

# ENGG3640 Lab 5: High-Tech Etch-a-sketch

School of Engineering, University of Guelph  
Fall 2004

**Due Date:** *Friday (Week #9) November 07 2004*

## 1 Objectives:

- Sample an analog signal and display result.
- Diamond shape display on the scope.
- Design and construct an electronic sketching device.

**Any additions that exceed the requirements of this lab will be considered as a bonus.** Be creative!! For example instead of all the requirement listed below you can design a small project that utilizes the M68HC11 to create a “Ping Pong” game where each player uses a potentiometer to control the ball and scores will be displayed on the LCD.

## 2 Analog Input Techniques

Any analog input signal has to be converted into a suitable signal before it can be processed by the microprocessor. This required signal conversion process is called the Analog-to-Digital (A/D) conversion. The circuit (or device) that accomplishes such conversion is called the A/D converter. There are different algorithms that can be used to accomplish this conversion. One of the more common approaches is the so called *successive approximation* type, which is known for its conversion speed.

The M68HC11 controller has a built-in A/D converter system. This A/D system is an 8-channel, 8-bit, successive approximation converter. Coming out of reset, this A/D circuit is disabled. It is turned on by setting the A/D power-up (ADPU) control bit in the OPTION control register (bit-7 of register, see address). When this A/D converter is activated, port E of the M68HC11 is used as the analog input. There are two additional input lines ( $V_{refh}$ ,  $V_{refl}$  that serve as the upper and lower reference lines). The final digital result of this conversion reflects, the relative placement of the unknown analog voltage  $V_x$  with respect to two reference voltages. In your setup,  $V_{refh}$  should be tied to  $V_{cc}$  (5.0v), and  $V_{refl}$  is tied to GND (0.0v). Therefore if  $V_x$  is 5.0v, the result is 0xFF. Connect a potentiometer to  $V_x$  to vary the voltage to be measured. See your text book and the Motorola reference manuals for further information regarding programming the A/D converter. Figure ?? illustrates how the potentiometer is connected to the A/D converter of the M68HC11. This A/D converter system is capable of converting upto 8 channels (4 channels at a time) of analog input voltages, using the same voltage reference levels. The mode of operation is controlled by the A/D Control/Status Register (ADCTL) at 0x1030. In this register, the lower 4 bits (CD, CC, CB, CA- Channle Selects) specify the A/D channel Assignments. The next bit (MULT) is the Multi-Channel/Single-Channel Control. When this bit is zero, the A/D system is configured to perform four consecutive conversion on the single channel specified by the four channel-select bits. **Bit-5 (SCAN)**

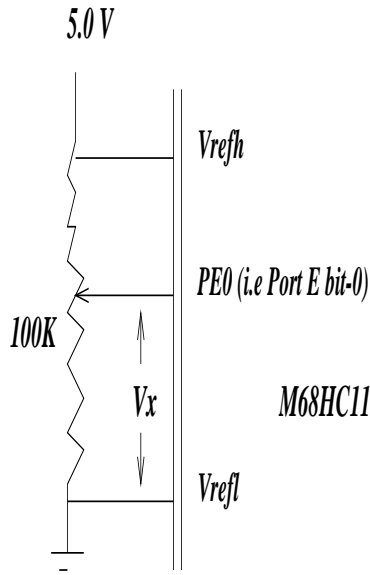


Figure 1: A/D Connection to a Potentiometer

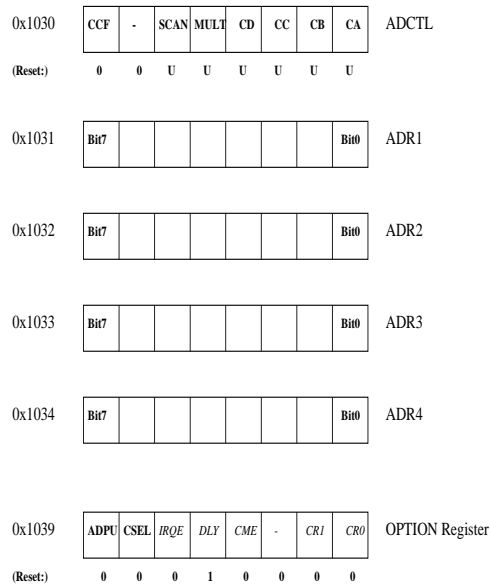


Figure 2: Relevant 6811 Registers Needed for A/D Conversion

is the Continuous Scan Control. When this bit is zero, the four conversions are performed, one each, to fill the four result registers (ADR1-ADR4, i.e 0x1031-0x1034). **Bit-7(CCF-Conversions Complete Flag)** is a read-only bit. This bit is set when all four A/D result registers contain valid conversion results. Each time the ADCTL is written, this flag bit is automatically cleared, and a new conversion sequence is started immediately.

## 2.1 Requirements

The following tasks are to be implemented within an assembly file.

- Write a subroutine to configure the A/D conversion system to select Port E bit-0 (PE0) in the *Single Channel/Single-Scan mode* via the ADCTL register.
- Write a subroutine to check the contents of the CCF bit until it is set, then return the contents of A/D result register #1 (ADR1).
- Write a subroutine to convert the binary reading of the A/D result into a two-digit decimal reading. Embed this reading into a suitable Ascii message, and send this message to the virtual terminal. Sample message: “The analog measured input voltage is 3.8 volts”.

## 3 Diamond Shape Display

A *digital-to-analog* (D/A) converter is a circuit that converts digital information to analog signals. The analog output signal from the D/A is quantized. As seen in Figure ??a a signal conditioning block may be used as a filter to smooth the quantized nature of the output. The signal conditioning block also provides isolation, buffering, and voltage amplification if needed. The most basic circuit is the *binary-weighted register* D/A shown in Figure ??b. As the switches for the bits are closed, a weighted current is supplied to the summing junction of the amplifier. For high resolution D/A converters, the binary-weighted type must have a wide range of resistors. This can lead to temperature stability and switching problems. Other types of D/As are **R-2R Ladder D/A**.

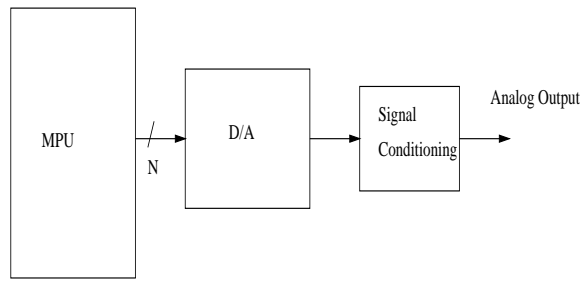
A vector graphic display is basically an x-y plot that requires two related waveforms. To display a “diamond-shape” x-y plot, you need a triangular waveform feeding the horizontal input, and another triangular waveform(phase-shifted by 90 degree) feeding the vertical channel of a scope. This relationship between the x-y plot and the two time-based waveforms is illustrated in Figure ??.

We basically use a D/A converter to convert an 8 bit binary number into a voltage proportional to it. In this case, 0x00 corresponds to the minimum voltage generated, and 0xFF (255 in decimal) the maximum voltage. The software problem, then, is to write a program that cycles two variables, x-volt and y-volt, between these two extreme values.

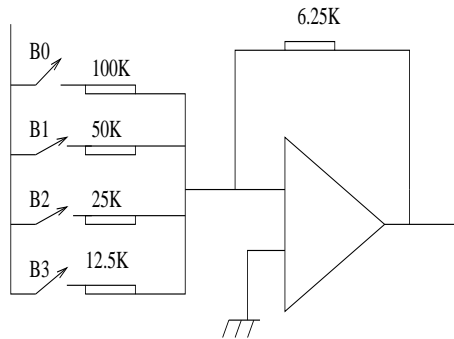
### 3.1 Requirements

You will need to use an D/A converter (i.e DAC0800, data sheet on the web). Write an assembly language program that display a diamond shape on the scope and use the following steps:

- Connect both analog outputs (x-out & y-out) from the D/A chips to the dual channel inputs of an oscilloscope through a set of probes(10:1 attenuation). Use DC coupling 0.1v/div vertical sensitivity, and 10ms/div time scale. You should see the display of two triangular waveforms. There should be some time lag between these two waveforms. Adjust the sync control to achieve a steady display. **Measure the period of the display.**



(a) Digital to analog converter.



(b) Binary Weighted D/A

Figure 3: Digital-to-analog converter

- Switch the display from time-domain to x-y display, and you should see the diamond shape display. (You may need to re-adjust some offset controls in order to center the display).

## 4 High-Tech Etch-a-Sketch

In the X-Y mode, the position of the beam spot on an oscilloscope is determined by the voltage applied to the X input and the voltage applied to the Y input. If the voltages on the inputs are changed, the beam will sweep across the screen in a straight line from the old position to the new position. To refresh a display so that it remains visible on the screen, you have to draw the display over and over.

### 4.1 Requirements

Primary functions of the software will be:

1. to add new X,Y coordinates to the list of points and to constantly refresh the screen. Use a circular buffer to hold the point list.
2. *Bonus:* to display the direction of movement as you change the X,Y coordinates (say for example to the right) display the message “right” on the LCD display.

#### 4.1.1 Components

- DAC's, DAC0800 (or any other D/A converter available)  
<http://www.national.com/pf/DA/DAC0800.html>.

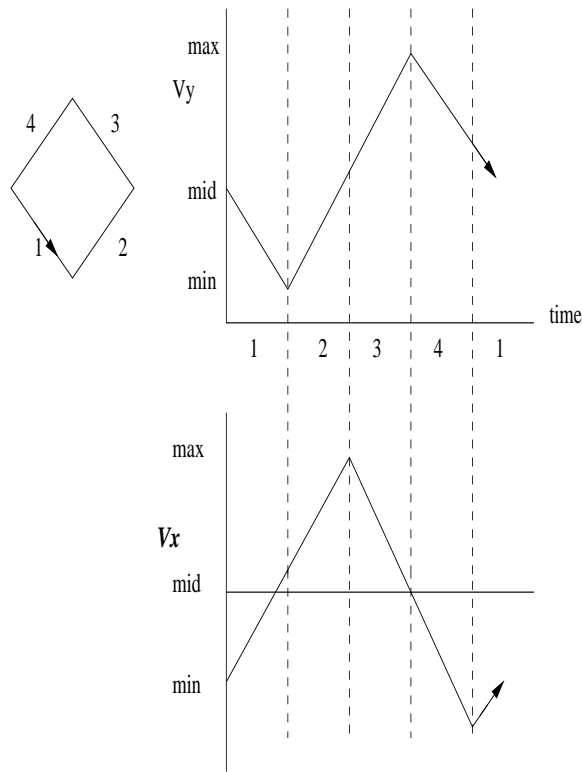


Figure 4: Diamond Shape Display

- op amps, potentiometers, oscilloscope
- code

## 5 General Hints:

- Be sure to keep the analog and digital grounds separate as long as possible.
- Use two potentiometers, one for the X-direction and the other for the Y-direction.
- Check the signals from the DAC0800 (current signals!).
- Do not set the oscilloscope to X-Y mode until you are sure you have the required voltage swing driving the X-input, or else the overly intensified beam will stay in one spot and **may damage the screen permanently**.