

24-Hour Clock

My clock consists of 10,6,3 mod up counters and 7 segment display (decoder)

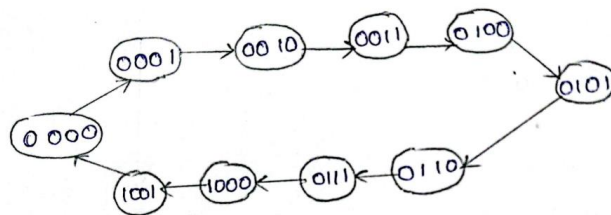
H ₀₋₂	H ₀₋₉	M ₀₋₅	M ₀₋₉	S ₀₋₅	S ₀₋₉
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As we can see each 2nd digit in seconds and minutes and hours can be counted by 10mod counter

1st digit of minutes and hours by mod 6 counter and hour by mod 3 counter

Designing mod 10 counter

State Diagram:



State Table:

Designing T-flip flops using state table

Present state				Next state							
Q ₃	Q ₂	Q ₁	Q ₀	Q ₃	Q ₂	Q ₁	Q ₀	T ₃	T ₂	T ₁	T ₀
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	1	0	0	0	1	1
0	0	1	0	0	0	1	1	0	0	0	1
0	0	1	1	0	0	0	0	0	1	1	1
0	0	0	0	0	1	0	1	0	0	0	1
0	0	1	0	0	1	1	0	0	0	1	1
0	1	1	0	0	1	1	1	0	0	0	1
0	1	1	1	1	0	0	0	1	1	1	1
1	0	0	0	1	0	0	1	0	0	0	1
1	0	0	1	0	0	0	0	1	0	0	1

Solving for T_3, T_2, T_1, T_0 Using K-maps:

for T_0

We say $T_0 = 1$

for T_1

$Q_3 Q_2$ $Q_1 Q_0$	00	01	11	10
00	0	0	x	0
01	1	1	x	0
11	1	1	x	x
10	0	0	x	x

$$\Rightarrow T_1 = Q_0 \bar{Q}_3$$

for T_2

$Q_3 Q_2$ $Q_1 Q_0$	00	01	11	10
00	0	0	x	0
01	0	0	x	0
11	1	1	x	x
10	0	0	x	x

$$T_2 = Q_1 Q_0$$

for T_3

$Q_3 Q_2$ $Q_1 Q_0$	00	01	11	10
00	0	0	x	0
01	0	0	x	1
11	0	1	x	x
10	0	0	x	x

$$T_3 = Q_1 Q_0 Q_2 + \bar{Q}_1 \bar{Q}_0 Q_3$$

$$= Q_1 Q_0 Q_2 + Q_0 Q_3$$

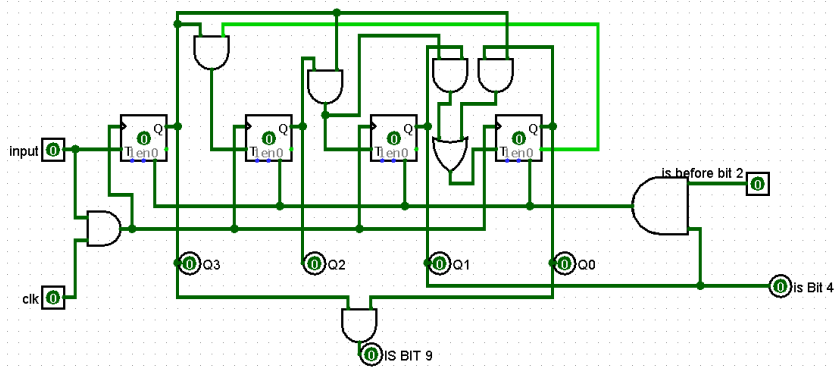
On solving We get

$$T_0 = 1 \quad T_1 = Q_0 \bar{Q}_3 \quad T_2 = Q_1 Q_0 \quad T_3 = Q_0 Q_1 Q_2 + Q_0 Q_3$$

Designing mod 10 Counter & making use of pattern recognition

Now we make mod 10 counter using the above equations also we check is the current state is 4 (in hours part, it makes mod 3 counter to reset so that hours don't exceed 23)

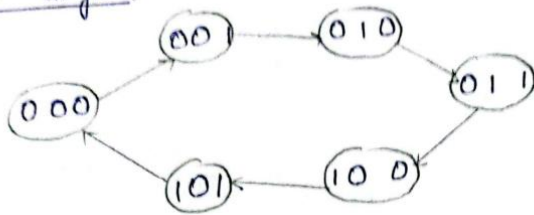
If current state is 9 then make the counter connected to it to count and reset the counter in hours part if the mod 3 counter is in state 2



Designing mod 6 counter

State Diagram:

State diagram



State Table:

state table

Q_2	Q_1	Q_0	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0
0	0	0	0	0	1	0	x	0	x	1	x
0	0	1	0	1	0	0	x	1	x	x	1
0	1	0	0	1	1	0	x	x	0	1	x
0	1	1	1	0	0	1	x	x	1	x	1
1	0	0	1	0	1	x	0	0	x	1	x
1	0	1	0	0	0	x	1	0	x	x	1

J-K excitation table

Q_n	Q_{n+1}	J	K
0	0	0	x
0	1	1	x
1	0	x	1
1	1	x	0

Solving for $J_3, J_2, J_1, J_0, K_3, K_2, K_1, K_0$ Using K-maps:

for $J, k,$

q_i	00	01	11	10
0	0	1	x	x
1	0	0	x	x

$$J_1 = \overline{Q_2} Q_0$$

$Q_1 \backslash Q_0$	00	01	11	10
0	x	x	1	0
1	x	x	x	x

$$K_1 = Q_0.$$

for J_2, K_2

Q_2, Q_0	00	01	11	10
0	0	0	1	0
1	x	x	x	x

$$J_2 = Q_1 Q_0.$$

Q_1, Q_2	00	01	11	10
0	x	x	x	x
1	0	1	x	x

$$k_2 = \frac{1}{r} q_0$$

$$K_2 = Q_0$$

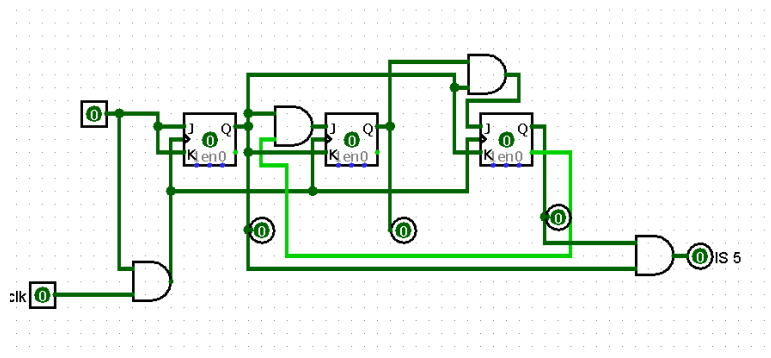
Thus we get

$$J_0 = K_0 = 1$$

$$J_1 = \overline{Q}_2 Q_0, K_1 = Q_0$$

$$J_2 = Q_1 Q_2, K_2 = Q_0$$

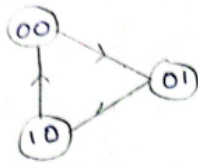
Designing mod 6 Counter & making use of pattern recognition



Now we make mod 6 counter using the above equations also we check is the current state is 5 (so that 1st bit of hours and minute part counts when the current bit is 5)

Designing mod 3 counter

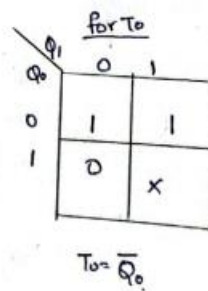
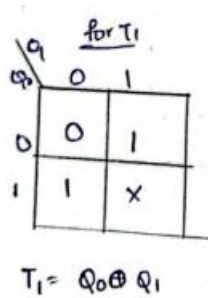
State Diagram:



State Table:

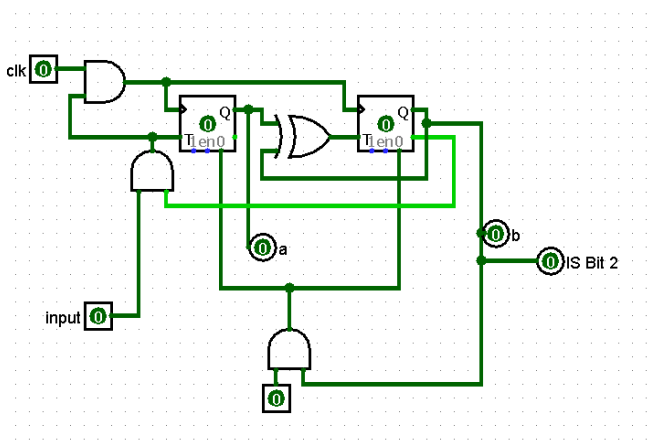
q_1	q_0	q_1	q_0	T_1	T_0
0	0	0	1	0	1
0	1	1	0	1	0
1	0	0	1	1	0
1	1	x	x	x	x

Solving for T_1, T_0 Using K-maps:



$$T_0 = \overline{Q_0} \quad T_1 = Q_0 \oplus Q_1$$

Designing mod 3 Counter & making use of pattern recognition



Now we make mod 6 counter using the above equations also we check is the current state is 2 and if 2nd bit of hr part is 3 then we reset both so they become 00 from 23

This makes out 24 Hr clock Complete.

Now we need to represent them using a 7-segment display

Truth Table of the combinational circuit of 7 segment Display :

A	B	C	D	a	b	c	d	e	f	g	h
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	0	1	1	0	0	0	0	0
0	0	1	0	1	1	0	1	1	0	0	0
0	0	1	1	1	1	1	1	0	0	1	0
0	1	0	0	0	1	1	0	0	1	1	0
0	1	0	1	1	0	1	1	0	1	1	0
0	1	1	0	1	0	1	1	1	1	1	0
0	1	1	1	1	1	1	0	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1	0
1	0	0	1	1	1	1	1	0	1	1	0

Solving It Using K-maps:

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	x	x	x	x
10	1	1	x	x

$$\begin{aligned}
 a &= A + BD + C + \bar{A}\bar{B}\bar{D} + \bar{C}\bar{D}\bar{B} + A\bar{B}\bar{D} \\
 &\quad + C\bar{D}\bar{B} \\
 &= A + \bar{B}\bar{D} + BD + C
 \end{aligned}$$

AB \ CD	00	01	11	10
00	1	1	1	1
01	1	0	1	0
11	x	x	x	x
10	1	1	x	x

$$\begin{aligned}
 b &= \bar{A}\bar{B} + \bar{A}\bar{B} + \bar{C}\bar{D} + CD \\
 &= \bar{B} + \bar{C}\bar{D} + CD
 \end{aligned}$$

BC \ AD	00	01	11	10
00	1	1	1	0
01	1	1	1	0
11	x	x	x	x
10	1	1	x	x

$$c = \bar{C} + D + B$$

for d

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	0	1
11	x	x	x	x
10	1	1	x	x

$$d = \bar{B}\bar{D} + B\bar{C} + C\bar{D} + B\bar{C}\bar{D} + A$$

BC \ AD	00	01	11	10
00	1	0	0	1
01	0	0	0	1
11	x	x	x	x
10	0	x	x	x

$$e = B\bar{D} + C\bar{D}$$

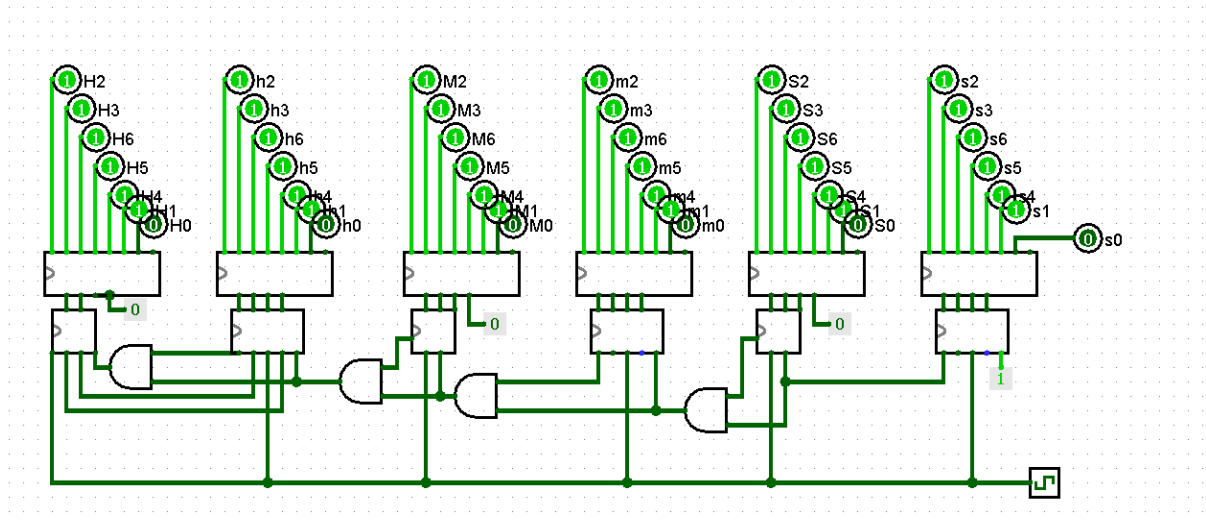
BC \ AD	00	01	11	10
00	1	0	0	0
01	1	1	0	1
11	x	x	x	x
10	1	1	x	x

$$f = \bar{C}\bar{D} + B\bar{C} + B\bar{D} + A$$

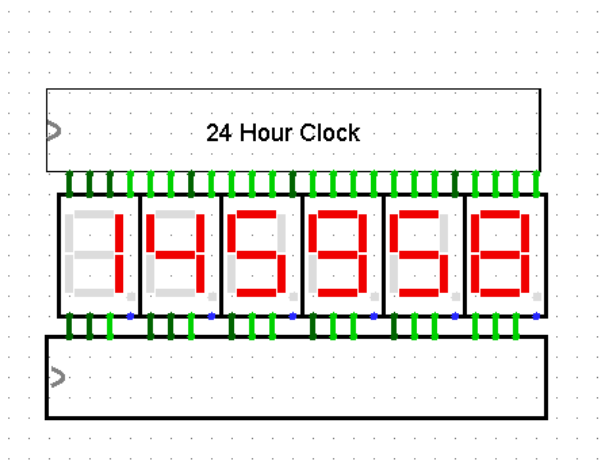
This completes our project and lets look into our implementation

Implementation:

Design of the core logic:



Making use of this lets make a Our clock with neat Design without many wires:



(A screenshot while clock is working)

Thank You

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