Tutorial 3

PWM

Power supply

Regulator

12V

5V

straighten

clock

Counter

Schmitt Trigger

NE555 timer

Comp. Input

Comparator

PWM signal

Let's review

- Generate a 1kHz pulse with duty cycle 70%.

Choose $C_1 = 0.1\mu F$

$T_2 = (1/1k) \times 30\% = 0.3ms$
$T_2 = 0.7(R_B)C_1 = 0.3ms$
$\rightarrow R_B = 4.3k\Omega$

$T_1 = (1/1k) \times 70\% = 0.7ms$
$T_1 = 0.7(R_A + R_B)C_1 = 0.7ms$
$\rightarrow R_A = 5.7k\Omega$

Choosing other C_1 will result in other resistor values which are valid too

$T1 = 0.7 (R_A + R_B) C_1$

$T2 = 0.7 (R_B) C_1$

$T = 0.7 (R_A + 2R_B) C_1$

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
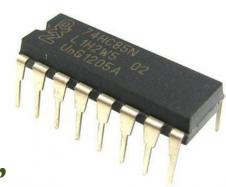- HOW?

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
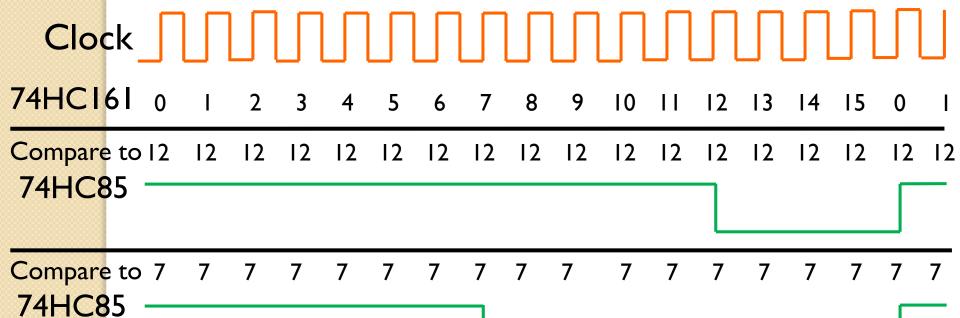
- ## 74HC85 4-bit Comparator

  ◦ Compares two inputs and output:
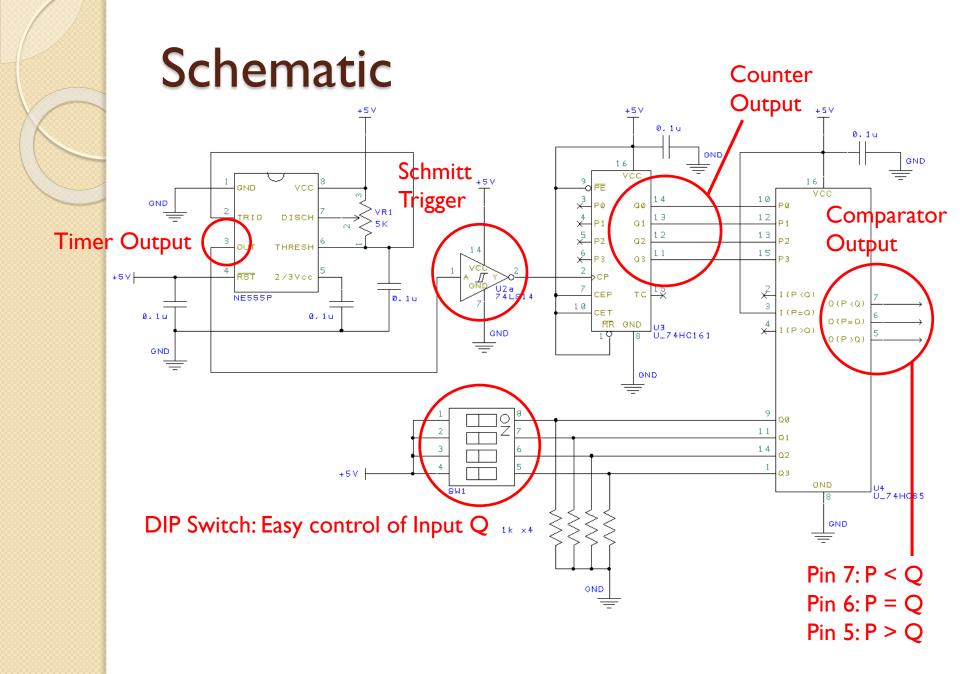
  ◦ "<", "=", ">"

  By combining these devices, we can change the duty cycle

Insight

- Use the counter to count, then use the comparator to determine the duty cycle
  - Q: Frequency = ?   1/16 !!

Clock																		
74HC161	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	0	1

Compare to	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

74HC85

Compare to	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

74HC85

Schematic

Counter Output

Schmitt Trigger

Timer Output

Comparator Output

DIP Switch: Easy control of Input Q

Pin 7: P < Q
Pin 6: P = Q
Pin 5: P > Q

Example 1

- 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 × 16 = 12 → 1 1 0 0

Q2: Period of NE555 timer?　　1 / (100 × 16) = 625μs

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

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

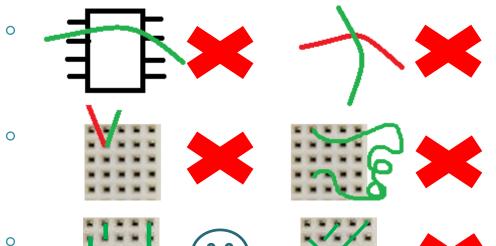(Given the variable resistance 5kΩ)　$R_A + R_B = 5000\ \Omega$ (2)

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

Breadboard time!

General rules:

- **Power supply**, **Ground**

Floor-planning makes your lab much easier

5V
0V

12V

555

14

161

85

DIP

DIP Switch