validation Procedures .....	12
3.9.6	Compliance and Standards: .....	12
3.9.7	Results and Outcomes.....	12
<b>4</b>	<b>CHAPTER FOUR: DESIGN .....</b>	<b>14</b>
4.1	Introduction.....	14
4.2	System Requirements Specification .....	14
4.2.1	Functional Requirements .....	14
4.2.2	Nonfunctional Requirements.....	14
4.3	Components used and their specifications .....	14
4.3.1	ATMEGA328P-PU MCU.....	14
4.3.2	Power supply design .....	17
4.3.3	7805 Voltage regulator.....	18
4.3.4	Zener Diodes.....	19
4.3.5	SIM800I GSM modem.....	19
4.3.6	DC Buck Converter.....	22
4.3.7	Indicators LEDs .....	23
4.3.8	LCD (JHD162A):.....	24
4.3.9	Current measurement using ACS712 Current sensor.....	26
<b>5</b>	<b>CHAPTER FIVE .....</b>	<b>28</b>
5.1	Challenges.....	28
5.2	Recommendation .....	28
5.3	Conclusion .....	28
<b>6</b>	<b>REFERENCES.....</b>	<b>29</b>
<b>7</b>	<b>Appendices .....</b>	<b>30</b>
7.1	Appendix one: Project budget .....	30
7.2	Appendix two: Project Timeline .....	31
7.3	Appendix Three: Pictures During Implementation .....	32
7.4	Appendix Four : Embedded Code .....	36

## List of Figures

Figure 3.1 circuit diagram.....	13
Figure 4.1 ATMEGA328P 28-DIP Top-view.....	15
Figure 4.2 AVR interfacing with crystal clock.....	15
Figure 4.3: Crystal Oscillator Connections.....	17
Figure 4.4 Range of frequencies.....	17
Figure 4.5: 240Vac to 9Vdc circuit. Source: practical electronics for invertors by Paul Scherz.....	17
Figure 4.6: 7805 TOP VIEW.....	19
Figure 4.7: Zener diode as a voltage regulator.....	19
Figure 4.8: SIM900 GSM modem. Source: www.simcom.com.....	20
Figure 4.9 DC buck converter.....	23
Figure 4.10: LCD pin map. Source: HD44780 Character LCD datasheet.....	24
Figure 4.11 LCD interface circuit.....	25
Figure 4.12: current sensor.....	26
Figure 4.13: Sine curve show peak voltage.....	26
Figure 4.14: Output voltage Vs sensed current. Source: ACS712 datasheet.....	27
Figure 7.1 Final Developed Prototype.....	32
Figure 7.2 Design and Soldering of the Prototype.....	33
Figure 7.3 fritzing image.....	34
Figure 7.4 First Completed Design Before Testing.....	35

## List of Tables

Table 4.1 Device Clocking Options Select. Source: device datasheet.....	16
Table 4.2: LED color PD definition.....	23
Table 7.1: Projected budget.....	30
Table 7.2: Project timeline.....	31

## Equations

Equation 1.....	18
Equation 2.....	18
Equation 3.....	24
Equation 4.....	24

# **1 CHAPTER ONE**

## **1.1 Introduction**

This chapter focuses on the background to the study, statement of the problem, general objectives of the study, research questions, and scope of the study, significance of the study and conceptual framework.

This project report therefore discusses the design and physical modeling of a GSM-based Electricity Recharge System for prepaid Metering systems in Uganda, commonly known as YAKA. The 20-digit token number provided upon any form of payment must be entered at most three times and beyond which the meter will be locked. When a meter is locked, the customer is required to through the same procedures they took when acquiring the electricity account. With this said, the chances of inputting a correct token wrongly are very high as the token number is so long, making it harder to get all token numbers right in order. Also, the process of entering a 20-digit token number is a challenge to users as it requires their physical presence to enter the 20-digits. Currently, a situation where one can remotely enter the token to activate the units purchased is currently impossible.

The aim of the project is to minimize the error by introducing a new mechanism of loading the 20-digits token number provided without requiring physical pressing of the buttons on the customer interface unit provided. This will enable the user to recharge his/her electricity account from anywhere without physically being at the customer interface unit.

## **1.2 Background**

Smart meters are integral to modern utility infrastructure globally, redefining energy consumption monitoring, management, and billing. These devices, initially deployed in regions like the United States, United Kingdom, Canada, and Europe, replace traditional analog meters with advanced technology, including digital displays and two-way communication capabilities. Analog meters posed several challenges, including limited accuracy, manual reading requirements, and inability to detect energy theft or tampering. In contrast, smart meters offer numerous benefits, such as remote monitoring, outage detection, and improved energy efficiency, empowering consumers to make informed decisions about energy usage. As global adoption continues to surge, smart meters play a pivotal role in promoting sustainability and efficiency in the energy sector through ongoing technological innovation and integration with renewable energy sources.

## 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