EE-3306 HC6811 Lab #5

Oscilloscope Lab

Objectives:
The purpose of this lab is to become familiar with the 68HC11 on chip Analog-to-Digital converter. In this lab, DC input voltages in 0V to +5V range are converted and displayed on the LCD. Also the digitized values are displayed on the oscilloscope.

NOTE: DO NOT APPLY NEGATIVE VOLTAGES TO THE A/D CONVERTER INPUTS. DAMAGE WILL RESULT, EVERYTIME.

Prelab:

Questions
1. Why is 68HC11 A/D converter called a “successive approximation” converter? How many external inputs can be connected to it?
2. If a 0 - +5V signal is applied to
   (i) 8 bit A/D converter
   (ii)12 bit A/D converter
   (iii)16 bit A/D converter
   what are the smallest voltage step sizes that can be detected?
3. Which bit selects the clock source for the A/D converter? What is the reason for switching to an RC oscillator if the system clock frequency is too low. What are the disadvantages of using the RC oscillator?
4. In part 1, there are discrepancies between the signal generator reading and the displayed voltage. What are the possible sources of error?

References:

Equipment for this lab:
• 68HC11 trainer kit, to include 68HC11 EVBU and prototyping strips.
• IBM compatible PC to connect to the trainer kit via an RS-232 serial cable.
• Agilent 33250A signal generator.
• Agilent 54621D oscilloscope.

**Laboratory Exercise**

**Notes**
• Make sure your development EVBU board is connected to power (green LED on board ON) and the serial port of the EVBU is connected to the serial port of your development PC containing the AXIDE software, configured to the correct port at the correct baud rate, etc.
• Copy the file “oscilloscope.RTF” from the “EE3301 Resources web site” to your floppy disk and modify.
• The lab TA has a copy of the oscilloscope program and you can request a demo.

**Procedure for the Lab:**

In this lab, you will program the A/D converter to read inputs PE0 – PE3 and output the result to the LCD display. To learn more about the A/D converter in 68HC11 go through the reference manual from pages 471-478. The 68HC11 A/D system is an 8 bit successive approximation converter with an input multiplexer. The A/D converter requires two reference voltages, VRL and VRH, and on the Axiom board, they are connected to 0V and +5V, respectively.

Before you can use the A/D converter, it must be configured by writing the appropriate values to the two control registers “OPTIONS” and “ADCTL.”

**OPTIONS $1039**

<table>
<thead>
<tr>
<th>ADPU</th>
<th>CSEL</th>
<th>IRQE</th>
<th>DLY</th>
<th>CME</th>
<th>-</th>
<th>CR1</th>
<th>CR0</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

The “OPTIONS” register has a bit (ADPU) to turn the power on to the A/D converter. To turn on the power this bit should be set to 1. Another bit to select the clock input to the converter is CSEL. When this bit is 0 the E clock is selected. Since the clock frequency of the Axiom board is 8MHz, you can choose the E-clock as the source for the A/D converter.
The ADCTL register selects the mode of operation, channel control, and channel selection. It also contains a flag (bit-CCF) to indicate the end of the conversion and the results of the conversions are in registers ADR1 – ADR4. When the bit is 1 it means that the A/D conversion is over. MULT bit is to select either single channel or multiple channels for conversion. SCAN bit is to select continuous scan mode or separate scan mode. You can read the reference manual for more information on this.

**NOTE: DO NOT APPLY NEGATIVE VOLTAGES TO THE A/D CONVERTER INPUTS. DAMAGE WILL RESULT, EVERYTIME.**

You are going to connect an external signal to the A/D converter and display the voltages on the LCD screen. Negative inputs and large inputs driving too much current can damage the A/D converter inputs. Therefore, use the following circuit to protect the inputs from negative voltages and excessive current. Make sure your input signal is positive and doesn’t exceed +5V. Your TA MUST verify inputs signals before you can connect to the A/D inputs.

![Protective Circuit](image)

Program the A/D to convert the channels PE0 – PE3 once with results being stored in registers ADR1 – ADR4. Fill in the required bits in the OPTIONS and ADCTL registers. The program should also include the code for displaying the digitized value of the voltage on the oscilloscope. The output which is an 8-bit number is sent out through an 8-bit port such as PORTC. Each bit can be sent through a separate channel to be displayed on the
oscilloscope. The port C has 8 bits which can be programmed to act as output port bits using the DDDRC register.

Modify the given program (oscilloscope.RTF) to continuously digitize and display the input channels PE0 – PE3 in the following format.

\[
\begin{align*}
\text{PE0 A/D} &= \text{aaa} = \text{mmmm} \text{ mV} \\
\text{PE1 A/D} &= \text{aaa} = \text{mmmm} \text{ mV} \\
\text{PE2 A/D} &= \text{aaa} = \text{mmmm} \text{ mV} \\
\text{PE3 A/D} &= \text{aaa} = \text{mmmm} \text{ mV}
\end{align*}
\]

‘aaa’ is the A/D reading. It is the decimal equivalent of the 8-bit digital value of the analog voltage. ‘mmmm’ is the corresponding voltage in mV.

Compute the input voltage (mmmm) from the A/D reading (aaa) for display. Note that A/D produces 0010 for 0 V input and 25510 for +5V input.

Apply a DC signal from the function generator to each of the inputs PE0 – PE3, one at a time, and demonstrate to the lab TA that your program is working. Fill in the columns for the A/D reading and the displayed voltage in the following table for the given input signals. Then connect the probes of the oscilloscope to the pins of PORT C to get the waveforms. Verify the digital values from the waveforms on the oscilloscope.

<table>
<thead>
<tr>
<th>SIGNAL GENERATOR READING</th>
<th>A/D READING</th>
<th>DISPLAYED VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1250 mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000 mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3500 mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4500 mV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T. A. Initials: ___________________________

Do the Following to document your program (Note: comments, structure, and readability counts!!!)
1. Sketch the waveform you observed on the oscilloscope. One sketch for each waveform is sufficient.
2. Hand-in a complete Flowchart and the entire program.
3. Hand in the listing of the complete, well-commented source-code that matches the flowchart. Remember, if the TA can not read your code with “reasonable” effort, then it is wrong!