Crane Safety Light Circuit

Name: ______________________________ Date: ______________

1. Determine **T1 (Time High)**, **T (Time Period)**, and **F (frequency)** if the setting on the variable resistor at location **R2** is adjusted to the following values:
   - **500 Ω**
   - **2,500 Ω**
   - **5,000 Ω**
   - **7,500 Ω**

2. Determine the value for R2 that is necessary for T (Period Time) to be equal to 1 second. Show all of your calculations.

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Introduction:

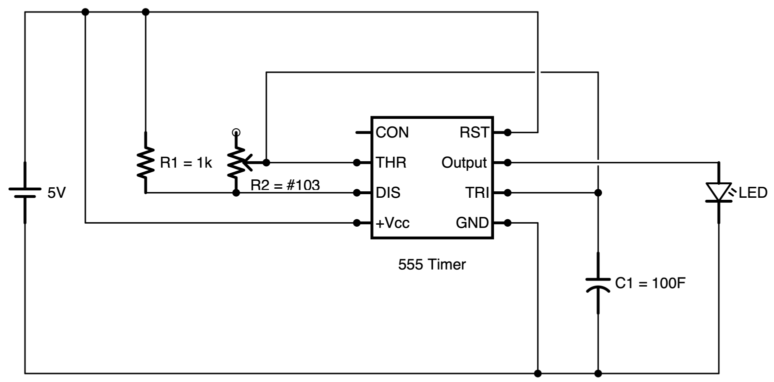
Real cranes will have complex electrical circuits that include microcontrollers, surge protectors, and relays circuits to control large high-powered lighting systems; however a scaled down version control circuit can be created using a 555 timer.

The 555 timer is one of the most widely used **Integrated Circuits (IC)**. It was designed in 1971 by Hans Camenzind under contract to Signetics. The versatility and functionality of the 555 timer quickly made it one of the most widely used ICs on the market with over 1 billion units being sold annually as of 2017. The 555 timer can be configured to operate in one of 4 different configurations:

1. **Astable:** In **astable mode** the 555 can operate as an electronic oscillator. Uses include LED and lamp flashers.
2. **Monostable:** In **monostable mode** the 555 functions as a "one-shot" pulse generator. Applications include timers
3. **Bistable:** In **bistable mode** the 555 functions as a flip-flop circuit. Uses include bounce-free latched switches.
4. **Schmitt Trigger:** As a **Schmitt trigger** the the 555 operates as an inverter gate which converts a noisy input into a clean digital output.

In “**Mode 1 - Astable**” the 555 timer can create an ***oscillating square wave pulse***. This configuration is very useful when creating a wide variety of digital circuits, but more importantly it can provide a consistent output that can control the rate that safety lights on a crane will flash. Since the pulse rate of the circuit can be calculated in advance an electoral engineer to create a very specific interval for the flashing of the lights. That is how long the lights are **ON (Time High)** and **OFF (Time low)**.

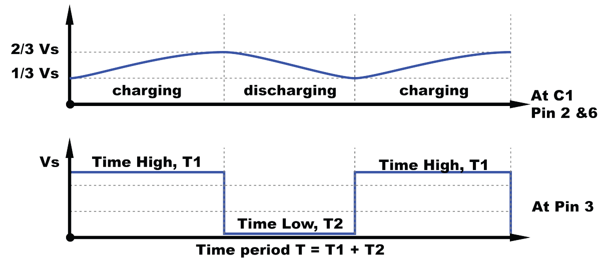
Simple 555 Timer Circuit



This simple 555 timer circuit can be used to produce a square wave in which the **T1 (High Time)** and the **T2 (Low Time)** can be calculated. This method of determining specific values ahead of time is used by electrical engineers to control the rate that an LED will blink. The final output obtained from **Pin 3 (Output)** is by the graph “***555 Timer Circuit Duty Cycles***”:

Crane Safety Light Circuit

555 Timer Circuit Duty Cycles



Time (T) is measured in seconds (s) and the Voltage measured in Volts (Vs).

This graph shows what is happening in this simple 555 timer circuit. In very simple terms the **capacitor (C1)** is constantly *charging and discharging*. This causes **Pin 6 (the trigger)** to be tripped. This then turns **PIN 3 (the output) ON** and then **OFF** again. This process of turning **Pin 3 ON** and **OFF** will happen as long as power is supplied to the circuit. *This causes the LED light to blink*.

The speed that the LED light will blink is controlled by the interaction between the **resistors (R1 and R2)** and the **capacitor (C1)** in the circuit. Therefore, the rate that the light flashes can be controlled by changing any or all the values for **R1**, **R2**, and **C1**. Since changing values will affect the frequency that the LED will blink, electrical engineers are able to create a circuit with a specific **rate** / **frequency** using the 555 timer circuit. That is how long **T1 (Time High / ON)**, and **T2 (Time Low / OFF)**. The following formulas can be used to calculate the variables:

Parameter	Formula	Unit
T1 (Time High)	0.693 x (R1 + R2) X C1	Seconds (s)
T2 (Time Low)	0.693 x R2 x C1	Seconds (s)
T (Timer Period)	0.693 x (R1 + 2 x R2) x C1	Seconds (s)
F (Frequency)	1.44 / (R1 + 2 x R2) x C1	Hetz (Hz)
DC (Duty Cycle)	(T1 / T) x 100%	Percentage (%)

NOTE: *It might be difficult to produce an exact rate based on available resistor values; however, by using a* ***variable resistor*** *for R2 precise values can be dialled in. This allows the engineer to calibrate or even adjust the frequency as needed; therefore, new parameters can be set as needed after the fact. That is why this simple 555 timer circuit has been designed with a #103 variable resistor for R2 instead of a standard fixed value resistor.*

Tips and tricks for customizing your 555 timer circuit:

- **T (Period Time)** and F **(Frequency)** are inversely proportional;
- Increasing **C1** will decrease the **F (Frequency)**
- Increasing **R1** will increase **T1 (High Time)** but will not alter **T2 (Low Time)**
- Increasing **R2** will increase both **T1 (High Time)** and **T2 (Low Time)**
- Increasing **R2** will decrease **DC (Duty Cycle**

Example Calculations:

In the provided simple 555 circuit diagram the value of resistors **R1 is 1K**, the value for **R2 can go up to10K**, and the value of capacitor **C1 is 100uf**.

R1 = 1,000 Ohms   R2 = 10 ~ 10,000 Ohms   C1 = .0001 Farads

T1 (Time High) is the amount of time during which the pulse stays high (5V) in the output wave. This can be calculated as:

T1 = 0.693 × (R1+R2) × C1
= 0.693 × (1,000 +10,000) × 0.0001
= 0.693 x (11,000) x 0.0001
= 0.693 x 1.1
= 0.762 seconds
= 762 milliseconds

T2 (Time Low) is the amount of time during which the pulse stays low(0v) in the output wave. It can be calculated as:

T2 = 0.693 × R2 × C1
= 0.693 × 10,000 × 0.0001
= 0.693 x 1
= 0.693 seconds
= 693 milliseconds

T (Time Period) is the sum of Time low and Time high and can be calculates as:

T = 0.693 × (R1 + 2 x R2) x C1
= 0.693 x (1,000 + 2 x 10,000) x 0.0001
= 0.693 x (1,000 + 20,000) x 0.0001
= 0.693 x (21,000) x 0.0001
= 0.693 x 2.1
= 1.455 seconds

Or = T1 + T2
= .762 + .693
= 1.455 seconds

F (frequency) is just the inverse of time. The frequency can be calculated as:

F = 1.44 / (R1+2×R2) × C1
= 1.44 / (1,000 + 2 x 10,000) x 0.0001
= 1.44 / 2.1
= 0.686 Hertz

Or = 1/T
= 1 / 1.445
= .692 Hertz

NOTE: *T1 andT2 have been rounded in previous steps which may result in a slight discrepancy in the answers.*

DC (Duty Cycle) is given in terms of percentage, if T1 is equal to T2 then the pulse has 50%. We can calculate the duty cycle as.

DC = (T1 / T) x 100%
= (0.762 / 1.455) x 100%
= 52.3%