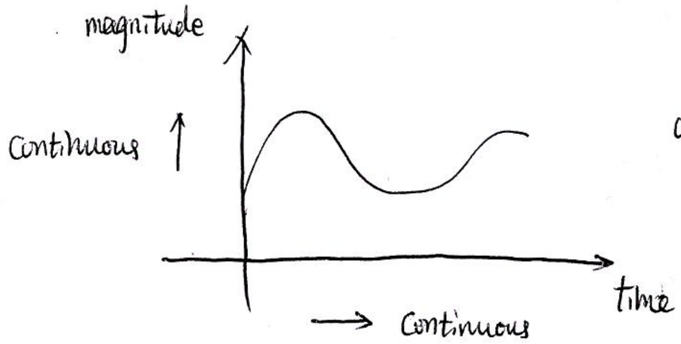
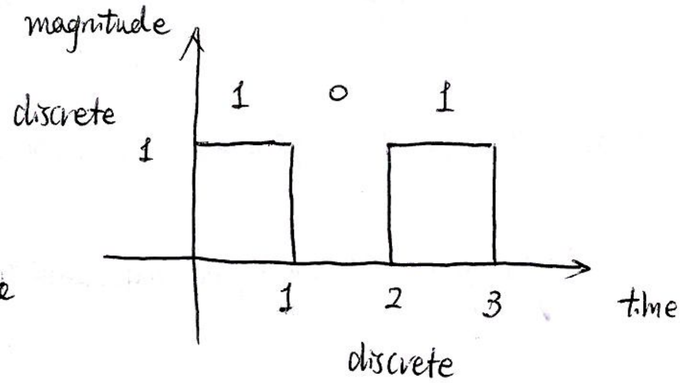
L6 PWM motor Control

We have known that we can control the power provided to a motor by a pulse signal by changing the duty-cycle. This is called Pulse Width Modulation (PWM). However, the signal by the NE555 IC is not digitally controlled. Today, we will solve this problem.

1. Analog vs. digital.

Almost all modern electronic devices process digital signals. What is a digital signal? A digital signal is different from an analog signal in the sense that it is discrete in both time and magnitude domain. For example,





2. Then, which "number" system fits digital signal?

We use decimal system in daily life. But, why? $\{0, 1, 2, \cdots 9\}$

However, binary number system $\{0, 1\}$ fits digital system, because

1. it is easy to be represented by two levels of voltage
2. it is computation is easier to be implemented (Discuss later).

Decimal 0 1 2 3 - - - - - -

$\updownarrow$

Binary 0000 0001 0010 0010 - - - - - -

The digital value is determined similarly to that in decimal number.

Decimal number : $a_1 a_2 a_3 a_4 = a_1 \times 10^3 + a_2 \times 10^2 + a_3 \times 10 + a_4 \times 10^0$

Binary 〃 : $b_1 b_2 b_3 b_4 = b_1 \times 2^3 + b_2 \times 2^2 + b_3 \times 2 + b_4 \times 2^0$

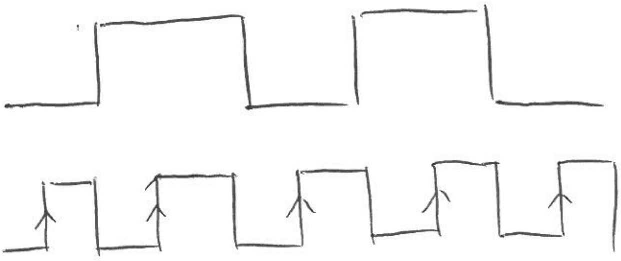
3. How do we represent binary number by signals ?

0 1 0 1 0

which one ?

00 11 00 11 00

For this purpose, a synchronization signal is needed. We call it "clock".



$\uparrow \quad \uparrow \quad \uparrow \quad \uparrow \quad \uparrow$

0 1 0 1 0 .

A clock is a series of pulses transmitted at a constant frequency for synchronization purpose.

$\Longrightarrow$ clock speed will determine the fastest data rate.

Intel Core i7 3.4G $\longrightarrow$ 3.4×10^9 pulses/sec.

4. Digitally controlled PWM signal.

Now, let's see how we can digitally control the duty-cycle of a clock.

1) We already know that NE555 can generate a pulse signal. (not digitally controlled)

2) Now, we introduce two more ICs.

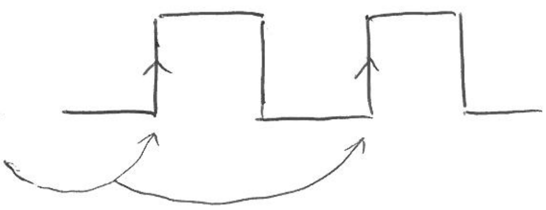
a. Counter (74HC161)

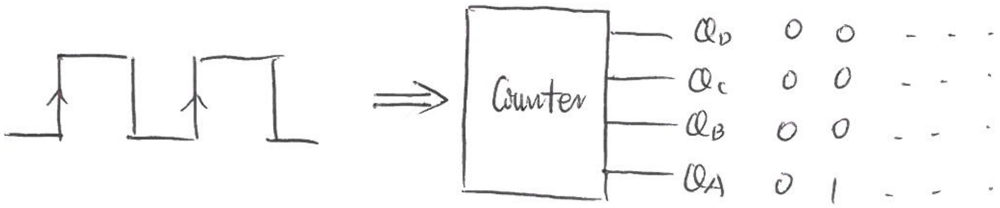
Function : Count the # of rising edges of the input clock.

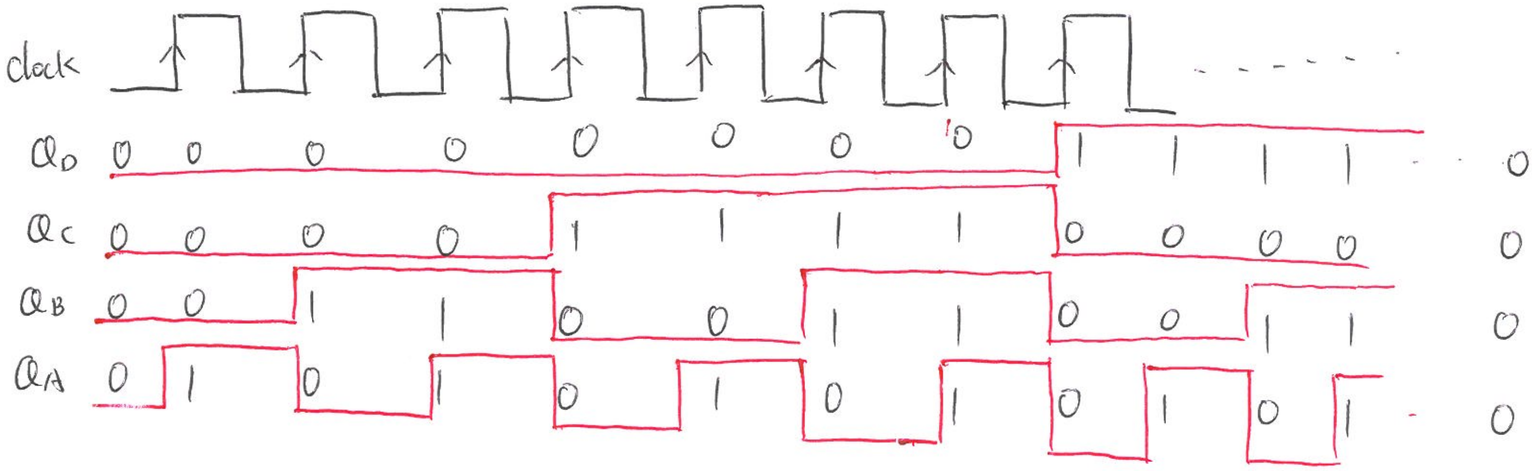
Input : clock

output : # of rising edges in binary form $Q_D\, Q_C\, Q_B\, Q_A$

rising edge







Remarks ① Let $f_{clock}, f_A, f_B, f_C, f_D$ denote the frequency of the clock, Q_A Q_B, Q_C Q_D.

Then, $f_A = \frac{1}{2} f_{clock}$ ⟶ Counting rising edge.

$f_B = \frac{1}{2} f_A$

$f_C = \frac{1}{2} f_B$

$f_D = \frac{1}{2} f_C$

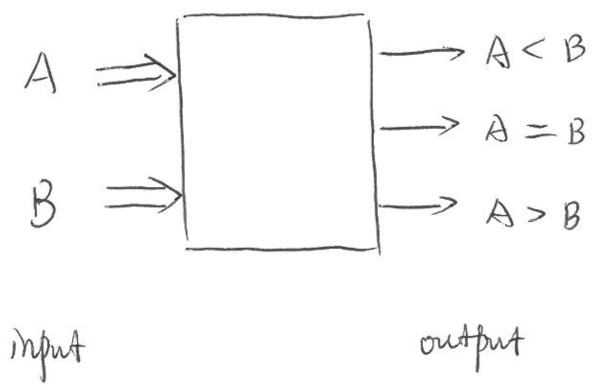
② $Q_D Q_C Q_B Q_A$ has a period of $2^4 = 16$.

$$\begin{matrix} 0 \\ 0 \\ 0 \\ 0 \end{matrix} \Longrightarrow \begin{matrix} 1 & 0 \\ 1 & 0 \\ 1 & 0 \\ 1 & 0 \end{matrix}$$

b. Comparator (74LS85)

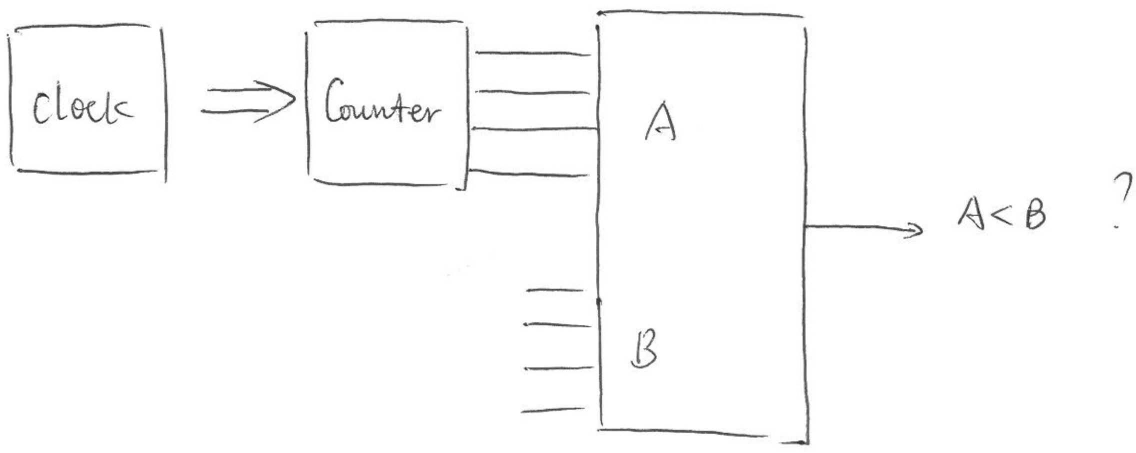
Function : Compares two binary numbers

Input : $A = Q_D^A Q_C^A Q_B^A Q_A^A$ $B = Q_D^B Q_C^B Q_B^B Q_A^B$



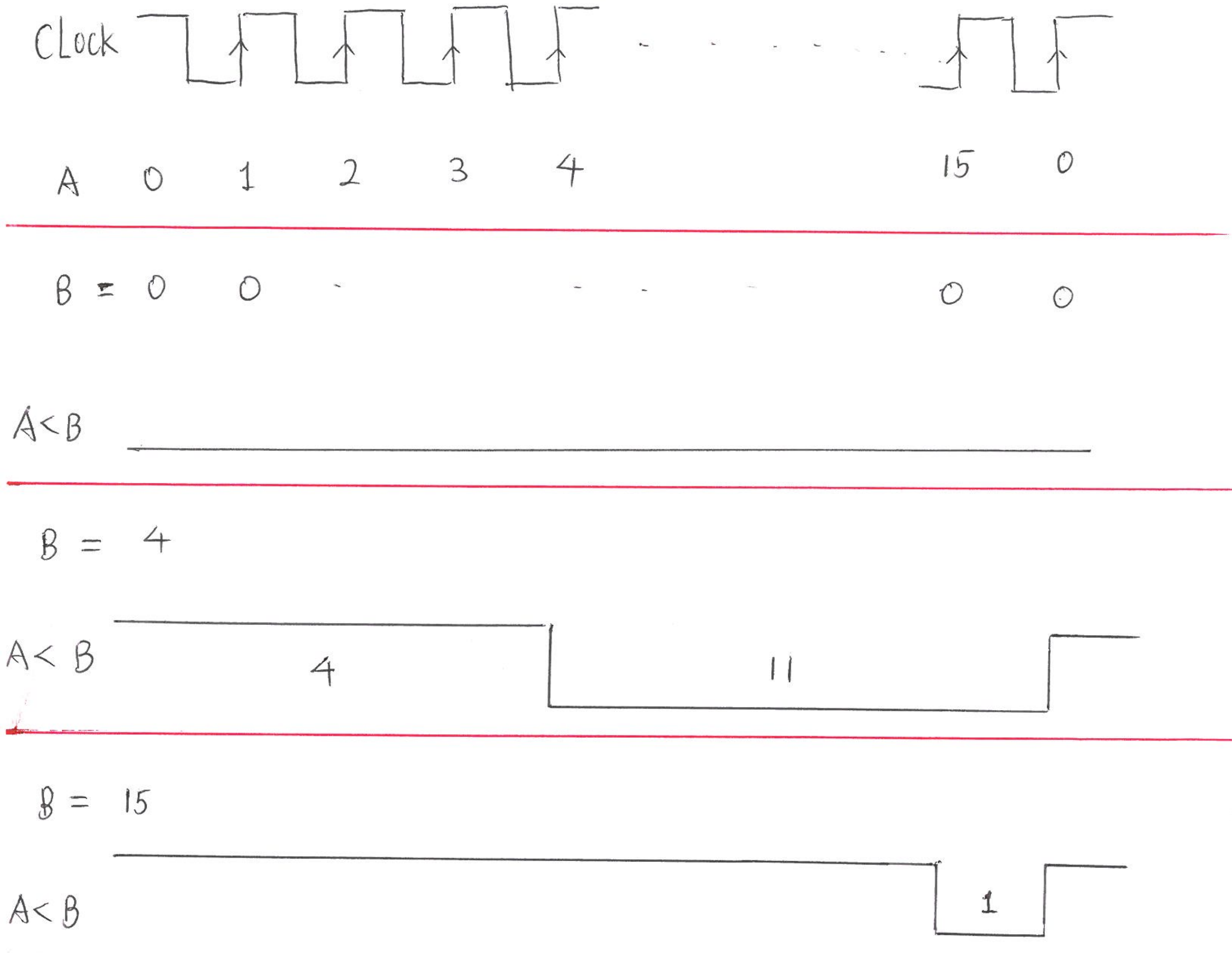
input :	A > B	A = B	A < B
output			
A < B	0	0	1
A = B	0	1	0
A > B	1	0	0

3) Putting things together.



What will be the output, for different B ?

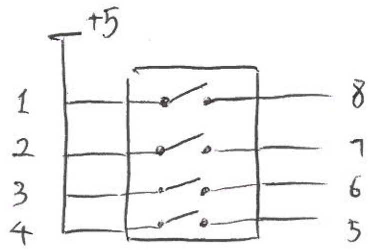
Consider three cases B = 0 , B = 4 , B = 15 .



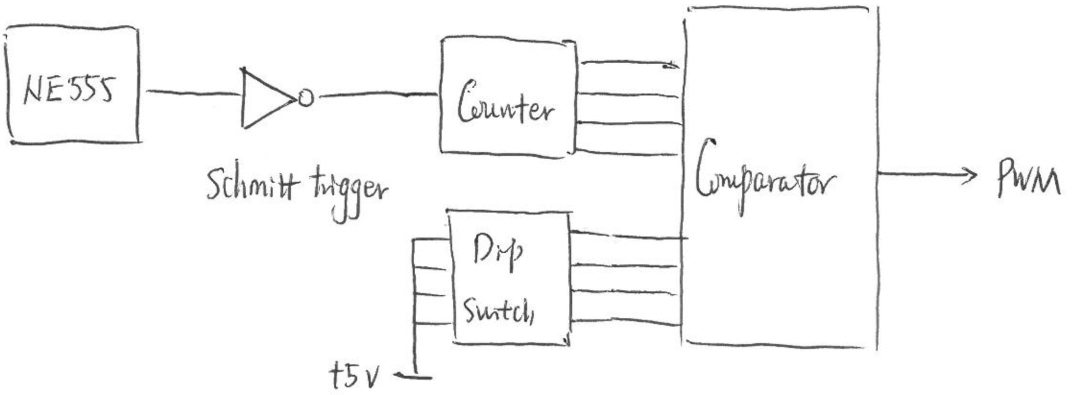
So, by setting different numbers to B, we can obtain pulse signal with different duty-cycles.

4) How to set the number ?

dip switch



Put things together



Next question: