BUSITEMA UNIVERSITY
Pursuing Excellence

FACULTY OF ENGINEERING

DEPARTMENT OF MINING ENGINEERING

FINAL YEAR PROJECT REPORT

DESIGN AND CONSTRUCTION OF AN UNDERGROUND COMMUNICATION SYSTEM

A Case Study of Tiira mining area

By

SSENNYONGA PONTIOUS NGONDWE

BU/UG/2019/0090

spnmitmax@gmail.com

SUPERVISORS:

MR. NASSASIRA MICHEAL BAKAMA

MR. NUWAREEBA EDISON

A final year project submitted to the Department of Mining Engineering as a partial fulfillment of the requirements for the Award of a Bachelor of Science Degree in Mining engineering

ABSTRACT

This project report presents the design and construction of an underground communication system for the Tiira mining area, with a focus on addressing the critical issues of safety and productivity among small-scale and artisanal miners. The existing communication methods, such as walkie-talkies, are expensive to acquire and maintain, leading miners to rely on outdated and inefficient bells and pipes, resulting in accidents and reduced production. The primary objective of this study is to design and construct an affordable and efficient underground communication system. The specific objectives of the study include designing the underground signaling system, assembling the system components, testing its efficiency, and conducting a financial analysis. The developed system utilizes a 7.4V power source consisting of two rechargeable lithium AA size cells with a capacity of 2600mAh each. It is controlled by an Arduino Uno microcontroller and incorporates 6 LEDs, a 4-ohm speaker, and a 16x2 LCD display. The system also features nine push buttons with pull-down resistors of 10k Ohms. The system's performance, based on testing, was found to be 73%, a significant improvement over the existing communication method, which operates at 45%. The financial analysis indicates that the system is profitable, with a Payback Period of 0.5 years and a Profitability Index (PI) of 2.14.

Implementing this improved communication system is expected to lead to increased production, enhanced safety, and reduced accidents. Furthermore, it aligns with the sustainable development goals, NDP III objectives, VISION 2040, and the NRM manifesto, supporting economic growth, modern technology-driven mining, job creation, and poverty eradication. In conclusion, the design and construction of this underground communication system offer a promising solution to the challenges faced by Tiira small-scale miners. It not only enhances communication but also contributes to the overall well-being and economic development of the region. For future research, it is recommended to develop a multi-functional system that can handle communication, production monitoring, and personnel tracking during emergencies, further improving safety and productivity in underground mining operations.

DECLARATION

I SSENNYONGA PONTIOUS NGONDWE, BU/UG/2019/0090, declare that all the material portrayed in this project report is original and has never been submitted in for award of any Degree, certificate, or diploma to any university or institution of higher learning

Signature:

....

Date:

....

SSENNYONGA PONTIOUS NGONDWE.

ACKNOWLEDMENT
I take this opportunity to thank the almighty GOD who has made me push it this far. I also thank my teachers for the entire course time. Great thanks MR. BAKAMA and MR. EDISON who have guided me in achievement of the course requirement.

APPROVAL

This project report on the design and construction of an underground signaling system for use in small scale underground mining and has been written under the supervision of;

Supervisor

Name: **NASSASIRA MICHEAL BAKAMA**

Signature:

…………………………………………………………………………………………………

Date

…………………………………………………………………………………………………

Co Supervisor

Name: NUWAREEBA EDISON

Signature

………………………………...

Date

…………………………………………………………………………………………………

TABLE OF CONTENTS

List of tables

List of figures

CHAPTER ONE INTRODUCTION

1.1 Background

Communication is crucial for safety, efficiency, and coordination in mining operations, enhancing worker well-being and optimal resource extraction. However, underground communication poses many challenges due to the harsh and complex environment of mines. Therefore, various communication systems have been developed to meet the specific needs and requirements of underground mining Yarkan *et al.* 2009.

The communication systems can be broadly classified into three categories: wired, wireless, and fiber optics. Each category has its own advantages and disadvantages, as well as examples of devices that use them.

Wired systems use cables to transmit signals between devices. They are reliable, secure, and can support high bandwidth and data rates. However, they also have drawbacks such as limited mobility, high installation and maintenance costs, susceptibility to damage and interference, and difficulty in extending or modifying the network. Some examples of wired devices are intercoms, telephones, leaky feeder cables, and power line communication devices(*CDC - Mining - Basic Wireless Communication and Electronic Tracking Tutorial - NIOSH*, 2016).

Wireless systems use radio waves or electromagnetic fields to transmit signals between devices. They offer mobility, flexibility, scalability, and low installation costs. However, they also face challenges such as interference, attenuation, multipath fading, limited signal range and bandwidth, security risks, and regulatory constraints. Some examples of wireless devices are Wi-Fi routers, RFID tags, Bluetooth devices, wireless sensor networks, and wireless mesh networks(Techniques, 2017).

Fiber optic systems use optical fibres to transmit signals between devices. They have many advantages such as high bandwidth and data rate, immunity to interference and noise, low attenuation and power consumption, security and privacy protection, and long transmission distance.

However, they also have disadvantages such as installation complexity and cost, vulnerability to physical damage and environmental factors, need for specialized equipment and skills, and difficulty in integrating with other systems. Some examples of fibre optic devices are fibre optic cables, transceivers, switches, routers, and repeaters(Yarkan *et al.* 2009.

The three categories of communication systems can be compared and contrasted based on various criteria such as performance, cost, reliability, security, scalability, flexibility, and compatibility. Depending on the specific application and context of underground mining, different communication systems may be more suitable or preferable than others. Therefore, it is important to evaluate the trade-offs and benefits of each system before selecting the most appropriate one for the project(Domer, Gajski and Zhu, 2019).

Mining is one of the most important sectors in Uganda’s economy, contributing to about 30% of its exports. However, mine communication faces many challenges due to limited infrastructure and resources. Many mines rely on basic walkie-talkies or mobile phones for communication, which are prone to interference, noise, and low battery life. These devices also have a limited range and coverage, making it difficult to communicate with workers in remote or underground locations(SAFERWORLD, 2017).

REFERENCES

Bandyopadhyay, L.K., Chaulya, S.K. and Mishra, P.K. (2010) ‘Mine Communication Technique BT - Wireless Communication in Underground Mines: RFID-Based Sensor Networking’, in L.K. Bandyopadhyay, S.K. Chaulya, and P.K. Mishra (eds). Boston, MA: Springer US, pp. 1–64. Available at: https://doi.org/10.1007/978-0-387-98165-9_1.

CDC - Mining - Advanced Wireless Communication and Tracking Tutorial: 2 - NIOSH (no date). Available at: https://www.cdc.gov/niosh/mining/content/emergencymanagementandresponse/commtracking/advcommtrackingtutorial2.html (Accessed: 6 April 2023).

CDC - Mining - Basic Wireless Communication and Electronic Tracking Tutorial - NIOSH (no date a). Available at: https://www.cdc.gov/niosh/mining/content/emergencymanagementandresponse/commtracking/commtrackingtutorial1.html (Accessed: 3 March 2023).

CDC - Mining - Basic Wireless Communication and Electronic Tracking Tutorial - NIOSH (no date b). Available at: https://www.cdc.gov/niosh/mining/content/emergencymanagementandresponse/commtracking/commtrackingtutorial1.html (Accessed: 6 April 2023).

Computer, G.P. (no date) ‘Embedded systems design’.

Domer, R., Gajski, D. and Zhu, J. (no date) ‘Speci cation and Design of Embedded Systems 2 A Generic Co-Design Methodology’.

Elshrief, S.A.E., Sadek, R.A. and Ghalwash, A. (2014) ‘Comparative analysis of authentication techniques to Secure Low Level Reader Protocol (LLRP)’, *2014 31st National Radio Science Conference (NRSC), Cairo, Egypt*, pp. 73–81. Available at: https://doi.org/10.1109/NRSC.2014.6835063.

Engineering, E. (no date) ‘DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING’.

Khalili, A. *et al.* (2020) ‘Wi Fi sensing: applications and challenges’, *The Journal of Engineering*, 2020(3), pp. 87–97. Available at: https://doi.org/10.1049/joe.2019.0790.

‘MINING IN EAST AFRICA’ (no date).

Murphy, J N *et al.* (1978) ‘Underground Mine Communications’, 66(1).

Nakua, E.K. *et al.* (2019) ‘Injury rate and risk factors among small-scale gold miners in Ghana’, *BMC Public Health*, 19(1), p. 1368. Available at: https://doi.org/10.1186/s12889-019-7560-0.

NPV (2007) *Net Present Value (NPV) - Definition, Examples, How to Do NPV Analysis*. Available at: https://corporatefinanceinstitute.com/resources/valuation/net-present-value-npv/ (Accessed: 20 April 2023).

Onifade, M. *et al.* (2023) ‘Challenges and applications of digital technology in the mineral industry’, *Resources Policy*, 85, p. 103978. Available at: https://doi.org/https://doi.org/10.1016/j.resourpol.2023.103978.

Patri, A., Nayak, A. and Jayanthu, S. (2013) ‘Wireless Communication Systems For Underground Mines–A Critical Appraisal’, *Ijettjournal.Org*, 4(7), pp. 3149–3153. Available at: http://www.ijettjournal.org/volume-4/issue-7/IJETT-V4I7P174.pdf.

Qiu, W. *et al.* (2020) 'Design of Wireless Communication System in Mine'. Available at: https://doi.org/10.1088/1742-6596/1626/1/012031.

Riurean, S.M., Leba, M. and Ionica, A.C. (2021) 'A Hybrid Communication System for Mining Industry. From RequirementS' Analysis to Testing the Product BT - Application of Visible Light Wireless Communication in Underground Mine', in S.M. Riurean, M. Leba, and A.C. Ionica (eds). Cham: Springer International Publishing, pp. 127–211. Available at: https://doi.org/10.1007/978-3-030-61408-9_3.

SAFERWORLD (2017) 'Mining in Uganda: A conflict sensitive analysis', *Democratic governance facility*, (August), pp. 1–25.

Solutions, C. (no date) 'Underground communication'.

Staff, B. (no date) 'Underground Mine Communications , Control and Monitoring Underground Mine Communications , Control and Monitoring'.

Techniques, C. (no date) 'RADIO FREQUENCY COMMUNICATION SYSTEMS IN UNDERGROUND MINES'.

Tilton, J.E. and Guzmán, J.I. (2016) 'Mineral economics and policy', in *Mineral Economics and Policy*, pp. 1–255. Available at: https://doi.org/10.4324/9781315733708.

WALLUM P (1970) *Mining Engineering*, *Mining Mag*.

Yenchek, M.R. (no date) 'Through-the Earth Mine Communication Systems Through-the-Earth Communications Communicator'.

Zhao, H. and Yang, W. (2018) 'An emergency rescue communication system and environmental monitoring subsystem for underground coal mine based on wireless mesh network', 14(10). Available at: https://doi.org/10.1177/1550147718805935.