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Smart Home Security and Intrusion Detection System

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ABSTRACT

Conventional security systems which are the very common form of protection to lives and properties, have certain limitations such as real time monitoring and control of activities such as intruders in the form of human beings, fire, smoke, et cetera. These limitations in most cases result in high financial loss to properties and lives. This work involves the design and construction of GSM intelligent home security system for real time monitoring of different forms of intrusion. It consist of intrusion detection sensors, (pressure, Smoke/Fire, Gas and PIR motion), wireless sensors, programmable microcontroller in embedded C^{++} language, regulated power supply unit, proteus (circuit simulator), relays, GSM modem, mobile phone, data acquisition node and an interface program development. The design calculation and analysis was carried out before it was modelled, simulated in proteus electronic simulator environment. When the PIR finds intruders (in form of variation in temperature, gas leakage, pressure), the relevant sensing device(s) respond and the microcontroller sends encoded alarm signal to the wireless sensor network established in home. The moment the alarm signal is received, it will send alarm short message to the users (owners of the building) through GSM network immediately. The design analysis and calculations were carried out and finally, a positive result was achieved.

KEYWORDS: *Intruder, Detector, GSM, Sensor and Security*

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INTRODUCTION

In recent time of digital technology and intelligent based systems, home automation is evolving to become one of the fastest developing application based technology. The concept and desire for comfortable living in homes has since changed for the past decade as digital and wireless technologies, are integrated into it. The main concept behind this research is receiving sent Short Message Services (SMS) and processing it further as required to perform several operational response.

There are several terminologies that are used extensively throughout this paper such as Global System for Mobile Communication (GSM) and SMS plays a major role. It is a service available on most digital mobile phones (also known as short messaging service). Smart homes in simple terms can be described as homes that are fully automated in terms of carrying out a predetermined task, providing feed back to the home users and responding accordingly to situations. Smart home security systems such as controlled networks, communication systems, emergency response, anti-theft monitoring systems requires automated and controlled system both near and at a distance of control. Smart home security systems play important roles in providing an extra layer of security through user authentication to prevent force entry at entry points and also to track illegal intrusions or activities within the vicinity of the home. There are many researches done in the design of various types of intelligent home security system like sensor-based system that reply and contact-based systems such as finger-print and palm-print scan that requires substantial amount with an input device. Many intelligent home security systems are based on a single system. GSM technology provides the benefit that intelligent home security system is accessible in remote areas as well.

This paper is aimed at designing a GSM based intelligent home security system for detecting an intrusion into a monitored area by different sensors including passive infrared (PIR) detector. For home safety, intrusion detector has a transmitter coupled

with portable receiver to alert home owners through SMS in situations of break-ins or entering into the home using force or unaccepted/uncertified access manner.

REVIEW OF RELATED WORKS

Smart home security system has been a feature of science fiction writing for many years, but has become practical since the early 20th century following the widespread introduction of modern internet services into the home and rapid advancement of information technology. Early remote control devices began to emerge in the late 1800s for example, Nikola Tesla, patented an idea for remote control of vessels and vehicles (Tesla, 1898) in a research work titled "Method for Controlling Mechanisms of Moving Vessels and Vehicles". The emergence of electrical home appliances began between 1915 and 1920. More so, the decline in domestic servants meant for the household needed cheap, mechanical replacement. Domestic electricity supply however was still in its infant stage-meaning this luxury was afforded only by the more affluent households as investigated and published by Harper in 2003. Ideas similar to intelligent home security systems originated during the world fairs of the 1930s (Mann, 2005) as reported in the work titled "Smart Technology for Aging, Disability and Independence Depicted Electrified and Automated Homes". In 1966, Jim Sutherland an engineer working for Westinghouse Electric developed home security system called "ECHO IV". This was however, a private project and never commercialized.

The first "wired home" were built by American hobbyist during the 1960's using the available technology of the times. The term "Smart Home" was first coined by the American Association of House builders in 1984 with the invention of microcontrollers. The cost of electronic control fell rapidly as time progresses thus making it more affordable.

Remote and intelligent control technologies were adopted by the building services industry and appliance manufacturers worldwide, as they offer end users easy accessibility and/or greater control in their products (Harper, 2003). During the 1990's, home security systems rose to prominence by the end of the decade, domotics was commonly used to describe any system in which informatics and telematics were combined to support activities in the home. The phrase appears to be a portmanteau word formed from domus (Latin meaning house) and informatics referring specifically to the application of computer technology to domestic appliances (Gerhart, 1999). As described by the author in the work titled "Home Automation and Wiring".

Despite interest in home security systems, by the end of 1990's, there was still no widespread uptake with such systems as it was still considered as the domain of hobbyist or the rich. The major challenge was however traced to lack of a single, simplified, protocol and high cost of the device, thus resulting in not making customers to be able to afford it. While there is still much room for growth, according to researchers, one million, five hundred thousand home security systems were installed in the US in 2012 and sharp uptake could see shipments topping over eight million in 2017 (ABI Research, 2012). In a recent publication, Managa, Priyadharshini, Subalakshmi et al (2021), designed a smart intruder detection system whose security module sends image notification only via wired and wireless lines. Intelligent home security system involves automation of homes or household activities such as security locks of gates and doors.

The overall idea is to provide improved efficiency and security in their place /areas of applications. In recent years, the popularity of home automation has been increasingly great because of its affordability and simplified design through smartphones, internet connectivity/facilities and cable connectivity. Devices may be connected through a computer network to allow control by a personal computer, and may allow remote access from the internet. Through the integration of information technologies with the home security, systems are able to communicate in an integrated manner which results in convenience, energy efficiency and safety benefit (Omorogiuwa E. and Elechi P, 2014).

Smart home security system can be described as the use of device and information technology to control home appliances and features (such as windows, doors et cetera.). Parameters to be controlled in any system could be very simple or complex. These can range from a simple lighting point through complex computer and microcontroller based networks with varying level of automation. A smart home security system is desired and adopted for ease, security and energy efficiency. The controller devices are properly interconnected such that there is obvious communication between the home appliance, device and the controller. For example, an alert message is sent through telephone line in case of any intrusion (abnormal accessibility) taking place (Mustafa P.F., Asraf S.M.H. and Idrus S.Z.S. 2020). It is the interconnected automated device that makes the home smart and will alert neighbour(s), or any other emergency line dedicated to intrusion(s) related cases/attempt. It does the monitoring via GSM

handset or web browser. One of the areas of application of intelligent home automation system is in smoke detection. An example of remote monitoring in smart home security system could be triggered when a smoke detector detect a fire or smoke condition. The system could also call the home owner on their mobile phone to alert them, or alert the neighbour(s).

Table 1 Smart Sensors for Intelligent Security Systems

SENSING VARIABLE	SENSOR PARAMETER	SENSOR NAME
Motion	Passive infrared	PIR motion sensor (N55)
Temperature	Band-gap	SHT 75
Humidity	Capacitive	SHT 75
Light	Light dependent resistor	Light Dependent Resistor chip
Smoke	Ionization	CHUBB smoke detector

OVERVIEW OF SMART INTRUSION DETECTION SYSTEM

The intruder alarm systems and detectors, giving special focus on the several technologies applied, include wireless transmission and reception of alarm messages and commands through GSM/GPRS, TCP/IP and it involves development of web-based intruder alarm monitoring and control hardware and software. Useful techniques concerning the installation of intruder alarm systems for home owners are also described in detail. New developments for distributed web-based intruder alarm systems, which can include not only traditional signalling functions but also new intelligent decision functions, are challenges today for the intruder alarm designers. Web-based intruder alarm systems may include the use of distributed nets ("grid") giving each node the ability to dynamically configure its functions within entire respect for the security scope issues (Antunes, 2007). The distributed network intelligence will allow an intruder alarm system to react to multi-signalization intrusion situations in much more efficient ways, being also able to distinguish more accurately real security violation adverted operations.

Supplementary ISDN services, are digital in nature, and include call diversion, closed user group, and caller identification. Supplementary services also include the short message service (SMS).

MATERIALS AND SYSTEM DESIGN

Power Supply Unit (PSU): The power supply unit whose block diagram is in figure 1 consists of 240V/12V step down transformer, bridge rectifier, 1000µF/35V capacitor, 7805 voltage regulator status indicator LED, and 1KΩ resistor to limit the voltage entering the LED. The 240V/50Hz input supplies the transformer and the voltage is then stepped down to 12V, which then passes through the rectifier where it is then converted to D.C voltage. Smoothening the direct current (D.C.) is carried out by the capacitor. The 7805 regulates the voltage to give an output voltage of 5V DC required as Vcc.

This Vcc is delivered to various loads that need the supply. It is well noted that the distribution of the D.C. voltage to various parts of the system have some effects on the performance of the circuit.

D.C. voltage is isolated from the mains by the 240V/12V transformer before delivering to the output of the bridge rectifier.

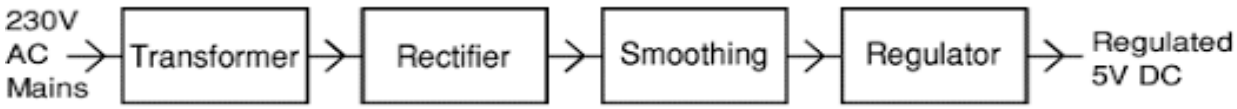

Fig.1: Block diagram of a Regulated 5 Volts Output Power Supply Unit

The rectifier circuit consists of diodes configured into a full wave bridge rectifier mode. The regulator used in the design provides regulated and stable D.C. voltage (5v+/-0.1%) and these output drive all chips used for the design .The capacitor is designed to filter and remove surges that appear on either the input or output of the supply.

The implementation of this work involves the use of hardware and software components. A list of the hardware components are as follows: GSM Module, Serial driver or communicator (RS 232), Microcontroller, Transistor, Relay, Gas Sensor, Fire/smoke and PIR motion sensor. Figure 2 shows the block diagram.

The software used includes: C++ Embedded programming language and Proteus Software (Circuit Simulation).

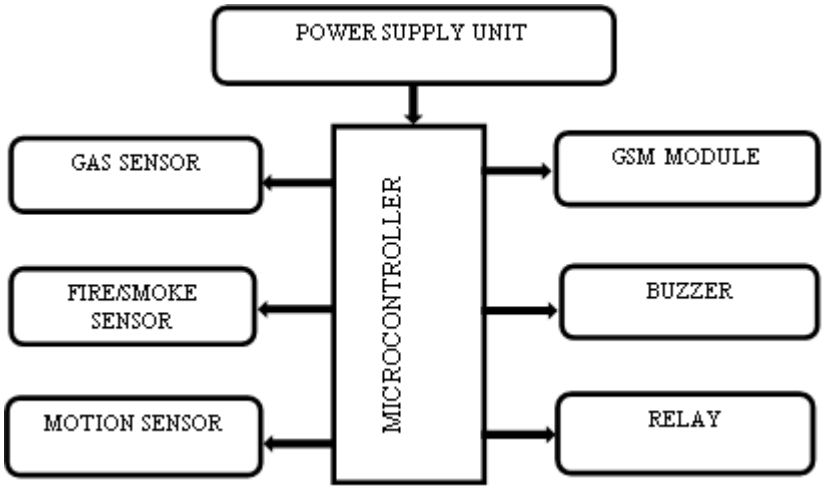

Fig.2: Smart Home Multiple Security Intrusion Detection System

GSM Module: GSM modem is a specialized type of modem which accepts SIM card, and operates over a subscription to mobile operators. The GSM modem can be interfaced with the computer system to establish communication over the mobile network. These GSM modems are most frequently used to provide mobile internet connectivity in addition to sending and receiving SMS and MMS messages. This device can also receive and process GSM signals from virtually all GSM bands.

GSM modem can be a dedicated modem device with serial, Bluetooth connection, USB or active mobile phone that provides GSM modem capabilities. The major usefulness of the module is its ability to interface with other circuit elements like the microprocessor hence making it possible to embed it with other systems.

Microcontroller: The microcontroller creates/enables interface between the different system units and manage communication between them. It is "computer-on-a-chip" and contains all the elements of computer. The microcontroller has been used in this work to measure, control, store, analyse and display information after it has been successfully programmed. It has built-in functions to minimize the need for external circuits and devices to the design in the final applications. See image of a typical microcontroller (AT89C2051) below.

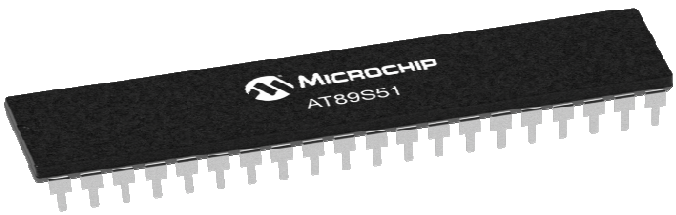

Fig. 2: AT89C2051 Microcontroller Source: www.8051.projects.net

PIR Motion Sensor: A passive infrared motion sensor is an electronic motion sensor that that has the ability to detect infrared light radiating from objects which are place close to it. They are used mainly in security alarms and automatic lighting systems.

This type of sensor uses the principle of signal differential between the pair of sensors to detect any motion within the sensors.

Fig. 3: PIR Motion Sensor. Source: axiselectronics.com

Gas Sensor: A **Gas Sensor** is a device which detects the presence and/or determine the concentration of various hazardous gases, volatile organic compounds, humidity and odours in the atmosphere. Based on the concentration of the gas the sensor produces a corresponding potential difference by changing the resistance of the material inside the sensor, which can be measured as output voltage. Based on this voltage value the type and concentration of the gas can be estimated.

Fig. 4: MQ-2 Gas Sensor. Source: www.microcontrollerslab.com

Temperature Sensor: Thermistor is a temperature sensing device whose resistance changes with temperature. Thermistors, however, are made from semiconductor materials. Thermistors exhibit a highly

nonlinear resistance versus temperature curve. In the Thermistor's operating range, a large resistance change can be observed for a very small temperature change. This makes it a highly sensitive device, which is ideal for set-point applications.

Thermistor is used to sense temperature of the home, when the temperature of the room increases beyond the reference temperature. It senses that the temperature of the home has increased. When it now senses heat, it converts temperature to voltage and the signal from it is small therefore it is amplified through the amplifier, LM385 and its amplified twice, before it is sent to the main board (microcontroller). It is powered from power supply unit (PSU).

Smoke Sensor

The smoke sensor is a device that senses smoke which typically indicates the presence of fire. It uses two devices, which are light dependent resistor (LDR) and light emitting diode (LED). When there is a smoke in the home, it casts a shadow on the LED, thereby Block the flow of light that goes to the LED, it sees the effect as an emergency 'the signal is further amplified and sent to the microcontroller.

Fig. 5a: Light Dependable Resistor

Fig. 5b: Light Emitting Diode
Source: electropeak.com

Relay Unit: Relays are simple switches used for switching. The switching mechanism is carried out with the help of an electromagnet.

Fig. 6: A Relay Board. Source: www.microcontrollerslab.com

Buzzer: Buzzer is an audio signalling device, which may be mechanical, electromechanical or piezoelectric.

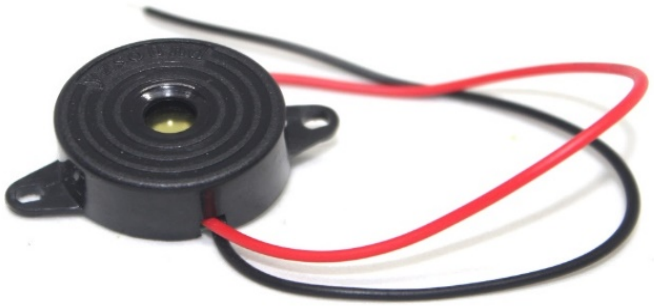

Fig. 7: High Decibel 5-24 Volts Buzzer.
Source: hub360.com.ng

CIRCUIT OPERATIONAL ANALYSIS

The sources of power to this smart home security system are from AC mains through a step down, AC to DC power supply unit. The AC mains can serve as the sole power source to the home security system. When the power is switched to the "ON" position, the whole circuit is complete and current flows. 2051 ATMEL microcontroller which is a 40 pin version of 8051 is used. 8051 ATMEL is a powerful microcomputer which provides a high flexible and cost effective solution to many embedded cost application. It is flash programmable and erasable electrically. The memory is 256bytes by 8bits of internal RAM streams of information and 32 programmable I/O lines. It is powered by 5volts. It has different ports, these ports can be used to send and receive information.

The input is filtered and regulated to 5_V with voltage regulator 7805, R_2 is a current limiting resistor, it limits the current supplied to the LED which is used for power indication. This is done to protect the diode from excessive current a resistor is placed in series with the LED.

The value of the series resistor Rs depend on the forward voltage V_f of the LED, the supply voltage Vt, and desired forward current I_f.

To find the value of Rs, applying ohm's law;

Given current limiting resistor,

$$Rs = \frac{Vc - Vf}{tf} = \frac{5v - 1.6v}{100mA} = 0.34K\Omega$$

But 1kΩ is resistor is used in the circuit.

Power is supplied to the microcontroller through pin 40, Vcc = 5_V and GND pin 0. At this point when power is supplied the microcontroller remains or stays in a low state waiting for an input signal. Port1.0 is used as input to the microcontroller, port 1.1 senses intrusion, port 1.2 senses high temperature, port 1.3 senses concentrated gas. Port 2 is used as output port from microcontroller to input of the buzzer and also for LED displays.

When an input pass through anyone sensors input, this is sensed by the microcontroller is interrupts. As such the microcontroller stops other software program running. It goes to access the address bus of the input signal and loads the program stored in the address register, after loading, it sends to control register, compute the signal based on the stored program and runs the instruction. It sends out streams of instruction to the output register or ports. The output instruction which set output high and to send information to the GSM Modem, initializing to send SMS to a program number and turn "ON" the indicator and buzzer.

The crystal oscillator determines the external frequency of the microcontroller, the rate at which it processes information is 11.0592MHz. From power supply unit (PSU), the power is supplied from the battery and filtered through capacitor C_1, to remove ripple or unwanted signal from the battery. The output port 2.2 is low and can't drive the buzzer. Therefore transistors Q_2, Q_3 are used to amplify the output to drive the buzzer; R_{10} is used to bias the input to base of the transistor Q_2, to set the current fed to the resistor. Q_2 starts conducting when the transistor's base receives a control voltage/current, the transistor will turn "ON" the buzzer. Switch S_1 is the reset button; is used to reset the microcontroller to its initialize state. The microcontroller in a voltage-deprived state and will have the tendency to behave erratically when the power supply voltage falls below the required 5V. For this reason, a reset chip I is incorporated into the design, forcing the PIC to reset to the beginning of the program and hold until the supply voltage is within acceptable limits.

TESTING

When the system was connected to power supply the LED lit up indicating the presence of power, initializing the microcontroller and GSM modem to send SMS. The HDMI Cable was connected to the GSM MODEM, and then the interface was lunched from the computer by double clicking on proteus icon, then we clicked the switch of the sensors, after selecting, press play; then it displays.

Each sensor is tested one after the other to confirm their conditions. Below are the test carried out on each sensor.

- **Gas Sensor**: The varying gas levels were all picked by the sensor and displayed on the interface. This was confirmed when a concentrated gas was brought close to the gas sensor and the gas level increased on the interface.
- **Temperature Sensor**: This was tested by taking the system close to a lighter and the temperature reading increased on the interface.
- **Passive infrared Sensor**: This was tested by taking my hand cross the receiver and transmitter, then buzzer sounded meaning an intrusion has taken place.

TEST RESULT

Each test result is displayed on the interface, and the entire result was satisfactory. Below is the display on the computer during the test:

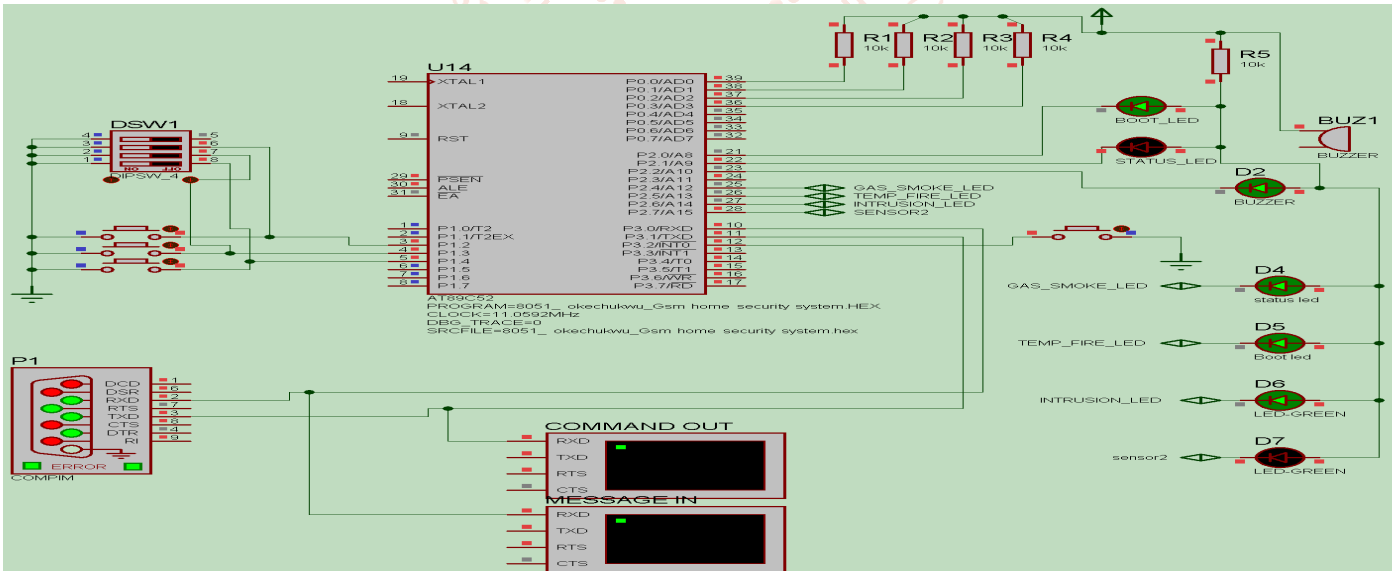

Fig. 8: Display of test Result on Computer

CONCLUSION

This work has presented the design and of a GSM based intelligent home security system. After the construction and component assembly, it was tested and they were responding to the GSM modem as detected by the infra-red sensors, high temperature sensor and gas sensor etc. But misuse of the system by end users may probably lead to lapses in the system performance. The system was designed and constructed in such a way that maintenance and repairs are easily done in the faults.

The design and construction of a GSM based intelligent home security system involves researches in different aspects of physics/electronics technology; this include; power electronics, operational amplifier, telecommunication, and software engineering. When the PIR finds intruders (in form of variation in temperature, gas leakage, pressure, etc), the relevant sensing device(s) respond and the microcontroller sends encoded alarm signal to the wireless sensor network established in home. The moment the alarm signal is received, it will send alarm short message to the users (owners of the building) through GSM network immediately. The design analysis and calculations were carried out and finally, a positive result was achieved.

RECOMMENDATIONS

In view of the limitations of this design, the following improvements are suggested as recommendations for future work in this area of study.

- An embedded system seems to be the direction in which electronics technology is headed. We recommend smart systems should be incorporated in the design.
- A digital camera can be incorporated to capture the real image in cases of human intrusion.
- Better microcontrollers are being produced all the time. We recommend the use of the latest microcontrollers and embedded microcontroller technology.

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