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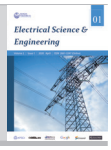

ARTICLE

A Petroleum Leakage Detection System

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ABSTRACT

This paper presents report of a design work on petroleum leakage detection system. It is a system that is designed to monitor seepage of petroleum products across pipeline installations. The design work which was simulated on a PROTEUS software, consists of a gas detecting sensor (GH-312), an 8-bit (AT89C51) Microcontroller, an alarm system and a remote PC. It was implemented as a laboratory prototype to sense seepages, generate an alarm and also send an alert message to a PC at remote location. Testing of the prototype was carried out in the laboratory using methane gas which is a component gas contained in petroleum products. Result shows an actuated alarm (upon the release of gas from test tube) and an instant alert message on the PC.

1. Background Study

Leakages from petroleum pipeline have been a subject of major concern to inhabitants of pipeline installations. Emissions from these leakages are hazardous due to the toxicity of the gasses. Seepages can also cause explosion that may lead to immeasurable loss of lives. It can also lead to environmental degradation and ecosystem destruction. Two major causes of leakages are identified; natural cause (e.g ruptures due to ageing) and man-made (through vandalism). Empirical data in the literature (Ogbeni O, 2000), shows that the former accounts for only 2.4% of incidences of leakage while the latter accounts for about 97.5% of incidences.

Pipeline vandalism refers to a deliberate act of damaging petroleum pipelines with criminal financial intent. In Nigerian context, it is termed oil bunkering or sabotage through ethnic militancy. Bunkering is the willful act of drilling into the pipelines with the intent of stealing petroleum products [4]. Apart from health hazards and environmental degradation, shortages of petroleum products, drastic drop in electricity generation and avalanche of socio-economic problems are other challenges associated with pipeline vandalism. Consequences of leakages from vandalism are immeasurable and unquantifiable for any nation that aims to attain greatness. One of the ways to get around these challenges is to prevent leakages, and even if it occurs, it must be detected and reported early enough so as to arrest the situation fast enough before it degenerate to a disastrous stage. To actualize this, gas or petroleum detectors can be installed at across pipeline installations and other vulnerable locations. A Number of research works on this have been conducted in the past.

Mahalingam et al. [3] proposed a cost effective gas leakage detector. Their work was designed to meet UK occupational and health hazard safety standards. In its

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implementation, a MQ-5 gas sensor was used which has the ability to sense multiple gases e.g propane and butane. This sensor was used in conjunction with a PIC 181320 Microcontroller. Their designed work has the ability to monitor gas level. If the gas level increases above normal threshold of 400ppm butane, the system will issue a warning alarm at 100ms interval. In a similar manner, Puran et al [5] proposed a gas leakage detection and monitoring system. In their work, a MQ-6 sensor and ARM microcontroller were used to sense and detect leakages. Report of any sensed gas would be sent through a Zigbee receiver to a PC for evaluation. In a bid to get a more robust system, Padmapriya et al. (2014) developed a wireless gas sensing network to detect gas leakage and equally generate an alert. A MQ-6 gas sensor was used in their work to sense seepage of gas in a pipeline. The system was interfaced with a GSM module and LCD to receive alert messages and display report. A little different approach to this challenge was developed by Zhang et al. [8] called a statistical pipeline system and tagged 'ATMOS PIPE'. This system was developed in Shell and has the ability to detect leakages using flow pattern recognition analysis. In its operation, this statistical method will actuate an alarm system only when there are changes in pressure flow pattern within the pipeline. It was implemented with a remote PC.

This work therefore, has proposed a petroleum leakage detector for use across pipeline installations in Nigeria. The design and implementation of the work comprises both software and hardware aspects. A laboratory prototype was built and tested with a component gas of petroleum product. This can further be adapted and integrated for use with petroleum pipelines. Major comparative advantage of this system is that when likely leakages are detected early, it will stimulate prompt attention by concerned authorities. This will prevent spillage, environmental degradation and loss of lives resulting from imminent explosion. More importantly, if this economic loss is curtailed, the nation will witness sustainable economic growth and development.

2. System Design & Implementation

The system is build on the block diagram as contained in Figure 1.

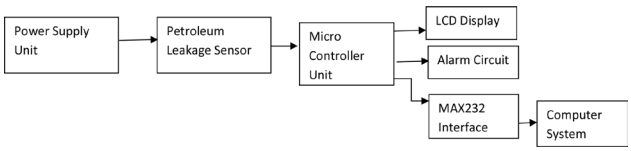

Figure 1. System block diagram

The power supply needed to drive the system is in two folds; a 5v d.c for the microcontroller and a 12vdc to power the gas sensor and the alarm circuit. Getting a 12vdc was straight forward since the step down transformer used is 12v, which was rectified to generate DC equivalent. However, caution was taken to guarantee a constant DC supply, irrespective of the output voltage from the transformer, hence, an LM7812 I.C regulator was used to achieve this. The 5v needed to power the microcontroller is sourced via LM7805 I.C regulator.

The microcontroller, Atmel AT89C51 is an 8bit component with 4K byte of flash programmable and erasable Read Only Memory (PEROM) with 1000 write/erase cycles for flexible programming and debugging.

The microcontroller is the heart of this system. It serves as a control interface between the gas sensor and the computer system.

The gas sensor is an Arduino gas sensor module which sends an output of 5volts on detection of Methane, butane, propane etc. The data sheet of the sensor shows, it has a high sensitivity of 10m². Though, the practical implementation shows a much less degree in sensitivity, as the sensor only detects a gas within a 100cm² reach.

The alarm unit consists of a 12 volts buzzer. A BC337 NON transistor which acts as a switch, such that, when a microcontroller output a high to the port that connects the buzzer, the transistor is biased, to switch ground to the buzzer whose positive terminal has been connected to a 12vdc supply.

The LCD is a 16x2 portable liquid crystals display which output a caption "Gas found" or "Gas not found" as controlled by the microcontroller. The max232 I.C is an interface unit that connects the microcomputer to a personal computer unit. The I.C has a circuitry, which convert the appropriate machine language suitable for computer process and also transmit the serial signal in parallel form due to the present of a UART circuitry in the chip.

3. Operation Technique

In its mode of operation, the operation relies on the fact that the petroleum is a highly inflammable product, the identified inflammable petroleum gasses are butane and methane. Hence, when the sensor detects any of these gasses, the output impedance of the sensor drops to less than 100ohms, which make it releases its output voltage to the microcontroller. The microcontroller, on getting the signal from the sensor, sends an output high signal to the buzzer, and also send a message to the LCD and to a remote computer system via the max232serial interface unit.

4. Testing and Result

Testing of this system was carried out in two sequence;

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before and after construction.

Before construction, a simulation test was carried out using PROTEUS software. To a large extent, it gave a satisfactory result. One of the greatest challenges of the software is however that, it does have component for the gas sensor (GH312). It was not listed the software components library. But knowing that the gas sensor will send some 5v output supply to the microcontroller upon detection of gas, a 5v output switch was use to serve as a sensor.

During the design stage, a variable power supply was used to power the breadboard in order to test the functionality in each stage. Results shows that, each of these stages was effectively driven upon supply of required voltage level.

The processor's output low is 0.5, and a high of 3-5volts. Therefore, on receiving a 5volts from the output of the sensor, it switches a high output signal of 5v to the buzzer through a BC337 NPN transistor. The current amplification factor of the transistor (B) is taking as 90 from the transistor's data sheet. The transistor is biased through the base current of 5mA.

i.e

$I_b = V_{bb} / R_b = 5v / 1X10^3$

$I_b = 5mA$

And;

$I_c = \beta I_b$

$= 90X5X10^3$

$Ic= 450mA$

The input impedance of the buzzer serves as RC, giving the output voltage Vout as;

$Vout= Vcc — IcRc$

$Vout= 12–450X10^3X8$

$Vout= 12–3.6$

$Vout = 8.4volts$

Therefore, output current

$Iout= Vout/Rc$

$= 8.4/8$

$= 1.05A.$

The high current makes the buzzer sound very loudly.

The Max232 output is a signal driven which serve as an interface to the computer system. This is connected to DB-9 serial connector, allowing a serial transmission to computer system. The microcontroller was programmed using assembly language which was assembled using SM-4 assembler and its Hex file is burned to the controller using a universal programmer and a turbo link program.

5. Conclusion

The gas leakage detector cannot be neglected in the effective monitoring of gas leakages and pipeline vandalisation. This device could also be used in homes to guide against any domestic gas leakages.

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