Decimal system: 0123456789 356 = 3*10^2 + 5*10 + 6

Binary system: 01 110 = 1*2^2 + 1*2^1 + 0

Why do computer use binary numeral system?

Why do we use decimal system? 10 fingers? Why do we have 10 fingers?

Why not decimal time?

Ancient China: decimal and duodecimal systems (base 12)

France revolution: duodecimal vs. decimal system 1795~1805

3:65:78 = 0.36578 day

***
Counter:

Synchronous counter

Logic on (5V)

Q0
Q1
Q2

CLK

Let's remind ourselves

Truth table of JK FF

<table>
<thead>
<tr>
<th>J</th>
<th>K</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>\bar{Q}</td>
</tr>
</tbody>
</table>

*rising edge triggered.

\[ Q_0 \text{ flips every time it is triggered} \]
\[ Q_1 \text{ flips every time } Q_0 \text{ & CLK switch on} \]
\[ Q_2 \text{ flips every time } Q_1 \text{ & CLK switch on} \]

\[ Q_0 \rightarrow Q_1 \rightarrow Q_2 \rightarrow \text{time} \]

\[ Q_0: 0\ 1\ 0\ 1\ 0\ 1 \]
\[ Q_1: 0\ 0\ 1\ 1\ 0\ 0 \]
\[ Q_2: 0\ 0\ 0\ 0\ 1\ 1 \]

\( (Q_2, Q_0) \) 0 1 2 3 4 5 ...
There is also the ripple counter: \( N \)th JK FF triggered by \((N-1)\)th JK FF.

But the cascade leads to delay which accumulates.

Variations:

Counting huge #:

\[ Q = (Q_{12} \ldots Q_1)_2 = (H_3 H_2 H_1)_16 \quad \text{Hexadecimal} \]

\[ H = (Q_3Q_2Q_1)_2 = 123 \ldots 9 \text{ABCDEF} \]
Other useful functions: reset → 000..  
decimal counter  
reverse counting  

Reset is typically provided by the IC.  

decimal counting ⇒ overflow when Q = 1001_2 = 9  

⇒ LED display