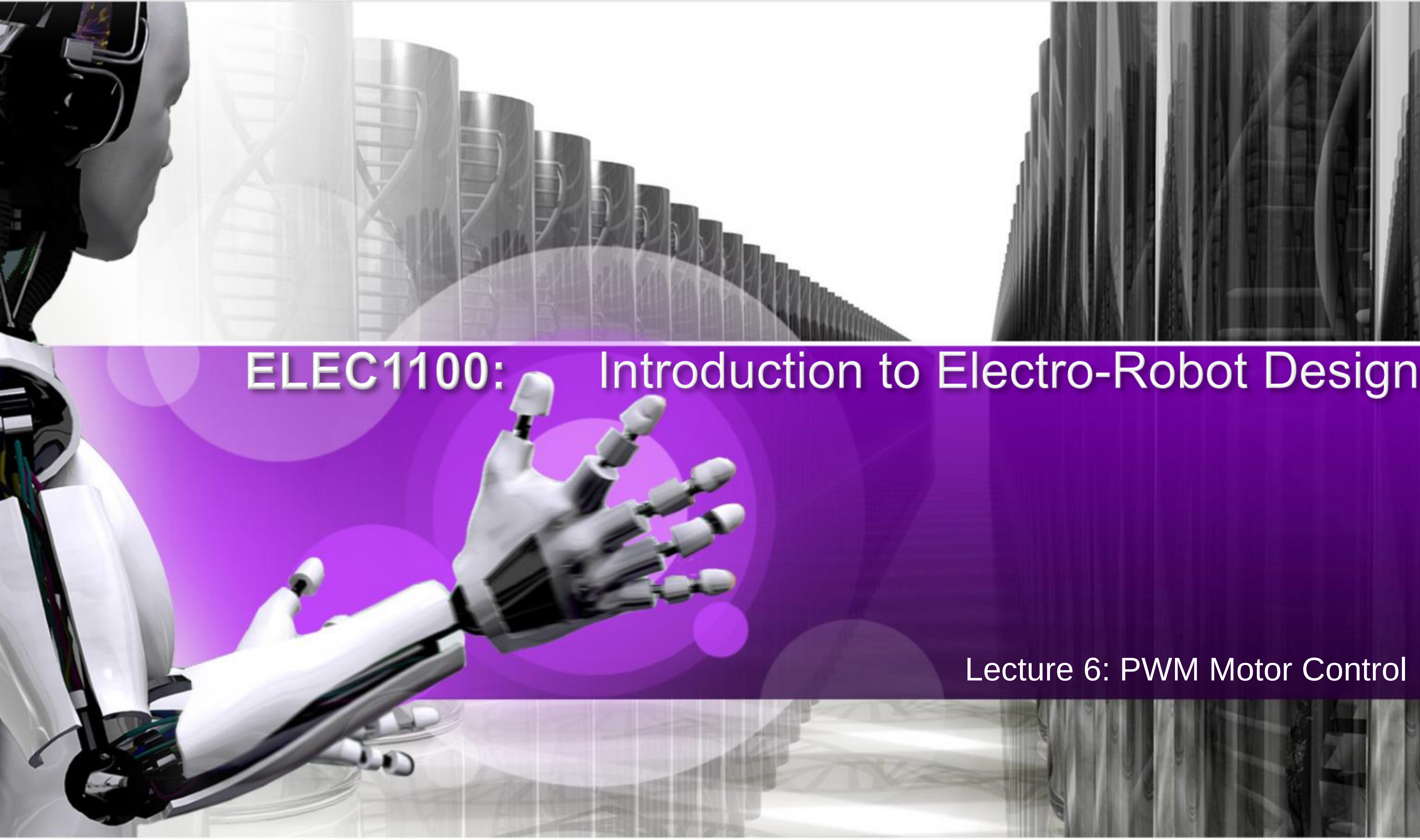

ELEC1100: Introduction to Electro-Robot Design

Lecture 6: PWM Motor Control

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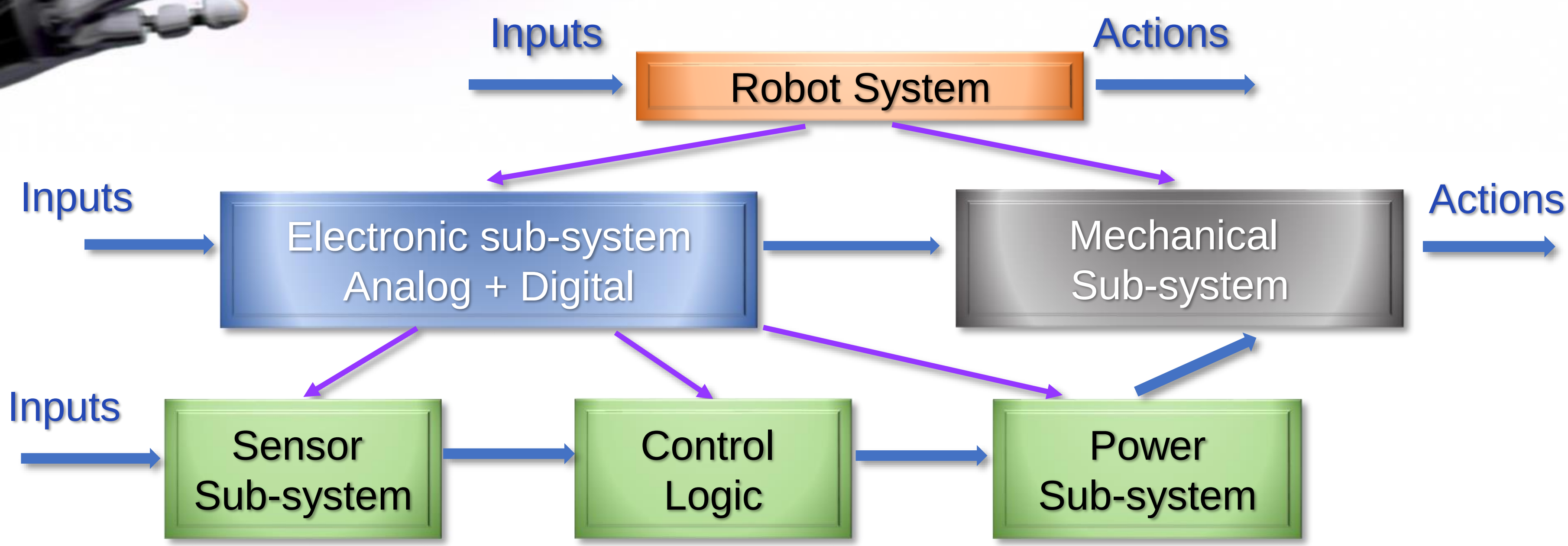
ELEC1100 ROADMAP



Basic electronics:

Wk1: Basic Electronics - Charge/Current/Voltage/Resistor

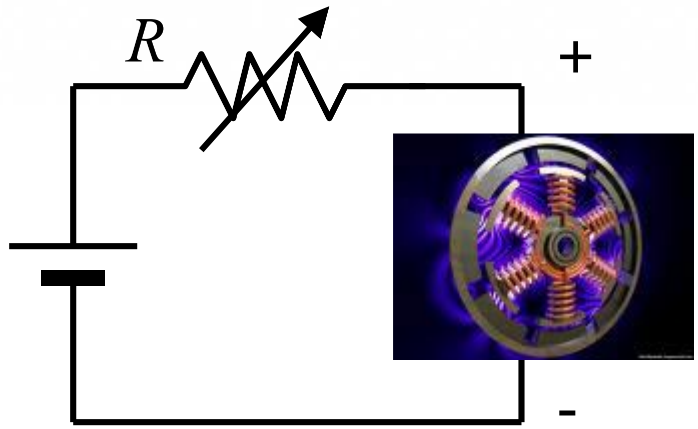
Wk2: Energy/Power and DC Sources

Motor Power Supply:

Wk3: Pulse Signal and PWM Control

LAST LECTURE: GENERIC MOTOR SPEED CONTROL

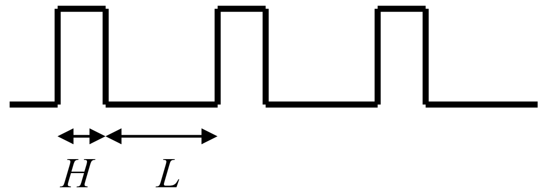
- ❖ Higher voltage leads to larger current, higher power and faster rotation
- ❖ Different voltages can be obtained by using a variable resistor



- ❖ Disadvantages:
  - ➢ It is not efficient- energy is wasted as heat in the variable resistor particularly at low speeds.
  - ➢ It is difficult to control the speed precisely
  - ➢ Need mechanical motion to tune the resistor and not computer friendly

PULSE WIDTH MODULATION (PWM)

❖ Turning the motor on/off quickly and repeatedly



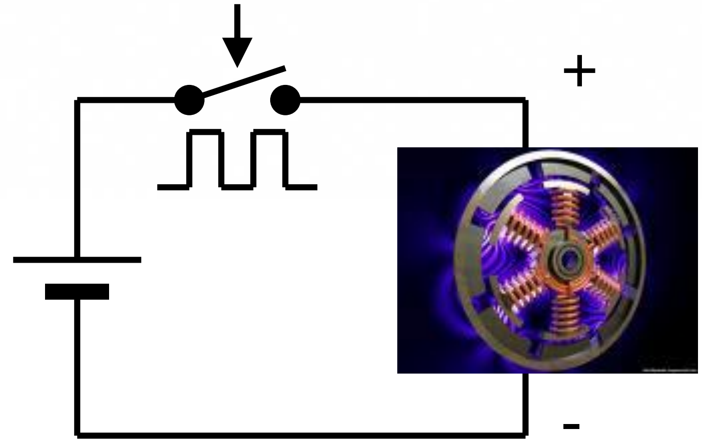
Period = $H + L$

Duty cycle = $\frac{H}{H+L}$

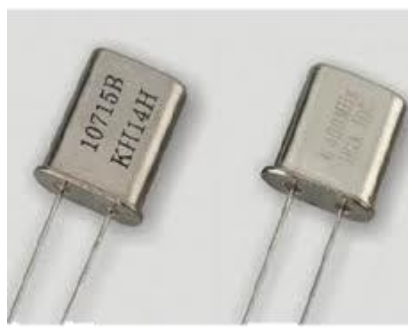
❖ By adjusting the duty cycle, the speed of the motor can be controlled

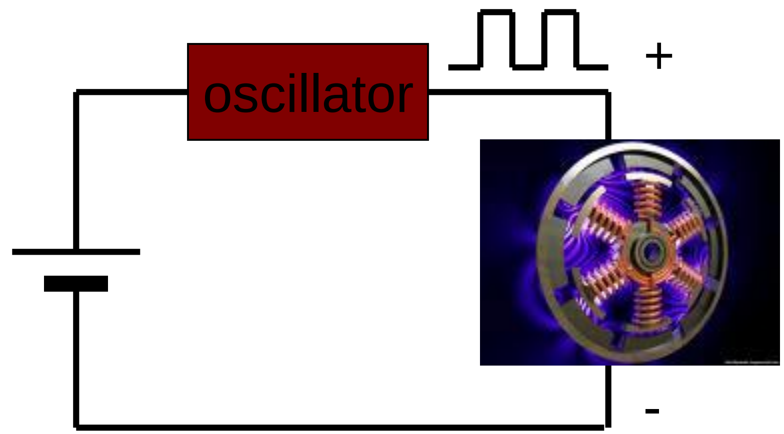
GENERATING PULSES

- By mechanically pressing a switch quickly



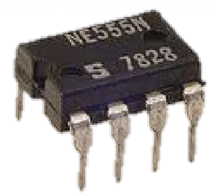
- By electrical means using an oscillator

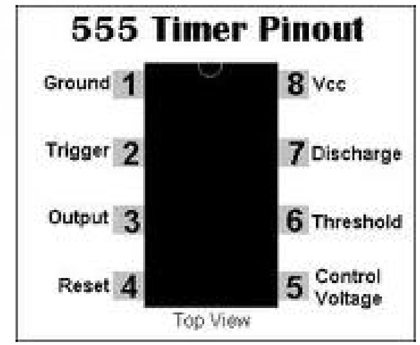




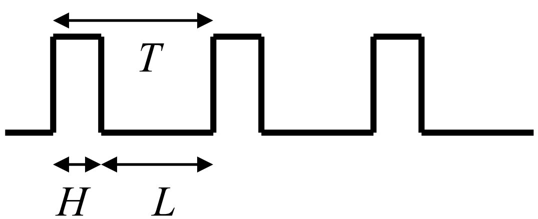
555 TIMER

- Oscillators can also be constructed using a 555 Timer IC (will be used in your project)





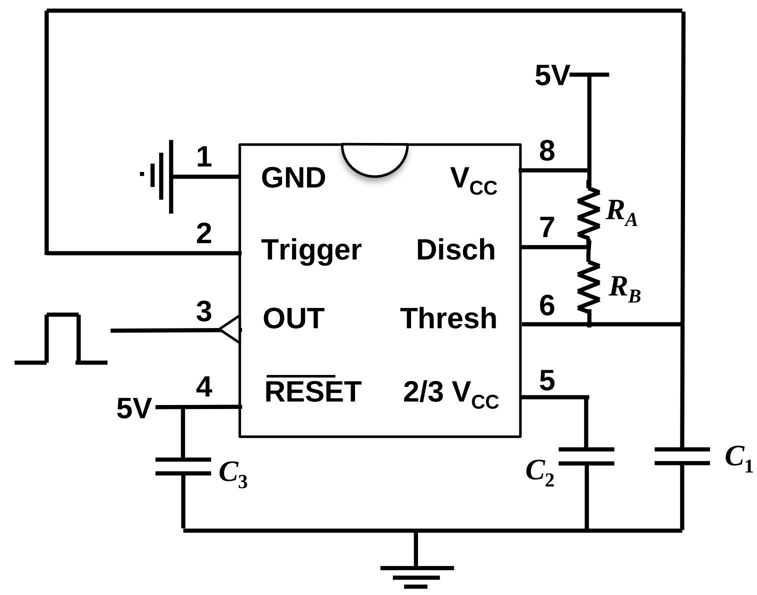
- The frequency of this clock signal depends on the values of R_A, R_B and C_1 according to the formulas below



$$H = 0.7\left(R_A + R_B\right)C_1$$

$$L = 0.7R_BC_1$$

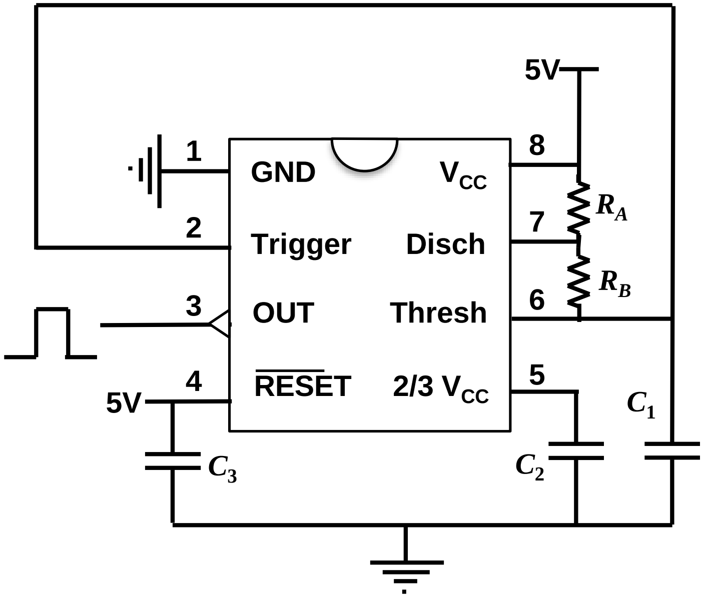
$$T = H + L = 0.7\left(R_A + 2R_B\right)C_1$$



PWM CONTROL WITH NE555

- Controlling the pulse width with R_A, R_B and C_1 also requires mechanical intervention

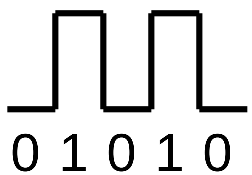
- Analog control also difficult to obtain the required speed precisely



- We will develop a method to control the pulse width digitally

BINARY NUMBERS

- Decimal number system – base 10, each digital is coming from the set {0,1,2,3,4,5,6,7,8,9}
- Binary number system – base 2, each digit is selected from the set {0,1}
- Why do we use a binary system?

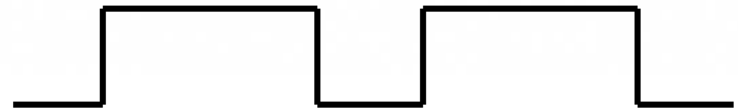


  - It can be represented by two voltage levels

Base 10	Base 2
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010

PULSE AND BINARY REPRESENTATION

- You may use pulses to transmit binary numbers … but



Is it 0 1 0 1 0

or 0 0 1 1 0 0 1 1 0 0

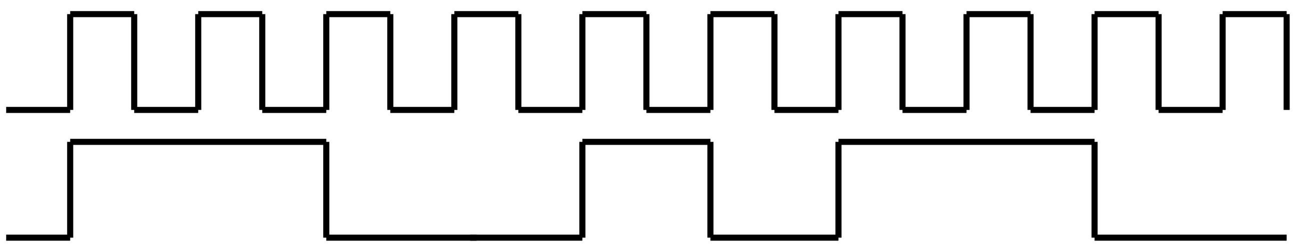
Is it 0 1 1 0 1 1 0

or 0 0 1 1 1 1 0 0 1 1 1 1 0 0

- A synchronization signal called a “clock” is needed

Clock

Data



Number 1 1 0 0 1 0 1 1 0 0

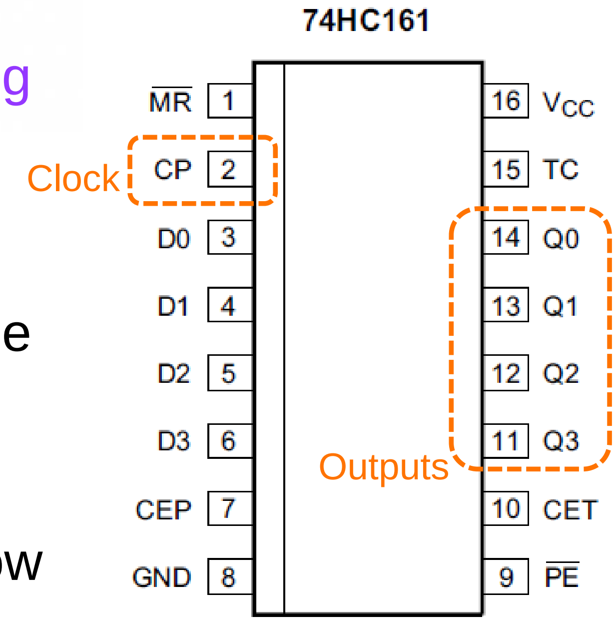
Q: how can you transmit more bits in the same time slot?

CLOCK

- A **clock** is a series of pulses transmitted at constant frequency for synchronization
- Clock speed usually represents the fastest rate data that can be handled or transmitted
- Most electronic systems require clocks
- Example: Intel Core i7 3.4GHz Quad-Core represents the fastest signal is at 3.4GHz (or 3,400,000,000 pulses per second)

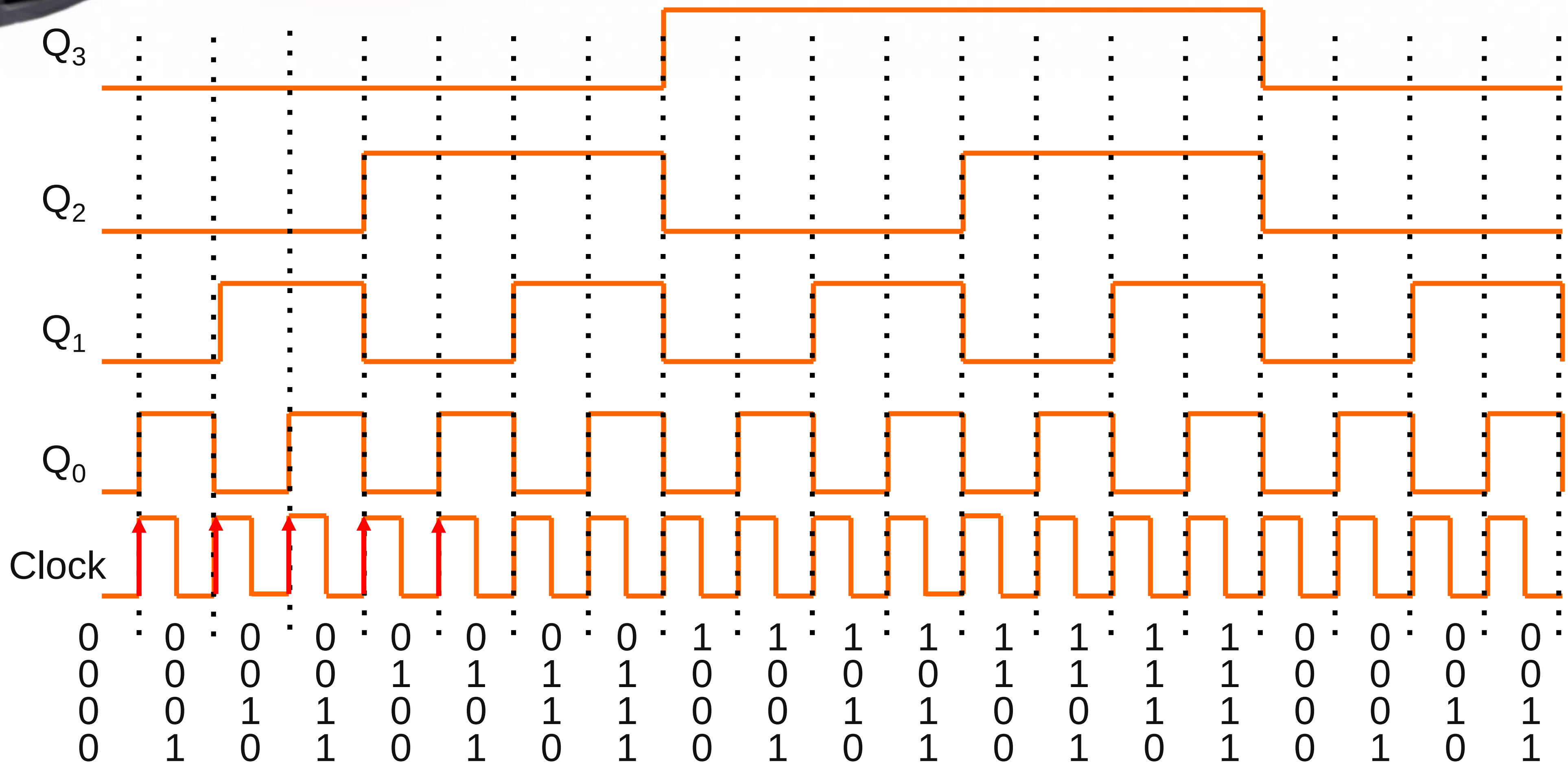
COUNTER (74HC161)

- A counter is an IC that counts the number of rising edges of input clock (for example, 74HC161)
- Its output is a binary number $Q_3Q_2Q_1Q_0$
- Binary number consists of only "0" and "1" and the equivalent decimal number is given below
- In circuit, "1" represents high and "0" represent low



Dec	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bin	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111

OUTPUTS OF 74HC161



BIT VALUE IN BINARY NUMBER

- Digit value in decimal number

  … x x x x x

  … 10^4 10^3 10^2 10^1 10^0

- Digit value in binary number

  … x x x x x

  … 2^4 2^3 2^2 2^1 2^0

  … 16 8 4 2 1

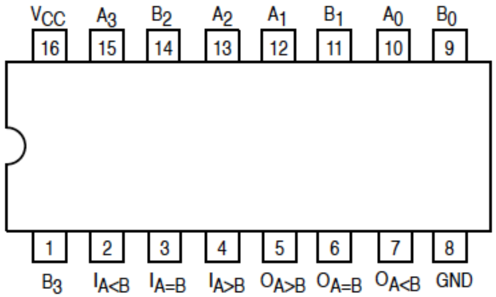
- For n binary digits, in total it can represent 2^n numbers, the largest number is 2^n-1

Q: For 74HC161, the 4-bit binary counter, what is the largest number it can output?

Answer: $2^4 – 1 = 15$ ($Q_3Q_2Q_1Q_0 = 1111$)

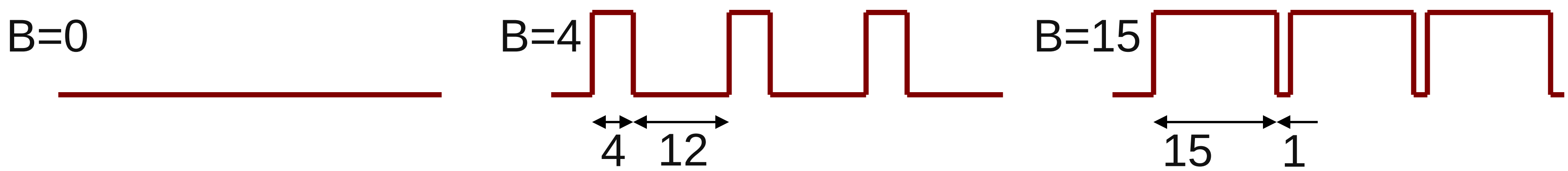
COMPARATOR (74HC85)

- A comparator compares 2 binary numbers A ($=A_3A_2A_1A_0$) and B ($=B_3B_2B_1B_0$)



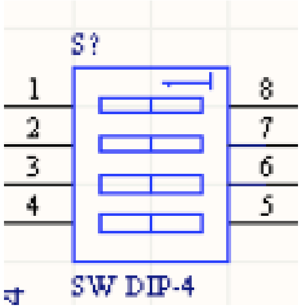
- If A < B, the pin A<B will go high and so on
- Suppose the number A comes from the counter 74HC161 and starting from 0000
- By inputting a fixed number to B, we can control the duty cycle at output of A < B

$O_{A<B}$ output



INPUTING TO THE COMPARATOR

❖ The input to the B value of 74HC85 is done by a dip switch to either connect it to ground or power supply

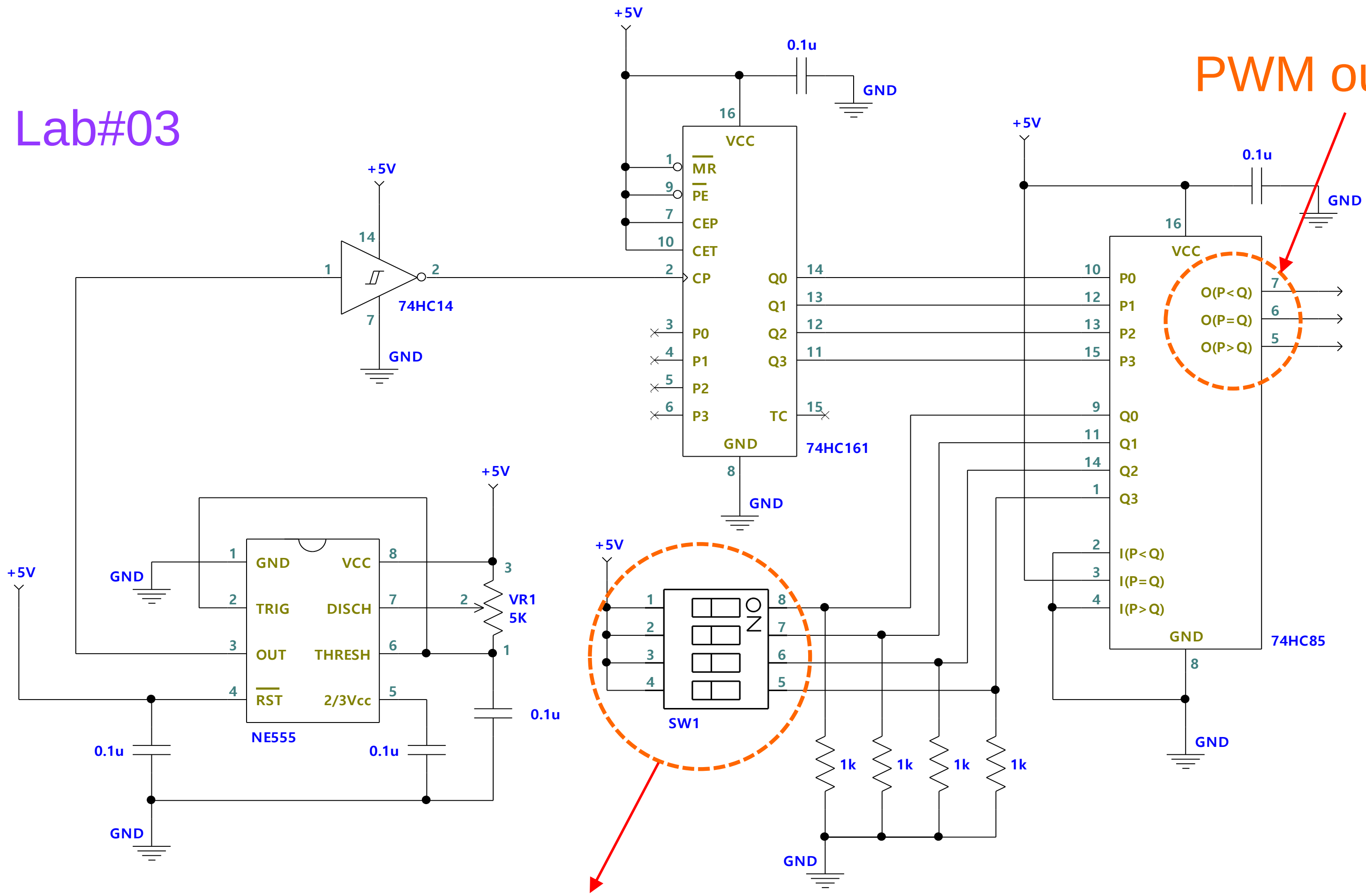


❖ Now you have a vague idea of the method to control pulse width (which you will do in Lab#03)

❖ It is time to put everything together

PUTTING EVERYTHING TOGETHER

❖ In your Lab#03

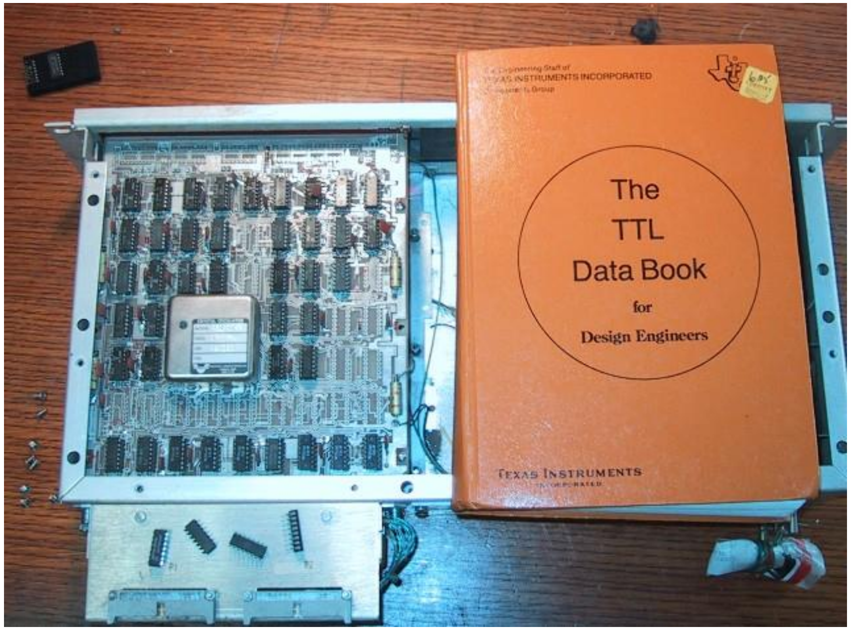


PWM outputs

Dip switch to control the value of 74HC85 input

THE TTL IC (7400 SERIES)

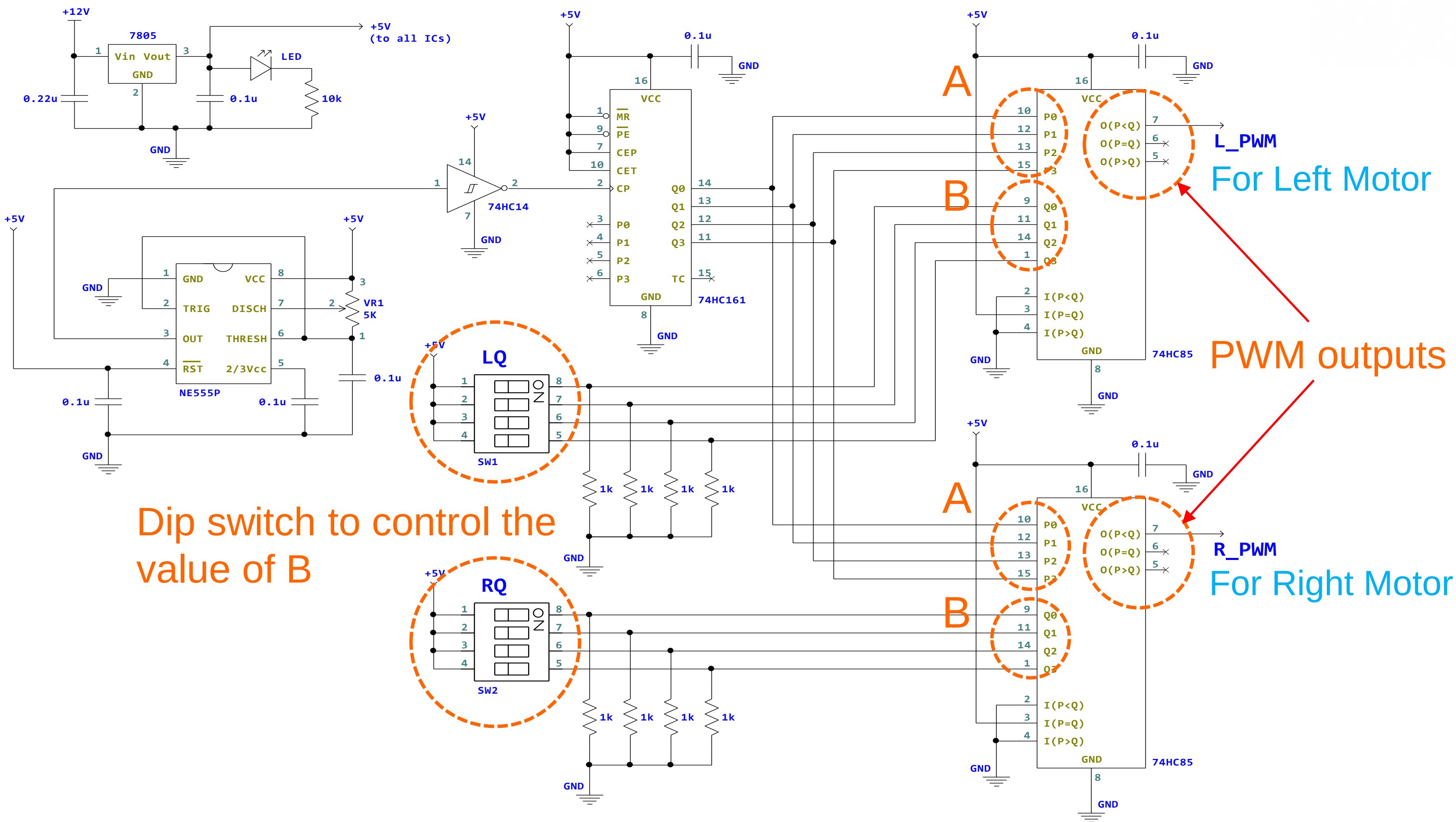
- The most widely used series to provide various functions to handle digital pulses
- Mainly developed by Texas Instruments (TI) with many compatible parts from AMD, Fairchild, Intel, Intersil, etc.



- Number with 74*xx*, 74L*xx*, 74H*xx*, 74S*xx*, 74LS*xx*
- Functionality can be easily found from the internet

TWO MOTORS FOR YOUR CAR

❖ You are going to construct the following circuit in Lab#04



LECTURE SUMMARY

- Even though the circuit diagram is a bit complicated, the final circuit is not that difficult to construct.
- Be patient and work carefully, you will be able to get the circuit working.
- Arrange your breadboard nicely for the future labs.

NEXT LECTURE

- Transistors and switches

QUESTIONS?