

## Laboratory 6

## Digital-to-Analog Converter

Last Revised: July 2000

### 1 Objectives

With the completion of this lab, you should be able to:

- Design and construct a circuit to interface a DAC integrated circuit to the MUN-88 microcomputer.
- Write simple assembly language programs to generate arbitrary analog signals.

### 2 Introduction

Analog-to-Digital Converters (ADC) and Digital-to-Analog Converters (DAC) are extremely useful devices which enable us to interface the real world events (which are frequently analog) with microprocessors (which are inexpensive and provide good precision and accuracy when compared to their analog counterparts) for monitoring or control.

There exist many types of ADCs and DACs differing in their internal construction, resolution, precision and accuracy, speed, compatibility with different micros, and other capabilities like power supply requirements, unipolar/bipolar operation and coding. In this lab, you will interface a DAC to the MUN-88 and test its operation. In next week's lab, you will interface an ADC.

#### Caution!

The ADC and DAC devices that you will be using in this lab are sensitive to electrostatic fields and can be easily damaged. **Do not insert these devices into powered sockets.** Remove power before insertion or removal. Do not touch the pins of these devices with your fingers. It is a good practice to switch off the power supply before you make any change to the hardware.

These devices are expensive – please be careful not to ruin any chips.

Measure the exact value of the resistors or the capacitors with an LCR meter before connecting these devices. This precaution may eliminate hours of frustration and debugging.

Note that, in this lab, a reference to a signal line/pin that is active low will have the \* symbol after its name (for example, CS\* or IOWR\*).

### 3 Digital-to-Analog Converter

You should have received a copy of the data sheet of AD558 – if not, it is available on the course web site in a PDF file. Read it fully before designing your circuit. This device is a simple 8-bit DAC.

### 3-1 Circuit Diagram

You will be using the AD558JN to output (unipolar) analog signal in the range 0V to 2.56V. The AD558 chip will be used as an output port. Sketch a circuit diagram of the interface between the AD558 and MUN-88, clearly showing all the interconnections and power supply connections. Use **Figure 1a** on the data sheet (DIP packaging) for the pin names and numbers. Refer to **Figure 4a** to configure the device in the required mode. Connect IOSEL5\* line to the Chip Select (CS\*) line of the AD558. The Chip Enable (CE\*) input should be connected to the IOWR\* line on the MUN-88 edge connector. The data bus lines and power supply points (+5V and ground) must also be connected.

**What will be the address of the AD558? Does it need to be configured like the PPI chip in lab 5?**

### 3-2 Circuit wiring

Wire the circuit as in your diagram. Wire your circuit neatly – colour code your wires, and cut your wires to the right length. Make sure that all the ground points are connected together. Get the circuit checked out by your partner before powering up.

Turn the power ON and test the DAC for various output voltages. This can be done by using the monitor **Output** command and using a CRO (cathode ray oscilloscope) or a DMM (digital multi-meter) to measure the output. **Explain your observations.**

### 3-3 Software

Write an 8088 assembler program that increments the accumulator AL, outputs it to the DAC port, and repeats these operations until a switch signal is received. **When you run this program, what output waveform do you obtain? Why?** Assuming that the microprocessor poses no timing constraints, determine how fast can this device operate --- see Figure 7 of the AD558 data sheet and its timing specifications. **Print out the list file for this program, and have a TA check for correct operation.** Comment on your results.

Modify your program to produce the same waveform, but with half of the frequency. Modify your original program again to produce a waveform of double the frequency. Then modify the original program to reduce the peak-to-peak voltage by one-half. **Submit the .ASM files of each of these programs.** Clearly label each of them, and comment on your changes and results.

Create a program that outputs a saw-tooth waveform with the maximum peak-to-peak voltage. **Report on your results, and submit the .ASM file.**

Based on the results of your programs, how could you generate a sinusoidal waveform? **Do not write a program**, but describe what would be involved in creating such a program.

### 3-4 Memory Mapped I/O

Switch OFF the power supply. Connect ROMSEL0\* and MEMWR\* in lieu of IOSEL4\* and IOWR\*, respectively. Now, the DAC device is *memory mapped*. This is an alternate method of connecting I/O devices to an 8088/8086 microprocessor. Instead of accessing

the device via input/output instructions (that is, IN and OUT), you access the device via an instruction using a memory operand. The obvious instruction is MOV, but most other instructions would work as well. For some more information on memory mapped I/O, consult your textbook, Section 8.1 (page 353).

***Determine the address(es) corresponding to the DAC from the MUN-88 circuit diagram.*** Power up the circuit and verify that you can write to this memory location to change the DAC output. You do not need to write a program – MUN-88 monitor commands will be sufficient. ***Report on your results.***

## 4 Submission

At the end of the lab submit the print-out of your files (.LST and .ASM, where appropriate). Also include your circuit diagram, answers to all questions in the lab and prelab, and results.

Before leaving the lab, unwire your circuit, and return your devices to the IC kit at your bench.