

# Development Of A Microcontroller-Based Traffic Light System For Road Intersection Control

Ganiyu R. A., Arulogun O. T., Okediran O. O.

**Abstract:** The control of traffic at road junction, which was done purely by human effort, proves to be inefficient owing to the increasing rate of both motorists as well as the complexity of road networks. This inadequacy brought about the use of discrete solid-state electronics up to the usage of a computer controlled microprocessor, but the intelligence of this method was still limited to meet the demand of modern age. Thus, the need for the development of a microcontroller-based traffic light control system. This paper explores the design and implementation of a microcontroller-based traffic light system for road intersection control. The traffic light system is designed using Programmable Integrated Circuit (PIC) 16F84A microcontroller, power section, crystal oscillator and light emitting diode (LED). Then, for effective traffic control, the PIC is implemented via an IC programmer using a mikrobasic program written in Basic language. The developed traffic light control system is tested by constructing a prototype that resembles the real application. The functionality of the prototype shows that the developed system can be used for a real life traffic control at road intersection. Besides, the developed system can be employed as a training kit in learning traffic light control system design and operation. Also, it can be used as a teaching aid in schools for various road users.

**Index Terms:** Road intersection, control system, crystal oscillator, light emitting diode, microcontroller, power section, traffic light.

## 1 INTRODUCTION

Traffic congestion problem is a phenomenon which contributed huge impact to the transportation system in country. This causes many problems especially when there are emergency cases at traffic light intersections which are always busy with many vehicles. A traffic light controller system is designed in order to solve these problems [1]. Traffic control establishes a set of rules and instructions that drivers, pilots, train engineers, and ship captains rely on to avoid collisions and other hazards. Motorists depend on traffic control devices to avoid collisions and travel safely to their destinations. Traffic control devices for highway travel include signs, signal lights, pavement markings, and a variety of devices placed on, over, near, or even under, the roadway. The signal light is probably the most easily recognized traffic control device. At a busy intersection in a large city, a traffic signal may control the movements of more than 100,000 vehicles per day. Less than 30 percent of all miles driven each year are on roadways controlled by traffic signals. Traffic signals direct streams of vehicles and pedestrians when to go, stop, or proceed with caution. The signals increase the traffic-handling capacity of most intersections. They can work independently on timers, or connect to a computer-controlled system that operates over several intersections. In a computerized system, traffic detectors are placed at several locations—generally in the pavement.

A computer continuously scans the traffic information from each detector. The computer then selects the best timing for each signal to reduce traffic congestion and minimize delays. Traffic signals often allow certain types of vehicles, such as ambulances, fire trucks, and police cars, to trigger light changes. This control over signals helps speed emergency vehicles along while reducing the chances of collisions with other traffic in intersections. In urban road networks, the traffic lights at intersections regulate and guide transportation for the purpose of improving the safety and efficiency of vehicles [11]. The ever increasing number of vehicles in most metropolitan cities around the world and the limitation in altering the transportation infrastructure, led to serious traffic congestion and an increase in the travelling time. [2] exploited the emergence of novel technologies such as the internet, to design an intelligent Traffic Management System (TMS) that can remotely monitor and control a network of traffic light controllers located at different sites. Also, the study in [3] was to design and implement a suitable algorithm and its simulation for an intelligent traffic signal simulator. The system developed was able to sense the presence or absence of vehicles within certain range by setting the appropriate duration for the traffic signals to react accordingly. In [4], a microcontroller-based versatile traffic light control system/trainer was also implemented while the concept proposed in [5] involves the use of wireless sensor networks to sense presence of traffic near junctions and hence route the traffic based on traffic density in the desired direction. To make traffic light controlling more efficient, [6] exploited the emergence of new technique called as "Intelligent traffic light controller". This makes the use of Sensor Networks along with Embedded Technology. In addition, [7] designed, simulated and synthesized a simple, suitable and reliable VLSI fuzzy processor for controlling the traffic lights while an evolutionary approach proposed in [8] was to estimate the traffic volumes of road networks. The "Intelligent Traffic Signal Controller using FPGA controller based on Neuro-Fuzzy system" is capable of taking decision to reduce delays at intersection. To develop the system, algorithm need to be developed using VHDL. The designing part of this controller into VHDL program eliminates the shortcomings of the other custom facilities and conventional controller design available today [9]. In furtherance, [10] focused on the use of Timed Coloured Petri

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Nets (TCPN) to model a multi-phase traffic light controlled cross-type intersection using cross-type junction of fixed signal timing plan located in Federal Capital Territory, Abuja, Nigeria, as a case study. Nevertheless, this paper explores the development of a microcontroller-based traffic light system for road intersection control.

## 2 RESEARCH METHODOLOGY

### 2.1 System Overview

The primary role of a microcontroller unit (MCU) in an embedded system is to provide inexpensive, programmable logic control and interfacing to external devices. This means MCU typically is not required to provide complex functions. It is well suited to monitoring a selected variety of inputs and responding to them in real time using the preprogrammed instructions that are executed by the built-in processor. An embedded microcontroller can respond to these inputs with a wide variety of devices. These capabilities are available to the designer at a very reasonable cost without a lot of effort. The overall system design for the implementation of developed microcontroller-based traffic light control system entails four subunits. The subunits include the power supply unit, the sensing unit, the control unit and LED display unit. The power supply unit provides the control unit with specified voltage from primary source. The versatility of the developed traffic light control system was made possible through the use of a Programmable IC PIC16F877A which enabled the researcher to use software to achieve a versatile, flexible and cost-effective solution. Also, other materials being employed include LED, Resistor, Capacitor, IC socket, Transformer, Diode, regulators, Crystal oscillator, Wires (jumper) and Ferro-board.

### 2.2 Hardware Design Consideration

#### 2.2.1 Power supply unit

The system is powered by the 240V AC mains. The 240V is applied to a step down transformer, which stepped the voltage from 240 to the required 12 volts AC. The output of the transformer is then passed through a rectifier which converts the AC supply to a DC voltage. The output of the rectifier is filtered by connecting a capacitor across its terminals to remove the AC ripples. The filtered output is then passed through a regulator that will limit the voltage to 5V needed by the TTL IC (PIC16F84A). The output of the regulator is supplied to every part of the circuit.

#### 2.2.2 Sensing unit

The sensing unit is designed using a pressure switch which will sense the weight of any car that steps on it. When the pressure switch is pressed, a high signal is sent to the control unit to inform the control unit that there is vehicle at that particular junction. The sensing unit is depicted in Fig.1.

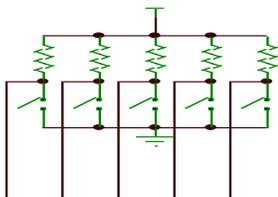


Fig. 1: The Sensing Unit Schematic

### 2.2.3 Control unit

The control unit is basically a programmable interface controller (PIC), which serves as the traffic controller based on the program written and sent into its flash memory and with consideration for the input signals that comes from the pressure sensors. The PORTB register of the PIC is used to control the LED display while the PORTA register is used to sense the input from the pressure sensors. Fig. 2 shows the control unit of a four way traffic controller. A crystal oscillator of 8MHz is connected to the oscillator input and output pins with a coupling capacitor of 22pF.

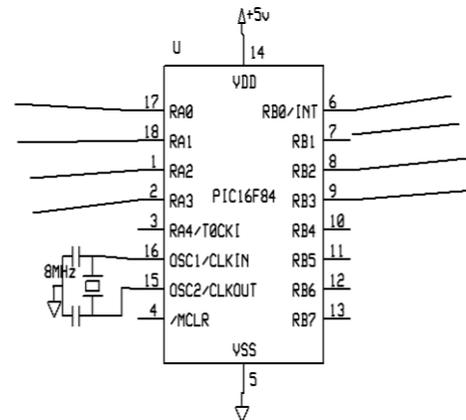


Fig. 2: Control unit of a four way traffic controller

### 2.2.4 The Microcontroller

A microcontroller is a complete computer on a chip having the elements of a basic micro-processor along with other specialized functions. The PIC16F84A microcontroller employed in this work belongs to the mid-range family of the PICmicro® microcontroller devices. Its program memory contains 1K words, which translates to 1024 instructions, since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 68 bytes. There are also 13 I/O pins that are user-configured on a pin-to-pin basis. Some pins are multiplexed with other device functions. These functions include:

- External interrupt
- Change on PORTB interrupts
- Timer clock input

### 2.3 Software Design Consideration

The microcontroller is a very resourceful chip and can be programmed to carry out a number of functions. The PIC16F84A was programmed with the aid of the computer software known as MikroBasic IDE; mikroBasic is a registered trade mark of mikro-Elektronika. The BASIC language was used to program the IC on this software. The software generated the hexadecimal equivalent of the code written which was loaded into the linker (IC prog IDE) that transfers the hexadecimal file into the memory of the IC.

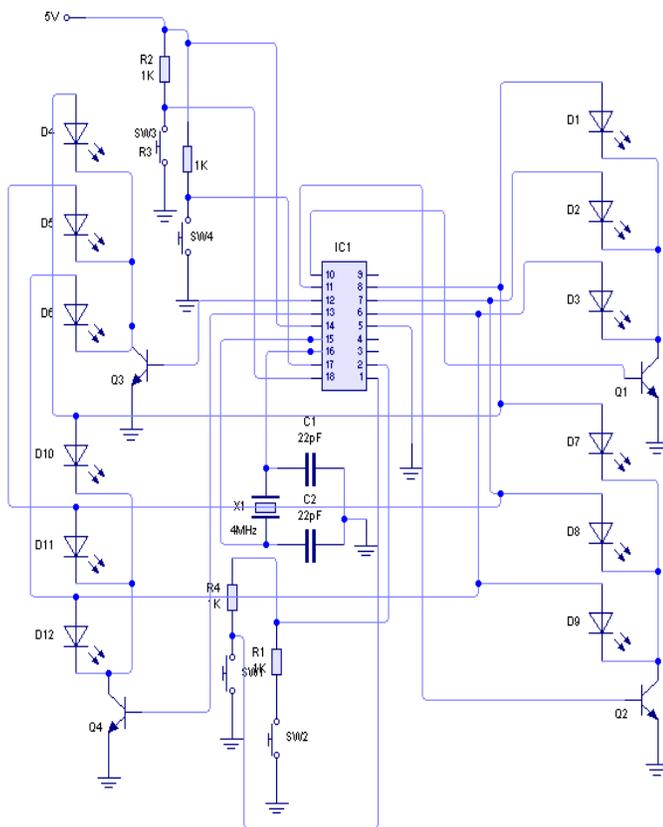
### 2.4 The System Construction

The construction of the circuit was done in stages, namely Assembling, Soldering and Casing. The components were assembled together according to the circuit diagram of the design shown in Fig. 4. The next stage is the soldering of the components. The soldering iron and lead were used to join the components to the ferro-board. The last phase of the project

construction was the casing of the project. The case is the frame where the built circuit is seated. Holes were made on the case using the drilling machine and the cases with the circuit were joined together with the use of bolts and nuts.

## 2.5 Design Details

The overall design of the microcontroller for road intersection is depicted in Fig. 4. The lanes of each intersection consist of a pressure switch sensor to detect the vehicle. Three different colour LEDs are placed on each of the four lanes for displaying purposes. The controller was designed in such a way that it samples all the lanes in turn to detect whether there is a vehicle on any lane and this is delay for a time period of 15sec. Once the input status is high, the PIC coordinates the action by given the lane with high input a passage immediately and indicates Red on the LED output of the three other lanes. If there is no high input on the other lane, the controller will pass the next turn on the same lane.



**Fig. 4:** Complete circuit diagram of the designed microcontroller-based traffic light system

## 2.6 The System Operation

The microcontroller-based traffic light system for road intersection control was developed to direct the movement of vehicles meeting at a road junction without any collision. To achieve this, the microcontroller allocates time for each path when the vehicles along that path will move and the other vehicles from the other path will stop. When the time allocated for a specific path has been exhausted, the red light will be ON meaning stop and the next line will be ON (green light) which means the vehicle in that path should start moving. When the time is about to be exhausted, the yellow light will be ON in the third path informing the vehicles in that path to be ready to move, and after some seconds the green light will be ON.

## 2.7 Testing of the Developed System

The process of testing of the developed system involves the use of some test and measuring equipments stated below:

- Power Supply: This was used to supply voltage to the various parts and stages of the circuit to enable easy determination of the performance of the system.
- Digital Multimeter: The digital multimeter was used to measure some values of voltage and current to determine the changes or variation in the signal level based on some responses in the circuit.

On completion of the project, the project was connected to the power supply to ensure that all the units were powered. The millimeter was used to measure the potential difference across every part of the circuits. After which the camera was used to determine if the infra-red LED was on. When it was confirmed that all the parts of the circuit have been correctly powered, an obstruction was placed in front of a prototype vehicle (toy car) to test how the system will respond to obstructions. Before placing the obstruction, the car was moving but after placing the obstruction, the car stopped moving. The car started moving again immediately the obstruction was removed.

## 3 CONCLUSION AND RECOMMENDATIONS

### 3.1 Conclusion

This paper has been successfully presented a functional and low cost microcontroller-based traffic light system for road intersection control. The traffic light system is designed using Programmable Integrated Circuit (PIC) 16F84A microcontroller, power section, crystal oscillator and light emitting diode (LED). Then, for effective traffic control, the PIC is implemented via an IC programmer using a mikrobasic program written in Basic language. The developed traffic light control system is tested by constructing a prototype that resembles the real application. The functionality of the prototype shows that the developed system can be used for a real life traffic control at road intersection. Also, developed system can be employed as a training kit in learning traffic light control system.

### 3.2 Recommendations

Every good engineering design has limitation; the limitation of the developed system could be improved upon by incorporating a wireless network into the developed system. This will add a lot of functionality such as monitoring traffic flow on the highway. Also, owing to the epileptic nature of power supply system, it is imperative to gear further research towards a solar-powered traffic control system.

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