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Design & Construction of A Closed Loop Traffic Light Control System

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ABSTRACT

Growing number of road users and the limited resources provided by current infrastructures lead to ever increasing traveling times. Traffic in a city is very much affected by traffic light controllers. When waiting for a traffic light, the driver loses time, manpower, increases air pollution and the car waste fuel. To make traffic light controllers more intelligent, this paper exploit the emergence of novel technologies, such as communication networks and sensor networks, as well as the use of more sophisticated algorithms for setting traffic lights. The Intelligent Traffic Control System is formed as a network of embedded systems. Intelligent traffic light control does not only mean that traffic lights are set in order to minimize wait-times, but also takes care of the perpetual need for safety critical traffic automation. The main goal however, is to make efficient planning and management of traffic control systems. This piece of work will proffer solution to the problem caused by the existing system in the state. Some of these problems will be highlighted in this report and analysis of the intelligent traffic signal light control system will be made. This work will lead to a novel system in which traffic light controllers and the behavior of car drivers are optimized using machine-learning methods.

Key words: Traffic Light, Microcontroller, Flow-Chart,

1.0 INTRODUCTION

A traffic light is a collection of two or more colored lights found at some junctions and pedestrian crossings which indicates whether it is safe and/or legal to continue across the path of other road users. In Nigeria, traffic lights are widely used both on major roads and in built-up areas. Their numbers have increased exponentially since they were first invented in 1868.The operation of standard traffic lights which are currently deployed in many junctions, are based on predetermined timing schemes, which are fixed during the installation and remain until further resetting. The timing is no more than a default setup to control what may be considered as normal traffic. Although every road junction by necessity requires different traffic light timing setup, many existing systems operate with an over-simplified sequence. This has instigated variousideas and scenarios to solve the traffic problem. To design an intelligent and efficient traffic control system, a number of parameters that represent the status of the road conditions must be identified and taken into consideration.

Traffic signals are the most convenient method of controlling traffic in a busy junction. But, we can see that these signals fail to control the traffic effectively when a particular lane has got more traffic than the other lanes. This situation makes that particular lane more crowd than the other lanes. If the traffic signals can allot different time slots to different lanes according to the traffic present in each lane, then, this problem can be solvedeasily.

A closed loop traffic light control system is an intelligent traffic light control that gives priority to lanes that has got more traffic without waiting other lanes endlessly.

One aspect of this work aims at developing a traffic control algorithm for future technology in the country. The design of the traffic control system can be evaluated in two steps – synthesis and analysis. Several models and multiple control strategies exist, and engineers must decide between them using a prior knowledge of the real system. Previously collected information can help to choose the appropriate model, parameters, measurement and control methodologies to create the optimal solution.

This project work will introduce the concept of sensor networks that supports the development of reliable and optimal control structures for urban traffic and for motorway systems.

Fig 1.0 shows the block diagram of a close loop traffic light control system

1.1 BLOCK DIAGRAM OF A CLOSED LOOP TRAFFIC LIGHT CONTROL

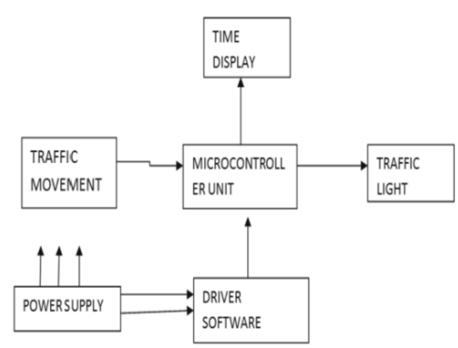

Fig. 1.0 Block Diagram of a Closed loop Traffic Light Control

The block diagram as shown in fig 1.0 is powered by a 5v regulated power supply. The traffic feedback unit is responsible for monitoring the vehicles at each lanes and supplying the result to the microcontoller. These result is used as a basis of priority for passing lanes with the help of a driver software embedded in the microcontroller. The time display section displays the waiting time of vehicles while the traffic light indicate a stop, ready and go signals.

1.2 PROBLEM DEFINITION

The aim of this project is to design a program for MicroController that could minimize the wait- time of the cars at intersections, when the trafficvolume is significantly high. Besides, it can prevent the emergency car stucked in thetraffic jam at the intersections as well.

1.3 OBJECTIVES OF PROJECT

1. To understand the structure and operation of a microcontroller
2. To study the assembly language design and their programming technique
3. To understand how to make the interfacing to the microcontroller
4. To design a program that works together with a model of three- junction traffic light and sensors.
5. To build the model of three-junctions of intelligent traffic light that can overcome some of major problem of current traffic light.

1.4 PROJECT SCOPE

1. Construct a model of three way junction of a traffic light model.
2. Program a microcontroller to control the traffic light.
3. Combine the software and the hardware part to simulate a traffic light system.

2.0 THE OGOLONTO JUNCTION TRAFFIC SIGNAL LIGHT SYSTEM, IKORODU, LAGOS, NIGERIA

The Ogolonto junction is a popular juction along the Ikorodu express road of Lagos State. This junction is important because it links two important local government in Lagos State (Ikorodu and Kosofe) and it is the only connecting junction between the Agric, Ebute and Mile 12 township, all of which harbours a substantial fraction of the Lagos population.

The population of residents in Ikorodu was estimated to be about 850,000 around May 1999. However with rapid increase in population across the country, it is expected to have increased by 3.8% by May 2009.

Therefore a substantial amount of car owners, commercial vehicles and company staff buses ply this route every day.

ROAD INTERSECTION OF THE OGOLONTO JUNCTION

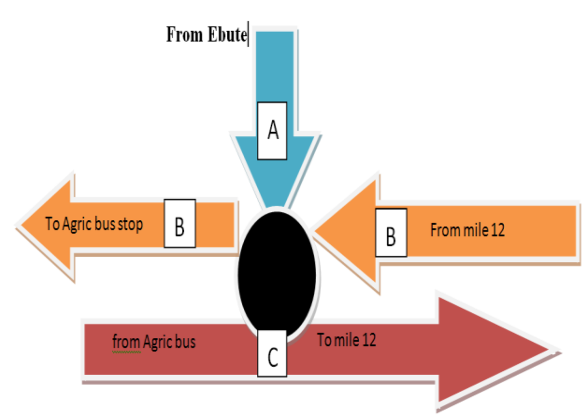

Fig 2.13 Road Intersection of the Ogolonto Junction

DATA ANALYSIS OF TRAFFIC SIGNAL LIGHT INSTALLED AT THE OGOLONTO JUNCTION

Table 2; Data Analysis of Traffic Movement at The Ogolonto Junction

Date of observation: 04/08/2011

TIME	NUMBER OF VEHICLES AT ROAD INTERSECTION			DELAY TIME	INTERSECTION PASSED
	A	B	C		
6:15 am	35	6	42	90secs	B
6:28 am	18	12	48	90secs	A
6:34 am	41	09	18	90secs	C
7:02 am	32	12	72	90secs	A
7:18 am	12	10	42	90secs	A
7:35 am	38	04	61	90secs	A
8:08 am	15	07	42	90secs	A

Date of Observation: 27/07/2011

TIME	NUMBER OF VEHICLES AT ROAD INTERSECTION			DELAY TIME	INTERSECTION PASSED
	A	B	C		
7:10 pm	13	54	21	90 secs	A
7:23 pm	33	62	11	90 secs	A
7:35 pm	12	68	23	90 secs	A
8:02 pm	32	72	09	90 secs	A
8:19 pm	14	95	14	90 secs	A
8:45 pm	19	98	24	90 secs	A
8:58 pm	25	103	17	90 secs	A
9:16 pm	07	108	08	90 secs	A

Date of Observation: 25/07/2011

TIME	NUMBER OF VEHICLES AT ROAD INTERSECTION			DELAY TIME	INTERSECTION PASSED
	A	B	C		
5:55 am	35	6	25	90 secs	B
6:02 am	42	4	34	90 secs	B
6:12 am	23	7	43	90 secs	A
6:23 am	32	5	34	90 secs	B
6:35 am	21	5	46	90 secs	A
6:46 am	37	10	21	90 secs	C
7:16 am	43	16	24	90 secs	B
7:34 am	32	8	29	90 secs	B

BRIEF DISCUSSION ON DATA ABOVE

It can be observed from data above that early in the morning more vehicles move out of ikorodu, Ebute and Agric inclusive. However the traffic light has been placed on a fixed time control thus it is observed that vehicles at road intersection that should be given priority still suffer delay. Also in the evening, more vehicles enter ikorodu (Agric and Ebute) from mile12. However the same problem still arises and road intersections with empty vehicles are often passed, reflecting the inadequacy of the traffic system without any prior feedback techniques.

3.0 DESIGN ANALYSIS

The project is simplified using the block diagram shown below to show various sections involved. Though the use of a microcontroller had simplified the whole circuit, nevertheless, the complicatory aspect had been taken over by the embedded software.

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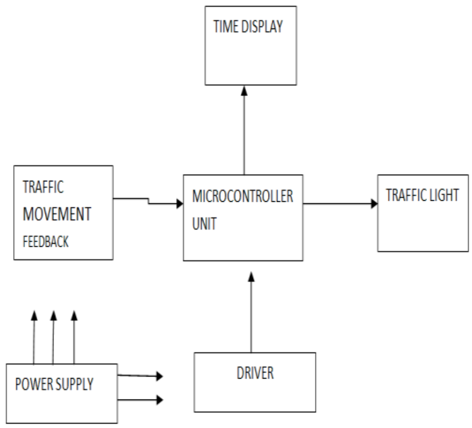


Fig. 3.0 Block Diagram of Traffic Light with Feedback

The circuit is powered with +5v from a regulated D.C power supply stage. The analyses of all the stages are done in the units below.

3.1 POWER SUPPLY STAGE

All stages in the project uses +5v. The power supply stage is a linear power supply type and involves in step down transformer, filter capacitor, and voltage regulators, to give the various voltage levels. The power supply circuit diagram is shown in fig 3.0 below.

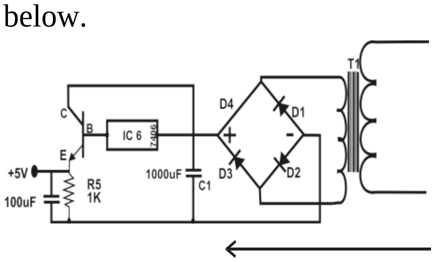


Fig 3.1 Power Supply Stage.

3.1.1TRANSFORMATION

This section comprises of a step down transformer. The transformer steps 220-240V ac voltage down to 12V which is to be converted into D.C. the circuit of the transformer is shown in fig. 3.2

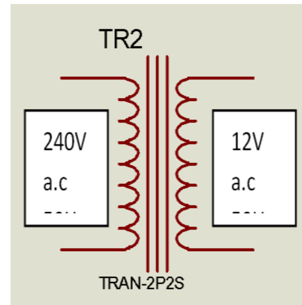


fig.3.2 Step-down Transformer

The rms voltage is 12v and the peak inverse voltageis given by
$\sqrt{2}Vrms = \sqrt{2} \times 12 = 16.9V$

3.1.2 RECTIFICATION

Thissection employs a fullwave bridge rectification. The diode allows the flow of current in one direction, hence finding its application in the conversion of A.C to D.C.Fig 3.3 is the circuit of abridge rectifier and the respective waveforms

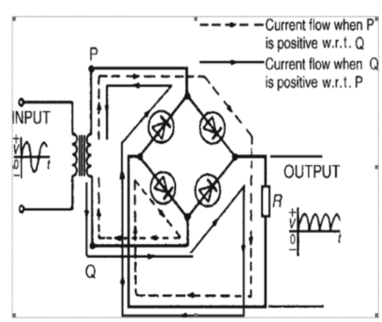


Fig 3.3 Bridge Rectifier Circuit

The choice of diode is determined by the peak inverse voltage and the maximum load current. The selected diodes has PIV of 50V and forward current 2A which makes it to be able to stand peak voltage of 16.97V and the 1A assumed load current.

The resultant output waveform is a pulsatin D.C. voltage with much ripple of frequency 100Hz. This ripples is removed using the filter circuit.

3.1.3 FILTER CIRCUIT

Introducing a capacitor at the output of the rectifier removes the ripple voltage.
The choice of the filter capacitor is dependent on the output current. Given that

$V_r\,(_{rms}) = 2.4\ I_l/C_{FI}$ ……….. (1)

Where

$V_r(_{rms})$ = Rectified D.C ripple voltage

I_l= Load current (mA)

C_{FI} =Filter capacitor (μF)

For a load current of a (500mA), and a ripple factor of 5 %

V_{rms}= Vpeakx√2

= 15v x √2

= 21.2V

For a ripple factor of 5%

$V_{r(rms)}$ = 5/100 x 21.2

= 1.06V

∴ From (1)

21.2V = 2.4 x 500mA/C_{FI}

C_{FI} =1,132μF

= 1000μF preferred value.

Hence, C1= 1000uF, C2 = 47uF.

3.1.4 REGULATION

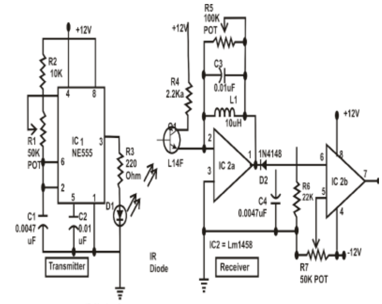
A 7806 regulator was used to get +6V. When the voltage passes through the transistor buffer TR1, a V_{BE} of 0.7V is dropped across the transistor, which reduces the output to 5.3V that is approximately 5V. The buffer transistor allows sourcing of current and prevents the regulator from overheating.

3.2 TRAFFIC MOVEMENT FEEDBACK

This section comprise of set of infrared transceiver circuit which is meant to sense the presence of vehicle at the lanes and feed the information back to the microcontroller in form of switching action. Fig 3.4 is the circuit diagram of an infrared motion detector that can be used to sense the presence of vehicles. Infra-red rays reflected from a static object will be in one phase, and the rays reflected from a moving object will be in another phase. The circuit uses this principle to sense the motion.

The IC1 (NE 555) is wired as an astablemultivibrator. The IR diode connected at the output of this IC produces infrared beams of frequency 40Khz. These beams are picked by the infrared sensor, photo transistor Q1. At normal condition, that is, when there is no detection the output pin (7) of IC2 will be low. When there is detection, the phase of the reflected waveforms has a difference in phase and this phase difference will be picked by the IC2. Now the pin 7 of the IC 2 goes high to indicate the detection. A LED or a buzzer can be connected at the output of the IC to indicate the detection of vehicles.

Circuit Diagram of a Transceiver.



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Vol. 2 Issue 12, December - 2013

Fig3.4 Circuit Diagram of Infrared Transciever Circuit

Notes.

- Comparators IC2a and IC2b are belonging to the same IC2 (LM1458). So the power supply is shown connected only once. No problem.
- When there is disturbance in the air or vehicles passing nearby, the IR motion sensor circuit may get false triggered.
- POT R5 can be used for sensitivity adjustment

3.3 MICROCONTROLLER UNIT

This section is the brain of the whole system. It handles all the intelligent activities of the system. It takes the informations from the feedback section, determines the time for each lane, controls the lane and as well drives the time display, the circuit below shows the microcontroller connected to the seven segment display and the traffic light for the three lanes.

The microcontroller employed in this section is the 16F877 type with four input-output ports.

The whole function of this section is made possible with the help of the embedded software (program).

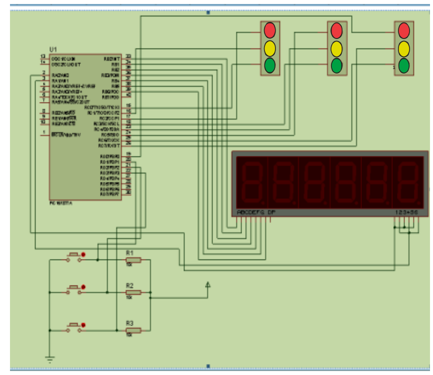

Fig. 3.5 Circuit Diagram of the Microcontroller

3.4 TIME DISPLAY

This is basically a seven-segment display unit connected to the microcontroller for the purpose of time display. The common cathode type is used in this respect. The display is driven by the controller. Each lane has two of the seven segment displays for displaying two digits. fig 3.5 shows two seven segment display of common cathode type.

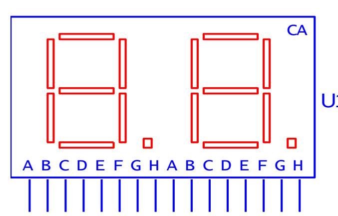

fig 3.6 Diagram of the Time Display (courtesy multism 2008)

The display used is the multiplexed type. This helped in the reduction of the number of ports on the microcontroller.

3.5 TRAFFIC LIGHT

The traffic light is another form of display but this time around, it displays colours red, yellow of green to indicate stop, ready and go respectively.

Though this project is a prototype, the colours are strictly adhered to. These lights are controlled and driven by the microcontroller.

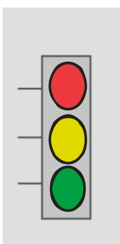

fig 3.7 Traffic Light Display.

3.6 DRIVER

The software is written in assembly language, assembled into hexcode and the hexcode finally embedded into the microcontroller.

The driver software is the engine room of the microcontroller. It determines what the microcontroller must do. This ranges from sensing and analysing the feedbacks, controlling the traffic light, setting the time for lane passage, terminating and allowing token when necessary, the conversion of time into seven segment displayable format and the driving of the seven segment display.

The assembly code of the driver software is in the appendix.

3.7 RESULT OF SIMULATION

The results taken from the simulation is tabulated as found in table 3.

Table 3; Simulation Result

TOKEN	INITIAL SWITCH STATUS	COUNT AT INITIAL STATUS	FINAL SWITCH STATUS	COUNT AT FINAL SWITCH STATUS	COUNTDOWN BEFORE TERMINATION OF TOKEN
Lane 1	OFF	85	OFF	___	75
Lane 1	ON	85	OFF	60	50
Lane 1	ON	85	OFF	33	23
Lane 1	ON	80	ON	05	00
Lane 1	ON	76	OFF	70	60
TOKEN	INITIAL SWITCH STATUS	COUNT AT INITIAL STATUS	FINAL SWITCH STATUS	COUNT AT FINAL SWITCH STATUS	COUNTDOWN BEFORE TERMINATION OF TOKEN
Lane 2	ON	85	OFF	50	40
Lane 2	ON	85	OFF	20	10
Lane 2	ON	85	OFF	10	00
Lane 2	OFF	80	OFF	------	75

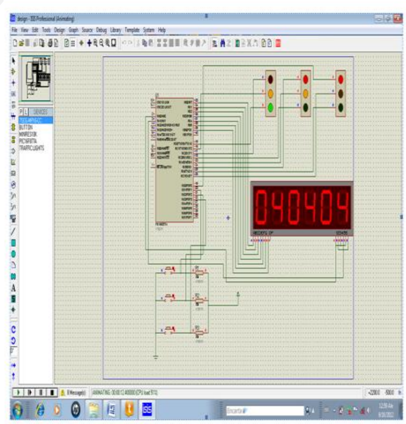

Fig 3.8 project simulation with proteus 7.1 software version

3.8 RESULT DISCUSSION

From the table, it could be deduced that for each token given to a lane, the last countdown time before the token is terminated indicates the extra time gain to allow other lane a token since this time would have been wasted for non-availability of vehicles in the lane with the token.

The feedback system senses non-availability of vehicles and terminates the token for other lanes.

A lane would be allowed all the token only if there is much vehicles to consume all the time.

4.0 CONCLUSION

The project which is the design and construction of a closed loop traffic light control system was designed considering some factors such as economy, availability of components and research materials, efficiency, compatibility and portability and also durability. The performance of the project after test met design specifications. The general operation of the project and performance is dependent on the user who is prone to human error such as pouring of liquid, plug into a higher voltage source etc

Also the operation is dependent on how well the soldering is done, and the positioning if the components in on the Vero-board (if logic elements are soldered near components that radiate heat, overheating might occur and affect the performance of the entire system).

The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user, should there be any system breakdown.

The project has really exposed us to digital electronics and practical electronics generally which is one of the major challenges I shall meet in my field, now and in future. The design of the closed loop traffic light control system, involves research in both digital and analog electronics. Intensive work was done on PIC microcontrollers and other electronic circuits.

The project was quite challenging and tedious but was a success.

However, like every aspect of engineering there is still room for improvement and further research on the project as suggested in the recommendations.

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