Journal of Engineering and Applied Scientific Research | Volume 6, Number 2, 2014

DEVELOPMENT OF AN INTELLIGENT TRAFFIC LIGHT CONTROL SYSTEM

A.O. Aleshinloye, A.O. Otuoze and J.B. Ogunsakin
Department of Electrical and Electronic Engineering, University of Ilorin, Kwara, State Nigeria
E-mail: Olasunkanmialesh@gmail.com, otuoze.ao@gmail.com

ABSTRACT: *Present Traffic light control systems are based on microprocessors and microcontrollers. These systems have limitations because it uses predefined time settings in switching controls which is not suitable for real life traffic light control system. Efficient traffic controls are based on a real time system and the traffic light to be used must accommodate such flexibility in its operation. Since, each timing signal in the present traffic light control system is fixed, vehicles may be unduly made to spend more time and use up much fuel. To make traffic light more efficient in its operation, development has been focused on "intelligent traffic light control systems". This paper describes the use of sensor interfaced with the traditional traffic light control system to actualise an intelligent system which gives control based on a real-time monitoring of vehicular flow.*

Keywords: Microprocessor, Microcontrollers, Intelligent Traffic Light Control System, Sensor, Embedded System.
Received for Publication on 17 October 2014 and Accepted in Final Form 20 October 2014

INTRODUCTION

Ease of transportation is a vital means of sustaining economic growth known worldwide. Ensuring there is a free flowing traffic on all possible routes has been the desire of all users but this hasn't been the case in recent time due to large boom in vehicular flow. Traffic congestion is a severe problem in modern cities of the world hence the need for traffic control systems. Traffic signals are generally classified according to operational type as pre-timed or fixed time operation, fully actuated and semi actuated operations [1]. Pre-timed operation includes phases of the duration of the timing interval for the vehicles are preset or fixed at the development stage such that it does not care about presence of vehicles. Fully actuated types include actuated phases using vehicle detectors, herein, the states are skipped if no vehicles are detected. Semi actuated designs include a phase being giving priority with a fixed amount of time and phase changes only when there is an actuation from other phases. In both fully acutated and semi-acutated operation, the actuation is achieved using vehicle detectors.

VEHICLE DETECTION SYSTEM

Vehicle detection system used for indicating the presence or passage of vehicles uses sensor to provide traffic flow data for traffic actuated signal control, traffic-responsive signal control, freeway surveillance, and data collection system. The use of sensor for vehicle detection has being in existence since the 1920s and, today; they are used widely for traffic management purposes [2].

TRAFFIC DETECTOR EVOLUTION

In the 1920s, when manually operated traffic signals were being replaced by automatic, pre-timed traffic signal control devices, engineers soon realised they needed a method to collect the traffic data previously obtained by the police officer on duty [3].

Sensors have been developed ranging from those activated by car horns, pressure-sensitive sensors through to sonar detectors. Improvements were soon made to improve the sensing mode and researches on traffic flow sensors was enhanced based on more subtle properties such as: Opacity (optical, infrared sensors and video image processors), Geomagnetism (magnetic sensors and magnetometers), Reflection of transmitted energy (infrared laser radar, ultrasonic sensors and microwave radar sensors), Electromagnetic induction (inductive loop detectors) and Vibration (triboelectric, seismic and inertia-switch sensors) [4]. In this work, Infrared sensors were utilised due to the constraints posed by the readily available resources.

INFRARED DETECTORS

An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. It is also capable of measuring heat of an object and detecting motion. Infrared waves are not visible to the human eye [6]. Basically, there are two fundamental IR detectors namely photon and thermal detectors. Photon detectors convert photons directly into free current carriers by photo-exciting electrons across the energy bandgap of the semiconductor to the conduction band. This produces a current, voltage or resistance change of the detectors. The photo-excitation is caused by the radiation interacting directly with the lattice sites. Therefore the temperature of the detector must be low enough so that the number of carriers thermally excited across the bandgap is less significant. Because a cooling system is required to maintain low temperature, the system considered costly and complicated.

Generally, the sensitivity of photon detectors depends on the spectral absorption and photo-excitation. The spectral response of photon detectors depends on the spectral absorption and photo-excitation. The spectral response of photon detectors depends on the energy. The absorption of IR energy heats the detection element in thermal detectors, leading to changes in physical properties which can only be detected by external instrument. It operates at room temperature and has a wide spectral response. Since the operation of thermal detectors involves a change in temperature, they have inherently slow response and relatively slow sensitivity compared to photon detectors.

Thermals detectors do not require cooling thus more economical and simple relative to photon detectors. The response time and sensitivity are influenced by the heat capacity of detector structure as well as the optical radiation wavelength. By analysing the various type of IR detector, this system would increase the functionality of the roads available in Nigeria.

MATERIALS AND METHODS

The materials required are Microcontroller (AT89S51), 7 segment displays, PIC12F683, Infrared Receiver module, Infrared Light Emitting diode (LED) and other electronic components including resistors, diodes, transformers, capacitors, Light emitting diode, transistors. The circuit diagram and block diagram is shown in figure 1 and 2 respectively.

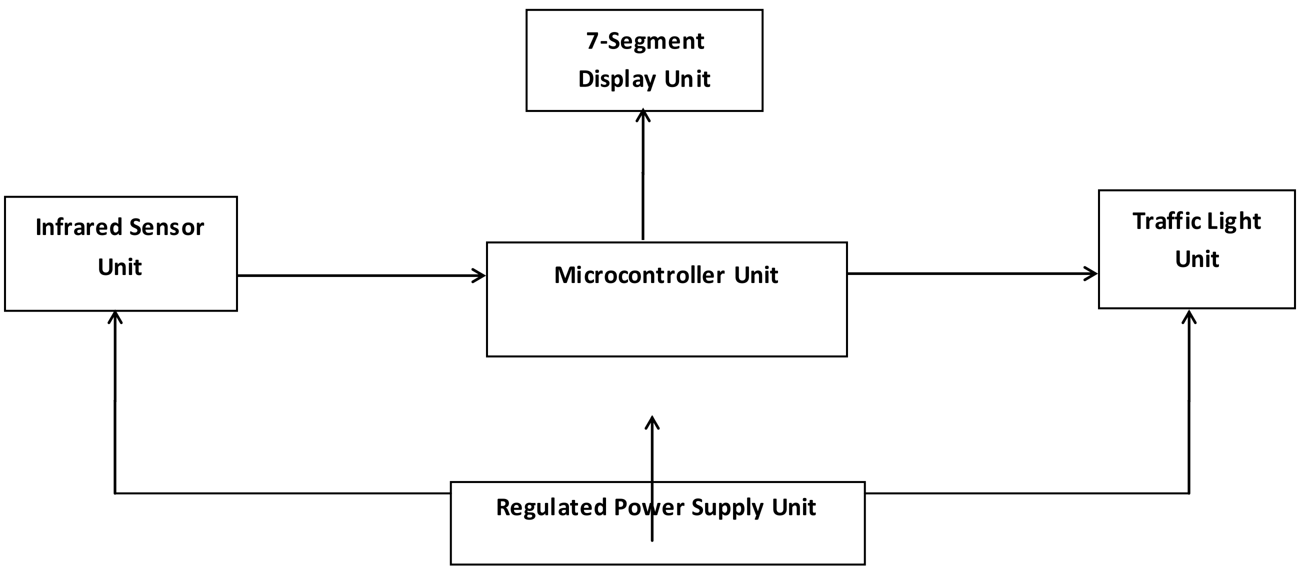

Figure 1: Block Diagram of an Intelligent Traffic Light Control System

MICROCONTROLLER UNIT

AT89S52 is a low-power, high performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The on-chip flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. AT89S52 contains 40 pin, 8K byte of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, three timers/counters. The microcontroller will have its pin interfaced with the external device including 7segment display, Infrared receiver module and traffic light made up of LED. The bit operation for each pin will be determined by the software code written on the microcontroller. The software code is written using any native language, compiled using an ATMEL compatible compiler and from this the Hex code is generated. The hex code is burnt in to the EEPROM of themicrocontroller using a programmer or burner.

THE INFRARED UNIT

This comprises both the infrared transmitter design and the infrared receiver design. The infrared transmitter output is the Infrared LED which is driven by a square wave.

The square wave can be generated by an oscillator clocked at a given frequency. The infrared operation is simply based on reflection against an object. The receiver output is set high where there is no Infrared ray focusing on it and it gives a low output when the ray is focused on it. Thus, the operation is digital in nature and this will be interfaced with the microcontroller to carry out its operation depending on the amplitude of the output signal from the receiver.

The receiver is connected via port 0 to the microcontroller. Pin 3 – Pin 7 is interfaced with the four IR receivers at each arm of the crossing for the four way junction.

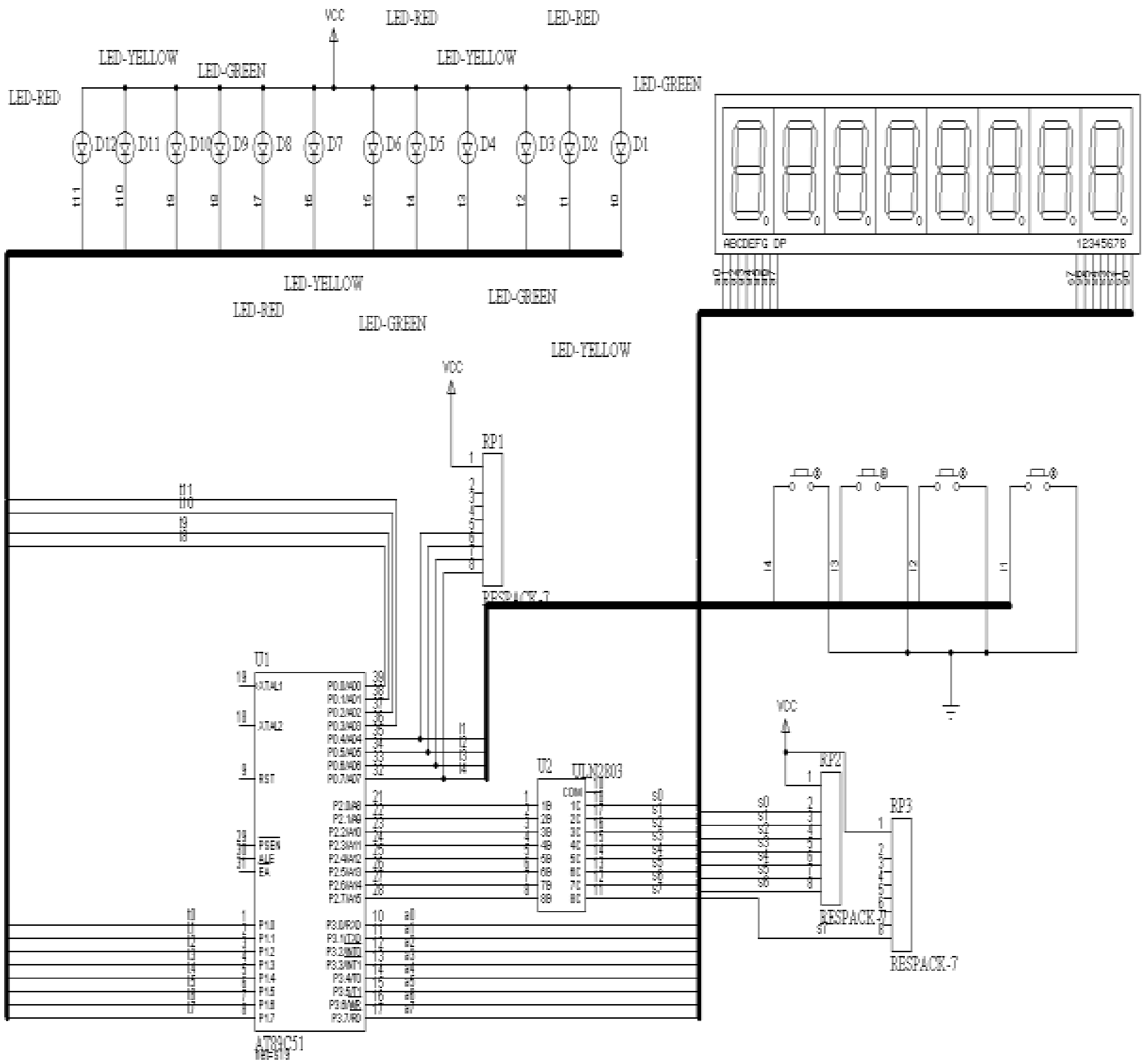

Fig 2: Circuit diagram of an intelligent traffic light control system

SEGMENT DISPLAY

A seven segment display consists of seven Light Emitting Diode (LEDs) arranged in the form of a squarish '8' slightly inclined to the right and a single LED as the dot character. Different character can be displayed by selectively glowing the require LED segments.

In this project work, the 7 segment display will be of the common cathode type. There are four 7-segment displays placed at each junction and multiplexed together. Thus, they occupy Port 2 and Port 3 of themicrocontroller. They are simply used to show the timing interval for each lane.

TRAFFIC LIGHT UNIT

These traffic lights are designed using Light emitting diode operating in the red, green and yellow frequency. Each arm of the crossing has a red, yellow and

green LED, thus making a total of 12 LEDs for the project. The color of each LED signifies the traffic standard symbols.
Port 0 and port 1 are used for interfacing the LED to the microcontroller. Each LED requires a current limiting resistor.

ALGORITHM DEVELOPED

The Algorithm developed to carry out the intended function is based on the principle of Finite State Machine (FSM). A finite state machine is a mathematical model of computation used to design both computer programs and sequential logic circuit. Finite-state machines, also called finite-state automata are much more restrictive in their capabilities than turing machine [7]. The Moore finite state diagram for the intelligent device is shown in figure 3.
Finite state machine depends on the present and next state depending on a set of input entry. The input in this project includes the four sensors in which each sensor is on a given arm of the crossing (L1, L2, L3, and L4), elapsed yellow time interval (YT) and elapsed green time interval. The system can exist in eight different states; GOL1, WAITL1, GOL2, WAITL2, GOL3, WAITL3, GOL4, and WAITL4, L1_LIGHT, L2_LIGHT, L3_LIGHT, and L4_LIGHT; the outputs are the traffic indicators and the set time. Table 4 shows the finite state table for the developed system.

Table 4: Finite State Table for the Intelligent Traffic Light Control System

INPUTS						PRESENT STATE	NEXT STATE	OUTPUTS				
GT	YT	L1	L2	L3	L4			ST	L1_LIGHT	L2_LIGHT	L3_LIGHT	L4_LIGHT
0	-	-	-	-	-	GOL1	GOL1	0	GREEN	RED	RED	RED
0	-	-	1	-	-	GOL1	GOL1	0	GREEN	RED	RED	RED
1	-	-	1	-	-	GOL1	WAITL1	1	YELLOW	RED	RED	RED
-	0	-	-	-	-	WAITL1	WAITL1	0	YELLOW	RED	RED	RED
-	1	-	1	-	-	WAITL1	GOL2	1	RED	GREEN	RED	RED
0	-	-	-	1	-	GOL2	GOL2	0	RED	GREEN	RED	RED
1	-	-	-	1	-	GOL2	WAITL2	1	RED	YELLOW	RED	RED
-	0	-	-	-	-	WAITL2	WAITL2	0	RED	YELLOW	RED	RED
-	1	-	-	1	-	WAITL2	GOL3	1	RED	RED	GREEN	RED
0	-	-	-	-	1	GOL3	GOL3	0	RED	RED	GREEN	RED
0	-	-	-	-	1	GOL3	WAITL3	1	RED	RED	YELLOW	RED
-	0	-	-	-	-	WAITL3	WAITL3	0	RED	RED	YELLOW	RED
-	1	-	-	-	1	WAITL3	GOL4	1	RED	RED	RED	GREEN
0	-	1	-	-	-	GOL4	GOL4	0	RED	RED	RED	GREEN
1	-	1	-	-	-	GOL4	WAITL4	1	RED	RED	RED	YELLOW
-	0	-	-	-	-	WAITL4	WAITL4	0	RED	RED	RED	YELLOW
-	1	1	-	-	-	WAITL4	GOL1	1	GREEN	RED	RED	RED

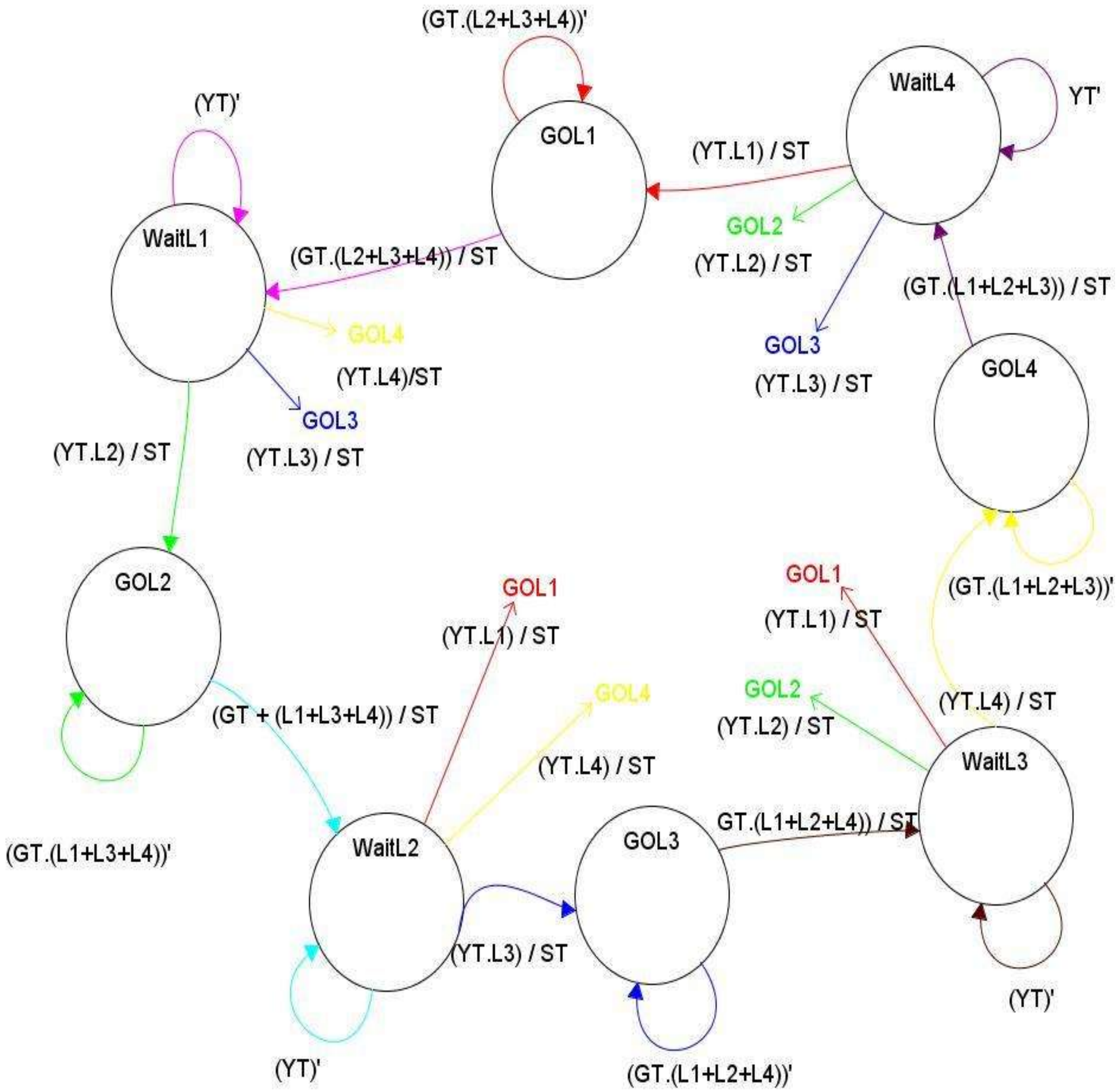

Fig 3: Finite State Diagram Implemented in the System Development

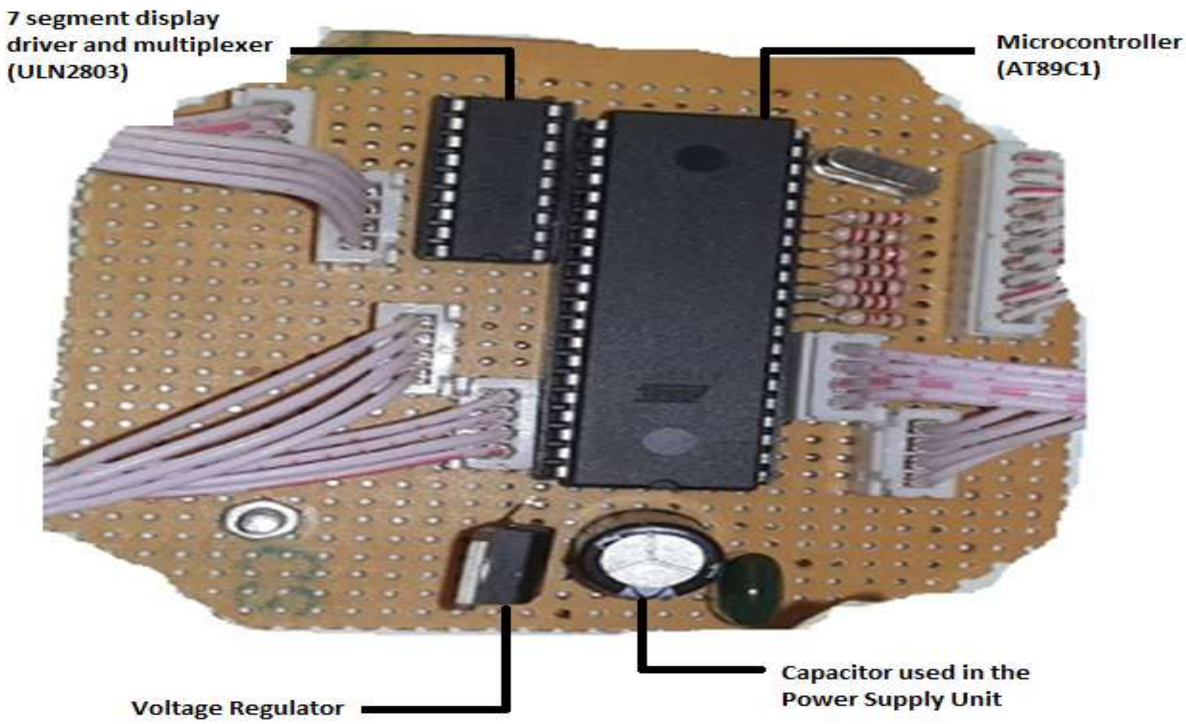

Fig 4: Picture Showing the Control and Power Supply Units

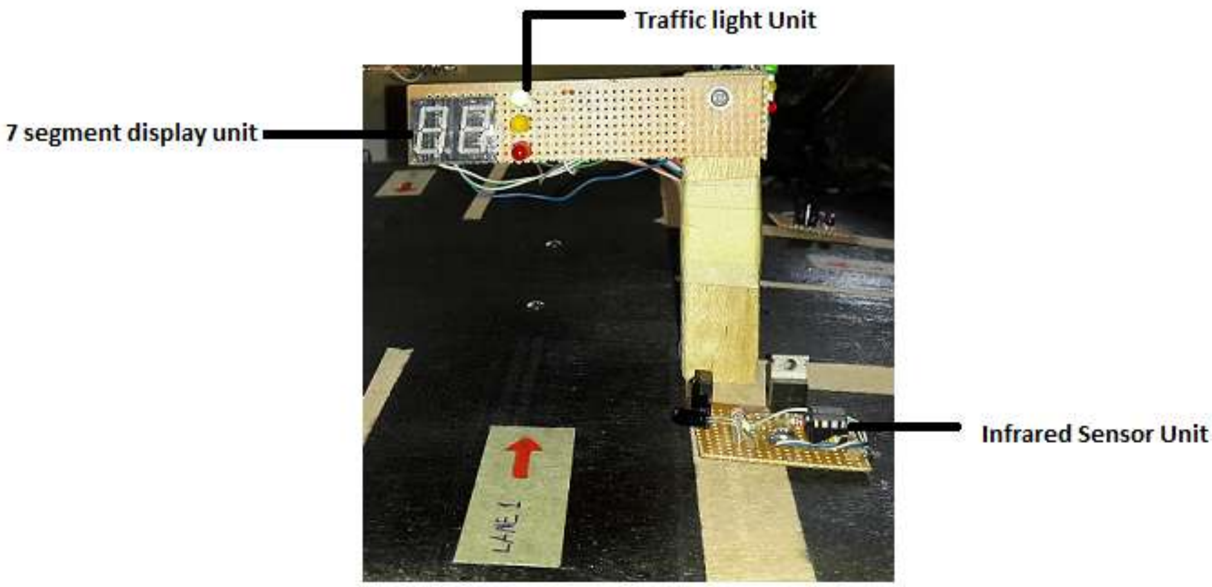

Fig 5: Picture Showing the Traffic Light, Display and Infrared Sensor Units

RESULTS AND DISCUSSIONS

The presence of vehicle on a given lane will set the input pin to the microcontroller as "HIGH", and otherwise, After the sensor has been actuated, the microcontroller was able to respond to the input signal and thus the lane with the sensor was given priority. In the case of multiple sensors being set "HIGH", the microcontroller goes through each state for the lanes with the actuated sensor.

The lane given the right of way would have its traffic light set green and 7 segment display set to 25. The traffic light system has a timing interval of 25 s for each lane which is displayed on the 7segment display. The green timing interval counts from 25 s to 5 s, the yellow timing intervalcounts from 5 s to 0 s, and the Red led comes on at 0 s.

CONCLUSIONS AND RECOMMENDATIONS

Traffic light control system is used in controlling traffic at any intersection and with the integration of a sensor; the system developed would monitor traffic condition to control the traffic efficiently. The microcontroller gives the right of way using the sensor input. The right of way accorded is shown to the user with the aid of traffic light consisting of a Green LED, Yellow LED and Red LED. The timing countdown is shown using a 7segment display. Each lane has two 7 segment display to allow for 2 digits output. the pin goes "LOW". Each sensor for each lane has an input to the microcontroller, thus for this project there are 4 input pin to the microcontroller.

I recommend the use of multiple sensors on each arm of the road thus dividing the traffic condition into series of states. This will directly increase the accuracy of the system. I also recommend the use of other sensors such as Camera, Loop sensors etc., less susceptible to interference.The traffic condition can be directly estimated from the vehicle count per unit time. This refers to the density on each lane. The vehicle count microcontroller can then be used to decide traffic light for next recording interval. I recommend the use of rs-232 to allow for communication between the microcontroller and a PC. The administrator on the computer can then issue command to download recorded data, update light delays, erase memory etc

REFERENCES

1. Kingsville, Texas. "Synthesis Study of Texas Signal Control Systems: Technical Report". 2012.

2. Zone, No passing, Get back to Right Lane, and Slow down. "Danger zone scanning and warning algorithm", 1998.

3. Kell, James H., Iris J. Fullerton, and Milton K. Mills. Traffic detector handbook. No. FHWA-IP-90-002. 1990.

4. Klein, L.A., M.K. Mills and D.R.P. Gibson, 2006. Traffic Detector Handbook Volume 1. 3rd Edition. FHWA., USA.

5. Yong, Ching Yee, RubitaSudirman, and Kim Mey Chew. "Motion Detection and Analysis with Four Different Detectors." Computational Intelligence, Modelling and Simulation (CIMSiM), 2011 Third International Conference on. IEEE, 2011.].

6. Military & Aerospace Electronic; Supplement, Vol. 6, Issue 2, p 30, February, 1995.

Reference to this paper should be made as follows: A.O. Aleshinloye, A.O. Otuoze and J.B. Ogunsakin (2014), Development of an Intelligent Traffic Light Control System. *J. of Engineering and Applied Scientific Research*, Vol. 6, No. 2, Pp. 28 – 36.