Application of Solar Powered Electronic Notice Board to Blasting Schedules in Mining Operations*

[1]E. Normanyo and [1]I. A. Danquah
[1]University of Mines and Technology (UMaT), Tarkwa, Ghana

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Abstract

Wireless electronic notice boards offer great advantages and are very significant in diverse areas. In this paper, a solar powered wireless electronic notice board was designed utilising global system for mobile communication technology, Arduino Uno board with ATmega328P microcontroller to display the blasting schedules in mining operations. A prototype of the system was constructed. The ATmega328P microcontroller was programmed using the Arduino Integrated Development Environment software while the system was simulated using the Proteus software before the physical implementation of the system was done. The simulated and the physical implementation results showed that the system is able to display the blasting schedules of the mine. Cost of implementation stood at US$ 864.05.

Keywords: Microcontroller, Notice Board, Photovoltaic, Simulation, Wireless

1 Introduction

Notice boards are one of the widely used means to convey messages. Nowadays people prefer to communicate while on the move since the invention of mobile phones which employs the use of Global System for Mobile Communication (GSM) technology. Globally over one billion people have recognised the use of GSM for mobile phone applications. With regards to this technology, GSM based electronic notice boards are used as a major way of displaying information in many public places such as the hospitals, railway stations, schools etc. Electronic notice boards can also be employed in the mining industry to simplify the real time noticing of blasting events. Blasting injuries sometimes result from failure to communicate the blasting schedules to the workers, visitors and the public.

In some mining companies, markers are used to write the new blasting events on the notice boards. This method is time wasting and costly considering the fuel used by cars to go round and update the notice boards. Furthermore, the information written on the notice boards is sometimes wiped away by rain preventing the information from reaching the targeted public. In some cases, the notice boards are not updated on time which sometimes leads to lack of awareness of the blasting events in particular.

Several research works have been reported in the literature regarding development of electronic notice boards using microcontrollers hence, telecommunication technology. Notable amongst them are GSM based electronic display boards using ATmega microcontroller (Bhoyar *et al*., 2014; Gurav and Jagtap, 2015; Kamboj and Abrol, 2013; Kamdar *et al*., 2013; Ketkar *et al.*, 2013; Otuoze *et al*., 2016; Reddy and Venkareshwarlu, 2013; Saini *et al.*, 2014; Sharma *et al*., 2015; Singh *et al.*, 2015), deploying PIC 16F877A microcontroller (Dogo *et al.*, 2014; Hakani, 2014; San *et al*., 2013). ARM microprocessor was utilised by Mao (2018) whilst ARM7 microcontroller was used by Kumar *et al*. (2016). Gaikwad *et al.* (2013) made use of Zigbee technology whilst Selvakumari *et al*. (2015) made use of the power consumption reducing Raspberry Pi with JavaScript coding to implement electronic information notice boards. However, Raspberry Pi was combined with Internet of Things (IoT) by Srivastava and Jakkani (2018). Gowrishankar *et al*. (2018) created an improved Light Emitting Diode (LED) display notice board with GSM technology by transferring the Short Message Service (SMS) through cellular device and provided a dual system for changing messages. The system was both AC and solar powered. The system turns ON or OFF automatically with the aid of a motion detector. Gayathri *et al*. (2015) introduced the development of wireless notice boards with self-generating power from a built-in solar panel for its working and the main advantage obtained from this work was the major reduction in power consumption and manpower. The messages were able to pass immediately to the display board without delay.

Clearly, wireless electronic notice boards offer great advantages. Little work, however, has been done in using them in mining operations. This paper offers a solar powered wireless electronic notice board based on GSM technology to display the blasting schedules for mining operations. Fig. 1 shows a typical blasting notice put on a board in a mine.

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Fig. 1 Metallic Blasting Notice Board at NGR

2 Resources and Methods Used

2.1 Materials

The hardware materials required are the GSM shield, Arduino Uno with ATmega 328P, 43 bar-type professional-grade large screen display, solar panel. The software used for the programming and simulations are Proteus version 8.1 and Arduino Integrated Development Environment (IDE), respectively. Fig. 2 to Fig. 5 depict the hardware materials utilised.

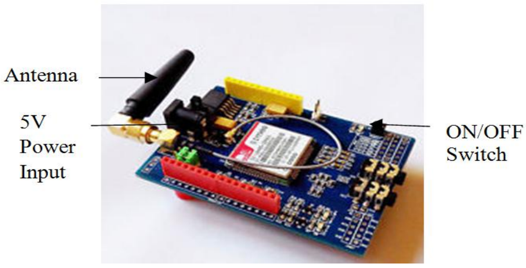

Fig. 2 The Arduino GSM Shield

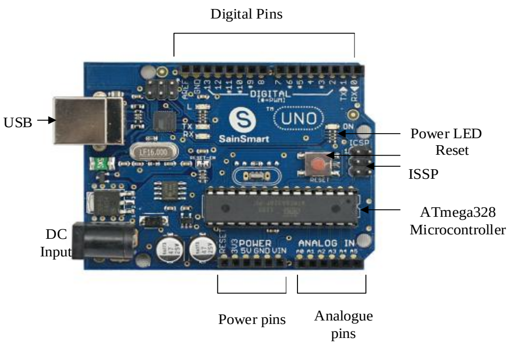

Fig. 3 The Arduino UNO Board

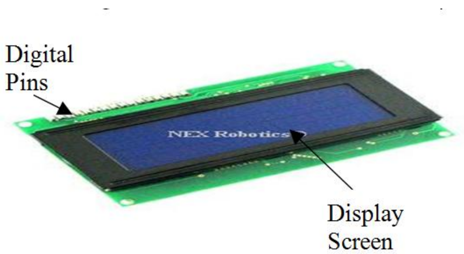

Fig. 4 The 20 × 4 LCD Display

Fig. 5 Solar Panel

2.2 Methods

The methods employed include the design concept, data collection and analysis, power supply computations, flowchart of the designed system, system modelling and simulations, physical implementation of the designed system and cost analysis.

2.2.1 Design Concept

In this design, the operator sends the blasting times in the form of a text message from his mobile phone to the GSM modem. The GSM modem is configured using simple AT commands which allow the GSM modem to interface with the microcontroller. When the GSM modem receives the message from the phone, it is then taken to the programmed microcontroller and then displayed on the LCD screen. Fig. 6 shows the block diagram of the design.

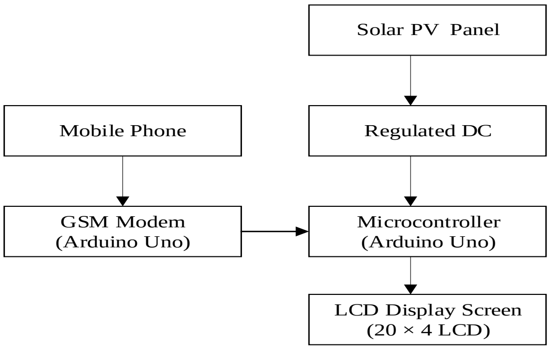

Fig. 6 Block Diagram of the Proposed Design

2.2.2 Data Collection and Analysis

The annual 22 - year average of direct radiation for most locations in Ghana is taken to be 4.40 (Anon., 2016). Distances from the mine for locations where blasting of rock is required could be averaged as 20 km. In any case, messaging using the GSM modem is not constrained by distances encountered in the mines.

2.2.3 Power Supply Computations

The power consumption of components is listed in Table 1.

Table 1 Power Consumption of the Components

Device	Rated Current (mA)	Operating Voltage (V)	Power Consu-med (W)	Energy Consumed in 24 Hrs (WH/day)
ATmega 328	50	5	0.25	6
Arduino GSM Shield	450	5	2.25	54
Large Screen Display	-	-	105	2580
Total			**107.5**	**2640**

Total energy required by PV panel is given by Equation (1), and the size of the solar panel is given by Equation (2).

$$E_{PV} = E_L \times E_c \qquad (1)$$
$$= 1.3 \times 2640 = 3432 \text{ WH/day}$$

where, E_{PV} = total energy required of PV panel, WH/day; E_c = energy consumed per day, WH/day; E_L = a constant for energy lost in the system.

$$P_S = \frac{E_{PV}}{P_F} \qquad (2)$$
$$= \frac{3432}{4.40} = 780 \text{ Wp}$$

where, P_S = size of the panel, Wp; E_{PV} = total energy required of PV panel, WH/day; P_F = panel generation factor.

The battery sized for 1day autonomy is given by Equation (3).

$$BC = \frac{E}{V} = \frac{E_c}{V} \qquad (3)$$

where, BC = battery capacity, AH; E = energy consumed by the system in a day, WH; V = nominal battery voltage, V; E_c = energy consumed by the system per day, WH/day

$$BC = \frac{2640 \text{ WH}}{12} = 220 \text{ AH}$$

For this system, battery is rated at 12 VDC, 220 AH.

For the power supply circuit, a capacitor (C1) of capacitance 0.1 µF, the 1N4744A zener diode with a reverse breakdown voltage of 15 V and the 7805 voltage regulator were employed. C1 is to prevent static discharge that is, the sudden flow of electricity between two electrically charged objects. The 1N4744A zener diode prevents the reverse flow of current which can destroy the solar panel. The 7805 voltage regulator IC steps down the 12 V from the battery source to 5 V as required by the system. The power supply circuit is shown in Fig. 7.

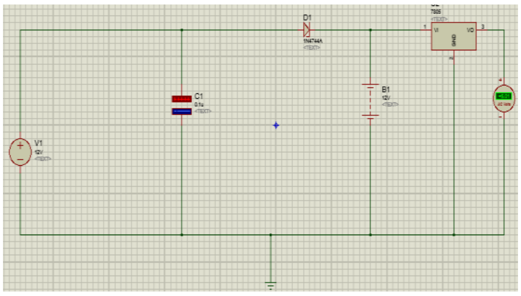

Fig. 7 Power Supply Circuit for the Designed System

2.2.4 Flowchart of the Designed System

The flowchart of the designed system is presented in Fig. 8.

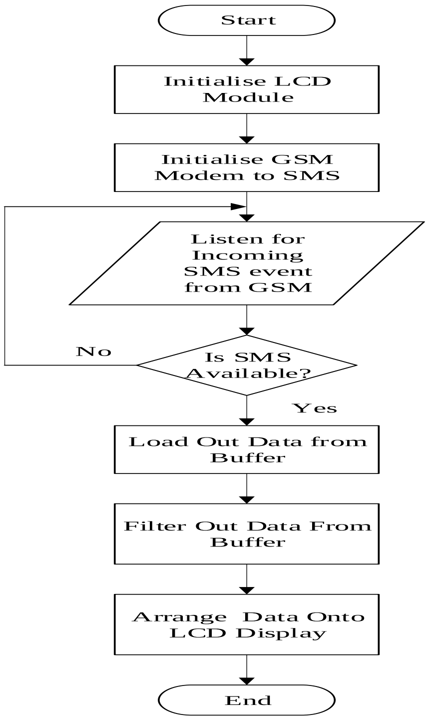

Fig. 8 Flowchart of the Designed System

The steps of the flowchart are as follows:
Step 1: Start the system and initialise mobile phone and LCD module.
Step 2: Initialise the GSM modem into short message service mode
Step 3: Peruse system for any incoming SMS message from the mobile phone – GSM modem.
Step 4: If no SMS message available, continue in anticipation; but if SMS message is available, then, load out and filter data from buffer.
Step 5: Send the data onto the LCD display.
Step 6: End.

2.2.5 System Modelling and Simulations

In the simulations, virtual terminal and the "compim" block in Proteus is used to represent the mobile phone. The blasting times are sent to the GSM modem represented in this circuit by the "compim" from the virtual terminal. The virtual terminal is interfaced with the GSM modem through the RXD and TXD which serve as the serial input and output pins. The TXD pin sends the data from the virtual terminal whereas the RXD pin of the GSM modem receives the data. The GSM modem is configured with AT commands. The message is decoded by the microcontroller which serves as the heart of the system and then sent to the LCD display board via the digital pins. A potentiometer is used for the regulation of the contrast of the LCD screen.

2.2.6 Physical Implementation of the Designed System

The physical connections of the design were made through the breadboard following the procedures used in the simulations. The Arduino Uno board provides two sources of power, 3.3 V and 5V. The power received from the USB port of the laptop, therefore helps power the board. Fig. 9 and Fig. 10 respectively show the circuit and physical implementation of the design.

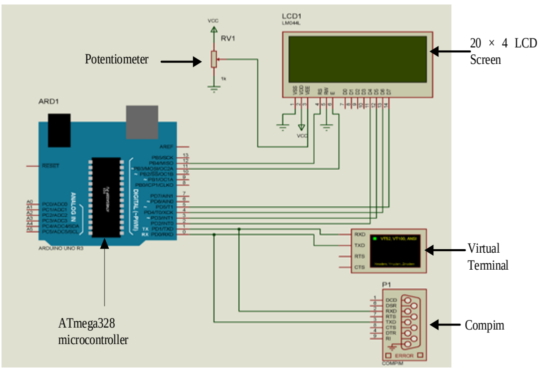

Fig. 9 Circuit Implementation in Proteus Software

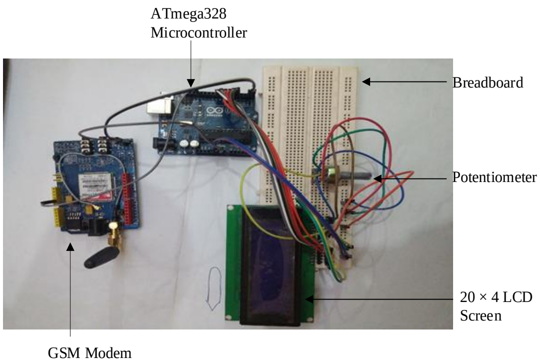

Fig. 10 Physical Implementation of the Design

3 Results and Discussion

3.1 Results

The results comprise those of the simulations, physical implementation and cost analysis.

3.1.1 Simulation Results

The simulation results with and without blasting schedules are presented in Fig. 11 and Fig. 12, respectively. The corresponding results of physical implementation are given in Fig. 13 and Fig. 14, respectively.

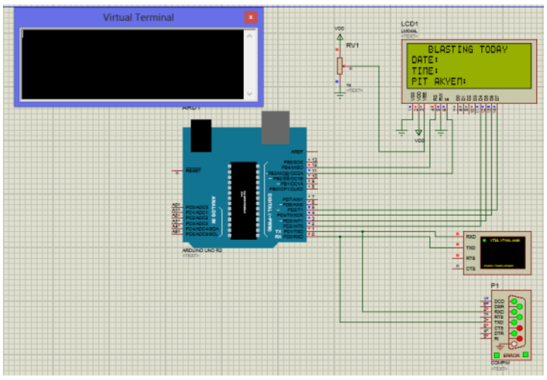

Fig. 11 Simulated System without Blasting Schedules

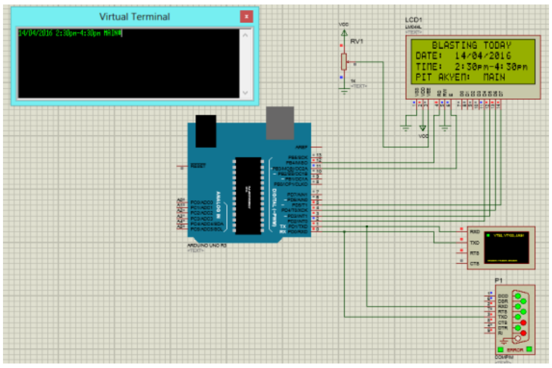

Fig. 12 Simulated System when Blasting Schedules are Sent

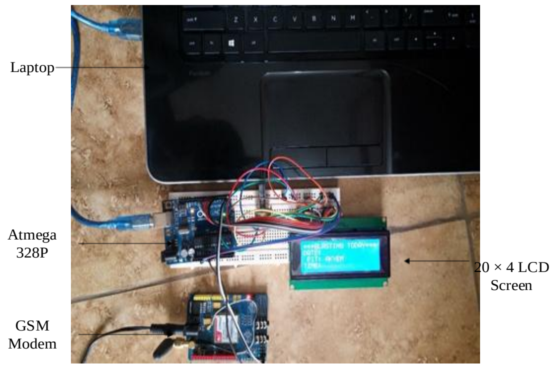

Fig. 13 Implemented System without any Blasting Schedules Sent to the System

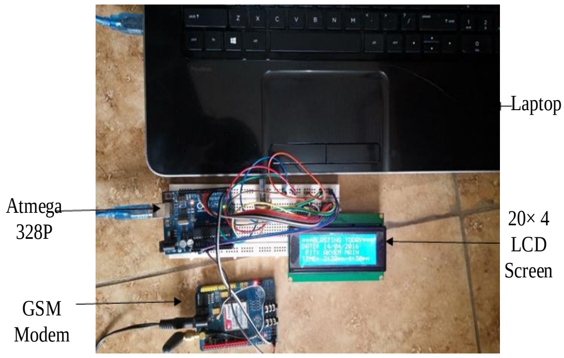

Fig. 14 Implemented System when the Blasting Schedules are Sent to the System

3.1.2 Results of Cost Analysis

A summary of the costing of the components used for the designed system is presented in Table 2. The conversion rate used for the cost analysis is US$ 1.00 is equivalent to GH¢ 5.50 as at February 1, 2020.

Table 2 Costing of the Components Employed

Component	Quantity	Cost, US$
Arduino Uno	1	37.50
Arduino GSM Modem	1	26.00
43 Bar-type Professional-grade Large Screen Display	1	699.00
Zener Diode	1	0.60
18 W Solar Panel	1	100
IC 7805	1	0.7
Capacitor	1	0.25
Total		**864.05**

3.2 Discussion

3.2.1 Discussion of Simulation Results

The proposed circuit was successfully simulated using Proteus software. The simulation was carried out to verify the functionality of design before physical implementation was carried out. When the system is ‘‘ON’’ and no blasting schedules have been sent through the virtual terminal to the GSM modem represented by the compim block in Proteus software, the microcontroller is programmed to display the information shown on the LCD screen as depicted in Fig. 10. When the user sends the blasting schedules as shown in the virtual terminal, the schedules are then displayed as shown in Fig. 11.

3.2.2 Discussion of Results of Physical Implementation

Physical implementation was done on a breadboard in order to demonstrate practical functioning of the system. When the system is ‘‘ON’’ without any blasting schedules sent to it, the information shown in Fig. 12 is displayed on the LCD screen. When the blasting schedules are sent in the form of SMS in the specified format on the mobile phone, the GSM modem receives the message and then sends it to the microcontroller for it to be decoded before it is displayed on the LCD screen as shown in Fig. 13.

3.2.3 Discussion of Results of Cost Analysis

The system was successfully simulated using Proteus software and implemented as well. Blasting schedules were easily sent in the form of Short Messaging Service (SMS) to the display board through the user’s mobile phone minimising the time spent and cost involved in going round to update blasting notice boards. With the use of solar power supply, the system can also be employed in isolated areas which are off grid.

Cost analysis showed that implementation of the system is very much affordable considering the benefits it would offer when deployed. An amount of GH¢ 4752.30 is required for the implementation.

4 Conclusions

From the results obtained from the simulation and physical implementation of the system, it can be concluded that GSM based electronic notice boards offer a faster and easier way of disseminating blasting schedules. The design is very cost effective considering the benefits associated when it is deployed. Mining companies could adopt this design for timely dissemination of information to the target public.

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Author

E. Normanyo is a Senior Lecturer in the Electrical and Electronic Engineering Department at the University of Mines and Technology, Tarkwa, Ghana. He holds MSc degree in Electromechanical Engineering from the Kharkov State University, Ukraine. He is a member of the Ghana Institution of Engineers. His research interests include industrial automation, industrial energy management, instrumentation systems, control engineering, artificial intelligence, automated electric drives and mechatronics.

I. A. Danquah obtained a Bachelor of Science Degree in Electrical and Electronic Engineering in 2016 from the University of Mines and Technology with First Class Honours. He is a student member of the Ghana Institution of Engineers. His research interests include energy management, industrial automation and instrumentation systems.