CSE3215 Embedded Systems Laboratory

Lab2 - Hardware debugging and test tools

Introduction

Embedded systems are composed of several different hardware systems that are interfaced to one or more processors (in this course the processor is the Motorola MC9SDP256B microcontroller). The controller communicates with the subsystems by sending and receiving various signals from the subsystems. Many interfacing problems can be due to the signals not having the correct frequency, amplitude, or they may be sending erroneous data. It is difficult to monitor these signals just using a software-debugging tool. Two common tools used to debug embedded systems are the oscilloscope and the logic analyzer. The oscilloscope is the most common piece of test equipment you will find in any environment involving the repair and design of electronic equipment. The logic analyzer is used for examining bus signals in digital circuits. In this lab, you will get "hands-on" experience on how to use both pieces of equipment and how to debug hardware systems using them.

Objective

The objective of this lab is to introduce you to the oscilloscope and the logic analyzer and provide you with some "hands-on" experience in using them when debugging hardware. To that effect a small logic circuit has been burned into the MAX chip on the Altera FPGA development board. In Part A you will use both the oscilloscope and logic analyzer to determine the truth table and to measure the propagation delay for this circuit. In Part B you will generate a specific timing sequence and measure your output signals using the oscilloscope and/or logic analyzer. Upon completion of this lab you will be able to do the following:

1. Examine signals and gather timing information using the basic functions of an oscilloscope.

2. Examine signals and gather timing information using a logic analyzer.

3. Generate a specific timing sequence in firmware.

Reference Reading

Dragon12 Schematics
Dragon12 Schematics. PDF

HCS12 Reference Manual
SC12CPUV2.pdf

MC9SDP256 Advance Information
MC9SDP256.pdf

Link Logic Analyzer Manual
la.pdf

Reference Guide For D-Bug12 Version 4.x.x
DB12RG4 April 04,2005.pdf

Digital Oscilloscope Operation Manual
DS-1000SRS(ENG).pdf

Evaluation

1. Prelab (including preliminary code) 20%
2. Lab demonstration; in-lab explanations,measurements and answers; debug and test approach 60%
3. Program/design documentation (code should be well documented but no report is required – submit electronically within 24 hours on Prism). **Brief answers to all questions/measurement in the lab procedure should be included (typed answers or scanned lab book pages are acceptable)**. 20%

Pre-Lab

1. What would the amplitude of a signal appearing on PORTA be?

2. The MC9SDP256B processor is running at 24MHz.   What would be the frequency of the waveform appearing at PA3 generated from the following lines of code?

    ```
            ldaa    #$10        (1 cycles)
            staa    PORTA       (2   "    )
        A:
            inc     PORTA       (4 cycles)
            bra     A           (3   "    )
    ```

3. According to the Logic Analyzers user manual what is the threshold voltage?

4. What is meant by the term HF Trigger coupling?

5. Review the in-lab procedure. Several small programs need to be written and these must be designed and coded before going into the lab (and debugged to the extent possible)

In Lab Procedure

Using an Oscilloscope to Measure Signals

The oscilloscope is the most common piece of test equipment found in any electronics lab or repair shop. The oscilloscope is used to measure amplitude, timing, shape and relationship between signals. This part of the lab is a simple introduction to using an oscilloscope to measure signals.

1. Create an assembler or C based project that continuously increments the contents of PORTA.

2. Attach a scope probe to CH1 of the oscilloscope and attach the probe tip to H5-PA3.

3. Attach the scope probe's ground, the alligator clip, to the GND terminal of the Dragon12.

4. Connect the COM1 serial cable to the Dragon12 then power up the Dragon12 and download the Monitor.abs.S19 file using HyperTerminal.

5. Push the AutoSet button on the oscilloscope.

6. Run your program.

Scope Triggering

Triggering controls when the oscilloscope starts to acquire data and display a waveform. There are two methods of triggering the oscilloscopes used in the lab, Edge and TV. Edge triggering is used to trigger the oscilloscope on either the rising or falling edge of the input signal when it crosses the trigger threshold. TV triggering is used when monitoring television signals which we will not be doing so you should use edge triggering.

This part of the lab deals with the issues surrounding scope triggering.

Trigger Level and Coupling

7. Adjust CH1's Volt/Div control for 2V/div and adjust the Time/Div control until you see at least two periods of the waveform in the display.

8. Adjust the trigger level until you get a stable waveform. If your waveform is stable then adjust the trigger level until the waveform is unstable then re-adjust the trigger level until the waveform is stable once again. Take note of what an unstable waveform looks like and how the trigger level affects the stability. Also note where the trigger level is with respect to the waveform when the oscilloscope is triggered.

9. Select the trigger menu and scroll through the coupling options taking note of the effect each has on the display. Adjust the trigger level for each option as well to see if this helps with the triggering.

Trigger Source

10. Monitor H5-PA7 on CH 2 of the oscilloscope using a second scope probe.

11. Select the CH 2 menu; this will automatically display the waveform appearing on CH 2.

12. Adjust the Volts/Div setting for both CH 1 and CH 2 to 2Volts/Div.

13. Separate the two waveforms by using the CH 1 position control. Make sure there is a space between the two waveforms, the entire amplitude of CH 1 is still visible, and the CH 1 zero volt reference is on a major grid line.

14. Adjust the Time/Div until you see at least one period of CH 2's waveform.

15. Is there anything wrong with the display? Could you make a quick measurement of the frequency of the waveform on CH 2.

16. Select the trigger menu and scroll through the trigger coupling choices. Does this help? Try changing the slope, adjusting the trigger level and changing the mode… ignoring the single mode. Does either of this help?

17. Ensure the trigger mode is set to Auto then cycle the trigger sources until the waveforms are stable. Try adjusting the trigger level for each choice until you find a combination of the two that gives you a stable display. What is the trigger source and level?
                    Source: Level:

18. Monitor PA0 with the trigger source from 17 and adjust the Time/Div to show at least two periods of the waveform on CH 1. What happens to the display?

19. Try to obtain a stable display by adjusting the trigger level and or the trigger source. What did you have to do to obtain this stable display?

20. What can you say about triggering an oscilloscope when viewing two signals? Is there a relationship between the trigger source and the displayed waveforms?

Measuring Amplitude and Time

Scope Coupling

21. Disconnect the scope probe from CH 2 and attach CH 1 to the Dragon12's GND terminal. Take note of the position of the CH 1 trace on the scopes display this is your 0 volt reference. You can move this reference using the CH 1 Position control.

22. Monitor H5-PA3 with CH 1 press the AutoSet button determine the Volts/Div and Time/Div scale factors for CH 1 from the display.
    Volts/Div: Time/Div:

23. Based on the current display settings for CH 1 what are the frequency and amplitude of the waveform with respect to ground or the zero volt reference?
    Freq: Amp:

24. Do these measurements make sense? Do they agree with your answers to questions 1&2 in the Pre-Lab? Are they a true representation of the signal appearing on H5-PA3? If not then why?

25. Add a sixteen bit counter to your program and increment the contents of PORTA every time the counter reaches zero. Don't bother initializing the counter to some preset value just let it overflow and continue counting.

26. Compile, download, and run your program on the Dragon12.

27. Adjust the Time/Div to get at least one period shown in the display then measure the frequency of the waveform and the amplitude of the waveform with respect to ground or the zero volt reference?
    Freq: Amp:

28. What happened to the waveform? Did you expect this and can you explain what you see?

29. Push the AutoSet button on the oscilloscope. Did this help? What is the Volts/Div and Time/Div scale factors for CH1 from the display? Did the AutoSet feature help?
    Volts/Div: Time/Div:

30. Put the oscilloscope back to the previous settings using the Undo AutoSet function.

31. Select the CH 1 menu and scroll through the Coupling choices and settle on the one that suits the signal on H5-PA3 based on your knowledge of the Dragon12 and MC9SDP256B processor.

Coupling:

32. Adjust the Time/Div to show at least one period and adjust the trigger level to get a stable display.

33. Did anything happen to the waveform on the display? Can you explain any changes?

34. Measure the frequency of the waveform and the amplitude of the waveform with respect to ground or the zero volt reference again.
    Freq: Amp:

Scope Probes

35. Take note of the vertical deflection of the displayed waveform then select the x10 position on the switch located on the scope probe. What do you see?

36. Adjust CH 1's Volts/Div setting to bring the waveform back to the same vertical deflection as in step 34. What is the amplitude of the waveform according to the oscilloscope settings? What can you say about the x10 probe?
    Amp:

37. Scroll through CH 1's probe selections and select the 10x option. What is the amplitude of the waveform according to the oscilloscope settings?
    Amp:

Determining the Truth Table

Now you will determine the truth table of the circuit contained on the Altera board.

1. Power down the Dragon12 and connect signals A,B,C, Y and GND between the Dragon12 and the Altera according to the Table 1 in Appendix A.

2. Power both the Dragon12 and the Altera up. Double check connections before powering.

3. Download your CodeWarrior program onto the Dragon12 and then run the program. *Hint: you might want to modify your program for determining the truth table.*

4. Monitor the Y output of the Altera using the oscilloscope with respect to the A, B, and C inputs and determine the truth table of the circuit embedded in the MAX chip on the Altera.

Measuring Propagation Delays

1. Connect CH 1 of the oscilloscope to the Y output of the external circuit and adjust the oscilloscope Time/Div so that only one period of the waveform is displayed. Connect CH 2 to one of the circuit inputs.

2. Measure the propagation delay of the circuit. You will require an input signal that has a transition occurring at the same time as a transition on the output.

    T_{PD}:

Using the Logic Analyzer to Measure Digital Signals

This is a repeat of the timing measurements you made with the oscilloscope only this time you will use the logic analyzer.

1. Power down the Dragon12.

2. Connect the LA2124 Logic analyzer to the parallel port of your PC.

3. Connect channels CH0 through CH7 of the IO3200 to H5-PA0 through H5-PA7 of the Dragon12. Connect CH8 to the Y output of your external circuit, MAX_EXPANSION.

4. Power up the Dragon12 and the IO3200.

5. Open the IO3200 application.

6. Download your 8-bit loop counter program onto the Dragon12, and run the program.

Timing Measurements

7. Ensure that the IO3200 is set to *24ch 128k* and *Internal* using the *Clock* menu command.

8. Based on the timing measurements you made in Part A select a suitable sampling clock frequency using the *Clock* menu command.

9. Clear the data buffer using the *View/Clear Data Buffer* menu command.

10. Click the Go button on the toolbar and let it run until waveforms appear within the *Timing view(Active window)* then click the Stop button, also located on the toolbar.

11. Using the Zoom In/Out buttons on the toolbar and the horizontal scroll position in the *Timing view(Active window)* expand the waveforms until you have at least two cycles of the CH3 waveform.

12. Move the cursor into the *Timing view(Active Window)* and click the right mouse button.

13. Click both the *B* and *Trig* buttons in the *Cursor to Win* group within the *Display Options* dialogue box. Click *OK* when you are finished.

14. Drag one of the cursors over to an edge, rising or falling, of the CH3 waveform. Drag the other cursor to a similar edge one cycle away from the other cursor on CH3.

15. From the placement of the cursors determine the frequency of the CH3 waveform and compare this to the value you measured using the oscilloscope. Note the time difference between the two cursors is displayed in the Cursor window.

16. If your measurements do not agree with the measurements you made using the oscilloscope then repeat steps 9 through 16 until they do (and/or verify the oscilloscope measurements).

Determining the Truth Table

Here you will verify the truth table of the external circuit using the logic analyzer.

17. Open the Timing setup window using the *Timing/Timing setup…* menu command.

18. Using the Zoom In/Out buttons on the toolbar and the horizontal scroll position in the *timing view(Active window)* adjust the display to show at least one cycle of CH 2.

19. Determine the truth table for your external circuit based on the input and output signals. Compare with the results you obtained using the oscilloscope. Do they agree? Given the choice which would you use, the oscilloscope or the logic analyzer when debugging logic circuits?

Measuring Propagation Delays

This again is a repeat of what was performed in Part A using the oscilloscope.

1. Based on the propagation delay time you measured with the oscilloscope select a suitable clock setting for the logic analyzer.

2. Click the Go button on the toolbar and let it run until waveforms appear within the *Timing view(Active window)* then click the Stop button, also located on the toolbar.

3. Expand the waveforms in the Timing view(Active window) and position the cursors to points suitable to measure the propagation delay.

4. Compare the value you measured here with the value you measured using the oscilloscope. Do they agree?

Part B

Generating the Required Timing Signals

The Altera has as part of the logic circuit burned into the MAX chip a device that can accept a four-bit data value from an external source and display it on the MAX_DIGIT_1 7-segment display. The write cycle for this device is ridiculously slow and is shown in Figure 1. Create a program that will write a four-bit data value into this "slow device". To help in generating the correct timing sequence the external device provides two active low error signals, "Too Fast" and "Too Slow". The "Too Fast" signal is driven low whenever the expected signal occurs before the required setup time and the "Too Slow" signal is driven low whenever the expected signal occurs after the required setup time.

1. Power down the Dragon12 and the Altera and add the Enable, CS, WR, and Data connections between the Dragon12 and the Altera
2. Power up both the Dragon12 and the Altera then download and run your program.

3. Use the oscilloscope to fine tune each of the timing parameters of your generated waveforms. Set the triggering to Normal and trigger off the falling edge of the Enable signal.

4. Once you are satisfied with the timing use the logic analyzer to measure your final waveforms. Compare your measurements against the specifications listed in Figure 1.

Appendix A:

Table 1 Signal Names & Connections

Signal Name	DRAGON12	MAX_EXPANSION
Enable	H5-PA7	15
CS	H5-PA6	17
WR	H5-PA5	19
C	H5-PA2	29
B	H5-PA1	31
A	H5-PA0	33
Y	--	16
TooFast	--	18
TooSlow	--	20
Data[3]	H1-PB3	27
Data[2]	H1-PB2	25
Data[1]	H1-PB1	23
Data[0]	H1-PB0	21
GND	H3-VSSR	60