# EEEN202, 2021, Microprocessor design exercise

# Digital Voltmeter

The first part of this exercise is to become acquainted with digital to analogue and analogue to digital conversion as well programming the 8051 series microprocessor in C. The task is to build up an analogue to digital converter circuit and compile some predeveloped code.

Firstly, build the circuit as per the diagram on the second page. Note, you should leave your display circuit intact as you will need it again in this lab. You will need to use the benchtop power supply to provide the +-15V power supply rails. Please check everything very carefully before you apply power.

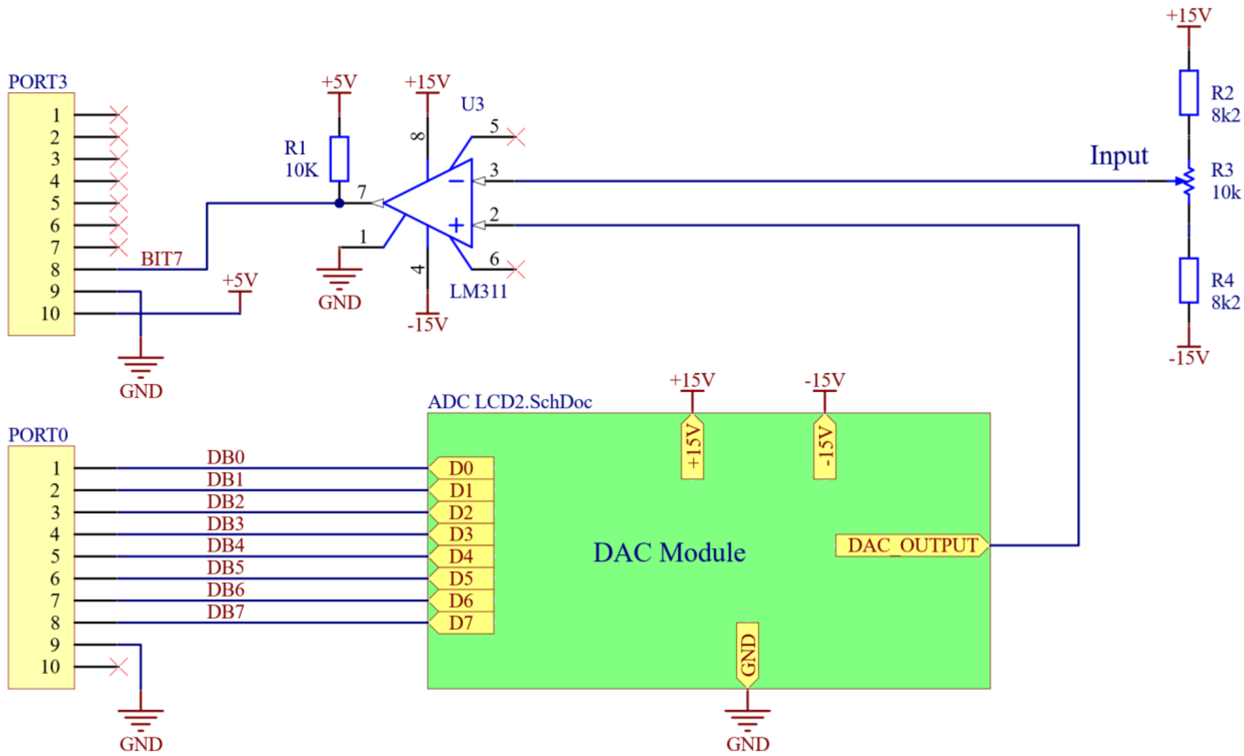
Secondly, download the ZIP file ECEN202_DIY_ADC and unzip it to a suitable area. Launch "Keil" and open the project ECEN202_DIY_ADC.

Build the project and then download the HEX file to the microprocessor board.

Press the RESET button to run the program. **You must press reset after each new upload to run your program.** Verify that your ADC is working by changing the output voltage of the potentiometer and seeing the display changing accordingly. Use the digital voltmeter to measure the voltage being applied to your ADC.

Once everything is working:

1. Connect two oscilloscope probes, one DAC output and one to the variable voltage input. You will notice that the output of the DAC is a staircase waveform that increments until it reaches the variable input voltage level.
2. Record some display values and respective input voltage and determine a calibration factor that could be applied in software to make the displayed value equal the input voltage.




## Design exercise task - Successive Approximation Converter

This follows on from the previous task where a staircase ADC was implemented. The task for the design exercise is to implement a Successive Approximation Converter by simply changing the C code provided for the staircase ADC.

You should only need to change the code in the ADC conversion function. Once you have completed that, build the project and then download the HEX file to the microprocessor board.

Press the RESET button to run the program. **You must press reset after each new upload to run your program.** Verify that your ADC is working by changing the output value of the potentiometer and seeing the display changing accordingly.

Once everything is working:

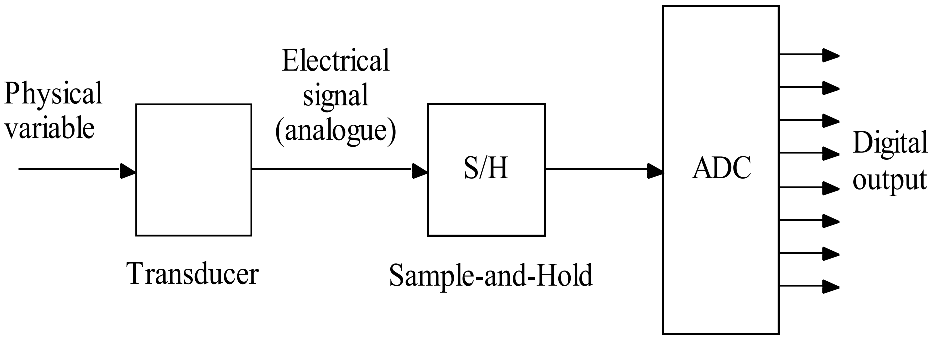
1. Connect two oscilloscope probes, one to DAC output and one to the variable voltage input. You will notice that the output of the DAC is a binary search waveform that converges to the input voltage level.
2. Record some oscilloscope plots so you have a record about how the system behaves.
3. Record some display values and respective input voltage to determine a calibration factor. Modify your software to make the displayed value equal the input voltage.

For your design project report, please cover the following:

1. Describe the behaviour and relative performance of the two convertors you have implemented.
2. Discuss the advantages of using "C" rather than assembler.

Question section:

1. The diagram below shows a typical data acquisition system where an analogue signal from a transducer is converted to a digital form suitable for subsequent digital signal processing.




(a) The block labeled ADC contains an 8-bit *successive-approximation* analogue-to-digital converter.

(i) With the aid of suitable diagrams describe the operation of this device.

(ii) The ADC is designed to operate over an input voltage range of 0 to 5V. Determine the *resolution* of the ADC.

(iii) During the conversion process each step takes $2\,\mu s$. Calculate the complete *conversion time* for a full-scale input signal of $5\,V$.

(b) Another of the blocks in the diagram is labelled sample-and hold.

(i) Explain the purpose and operation of this device.

(i) The sample period is 25μs. Find the highest frequency component that may be present in the signal before aliasing occurs.

2. It is often necessary to acquire data from several analogue input channels. Describe how a simple addition to the above data acquisition system can convert it to a system which can digitise four input channels of data and yet use only one ADC unit. (There will be a corresponding reduction in the sampling rate for each channel).

3. For the following analogue to digital converter case, calculate both the binary and decimal output code.
   (i) An input voltage of 3.293 V into a 8-bit ADC with a 0 – 10 V input range.

4. A 16 bit ADC system with a sample period of 20μs is used to record a song that lasts for 5 minutes. Calculate how much memory is required to store the song.

5. Discuss the difference between SRAM and DRAM.

6. Discuss the difference between SDR and DDR DRAM.