INTRODUCTION:

A digital clock is a type of clock that displays the time digitally (i.e., in numerals or other symbols), as opposed to an analogue clock. Digital clocks are often associated with electronic drives, but the "digital" description refers only to the display, not to the drive mechanism. (Both analogue and digital clocks can be driven either mechanically or electronically, but "clockwork" mechanisms with digital displays are rare). Digital clocks typically use the 50 or 60 hertz oscillation of AC power or a 32,768 hertz crystal oscillator as in a quartz clock to keep time. Most digital clocks display the hour of the day in 24-hour clock format; in the United States and a few other countries, a commonly used hour sequence option is 12-hour format (with some indication of AM or PM). Some timepieces, such as many digital switches, can be switched between 12-hour and 24-hour modes. Emulations of analog-style faces often use an LCD screen, and these are also sometimes described as "digital".

So, now we are going to design a 24-hour format digital clock. The clock has 4 blocks. These are

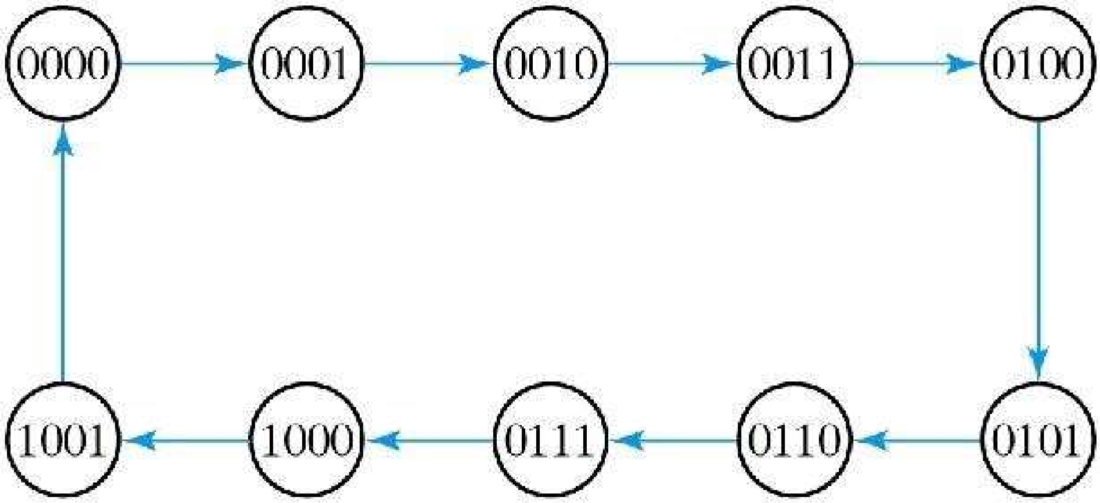
- *1 Hz clock generator to generate 1 PPS (pulse per second) signal to the second's block.*
- ***SECONDS block** - contains a divide by 10 circuit followed by a divide by 6 circuit. Will generate a 1 PPM (pulse per minute) signal to the minutes block. The BCD outputs connect to the BCD to Seven Segment circuit to display the seconds values.*
- ***MINUTES block** - identical to the seconds block it contains 2 dividers; a divide by 10 followed by a divide by 6. Will generate a 1 PPH (pulse per hour) signal to the HOURS block. The BCD outputs connects to the BCD to Seven Segment circuit to display the minutes values.*
- ***HOURS block** - depending on whether it is a 12 or 24H clock, will have a divide 24 or divide by 12. For 24H, it will count from 00 to 23. For 12H, it will count from 00 to 11. The BCD outputs connects to the BCD to Seven Segment circuit to display the hours values.*
- *We use **7473** jk flip flop as t flip flop by making the input j and k are the same.*
- *We use a BCD counter for each bit of the second; minute and hour*

  Let us do the analysis the BCD counter as follows

  We have to start from 0-9

  Thus, we need 4 T flip flop. And we use moor type sequential circuit

Step 1 state diagram



Step 2 state table

	Present state	Next state	Output
A	A	B	A
B	B	C	B
C	C	D	C
D	D	E	D
E	E	F	E
F	F	G	F
G	G	H	G
H	H	I	H
I	I	J	I
J	J	A	J

Step 3 state assignment

When implemented in a logic circuit each state is represented by a particular valuation of state variables.

Each state variable may be implemented in the form of a T flip flop. since 10 states have to be realize. it sufficient to use four state variables, let those variables be Q3, Q2, Q1 and Q0.

Each active edge of the clock will cause the flip flops to change their state to the values of Q3, Q2, Q1, and Q0 that time.

Now we create the truth table that define this circuit ,the table is called state assigned table.

	Present state				*Next state*				*Output*			
	Q_3	Q_2	Q_1	Q_0	Q_3^+	Q_2^+	Q_1^+	Q_0^+	Z_3	Z_2	Z_1	Z_0
A	0	0	0	0	0	0	0	1	0	0	0	0
B	0	0	0	1	0	0	1	0	0	0	0	1
C	0	0	1	0	0	0	1	1	0	0	1	O
D	0	0	1	1	0	1	0	0	0	0	1	1
E	0	1	0	0	0	1	0	1	0	1	0	0
F	0	1	0	1	0	1	1	0	0	1	0	1
G	0	1	1	0	0	1	1	1	0	1	1	0
H	0	1	1	1	1	0	0	0	0	1	1	1
I	1	0	0	0	1	0	0	1	1	0	0	0
J	1	0	0	1	0	0	0	0	1	0	0	1

Then

The implementation using flip flop

T	*Q*	Q^+
0	0	0
0	1	1
1	0	1
1	1	0

The excitation table for the counter with T flip flop

	Present state				*Next state*				*Flip flop input*				*Output /counter*			
	Q_3	Q_2	Q_1	Q_0	Q_3^+	Q_2^+	Q_1^+	Q_0^+	T_3	T_2	T_1	T_0	Z_3	Z_2	Z_1	Z_0
A	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
B	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	1
C	0	0	1	0	0	0	1	1	0	0	0	1	0	0	1	0
D	0	0	1	1	0	1	0	0	0	1	1	1	0	0	1	1
E	0	1	0	0	0	1	0	1	0	1	0	1	0	1	0	0
F	0	1	0	1	0	1	1	0	0	0	1	1	0	1	0	1
G	0	1	1	0	0	1	1	1	0	0	0	1	0	1	1	0
H	0	1	1	1	1	0	0	0	1	1	1	1	0	1	1	1
I	1	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0
J	1	0	0	1	0	0	0	0	1	0	0	1	1	0	0	1

Let's simplify by using K- map

For T_3

Q_3Q_2	Q_1Q_0

	00	01	11	10
00	0	0	0	0
01	0	0	1	O
11	D	D	D	D
10	0	1	D	D

$T_3 = Q_3Q_0 + Q_2Q_1Q_0$

FOR T_2

Q_3Q_2	Q_1Q_0

	00	01	11	10
00	0	0	1	0
01	0	0	1	O
11	D	D	D	D
10	0	0	D	D

$T_2 = Q_1\boldsymbol{Q_0}$

FOR T1

Q_3Q_2	Q_1Q_0

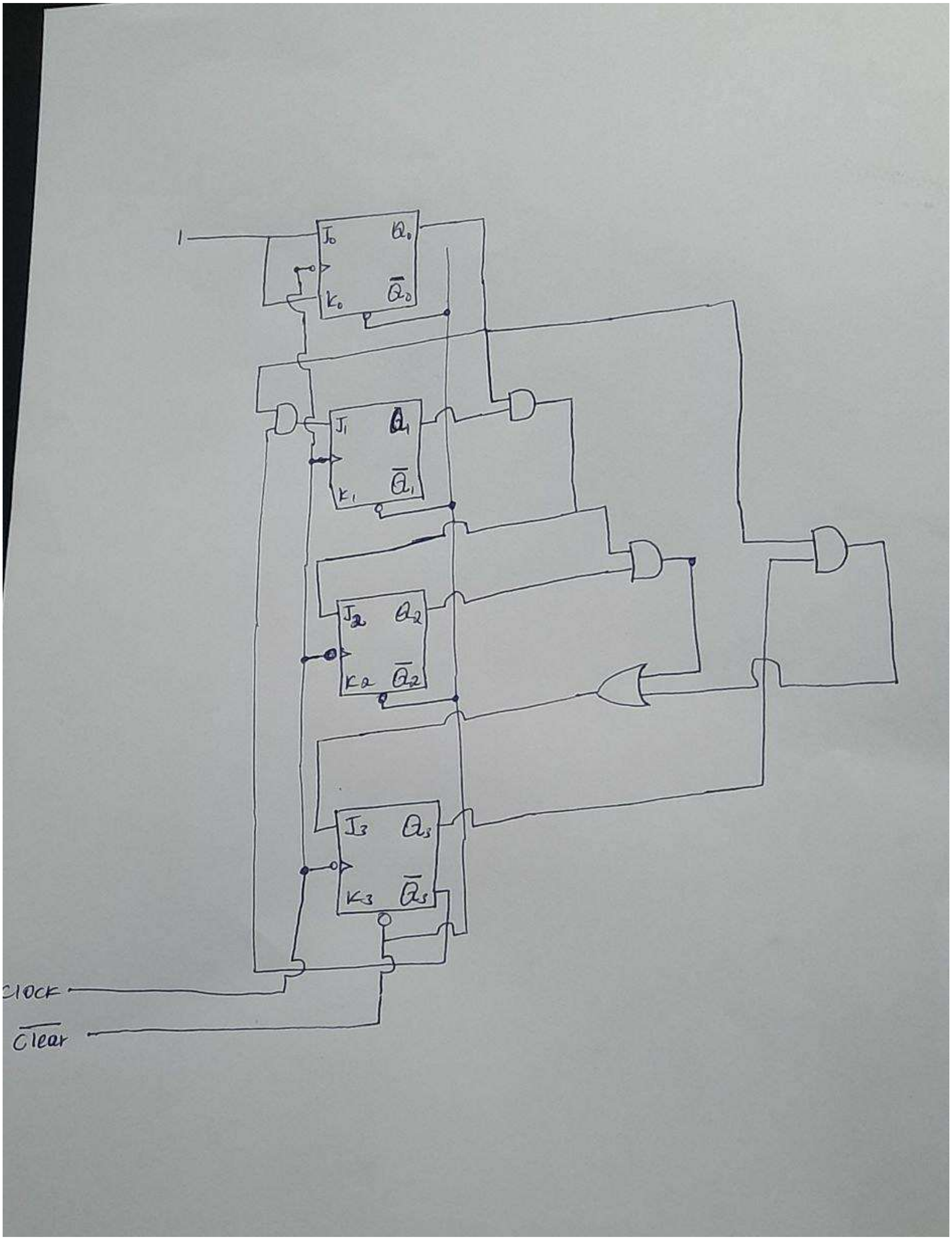
	00	01	11	10
00	0	1	1	0
01	0	1	1	O
11	D	D	D	D
10	0	0	D	D

$T_1 = \overline{Q_3}Q_0$

FOR T0

Q_3Q_2	Q_1Q_0

	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	1	1
10	1	1	1	1

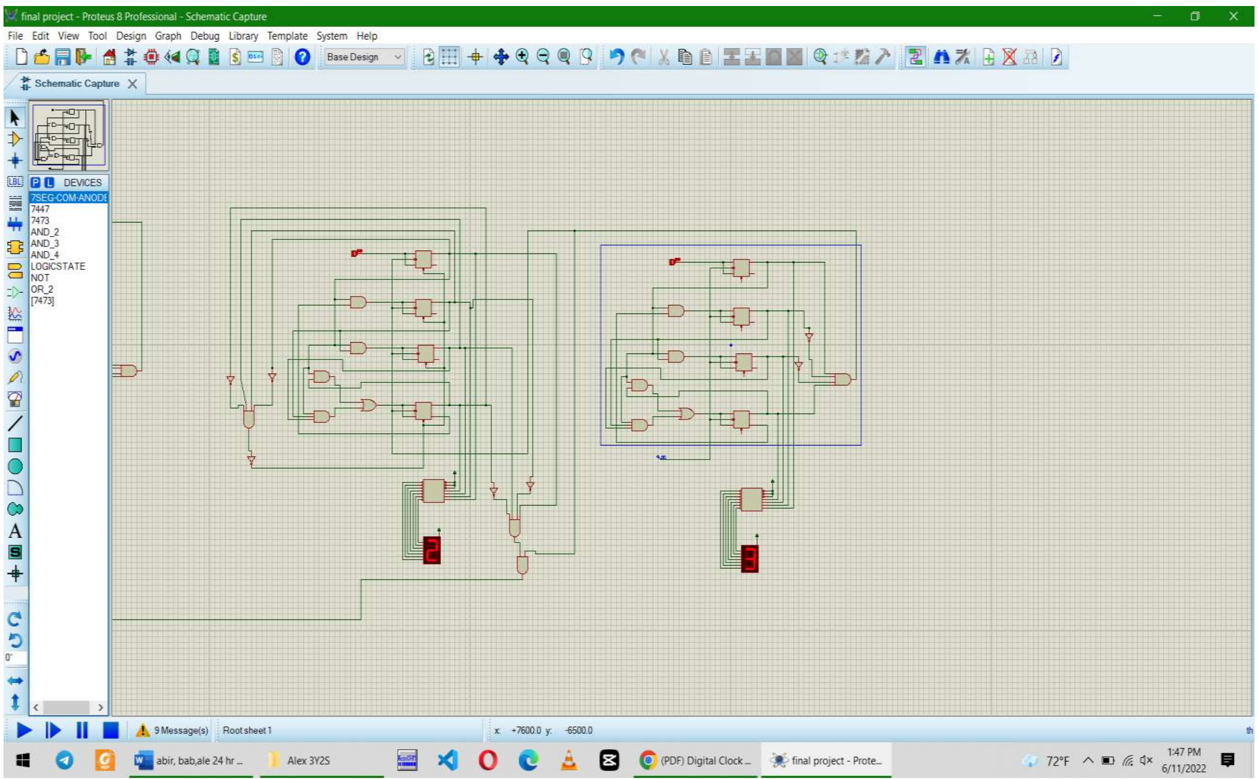


This circuit a BCD counter which is used for counting 0-9

For second

- ✓ We use BCD counter for each bit of (the second the second has two bit)
- ✓ The counter for the least significant figure bit of the second counts from 0to 9
- ✓ The clock of the most significant bit count is controlled by the least significant bit of counter, The second itself has two bit let BA, Where the value of A is from 0 to 9 And The value of B is 0 to 5. The value of B changes when the value of equals to 9

When B =5 and A= 9, the value of B changes to 0 (that means the reset is active)

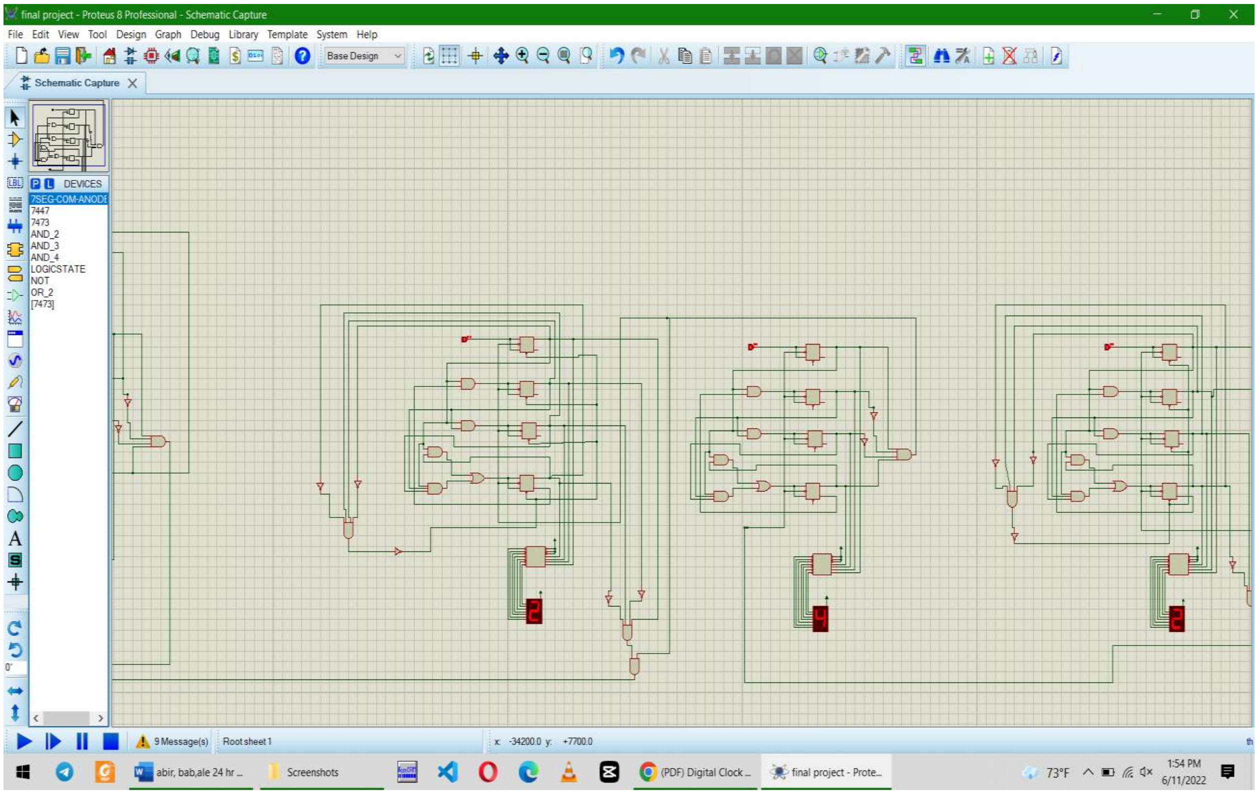


For minute

- ✓ Like second we use one BCD counter for each bit of the minute (the minute has two bit) Let it DC, Where the value of C is from 0 to 9 and the value of D is from 0to 5

The value of C changes when the value of D the second bit changes

The value of D changes when the value of C=9.and when D=5 and C=9, the value of D changes to 0(that means the reset is active)



For hours

- ✓ like minute and second, we use one **BCD** COUNTER for each bit of the hour (the hour has two bit let FE), the value of E changes when the minute bit=59

the value of F is from 0-2, the value of F changes when either the value of E=9 or the value of F=2 and E=4