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Study the types of energy, its transformation from one form to another, and the practical applications in the daily life

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Abstract

This research investigates the design and implementation of a basic traffic light system for a four-way intersection. The project underscores the importance of traffic lights in managing traffic flow and ensuring road safety.

This research also reviews some of the different types of energy and some examples of its transformations from one form to another such as the electrical energy utilized in operating traffic signals, as well as the kinetic energy of vehicles regulated by this system. It underscores the importance of comprehending energy conversion and efficient utilization to ensure the effectiveness of design systems, like traffic signal systems.

The core concept explored is energy transformation, specifically focusing on the conversion of electrical energy into light energy to operate the traffic light system. A prototype circuit using resistors, capacitors, and a timer chip is designed to

simulate the traffic light sequence, with green, yellow, and red lights for each direction.

The findings demonstrate the effectiveness of a simple traffic light system in regulating traffic flow at intersections. The research concludes by acknowledging the significance of traffic lights in maintaining order and safety on the roads. Additionally, the project emphasizes the value of mimicking real-world traffic light systems through circuit simulations for educational purposes.

keywords: Energy – Energy forms - Transformation of energy - Traffic light

1. Introduction:

Energy, a crucial component of society, is essential for various activities like transportation, manufacturing, and domestics. It is a conserved, finite quantity in the universe, and is essential for all life forms and processes. Energy is the ability to do work and can be found in various forms, such as kinetic and potential energy. Scientists classified energy according to 2 main categories: according to its forms and according to renewability.[1]

According to its forms:

- **Electrical energy** is energy stored in electric fields that results from the presence of electric charges, it is produced by moving electrons and made available by the flow of electrical charge through a conductor.
- **Mechanical energy** is the energy of the moving parts of machines or humans, for example, a moving bike or a handshake. It is the energy that machines create. Mechanical energy is the sum of potential (stored energy of position) and kinetic energy (energy of motion) of a mechanical system.
- **Thermal energy** is considered the most internal energy of objects, which is created by vibration and movement. It is a form of kinetic energy and transferred as heat. It manifests itself as an increase in temperature. Heat is thermal energy that is transferred due to a temperature difference.

According to Renewability:

- **Renewable Energy Resources** are resources that cannot be exhausted even after continuous utilization are termed renewable resources. Examples of renewable resources are: **Solar energy**; solar energy is the cleanest and most abundant renewable energy source available, solar power is energy from the sun that is converted into thermal or electrical energy. **Wind energy**: Wind is used to produce

electricity by converting the kinetic energy of air in motion into electricity. **Water energy**: the energy that is derived from water, generally through its motion. A common example of water energy is hydroelectricity, which converts power from the water that flows over dams into electrical energy.[2]

- **Non-renewable Energy Resources:** The resources that cannot be immediately replaced once they are depleted are called non-renewable resources. Examples of non-renewable resources include fossil fuels, such as coal, petroleum, natural gas, and rare minerals typically found in meteorites.[3]

Studying forms of energy directs us to study energy transformations. **Energy transformation**, also known as energy conversion, is the process of changing energy from one form to another. The conversion from electrical energy to light energy is one of the most important examples of energy transformation that is in our daily life such as traffic light. When a light switch is turned on, electrical energy heats the filament inside a light bulb and transforms the energy into light and heat energy that is seen and felt in a glowing light bulb.[4] Traffic congestion is a serious problem in many modern cities. To solve the problem, we proposed creating a smart traffic light, a technology that is expected to be able to solve congestion problems. In this paper, the methods and techniques used in the development of smart traffic signals will be analyzed, as it is expected that in the future the smart traffic signal will manage traffic independently.

We want to study traffic flow-controlled traffic lights on a four-intersection road using the optimal speed model. For example, Roxy square, a traffic light regulates traffic in each direction, allowing only two directions to go simultaneously while the other two directions are closed, and vice versa. After the green light goes out, the yellow light stays for up to 7 seconds, followed by 14 seconds for a red light. Then finally, when pedestrians are allowed to cross in all directions, the red light flashes.

2. The Theoretical Framework

The Indonesian Government Scholarship PMDSU from the Ministry of Research, Technology, and Higher Education (Kemristekdikti). [5]
(Study 1)

- Design and Implementation of a Portable Traffic Light Control System.[6]

(Study 2)

These two studies view that:

One device that is anticipated to help with traffic congestion is the smart traffic light. The techniques and tools utilized in the creation of smart traffic signals to lessen traffic volume and identify emergency vehicles**.**

In order to lower the possibility of human mistakes in this work, smart traffic lights are anticipated to regulate traffic independently in the future.

As everyone is aware, the fundamental principle of a traffic light is the conversion of electric energy into heat and light energy.

The following are a few of the primary goals of the traffic light design in those studies:

- To simplify the design and make it simple to use in real-time.

- To increase job flexibility and ease of adaptation to the current traffic condition.

Lastly, to lower the design's overall cost.

- Light Energy Conversion Research || The Prashant Kamet lab. University of Notre Dame.[7]

(study 3)

- North Dakota Studies (.gov) Energy Conversion | ND Studies Energy Level 2. [8] (study 4)

Generally speaking, photons—small energy "packets" whose energy varies depending on the color or wavelength of the light—make up all light. An electron in a substance receives photon energy when it absorbs one; this electron is referred to as an excited electron. Every colored object we see does this process continuously; for example, the dye molecules in a red shirt continuously absorb blue, green, and yellow photons and reflect red photons back to our eyes.

The energy from the photon is converted to an electron, which then loses that energy as heat. However, if the system is built properly, we can use the excited electron to do tasks. These excited electrons can be propelled via a wire, much like in a traffic light, depending on the system. This will generate electricity, which can subsequently be transformed into heat energy and light energy, which is represented by the three colors of the traffic light.

The connection between these research projects.

1-The value of traffic signals in reducing traffic.

2 - how our eyes saw the colors of traffic lights.

3 - All those studies demonstrated that energy changes into a variety of forms.

Electric energy is converted to light and heat energy, as demonstrated by the traffic light.

Theories :

Traffic lights are designed to safely manage vehicle, bicycle, and pedestrian traffic. There are two main types: fixed time and dynamic control.

Fixed-time traffic signals use a timer to change the lights at a fixed interval. They could be as short as 30 seconds or as long as several minutes, depending on the intersection's historical traffic data. These traffic lights use an electro-mechanical signal controller, which has movable components and a dial timer. This allows the light to switch and hold light colors for a predetermined amount of time.[9]

Concepts

Traffic lights (traffic signals) :are signaling devices that control the flow of traffic at road intersections, pedestrian crossings, and other locations. They use colored lights (red, yellow, and green) to indicate when vehicles and pedestrians should stop, slow down, or go.

circuit: In electronics, a circuit is a complete circular path that electricity flows through. A Simple circuit consists of a current source, conductors, and load.

Capacitor: A capacitor is an electric element used in electric circuits where its function is Based on the principle of the two oppositely charged and parallel plates or electric Conductors.

RC circuit: R stands for resistor, and C stands for capacitor. An RC circuit is a resistor and Capacitor connected in series with a power source.

Resistor: A resistor is an electrical device that passively resists the flow of electrical Current.

A charging RC circuit is when the capacitor and resistor are connected to a power Source, allowing for opposite charges To build up on the plates of the capacitor.

A discharging RC circuit is a charged capacitor connected to a resistor, with the Capacitor's electrical energy flowing through the circuit as current.[10]

3. Methods of Research and the tools used

- **Tools**

Breadboard 2 - Jumper Wires 32

Capacitor [10 µF] 1 - Capacitor [470 µF] 5

Resistor [220 Ω] 5 - Resistor [1 KΩ] 1

Resistor [10 KΩ] 1 - Green LED 4 - Yellow LED 4 Red LED 4Diode 10 - 555-Timer1

Counter [4017BP]1 - Adapter [5 v] 1

- **Method**

1. Connecting a 5-volt battery to the positive and negative of the board.
2. (Connect triple 5 timer).
    a. Connect PIN 8 to the positive of the battery, and PIN 1 to the negative of the battery.
    b. Control pin (num 5) One end connects to the capacitor 1 {10nf} and the other connects to the negative of the battery.
    c. Connect PINs 2 and 6 in series.
    d. Pins number 7 and 8 connect with a 1 KΩ resistor. PIN 6 and 7 connect with a resistance of 10KΩ.
    e. Capacitor number 2: One end connects to the negative of the battery and the other to PIN 6
3. Connect (counter (4017 Bb.)
    a. Connect PIN 16 to the positive of the battery, and PIN 8 to the negative of the battery.
    b. CLK (PIN 14) connects to the output of a triple 5 timer.
    c. CI (PIN 13) connects to the negative of the battery.
    d. MR (PIN 15) to PIN 7.
4. LED connects. Green led (top/ down)
    a. Connect both green LEDs in series.

    Connect Q1 to the positive of LED 1, the negative of LED 1 to the positive of LED 2, the negative of LED 2 to the positive of the resistor, and the negative of the resistor to the negative of the battery.
    b. Connect Q1 to the beginning of diode 1, connect Q2 to the beginning of diode 2, and connect them together.
    c. Connecting green LED (left/right)
    d. Use 2 diodes, connect output 4 to the first diode and output 5 to the second diode.
    e. Connect their ends together.

5. Connecting the yellow LED in series (top/down)

    a. Connect Q3 to the positive of LED, the negative of LED 1 to the positive of LED 2, the negative of LED 2 to the positive of the resistor, and the negative of the resistor to the negative of the battery.

6. Connecting the red LED (left/right)

    a. Use 3 diodes, Connect the first diode to the diode of the green LED, the second diode to output 3, and the third diode to output 7. Connect their ends together, then connect them to the positive of red LED 1 and the negative of red LED 1 to the positive of red LED 2, the negative of LED 2 to the positive of the resistor, and the negative of the resistor to the negative of the battery.

    b. Connecting the red LED (top/down)

    c. Use 3 diodes, Connect the green diode with the first red diode, output 6 with the second red diode and output 7 connect to the third diode.

    d. Connect a diode to the positive of the red LED 1, the negative of red LED 1 to the positive of red LED 2, the negative of red LED 2 to the positive of the resistor, and the negative of the resistor to the negative of the battery.

4. Results of Research

After trying all possible electrical circuits, we arrived at the appropriate and simplest circuit:

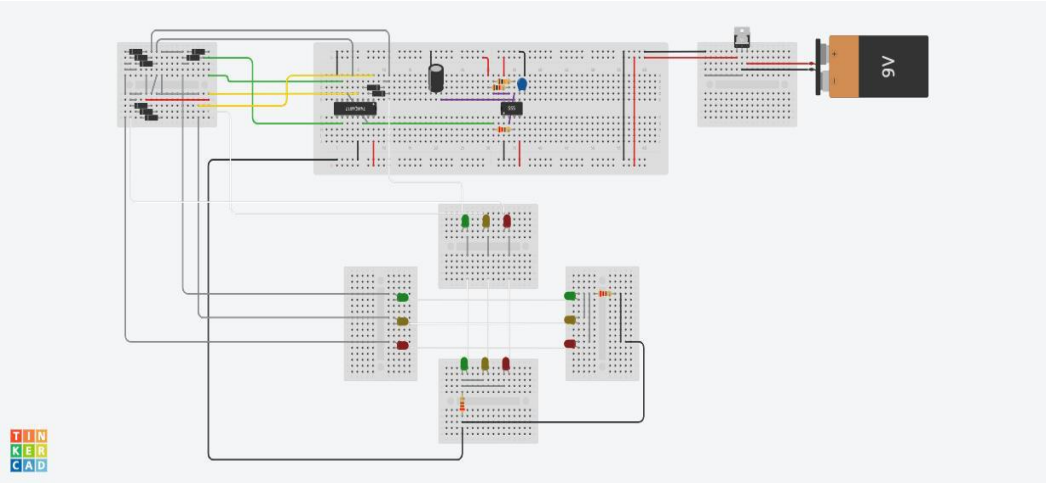

Fig (1): A simulation of the electrical circuit used in the project.

The simplicity of this traffic light control system gives us the opportunity for direct implementation.

We made an intersection of 4 roads as shown in the picture below:

Fig (2): An intersection of 4 roads.[11]

Both opposite routes will be running at the same time

Case implementation:

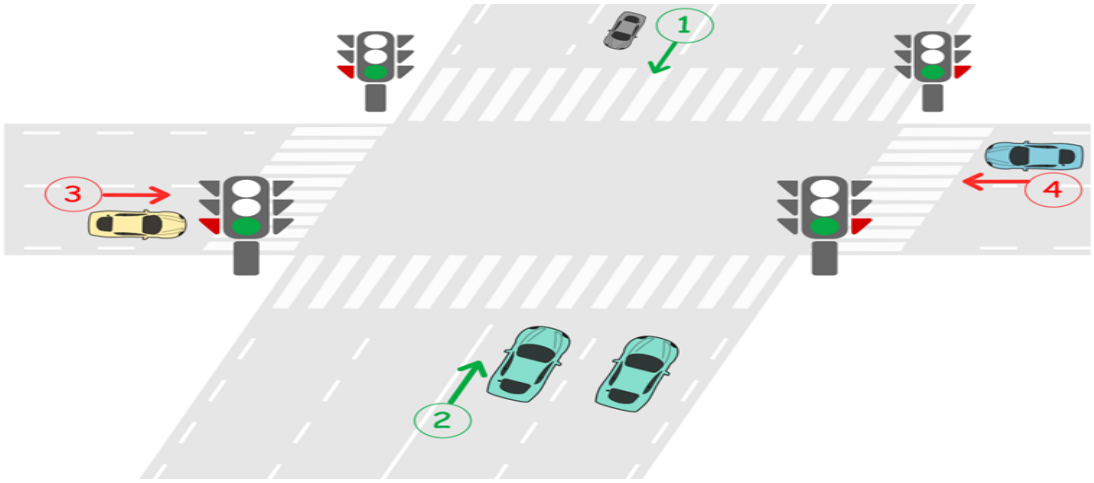

Fig (3): a simplified diagram of a four-way intersection controlled by a traffic light. The text labels 1, 2, 3, and 4 likely represent the different directions or lanes of traffic.[12]

During this case, starting the circle with a green light for both sides 1 and 2 will turn ON while sides 3 and 4 are red. Routes 1 and 2 are opposite roads. During green, both vehicles on both roads will have two options, either forward or turning right.
After the specified time has elapsed green light for both sides 1 and 2 is turned OFF and red light turns ON, while for sides 3 and 4 red light is turned OFF and the green light will turn ON.

After sides 3 and 4 turn red. all 4 sides will be red for a certain time for pedestrians to have time for crossing the roads.

5. Interpretation of Results

This circuit is based on the RC circuit law. We will use a breadboard to make it because we do not need to solder the wires. We use a 555 timer to give us a square wave to control the time of opening and closing. It has 8 legs. The first leg is GND, or negative of the battery, and leg number 8 is VCC. The positive of the battery and No. 3, and this is the output that gives us the square wave, and the pin No. 5 is not important, so we connect it to a capacitor with a capacity of 10µF, and after that, we connect it to the negative of the battery so as not to cause any disturbance, and the pin No. 4 to the positive of the battery, and to fulfill the law of the RC circuit, we connect the leg. 8 in its place, and we give it the name R1 and connect it to pin 7 and connect pin 7 to a resistor and give it the name R2 and connect it to pin 6 and then connect them to a capacitor with a capacity of 470µF.

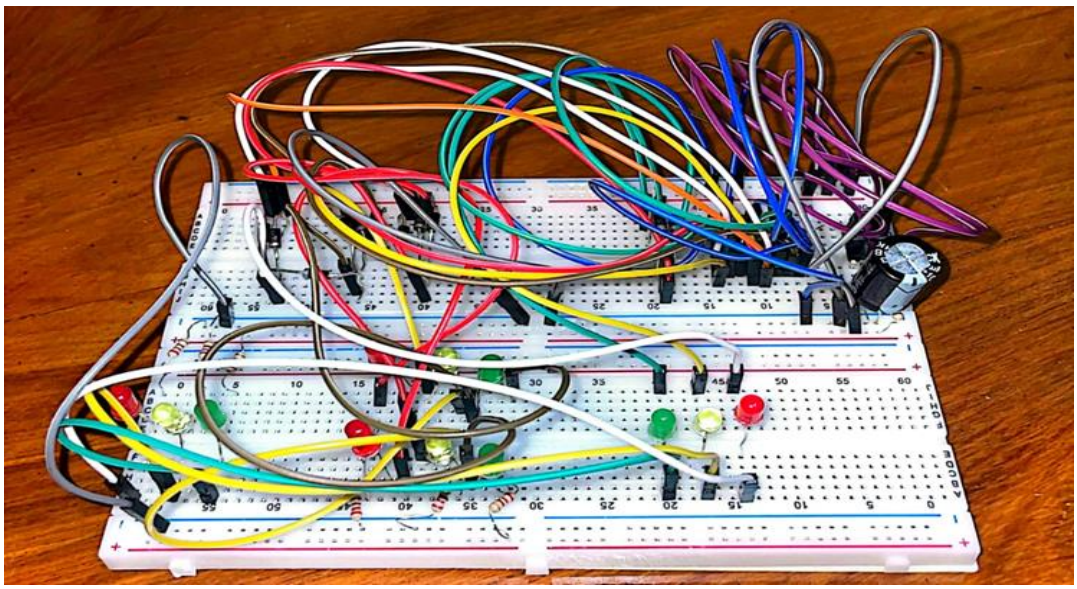

Fig (4): A real picture of the electrical circuit used in the project.

The charging process is carried out by the law of Charging = 0.693 (R1 + R2) c1[13], and this is the open time, while the closed time is done by discharging R2. and converting the battery by the regulator.

And used R3 resistance to reduce the current that will enter the LED.

We also used a counter consisting of 16 pins.

We will connect pin No. 16 to the positive of the battery, and pin No. 8 to the negative of the battery. It is made up of ten pins from Q0 to Q9 that work interchangeably, and pin No. 14 is the output of the 555 timer, which we used as a square wave.

In a square wave, high and low are volts, and when one of the pins is high, the rest is low, and so on in alternation, and there is a pin called MR. It is connected to the positive of the battery and works as a reset to repeat the count from the beginning again. The duration of each pin is 7 seconds and PIN 12 is neglected.

We come to the stage of turning on the lights:

First, the green color above and below is connected to two pins Qo & Q1, and lights up for 14 seconds, and on the other side, left and right, it is connected to Q3 & Q4 and lights up for 14 seconds, alternating between both sides.

The yellow color above and below reaches Q2 and the left and right of Q5, and they operate alternately.

Finally, the red color above and below is connected with four pins, here Q3, Q4, Q5, Q6, and left and right with four pins, Q0, Q1, Q2, and Q6.

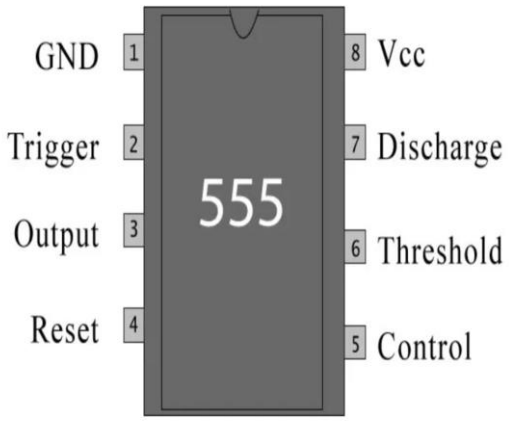

Fig (5): Triple 5 timer

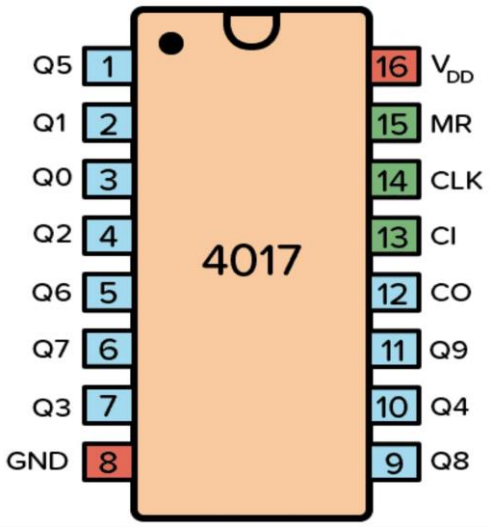

Fig (6): Counter

6. Conclusion

The utilization of a basic traffic light system at a four-road intersection proves crucial for maintaining order and safety on the roads. By providing clear signals for when to stop, proceed, or yield, it effectively manages the flow of vehicles and reduces the likelihood of accidents. Take an example from Roxy Square, where a signal system consisting of four traffic lights regulates the movement of vehicles in each direction, with only two directions permitted to proceed at a time while the other two are closed off. This means that the green light burns for 14 seconds in the two opposite directions, while the red light burns in the other two, and vice versa. After the green light extinguishes, the yellow light remains for up to 7 seconds, followed by a 14-second duration for the red light. Finally, when pedestrians are permitted to cross in all directions, the red light flashes in all directions.

Finally, we designed a circuit to mimic a traffic signal, and we've come to appreciate the vital role these signals play in our daily lives. Much like the orderly flow of electrons in our circuit, traffic lights guide the orderly flow of vehicles, ensuring safety and efficiency on our roads."

Acknowledgment

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