



Design of Microcontroller Based Intruder Lighting System (MBILS)

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Authors' contributions

This work was carried out in collaboration between both authors. Author MO designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author OAA managed the literature searches, analyses of the study performed the spectroscopy analysis and managed the experimental process. Both authors read and approved the final manuscript.

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ABSTRACT

The microcontroller based intruder lighting system is an intelligent system which applies to automated lighting systems in homes, offices, industries, military zones etc. The research will feature design microcontroller based intruder lighting system that will activate light in environment in the presence of an intruder and inform the user about the coordinate position of the intruder.

The microcontroller AT89C51 and other electronic designs were employed for the above-mentioned purpose. The interfacing layer will make use of bi-directional communication in which the sensors is used as input device to receive signal when the intruder obstruct signal path while the control program will translate the received signal from the sensors to useful information and activate lighting system and camera. The camera will capture image of intruder and save to external memory. The design is to achieve energy-saving techniques and increase security strength of target environment.

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1. INTRODUCTION

There are various research works on intruder systems with different technologies that focus on securities, and energy saving patterns [1]. This design of microcontroller based intruder system is based on the simple Boolean logic concept that a sensor's switch contacts can be either open or closed for signal processing and control [1].

The need to secure home, industries and other related properties has been a major priority, since then, an aggressive development of technology in the area of security has exponentially been driven to today's trend and a system cannot have high assurance if it has poor security and requirements in its design. For maximum assurance, systems will logically include security protocol requirement, as well as availability, reliability and robustness requirements to satisfy prototype system design [2].

The intrusion techniques required logistic person workflow in the environment where intelligent device is planted to measure Security Bridge or tendency of activating nearby light in a matter of obstruction. Recently, it has become one of the most interesting aspects of individual, national and even international concern. In this study, three procedures will be highlighted which regards as significant factors required to initiate a home intruder system before integrating any technological component: (1) Install exterior lights and add either a timer or a motion detector device (2) Build security at all exterior doors and windows with strong locks (3) Trim and cut down trees that may cause obstruction especially around windows and doors. Many home intruder system tasks are easy and simple projects to install which can offer paramount security [3].

Looking at trends of technologies, there are different kinds of properties invader systems which are based on dynamic system protocols, for which the basic types of components are categorized as follow;

1.1 Wireless Security Alarms

A wireless security system that offers user broad coverage signal strength therefore, suits a home intruder system that will stop intruders before gaining entrance and summon for help immediately to ensure home protection.

1.2 Micro Computer Based Security System

This system senses the presence of an intruder and alerts the user of the obstruction detected in the area. It also displays the position of the intruder on a screen.

1.3 Motion Sensor Lights

Motion sensor lights system make intruders react like a deer with headlights. It is difficult to break into a home or an office when there is a spotlight shining down right on user.

1.4 Access Control Gates

This technology makes it hard for the intruder even to penetrate property, let alone into an office or a house, by surrounding environment with a high fence and installing an access control gate. An access control gate gives specific points of entry and exit onto user properties, and this can be monitored from inside therefore, the gate allows user, like family, co-worker and friends to enter and exit. A home intruder lighting system saves energy and keeps criminals further away from private or public properties [4].

1.5 The MBILS Device Framework

Microcontroller based Intruder lighting system (MBILS) device is an evolutionary interface module that renders full duplex communication using microcontroller device and this will be described using block segments as it's interfaced on framework.

1.6 An Overview of DMBILS Components

From the Fig. 1 above, the microcontroller operate the bi-directional mode as seen at the centre of design, receiving the input from intelligent sensor and transmit to the output peripheral (camera module and light module). The block diagrams consist of three stages, which are:

1.6.1 Sensor module

The sensor module consists of the touch sensor, the light detector and the darkness detector and each of these alarm sensing units makes up the different type of intruder detection system incorporated in this design.

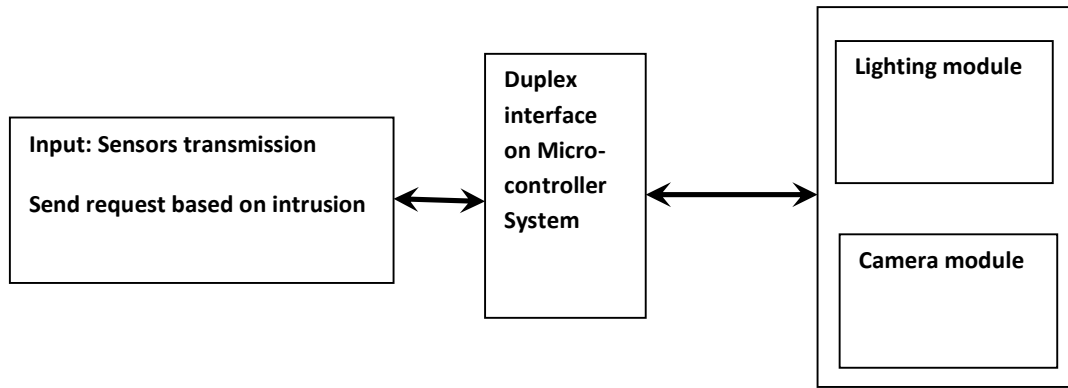


Fig. 1. An overview of the internals of a MBILS network

The sensor can be activated at the close contact of the object which varies internal resistance of LDR and voltage divider is used to convert the varying voltage for activation therefore, the voltage signal in this design feeds as an input into a NPN (C945) transistor switch [5].

1.6.2 Selection of resistor value

The output voltage depends on resistor (R) values therefore its is required to use an ohmmeter to calculate the minimum and the maximum values of the sensor’s resistances R_{min} and R_{max} :

In this context:

$$R_{min} = 1.50 \text{ k}\Omega \text{ and } R_{max} = 560 \text{ k}\Omega$$

Which gives $R = \sqrt{R_{min}R_{max}} \dots\dots\dots (1)$

Since the MBILS is capable of monitoring three different intruders from coordinate point, the above design was repeated three times to represent the input to the parallel port status pins.

1.6.3 The transistor input state

$$V_{out} = \frac{V_{in}R_2}{R_1+R_2} = \dots\dots\dots (2)$$

Taking $V_{in} = 5V$, $R_1 4.7 \cdot 10^3 \Omega$ and $R_2 560. 10^3\Omega$

We obtain $V_{out} = 4.96V$

This increases the base current that drives the transistor to saturation.

The light will change with respect to object distance herefore, brighten lights as the person

walk along the passage or coverage area, we have $R_1 = 4.7. 10^3 \Omega$ and $R_2 = 9.5. 10^3 \Omega$

$$\text{So } V_{out} = 0.01V$$

1.6.4 Microcontroller (AT89C51) duplex mode

The specification for this design is AT89C51, as shown in Fig. 2. The microcontroller used has 32 bits I/O ports, 4 interrupt, 128 ROM and 16MB RAM with 2 timers generally classified as 8051 family which can be programmed. This chip (AT89C51) was programme to receive input signals and transmit to other interfaced sub-module attached [6].

1.6.5 The serial ports interrupt

The 8051 family used in MBILS design is characterized with Serial Control (SCON) and was configured for data bit (address bit) and baud rate by writing a SFR to write ‘X’ a value to serial port then the port mode was set to 1 or read SFR to read ‘R’ a value to serial port while the port mode was set to 1. The external INT 1 are used by external CKT and later configured to either X’ transmission and this can also be link to external device as communication port and the internal registers is shown in Fig. 3 [7,8].

1.6.6 MBILS cycle and crystal frequency

The microcontroller used in the design contains on-chip oscillator and also requires an external clock to run it. In most cases, a quartz-crystal oscillator is connected to inputs terminals XTAL1 (pin 19) and XTAL2 (pin 18) and therefore meet the requirement used in the design. The quartz-crystal oscillator connected to XTAL1 and XTAL2 pins coupled with two capacitors of 33 pF value.

One side of each capacitor is connected to the ground as shown in Fig. 4.

To determine MBILS cycle for compactable chips also response rate was expressed bellow; If XTAL = 11.0592MGZ

For (a) AT89C51:- $1/11.05952MGZ = 90.42$ nanoseconds (ns)

Therefore MBILS cycle = $12 \times 90.42 \text{ ns} = 1.085 \mu\text{s}$

$1 \times 90.42 \text{ ns} = 90.42 \text{ ns}$
 $4 \times 90.42 \text{ ns} = 361.68 \text{ ns}$

Various time responses can be deduced by calculating cycle for recommended crystal that is suitable for MBILS device. Speed refers to the maximum oscillator frequency connected to XTAL (Crystal Oscillator) therefore; a 12-MHz chip is required to be connected to a crystal with 12 MHz frequency or less. Likewise, a 24-MHz microcontroller requires a crystal frequency of no more than 24 MHz to function well. When the 8051 is connected to a crystal oscillator and is powered up, the frequency from the pin XTAL2 is clearly observed over oscilloscope for its performance.

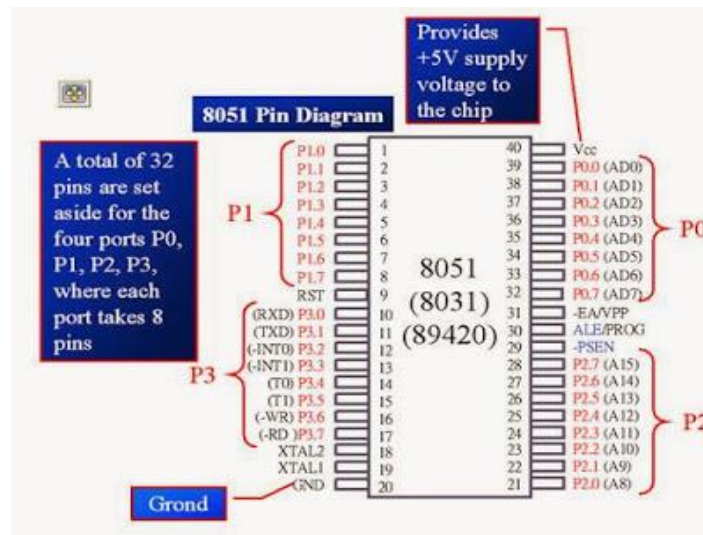


Fig. 2. showing Pin description of 8051/AT89C51 microcontroller

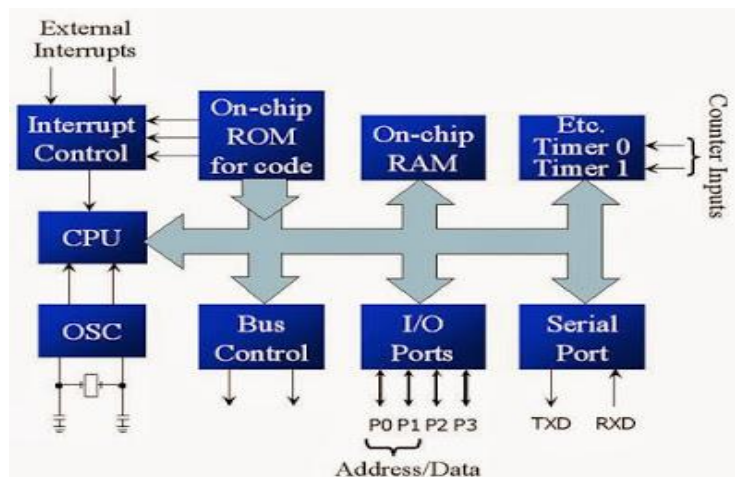


Fig. 3. Internal registers of 8051/AT89C51 microcontroller

For this foresight the experiment deduced that the number of machine cycles it takes to execute an instruction is not the same for the microcontroller AT89C51 and DS89C4xO digital signal processing chip as narrated in [7,9].

1.7 Lighting Module

In the output interface of the design, relays was used to control bulb that illuminate the environment and since relay is made up of electromagnet material, will received signal from microprocessor using Single Pole Double Throw (SPDT) or Double Pole Double Throw (DPDT) switching method. Its pin-out interface consist of 3 pins to control switching ON and OFF.

- COM** = Known as Common, always connected to NC pin; it is the moving part of the switch.
- NC** = Known as Normally Closed pin, (COM) is connected to this when the relay coil is off.
- NO** = Know as Normally Open pin, COM is connected to this when the relay coil is on.

The light (Bulb) was connected to the relay and communicate with microcontroller on port 0 (P3.2). Once the relay receive high and low signal from the microcontroller then the relay will open and close the output terminals (NO, COM) respectively. This description in the designed

was shown in Fig. 5 which indicates single-directional communication with microcontroller AT89C51.

In other part of the MBILS device output interface, the camera display module was used and its made up of intelligent 4.5 pixels to display the point of intrusion from camera view. The circuit design indicates open terminal output for IP camera and its interface with microcontroller on pin P_o_1. Other open ports (P₃_6 and P₃_7) are used to Light Systems. The display unit is used in the design to make it easy for security operatives and users using the system to locate the intruder position [10].

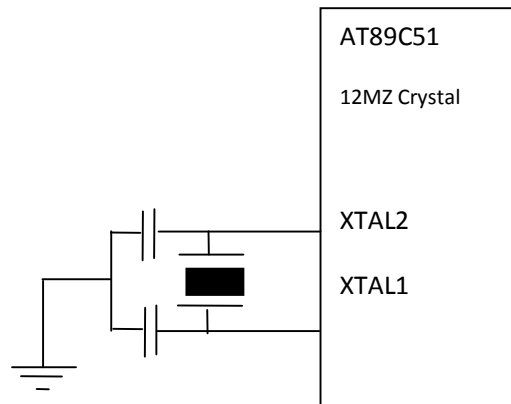


Fig. 4. Crystal oscillator

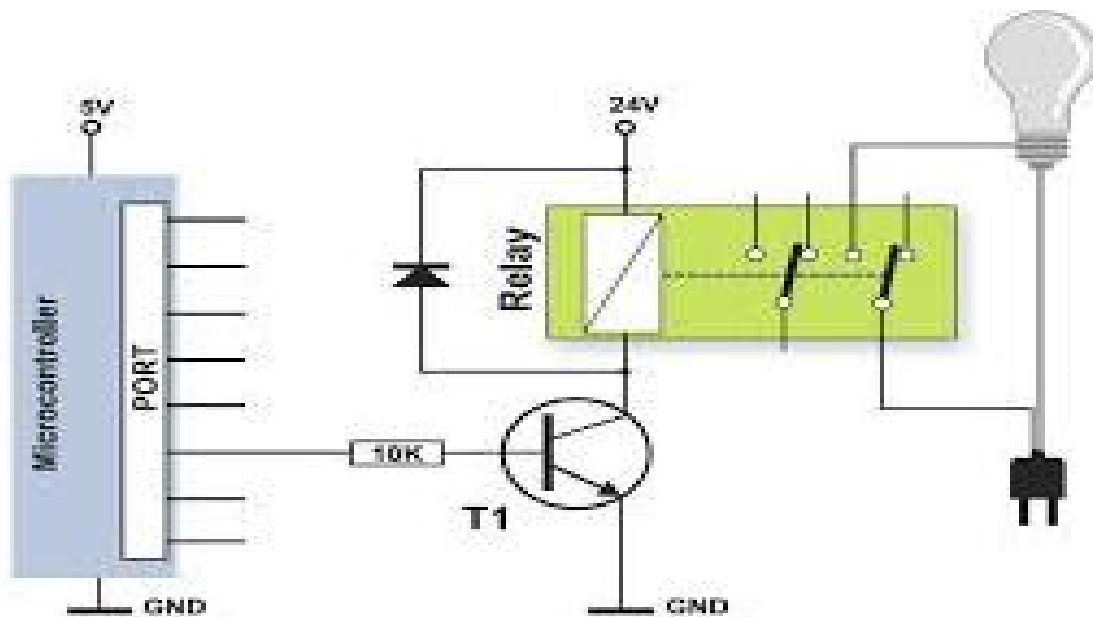


Fig. 5. Camera / light modules

1.8 Power Supply Transmission Model

The design power specification has 220AC (Alternating Current) input from utility or power grid with 12V/5V (VDC) output voltage. The power is made up of 220/12V step-down transformer was used for transformation of AC signal, bridge rectifier diodes IN4141 was used as rectification, capacitors (16V/100uf, 0.01uf) used as filter by allowing AC components to pass by block DC component and lastly, a voltage regulator LM705 was used to regulate output to voltage to +5 V [11]. The power produces 12VDC which used to drive relay only and regulated to 5VDC to drive other interface units (camera, splitting layer and processing module) as shown in Fig. 6.

1.9 Benefit of MBILS Device

The MBILS helps detecting unauthorized entry onto a target environment with the interior motive to sends a signal to monitoring centre or security unit when ever motion objects of object detection within the coverage point. The monitoring centre serves as security agent or owner that will receive alert based in intrusion and the design will capture image of victim and safe in its memory which will be available for investigation where necessary [10,12].

1.10 Design Analysis

The design methods and then analysis employed in the design of the microcontroller based provided duplex communication between input and output [13]. These analyses are required to make the correct choice of component values for effective performance. The analysis is divided into modules namely

- i. The power supply module
- ii. The light detector module
- iii. The darkness detector module
- iv. The processor module
- v. The camera module

1.11 Design of the Light Detector Module

The design of the light detector module was achieved using a Light Dependent Resistor (LDR) interfaced to an NE555 timer to detect the presence of light in the dark environment when an intruder flashes a light device in the restricted zone, the LDR resistance decreases and the NE555 is triggered through pin 2 and then sends

out an output through pin 3 to the microcontroller pin as a high signal [14].

The light detector detects an intruder either trying to open a door in a secured area kept in darkness; therefore, once light is detected, this will trigger or activate the camera to snap image at the scene and initialize video stream with support of activated lighting module to ensure clear image detection over active camera as (shown in Fig. 4).

1.12 Design of the Darkness Detector Module

The design and implementation of the darkness detector unit was achieved using a Light Dependent Resistor (LDR) interfaced to an NE555 timer to detect the absence of light. When an intruder obstructs a lighting point or casts a shadow to block light falling on the sensor, will activated LDR, therefore, send signal to microprocessor and that will activate light module via pin 29 (P_{3_7}) as shown in Fig. 11 [14,15].

1.13 Design of the Processor Module

The design used AT89C51 microcontroller which connected LDR and light module purposely to process signal from LDR sensors and deployed to output module (light and camera module) as a result of change in input and the camera will show the point of intrusion or enable lighting system for clear vision and will illuminate the environment [16]. The microcontroller controls the overall functions of the system since its communicate all interfaced modules on I/O ports therefore gives room to received, control and transmit signals under programmed routine. The output depends on the changes in input in order to activate output devices (camera and light) through signal processing therefore, microcontroller used in the design will enable multiplex communication for LDR, light module and camera [17,18].

1.13.1 The camera module

IP camera used for MBILS was interfaced with microcontroller to capture image of intruder and depend on LDR status (High or Low) in order to trigger that camera therefore user can access to stored image by connecting the camera with computer system or laptop. The LCD used for the design can only displace temperature, and access status (Legal or illegal).

1.14 The Software Design Module

This control program was written in C programming language using keil micro-vision ver 4.1.1 software and the source code was compile to generate hex file (output file). The output hex file is the execute file used for chip programming therefore, universal programmer was used to transfer the executive file (HEX file) via unipro driver software.

2. DISCUSSION

During the design and construction of this project, testing was carried out at different stages to determine if the results obtained at each stage met the desired output. Then the sub-system module was built and tested for durability, efficiency, and also to ascertain if there is need to modify this design. The system was first assembled using a breadboard. All components were properly inserted into the breadboard from whence some tests like (reliability, performance evaluation and service response test) were carried out at various stages. Considering design path of camera module, the captured image was found on internal memory of the IP camera and could be access with computer system or laptop and also accessible using internet protocol (IP) <http://192.168.1.1/html/profilesmgr.html>

In Fig. 7, the sensor is used as input signal while camera depends on illumination of the environment to capture image of intruder and store in external memory to compensate signal alert at the security unit for further investigation. The other way around, this is efficient for safe energy usage because light system in environment where there is no human or intruder passage will remain off till the system detects obstruction on sensors path.

In Fig. 8 shown mounted position of MBLIS device. A lab testing was conducted using light bulb and human intrusion from entry points and the desire output was achieve since the MBLIS illuminate the environment.

With Fig. 9 indicate current temperture on the environment, a temperature bellow 25° will trigger OFF the MBILS device while temperatture within 25°-29° indicated normal working range and a temperture above 29° will trigger off the MBLIS device.

In Fig. 10, outlook of the MBLIS device connected with light bulb and 15A socket outlet

The Fig. 11 is used to construct MBILS device and further modifications can improve our design by improvising motion detector device instead of using sensor (LDR).

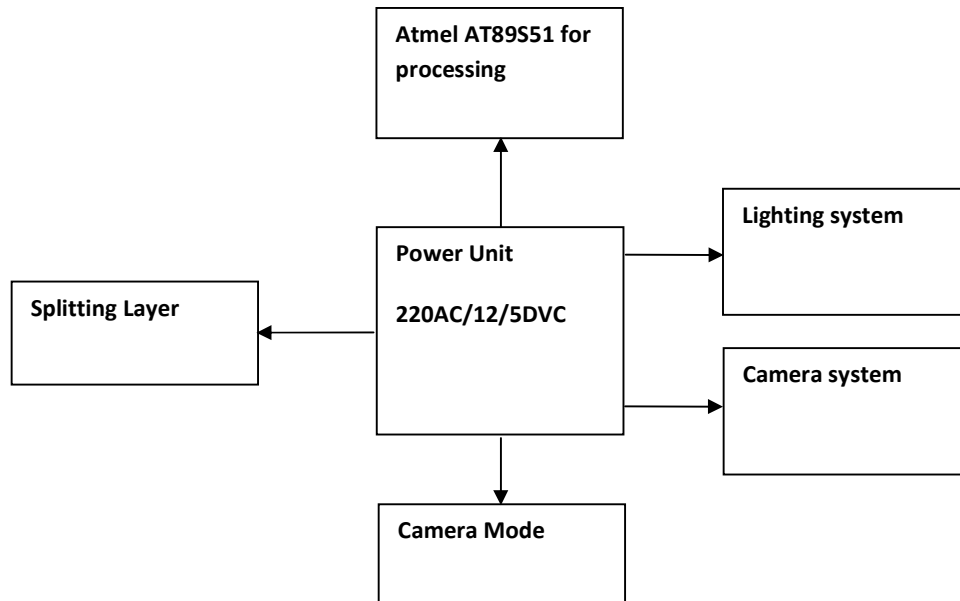


Fig. 6. Power configuration to sub-systems

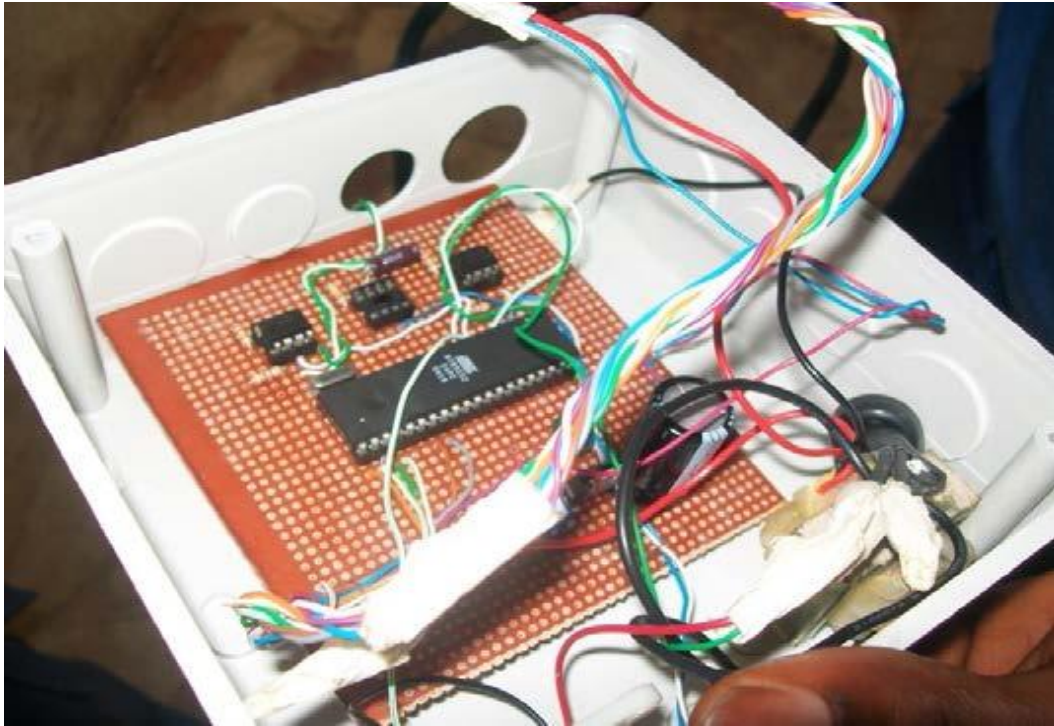


Fig. 7. Internal structure of sensors, and light device



Fig. 8. Indicate unauthorised entry with on light from door opening



Fig. 9. ON state at 25°C on object intrusion



Fig. 10. MBLS system

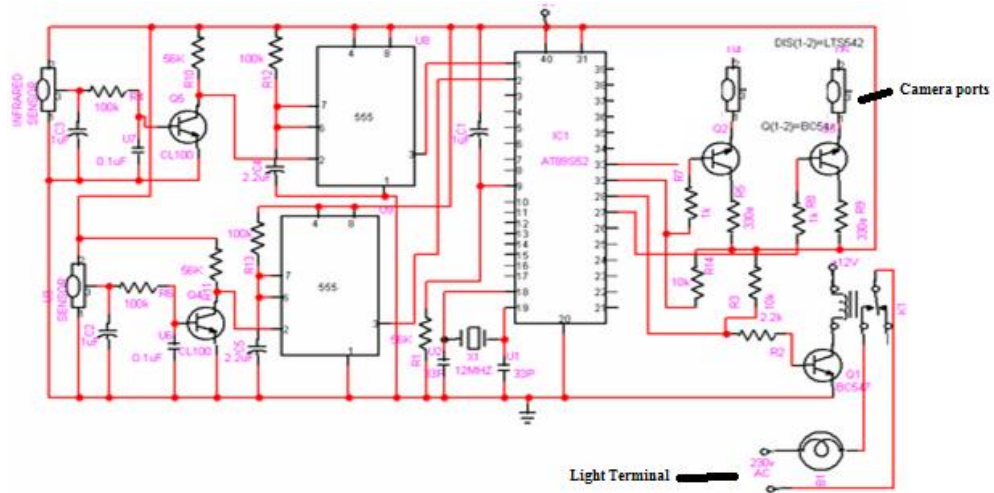


Fig. 11. MBILS circuit design

3. CONCLUSION AND RECOMMENDATIONS

An MBILS device is designed to security in homes and offices purposely to protect human being and properties. Whenever light and camera is triggered, image will be captured via camera which will be needed for investigation. The authority or security agency must put in-place, recovery personnel or must access stored images immediately alert signal received for further investigation on the intruder. On the other hand the device can serve as energy saving device for situation when light has to be used and customize energy-consumption patterns when necessary, using intrusion to automate in the environment.

This project undergoes sequential experimental design and construction. These included power unit, controller unit, input and output that were interfaced as a system. This research can be use to solve problems in workshop, houses, offices, etc. Further work is required in aspect of casing and portability.

Therefore, this research work has involved the use of both hardware and software to bring about the project entity. Going through the facility planning, flow process, design and software implementation the system had extensive prototype but there are multiple numbers of security systems which are available to protect life and properties likewise energy-saving devices for electrical and electronic systems. Future work is required to develop extension link for adaptive alert module and wireless network intrusion but this will having additional cost and resources for future upgrade using Atmel AVR ATmega16 microcontroller that has high memory for image storage moreso, incorporate graphics Organic Light Emitting Diode Device (OLCD) for image display.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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