



Homework 2

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I declare that the work described in this report was done by me, and that the description and comments in this report are my own work, except where otherwise acknowledged. I have read the University's policy on plagiarism, and accept it.

Signed: Seán Fahey **Date:** 4 / 12 / 2020

4 Modes of operation:

{ only one mode must be enabled at any given time }

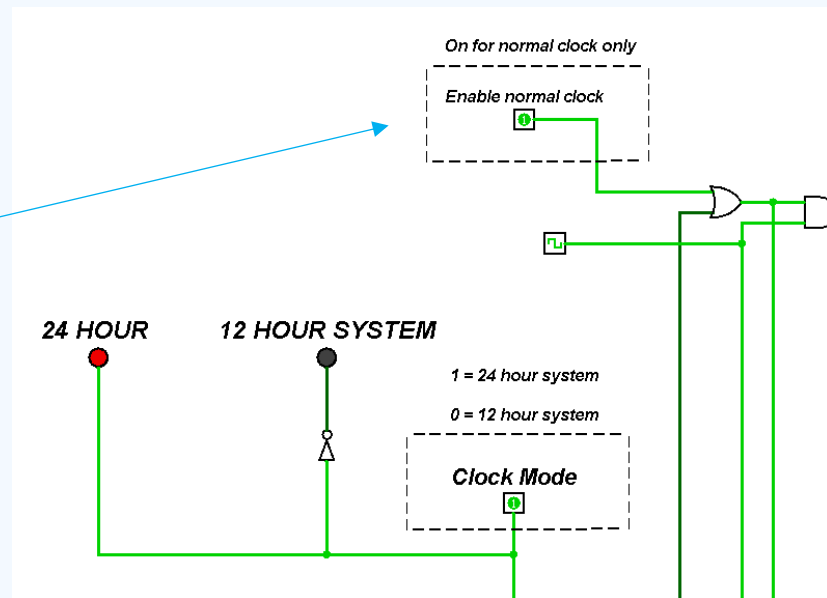
Make sure this is disabled when pressing any buttons



- ❖ The ticker must be OFF when selecting different modes (pushing buttons)

1) Standard Clock

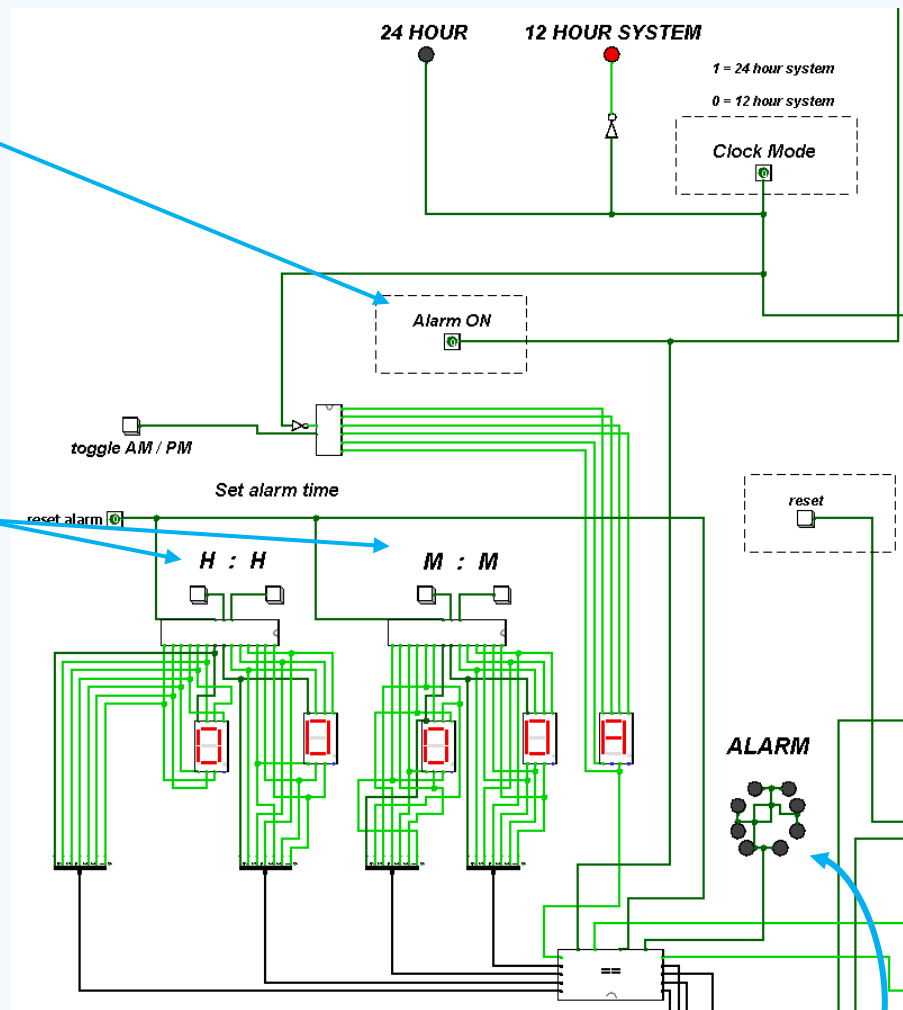
- Enable the top button to enable the normal clock mode, and select which type (24 hour or 12 hour)



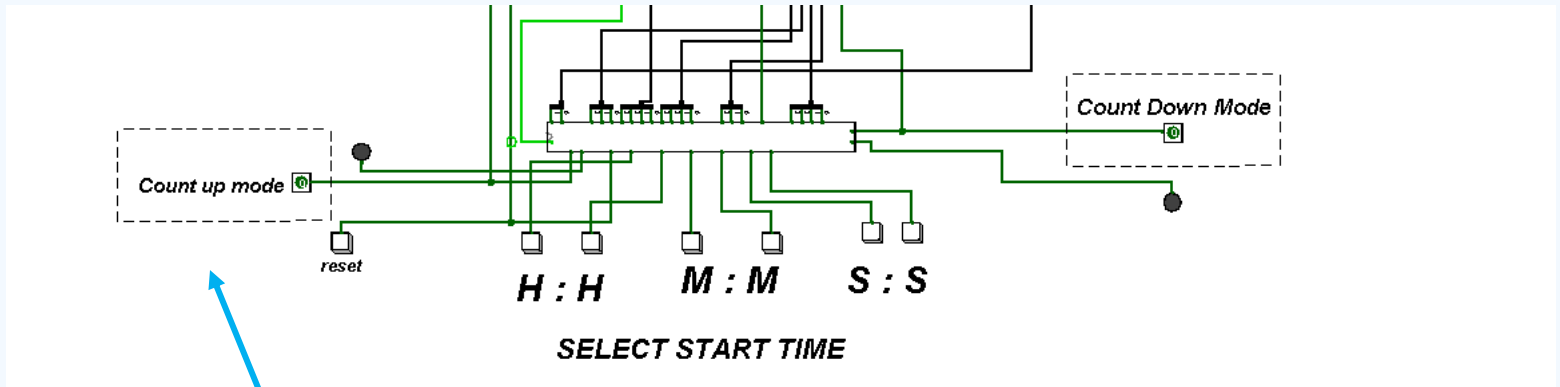
- Set the tick rate to any frequency and the clock will run.

2) Alarm Clock

- Enable the alarm
- Select AM or PM if using the 12 hour clock
- Use the buttons to set the alarm (to the nearest minute) on the alarm display (the image on the right is not the main clock)
- When the time on the alarm display matches the time on the main clock, the alarm lights will flash for 30 seconds and then stop.

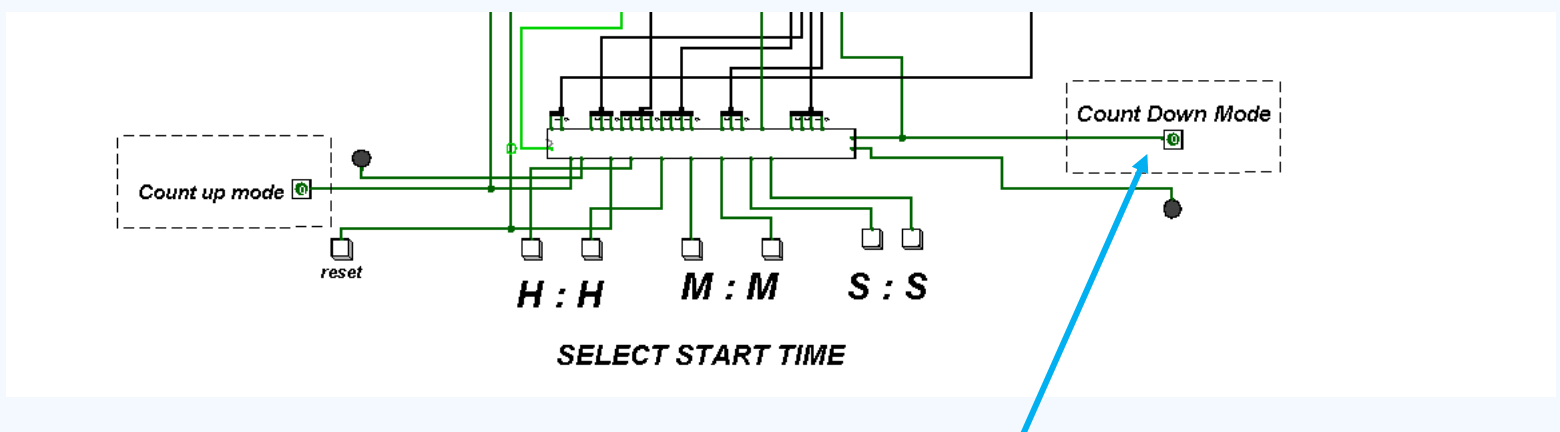


3) Count Up

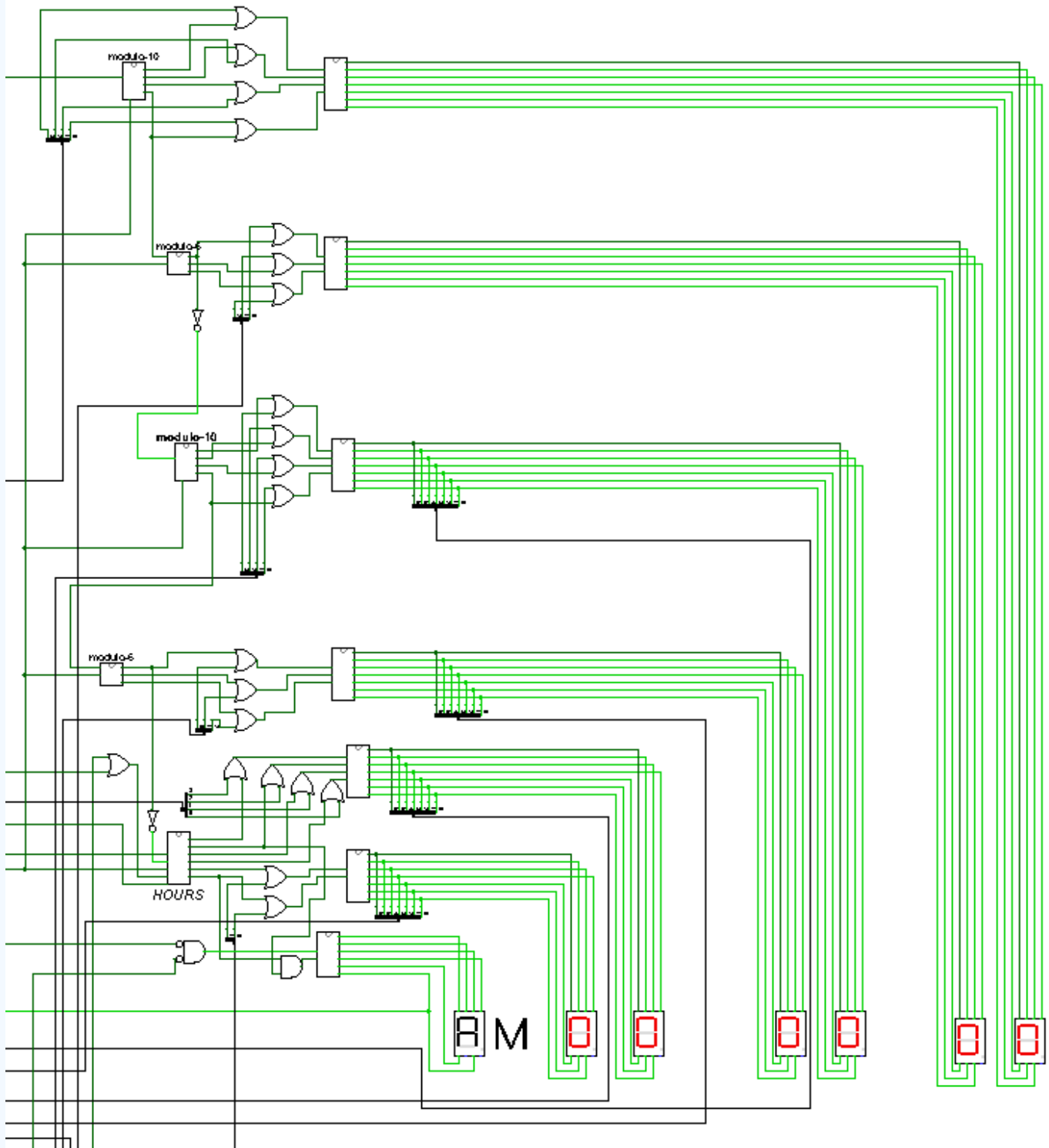


- When this is enabled, the main clock counts up to 30. hours then goes back to 00:00 and starts again
- The count can be paused at any time by disabling the 'Count up mode' button.
- The Count Up mode cannot be set from a specific time, it must start from 00:00 (so the HHMMSS buttons do nothing in this mode)

4) Count Down



- To count down, enable the count down mode and use the below it to set the hours, minutes and seconds to count down from.



<this is the main clock>

DESIGN PROCEDURE

Main clock

Seconds: Modulo-10 & Modulo-6

(4-bit)

(3-bit)

[asynchronous]

Minutes: Modulo-10 & Modulo-6

(4-bit)

(3-bit)

[asynchronous]

Hours: Has both 12 and 24 hour systems

12 Hour system: 6-bit output total:

4-bits for 10 hour number {00,10,20}

2-bits for 1 Hour number {1,2,3,4,5,6,7,8,9}

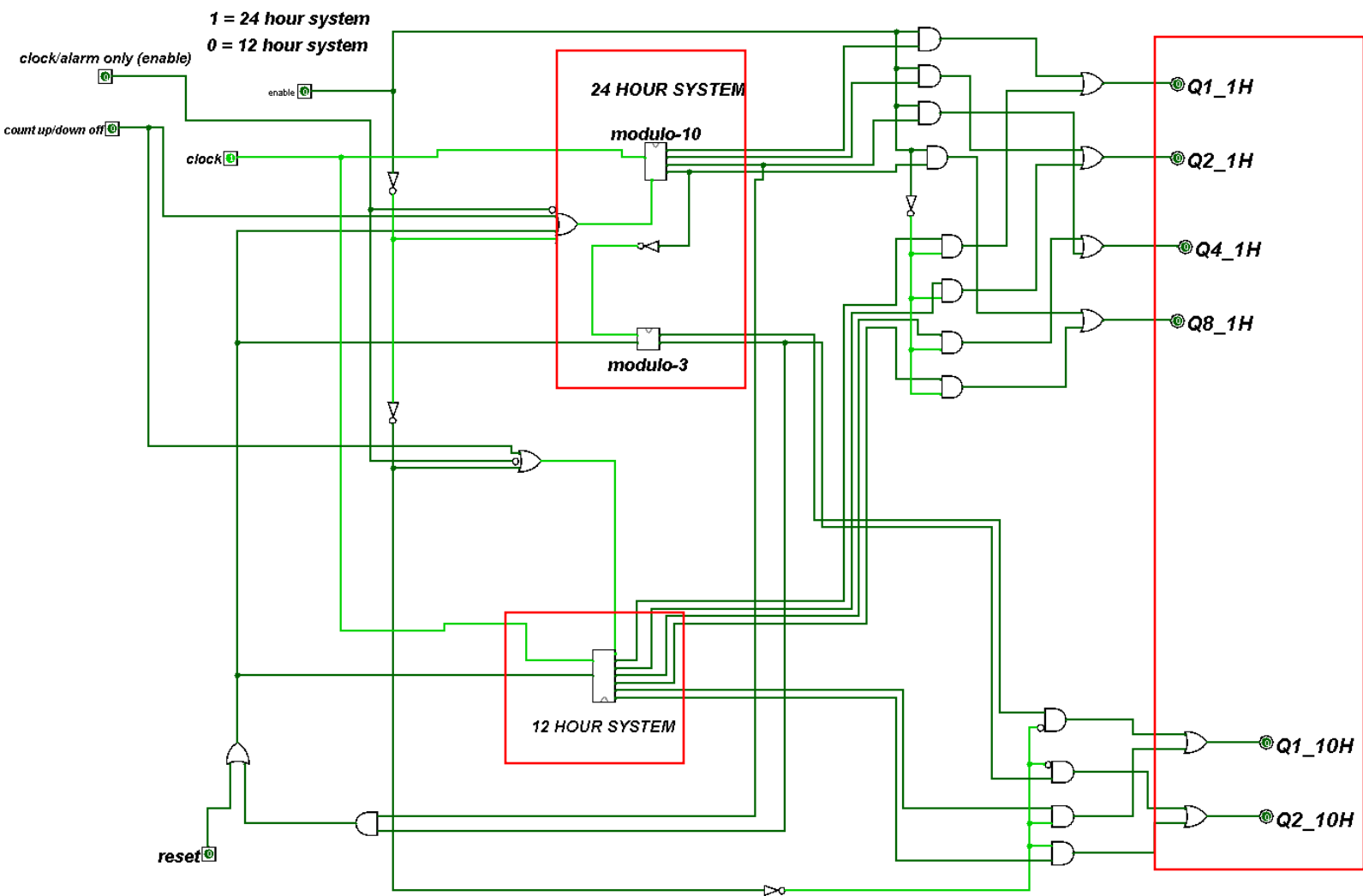
Only 1 mode is enabled at a time. When a mode is disabled, the output is all zeros.

24 Hour System: Modulo-10 & Modulo-3

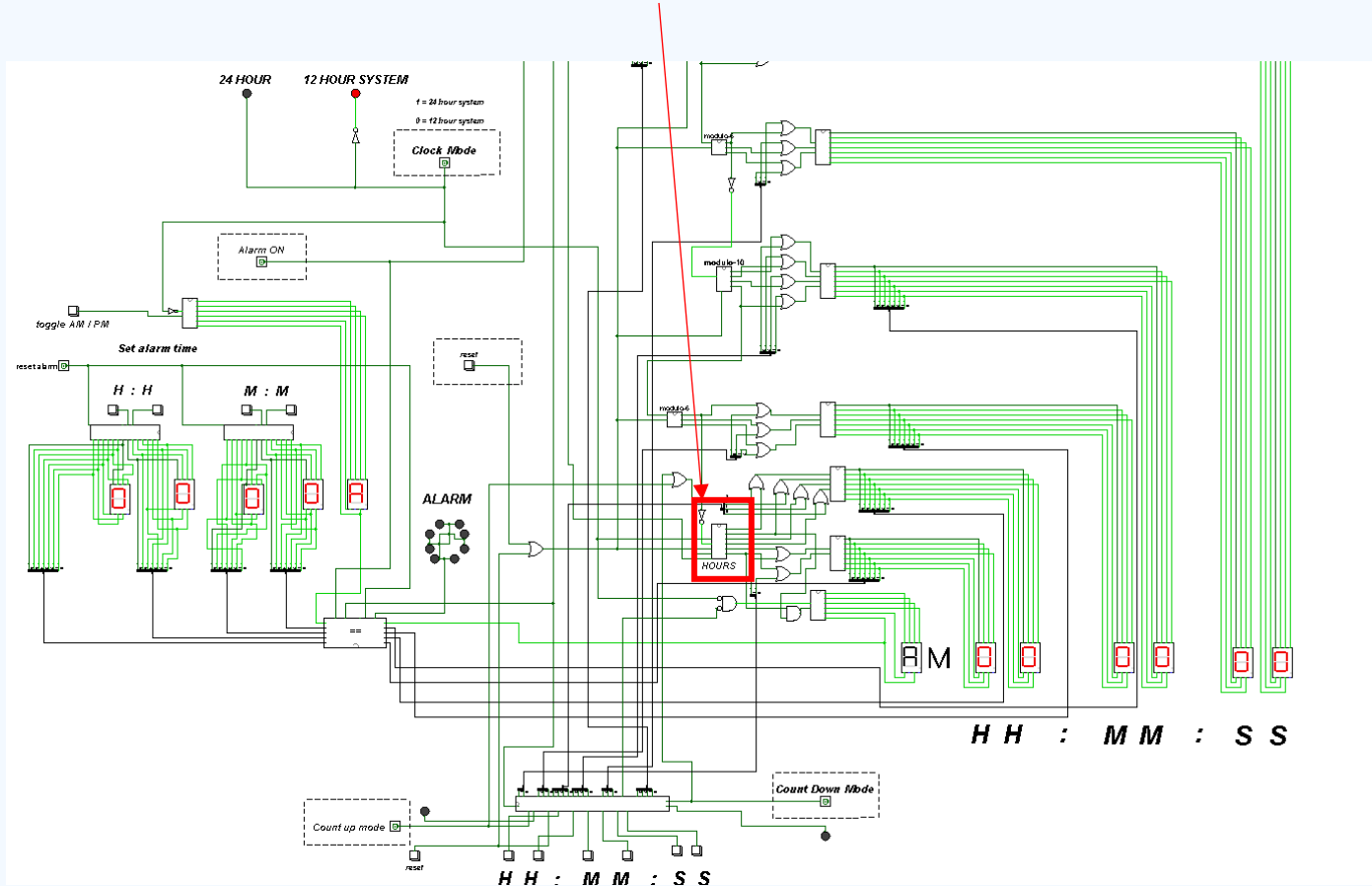
(4-bit)

(2-bit)

[asynchronous]

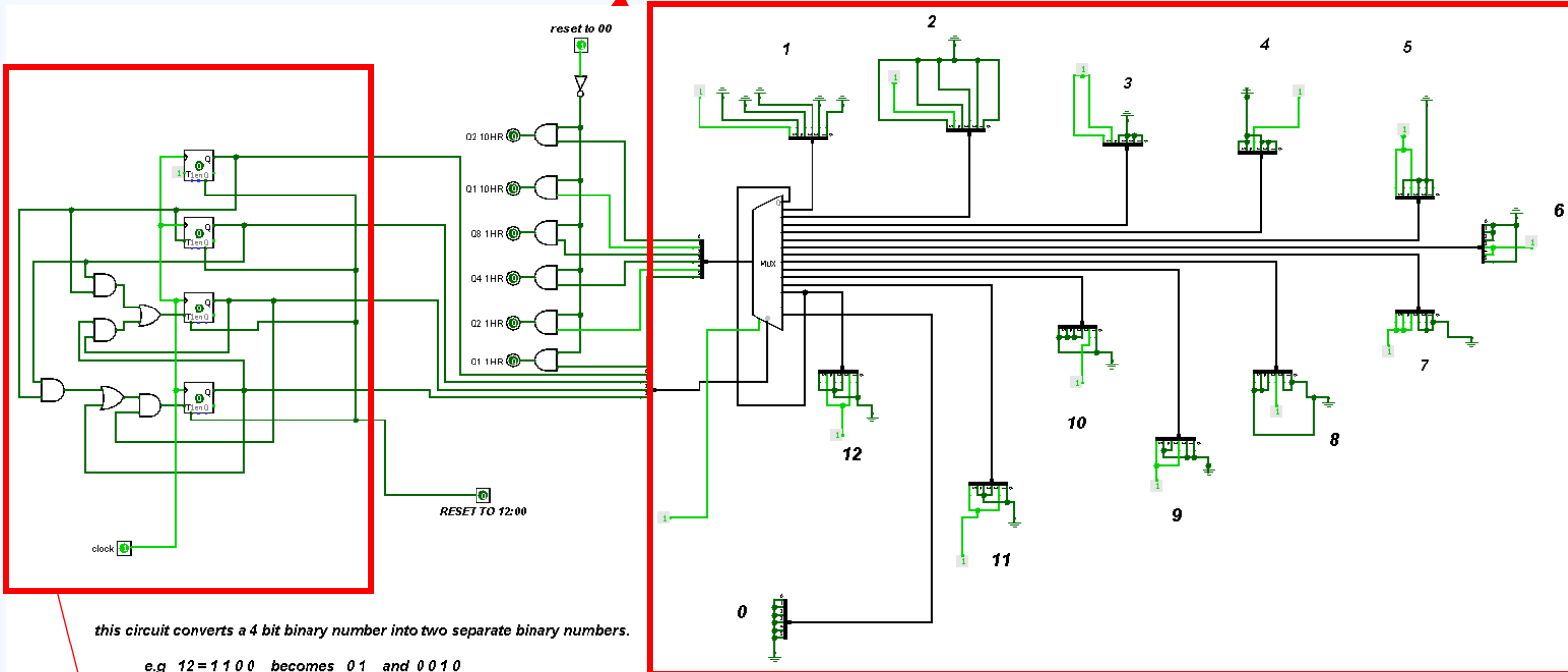


The HOURS circuit (above) is here in the main circuit (below):



12 Hour System

OFF when 12 hour system is enabled



this circuit converts a 4 bit binary number into two separate binary numbers.

e.g 12 = 1100 becomes 01 and 0010
1 2

Sequential circuit:

12 → 1 → 2 ... 11 → 12

Converts 4 bit number (from 1 to 12)
to two binary numbers (using multiplexer);
4-bit number (from 0 to 9)
2-bit number (from 0 to 2)
= 6-bit number total

e.g 12 = 1 1 0 0 → 0 1 0 0 1 0

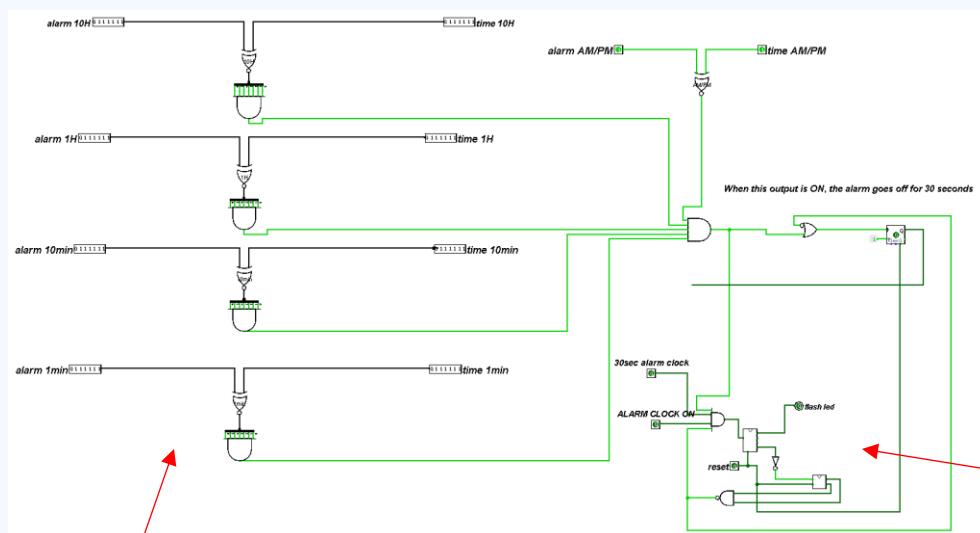
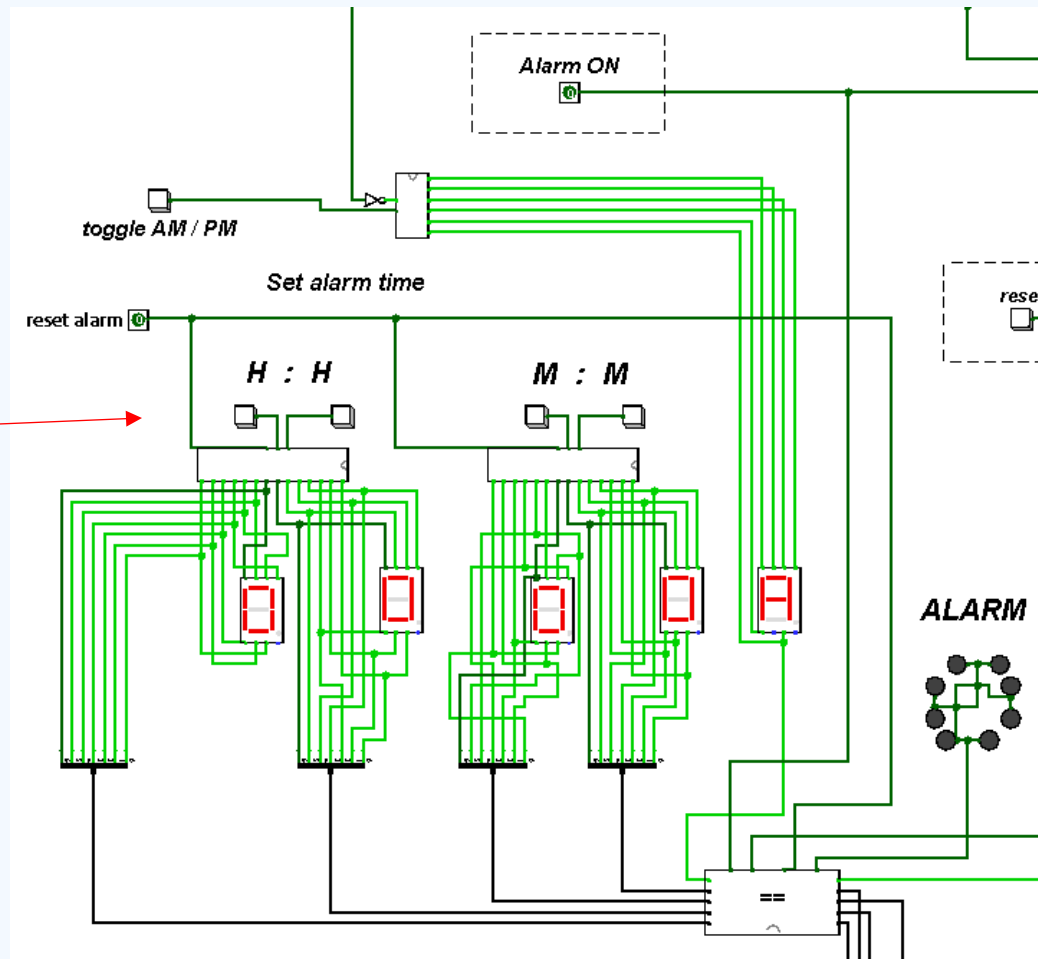
1 2

Alarm Clock

These circuits set the time for the alarm.

Pushing the buttons for HH:MM changes the numbers displayed.

The alarms flashes for 30 seconds when the digits on the alarm 7-segment display match the main clock display.



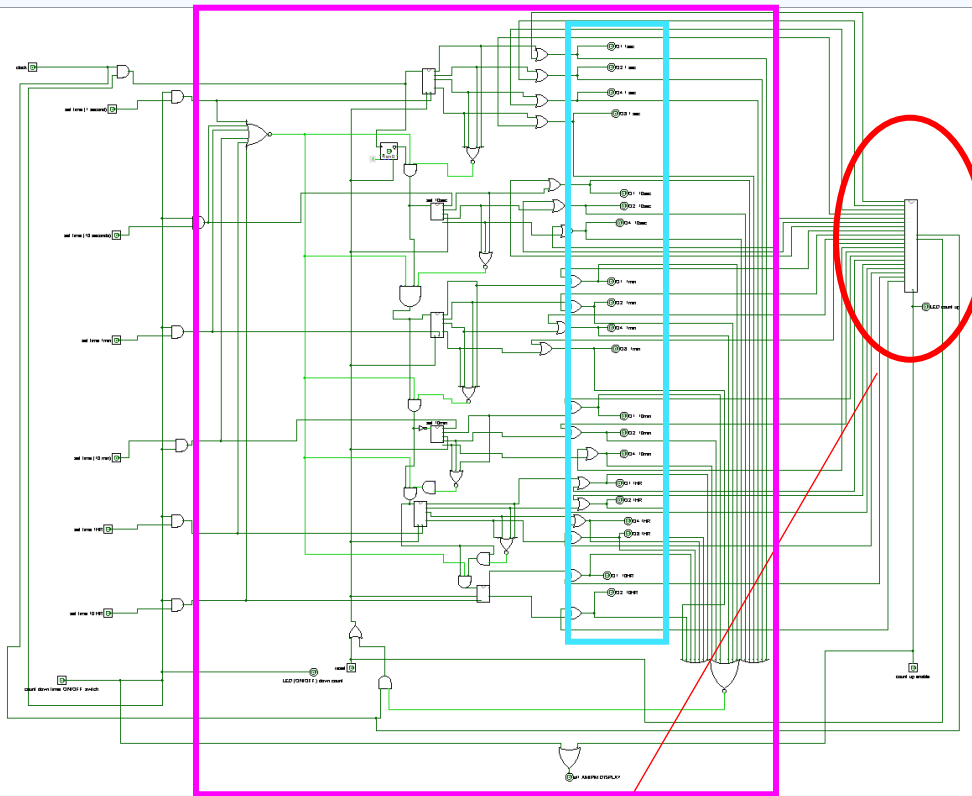
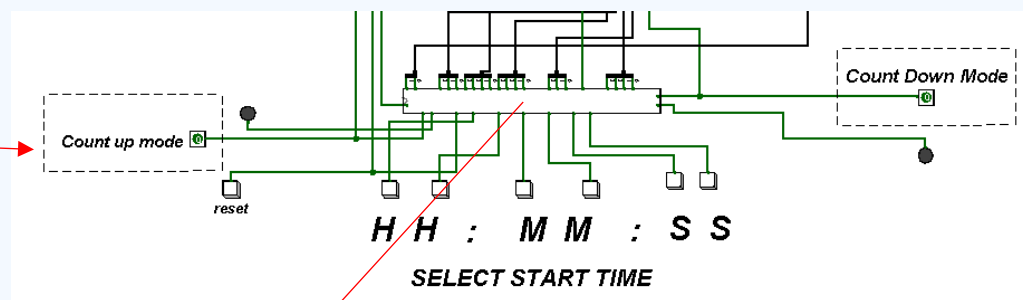
This circuit ('==') compares the two displays and flashes the alarm LED.

30 second timer

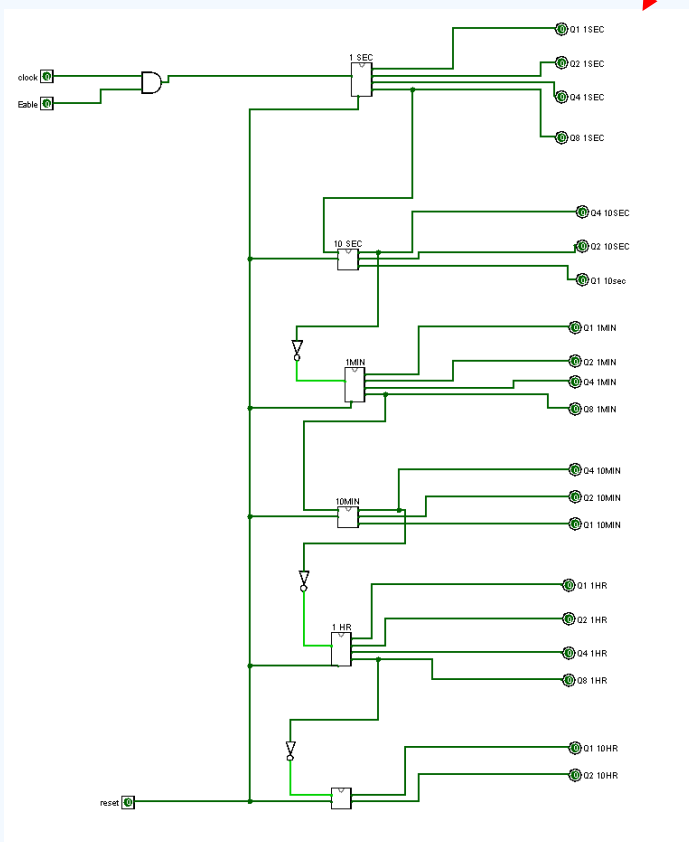
Compare the times (and AM/PM letter) :

each gate compares 1 digit. All gates output 1 when the digits match.

count up

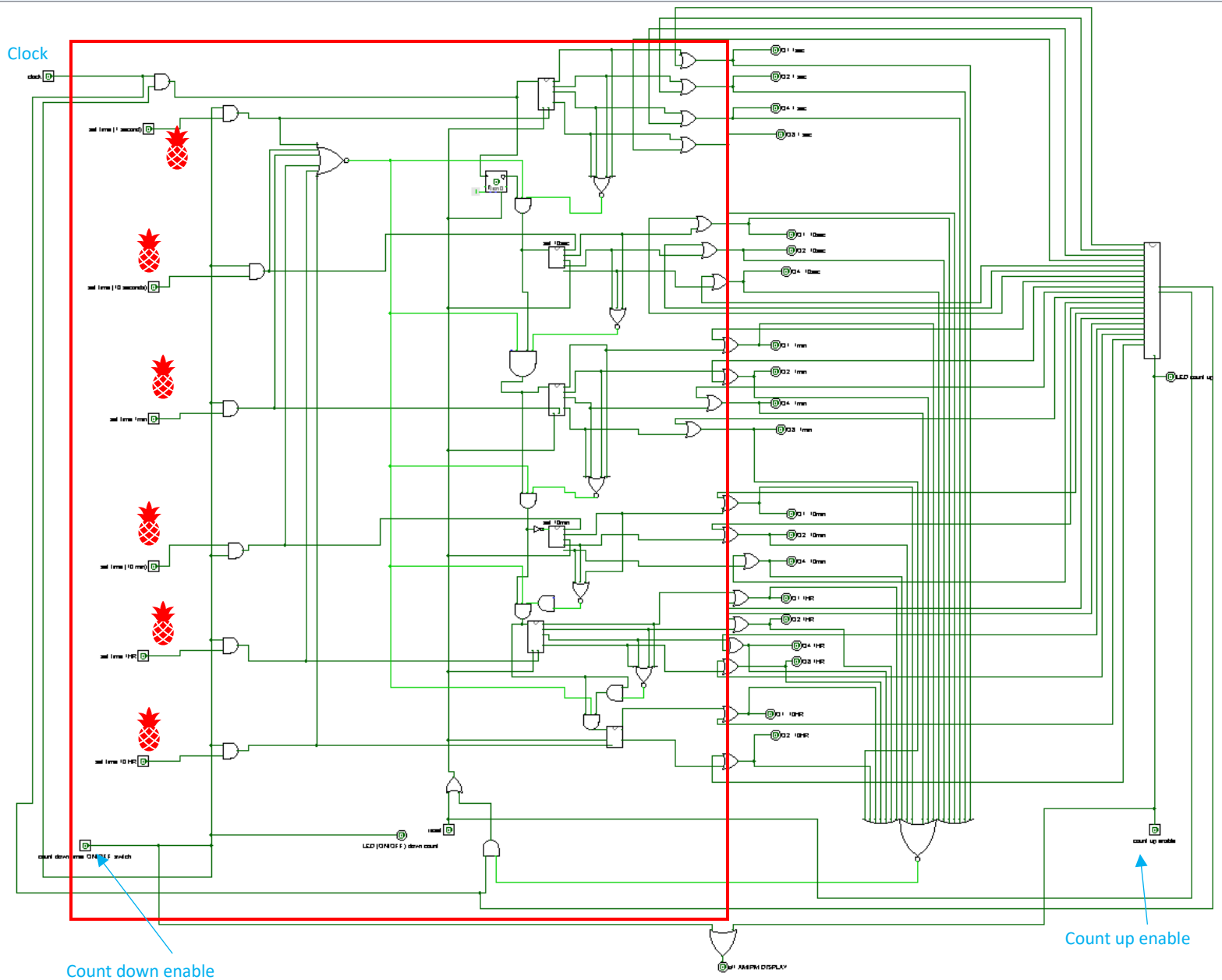


When the count up mode is enabled, the modulo-10, modulo-6 and modulo-3 circuits count (output to the main clock) up to 30 Hours and then goes back to 00:00 and starts over.



[all of this circuitry is for the count down only. The outputs are shared between the count up and count down modes.]

Count Down



This circuit counts down from the set time. Time is set by pressing buttons in the main circuit, which are seen in the above circuit at the 🍌 symbols.

CIRCUIT DESIGN

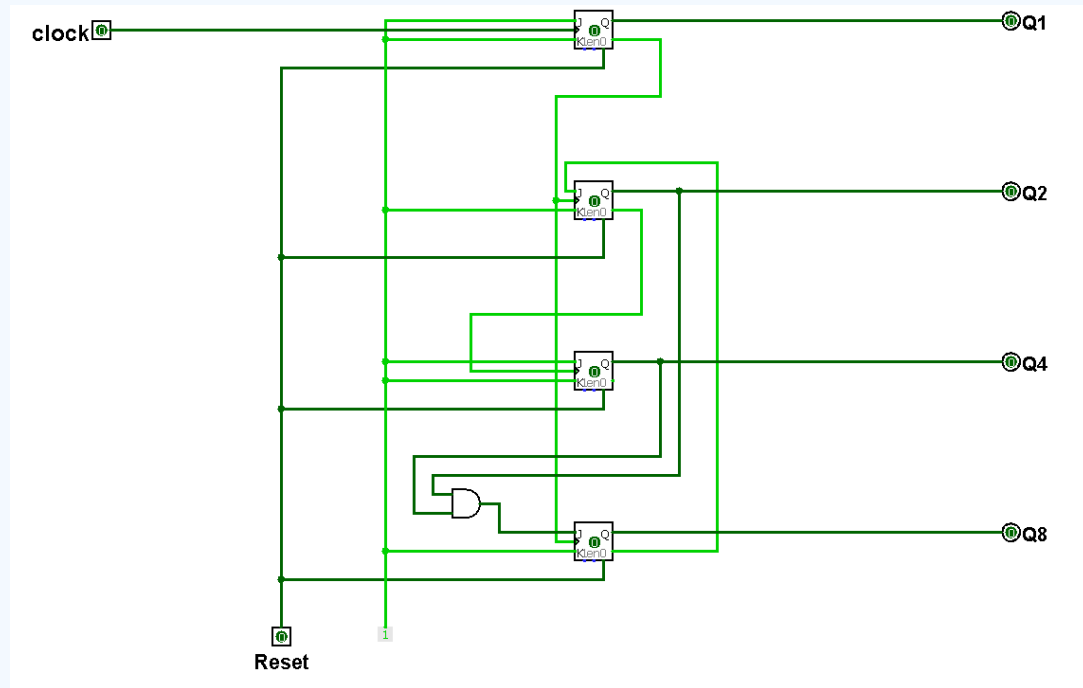
Click on 'go to'

HW2	
Modulo-10	go to
modulo-6	go to
BCD TO 7SEG	
modulo-6 TO 7SEG	
Modulo-3 TO 7SEG	
modulo-3	go to
Clock	
12HR_system	go to
12/24__HOURS	go to
AM/PM	go to
Alarm_AM/PM	go to
AM/PM_Hours Select	go to
modulo-2	
AM/PM_Minutes select	go to
count down	go to
modulo-6 count down	go to
modulo-3 count down	go to
modulo-10 24 count down	go to
count up	go to

Not listed above:

- *Clock* is the main circuit
- The '*TO 7SEG*' circuits are the same as shown in lab4 and simply output binary values to 7segment displays.

MODULO-10



Standard binary coded decimal ripple counter. Counts up to 9 (1001) then back to 0.

Q8	Q4	Q2	Q1
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
1	0	0	0
1	0	0	1

MODULO-6

Counts up to 5 then returns to 0

T1	Q1	0	1
Q4, Q2			
00		1	1
01		1	1
11		X	X
10		1	1

← TRUTH TABLES

LOGIC FUNCTIONS

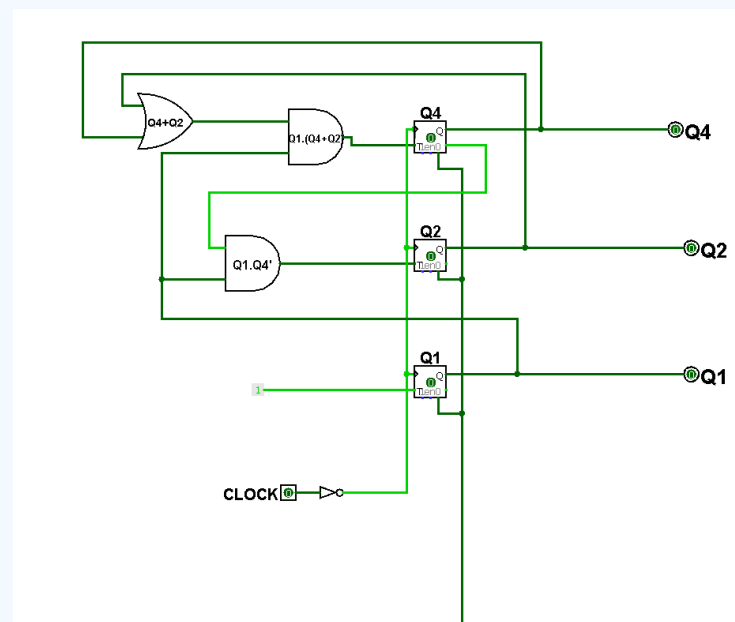
$T_1 = 1$

$T_2 = Q_4' \cdot Q_1$

$T_4 = Q_1 \cdot (Q_4 + Q_2)$

T2	Q1	0	1
Q4, Q2			
00		0	1
01		0	1
11		X	X

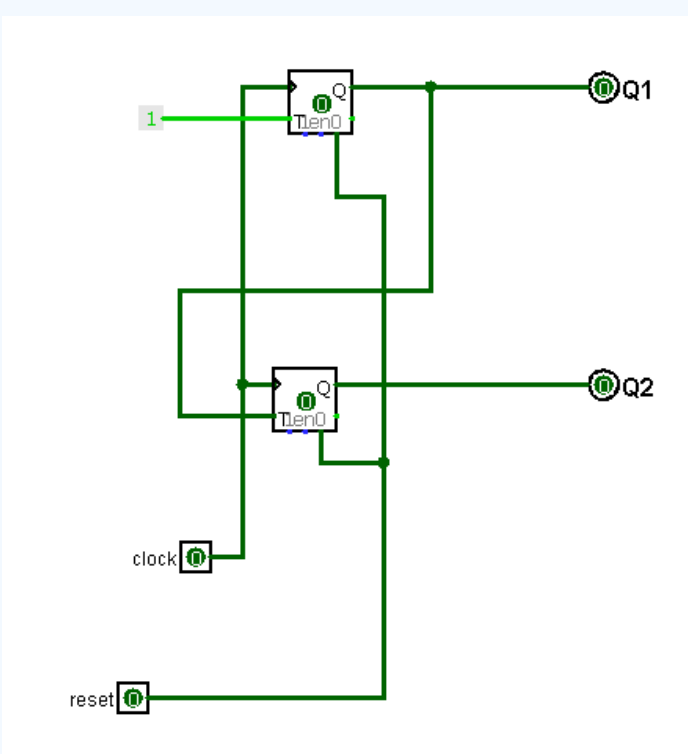
T4	Q1	0	1
Q4, Q2			
00		0	0
01		0	1
11		X	X



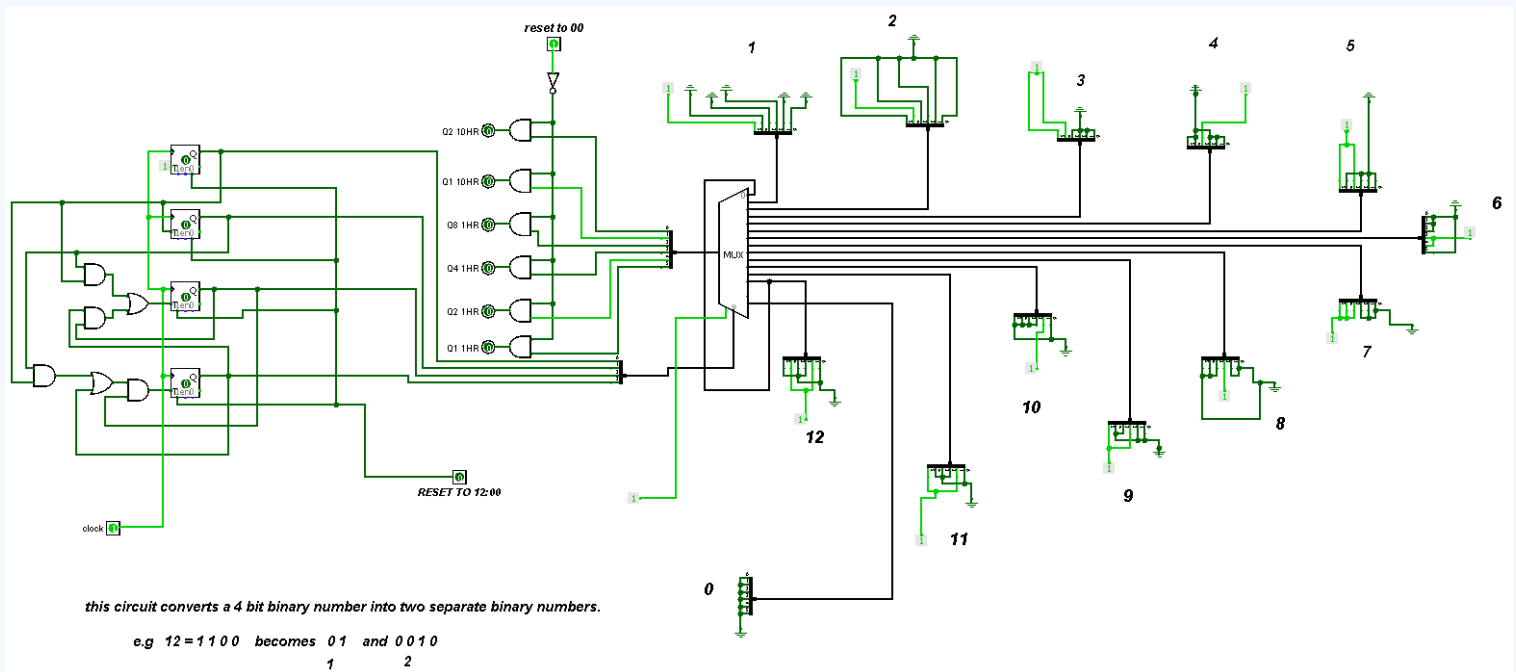
Modulo-3

Counts to 3 then returns to 0. In this Project modulo-3 is only used To count from 0 to 2.

Q2	Q1	#	T2	T1
0	0	0	0	1
0	1	1	1	1
1	0	2	0	1
1	1	3	1	1



12 Hour System



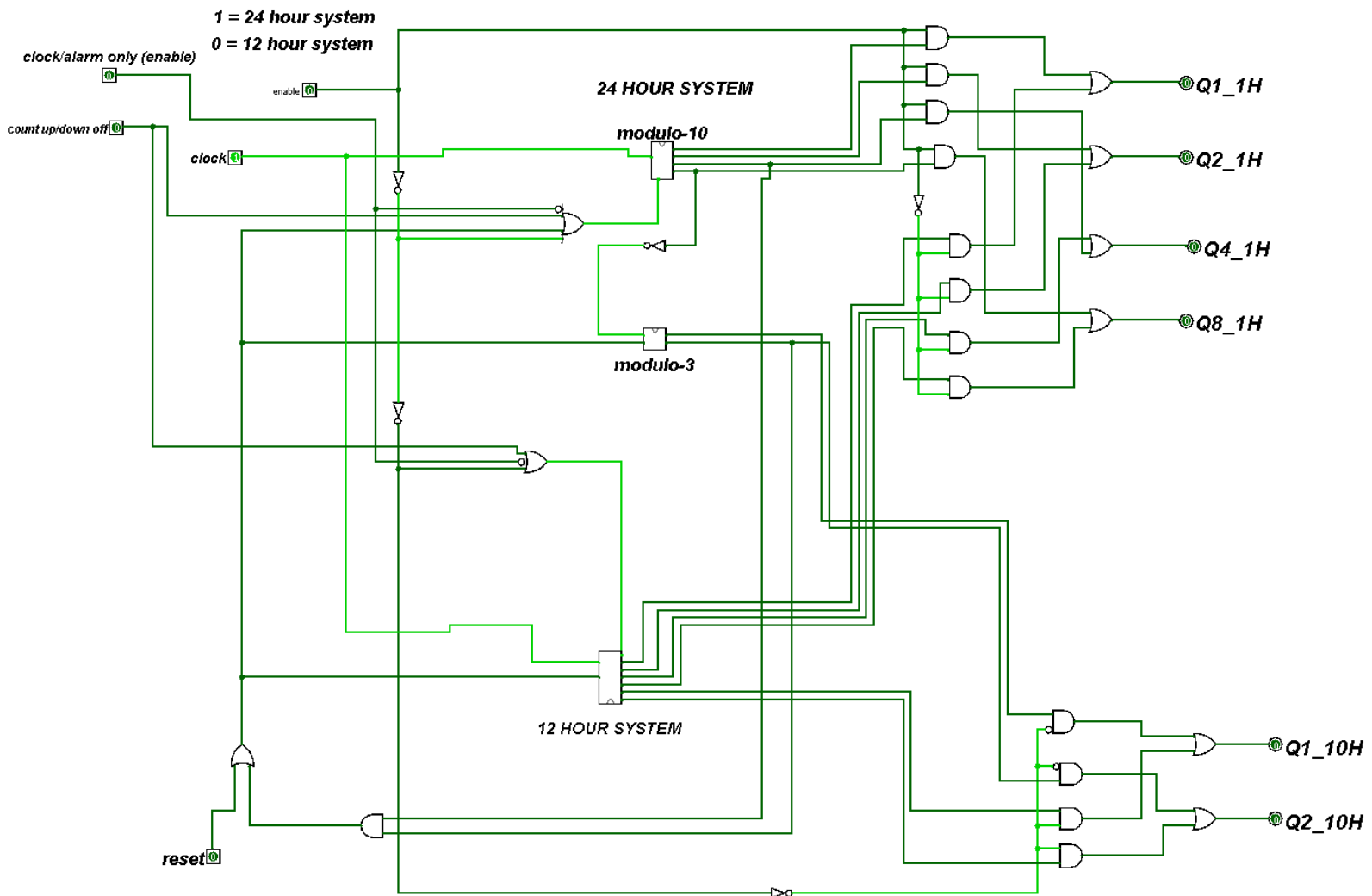
This controls the clock when it is in AM/PM mode.

On the left the sequential circuit counts 1 to 12.

On the right, a multiplexer turns the 4 bits into 6 bits (4bits + 2bits) to display two decimal numbers on the 7 segment displays.

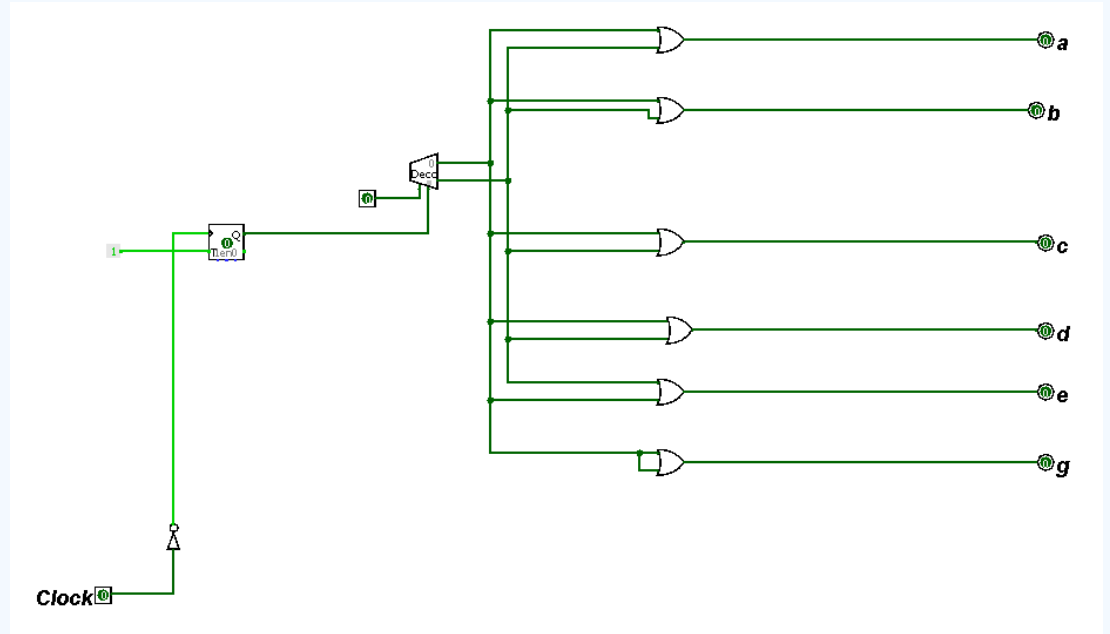
Q8	Q4	Q2	Q1	#	T8	T4	T2	T1
0	0	0	1	1	0	0	1	1
0	0	1	0	2	0	0	0	1
0	0	1	1	3	0	1	1	1
0	1	0	0	4	0	0	0	1
0	1	0	1	5	0	0	1	1
0	1	1	0	6	0	0	0	1
0	1	1	1	7	1	1	1	1
1	0	0	0	8	0	0	0	1
1	0	0	1	9	0	0	1	1
1	0	1	0	10	0	0	0	1
1	0	1	1	11	0	1	1	1
1	1	0	0	12	1	1	0	1

12/24 Hour System (Combined)



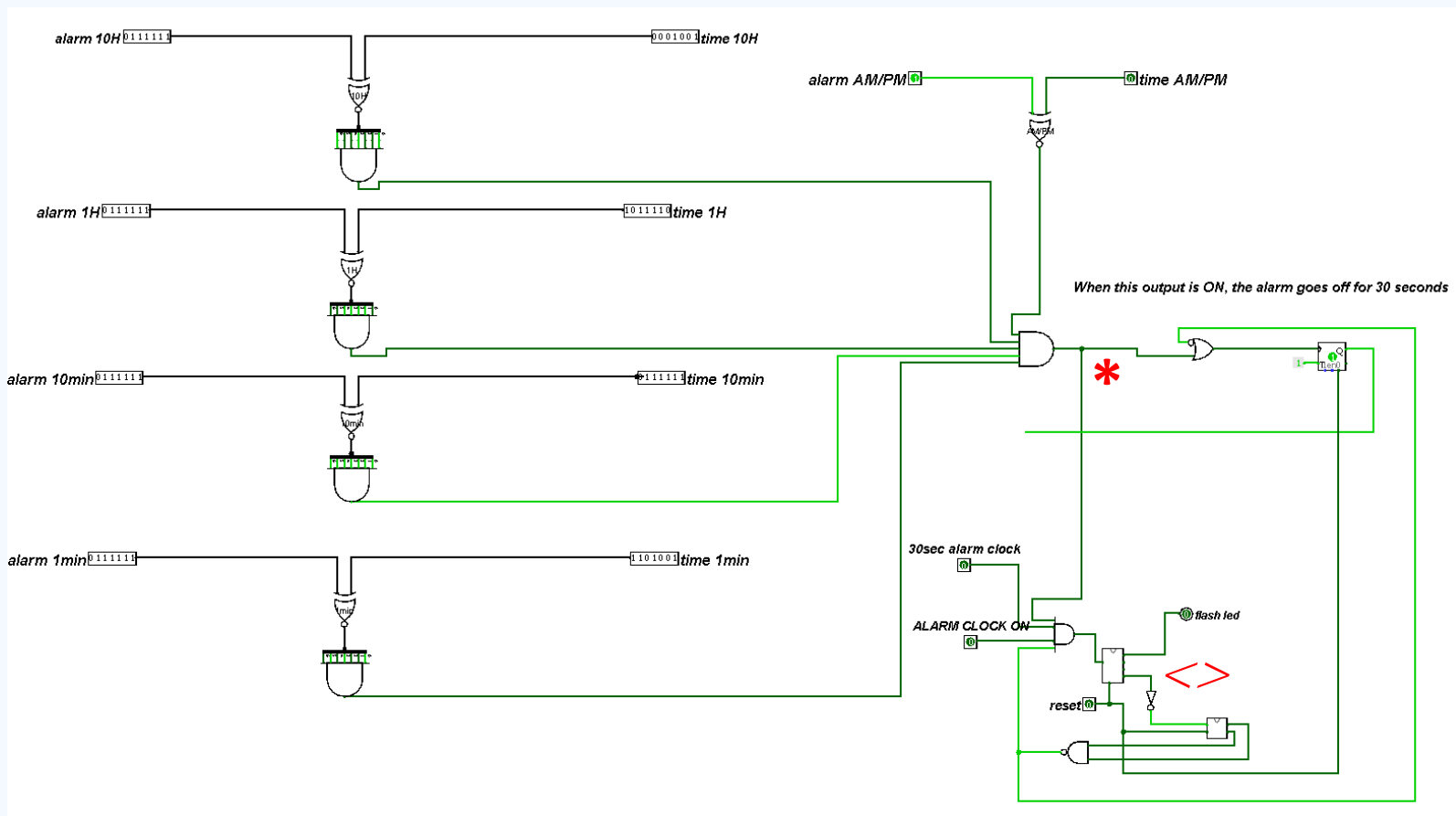
Both the 12 hour and 24 hour system are put together so that they share the same clock output display on the main clock. In the top left there are some inputs for enabling or disabling the system.

AM/PM



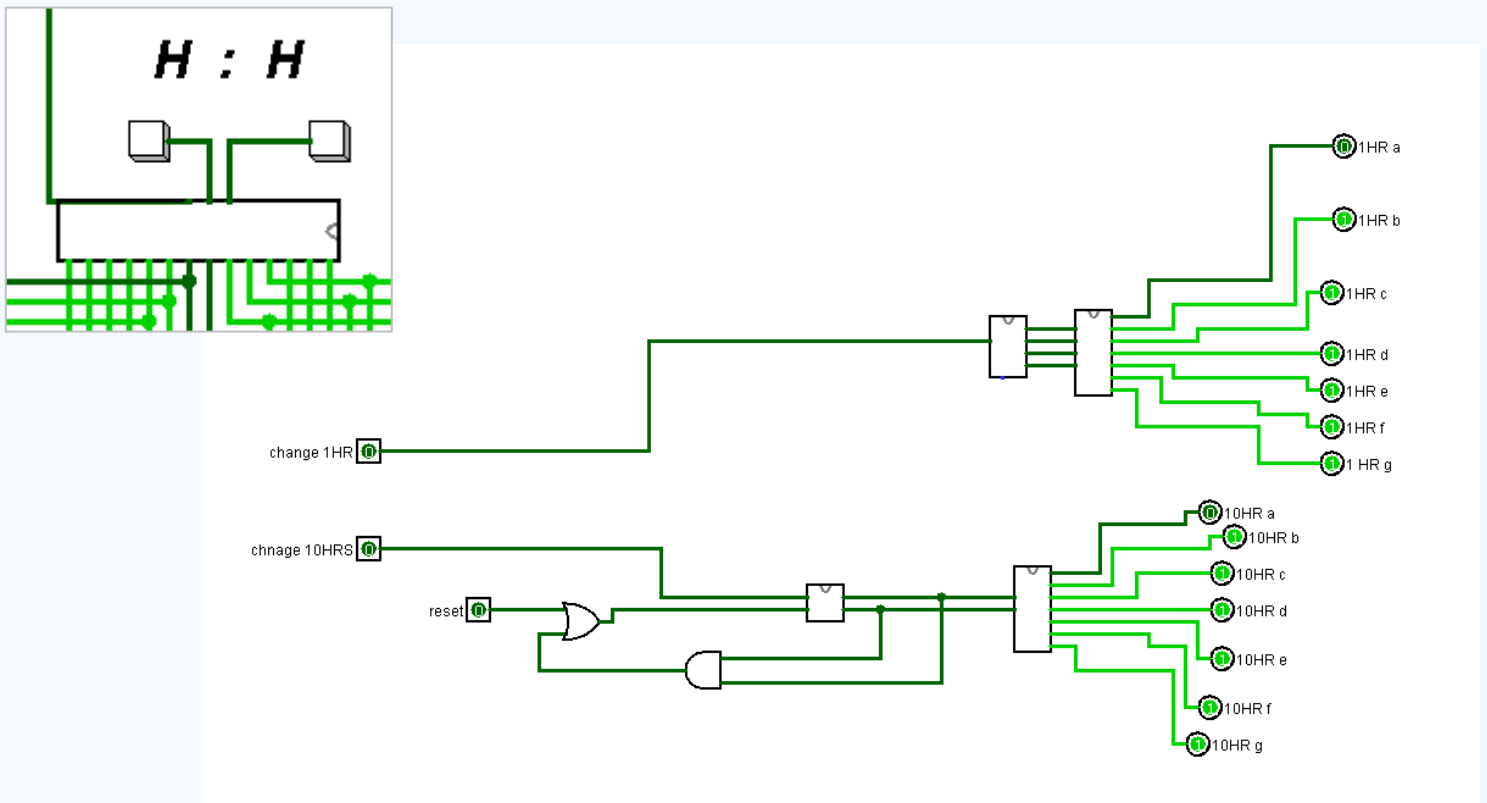
Switches the display from AM to PM.

Alarm_AM/PM



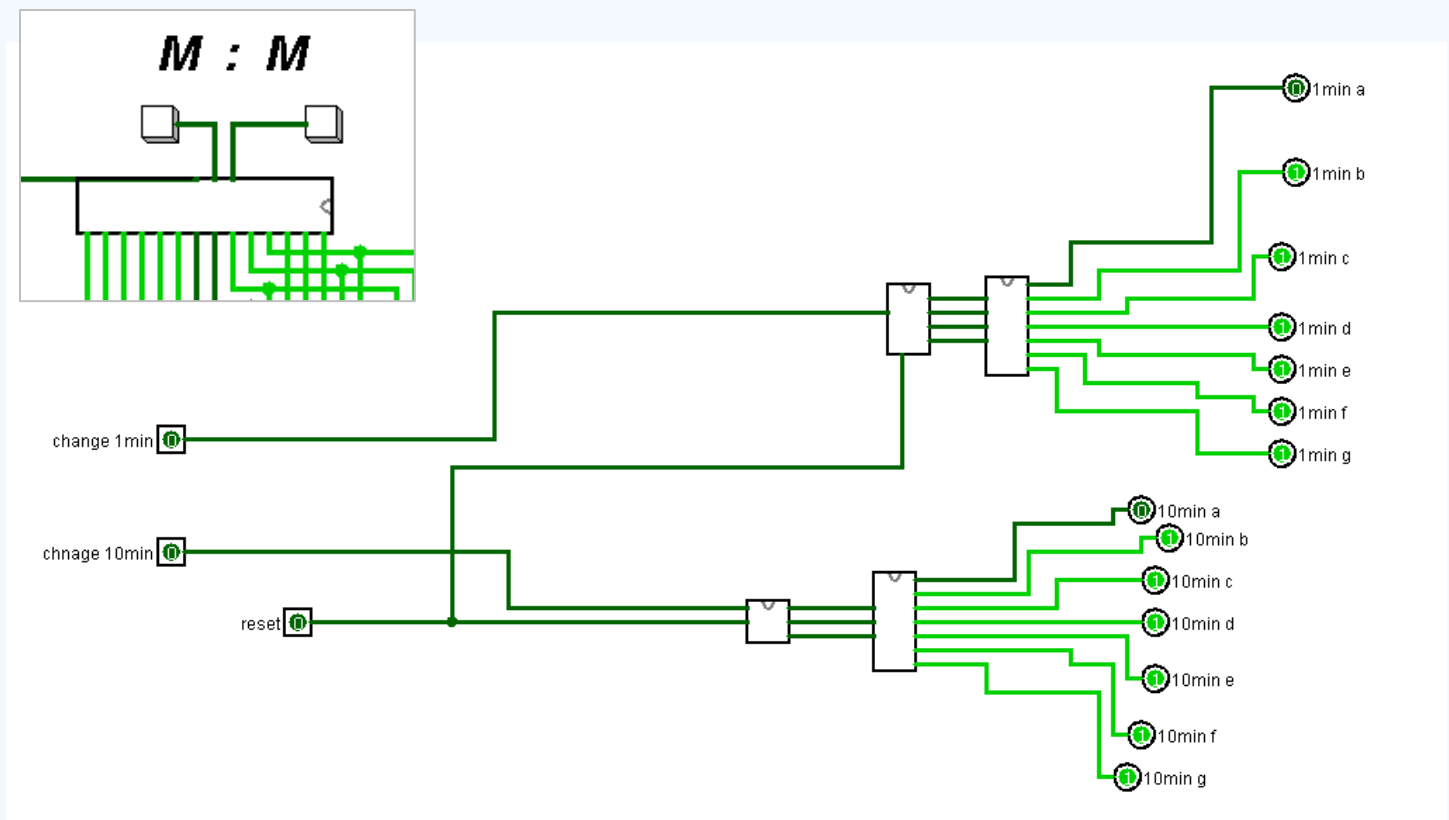
7-bit inputs (from 7segment displays) are compared. If all the bits are the same, the output at * will be ON. This trigger the 30 second timer at <>, made with a modulo-10 and modulo-3 counter. On each count on the modulo-10 outputs a flash to the LED lights in the main circuit.

AM/PM_Hours Select



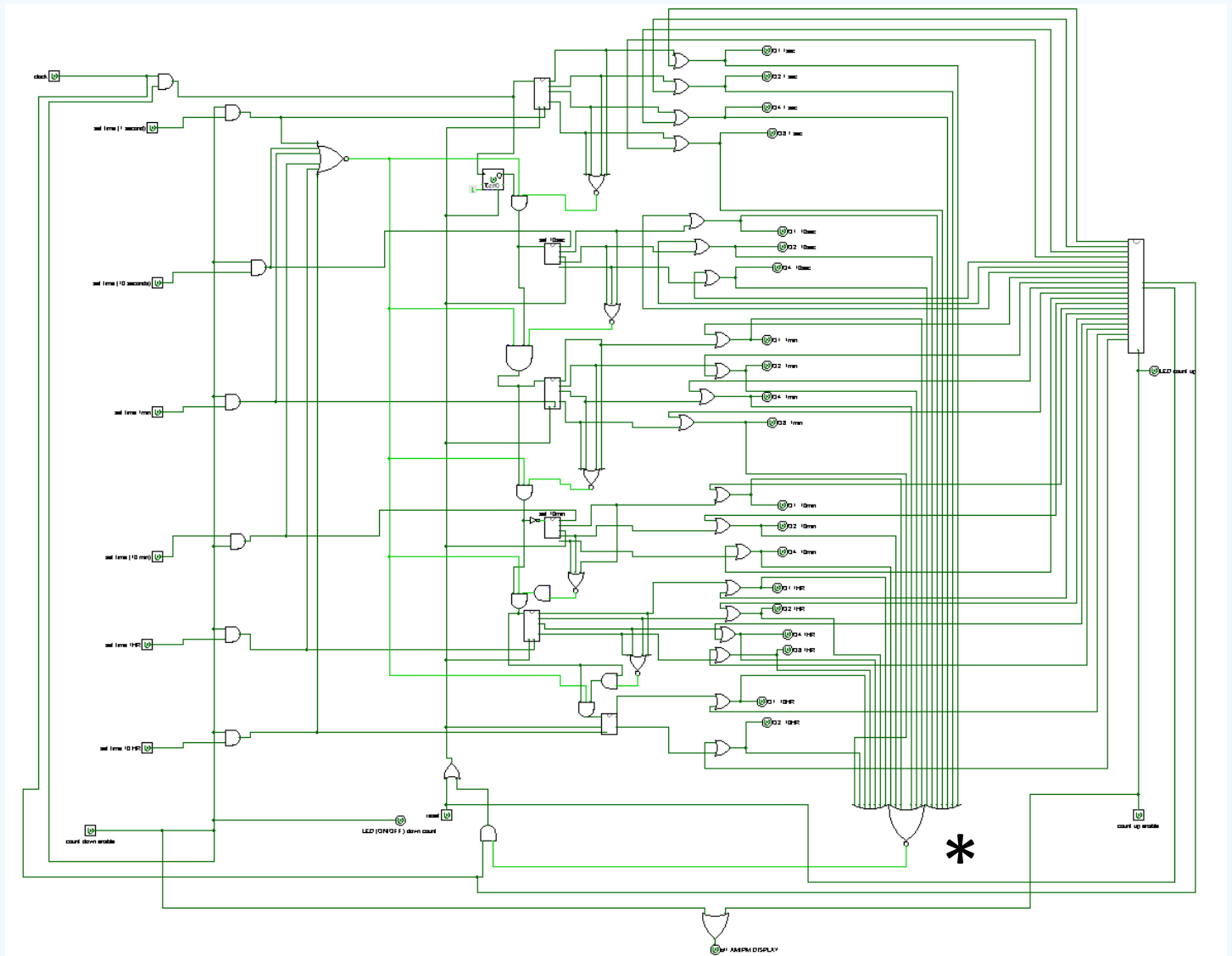
This is used to change the time (hour) at which the alarm will go off. Made of a modulo-10 and modulo-3 counter with converters to 7 segment displays.

AM/PM Minutes Select



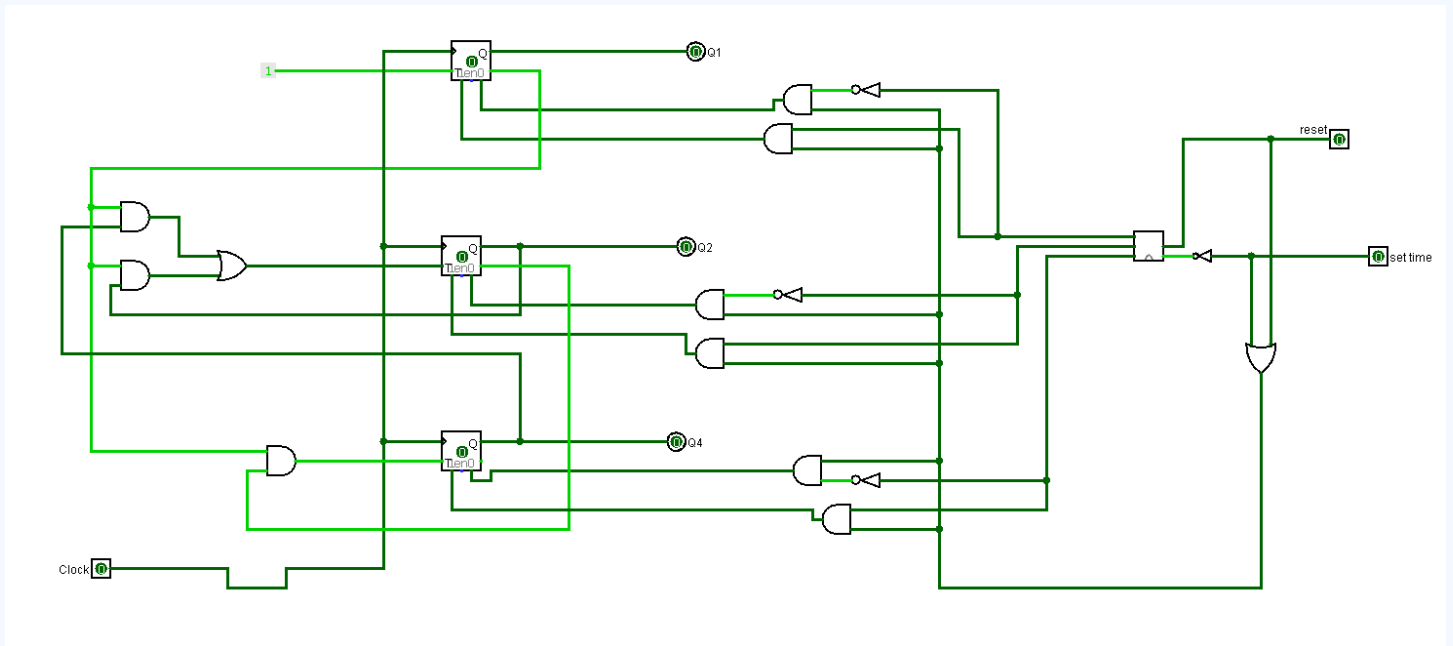
This is used to change the minutes at which the alarm will go off. Made of a modulo-10 and modulo-3 counter with converters to 7 segment displays.

Count Down



This can be set to a time by the user, and then the clock counts down to 00:00. Made up of modulo-3, modulo-10_24, and modulo-6. The NOR gate at * stops the clock at 00:00 permanently and prevents it from restarting.

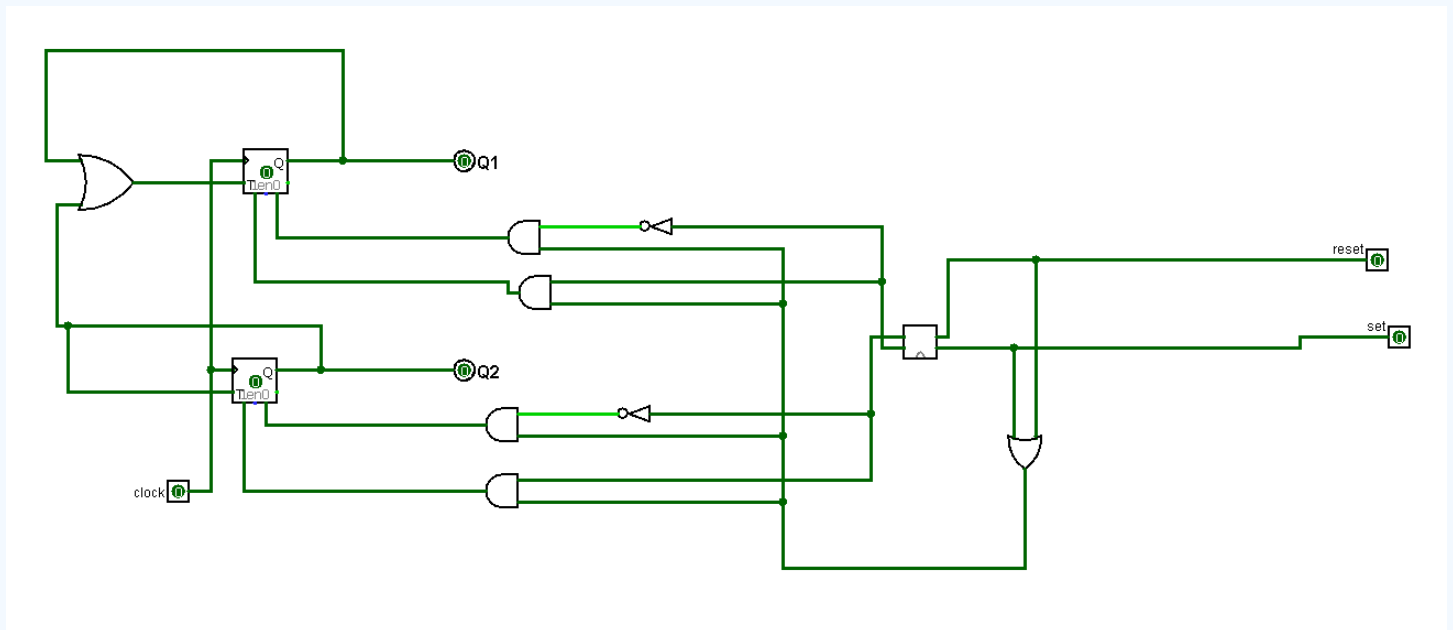
Modulo-6 count down



This circuit is used in the Count Down mode .

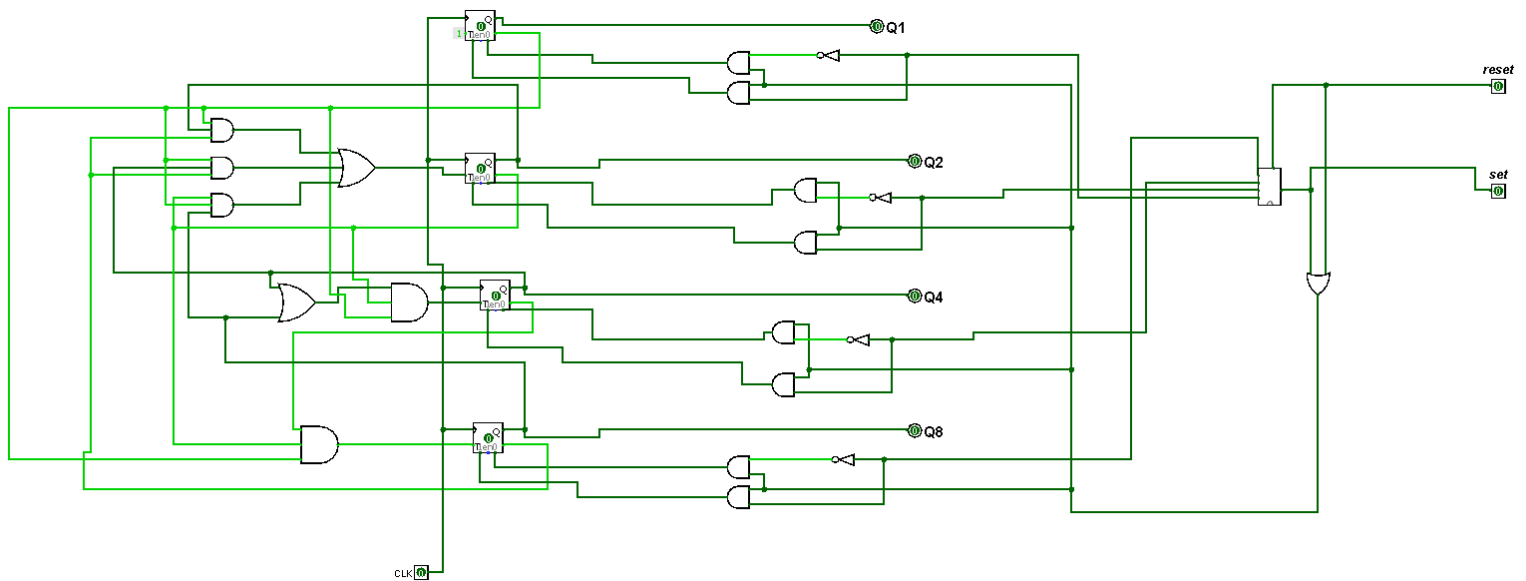
The time can be set to any time using the 'set time' button, and reset to 0 0 0 using the 'reset' button.

Modulo-3 Count Down



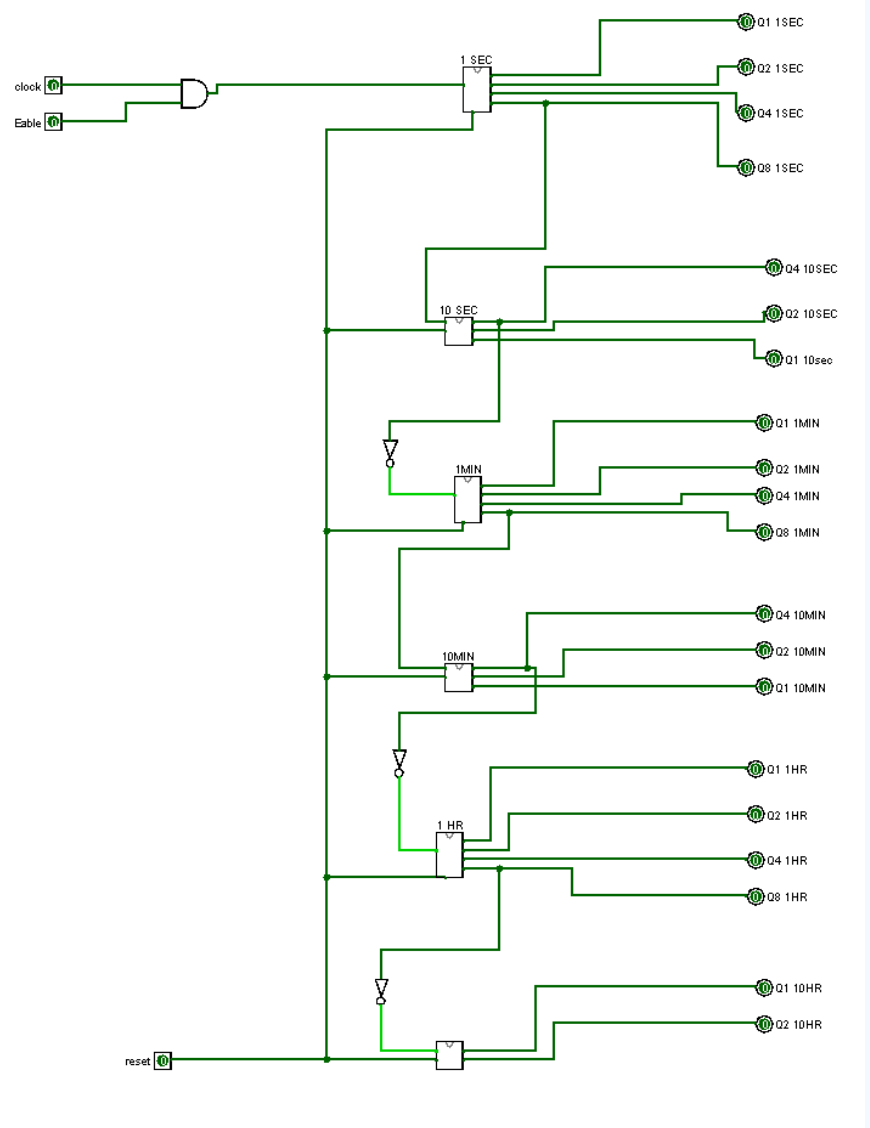
This is used in Count Down mode. The reset button resets to 0 0 and the set button can change to any time (10h, 20h, 0h)

Modulo-10 24 count down



This counts down from 9 to 0 for seconds, minutes and hours in count down mode. It can be used to change to time using the 'set' button or reset to 0 using the 'reset' button.

Count Up



This simply counts up from 00:00 (the time cannot be set) up to 30:00 then restarts from 00:00 again.

It is made using modulo-10, modulo-6 and modulo-3 counters.