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Improved Traffic Control in Portharcourt using Solar Dependent Traffic Light System

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ABSTRACT

The Charge controller regulates the voltage output from the solar panel which is used to charge the battery and also the fixed logic system for control and timing, with the help of voltage regulator (LM7805 and LM7812) to achieve a steady output, which was used to power the 555-timer for the generation of pulses and Johnson counter, CD4017 (CMOS counter/divider). The CD4017 counter serves as a decade counter, decoder and synchronous counter. The decoder is clocked from the decade counter after a count of ten and its outputs are inverted and put into the clock inhibit input of ten synchronous counters. Based on the traffic flow data collected from the junction, timing was given to each of the roads so as. At the beginning of the counts, the first pulse is fed into the S-input of an RS-flip flop and the end of that same count is fed into the R-input of the same flip flop. The output of the RS flip flop is then fed into a transistor amplifier for amplification for the indicators. This is done for the Green and amber/yellow of all the roads while that of the Reds for the roads are fed into an inverter (CD40106) and the outputs are fed into the amplifier en-route to the indicators (LEDs).

Keyword: *Solar, 555 timer, decade counter, R-S flip-flop, LED display*

1. INTRODUCTION

Port Harcourt is the capital of Rivers State, Nigeria. It lies along the Bonny River and is located in the Niger Delta. According to the 2006 Nigerian census, Port Harcourt has a population of 1,382,592. It has an estimated area of 360 km². Port Harcourt's primary airport is the Port Harcourt International Airport located in the periphery of the city; Nigerian Air Force (NAF) base is the location of the only other airport in the city; used by commercial airlines Aero Contractors and Virgin Nigeria (now Air Nigeria) for domestic flights. The main educational establishments in the city are the University of Port Harcourt, Rivers State University of Science and technology and Ignatius Ajuru University of Education. The city of Portharcourt like other cities in Nigeria lacks regular electricity supply.

Transportation is important since it enables trade between people which in turn establishes civilization. Poor traffic management and control system results in time wasting, loss of fuel and funds, causing many problems in major cities [Abu-Lebdeh and Ahmed, 2012]. Transportation is useless without proper control, it is therefore necessary to have a fast economical and efficient traffic control system for national development [Forrest, 2010]. Epileptic power supply is a major problem in Nigeria today; it is affecting all forms of life. The ever increasing number of vehicles and low rate of high way development has lead to traffic congestion, being the major setback in road transportation in major cities across (the nation) Nigeria.

Traffic light is a system of coloured lights, usually automatically controlled, at road crossings or points of traffic concentration to regulate traffic. Traffic light has remained the most efficient way of controlling and navigating land (road) transportation as other means of controls, are used in other means of transportation [Pallas-Areny and Webster, 2011].

In this paper, the circuit is powered using two voltage sources, the battery and the solar cell in order to keep the traffic light operating at all times. The battery (lead acid battery) is charged by the solar cell during the day and supplies electricity to the circuit during periods when the solar cell cannot generate enough voltage to run the circuit. The solar panel provides a clean source of energy to run the circuit and charge the battery during the day. CMOS fixed Logic are used for determining the timing and sequence. LEDs are used as indicators as it is more reliable and more energy efficient and have a longer life span over other lighting devices.

This paper is aimed at designing and implementing an improved digital traffic system, using continuously generated pulses to drive light emitting diodes in a sequential manner using digital logic circuit and powered by a solar energy which provides efficient backup power supply to signalized traffic intersection. Figure 1 is the popular UTC junction in Portharcourt.

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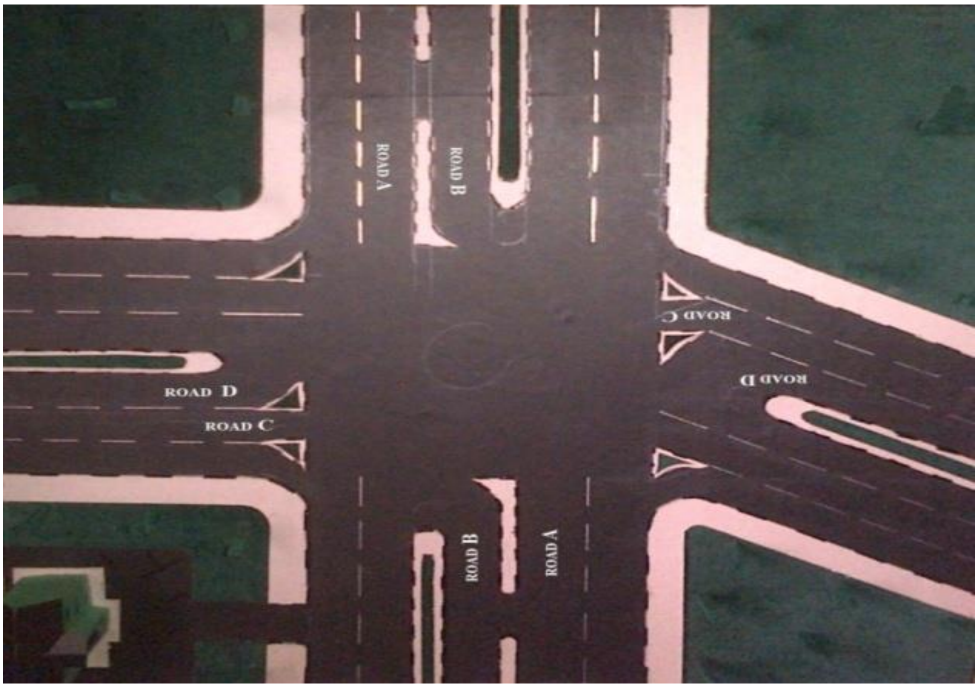

Fig 1: Layout of UTC Junction

2. MATERIALS AND METHODS

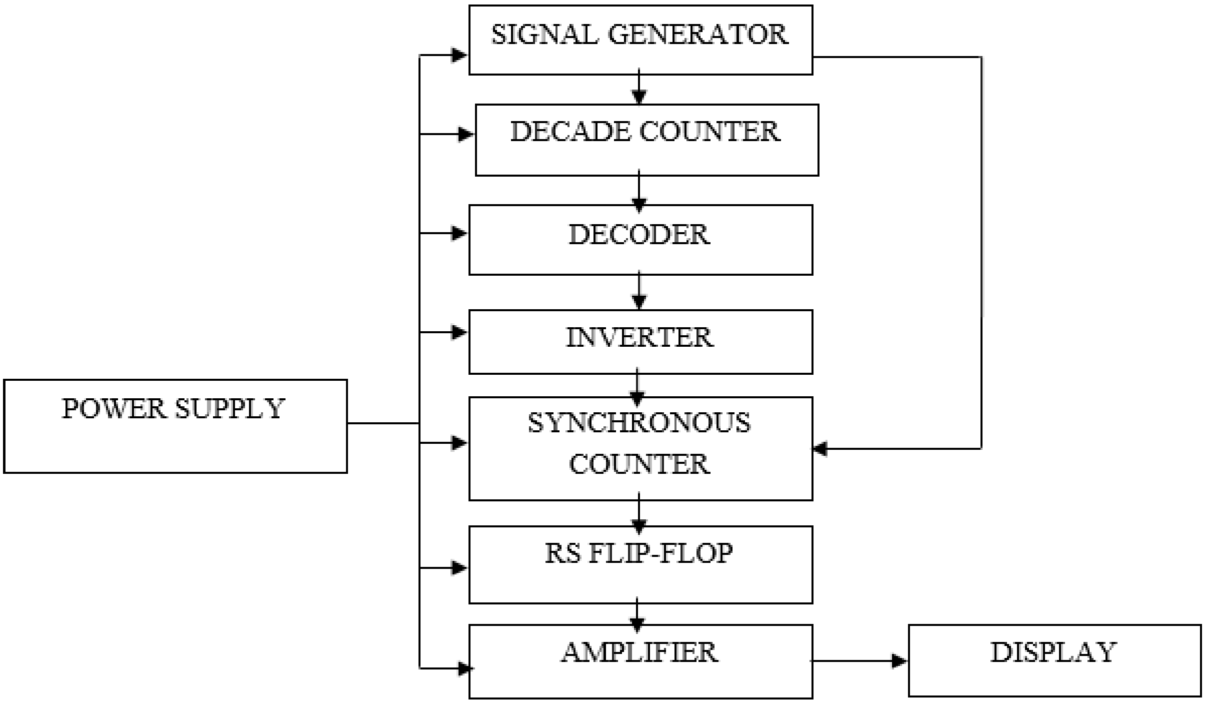

Fig 2: Block Diagram of Design

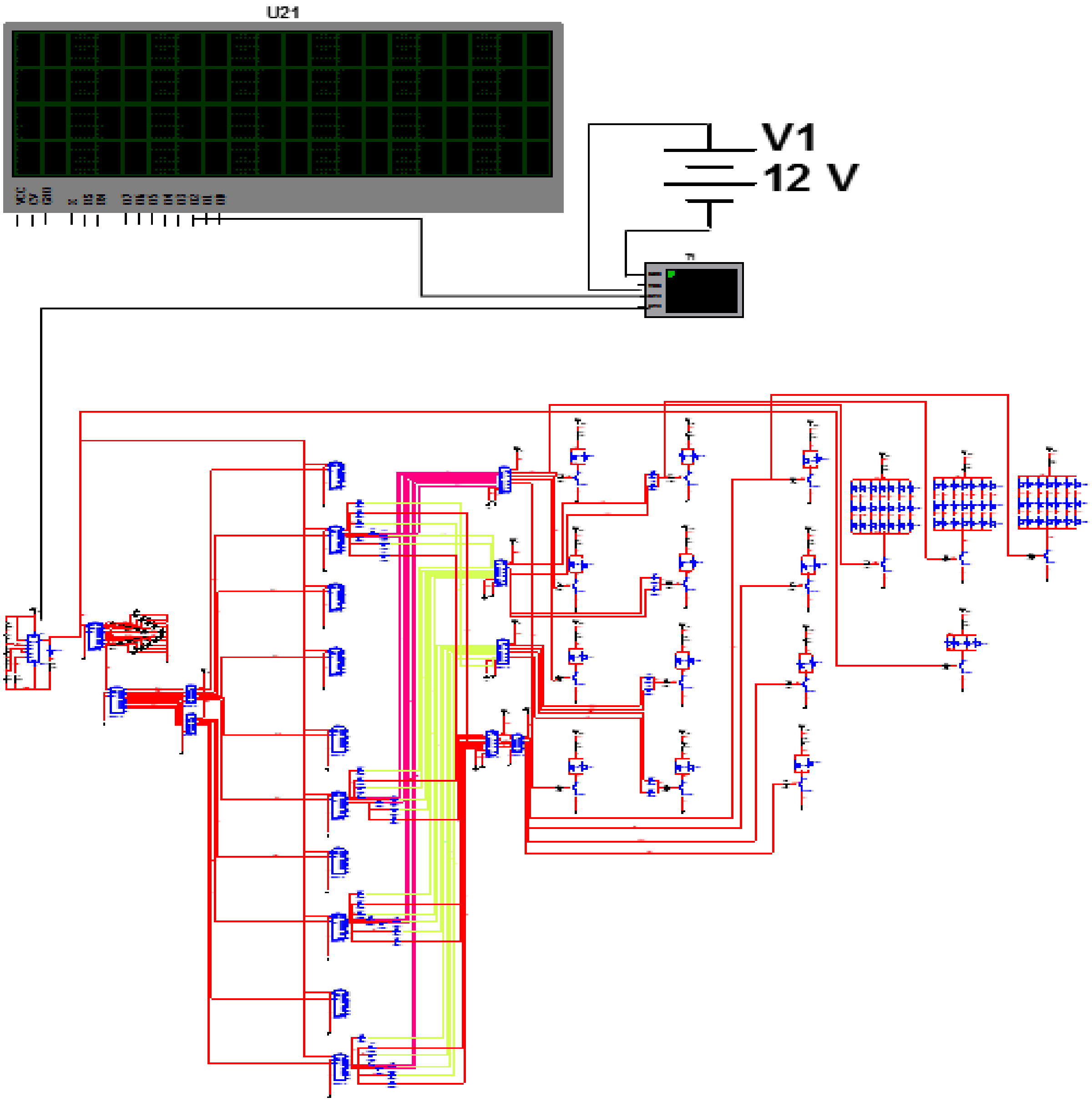

Fig 3: Circuit Diagram

Principle of Operation

- In figure 3, the solar panel generates electricity from the sun, which is supplied to the charge controller, the charge controller feeds the battery and the DC regulators power, but in time of no sun light the battery supplies the DC regulator with power as shown in figure 2.
- The circuit is fed from a regulated voltage supply.
- An adjustable LM555 astable oscillator is used as the signal generator to generate pulse.
- The output pulse from the signal generator is driven to CD4017BP which divides the signal into 10.
- The output of each divided signal is then divided by 10 by another CD4017 decoder. At every count of 10 the decoder is clocked.
- The output of the decoder is then fed after inverting into the clock inhibit of 10 synchronous counters that are clocked from the oscillator. The clock inhibit is actively low so as to allow the counter function effectively

- The circuit thus uses 40106 flip flop, indirectly to drive the CD4017 synchronous counters to control the inputs. The disallowed states prevent any of the ten outputs on their particular device from being turned ON while the other 4017 synchronous counter is counting to 10.
- This gives rise to a system where only one of the CD4017 is able to produce a high output state at a time.
- The adequate time assignment for the green, yellow and red lights for each of the roads were done by the RS latch.
- The RS latch is ON when a signal comes in and turns OFF when another signal comes in.
- The outputs of the RS latch for green and yellow are joined to their respective amplifiers and display circuits.
- The outputs of the RS latch for the red lights are OR-ed together with the aid of a three input, triple 4075 logic.
- The outputs of the 4075 are connected to the respective red display circuits.
- This may seem like an unusual method but it allows the circuit to make economical use of the open collector outputs of the CD4017 synchronous counter rather than using output buffer IC's driven by CD4017 logic device
- The circuit/design are in a continuous running mode, it can also be stopped externally and reset.

3. DESIGN ANALYSIS

Data Collection and Analysis

Let the traffic flow for roads leading to UTC junction in Portharcourt be:

Government House to Isaac Boro Park and Isaac Boro Park to Government House = A

Government House - Wharf and Isaac Boro Park - Force Avenue = **B**

Force Avenue - Wharf and Wharf - Forces Avenue = **C**

Force Avenue- Government House and Wharf - Isaac Boro Park = **D**

Table 1: Traffic Data Collection for UTC Junction

DAYS	ROADS	DURATION	NO. OF AUTOMOBILES
MONDAY	A	7AM- 10AM	30,000
		3PM-6PM	25,000
	C	7AM- 10AM	18,000
		3PM-6PM	14,000
	B	7AM-10AM	5,000
		3PM-6PM	8,800
	D	7AM-10AM	4,000
		3PM-6PM	3,000
WEDNESDAY	A	7AM-10AM	27,000
		3PM-6PM	23,000
	C	7AM-10AM	17,000
		3PM-6PM	13,400
	B	7AM-10AM	7,000
		3PM-6PM	4,900
	D	7AM-10AM	4,200
		3PM-6PM	3,400
FRIDAY	A	7AM-10AM	32,600
		3PM-6PM	31,550
	C	7AM-10AM	15,600
		3PM-6PM	10,500
	B	7AM-10AM	6,404
		3PM-6PM	4,100
	D	7AM-10AM	4,000
		3PM-6PM	2,900
SATURDAY	A	7AM-10AM	22,221
		3PM-6PM	19,065
	C	7AM-10AM	15,006
		3PM-6PM	13,000

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	B	7AM-10AM	3,000
		3PM-6PM	2,200
	D	7AM-10AM	2,800
		3PM-6PM	1,980

For the major Road A, cars are twice that coming from Road B, C and D. Based on this, count assignment for the junction assuming 100 counts becomes;

A …………………………………. 40 counts

B …………………………………. 20 ‘’

C …………………………………. 22 ‘’

D ………………………………… 18 ‘’

Design of the Timer

The timing of the system was achieved using the 555 timer integrated circuit.

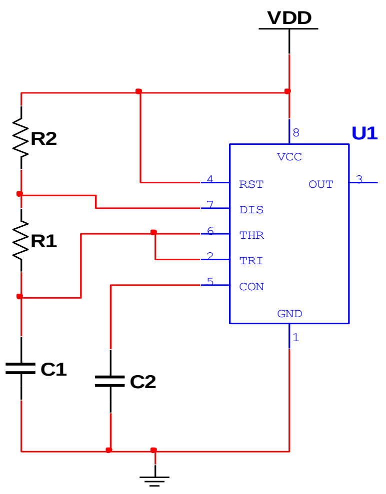

Fig 4: Timer in Astable Mode of Operation

Principle of Operation

In figure 4, when power is first applied to the circuit, since the capacitor, C_1 is uncharged, both the trigger and threshold inputs will be near zero volts, the lower comparators sets the control flip flop causing the output to switch high. That also turns off transistor T_1. The capacitor, C_1 begins to charge through R_1 and R_2. As soon as the capacitor is fully charged, it triggers the flip-flop to reset and the output goes low while transistor T_1 conducts. The effect of T_1 conducting causes resistor R_2 to be connected across the external capacitor. Resistor R_2 is effectively connected to ground through internal transistor T_1. The result of this is that the capacitor now begins to discharge through R_2.

Using an ON time of 1.8s and a duty cycle of 80%,

The frequency of operation of the astable circuit is dependent upon the values of R_1, R_2 and C_1 [Boylestad and Nashelsky, 2004], [Stan, 1998]. it could be calculated as:

$$f = \frac{1}{In2(R_1+2R_2)C_1} \quad (1)$$

$$T = \frac{1}{f} \quad (2)$$

$$\tau = \frac{R_1+R_2}{R_1+2R_2} \quad (3)$$

$$Rise\ Time = \ln 2\,(R_1 + R_2)C_1 \quad (4)$$

$$Fall\ Time = \ln 2 \times R_2 \times C_1 \quad (5)$$

$$T = \frac{5 \times 60s}{100} = \frac{300}{100} = 3\text{sec}$$

$$\tau = \frac{80}{100} = 0.8$$

$$f = \frac{1}{T} = \frac{1}{3}$$

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$$\frac{1}{3} = \frac{1}{\ln 2\,(R_1 + 2R_2)10\mu F}$$

$$3 = 0.693(R_1 + 2R_2)10 \times 10^{-6}$$

$$(R_1 + 2R_2) = \frac{3}{0.693 \times 10 \times 10^{-6}}$$

$$R_1 + 2R_2 = 0.43290 \times 10^6 \tag{6}$$

$$0.8 = \frac{R_1 + R_2}{R_1 + 2R_2}$$

$$0.8(R_1 + 2R_2) = R_1 + R_2$$

$$0.8R_1 + 1.6R_2 = R_1 + R_2$$

$$1.6R_2 - R_2 = R_1 - 0.8R_1$$

$$0.6R_2 = 0.2R_1$$

$$R_2 = \frac{0.2}{0.6} R_1 = 0.333R_1 \tag{7}$$

$$R_1 + (2 \times 0.333R_1) = 0.43290 \times 10^6$$

$$R_1 + 0.6667R_1 = 0.43290 \times 10^6$$

$$1.6667R_1 = 0.43290 \times 10^6$$

$$R_1 = \frac{0.43290 \times 10^6}{1.6667}$$

$$R_1 = 0.25984 \times 10^6 = 259.84k\Omega$$

$$R_2 = 0.333(259.84k) = 86.53k\Omega$$

$$High\ Time = In2(259.8k + 86.53)10 \times 10^{-6} = 2.40sec$$

$$Low\ Time = In2 \times 86.53 \times 10 \times 10^{-6} = 0.60\text{sec}$$

$$Total\ Time = High\ Time + Low\ Time \tag{8}$$

$$Total\ Time = 2.40sec + 0.60sec = 3.00sec$$

Design of Display Section

Current Limiting Resistors:

These resistors are responsible for limiting the amount of current entering each LED of a seven segment display and without this limiting resistor the LED will just burn out. In this project the LEDS are rated to operate at 10mA at 2.7V for each LED the value of the each limiting resistor is calculated as shown

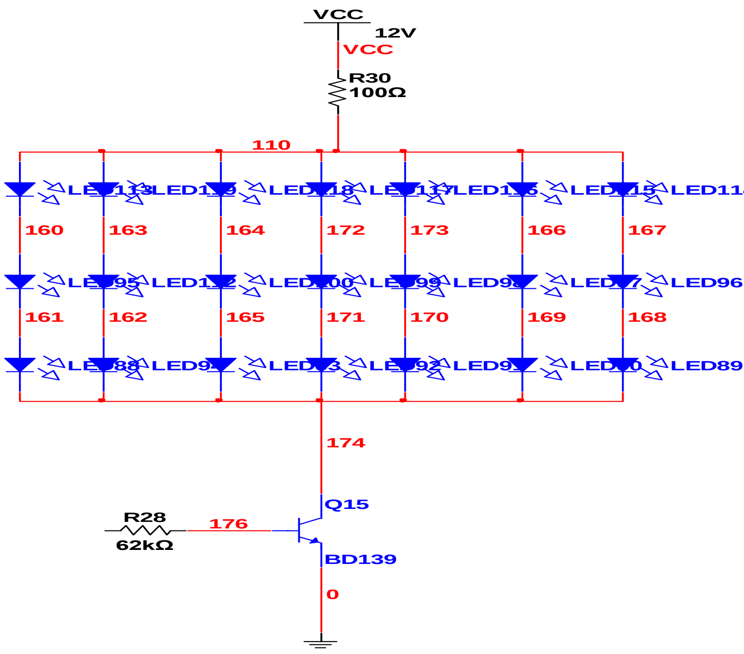

Fig 4.5: Display Section of Design

Calculation of the Limiting Current Resistor

Using the following values, the limiting current resistor is calculated [Tocci *et al*, 2001], [Sun and Moukos, 2000]:

$$V_{cc} = 12v$$

$$V_f = 3.2v$$

$$V_{ce(sat)} = 0.2v$$

$$I = 15mA$$

$$V_{r1} = 15mA \times R_1 \tag{9}$$

$$V_{ft} = V_f \times N \tag{10}$$

$$V_{ft} = 3 \times 3.2v = 9.6v$$

$$V_{be} = 0.7v$$

$$hfe(max) = \beta = 250$$

$$V_{co} = 80$$

$$V_{cc} = V_{r1} + V_{ft} + V_{ce(sat)} - V_{be} \tag{11}$$

$$V_{cc} = IR_1 + V_{ft} + V_{ce(sat)} - V_{be}$$

$$R_1 = \frac{V_{cc} - V_{ft} - V_{ce(sat)} + V_{be}}{I}\ \Omega$$

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$$R_1 = \frac{12 - 9.6 - 0.2 + 0.7}{15 \times 10^{-3}} \Omega$$

$$R_1 = 100\Omega$$

Calculation Base Resistors

$$I_c = 15\text{mA}$$

$$V_{bb} = 5\text{v}$$

$$I_c = \beta I_b \quad (12)$$

$$I_b = \frac{I_c}{\beta} = \frac{15\text{mA}}{250} = 0.06\text{mA} = 60\mu\text{A}$$

$$V_{bb} = I_b R_b + V_{be} \quad (13)$$

$$R_b = \frac{V_{bb} - V_{be}}{I_b}$$

$$R_b = \frac{5 - 0.7}{60 \times 10^{-6}} \Omega$$

$$R_b = 0.058 \times 10^6 \, \Omega$$

$$R_b = 58.33\text{k} \cong 62\text{k}\Omega$$

Calculation of total Power

The total power of the circuit system can be estimated as the sum of the powers contributed by the LED powers, Limiting current resistor powers and the transistor powers [Sun and Moukos, 2000].

$$P_t = V_{ce} \times I_c \quad (14)$$

where P_t is the transistor power, V_{ce} is the emitter collector voltage of the transistor and I_c is the collector current of the transistor.

$$P_t = 80\text{v} \times 15\text{mA} = 1.2\text{W}$$

$$P_r = I^2 \times R \quad (15)$$

$$P_r = (15\text{mA})^2 \times 100\Omega$$

$$P_r = 0.0225\text{W} = 0.5\text{W}$$

$$P_d = IV_f \quad (16)$$

$$P_d = 15\text{mA} \times 3.2\text{v}$$

$$P_d = 0.048\text{W}$$

$$P_d t = 0.048\text{W} \times 21 = 1.008\text{W}$$

$$P_{ta} = P_t + P_r + P_d t \quad (17)$$

$$P_{ta} = 1.2\text{W} + 0.5\text{W} + 1.008\text{W} = 2.708\text{W}$$

$$P_{tw} = 3 \times 2.708\text{W} \quad (18)$$

$$P_{tw} = 8.124\text{W} \quad (19)$$

$$P_{ts} = 8 \times 8.124\text{W}$$

$$P_{ts} = 64.992\text{W}$$

$$P_{tc} = 4 \times 2.708\text{W} \quad (20)$$

$$P_{tc} = 10.832\text{W}$$

$$P = P_{ts} + P_{tc} \quad (21)$$

$$P = 64.992\text{W} + 10.832\text{W}$$

$$P = 75.824\text{W}$$

$$I = \frac{P}{V} = \frac{75.824\text{W}}{12\text{V}} = 6.319\text{A} \quad (22)$$

The BD139 transistor has a maximum output current of 2A [Philips Semiconductors, 1997]. Therefore, for the display, we can cascade up to 21 LEDs together without necessarily over-working the transistor.

It is clear that the circuit uses 80 watts, but a battery of 100 Ampere Hours is needed for hours of no sun light, (12 to14) hours, that is 6pm to 7am. Giving the current of the circuit as $\cong$ 7 Amps connected to a charge controller.

4. CONCLUSION

The efficiency in the design and construction an improved digital traffic light for the junction, data was collected and analyzed to know the traffic density at the junction during a specified duration of time that the traffic may likely be intense. The signal generator generates the signal that was counted and divided by the CD4017 but inverted and fed into the clock inhibit input of the synchronous counters. For selection, based on time assignment, RS flip flop was used to the displays of the roads respectively. Consequent upon this, this project was done with the aim of an improved signal display achieved. Though, it was observed that only a good selection of CMOS IC's and pin recognition made the project successful.

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Recommendation

We wish to recommend that a metal detector circuit can be incorporated to each of the signals to the RED display of the roads so as to beep when a vehicle/car beats the traffic. This would ensure that security/traffic officials are alerted and monitor driver behavior at the junction. These metal detectors can be placed at the zebra crossing of each of the roads and only activated when display is RED. That there should be a seven segment display attached to each of the roads and these counts down to zero the time it takes for RED display on each road to stay ON.

The design approach can be expanded to accommodate more new technologies like speed sensor.

The Solar powered traffic system should be fully implemented, with more research to provide methods of traffic signal for those with disability and low literacy rating.

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