# Design of an Intelligent Traffic Light Control System

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## ABSTRACT

Today, the number of cars is rapidly increasing which creates a real traffic control problem. While the conventional traffic control systems are inconvenient to provide fast and fair solutions for the congestion problem.

This research addresses the traffic control problem and hence proposes an intelligent traffic light control system. In particular, the proposed system senses the presence or absence of cars on each lane, and then estimates the time to open each lane, which is proportional to the number of cars on that lane.

Practically, the system circuit has been printed on a board with three main components; namely pressure sensors, microcontroller, and traffic lights. Then a C program has been developed to enable the microcontroller for receiving inputs from sensors, calculating the times to open lanes and sending appropriate logic decisions to traffic light. The obtained results prove the accuracy and reliability of the system.

In addition to the practical test, the intelligent traffic light control system has been successfully simulated, where the simulation results are found to be the same as the calculated ones.

**Keywords:** Sensors, Microcontrollers, Traffic Light Control Systems

## INTRODUCTION

Recently, the number of cars has been exponentially increased due to the rapid growth of population and personal income. Today, roads in large cities are crowded and conventional traffic control systems are unable to solve the congestion. Accordingly traffic control has become an important issue for movement of city people as well as for business prosperity.

Most of the conventional techniques used for controlling the traffic are fixed-time traffic light systems, i.e. they operate on a timing mechanism that changes the light after a given interval. As a result drivers spend unnecessary time waiting for the traffic lights to change. On the other hand, modern traffic light systems sense the presence or absence of cars and react accordingly. In particular, this research designs a microcontroller-based intelligent traffic light control system. The proposed system receives inputs from sensors which indicate the traffic load or number of cars on each lane for the given intersection, and hence it computes the time for each lane which is directly proportional to the number of cars on that lane. Thus, the intelligent system can dynamically create time balancing based on the current number of cars on the lanes.

The rest of the paper is organized as follows: the next section reviews a number of traffic light control systems. An intelligent traffic light control system has been designed in Section 3, i. e. it develops an algorithm for traffic forwarding decision and constructs a circuit for connecting sensors and traffic lights to the microcontroller. Section 4 has simulated the proposed system. Finally, Section 5 concludes the paper with some remarks.

## OVERVIEW OF TRAFFIC LIGHT CONTROL SYSTEMS

Traffic signaling devices are positioned at road intersections, pedestrian crossings, and other locations to control competing flows of traffic. They assign the right of way to road users by the use of lights in standard colors (RED, AMBER, GREEN), using a universal color code (WIKIPEDIA, 2009a). The most common traffic lights consist of a set of three lights: red, yellow (officially amber), and green. When illuminated the red light indicates for vehicles facing the light to stop; the yellow indicates caution, either because lights are about to turn green or because lights are about to turn red; and the green light to proceed, if it is safe to do so. There are many variations in the use and legislation of traffic lights, depending on the customs of a country and the special needs of a particular intersection. There may, for example, be special lights for pedestrians, bicycles, buses, trams, etc. Also light sequences may differ, and there may be special rules or set of lights for traffic turning in a particular direction. Complex intersections may use any combination of these lights (WIKIPEDIA, 2009a).

**Types of Traffic Lights**

In many regions traffic lights function differently or have different displays depending on available technology, traffic patterns, or other vehicles that also use the intersection. For example; some fixtures feature a flashing green light or more than one arrow lit at one time (WIKIPEDIA, 2009a).

**Three set lights:** the universal standard is for the red to be above the green, and if there is also amber it is placed in the middle. If three-set lights are mounted horizontally, the red will typically be to the left of the green. The standards apply whether the country drives on the left or the right, but the placement of the mountings on the road would be mirror images of the other. Each country has different road rules, including how traffic lights are to be interpreted. For example in some countries a flashing yellow light means that a motorist may proceed with care if the road is clear, giving a way to pedestrians and to other road vehicles that may have priority. A flashing red may be treated as a regular stop sign. In most countries, the sequence is green (go), amber (prepare to stop), red (stop). In New Zealand and Canada (NZTA, 2009; PEI, 2009)) amber officially means " stop (unless it would cause an accident to do so)" but in practice, is treated as " prepare to stop". In some places such as the UK, the sequence is red (stop), red and amber (stop) (Directgov, 2009), green (go if green), amber (stop). In Russia, Serbia, Austria, and parts of Canada and Mexico, the green light flashes for a few seconds before the amber light comes on (Directgov, 2009). The single flashing amber signal is used in the UK, Ireland and Australia at pelican crossings (Directgov, 2009). It is used in Serbia and United States (Directgov, 2009) to mark places where greater attention is needed (dangerous crossings, sharp curves etc.). In Canada flashing amber light means "drive with caution" and is frequently combined with a flashing red light (meaning "stop") at four way intersections. In many Asian countries flashing amber light indicates a driver may proceed cautiously across a junk where signals only operate at busy periods (Directgov, 2009).

**Pedestrian Crossing Lights:** normally have two main lights: a red light that means "stop" and green light that means "go" (or proceed with caution). There is usually a flashing phase (red in the US and Australia, green in Europe) that means "complete your crossing" (WIKIPEDIA, 2009a). In most locales in North America, the colors used are red/orange for "stop/wait" and a bluish – white for "go". While the "walk" signal generally a walking human figure, North America pedestrian signals show an upraised hand for "stop", while most other countries display a standing human figure. At selected pedestrian crossings in some countries, pedestrian traffic lights includes a siren, beeper or warbler, which sounds in order to alert visually impaired pedestrians that it is safe to cross. Some also include tactile warnings, like a vibrating plate, or a rotating cone, to help people with hearing impairment. Some pedestrian crossing lights are only activated after a pedestrian presses an activating button, while others operate automatically, and others still operate automatically but only at certain times of the day. Some traffic - light controlled junctions have a light sequence that stops all vehicular traffic at junction at the same time, and gives pedestrians exclusive access to the intersection so that they can cross in any direction. This is known as a pedestrian scramble in some places (WIKIPEDIA, 2009a).

**Lights for Public Transport:** often use signals that distinct from those for private traffic. They can be letters, arrows or bars of white or colored lights (WIKIPEDIA, 2009a).

**Lane Control Lights:** are specific types of traffic lights used to manage traffic on a multi-way road or highway. Typically they allow or forbid traffic to use or move of the available lanes by the use of green lights or arrows to permit, or by red lights or crosses to prohibit (WIKIPEDIA, 2009a).

**Dummy Light:** a traffic light which stands on a pedestal in the middle of an intersection. There are at least three which still operate in the United States today. There have been number of requests in recent years for these traffic lights to be removed due to safety concerns, but the historic value has kept these landmarks at their original locations (WIKIPEDIA, 2009a).

**Advanced Hardware Systems**

A traffic signal is typically controlled by a controller inside a cabinet mounted on a concentrate pad (Mn/DOT, 2009). Although some electro-mechanical controllers are still in use, modern traffic controllers are solid state. The cabinet typically contains a power panel, to distribute power in the cabinet; a detector interface panel, to connect to loop detectors and other detectors; detector amplifier; the controller itself; a conflict monitor unit; flash transfer relays; a police panel to allow the police to disable the signal; and other components (Mn/DOT, 2009). Traffic lights can be controlled in two ways, fixed time or dynamic control.

**Fixed Time Control**

The simplest control system uses a timer (fixed - time), each phase of the signal lasts for a specific duration before the next phase occurs; this pattern repeats itself regardless of traffic. Many older traffic light installations still use these, and timer – based signals are effective in one way grids where it is often possible to coordinate the traffic lights to the posted speed limit. They are however disadvantageous when the signal timing of the intersection would benefit from being adapted to the dominant flows changing over the time of the day (Robinson and Christopher, 2009).

**Dynamic Control**

Dynamic or actuated, signals are programmed to adjust their timing and phasing to meet changes of traffic conditions. The system adjusts signal phasing and timing to minimize the delay of people going through the intersection. It is also common place to alter the control strategy of traffic light based on the time of day and days of the week, or for other special circumstances, such as a major event causing unusual demand at an intersection (WIKIPEDIA, 2009b). The controller uses input from detectors, which are sensors that inform the controller's processor whether vehicles or other road users are present, to adjust signal timing and phasing within the limits set by the controller's programming. It can give more time to a lane on an intersection approach that is experiencing heavy traffic, or shorten for that has little or no traffic waiting for a green light (WIKIPEDIA, 2009b). Detectors can be grouped into three classes: in-pavement detectors, non-intrusive detectors, and detection for non-motorized road users (WIKIPEDIA, 2009b).

**In-pavement Detectors:** these are buried in or under the roadway. Inductive detector loops are the most common types. They are sensors buried in the road to detect the presence of traffic waiting at the light, and thus can reduce the time when a green signal is given to an empty road. A timer is frequently used as a default during times of very low traffic density and as backup in case the sensors fail (WIKIPEDIA, 2009b). The sensor loops typically work in the same fashion as metal detectors. Consequently small vehicles or those with low metal content may fail to be detected causing them to wait indefinitely unless there is also a default timer as part of the control system (WIKIPEDIA, 2009b).

**Non-intrusive Detectors:** sometimes more advantageous and cost effective to install over-roadway sensors that cutting the road and embedding inductive loops. These technologies include video image processors, sensors that use electromagnetic waves, or acoustic sensors to detect the presence of vehicles at the intersection waiting for right of way. These over-roadway sensors are more favorable than in-roadway sensors because they are immune to the natural degradation associated with paved right – of – way , competitively priced to install in terms of monetary and labor cost and danger to installation personnel, and have the capacity to act as multi-lane detectors, and collect data types not available from in-roadway sensors (BNET, 2009).

**Non-motorized User Detection:** are classified as pedestrians, bicyclists, and equestrians. Provisions for detecting these users include demand buttons and tuned detectors. Some traffic lights at pedestrians crossings, include a button which must be pressed in order to activate the timing system. This is generally accompanied by a large display reading "wait", which lights up when the button is pressed, and off when the lights enter red phase (WIKIPEDIA, 2009b). Standard signal detectors have a hard time detecting bicyclists, because of the low metal content of typical bicyclist. If bicyclist rides directly over the wires of a detector loop, it may detect the cyclist. However, it doesn't always work and few cyclists know to do it. At locations where cyclists are common, a special detector loop tuned for cyclists may be used. A small bicycle symbol is often marked on the pavement to inform the cyclist where to stop in order to actuate the signal. Other places simply places an additional pedestrian button bear the curb where a cyclist can reach it (WIKIPEDIA, 2009b).

**Microcontrollers**

Microcontrollers are used to automatically control products and devices, such as automobile machine control systems, remote controls, office machines, appliances, power tools, and toys. By reducing the size and cost compared to a design that uses a separate microprocessor, memory , and I/O devices, microcontrollers make it economical to digitally control even more devices and processes (WIKIPEDIA, 2009c).

**Interrupts:** Microcontrollers provide real time response to events in the embedded system they are controlling. When certain events occur, an interrupt system can signal the processor to suspend processing the current instruction sequence and to begin an interrupt service routine (ISR). The ISR will perform any processing required based on the source of the interrupt before returning to the original instruction sequence. Possible interrupt sources are device dependent, and often include events such as an internal timer overflow, completing an analog to digital conversion, a logic level change on an input such from a button being pressed, and data received on a communication link. Where power consumption is important as in battery operated devices, interrupts may also wake a microcontroller from a low power sleep where the processor is halted unit required to do something by a peripheral event (WIKIPEDIA, 2009c).

**Programs:** Microcontroller programs must fit in the available on – chip program memory, since it would be costly to provide a system with external, expandable, memory (WIKIPEDIA, 2009c). Compilers and assembly languages are used to turn high – level language programs into a compact machine code for storage in the microcontroller's memory. Depending on the device, the program memory may be permanent, read only memory that can only be programmed at the factory, or program memory may be field-alterable flash or erasable read – only memory.

## DESIGN OF THE TRAFFIC LIGHT CONTROL SYSTEM

In this research an adaptive traffic light control system has been designed and tested. It gives each lane a time that is proportional to the number of cars on that lane. The system consists of two parts, hardware and software. The following sections discuss the design details.

### Hardware Design

The system is composed of three main parts namely; sensors, microcontroller and traffic lights as shown in Figure 1. The sensors are used to count the number of cars at each lane, i.e. when a car passes a sensor the sensor generates an electrical signal that will be received by the microcontroller. The microcontroller receives signals from sensors and sends signals to the traffic lights after calculating the time to pass each lane. The microcontroller works under software control. The traffic lights represent the outputs of the system, which are directly controlled by the microcontroller.

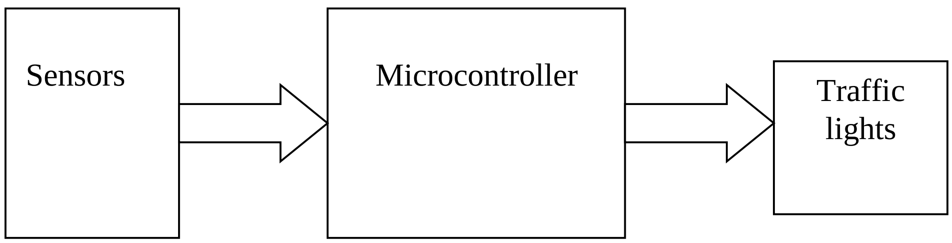


Figure 1: System Block Diagram

Figure 2 shows the circuit diagram of the system. It uses an AT90S3585 microcontroller which has four 8-bit ports (A, B, C and D). Port A is configured as an input port and the other ports are configured as output ports. An 8 MHz crystal is used to generate clock signal for the microcontroller and is connected to pin 12 and 13 (XTAL2 and XTAL1) respectively. The microcontroller is supplied by a 5V power source which is

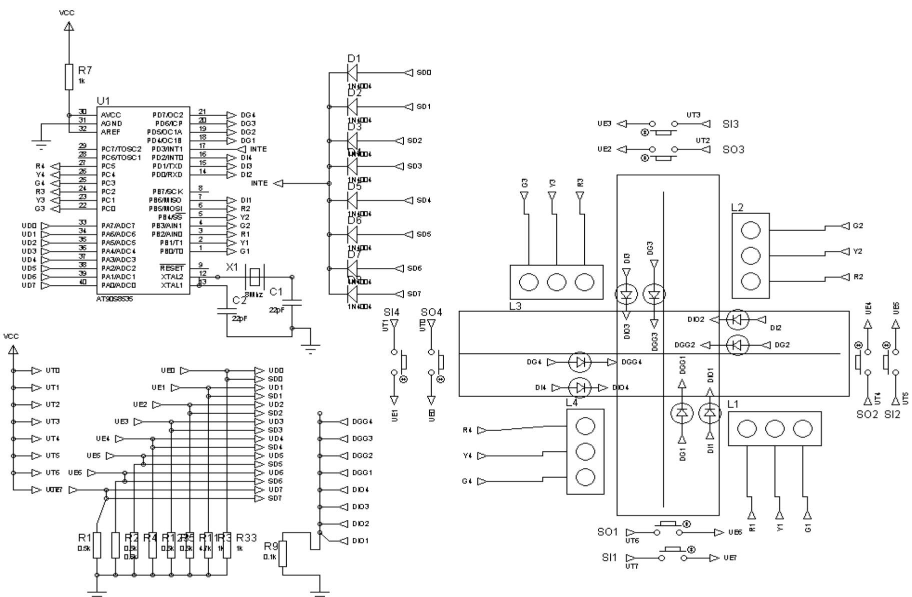

Figure 2: System Circuit Diagram

Connected to pin 30 (AVCC). And pin 31 (AGND) is connected to the ground. In each lane there are two sensors, the first is for counting the arriving cars and the other is for counting the departing cars. The system has been designed for a four lane intersection, where eight sensors are used. Each one of the eight sensors is connected to one of the eight pins of port A. If a car passes across the sensor coverage, logic1 appears at the corresponding pin, which is read by the microcontroller when the interrupt is issued. Each sensor is connected to a diode, and all of the eight diodes are connected in parallel to the interrupt pin (INT1) on the microcontroller. This configuration operates in such a way that logic 1 signal appears on the interrupt pin each time a sensor discovers a passing car. When the interrupt occurs the microcontroller reads the values of all sensors to determine which sensor is activated. Each one of the traffic lights is connected to one of the pins of the output ports (B, C and D). When logic 1 appears on a pin the corresponding light is turned on otherwise it is turned off.

**Software Development**

The software configures the microcontroller's ports, monitors the sensors, calculates the time to open each lane, and send output signals to traffic lights. The development tool is called Code Vision AVR which is an integrated development environment, automatic program generator and in-system programmer, for Atmel AVR family of microcontrollers. The program has been written in C language. It is composed of two main parts, main loop and interrupt service routine.

**Interrupt Service Routine:** In each lane there are two sensors, the first (Si1) is for counting the arriving cars and the other (So1) is for counting the departing cars. A signal from the in-sensor (Si) increases the count of the incoming cars. A signal from the out-sensor (So) increases the count of the departing cars. When a car passes a sensor an interrupt is issued to the microcontroller. This interrupt is issued by Interrupt Service Routine (ISR). The ISR is a function that is executed each time an interrupt signal is received on the interrupt pin. The operation of the ISR is shown in Figure 3. When the ISR receives an interrupt signal it reads the values of input port pins which are connected to the sensors. If it finds logic1 on one of the pins it increases the corresponding counter by one. For example; if pin1 is connected to in-sensor in lane1 (Si1), then logic1 on that pin means that Si1 detects a passing car and the ISR should increase the corresponding counter by one. And if pin2 is connected to the out-sensor in lane1 (So1), then logic1 on that pin means that So1 detects a departing car and the ISR should increase the corresponding counter by one. Accordingly the number of cars of each lane can be determined by subtracting the value of so counter from Si counter. For instance, C1 = Si1 – So1, where C1 is the count of cars on a lane1. Thus, after determining the count of cars on each lane, a calculation is performed to determine the time to open each lane. As a result the time to open each lane is proportional to the number of cars waiting on that lane.

**Main Loop:** Figure 4 illustrates the operation of the main loop, where the time to open each lane is calculated, and the signal to control traffic lights is sent. The variables C1, C2, C3 and C4 correspond to the cars waiting on lane1, lane2, lane3 and lane4 respectively. T1, T2, T3 and T4 correspond to the times to open lane1, lane2, lane3 and lane4 respectively. Assuming that the time to pass the four lanes is Tt and with the values of C1, C2, C3 and

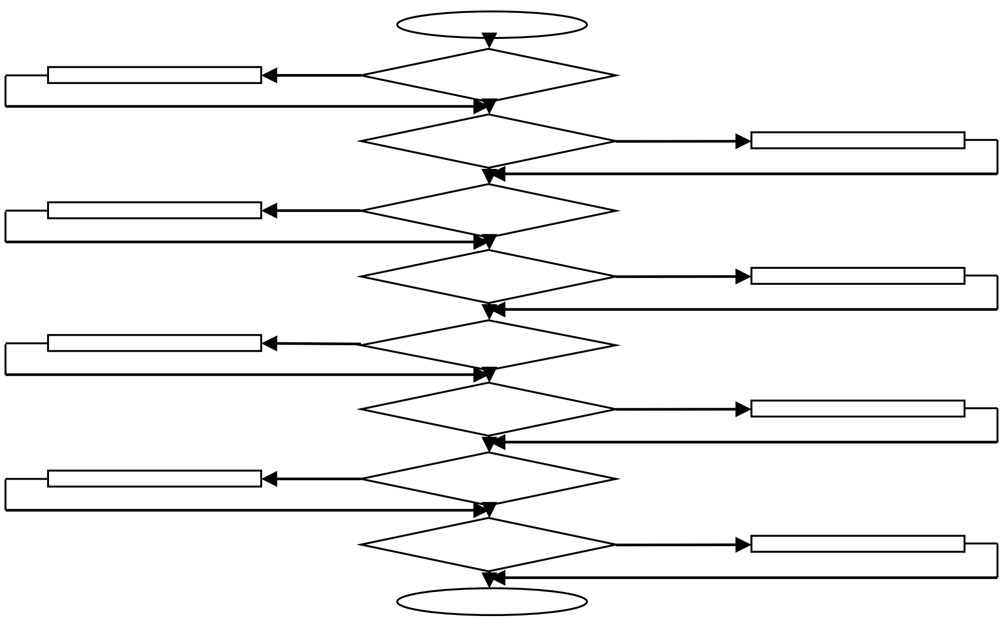

Figure 3: ISR Flow Chart

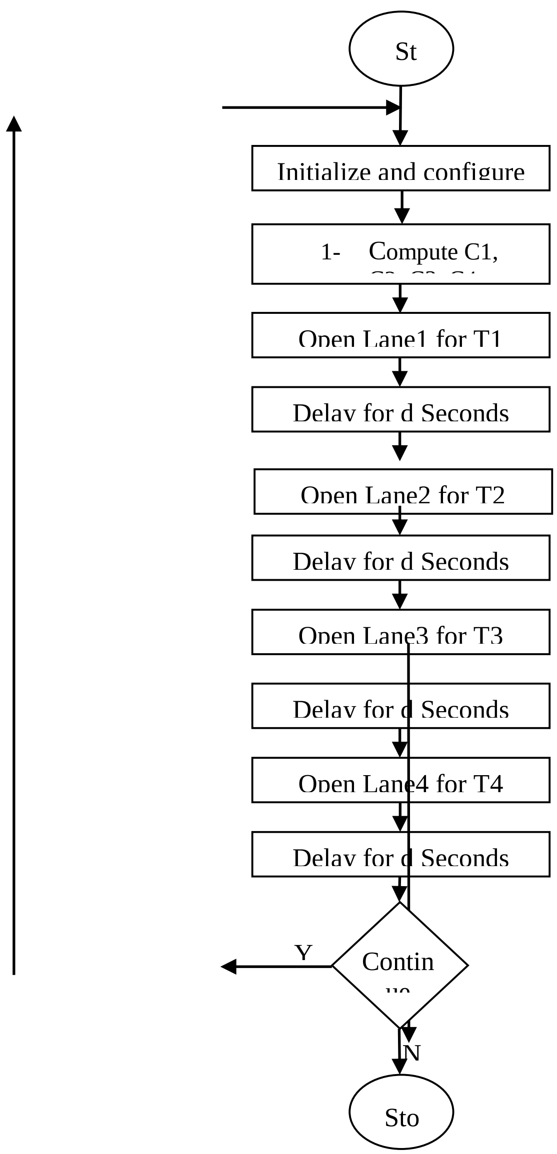


Figure 4: Main Loop Flow Chart

C4 we can derive the equations for determining the time to open each lane, i.e. calculating T1, T2, T3 and T4.

The time to pass the four lanes (Tt) is given by (1) as follows:

$$Tt = T1 + T2 + T3 + T4 \quad \text{------------------} \ (1)$$

It is assumed that the time to open each lane is proportional to the number of cars on that lane which can be expressed in (2):

$$\frac{T1}{C1} = \frac{T2}{C2} = \frac{T3}{C3} = \frac{T4}{C4} \quad \text{-------------------------} \ (2)$$

By using (2) all lane times can be found in terms of T1 as shown in (3):

$$\left.\begin{aligned} T2 &= \frac{T1C2}{C1} \\ T3 &= \frac{T1C3}{C1} \\ T4 &= \frac{T1C4}{C1} \end{aligned}\right\} \quad \text{---------------------------} \ (3)$$

By substituting the values of T2, T3 and T4 into (1) T1 can be found as follows:

$$Tt = T1 + \frac{T1C4}{C1} + \frac{T1C3}{C1} + \frac{T1C2}{C1} = T1\left[1 + \frac{C2+C3+C4}{C1}\right]$$

$$T1 = Tt \quad \text{--------------------} \ (4)$$

Similarly by substituting the value of T1 into (3) the values of T2, T3 and T4 can be found. After calculating the time to open each lane, the appropriate logic is output to the traffic lights. Table 1 shows the output logic for the traffic lights.

The program outputs the logic as shown in the first entry of Table 1 and waits for T1 seconds, this will open lane1 for T1 seconds, and then it will output the logic in the second entry and waits for a fixed time delay (Td). The Td is to warn the passing lane's cars that they will be stopped soon; and the cars on the next lane that they will be passed soon. This process will be repeated for the remaining entries until the round is finished. In

| DESCRIPTION | R1 | Y1 | G1 | RL1 | GL1 | R2 | Y2 | G2 | RL2 | GL2 | R3 | Y3 | G3 | RL3 | GL3 | R4 | Y4 | G4 | RL4 | GL4 | DURATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPEN LANE1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | T1 |
| YELLOW | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | Td |
| OPEN LANE2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | T2 |
| YELLOW | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | Td |
| OPEN LANE3 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | T3 |
| YELLOW | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | Td |
| OPEN LANE4 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | T4 |

Table 1: Logic sent to traffic lights

The next round a time to open each lane will be performed and the same operation will be repeated.

## EXPERIMENTAL TESTING OF THE TRAFFIC LIGHT CONTROL SYSTEM

This section describes the experimental setup for the intelligent traffic light control system. Also it discusses the microcontroller programming together with experimental results.

### Experimental Setup

Table 2 provides a list of components which have been used. Note that the components have been selected because they are available, simple or convenient to be used in the lab environment. Using conventional method the circuit has been printed on a board as shown in Figure 5.

Table 2: List of Components

| Component | Specifications | **No** |
|---|---|---|
| Microcontroller | AT90S8535 AVR | 1 |
| Crystal | 8MHz | 1 |
| LED-Green | Analog , forward voltage 2.2v, full derive current 10mA, breakdown voltage 4v | 8 |
| LED-Red | Analog , forward voltage 2.2v, full derive current 10mA, breakdown voltage 4v | 8 |
| LED-Yellow | Analog , forward voltage 2.2v, full derive current 10mA, breakdown voltage 4v | 8 |
| Capacitor | 22pF | 2 |
| Resistor | 1KΩ | 9 |
| Diode | 1N4004 | 8 |
| Sensor | Pressure Sensors | 8 |

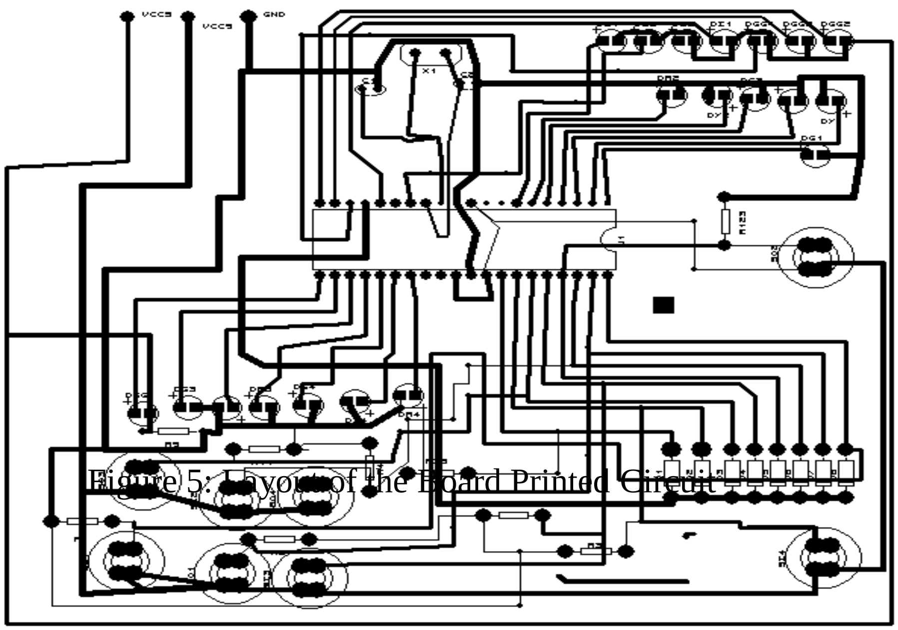


Figure 5: Layout of the Board Printed Circuit

**Microcontroller Programming**

As mentioned in the previous section the program was written in C language. And then it has been loaded into the microcontroller. A Top2004 Universal Programmer was used to load the program into the AT90S8535 microcontroller. The procedure to program the microcontroller can be described by the following steps

1. Connection of the programmer and installation of its driver to the computer.
2. Fitting of the microcontroller into the 40-pin programmer socket.
3. Running of the TopWin programming tool. Figure 6 shows the main window of the program.

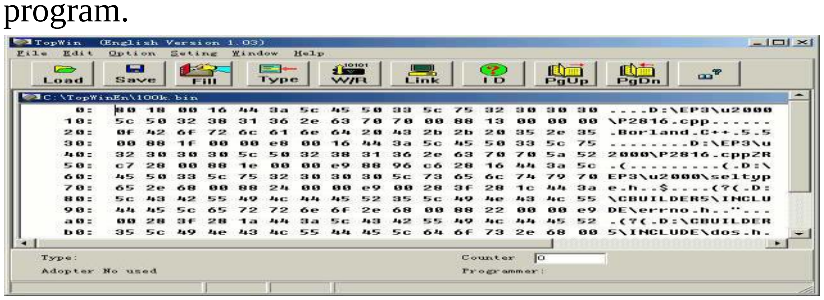


Figure 6: TopWin Interface

4-Loading of the program by specifying the file name as shown in Figure 7.

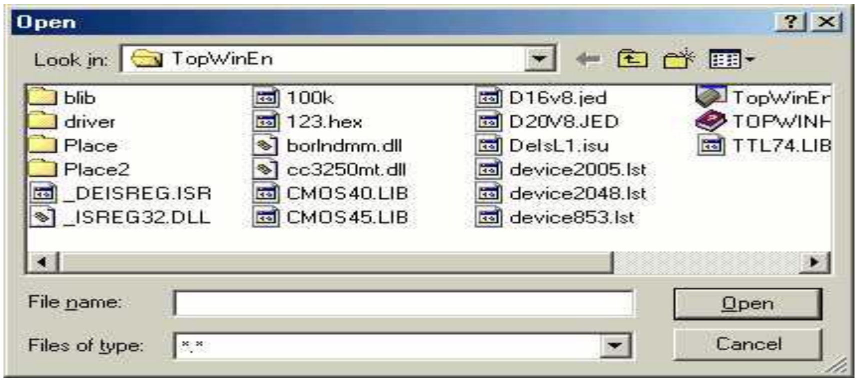


Figure 7: Program Load Window

4. Selection of the file format and load mode (Figure 8).
5. Searching for the manufacture, type and class of the AT90S8535 microcontroller as illustrated in Figure 9.
6. The final step is the execution of the program by pressing the 'RUN' button.

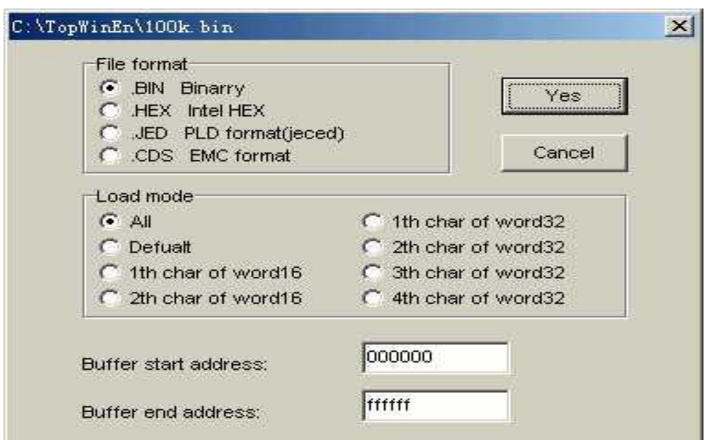


Figure 8: Program Format Window

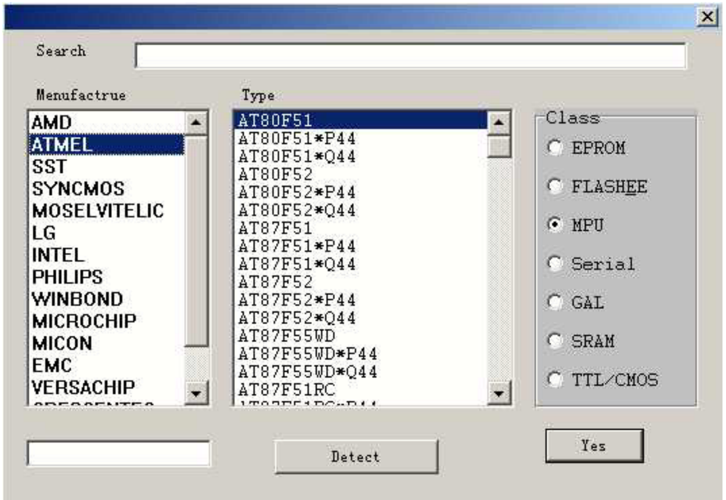


Figure 9: AT90S8535 Microcontroller Specifications

## Simulation Results

The traffic signal operation for the initial phase will start by giving equal times to each lane. The traffic signals will start illuminating in the anticlockwise direction, which means that it will start by lane1, lane2, lane3, lane4, and then it will go back to lane1 to repeat the same sequence. During the initial phase, each counter will count the number of cars of the corresponding lane. Then the time calculation will be performed to open each lane according to the number of cars at that lane. For the next phase, after time calculation, the appropriate logic will be sent to traffic signals.

In this simulation scenario the total time (Tt) has been set to 2 minutes and the time delay (Td) to 5 seconds. During the initial phase the Tt has been equally divided been the lanes, i.e. each lane has been given equal time to be opened. Meanwhile the sensors of lane1, lane2, lane3, and lane4 have been differently pressed a certain number of times to simulate that number of cars has arrived or departed at each lane. In the next phase the time to open each lane is calculated based on the number of cars on that lane in the previous phase. Thus, the simulation has been repeated for a number of phases and some of the results have been recorded as presented in Table 3.

Table 3: Simulation Results

| Random phase no | Lane | No of presses on sensor | | No of cars | Time to open lane (sec.) |
|---|---|---|---|---|---|
| | | In-sensor | Out-sensor | | |

| | | | | | |
|---|---|---|---|---|---|
| 2 | Lane1 | 3 | 2 | 1 | 12 |
| | Lane2 | 6 | 4 | 2 | 24 |
| | Lane3 | 9 | 6 | 3 | 36 |
| | Lane4 | 12 | 8 | 4 | 48 |
| 5 | Lane1 | 7 | 3 | 4 | 40 |
| | Lane2 | 7 | 4 | 3 | 30 |
| | Lane3 | 9 | 6 | 3 | 30 |
| | Lane4 | 10 | 8 | 2 | 20 |
| 8 | Lane1 | 13 | 10 | 3 | 24 |
| | Lane2 | 8 | 4 | 4 | 32 |
| | Lane3 | 11 | 6 | 5 | 40 |
| | Lane4 | 11 | 8 | 3 | 24 |

It is found that the results are consistent with the estimated values that could be calculated using the equations in Section 3.2. Also as mentioned before, the time to open the lane is proportional to the number of vehicles at that lane.

## CONCLUSION

Conventional traffic light control systems are characterized by fixed-time intervals. Sometimes drivers spend unnecessary time waiting for the traffic lights to change while no car on the opposite lane. That is why most of modern traffic light control systems are dynamic in nature.

This research designs an intelligent traffic light control system, which consists of sensors, a microcontroller, and traffic lights. The proposed system works as follows: the sensors are activated by arriving or departing of cars on each lane for the given intersection. The microcontroller receives inputs from the sensors, counts the number of cars on each lane and accordingly computes the time interval to open that lane. The outputs of the microcontroller are used to operate the traffic lights.

Practically, the main circuit was printed on a board and the microcontroller was programmed. The overall system has been successfully simulated, where the results prove the accuracy and reliability of the system.

Finally, it is recommended to implement the proposed system on a real intersection with more accurate sensors and uninterrupted power supplies. Also further enhancements can be added to the system for integrating a number of intersections with a centralized control.

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# تصميم نظام ذكي للتحكم في إشارات المرور

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**الملخص**

عدد المركبات يزداد يومياً بسرعة فائقة مما خلق مشكلة كبيرة في التحكم في حركة المرور. فى الوقت الذى أصبحت فيه الأنظمة التقليدية المستخدمة للتحكم بإشارات المرور غير مناسبة لتقديم حلول سريعة وعادلة لمشكلة الإزدحام.

هذا البحث يستعرض مشكلة التحكم في حركة المرور ومن ثم يطرح نظاماً ذكياً للتحكم في إشارات المرور. وتحديداً يقوم النظام المقترح يتحسس وجود أو غياب المركبات بأى شارع، ومن ثم يقوم بتقدير الزمن المناسب لفتح كل شارع مع تقدير عدد المركبات في الشارع.

تم عملياً طباعة دائرة النظام على لوحة إلكترونية تشتمل على ثلاثة مكونات رئيسية: محسات ضغط، متحكم دقيق وإشارات المرور. ومن ثم تمت كتابة برنامج بلغة السى لتمكين المتحكم الدقيق من إستقبال المدخلات من المحسات وحساب أزمان فتح الشوارع المناسبة ومن ثم إصدار القرار المنطقى إلى إشارات المرور.

النتائج التى تم الحصول عليها أثبتت دقة وإعتمادية النظام. بالإضافة إلى الإختبار العملى، تمت محاكاة النظام الذكي للتحكم فى إشارات المرور بنجاح، حيث أثبتت نتائج المحاكاة مطابقتها للنتائج المحسوبة.

**كلمات المفتاح:** المحسات، المتحكمات الدقيقة، نظم التحكم فى إشارات المرور