ECSE-323

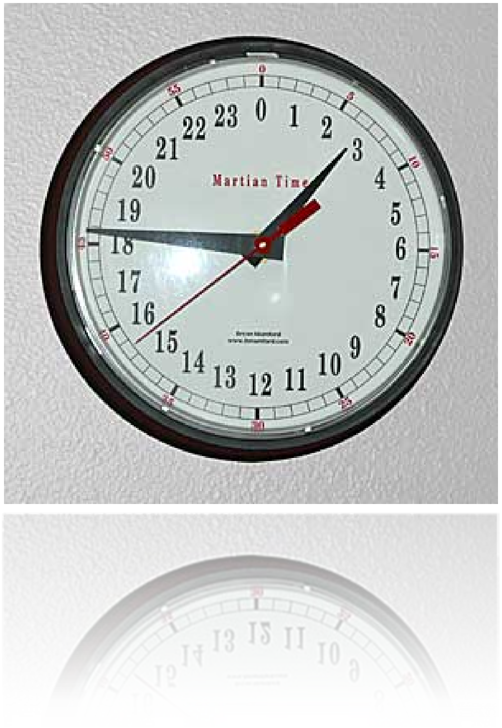
Digital System Design

Lab #5 – ***System Integration for the Mars Clock System***

Winter 2014

Introduction

In this lab you will put together all of the parts for the complete Mars Clock system and implement it on the Altera DE-1 board.



(Image from http://www.bmumford.com/clocks/martian/)

Learning Outcomes

After completing this lab you should know how to:

• Get a complete digital system working on the Altera board, and will have gained experience in implementing user interfaces.

Table of Contents .

This lab consists of the following stages:

1. Design of the time zone circuitry
2. Design of the user interface circuitry
3. Integration of all the parts to form the complete system
4. Testing of the complete system on the Altera board
5. Writeup of the lab report

System Specifications

The complete system must provide the following functions:

Display of the Time on Mars

• In this mode, the system displays the time on Mars in the selected time zone.

Display of the Time on Earth

• In this mode, the system displays the time on Earth int the selected time zone. Also display (using a single LED) whether Daylight Savings time is enabled.

Display of the Date on Earth

• In this mode, the system displays the date (Day/Month/Year) on Earth. There is no Mars date display function.

Setting of the Martian and Earth Time zones

• In this mode, the user can select which time zones to use in displaying the Earth and Mars times.

Setting of theTime and Date on Earth, including Daylight Saving Time

• In this mode, the user can set the time and date on Earth. You may wish to split up the time and date setting functions. Your system should allow setting of dates from January 6 2000 to at least January 1 2100. Manually indicate whether or not Daylight Savings time is in effect (i.e. just use a switch to manually indicate this rather than having the system determine it from the current date).

Synchronization of Earth and Mars Times

• In this mode, pressing a button should synchronize the time on Mars with the currently set time on Earth.

Setting the Time Zones on Earth and Mars.

As mentioned in lab 4, on Mars, as on Earth, there are 24 time zones. Unlike on Earth, the Martian time zones are all equally spaced, at 15 degree intervals.

Your Mars Clock system should keep track of the time zones on both Mars and Earth, and correct the displayed times accordingly. The time counters should always be providing the time at the prime meridians (e.g. the Greenwich meridian on Earth, and the prime meridian of Mars as defined by the location of the crater Airy-0).

Thus, you will have to add some circuitry for the user to enter in the values (0-23) of the time zones on Earth and Mars and you will have to modify the time display to include an offset of the hours based on the time zone.

You will also have to modify the time setting circuitry of the Earth clock, to account for the time zone (you want to provide the time at the desired time zone, but set the time counter to Universal time).

The Earth time zone is represented by a number that varies from -12 to +11, with 0 corresponding to the time zone of the Prime Meridian (Greenwich meridian).

The time zone for Montreal in this approach is represented by the number -5.

You should also implement the modification in the time imposed by Daylight Saving Time (DST), which should shift the displayed time ahead by one hour when DST is enabled. Note that DST does not affect the UTC time that is kept by the Earth counter. Also, note that there is no such thing as DST on Mars.

To determine the time zone for a location on Mars, divide the longitude of the location by 15 degrees, take the integer part. If this number is greater than 11, subtract 24. Longitude on Mars is relative to the location of the *Airy Crater* which is assumed to have a longitude of zero.

For example, suppose you want to know what time it is on Olympus Mons on Mars, when it is midnight on April 11, 2014 (the time that the lab report is due!) on Mount Royal.

The time zone on Earth for Montreal is UTC – 5 (where UTC, or Universal Time, is the time at the Prime Meridian of Earth, and the time that is kept by the Earth time counter). But since April 11 is in Daylight saving time to display the time on Mount Royal you would subtract 5 from the Earth hours count and then add 1.

To set the time to correspond to midnight at Montreal on April 11, 2014, you would actually set the Earth counter to 4 am on April 12, 2014.

The longitude for *Olympus Mons* on Mars is 226.2 degrees. Its time zone representation is *floor*(226.2/15) = 15. Since this is greater than 11 we subtract 24, to give -9 as the time zone (i.e. Olympus Mons is 9 Martian hours behind the Airy crater). Thus, to display the time at Olympus Mons we have to subtract 9 from the Mars time clock value.

Design of the User Interface .

You need to integrate all of the parts of the system together and provide a ***User Interface***. This permits the user to move between operation modes.

Such a system integration is often most easily accomplished using a datapath/controller approach. The controller FSM will handle all external user inputs (such as button presses) and guide the operation of the datapath elements (such as your HMS and YMD counters, and the synchronization subsystem) to carry out the desired functions.

Use all of the resources that you have at your disposal on the Altera board to make the user interface as easy on the user as possible.

Tip: Provide an asynchronous reset, connected to one of the pushbuttons on the Altera board, to all of your sequential modules, so that you have a way for the user to rescue the system from invalid or stuck states.

Design of the Complete System .

You now have all the parts needed to make your Martian clock. Use VHDL, with component instantiation statements to include the modules you have designed, to describe the complete system, using the approach you used in previous labs to make testbeds.

Testing of the Complete System on the Altera Board.

Once you have the full system designed, compile it and download it to the Altera board.

Demonstrate the functioning of your system to the TA showing the following items:

- **Setting of the Earth Clock and Calendar** – demonstrate the setting capability for at least three different times and dates.
- **Display of the Earth Time and Date -** set the time to 11:59:59 and run the Earth clock for a few minutes to show that the time changes correctly. Show that the Daylight Saving Time switch correctly modifies the time being displayed.
- **Display of the Mars Time -** run the Mars clock for a few minutes. Observe that it runs slightly slower than the Earth clock.
- **Setting and Display of the Mars and Earth Time Zones**
- **Synchronization of the Earth and Mars Clocks -** demonstrate proper synchronization by comparing the current Earth and Mars times to that provided by the current Mars time app: ***http://jtauber.github.io/mars-clock/***
- For your report, determine the time at Olympus Mons on Mars, at the following Montreal dates/times: midnight April 11, 2014; 2pm April 23, 2014; 5pm April 23, 2014
- How many Martian hours would the DSD final exam take?

Writeup of the Lab Report

Write up a report for the complete ***Mars Clock*** system that you designed.

The report must include the following items:

- A header listing the group number and the names and student numbers of each group member.
- A title, giving the name of your system.
- A description of the system's features (i.e. what it does).
- A block diagram of the entire system.
- A *detailed* description of how your system works, referring to the block diagram.
- A description of the user interface (e.g. a users guide to operation).
- A discussion of how the complete system was tested. Include details of all test cases used.
- A summary of the FPGA resource utilization.
- A conclusion section discussing problems or significant issues that arose during the design process, as well as a discussion of possible enhancements or extensions that could be made to your system.

Some items to remember when preparing the report for lab #5:

- All diagrams, tables, and figures should have captions describing the contents of the figure and be given a figure number.
- All such figures must be referred to in the text of the report. Do not just throw a figure into the report without referring to it. Figures should be used to augment the textual matter.
- If you include figures or text taken from other sources, be sure to cite these properly. **Avoid plagiarism!** All VHDL descriptions must contain the name(s) of the designer(s) and the date written.
- Hand-drawn figures and diagrams are not acceptable!
- Turn off the grid in the Quartus schematics when making screenshots!
- Break large block diagrams into multiple smaller ones when inserting them into the report.
- Do not include long vhdl descriptions into the report. Instead, include the .vhd files in your report submission zip file.

Don’t wait until the last day to start writing the report. Start writing it early on in the lab 5 period. The report is due on the last day of classes, and not one week later!

The report should be done in html or pdf (preferred), or in Microsoft Word, and uploaded to the WebCT site using the lab #5 assignment submission icon.

The presentation of the report (grammar, spelling, and clarity of the diagrams) will also be graded. *Professor Clark will grade the final reports.*

Make sure that you have uploaded ***all*** of the design files (e.g. .bdf and .vhd files) used in your project. Also include the device programming file (.sof or .pof file) so that Prof. Clark can download your design to his Altera board.

The report is due at midnight on the last day of classes, *Friday, April 11*.
Late submissions will be accepted, but will be assessed a penalty of *2 marks per day*, (out of a possible maximum of 10).

Grade Sheet for Lab #5

Winter 2014.

Group Number:______________.

Group Member Name:_______________. Student Number:__________________.

Group Member Name:_______________. Student Number:__________________.

Marks			TA Signatures
	1.	Hardware demo – Setting and display of time zones	
	2.	Hardware demo – Earth time and calendar setting	
	3.	Hardware demo – Display of the Earth and Mars time clocks	
	4.	Hardware demo – Enabling of the Daylight Saving Time	
	5.	Hardware demo – Earth and Martian time synchronization	
	6.	Hardware demo – Earth-Mars time comparisons	

Each part should be demonstrated to one of the TAs who will then give a grade and sign the grade sheet. Grades for each part will be either 0, 1, or 2. A mark of 2 will be given if everything is done correctly. A grade of 1 will be given if there are significant problems, but an attempt was made. A grade of 0 will be given for parts that were not done at all, or for which there is no TA signature.