

Lab 4: Analog to Digital Conversion and Display

Fall 2017

Objective

To get familiar with the concept of A/D conversion and 7-segment displays.

References

- Dragon12-JR Trainer User's Manual
- Freescale MC9S12DG256 Device User Guide
- Freescale HCS12 Core User Guide
- Reference Guide for D-Bug12 Version 4.x.x
- ATmega328 datasheet
- Online Arduino Reference (<https://www.arduino.cc/en/Reference/HomePage>)

Equipment

- PC running MS Windows
- Digital Multi-Meter (DMM)
- Dragon12-JR 9S12DG256 EVB
- Arduino Uno
- Breadboard (you need to bring one)

Parts

- 2 each 7-segment display, common cathode
- 1 each 10 k Ω potentiometer (or equivalent to create an adjustable voltage divider circuit)
- 2 each 390 Ω x 8, independent resistor network (DIP)

Software

- Freescale CodeWarrior for HC12 v5.1
- Arduino IDE
- RealTerm

Background

In this lab, we will be working with the 9S12DG256 A/D converter. Please read the appropriate background material on this module, like the Lecture Note of Analog to Digital and Digital to Analog Conversion and the MC9S12DG256 reference manual.

Pre-lab Questions

Due at the start of the lab period:

- 1) What type of analog-to-digital conversion does the 9S12 chip use?
- 2) What type of analog-to-digital conversion does the Arduino use?

Lab Exercise

In this experiment, we will create a simple voltage divider circuit using the potentiometer, and then measure the voltage with the ADC module on the 9S12DG256. The ADC module should be configured for a range of 0 to 5 volts. Dedicated power supply and ground are required for the ADC in order to isolate the sensitive analog circuitry from the normal levels of noise present on the MCU. V_{DDA} (Pin 83) and V_{SSA} (Pin 86) are the power supply and ground input pins for the ADC. These pins can also provide the reference for the internal voltage regulator.

In your code, make sure to wait for at least **10 msec** after turning on the A/D converter to allow the analog circuitry to settle.

1. The 9S12 microcontroller will translate the voltage and output the results. The voltage should be displayed on two 7-segment LED displays, where the voltage reading will range from **0.0** to **5.0** volts.

Make sure your program is accurate and concise, and is a similar implementation of the following pseudo-code:

```
Configure Port A to be an 8-bit output port;
Configure Port B to be an 8-bit output port;

Initialize Port A;
Initialize Port B;

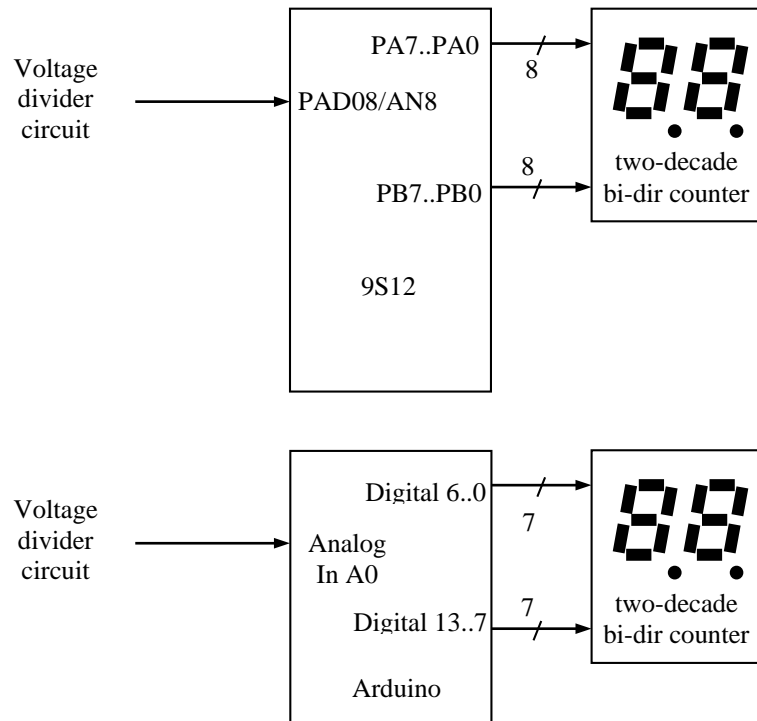
Turn on ADC;
Wait at least 10 milliseconds for initialization;
Configure ADC for 8-bit resolution;

While (1)
{
    Wait for the A/D conversion completion flag in status register;
    Read the corresponding A/D result register;
    Send the result to the corresponding LED display;
}
```

2. Repeat Step 1, but at this time configure the A/D converter to **10-bit resolution** mode. How much precision was gained in your output?
3. Repeat Step 1, but at this time, use the **Arduino** board. The Arduino has 14 digital input/output pins and has an ADC with 10-bit resolution. Details can be found on page 250 of the datasheet of the ATmega328, which is the microcontroller chip of the Arduino board (the datasheet is available at ilearn). Since there are only 14 digital input pins and we do not use any hardware decoder, we can use 7 digital I/O pins for each 7-segments LED display.

For the schematic drawing, you will need a Cadence library for ATmega328 (atmega328p.OLB). Download it from the class website, copy it to the PSpice library folder (i.e., <cadence_directory>\tools\capture\library\pspice), and reload all PSpice libraries in Cadence Capture CIS.

General Diagram



Demonstration

Show Steps 1, 2, and 3 by changing the potentiometer by hand.

Report

Make sure you include the following in your report:

- A short abstract (one paragraph stating the objectives and accomplishments)
- Experiment system specification (what is to be designed and implemented)
- Block diagram and hardware design
- Detailed schematic diagram
- High level description of the software
- Program listing (including comments)
- Technical problems encountered, and how they are solved
- Answer to the questions
- A very brief conclusion