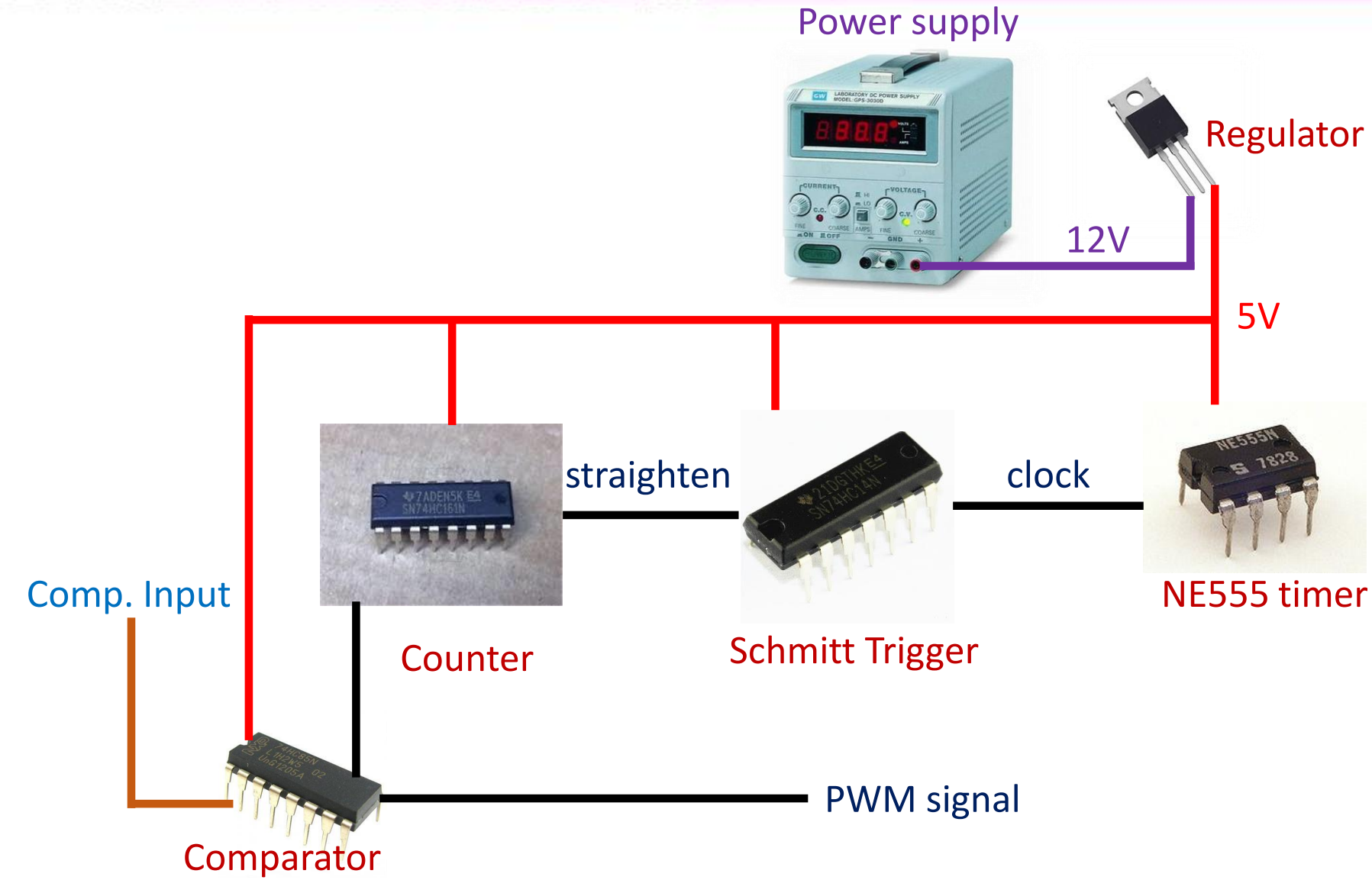
ELEC1100 - Tutorial 3

Pulse and PWM Control

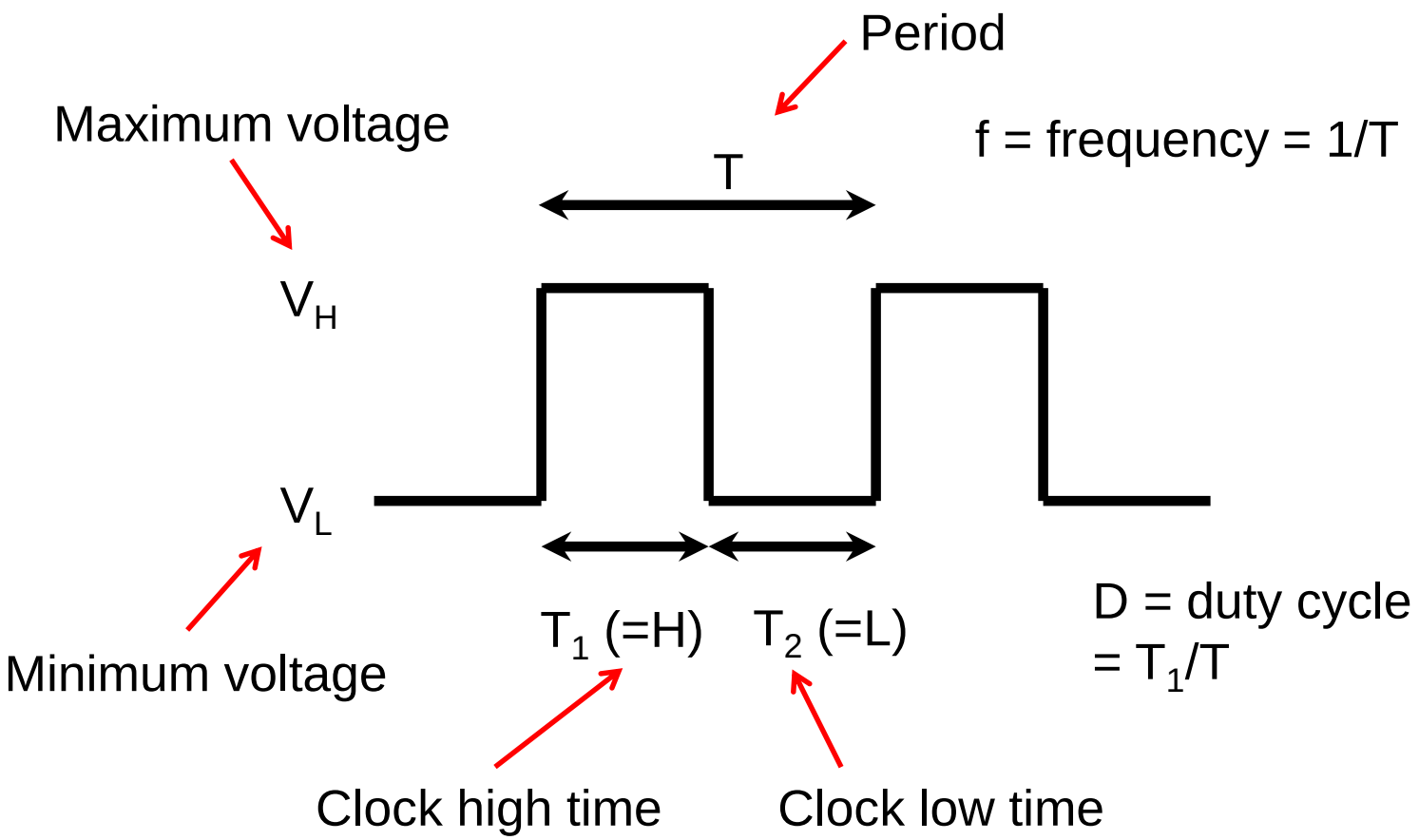
Introduction to Lab#03

Preview – what's at physical lab



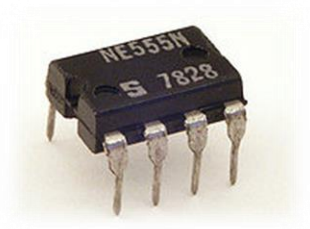
Pulse Signal

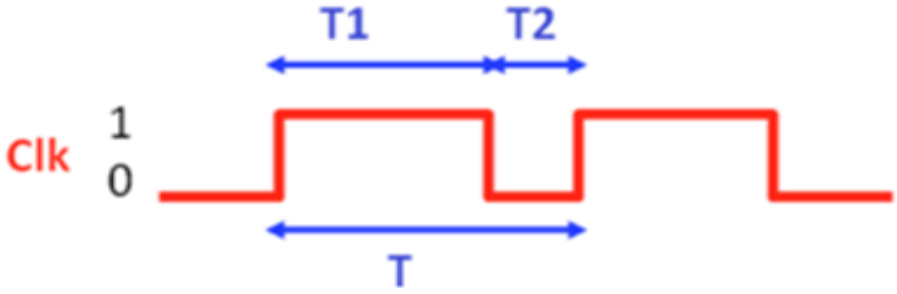
- **A rectangular pulse looks like this.**

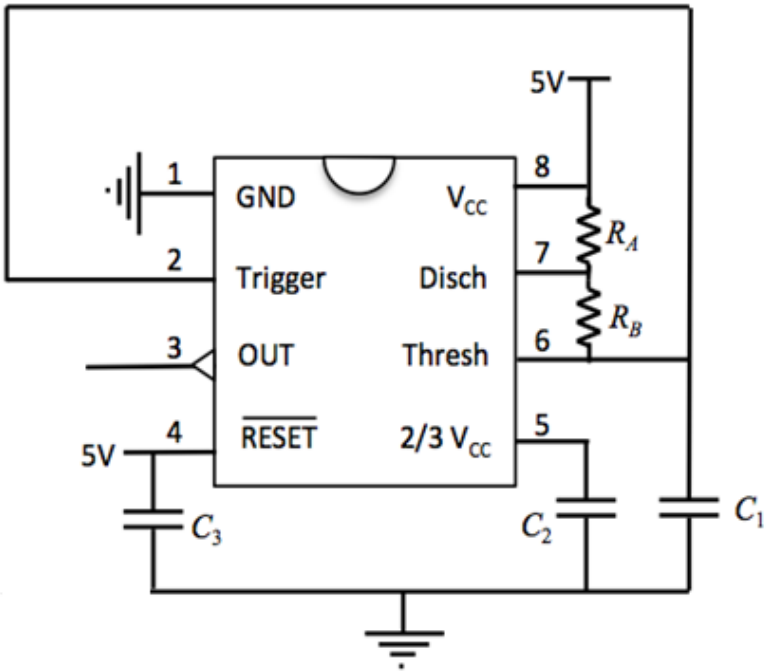


NE555 Timer Circuit

❖ **This is a NE555 timer. Equations given.**







$$\mathbf{T1} = 0.7\,(R_A + R_B)\,C_1$$

$$\mathbf{T2} = 0.7\,(R_B)\,C_1$$

$$\mathbf{T} = 0.7\,(R_A + 2R_B)\,C_1$$

Observation:

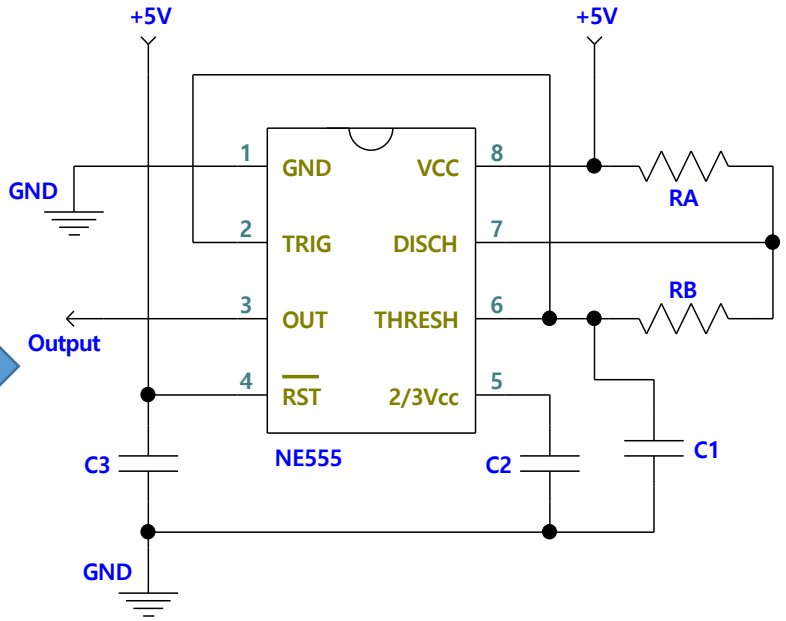
Duty Cycle ≥ 50%

NE555 Timer Circuit

Lab#03: Simulation 2

R_A = 30kΩ R_B = 10kΩ

$C_1 = C_2 = C_3$ = 0.1μF



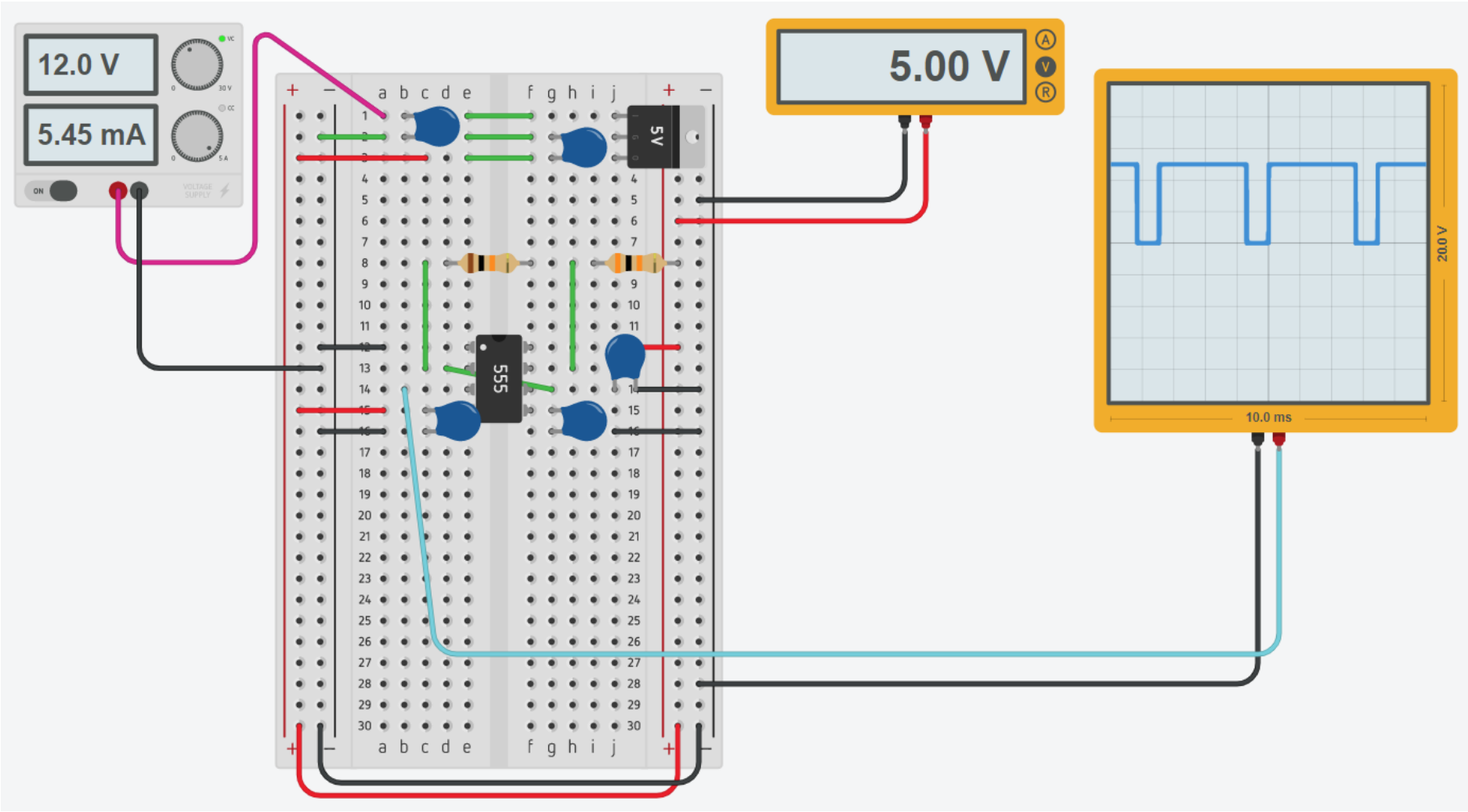
Frequency = ? Duty cycle = ?

$$\text{Frequency} = \frac{1}{T} = \frac{1}{0.7(R_A+2R_B)C_1} \approx 286\text{Hz}$$

$$\text{Duty cycle} = \frac{R_A+R_B}{R_A+2R_B} = 80\%$$

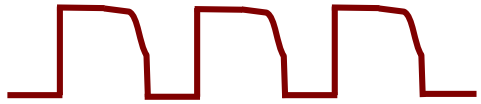
In Tinkercad

Lab#03: Simulation 2

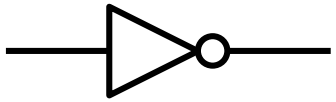


Schmitt Trigger 74HC14

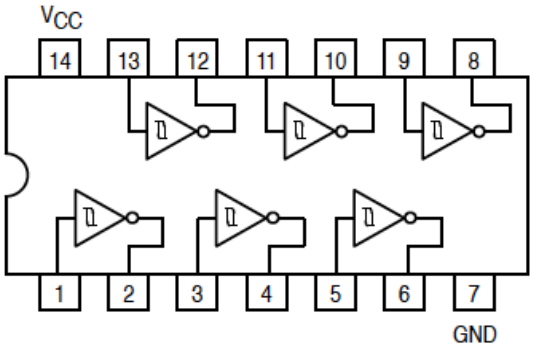
Practical output of timer:



Solution: Schmitt Trigger. Straighten up the pulse



- ✓ There are 6 Schmitt Triggers and you only need to use one 14 pins, 6 pairs
- ✓ The V_{CC} (positive supply) and GND has to be connected to power for proper function 1, 2, 7, 14



+

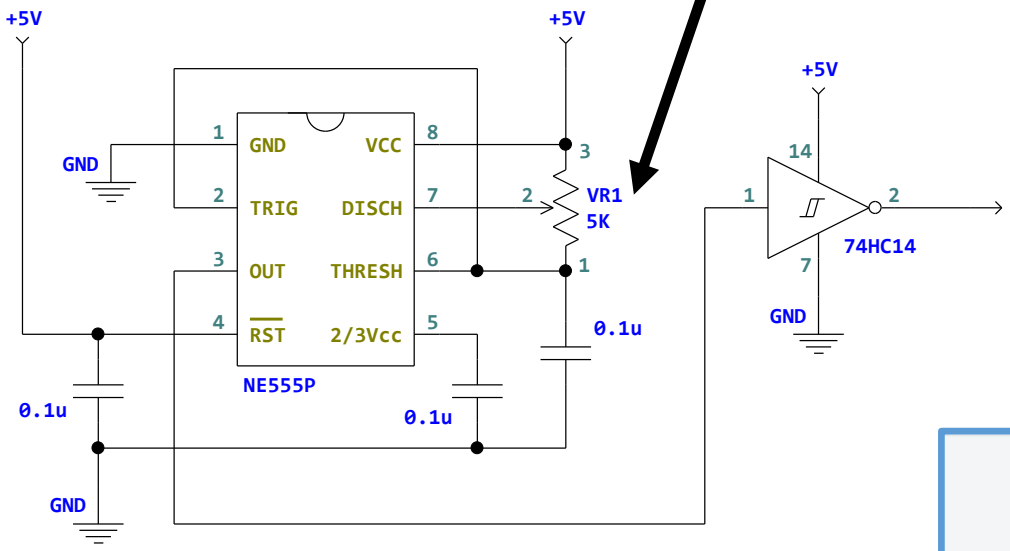
=

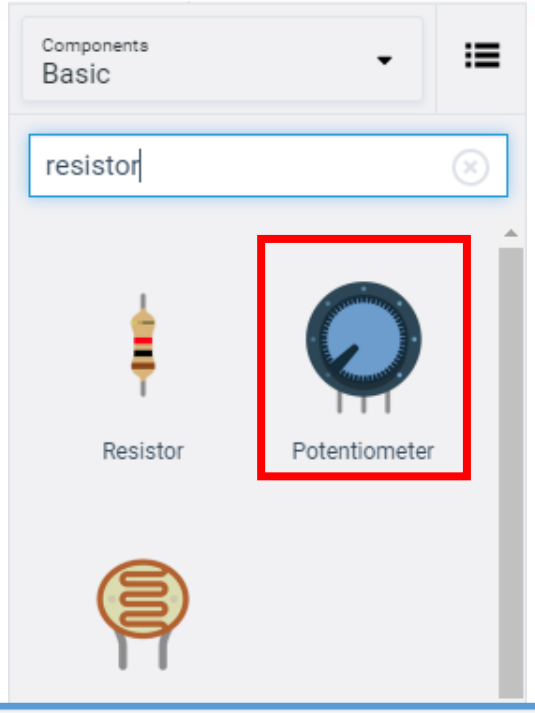
****The output is inverted**

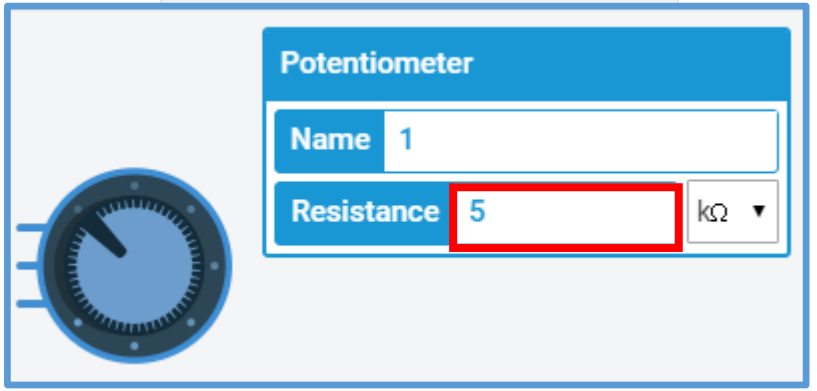
NE555 + 74HC14

Lab#03: Simulation 3

Use a variable resistor to replace R_A and R_B

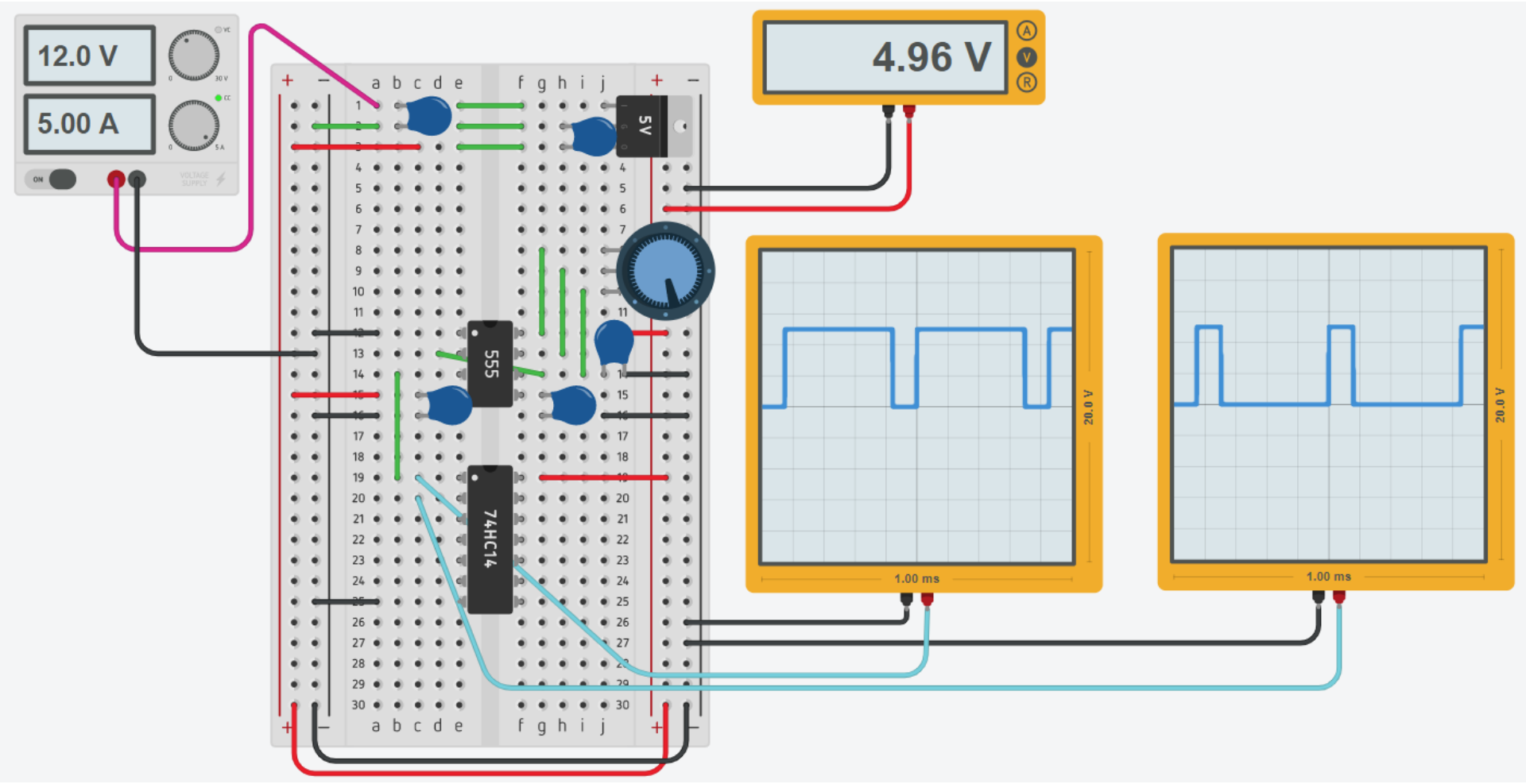






In Tinkercad

Lab#03: Simulation 3



PWM Insight

❖ Let's say you use a pulse to drive a motor

- By changing resistances, we can form pulses with variable duty cycles => adjust motor speed
- But we can't change the hardware while the motor is moving!
- We need a way to change the duty cycle without modifying the hardware
  - The change will be determined by the circuit itself

HOW?

74HC161 & 74HC85

❖ 74HC161 4-bit Binary Counter

- It does this:

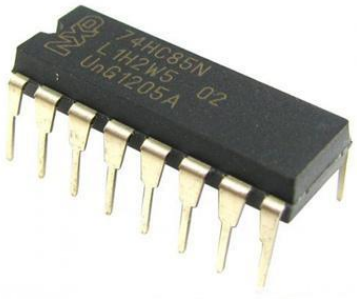
Input

Output 1 2 3 4 5 6 7 8 9 10 11 Counting!

Note: Output are in binary, i.e. 9 →1001

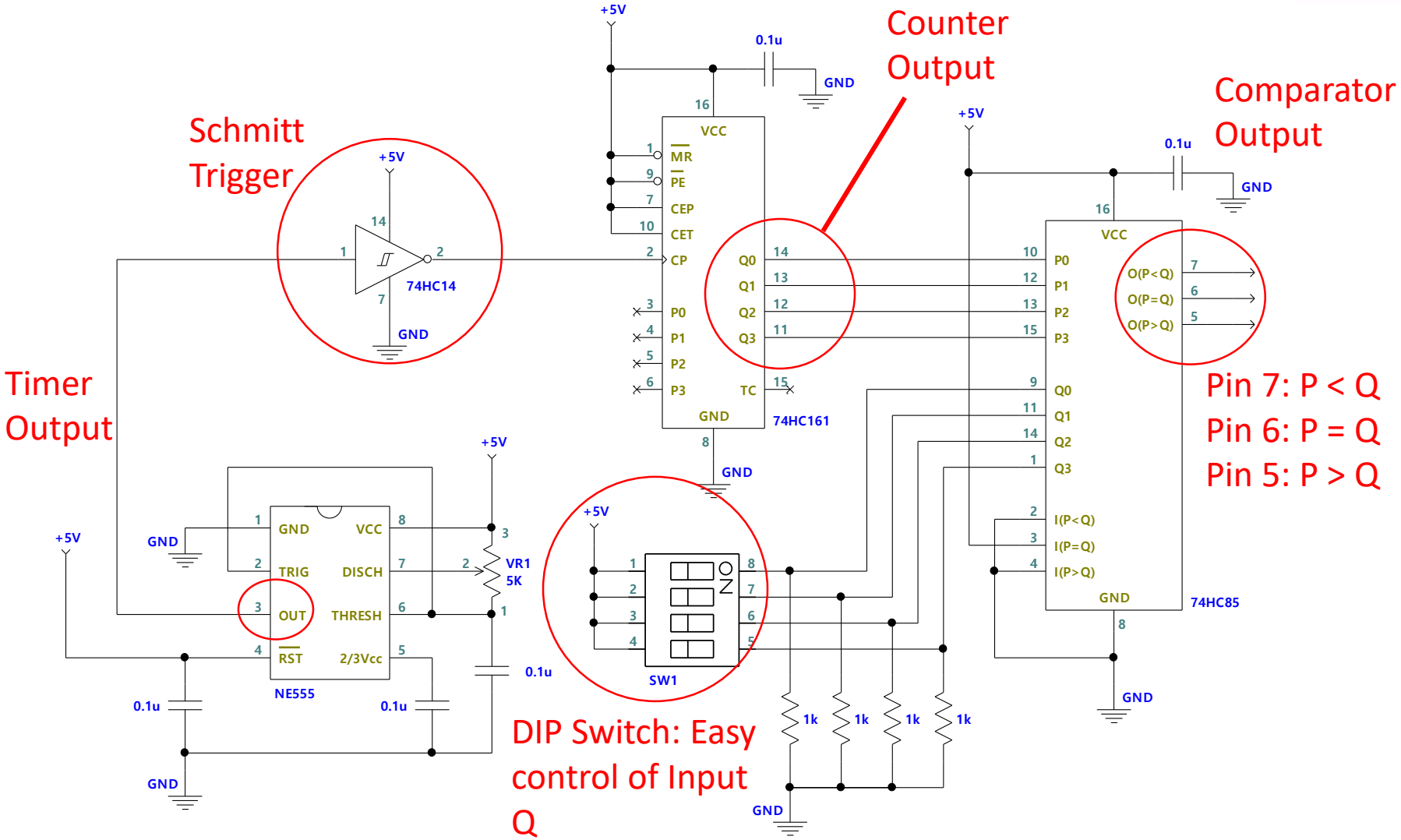
❖ 74HC85 4-bit Comparator

- Compares two inputs and output:
- “<“, “=”, “>“



By combining these devices, we can change the duty cycle

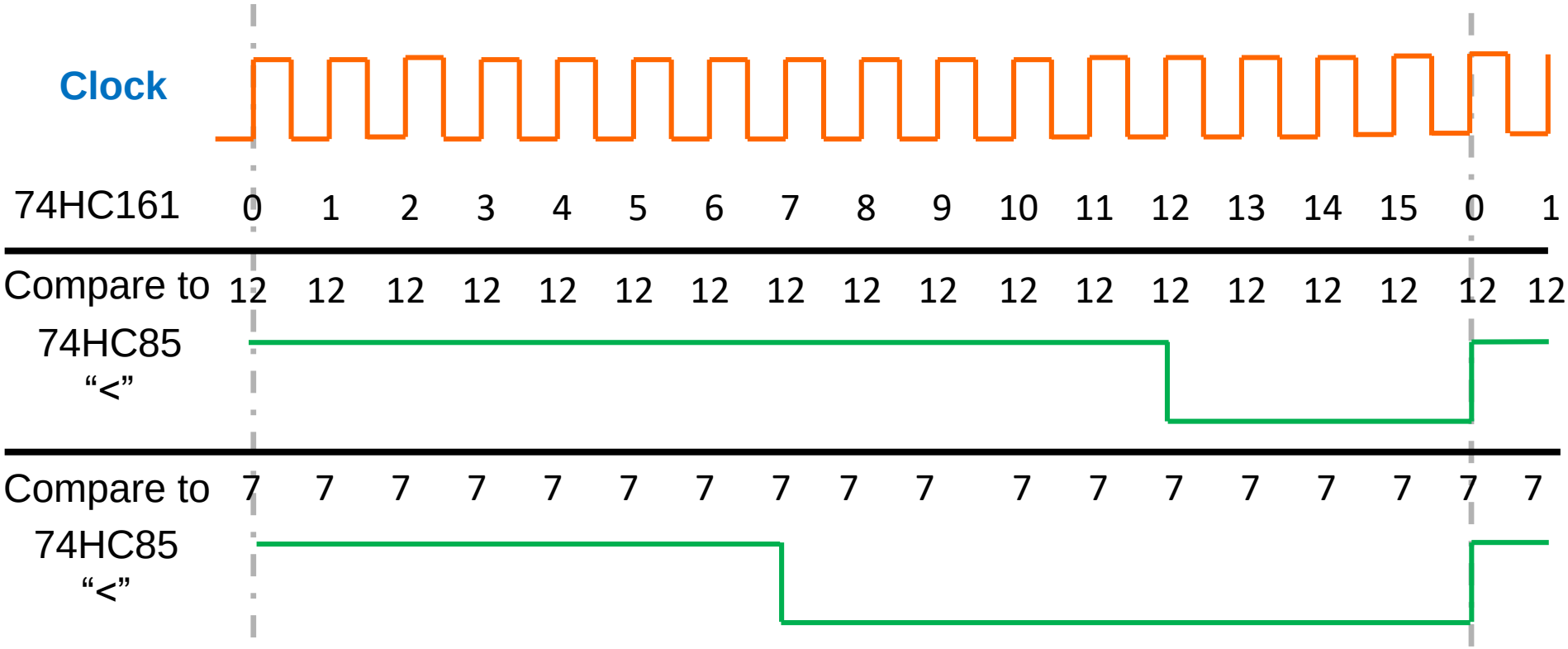
Schematic


Schmitt Trigger
Counter Output
Comparator Output
Timer Output
Pin 7: P < Q
Pin 6: P = Q
Pin 5: P > Q
DIP Switch: Easy control of Input Q
+5V
GND
0.1u
74HC14
74HC161
74HC85
NE555
SW1
VR1
5K
1k
VCC
MR
PE
CEP
CET
CP
P0
P1
P2
P3
Q0
Q1
Q2
Q3
TC
GND
TRIG
OUT
RST
DISCH
THRESH
2/3Vcc
O(P<Q)
O(P=Q)
O(P>Q)
I(P<Q)
I(P=Q)
I(P>Q)

PWM Signal

- **Use the counter to count, then use the comparator to determine the duty cycle**

  Q: Frequency = ?



Example

❖ Suppose we use PWM to control motor

- Pin 7 (P < Q) of comparator is 100Hz
- Duty cycle = 0.75

Q1: Manual input Q = ? $0.75 \times 16 = 12 \rightarrow 1\ 1\ 0\ 0$

Q2: Period of NE555 timer? $1 / (100 \times 16) = 625\mu s$

Q3: Given C1 = 0.1μF, what are the theoretical resistance values of the two parts of 5kΩ variable resistor RA and RB ?

$$T = 1/1600 = 0.7(R_A + 2R_B)\, C_1 \rightarrow R_A + 2R_B = 8929\Omega \quad (1)$$

(Given the variable resistance 5kΩ) $R_A + R_B = 5000\ \Omega \quad (2)$

$$\rightarrow R_A = 1071\Omega,\ R_B = 3929\Omega$$

Notes

- In Lab#03, we will construct NE555 Timer and 74HC14 Schmitt Trigger circuits (online version).
- For 74HC161 counter and 74HC85 comparator circuits, we only study on how to use them to generate the PWM signal at theory level.
- We will use Arduino board to generate the PWM signal in your project.