EXPERIMENT #8 ANALOG TO DIGITAL CONVERSION

I OBJECTIVES

The objective of this experiment is to familiarize the student with the basic principles of analog to digital conversion. The aspects of converting a uni-polar analog signal to a 8-bit digital signal are explored. The emphasis will be on the Successive Approximation technique based conversion.

II COMPONENTS AND INSTRUMENTATION

The focus will be on the ADC0809 which is a 8-bit Successive Approximation type ADC. For power, you will use +5 V. As well, you need some resistors, capacitors and a few LEDs. Also a hex inverter IC (SN7414) for generating the clock signal. Note that it is important to bypass the power supplies directly on your prototyping board, using, for each supply, a parallel combination of a 100µF tantalum or electrolyte capacitors and or 0.1 µF low inductance ceramic capacitor. For measurement, you will use a bench multimeter.

III BRIEF THEORY

To convert an analog signal to digital form (i.e. to represent an analog voltage of 2.83623V using a binary number such as 101) we must know both the maximum possible range of the input signal (from 0V to a maximum, traditionally called V_{ref}) and the number of bits that will be used to represent it (called N). Dividing a 0-4V range into 4 distinct levels gives four 1V steps: these are 0, 1, 2, and 3V (NOT 4V). So, in summary, if you power your A/D converter with 0 and V_{ref} volts, you can get out of it anything from 0V to just 1 step less than V_{ref}, which mathematically is 0V to $V_{ref}(2^N - 1)$.

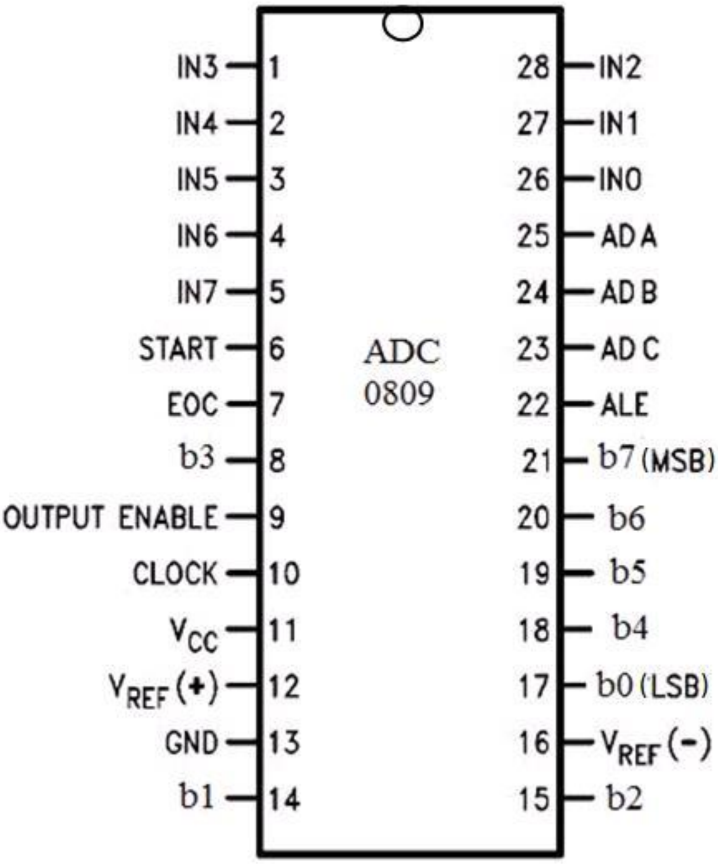

Fig.8.1 Pin diagram of ADC 0809
(refer to data sheets for more details)

The following general formula converts an analog input voltage V_{analog} to a digital output V_{out} (decimal equivalent of N-bit binary input with scaling):

$$Vout = \frac{B}{2^N} V_{ref} \quad (8.1)$$

where 'B' is the decimal equivalent of the N-bit binary output. That is

$$B = \sum_{i=0}^{N-1} b_i 2^i$$

Fig.8.2 shows the transfer characteristics which is also known as the stair-case waveform of a 3-bit ADC. This is extended to 256 steps in a 8-bit ADC such as ADC0809. The operation of ADC-0809 is based on 'Successive Approximation' principle using (8.1).

The digital output voltage can be computed as

$$V_{out} = \frac{V_{ref}}{256}\left[\sum_{i=0}^{7} b_i 2^i\right]$$

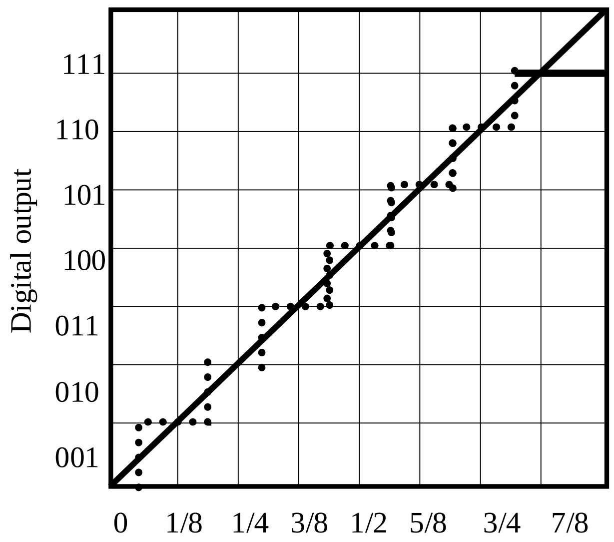

Fig. 8.2 Transfer characteristics for a 3-bit ADC

The resolution of an ADC is the smallest change in the analog signal that can be processed by the ADC. It is given by

Resolution = $1/2^N \; pu$.

IV PREPARATION

1. An 8-bit ADC outputs all 1's when the input voltage is 5.1V. Calculate the resolution. Find the output voltage for an input of a)1 V b) 2.50 V c) 3.40V d) 4.68 V

2. An ADC converts a given positive analog signal into a digital signal. The reference voltage is 5 V. The least measurable voltage is not greater than 0.0048828 V. What is the number of bits at output?

3. What is the purpose of a clock input signal in the experiment using ADC-0809?

4. Specify the required voltages at AD A, AD B and AD C for selecting input channel 3 in ADC0809. (refer to data sheets)

V EXPLORATIONS

5.1

5.11 Design: Configure the voltage levels at AD A, AD B and AD C for selecting input channel _________ in your set up using ADC0809. Use Vref= +5V. Indicate how the channel is selected.

5.12 Draw a neat circuit diagram with all details for your ADC circuit.(Include details of input channel selection, clock frequency).

5.2 Procedure:

1. Make the connections as shown in the circuit diagram.
2. Set the analog signal input at the minimum level.
3. Set the **ALE** pin to logical high.
4. Set the **SOC** pin to logical high momentarily and then connect back to ground.
5. Set the **ALE** pin to back to logical low. The **EOC** should now be seen (indicated by the glow of the EOC LED).
6. Record the state of the output bits (logical high or low , indicated by the corresponding LED glowing or otherwise). Compute the equivalent analog output voltage.
7. Repeat the above steps (2-6) for different values of analog inputs (from 0 V to 5 V) and fill in the rest of the Table 8.1.

S.No.	Analog input V	Digital output (logical '0' or '1')								Decimal count (B)	V_{out} (measured) V	% error
1		**b7**	**b6**	**b5**	**b4**	**b3**	**b2**	**b1**	**b0**			
2		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**			
3												
4												
5												
6												
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8												
9												
10												
11												
12												
13												
14												
15												
16		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**			

5.3 Plot the transfer characteristics for the ADC0809 using both predicted (continuous line) and your measured data (markers).

VI. INFERENCE/CONCLUSIONS