# Project 3: Digital System Design

**Instructor Prof. Joanne E. Degroat**

This project will be completed in groups of two. If you cannot find a second group member, let the instructor know within a week of the project assignment.

## Project Description

Design an alarm clock using the system controller approach. The clock uses military time (00:00 – 23:00).

**Inputs:**

- **CLK**: a 2 Hz clock signal.
- **AON**: when asserted, alarm is enabled.
- **SALARM**: when asserted,
  - **DHR** is **AHR**
  - **DMIN** is **AMIN**
  - **HRUP**, **MINUP** will increment **AHR**, **AMIN** (respectively) at 2 Hz while **SALARM** remains asserted.
- **STIME**: when asserted,
  - **DHR** is **HR**
  - **DMIN** is **MIN**
  - **HRUP**, **MINUP** will increment **HR**, **MIN** (respectively) at 2 Hz while **STIME** remains asserted.
- **HRUP**: when asserted with **SALARM**, increments **AHR**. When asserted with **STIME**, increments **HR**. No effect if neither **SALARM** nor **STIME** is asserted. Increments continue at 2 Hz while **HRUP** remains asserted.
- **MINUP**: when asserted with **SALARM**, increments **AMIN**. When asserted with **STIME**, increments **MIN**. No effect if neither **SALARM** nor **STIME** is asserted. Increments continue at 2 Hz while **MINUP** remains asserted. Overflow of **AMIN** or **MIN** does not cause **AHR** or **HR** to increment.

- **SNOOZE**: when asserted, causes **AMIN** to be incremented by one. Increments occur at 2 Hz while **SNOOZE** remains asserted.

Note: **SALARM** has priority over **STIME**.

**Outputs:**

- **DHR[4:0]** displays the hour (a binary number between 0 and 23). **DHR[4]** is the MSB. Note: can display either the hour of day or the hour that the alarm will sound, depending on **SALARM** and **STIME**. Hint: multiplexer.
- **DMIN[5:0]** displays the minute (a binary number between 0 and 59). **DMIN[5]** is the MSB. Note: can display either the current minutes-past-the-hour or the minutes-past-the-hour that the alarm will sound, depending on **SALARM** and **STIME**. Hint: multiplexer.
- **AENABLED**: asserted when **AON** is asserted. This causes a small light to be illuminated on the front panel of the clock.
- **ALARM**: asserted when **AON** is asserted, **STIME** and **SALARM** are not asserted, **HR** = = **AHR** and **MIN** = = **AMIN**. This causes a loud buzzer to turn on.

**Data units:**

- **HR[4:0]**: a 5-bit register holding the current hour of the day (0-23). **HR[4]** is the MSB.
- **MIN[5:0]**: a 6-bit register holding the current minute of the hour (0-59). **MIN[5]** is the MSB.
- **SEC[5:0]**: a 6-bit register holding the current second of the minute (0-59). **SEC[5]** is the MSB.
- **AHR[4:0]**: a 5-bit register holding the alarm hour (0-23). **AHR[4]** is the MSB.
- **AMIN[5:0]**: a 6-bit register holding the alarm minute (0-59). **AMIN[5]** is the MSB.

Note: When **SEC** overflows, **MIN** should be incremented; when **MIN** overflows, **HR** should be incremented.

Design a system controller that manages the operation of this clock. At a minimum, there should be a state for normal operation (keeping time), a state for setting

the alarm time and a state for setting the time-of-day. Be sure to document the system controller in your report by giving its state diagram and other steps to implement it.

Implement and simulate your design in the *Xilinx* environment. You may use either VHDL or schematic entry to implement this design. Simulations should demonstrate proper time keeping (including overflow of **HR**, **MIN**, and **SEC**), proper handing of **STIME**, **SALARM**, **HRUP** and **MINUP**, proper control of **DHR** and **DMIN** and proper control of **AON**, **AENABLED** and **ALARM**. In your simulations, group the signals of **HR**, **MIN**, **SEC**, **DHR**, **DMIN**, **AHR**, **AMIN** into buses and display their values in decimal so that the instructor may follow your simulation results.

You will need to make assumptions about the design to handle issues not specified above. State any such assumptions made.

## Project Report Format

The report should be typeset on 8.5" × 11" paper and conform to the following specifications:

1. There should be a title page which includes the project number, the names of the group members, and the date the project is due. The title page should not contain a page number.
2. Pages should be numbered consecutively, with the title page as page number 1. See below for page numbering of the appendices.
3. The body of the report should be narrative and include the sections enumerated below. Each section should be designated with a section heading and numbered. Each section, however, does not necessarily need to begin on a new page.

    (a) **Introduction:** A succinct discussion of the project and its goals.
    (b) **Design:** Gives details of any design process that was used in the project. It should include, but is not limited to, the problem definition, method of attack, rationale of the methods, simulation, and analysis. It should also include any problems you encountered with your design and/or the software. Think of any possible reasons that cause the problem.
    (c) **Results:** Includes the data you gathered for the project. This data should be presented in a clear, concise format such as in a table, list, or other form. This section should also include answers to any questions posed in the project handout.
    (d) **Comparisons:** Includes discussion of the similarities and differences between the results you expected *before* running the circuit and what you obtained from the simulations.
    (e) **Conclusions:** Final summary of the project. Include what you learned, what was unexpected, and any additional observations you wish to make. If you couldn't successfully complete the project in any way, you can put the reasons in your conclusion.

4. All data such as trace printouts, schematics, simulation lists, any detailed derivations, or any other item which would interrupt the flow of the body of the report should be included as an *appendix*.

    (a) Appendices should be lettered and include a title which indicates the content of the appendix.
    (b) If a particular appendix consists of multiple pages, number them sequentially along with the letter of the appendix (i.e., "B1, B2, B3, . . . ").
    (c) When referencing data in your report, include a parenthetical reference to the appropriate appendix. For example, " . . . this delay can be seen in the timing trace (Fig. 1, A3).".
    (d) Provide a caption for each of your figures, tables, lists, etc.

Those listed above are just suggestions. You can cover other things if you think they are important. In general, take the project reports as a practice for your future job. It is essential to be able to write a good report at work.

The bottom line on grading the report is that the majority of the grade will be based on the simulation results, circuitries, and your answers to each problem. However, a well-written report is necessary in order to get a good grade on the project.