Lab2: Digital Voltmeter

Introduction and Objectives

The purpose of this lab is to design a digital voltmeter and display the voltage value on the multiplexed 7-segment display of the EasyPIC 7 demo board.

1. A/D Transfer Function

The A/D converter maps an applied analog voltage V_{in} into an n-bit digital code *ADRES* (A/D result) in accordance with the characteristic curve of figure 1.

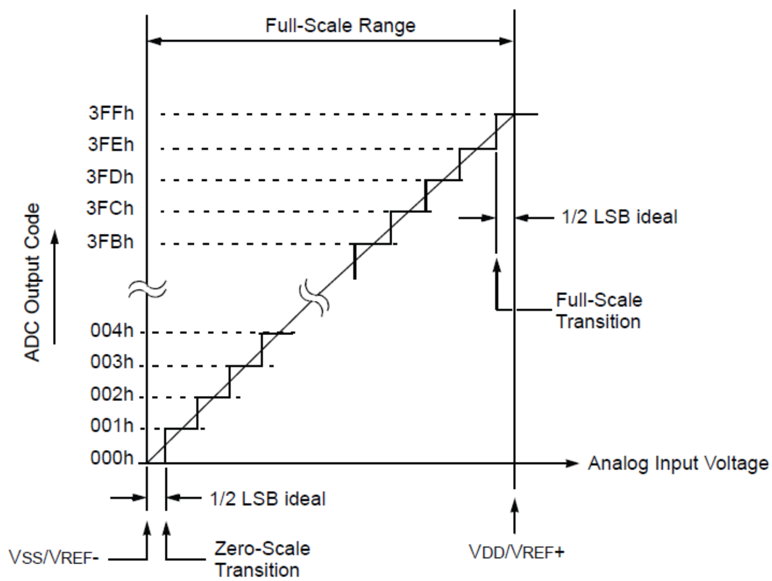

Figure1: A/D Characteristic curve

The A/D characteristic equation is given by:

$$ADRES = (2^n / V_{REF})\ x\ V_{in} \qquad (1)$$

where *n* is the A/D resolution in bits and V_{REF} corresponds to the highest voltage that may be applied to the A/D. It is assumed that low voltage reference is ground in this case. Solving for V_{in} as a function of *ADRES*, we get

$$V_{in} = \frac{V_{REF}}{2^n} ADRES \qquad (2)$$

This equation shows that the error in computing the voltage is $\pm V_{REF} / 2^{n+1}$. This is equivalent to ± 9.76 mV for n = 8 and ± 2.44 mV for n = 10.

2. Digital Voltmeter with 1-digit Precision

It is desired to implement a 2-digit voltmeter to measure an applied voltage between 0.0 V and 5.0 V. In order to measure the voltage with one digit after the decimal point, we can multiply V_{in} of equation (2) by 10 then place the decimal point on the display at the appropriate position. This removes the hassle of having to work with fractions. Therefore, the voltage to be displayed, for n = 8 and V_{REF} = 5 V, is given by equation (3) which happens to be a nice equation from a coding point of view.

$$V = 10V_{in} = 10\,(V_{REF}\,/\,2^n)\,ADRES = 50\ ADRES\ /\ 256 \qquad (3)$$

Using the multiplexed display, write a program to test the 2-digit voltmeter. Justify the fact that 8-bit mode operation is sufficient for 1-digit of precision after the decimal point.

3. Digital Voltmeter with 2-digit Precision

Redo the voltmeter example of part (2) with 2 digits of precision after the decimal point. Justify using the ADC with a resolution of 10 bits. Derive the new expression to be computed.

4. AC Voltmeter

The concept of measuring DC voltage can be easily employed to measure AC voltage. In fact, the high voltage can be dropped down to a low level (say around 12 Vrms) via a step down transformer (isolated case) or a voltage divider (non-isolated case). From this point on, the voltage can be converted to DC via a bridge rectifier followed by a capacitor filter. The overall interface circuit can be designed to provide a DC voltage level between 0 and 5V for an AC input between 0 and 255 V_{rms}. Since the A/D reading provides a digital code proportional to the applied voltage, a value of **ADRESH** = 255 (8-bit mode) is equivalent to an applied AC voltage of 255 Vrms, and so forth. Design the hardware configuration.