

Laboratory Project #6

Parallel Printer Port Use and Digital-to-Analog Conversion

Important Note Concerning Equipment.

This is the first lab that has required the use of hardware external to the PC. The external hardware to be used will be provided. Each group will use a Digilab XLA board and two R2R Resistor Ladder boards. Each workstation in the lab also is provided with a Tektronix TDS3014 Digital Oscilloscope. This equipment is not to be removed from the lab under any circumstances.

The Digilab board is shown in appendix A, with all of the features required in this lab highlighted. (The boards in the lab will look slightly different than this drawing as they are a newer version of the board) Note the large chip (U3) at the top-center of the board. This chip, called a Field-Programmable Gate Array (or FPGA), is a programmable logic device, and can be programmed to contain a digital circuit to implement any digital design. For this lab, it is programmed with the circuit shown in appendix B. The process of programming the gate array to contain a particular circuit design is called configuration. For this lab, a DOS program, called CDALAB.EXE will be provided which will configure the board with the appropriate circuit design for this lab.

For the Digilab board to work properly, a 6VDC wall-plug power supply must be attached to the power supply connector (J12); a parallel cable connected to a printer port on the PC and attached to the 25 pin connector on the Digilab board. Switch SW9 on the Digilab board is used to switch the parallel port on the board between configuration mode (PROG position) and parallel port access mode (PORT position). When using the CDALAB.EXE program to configure the board, SW9 must be in the PROG position. After the board has been configured, SW9 must be placed in the PORT position. If SW9 is not placed in the PORT position before use, the configuration in the gate array will be erased as soon as your software tries to write to the parallel port and nothing will work properly. This won't damage the board, it simply won't work properly. If you forget to set the switch to the PORT position, simply run the CDALAB.EXE program again to re-configure the gate array.

IBM PC type parallel printer ports can appear at one of several I/O addresses. All of the machines in the lab have their printer ports at address 0x278 or 0x378. The CDALAB.EXE program allows specification of the parallel port to use via the -p option:

| | |
|---------------------------|---------------------------------------|
| <code>cdalab -p278</code> | configure board at port address 0x278 |
| <code>cdalab -p378</code> | configure board at port address 0x378 |

If you try to configure the board at one port address and the program tells you that it can't find the board, try the other port address. If you are interested in seeing how the CDALAB.EXE program works, the source code is included on the class web site in the DOSCFG.ZIP file. The program is written in 8086 assembly language.

For this lab, each team will also be provided with two R2R resistor ladder boards. As described later in this document, an R2R ladder is a way of constructing a digital to analog converter. Each R2R ladder board is a single, 8 bit, D/A converter. In this lab the two R2R boards will be used to create two analog output channels which will be used to draw pictures on an oscilloscope. The R2R ladder boards are to be plugged

into the 72 pin connector, labeled J1, on the Digilab board. The boards must be plugged into the correct locations and with the correct orientation for the lab to work. The X channel board is to be plugged into the LD1 – LD8 outputs with the most significant bit position (D7 on the R2R board) connected to LD1. The Y channel R2R board is to be connected to signals DP and CA-CG with the most significant bit (D7 on the R2R board) connected to CG on the Digilab board. If the Digilab board is positioned so that the switches and buttons are near you, the LD1 – LD7 signals are just to left of center on the top row of J1 and the X channel R2R board will be positioned so that the yellow resistor networks on the board face you. The Y channel R2R board will be just to the left of the X channel board on the bottom row of contacts and facing away from you.

Use of Oscilloscope

The oscilloscopes in the lab are Tektronix TDS 3014, four channel Digital Phosphor Oscilloscopes. These are very high quality and expensive oscilloscopes that were recently donated by Tektronix. Please don't mistreat them. For this lab, only two of the four channels (channel 1 and channel 2) will be used. The X channel D/A converter should be connected to scope channel 1, and the Y channel D/A converter should be connected to scope channel 2.

Select Vertical Scale: The output of the D/A converters will range from 0 to about 4 volts, so 1 volt per division should be selected for the vertical scale for each channel. Select channel 1 (the yellow channel button) and adjust the Vertical Scale knob until the CH1 value in the lower left corner of the display indicates 1V. Similarly, adjust channel 2, by pressing the blue channel button and adjust the Vertical Scale knob until CH2 indicates 1V.

Set up the triggering: Press the Trigger Menu button. A menu will appear on the bottom and right of the display. Select channel 1 as the trigger channel by pressing the menu button for Source and then press the right side menu button to select channel 1. Select DC Coupling, rising edge Slope, and set the Level at about 2V by adjusting the Trigger Level knob. After the triggering is set up, the menu can be removed from the display by pressing the Menu Off button at the lower right corner of the display.

Set display to normal mode: For checking the linearity of the D/A converters, the oscilloscope needs to be in the normal display mode. To set the oscilloscope into the normal display mode, press the Display button (in the lower middle of the group of six buttons at the top right of the control panel) to bring up the Display Menu. Select XY display from the lower menu buttons, and then Off (YT) from the right set of menu buttons. In the normal display mode, the oscilloscope plots channel voltage on the Y axis vs. time on the X axis. The time scale is controlled by the Horizontal Scale knob.

Set display to XY mode: For the main part of this lab, the oscilloscope should be placed into XY mode. This is done by pressing the Display button (in the lower middle of the group of six buttons at the top right of the control panel), which brings up the Display menu. Select XY display on the bottom row of menu buttons and then Triggered XY from the right set of menu buttons.

Overview and Introduction To the Lab Procedure

In this laboratory you will be using a 2 channel digital to analog converter to draw images on the display of an oscilloscope operating in XY mode. The digital to analog converters are attached to a logic circuit implemented in the gate array on a Digilab board and accessed through the parallel printer port interface on an IBM PC type computer.

Objectives

Goals for this lab are:

- (1) Understand how to use the printer port hardware interface.
- (2) Understand how an R-2R ladder works for D/A conversion.

- (3) Write a program which uses both C/C++ and Assembly language to interface to external hardware through the parallel port.

Pre - Lab

(Due at the beginning of the lab period.)

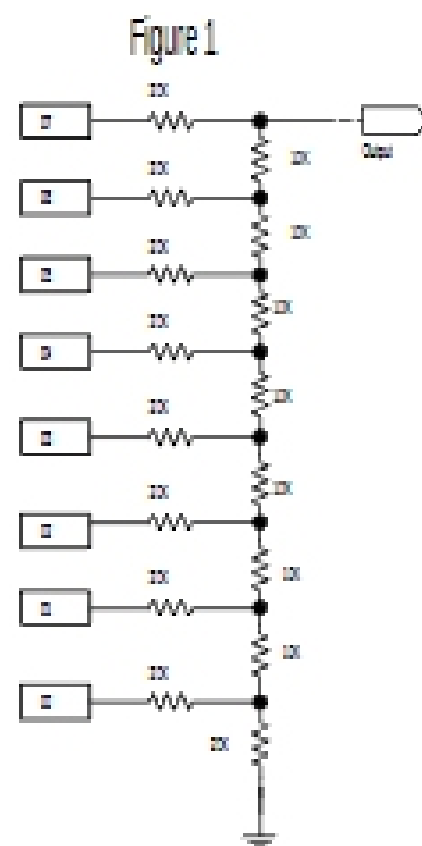
- Review the detailed schematic for a simple two-channel D/A converter (attached, appendix B). Note how the D/A converter is controlled by the standard printer port. Also review the given printer port organization. What values need to be output to the printer port registers to load data into each set of registers (the X and Y channels)? You will need to find more information on parallel port usage. One good source the web site www.beyondlogic.org. You can find many more such documents by searching the web.
- Write a program in Turbo C++ (provided on all the lab machines in EEME 136) that uses the provided `pputils.cpp` and `pputils.h` to:
 - Determine the location of the parallel port registers.
 - Print the location of these registers to the screen (Base Address, Control Address, and Data Address)
 - Drive all Data pins low (Verify this with a multimeter or an oscilloscope).

Use the zipped project posted to the web-site to get started.

- Determine what the output voltage is on the R2R ladder in **Figure 1** if the value of the inputs is:

| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

Assume $V_{dd} = 5\text{volts}$ (Hint: use superposition)



Lab Procedure

- Set up your hardware. Unplug the Digilab power supply, and install the R2R ladder boards. Attach the oscilloscope probes for the two channels to the outputs of the R2R ladder boards. Attach the ground leads on the scope probes (the alligator clip) to the GND pads on the R2R boards. Connect the parallel