# Department of Computer and Software Engineering – ITU

# SE201L: Digital Logic Design Lab

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| **Course Instructor: Ms Aqsa Khalid** | **Dated: 27–11–2024** |
| **Lab Engineer: Muhammad Kashif** | **Semester: Fall 2024** |
| **Batch: BSSE 23 A** | |

## LAB 12 Study of Operation of an 8-bit Analog-to-Digital Converter IC

| Name | Roll Number | Lab Marks |
|---|---|---|
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Checked on: _____

Signature: _____

# Study of Operation of an 8-bit Analog-to-Digital Converter IC

## 12.1. Introduction

This lab exercise familiarizes students with the technique of analog to digital conversion. By use of a voltage divider circuit, it is shown how a voltage signal can be converted into a digital value by use of an ADC IC and then how the actual value of the voltage can be estimated from this digital value. Calculations regarding the error in calculations are also performed in this lab.

## 12.2. Objectives

This lab will enable the students to achieve the following:

- Learn about range and resolution of an ADC
- Learn how to use an ADC IC, namely ADC0804
- Demonstrate analog-to-digital conversion using ADC0804
- Calculate the error percentage of the ADC

## 12.3. Conduct of Lab

1. All tasks of this lab have to be performed using the logic trainer in Embedded Lab.
2. Bring printout of this lab manual when you come to perform the lab.
3. You can work and get evaluated in groups of two. However, manual submission has to be separate.
4. If there is difficulty in understanding any aspect of the lab, please seek help from the lab engineer or the TA.
5. If a lab task contains an instruction to show the work to lab engineer, make sure that the lab engineer evaluates and marks on your manual for that task. If your manual is unmarked for this task, it can result in mark deduction.
6. All tasks must be evaluated within the lab time. Submit the lab manual before leaving the lab.

## 12.4. Theory and Background

### 12.4.1. Analog to digital conversion

To input an analog (continuous) quantity into a computer or a microcontroller or, in general, in any digital logic circuit for any manipulation, its electrical signal has to be converted into digital form. By conversion to digital form, it is meant that the magnitude of the electrical signal is converted into a digital number (an n-bit binary number). A device that carries out this conversion from analog to digital is called an analog-to-digital converter (ADC, A/D converter, etc.). ADC can make use of different algorithms to carry out analog to digital conversion such as direct conversion, successive approximation, ramp-compare, etc.

Pertinent to this lab are following two important definitions related to ADC:

#### 12.4.1.1. Range

Range of ADC is the range of analog values over which it can produce distinct digital values.

#### 12.4.1.2. Resolution

Resolution of ADC is the minimum change in the analog input that the ADC is able to perceive and show as a change in the digital output. Resolution is obtained by dividing the range of ADC with $2^n$, where n is the number of bits of digital output of the ADC.

$$Resolution = \frac{Upper\ limit - lower\ limit}{2^n}$$

## 12.5. Parts and Equipment

1. Digital Logic Trainer
2. Digital Multi-meter
7. ADC0804: 8-bit successive approximation A/D converter
8. Resistors (Ω): 2.7k, 2.7k, 10k, 10k, 330, 5k variable
9. Capacitors: 100pF, 47pF
10. LDR

## 12.6. Lab Tasks

### 12.6.1. Task 1: Analog-to-digital conversion using voltage input from potentiometer [Marks: 20]

1. ADC 0804 is an 8-bit successive approximation A-to-D converter. Its pin configuration is as shown in Figure 12.1 with the pin description given below:

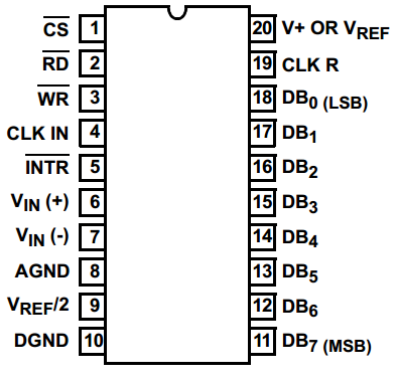


Figure 12.1: Pin Configuration of ADC0804

CS (Active-low): Chip Select, must be set to 0 to enable operation of ADC
RD (Active-low): Read, sends data stored in the internal registers to output pins when conversion has completed
WR (Active-low): Starts conversion
CLK IN: External clock is connected to this pin
INTR (Active Low): Goes low when conversion is complete
$V_{IN}$ (+): Non-inverting analog input voltage
$V_{IN}$ (-): Inverting analog input voltage; normally connected to ground
AGND: Analog ground
$V_{Ref}/2$: Half of reference voltage is connected to this pin
DGND: Digital ground
V+: VCC to power the IC, 5V
CLK R: This pin is used when internal clock of ADC 0804 is to be used
$DB_0$-$DB_7$: Digital output pins

2. Give answers to questions 1 and 2 of Analysis.
3. Now, build the circuit of Figure 12.2 on the breadboard of logic trainer. [15]
4. This circuit has a VREF equal to 5V. It takes analog input from a potentiometer (R1) at VIN+ (pin 6) and converts it into an 8-bit binary number that is outputted at DB0-DB7. You may use the on-board potentiometer of the logic trainer in your construction. This circuit uses the self-clocking mode of the ADC0804 by connecting an RC circuit between CLKR and CLKIN pins. Clock frequency from the RC circuit can be found by the following relation:

$f_{CLK} = 1 / (1.1*R*C)$

5. Give answer to question 3 of Analysis.

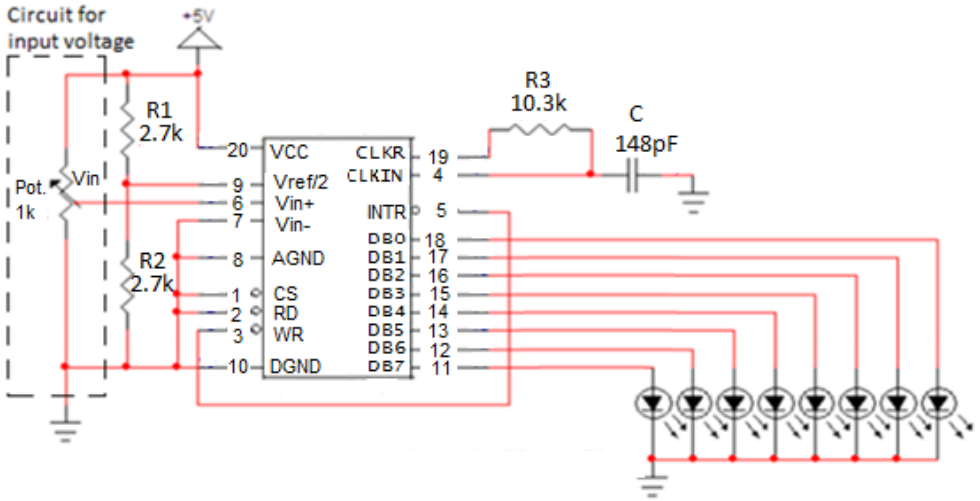


Figure 12.2: Circuit to set up ADC0804

6. Rotate the control knob of the potentiometer and note down the digital output for three different values. Also, for each observation, measure the analog voltage from the potentiometer using a DMM and find out the percentage error in the digital output. Show working circuit to the lab engineer to obtain credit. [15]

Table 12.1: ADC measurements with input from potentiometer

| Sr. no. | DMM measurement (Vin) | 8-bit output of ADC (X) | Decimal equivalent of X (Y) | Calculated value from digital outputs (Vo = Y × ADC resolution)) | % error =((Vin -Vo)/Vin) × 100 |
|---|---|---|---|---|---|
| 1. | 4 | 11001100 | 204 | 3.98 | 0.57 |
| 2. | 3.5 | 10110010 | 178 | 3.47 | 0.86 |
| 3. | 3 | 10011001 | 153 | 2.98 | 40.3 |

## 12.6.2. Analysis [Marks: 5]

1. With Vref = 5V and Vref/2 (pin 9) set to 2.5 V, find the range of this 8-bit ADC. [3]

2. With Vref/2 (pin 9) set to 2.5 V and the range calculated above, calculate the resolution of this ADC. [2]

# Assessment Rubric

**Method:**
Lab report evaluation and instructor observation during lab sessions.

| Performance | CLO | Able to complete the tasks over 80% (4-5) | Able to complete the tasks 50 – 80% (2-3) | Tasks completion below 50% (0-1) | Marks |
|---|---|---|---|---|---|
| 1. Teamwork | 1 | Actively engages and cooperates with other group members in an effective manner | Cooperates with other group members in a reasonable manner | Distracts or discourages other group members from conducting the experiments | |
| 2. Laboratory safety and disciplinary rules | 1 | Observes lab safety rules; handles the development board and other components with care and adheres to the lab disciplinary guidelines aptly | Observes safety rules and disciplinary guidelines with minor deviations | Disregards lab safety and disciplinary rules | |
| 3. Realization of experiment | 2 | Conceptually understands the topic under study and develops the experimental setup accordingly | Needs guidance to understand the purpose of the experiment and to develop the required setup | Incapable of understanding the purpose of the experiment and consequently fails to develop the required setup | |
| 4. Conducting experiment | 2 | Sets up hardware/software properly according to the requirement of experiment and examines the output carefully | Makes minor errors in hardware/software setup and observation of output | Unable to set up experimental setup, and perform the procedure of experiment | |
| 5. Data collection | 2 | Completes data collection from the experiment setup by giving proper inputs and observing the outputs, complies with the instructions regarding data entry in manual | Completes data collection with minor errors and enters data in lab report with slight deviations from provided guidelines | Fails at collecting data by giving proper inputs and observing output states of experiment setup, unable to fill the lab report properly | |
| 6. Data analysis | 2 | Analyzes the data obtained from experiment thoroughly and accurately verifies it with theoretical understanding, accounts for any discrepancy in data from theory with sound explanation, where asked | Analyzes data with minor error and correlates it with theoretical values reasonably. Attempts to account for any discrepancy in data from theory | Unable to establish the relationship between practical and theoretical values and lacks the theoretical understanding to explain any discrepancy in data | |
| 7. Computer use | 2 | Successfully uses lab PC and internet to look for relevant datasheets, carry out calculations, or verify results using simulation | Requires assistance in looking for IC datasheets and carrying out calculation and simulation tasks | Does not know how to use computer to look up datasheets or carry out calculation and simulation tasks | |
| | | | | **Total** (out of 35) | |