EXPERIMENT 6

6. An Alarm Clock – Phase 1

6.1 Objectives

- More practice on macros.
- First lab to build an alarm clock, which displays minutes and hours.

6.2 Overview

This lab is the first of a series of four labs, in which you will eventually build a digital alarm clock. The clock should display minutes and hours in the seven-segment displays available on the Digilab board. Furthermore, the clock is to have two modes of operation, controlled by an input *MODE* signal.

MODE-0 is the normal mode where the clock displays the current time. In this mode, time can be adjusted by individually adjusting either the minutes or the hours. Two buttons are needed for this purpose. One button is for advancing-minutes (AM-button) and the other for advancing-hours (AH-button).

MODE-1 is the alarm mode, where the clock displays the time at which the alarm is set. In this mode, the AM & AH buttons are used to adjust alarm time. For example, pressing button AH in this mode (MODE=1), advances the hour entry of the alarm time and the clock display shows the alarm time as the hours are advanced. Table 6.1 summarizes the operation of the alarm clock.

Table 6.1: Operation of the Alarm Clock.

MODE	Alarm Clock Function
0	Displays current time. Use buttons *AH* & *AM* to advance the hours & minutes of current time.
1	Displays alarm time. Use buttons *AH* & *AM* to advance the hours & minutes of alarm time.

We need to run our clock at 1 Hz during normal operation. However, when setting the time, we would like to run our clock at twice the speed, i.e. 2 Hz.

6.3 Design Specifications

The digital alarm clock to be designed requires use of five counters

For Current Time Clock:

- Two Mod-60 counters for the seconds and minutes,
- One Mod-24 counter for the hours.

For Alarm Time Clock:

- One Mod-60 counter for the minutes.
- One Mod-24 counter for the hours.

6.3.1 The Clock

Recall, that our specifications required running the clock at

- 1 Hz in normal operation
- 2 Hz (Fast mode) during time setting.

This can be achieved as shown in Figure 6.1 using a multiplexer. A *multiplexer* (also called a *selector*) is a circuit that accepts a number of inputs and outputs one of them depending on some control inputs on the selection lines. In our case, we are using a 2-1 MUX (M2_1). This component (M2_1) accepts two data inputs, D0 and D1, and depending on the value of S0 (the selection line), one of the data lines will be output through the output line O. If S0=0, then O=D0. Otherwise O=D1.
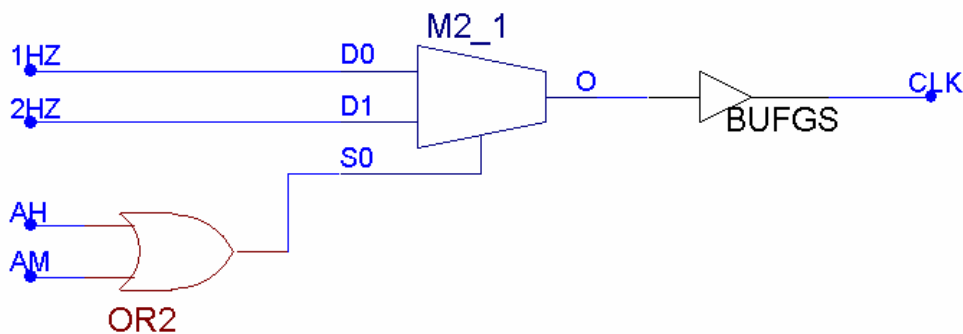

Figure 6.1: Clock Selection logic

A special global buffer, BUFGS, is used to derive the clock. This buffer ensures that the clock signal is not only buffered but it also reaches the different regions at the same time, a very important requirement for correct operation of clocked circuits.

6.3.2 Modulo-24 Counter

In previous lab, you designed modulo-10, modulo-6 and eventually a modulo-60 counter. Similar to the counters you designed previously, modulo-24 counter counts from 0 to 23 and then roll backs to 0. In this lab we require modulo-24 counter for keeping track of hours in our digital-clock.

The modulo-24 counter is very similar to a modulo-60. The difference with modulo-60 counter is in the way the asynchronous clear signal is generated. In mod-24 counter we need the following:

- Clear the Least Significant Digit (LSD) of hours if it counts to a value 10 and the Most Significant Digit (MSD) of the hours is not two.
- Clear the Least Significant Digit (LSD) of hours if it counts to a value 4 and the Most Significant Digit (MSD) of the hours is equal to two.
- Reset the mod-24 counter to all zeros if we reach the value of 24, i.e. 24 hours.

Based on the above logic, you need to design a macro for mod-24 counter.

6.3.3 Current Time Mode (Mode-0).

The current time clock consists of the seconds, minutes, and hours counters.

The seconds counter should be enabled all the time unless the current time is being adjusted.

The minutes counter should be enabled if:

- The seconds counter shows 59 and the seconds counter is enabled. OR
- The minutes counter is manually incremented.

The hours counter should be incremented if:

- Both the seconds and the minutes counters show 59 and the seconds counter is enabled. OR
- The hours counter is manually incremented.

6.3.4 Alarm Time Mode (Mode-1).

The alarm time clock consists of the minutes, and hours counters.

The minutes counter should be enabled only if the minutes counter of the alarm time is being adjusted manually.

The hours counter should be enabled only if the hours counter of the alarm time is being adjusted manually.

6.4 Pre-Lab

Bring the following from the previous labs:

- One & two Hz clock macros you developed in previous lab.
- MOD60 counter built in the previous lab
- Design and bring, modulo-24 counter. Call it as MOD24 (you must have only six outputs and no CEO).

6.5 In-Lab

6.5.1 Mod-24 Counter

1. Start a new schematic.
2. Import your designed mod-24 counter.
3. Connect the clock input of the macro to the output of the 1Hz clock Macro
4. Connect the input for clock macro to internal clock available at P13.
5. Constraint the six outputs to six LEDs. Use the input/output macros you previously developed.
6. Implement and download the design. Verify the operation on the board.
7. Demonstrate your work to the instructor

6.5.2 The Clock

8. Start a new schematic.
9. Import the clock selection logic shown in Figure 6.1.
10. Connect the proper inputs of the logic to the outputs of the clock Macro
11. Connect the input for clock macro to internal clock available at P13.
12. Connect the select input of the multiplexer to a button switch BTN1.
13. Constraint the output to a LED. Use the input/output macros you previously developed.
14. Implement and download the design. Verify the operation on the board.
15. Demonstrate your work to the instructor

6.5.3 Chip enabling logic

Based on section 6.3.3 design the following:

16. The chip enabling logic for the seconds counter.
17. The chip enabling logic for the minutes counter.
18. The chip enabling logic for the hours counter.
19. Full schematic of the current time clock with the chip enabling logic.