Lab 20 Graphics Display using a Digital to Analog Converter

This laboratory assignment accompanies the book, Embedded Microcomputer Systems: Real Time Interfacing, by Jonathan W. Valvano, published by Brooks-Cole, copyright © 2000.

Goals	• DAC conversion,
	• Develop a simple graphics display.
Review	• Data sheets on MAX549A DAC (serach CD for MAX548.PDF),
	• Valvano Chapter 7 on SPI interfacing,
	• Valvano Chapter 11 on DAC converters.
Starter files	• OC3.H, OC3.C, OC3TEST.C, DAC8043.H, DAC8043.H, DACTEST.C

Background

Most computer graphic displays rely on high-speed DAC converters to create the analog waveforms required to draw images on the screen. In this lab you will create a very simple graphical interface that illustrates this application of the DAC. Your goal is to draw the initials of your favorite school on a two-channel oscilloscope. You will interface a Maxim MAX549A dual-channel 8-bit DAC to the SPI port. Please refer to the MAX549A data sheets for the synchronous serial protocol. Two 8-bit SPI frames are required to set one of the DAC outputs. One approach is to first set the input data register for channel A, then send the data for channel B and simultaneously activate the DAC outputs for both channels. The output range of the DAC is 0 to +5 volts. The DAC output impedance is 33K . Therefore it should be able to drive a scope as long as the scope input impedance is above 1M . The 220pF capacitor filters the DAC output. The 0.1µF bypass capacitor on the power connection is necessary to prevent output glitches during serial input transmissions.
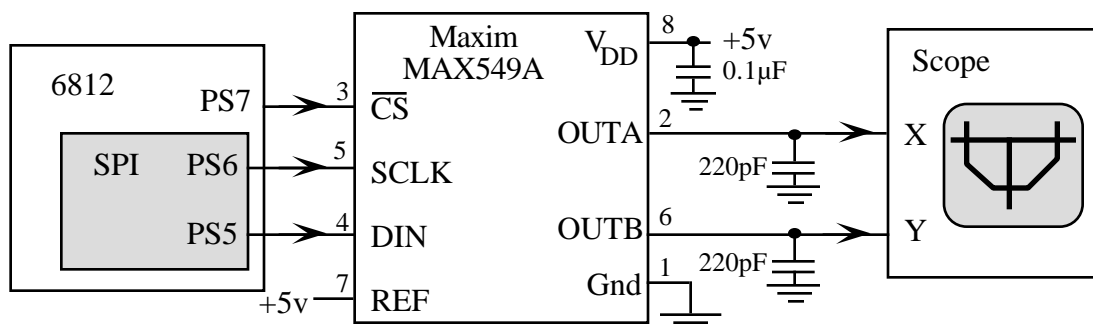

Figure 4.1. Dual DAC allows software to draw dots on the scope display.

The scope should be setup in X-Y mode, and the gain/offset adjusted to view the full scale 0 to +5V signals.

The next step is to design a data structure to store the graphical image. A complete list of (x,y) points will be simpler to process, but require more storage. A list of line segments will require less storage, but be harder to process. You are free to design and implement any data structure you wish. The software will continuously scan the structure, outputting the (x,y) coordinates to the dual DAC. No interrupts or output compare timer will be needed. It will be important to scan through the entire image at a rate fast enough to prevent flicker.

Preparation (do this before your lab period)

1. Wire up the circuit required for the DAC interface to the 6812 SPI port. The bypass capacitor on the +5 V supply can range from 0.1 µF to 0.22 µF, and the filter capacitors can range from 100 to 1000 pF.

2. Design and write low-level DAC device driver software. Create separate DAC.H and DAC.C files.

3. Write simple main program that outputs sawtooth waveforms on the two channels.

4. Write the graphical display main program.

Jonathan W. Valvano

A "syntax-error-free" hardcopy listing for the software is required as preparation. The TA will check off your listing at the beginning of the lab period. You are required to do your editing before lab. The debugging will be done during lab. Document clearly the operation of the routines.

Procedure (do this during your lab period)
1. Use the simple main program to debug the DAC interface. For this part the oscilloscope can be used in regular voltage versus time mode. Adjust the scope cables and capacitor values to get clean images on the scope.

2. Using a simple digital port output, measure the time required to scan through your entire image. Adjust your approach until this time is less than 20 ms (scan rate faster than 50 Hz).

3. Debug the graphical display system.

4. Read the Lab 22 assignment. As part of the Lab 20 procedure you are required to perform a very crude temperature calibration experiment with three points somewhere in your temperature range of 20 to 40 ˚C. The thermistor resistance varies nonlinearly with its temperature. It is very important to use temperature units of Kelvin in this equation and not ˚C.

$$R = R_0 \, e^{+ \, /T}$$ (where T is temperature in degrees Kelvin)

The thermistors have a resistance of about 500 k   at 25 ˚C. For example, the skin temperature in the axilla region (arm pit) is about 36˚C=309K, and the room temperature is about 25 ˚C. Use simple algebra to determine R_0 and   from the calibration points.

Checkout (show this to the TA)
You should be able to demonstrate the proper operation of display. You should be prepared to discuss alternative approaches and be able to justify your solution.

Hints
1) If the signals are distorted, you could add voltage follower analog circuits using the TLC2274 rail-to-rail op amps. If you do use the TLC2274, please attach ground and +5V power and not +12V and –12V.
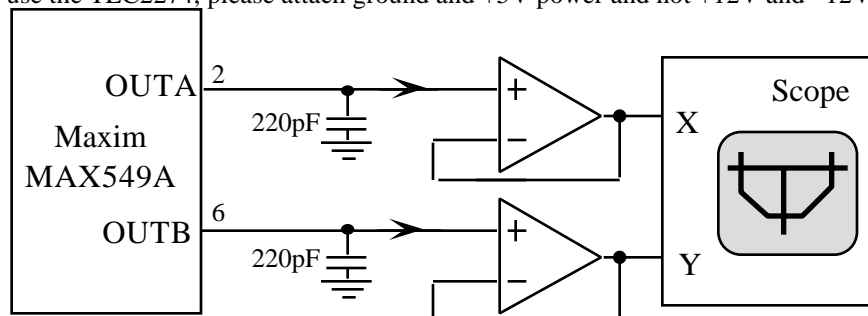

Figure 20.2. Dual DAC interface with analog buffering.

2) If the software executes properly but too slowly, then you could hand optimize time-critical sections. Start by observing the assembly code generated by the compiler. You might be able to rewrite the C code in such a way as to make it run faster. For example the compiler actually handles 16-bit numbers faster than it handles 8-bit values. You could also use the compiler's assembly output as a starting point to rewrite time-critical functions in assembly. See the introduction of this lab manual for examples of how to interface C with assembly language. Another approach is to write the entire system in assembly language.

3) The DAC8043.H, DAC8043.C, DACTEST.C is a software interface for a single channel 12-bit DAC. Although the protocol is different from your 2 channel 8-bit DAC, the approach is similar.

4)There are two versions of the Adapt812 board[1].

---

[1] Rev1 and Rev2 have different H1 connector pin assignments for PS5 PS6, PS7

Jonathan W. Valvano