Implementation of wireless intelligent street lighting with phase-detection system

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***Abstract*: The advancement of technologies in wireless communication has led to several engineering designs for human requirements to solve a country's problems. Ghana as a country has issues with power instability on domestic, single-phase lines, to monitor some of these line faults "example when an area power outage occurs is a problem for the power distribution company to be aware of this fault ", this intelligent wireless street lighting with a phase-detection system is to solve this problem by automatically switch power sources to the battery which powers the streetlight when the national gridline is off, for temporal light at the location or area and also send a monitoring notification to the fault monitoring office, with the fault code for feather investigation. The project consists of a battery, inverter circuit, microcontroller, LCD, and current sensor. The system power battery stores a current of 9Ah (Ampere-hour), which means the battery can provide 9 amperes of current in one hour which can sustain three light units to the next morning. Since the system uses a 3.3 ampere the lamp, the battery can produce power within 6 hours before the power supply will be switched to the power grid for charging or for the fault to be rectified. From the data gathered, we can say that it is possible to use a streetlight to monitor line faults and also produce a two-way powering street light. The system is proven to be effective and operational.**

***Key Words*: LED lamp, Energy Efficient, Street Lighting, Battery, microcontroller, sensors, and inverter circuit**

I. INTRODUCTION

Illumination of streets and community at night is very important to society, as this could go a long way to prevent or curtail to a large extent the rate of crime during dark hours and motor accidents, this has strategic importance for the economic and social stability of a developing country [1]. Street lighting is one of the largest energy expenses for a community, the problems associated with the Ghana power system is not only with the streetlight illumination but the problem of fault detection on the community power line. The wireless intelligent street lighting systems is to cut consumer street lighting costs down and also provide a better way for a fault monitoring system online. A wireless intelligent street lighting with a phase detection system is a system that controls light output based on Day and Night, this intelligent street light will be managing a light output and power line through a wireless-based system by remotely monitoring faults that occur on the line and maintaining the actual energy consumption of the street lights and taking appropriate energy consumption reduction measures through control and battery backup when the phase is off. The system consists of a microcontroller along with a current/voltage sensor, wireless module, photocell, and battery system, the system will be on a pole that will control LED street lighting depending on day and night saturation, and communicate various faults between lines and street light. The data recorded from the street light and phase line will be transferred to the base station using wireless technology to monitor the system. The control system will switch on-off the lights at required timings depending on the value of the photocell[2] By using this system energy consumption will be reduced and also a response to power faults which include low current, high voltage, line off in the community will be attended to, in fast response on. One of the biggest disadvantages of employing timed circuits or manual is that the ON and OFF times varied greatly on sunny and wet days. This project uses an electromagnetically driven switch to switch on and off the lights at the proper moment by utilizing the operation of a transistor in the saturation and cut-off regions. It automatically turns off lights when exposed to sunshine. This is accomplished through the use of a photocell sensor, which detects light in the same way that human eyes do[3]

Problem definition

We have witnessed in a lot of towns where street lighting is one of the community's major energy bills. Some towns and portions of the city are still utilizing the manual method, in which the light is turned on in the evening before sunset and turned off the next morning once there is enough light outdoors. So, there is a lot of energy waste between ON and OFF timing and the issue of when part of the community power is off when it may be due to high voltage, low current, or short, this fault happens without the knowledge of power distribution company, this saturation will sometime put the community into total darkness, for, number of days before power office will come and rectify the fault. with the wireless sensor communication, information can be shear between the pole line and the power monitoring station [4]

Objectives

The study aims to develop a wireless intelligent street lighting with a phase-detection system that will automatically turn on/off lights with either the main gridline or back battery

and also be able to detect line faults and send wireless notifications.

II. OVERVIEW OF POWER TRANSMISSION

A power transmission system is critical to the uninterrupted delivery of power to customers. The monitoring of these systems is critical if healthy electricity is to be supplied to customers. The transmission system includes a safety mechanism that aids in the detection of aberrant or defective signals. The protective mechanisms protect the system and separate the faulty component from the rest of the system, resulting in minimum equipment damage and disruption. Fault analysis is a critical concern in power systems, in order to promptly to known the problems and guarantee power supply is restored as soon as feasible [7]. Power demand has resulted in increasing line current loads, although operators are still constrained by the system and line capacity, Overloading the system will cause overheating of the system insulation, resulting in system failure [9].

2.1 Short circuit fault

Faults can be classified into four types: line-to-line fault, double line-to-ground fault, single line-to-ground fault, and three-phase fault. Each of these types of faults can produce a different quantity of fault current. Short circuit damage can be avoided by using circuit breakers, relays, or other types of protection that help to cut power in reaction to excessive current [10].

2.2 Causes of Over voltage in Power System

Overvoltage is defined as an increase in voltage over a relatively brief period of time in a power system. It is often referred to as a voltage surge or voltage transients. Overvoltage can generate voltage stress, which can harm the lines and equipment linked to the system.

Overvoltage in a power system can be caused by one of two factors.

- External sources of overvoltage
- Internal sources of overvoltage

Transient overvoltage's can be produced at high (load switching and lightning), medium (capacitor energizing), or low frequencies.

External reasons for overvoltage: Lightning strikes in the cloud are the source of overvoltage in the electrical system. Now consider how lightning strikes are created. So, when electric charges collect in clouds as a result of a thunderstorm induced by a faulty atmospheric process, this form of overvoltage is caused by meteorological disturbances, most notably lightning. This takes the form of a surge and has nothing to do with the line's operational voltage.

III. WIRELESS NETWORK

Wireless networks are experiencing exponential traffic growth and increasing user significance. In some countries, such as Finland, the number of mobile subscribers has surpassed that of fixed subscriptions. The drawbacks of expensive pricing, limited data rates, and licensing requirements have been alleviated by technological and legislative improvements, which include the use of GSM as the main source of data information

3.1 GSM technology

GSM is an abbreviation for "Global System for Mobile Communications." It was created in 1990 and has since become the world's most widespread mobile phone standard. The coverage region of each cell is determined by the implementation environment. The edges of neighboring cells can overlap (big cells can be turned into smaller cells) [11]. The technique combines frequency division multiplexing (FDM) with temporal division multiplexing (TDM) (TDM). Different users utilize different frequencies at different time slots, so when the user is ON, it uses channel 900MHz for three seconds, then hops to channel 910MHz for the next three seconds, and so on. This method is known as frequency hopping. Among the different GSM frequencies, 900MHz is the operating frequency

3.2 Short Message Service

The Short Message Service is a common and inexpensive service used for receiving and sending messages in text. uses the GSM network to transfer information. This method of transmitting data is quite popular due to its convenience and low-cost factor. A single text message can consist of up to 160 characters. SMS mobile originated is a term used when a message is sent by a mobile. However, when a message is received by a mobile, it is termed SMS mobile terminated. Remote data communication and monitoring are supported by SMS due to its bi-directional data transfer and stability. Amit Sachen et al. have discussed how the user can read remote electrical parameters by sending a command in form of SMS messages [14]. Based on the setting, real-time electrical parameters can be automatically sent in the form of SMS periodically. Rectification of faults during the occurrence of any abnormality in power lines is also possible, as is the use of SMS via the GSM network to notify personnel of this action. Andriy Palamar et al. proposed the system, a Cellular phone, which has a Subscriber's Identifying Module (SIM) card with a specific number through which communication is made [15]. The medium of communication is wireless and works on the Global System for Mobile communication technology (GSM). Using cooperative relaying strategies [16–20], these gains are also possible for single-antenna nodes. The scholars considered it necessary. Depending on the settings, real-time electrical parameters can be automatically provided in the form of SMS on a regular basis. Rectification

of faults during the occurrence of any irregularity in power lines is also made accessible, as is the use of SMS via the GSM network to notify staff of this action.Andriy Palamar et al presented the system, which includes a cell phone with a Subscriber's Identifying Module (SIM) card with a unique number for communication [15].Wireless communication is used, and it is based on the Global System for Mobile Communication technology (GSM).These increases are also feasible for single-antenna nodes using cooperative relaying schemes [16-20].The intellectuals thought it was necessary

IV. METHODOLOGY

The proposal research block diagram is shown in Figure 1 which explain various connection of the enteral system, The atmega 328 microcontroller, which serves as the system's controller, allows access to the system's real-time status. It gets the observed parameter during power transmission on the pole and detects short circuit and high voltage limit violations by comparing the both current/voltage sensed with the pre-set limit value. If the current measured exceeds the pre-set current short circuit limit, the microcontroller sends a signal to the relay, causing the system to be disconnected and connect to the backup battery which inverts DC voltage to AC voltage to power the streetlight; otherwise, the system stays connected. When the system's relay trips, SMS information containing the error or the fault code is delivered to the fault detection monitoring interfacing over the GSM network.

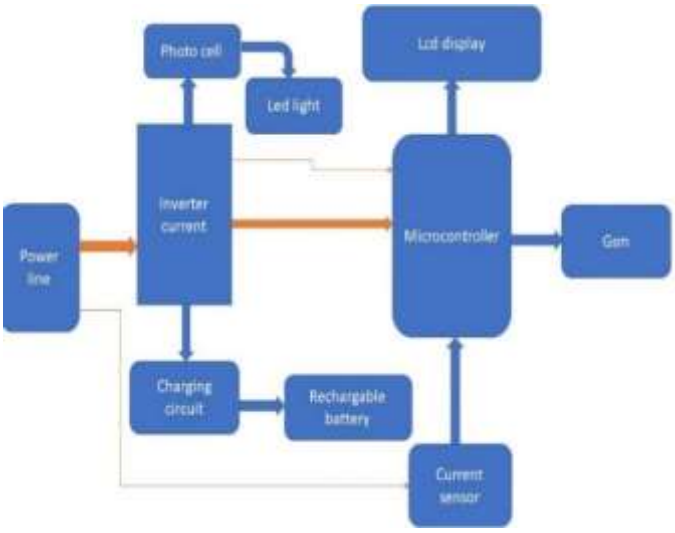

Figure 1

The system circuit diagram is made up of different components that when incorporated or interfaced gives the expected outcome which is the automatic pole fault system with a streetlight system, The automated wireless street light will be explained using the building circuit diagram illustrated in figure 2.

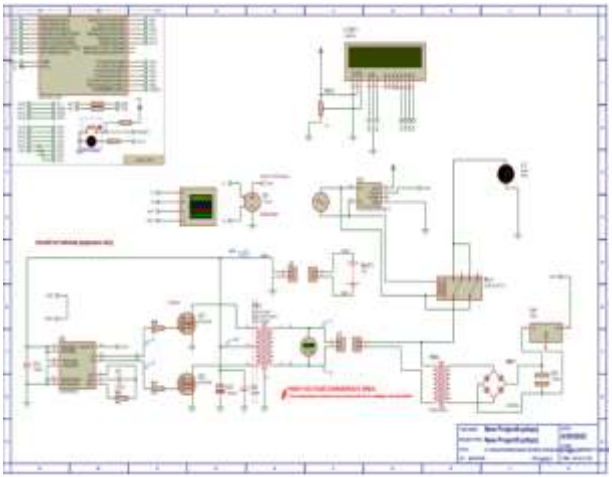

Figure 2

the circuit consists of the various sections stated:

- Backup battery.
- Microcontroller
- LCD – display
- Current sensor
- Wireless communication section
- Inverter circuit (sg3025)
- Transformer
- Photocell

The GSM modem is a wireless modem that connects to a GSM network. Unlike dial-up modems, GSM modems deliver and receive data through waves. To function, it requires a SIM card from a cellular network carrier. When the defined threshold is crossed, the system uses the GSM modem to send an immediate message to the utility cell phone, detailing the present issue and its location.

Operation of the GSM network

The AT instructions are used by the microcontroller to operate modems. The GSM modem, on the other hand, provides a fixed and expanded set of AT instructions. The following functions are enabled by the GSM standards-defined expanded set of AT commands:

- Send SMS messages
- Reading, writing, and searching for phone numbers.
- Check the signal strength.
- SMS message reading, writing, and deletion

4.1 Photocell

According to Rashid (2004), the device contains a very small light sensor (light-dependent resistor) which depends on the amount of light it is exposed to. In the absence of light, it limits the flow of current to its load and when it is exposed to light, its resistance reduces to allow the flow of enough current to the load

4.2 Current Detector

A current sensor is a device that detects and generates a signal proportional to the amount of electric current (AC or DC) in a wire. The signal created might be analog voltage, current, or even digital output. It can then be used to show the measured current in an ammeter, save it for future study in a data gathering system, or regulate it.

4.3 Relays

A relay is an electromechanical device that is often activated by an electrical current. The passage of current in one circuit causes the other circuit to open or close. Relays, which are similar to remote control switches, are widely employed in a variety of applications due to their relative simplicity, long life, and demonstrated high dependability. Although most people identify relays with electrical circuits, there are numerous additional varieties, including pneumatic and hydraulic. The input might be electrical and the output could be mechanical, or vice versa. Relays are primarily designed for two core functions.

4.3 Sensing unit

The sensing unit consists of voltage sensing, current sensing, frequency sensing,and temperature sensing, as it helps to acquire electrical parameters and make the respective signals available for the PIC to process

System Operation

The system operations are in three phases (a) the inverter system and (b) streetlight, (c) GSM and the sensor detection

the inverter system act as a backup system with a DC battery, and the system uses the main gridline voltage in the rectification process to change the battery. The operation of the main gridline is to power the street light when darkness approaches. Part of the 12v from the battery is being stepped down with lm7805 to 5v to supply to the microcontroller. The output of the microcontroller Analog pins 3, and 3 are connected to the current sensor and inverting sensing pins, these connections are for monitoring current and signal phasing fault

The battery charging circuit is a separate circuit that utilizes the same transformer used for the inverting, When the circuit opens and closes for the main power to flow through the transformer for the battery to charge, this is the work of the charge control system. The change circuit consists of Circuit Op-amp uA741 which acts as the main distributor.

The load (streetlights) between the main supply and the inverter power from the battery is alternated by the automatic load transfer. 24VDC powered single pole double through (SPDT) relays as electromagnetic switches to control the operation of the inverter turn on and off immediately grid mains fail. Based on this mode the loads automatically connect to the electricity power whereby the DC supply to the regulator is being cut off which prevents the inverters from operating. When the electric power goes OFF which when this happy, we classified as a power fault and the streetlight automatically connects itself to the inverter output

V. RESULTS AND OBSERVATIONS

The setup of the short circuit limit was tested. The system was program and was used to set a current limit of 20A. Because the microcontroller understands it, this was accomplished by training the system with pre-fault codes, the system was connecting a streetlight with a current rating greater than the of the inverter, this is to monitor the hours it will take the battery to supply the lighting. The system tripped off after the short circuit fault was imposed on the system. Hence confirming the test for fault detection and switching system using a relay to the inverter to supply the streetlight shown in figure 3

Figure 3 shows streetlight when the system is on battery mode Current Sensing testing

The output current of values of various faults was measured and recorded. As stated in Table 1, these results were compared to pre-set values and fault codes.

Part of the mainline is been further stepped down to 5v to be used as sensor voltage to check the live line, this was connected to the digital pin of the microcontroller. The microcontroller uses the 5v to decide between (0 and 1) when its one, the system records (no fault detect) and (0 recorders fault detected) this decision allows the relay to switch between the mainline and the inverter output when it senses 5V or 0v at the input Pin when this happen photosensor determine whether darkness or light or not before allowing the switching to the streetlight.

Table 1: Current value and its outcome when the system is detected

The current value in Amperes	Condition	Action
6A	Normal current	No-fault detected
5A	No	No-fault detected
4A to 1A	LOW current	Fault detected
10A	HIGH current	Fault detected

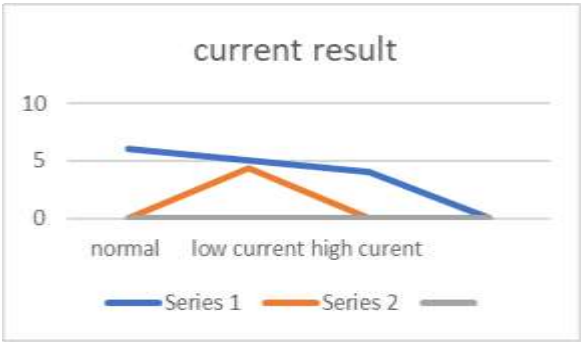

Figure :5 Graphical representation of Table 1

Table 2 – The Table below shows the Charge Condition of the 12V battery.

BATTERY CONDITION	12 V
BATTERY NEAR FULL CHARGE WHILE CHARGING	14.4 – 15.0
BATTERY NEAR FULL DISCHARGE WHILE CHARGING	12.3- 13.2
BATTERY FULLY CHARGED WITH LIGHT LOAD	12.4-12.7
BATTERY FULLY CHARGED WITH HEAVY LOAD	11.5-12.5
DISCHARGE BATTERY NEAR FULL WHILE DISCHARGING	10.2 – 11.2

Fig 5 shows the system display fault detection and the system is on battery mode, this is because at this saturation the system has detected either phase off on the mainline or high current, which needs to send notifications to the fault monitoring station

Table 3 –The ON and OFF test results of the Switching

Test day	Switch on time	Switch off time
1	6.55 pm	6.52 am
2	7.01 pm	6.54 am
3	6:59 PM	6:55 AM
4	6:58 PM	6:52 AM
5	6:55 PM	6:55 AM
6	7:00 PM	6:52 AM
7	6:59 PM	6:52 AM

V. CONCLUSION

The system is a cost-effective, practical, eco-friendly, and safe approach to saving energy, and the light status information in this system can be monitored at any time and from any location. It effectively addresses the two concerns that the world is experiencing today: energy conservation and the disposal of incandescent bulbs and fast reporting of fault, the use of the GSM cellular network for communication enables the development of a defect detection system. The primary goals of this research were met since the system created could identify transmission faults.

The fault occurrences were shown, and the notification was delivered to the utility cell phone over the GSM network. The system was able to receive an order from the utility phone to set a short circuit limit, establishing bi-directional communication.

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