COS10004 Computer System

Assignment 1 Report

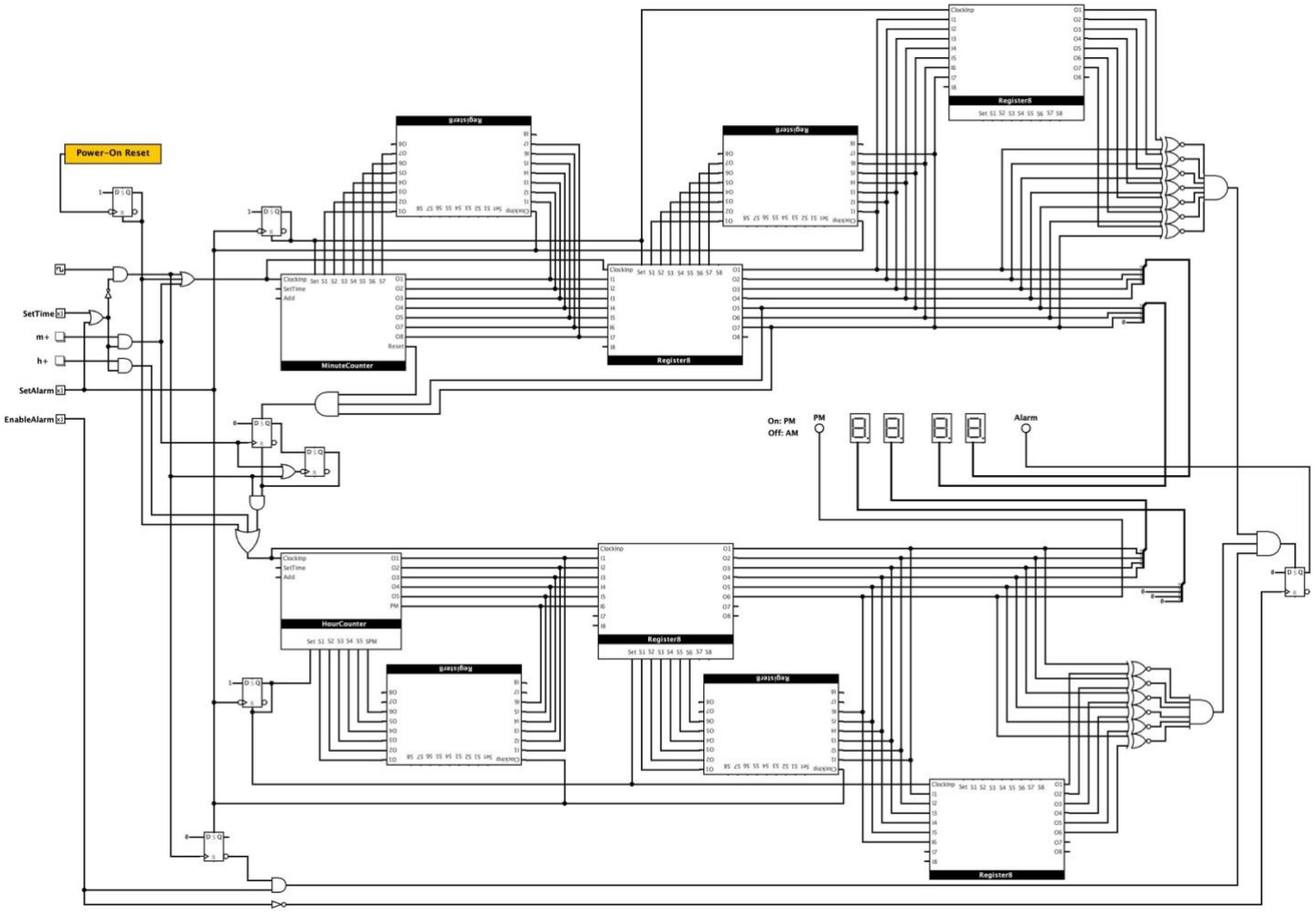
Student name: Kien Quoc Mai
Student Id: 103532920
Lab 17 (Friday 8:30 am EN409)

1. Description

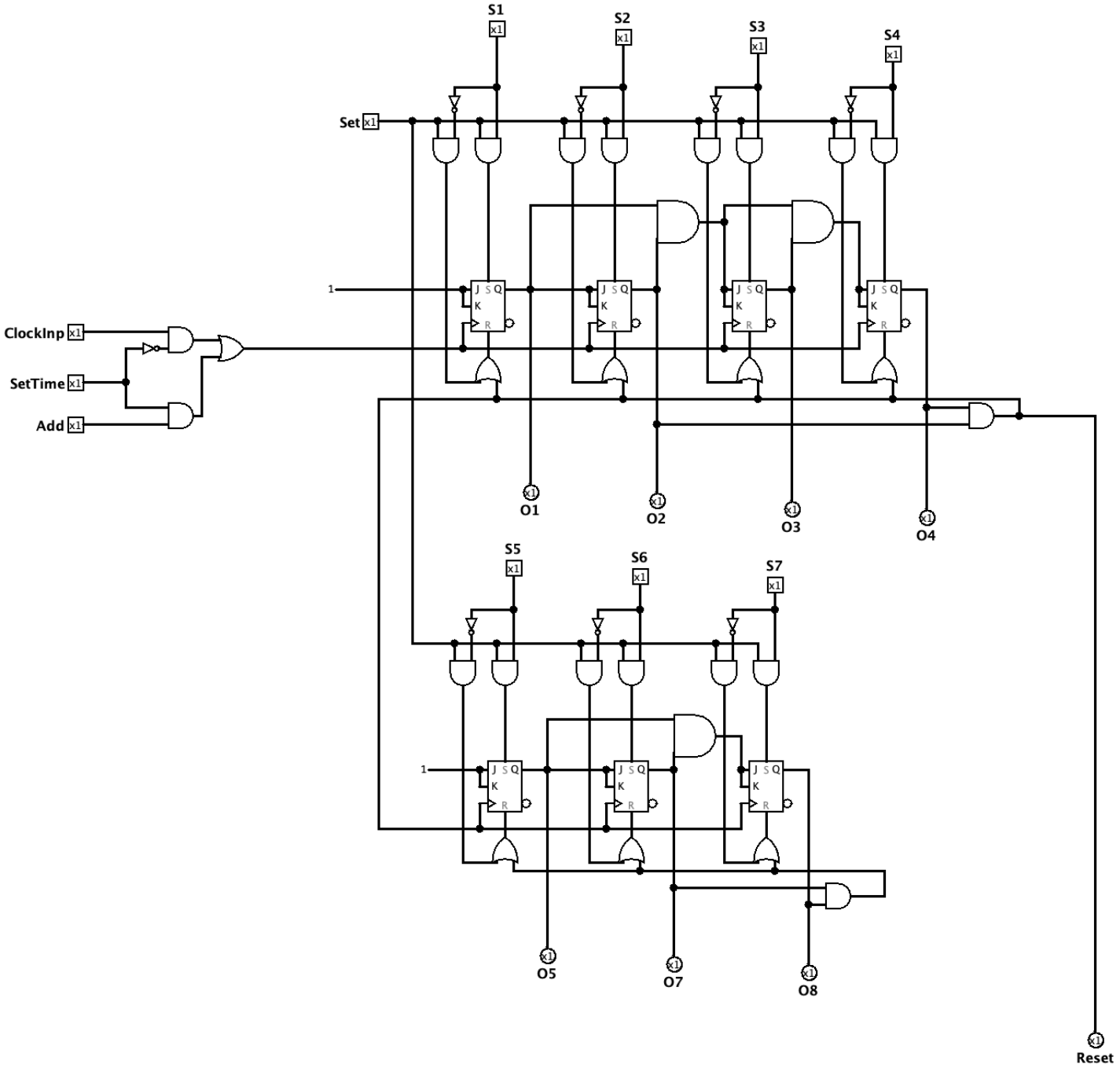
The circuit resembles a 12-hour digital clock with a function to manually set the time. In addition, an alarm can be set at a specific time, and it will be triggered when the clock reaches the set time.

2. Screenshot

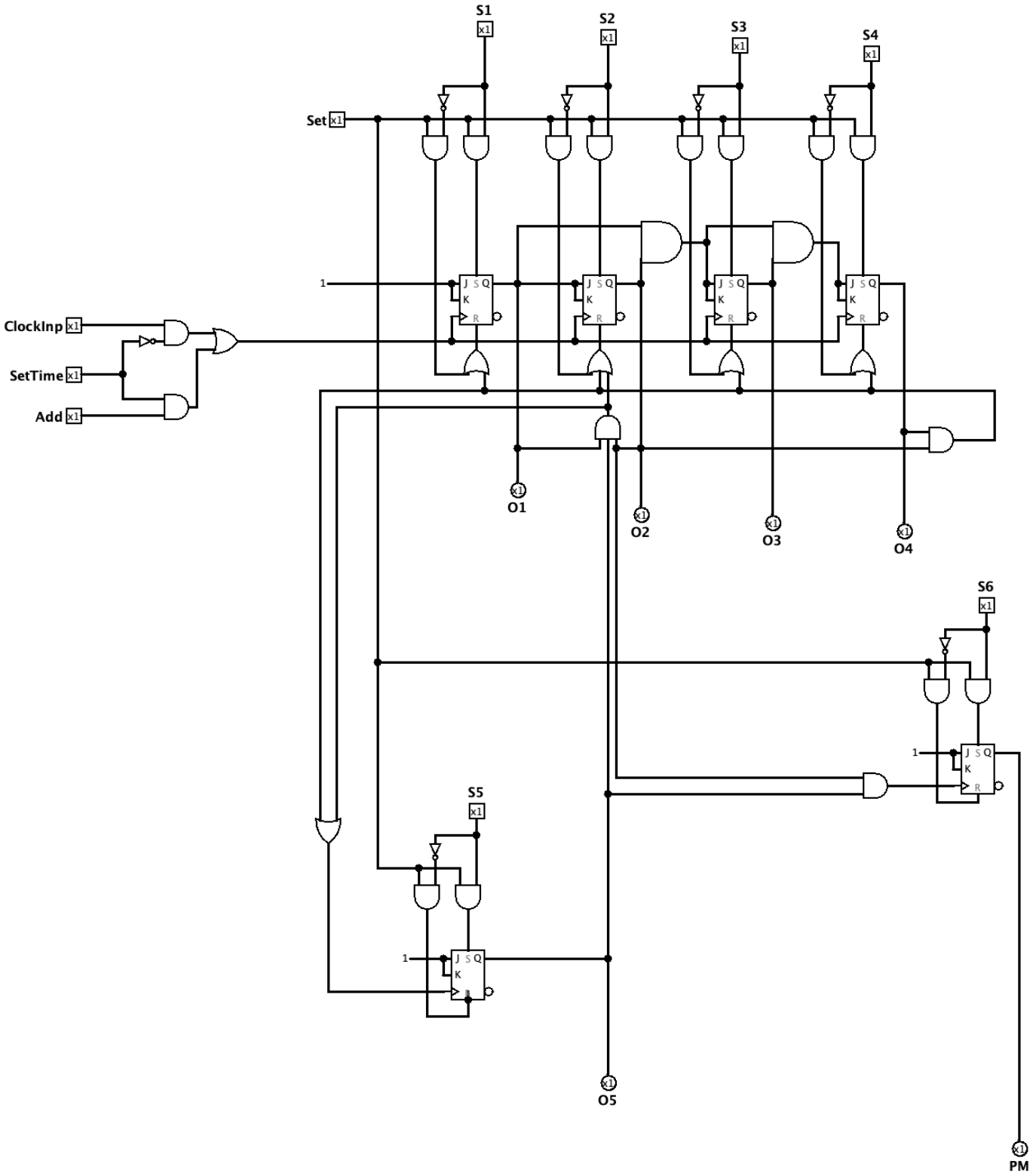
Main circuit:



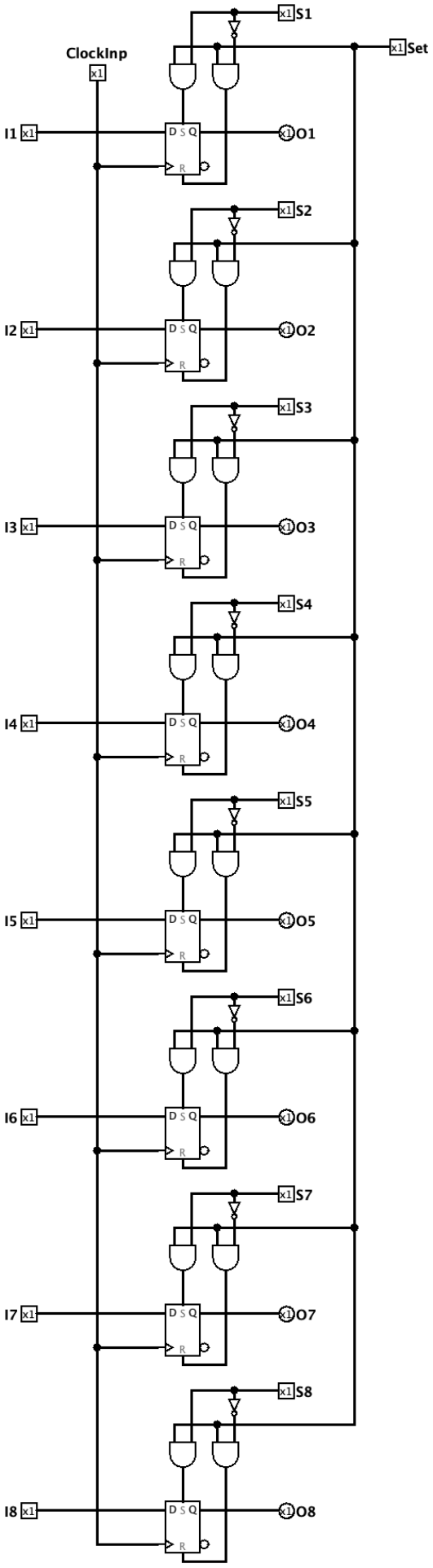
Minute counter circuit:



Hour counter circuit:



8-bit register circuit:



3. Outline

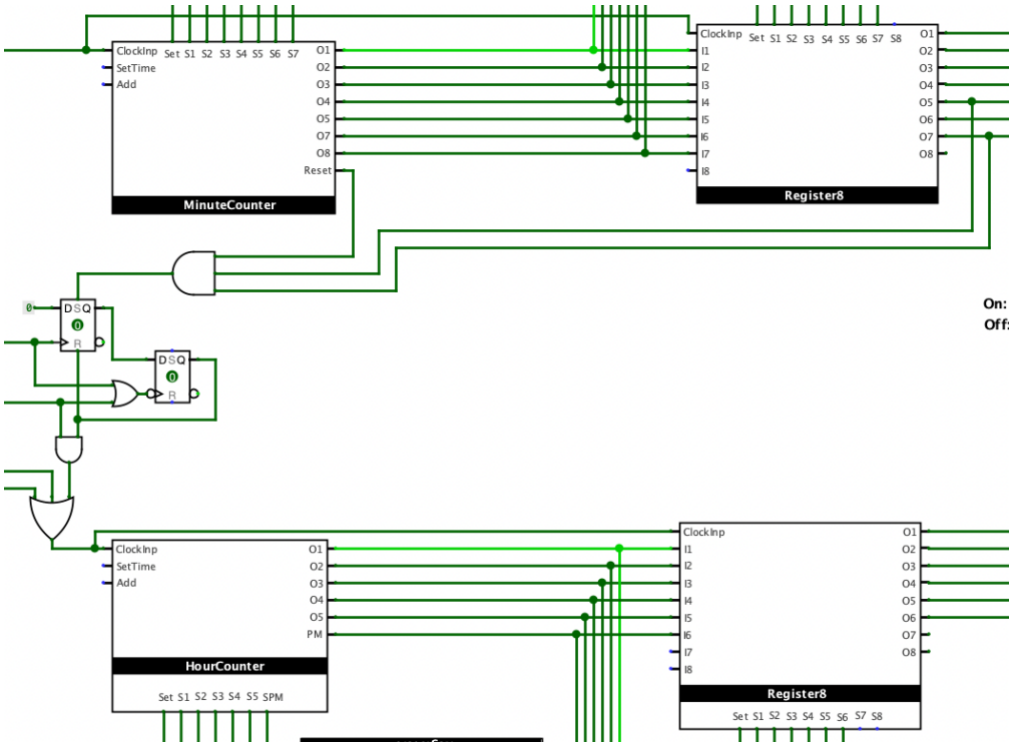
The circuit consists of 5 main components:
- A minute counter
- An hour counter
- Registers for setting and storing alarm
- An input control block
- Output components

The minute counter is built using modulo 9 and modulo 5 synchronous counters for the “units” and “tens” columns respectively. The modulo 5 counter is incremented whenever the modulo 9 counter wraps back to 0 by connecting the reset signal of the latter to the former’s clock input.

Similarly, the hour counter is made up of 2 counters. However, there are 2 reset signals: one when the “units” counter goes back to 0 from 9 and one when the hour wraps back from 12 to 1. The latter is accomplished using both counters’ inputs to create a reset signal. Moreover, as this is a 12-hour clock, there is a circuit to handle AM/PM which is toggled when the hour reaches 12.

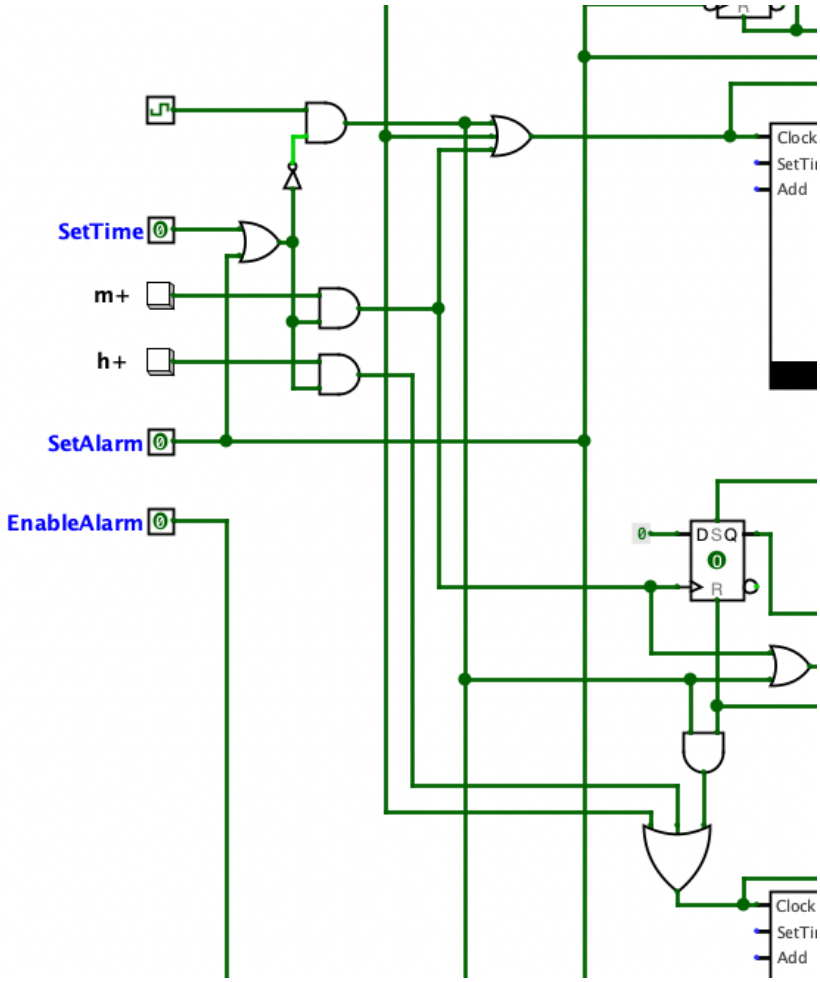
Each of those two counters is connected to a register, which acts as a buffer, to prevent illegal states. Furthermore, both counters can be parallelly loaded using the set/reset input of their JK flip-flops.

A block of control gates is implemented to handle the hour increment whenever the minute counter wraps back to 0. The reset signal from the minute counter is fed into a half-clock buffer that allows the next clock pulse to trigger the hour counter and its buffer.

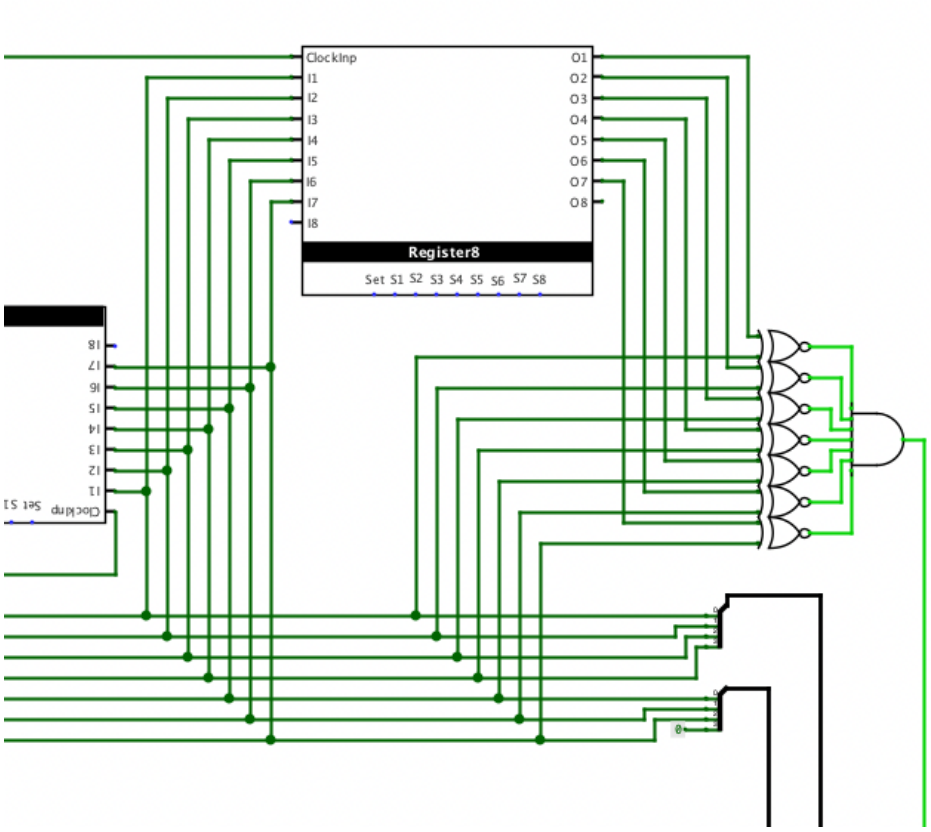


The control circuit includes the following:

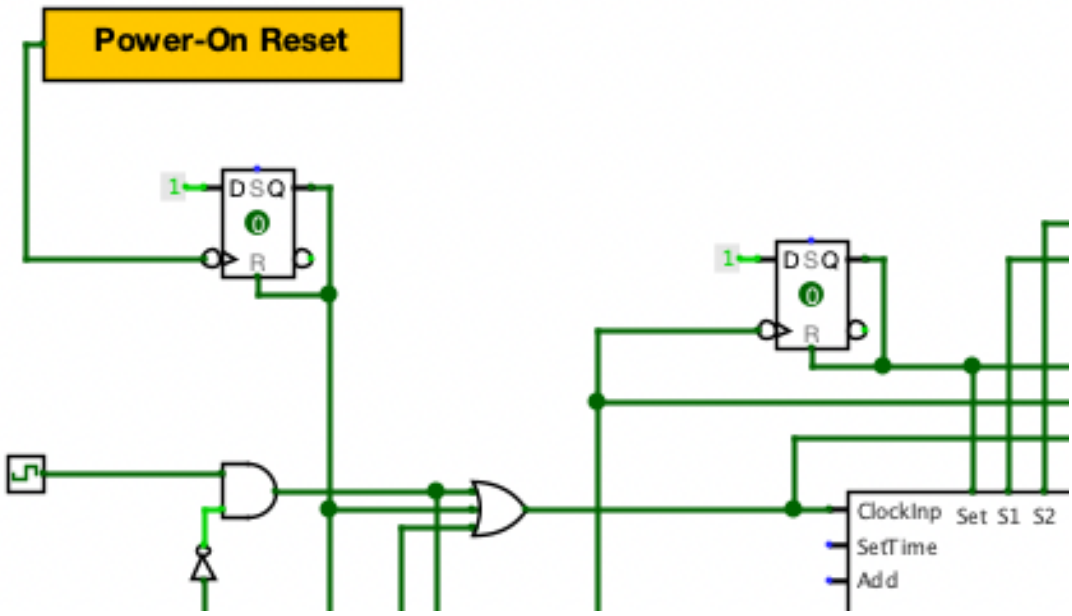
- A “Set time” pin: When set to high, the clock is disconnected from the circuit and the outputs from the “m+” and “h+” buttons are allowed to enter the circuit. When set to low, the clock’s output can pass into the circuit while the “m+” and “h+” buttons are blocked.
- An “m+” button: When clicked, a pulse is sent to the minute counter and its buffer’s clock input, which increments the minute by 1. However, when incrementing the minute from 59 to 00, the circuit is designed so that the hour counter will not be incremented.
- An “h+” button: When clicked, a pulse is sent to the hour counter and its buffer’s clock input, which increments the hour by 1.
- A “Set alarm” pin: When set to high, the current states of the two counters and their buffers are dumped into some registers. At the same time, the output from “Enable alarm” is blocked until the next clock pulse after escaping the set alarm mode. While this pin is high, output from the “m+” and “h+” buttons can pass through to change the time and it is also dumped into some registers to save the alarm time. When this pin is set to low, a falling edge pulse is triggered and the previous states of the clock that is stored in registers will be loaded back into the counters parallelly.
- An “Enable alarm” pin: When set to high, the alarm LED will turn on when the current time reaches the alarm time. When set to low, the alarm LED will turn off and it will not turn on when the current time reaches the alarm time.



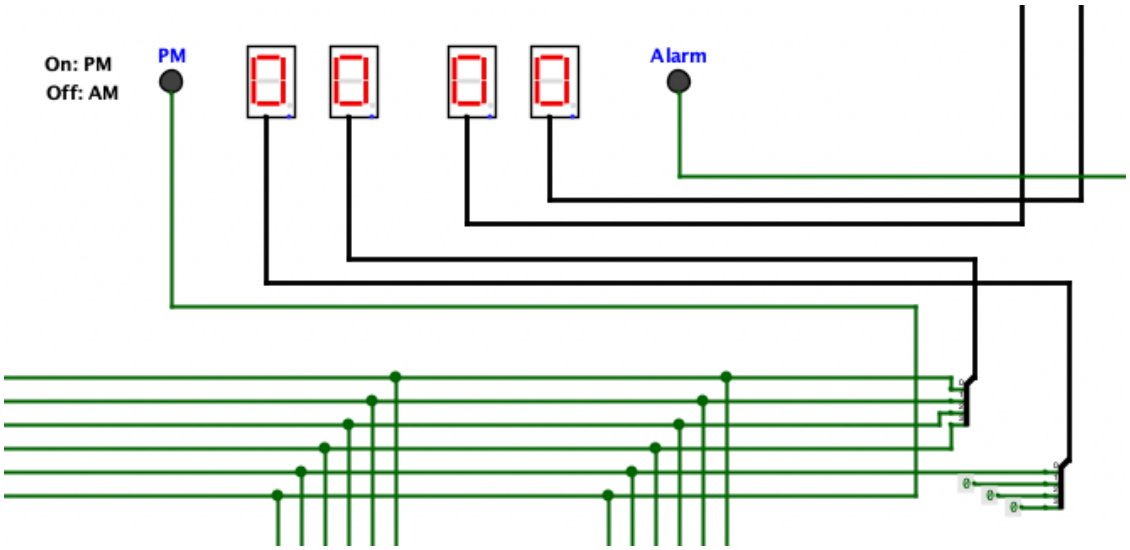
A set of XNOR gates are utilised to determine whether the current time has reached the alarm time or not. XNOR gate value is 1 if its inputs are equal. This is used to compare the current time and the alarm time stored in the registers.



Since the minute and hour counters are one clock pulse ahead of their buffers, the circuit needs to be initialised on the first load. This is accomplished by using the "Power-On Reset" component which is turned on for 1 second when the circuit is loaded for the first time. The output of it increases the minute and hour counter by 1.



The output component consists of two LEDs and a 4-digit hex display. The PM LED is turned on when the time is between 12 pm and 11:59 pm. The alarm LED is turned on when the alarm is triggered. The hex displays take input from the buffers, which is converted to hexadecimal using the splitter, and display the corresponding values.



4. Assumptions

With regard to the alarm function, there is an assumption that when an alarm is set to the current time, the alarm will not be triggered immediately after escaping the set alarm mode. Instead, it is triggered the next time the clock reaches that time. For example, if the current time is 10 am and an alarm is set at 10 am, the alarm will only be triggered at 10 am on the next day. This is true for many real alarm clocks.

5. Unresolved Problems

If the aforementioned assumption is irrelevant, there is a problem with the circuit. The alarm is designed so that it can only be triggered on the following clock pulse after exiting the set alarm mode. This is necessary because when setting the “Set alarm” pin to low, it takes a moment for the clock to be set back to the previous state. At that time, since the time on the display and the alarm time stored in the register matches each other, the alarm will be triggered.