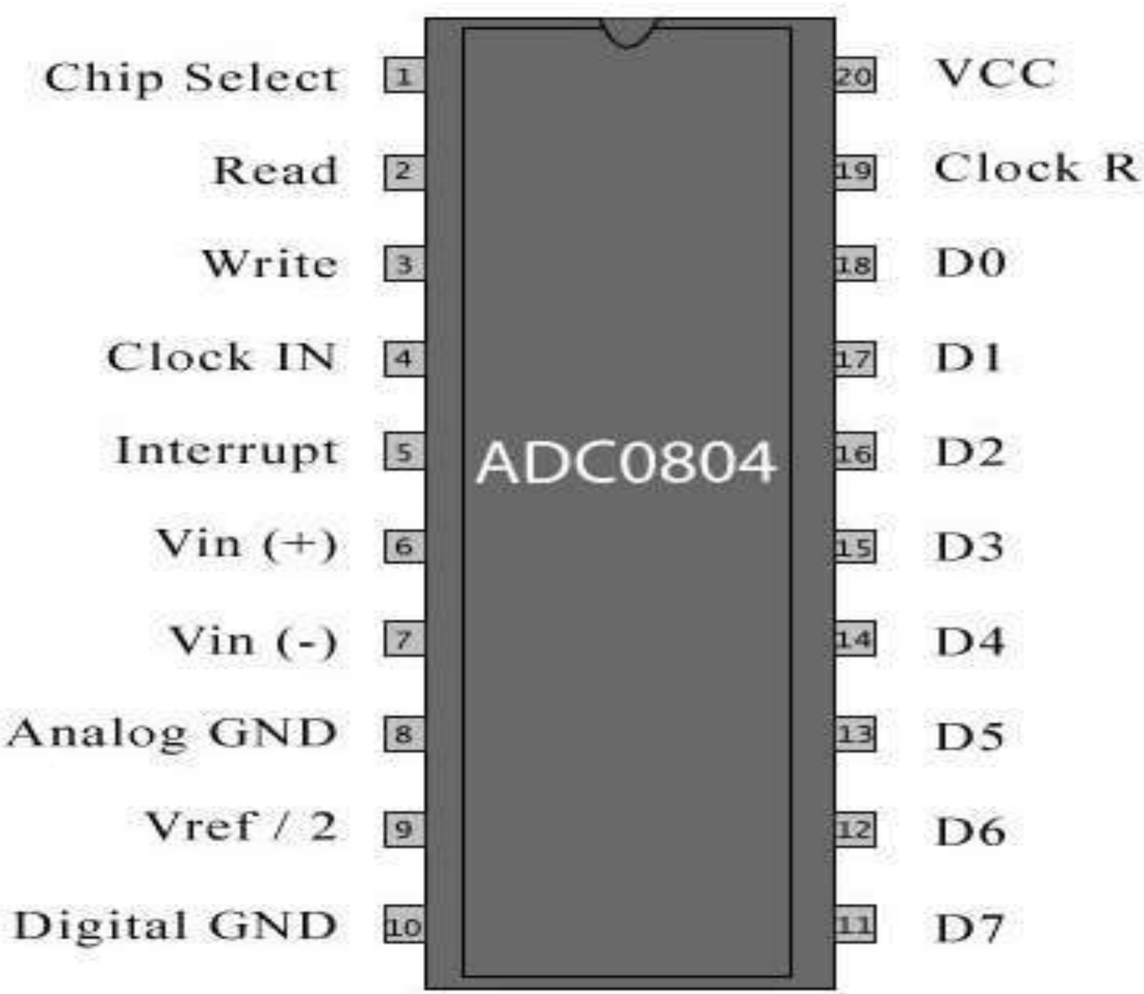
ADC(0804) INTERFACING

ADCs(Analog-to-Digital Converters) are among the most widely used devices for data acquisition.

A Physical quantity, like temperature, pressure, humidity, and velocity, etc., is converted to electrical (Voltage , current) signals using a device called a transducer or sensor.

We need ADCs to translate the analog signals to digital numbers, so that the microprocessor/microcontroller can read the data for further implement.

ADC 0804



Chip Select
Read
Write
Clock IN
Interrupt
Vin (+)
Vin (-)
Analog GND
Vref / 2
Digital GND
1
2
3
4
5
6
7
8
9
10
ADC0804
20
19
18
17
16
15
14
13
12
11
VCC
Clock R
D0
D1
D2
D3
D4
D5
D6
D7

Important Points on ADC 0804

1. V_{cc} It works with +5 volts and has a resolution of 8 bits.
2. Conversion time is another major factor in judging an ADC.
    a. Conversion time is defined as the time it takes the ADC to convert the analog input to a digital (Binary) number.
    b. In ADC804 conversion time varies depending on the clocking signals applied to CLK R and CLK IN pins, but it cannot be faster than 110 µs

3. CLK IN and CLK R

a. CLK IN is an input pin connected to an external clock source

b. To use the internal clock generator (also called self-clocking), CLK IN and CLK R pins are connected to a capacitor and a resistor, and the clock frequency is determined by

$$f = \frac{1}{1.1\,RC}$$

Typical values are R = 10K ohms and C = 150 pF.

We get f = 606 kHz and the conversion time is 110 µs.

4. $V_{Ref}/2$: It is used for the reference voltage

- If this pin is open (not connected), the analog input voltage is in the range of 0 to 5 volts (the same as the Vcc pin)
- If the analog input range needs to be 0 to 4 volts, $V_{Ref}/2$ is connected to 2 volts

$V_{ref}/2$ Relation to V_{in} Range

$V_{ref}/2$(v)	V_{in}(V)	Step Size (mV)
Not connected*	0 to 5	5/256=19.53
2.0	0 to 4	4/255=15.62
1.5	0 to 3	3/256=11.71
1.28	0 to 2.56	2.56/256=10
1.0	0 to 2	2/256=7.81
0.5	0 to 1	1/256=3.90

Step size is the smallest change can be discerned by an ADC

5. Analog ground and digital ground

- Analog ground is connected to the ground of the analog Vin.
- Digital ground is connected to the ground of the Vcc pin.

6. CS(Chip Select)

Chip select is an active low input used to activate the ADC0804 chip.

7. RD(Read)

This is an input signal and is active low. The ADC converts the analog input to its binary equivalent and holds it in an internal register. RD is used to get the converted data out of the ADC0804 chip. When CS=0, if a high-to-low pulse is applied to the RD pin, the 8-bit digital output can be read from D0-D7. The RD pin is also referred to as Output Enable(OE).

8. WR(Write , a better name might be **“start of Conversion”**)

This is an active low input used to inform the ADC0804 to start the conversion process. If CS=0, when WR makes a low-to-high transition, the ADC0804 starts converting the analog input value of V_{in} to an 8-bit digital number

9. INTR(Interrupt, a better name might be **“End of Conversion”**)

This is an output pin and is active low. It is normally high pin and when the conversion is completed, it goes low to signal the CPU that the converted data is ready to be picked up. After INTR goes low, we make CS=0 and send a high- to- low pulse to the RD pin to get the next analog data to be converted.

10. V_{in} (+) and V_{in}(-)

These are the differential analog inputs where $V_{in} = V_{in}(+) - V_{in}(-)$. Often the V_{in} (-) pin is connected to ground and the V_{in} (+) pin is used as the analog input to be converted to digital.

11. D0-D7

These are the data 8-bit pins with D7 as MSB and D0 as LSB. These are connected parallel to any port of CPU. To calculate the output voltage use the following formula

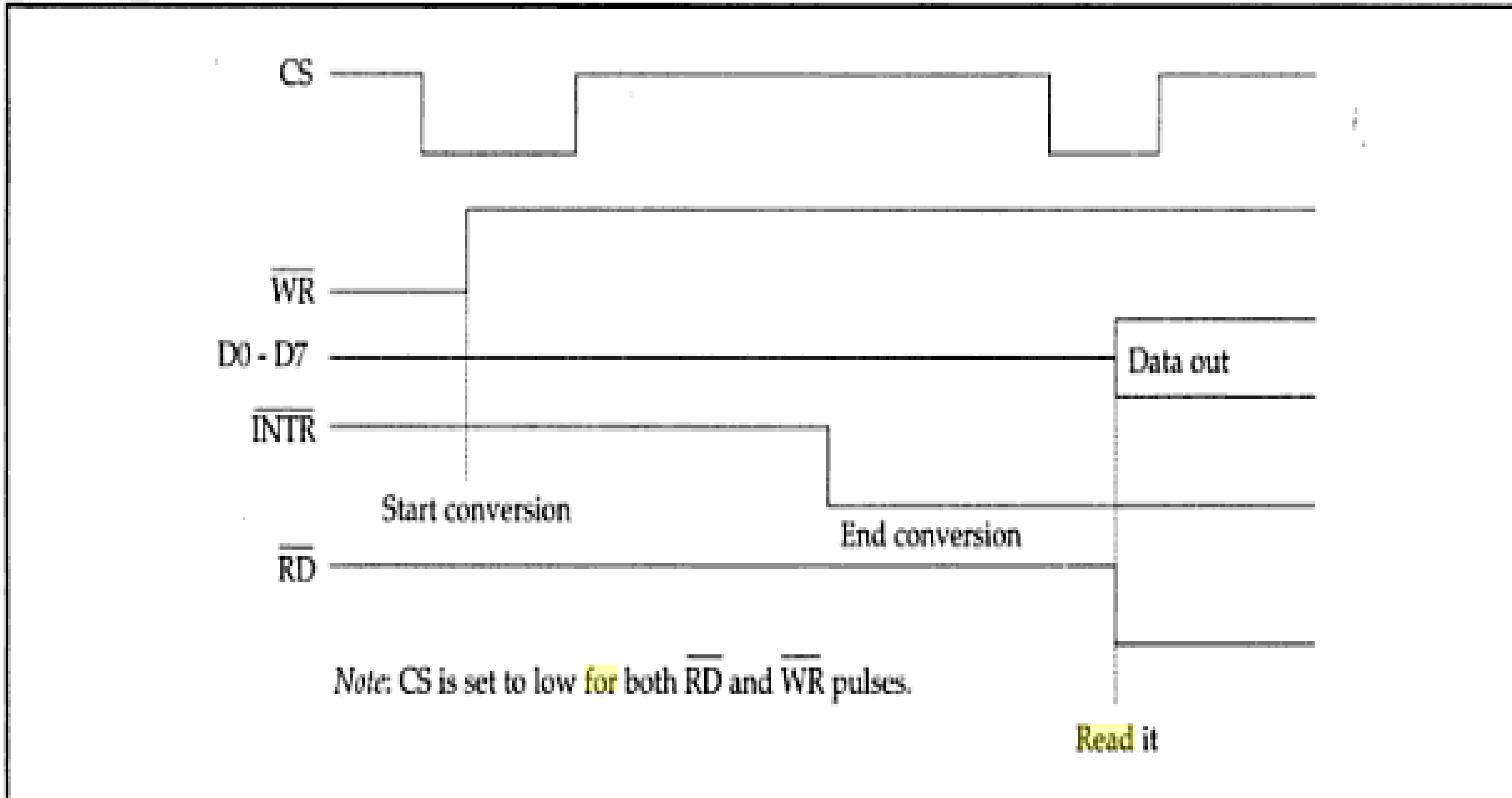
$$D_{out} = \frac{Vin}{Step\ size}$$

Where D_{out} is the digital data output in decimal

V_{in} is the analog input voltage and

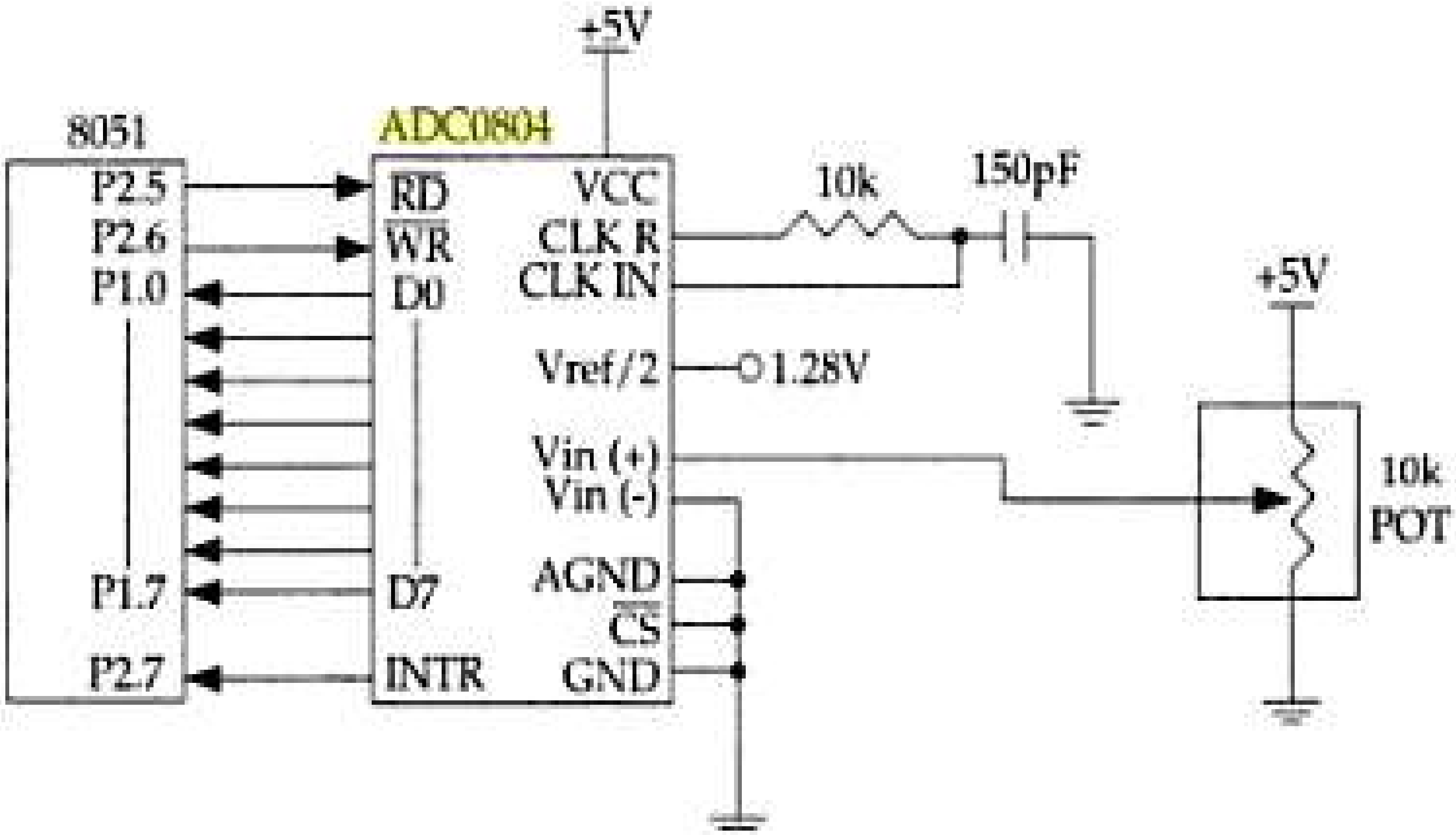
step size is the resolution the smallest change, which is $[2x(V_{ref}/2)]/256$.

Timing diagram of ADC 0804

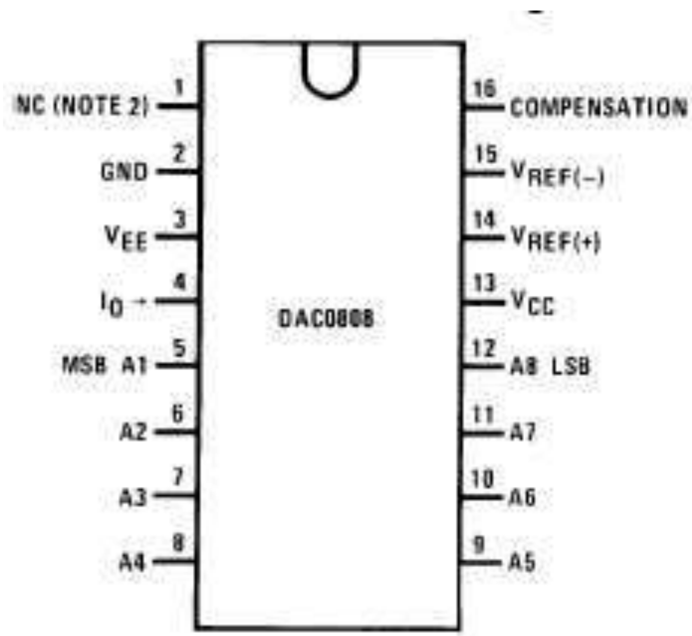


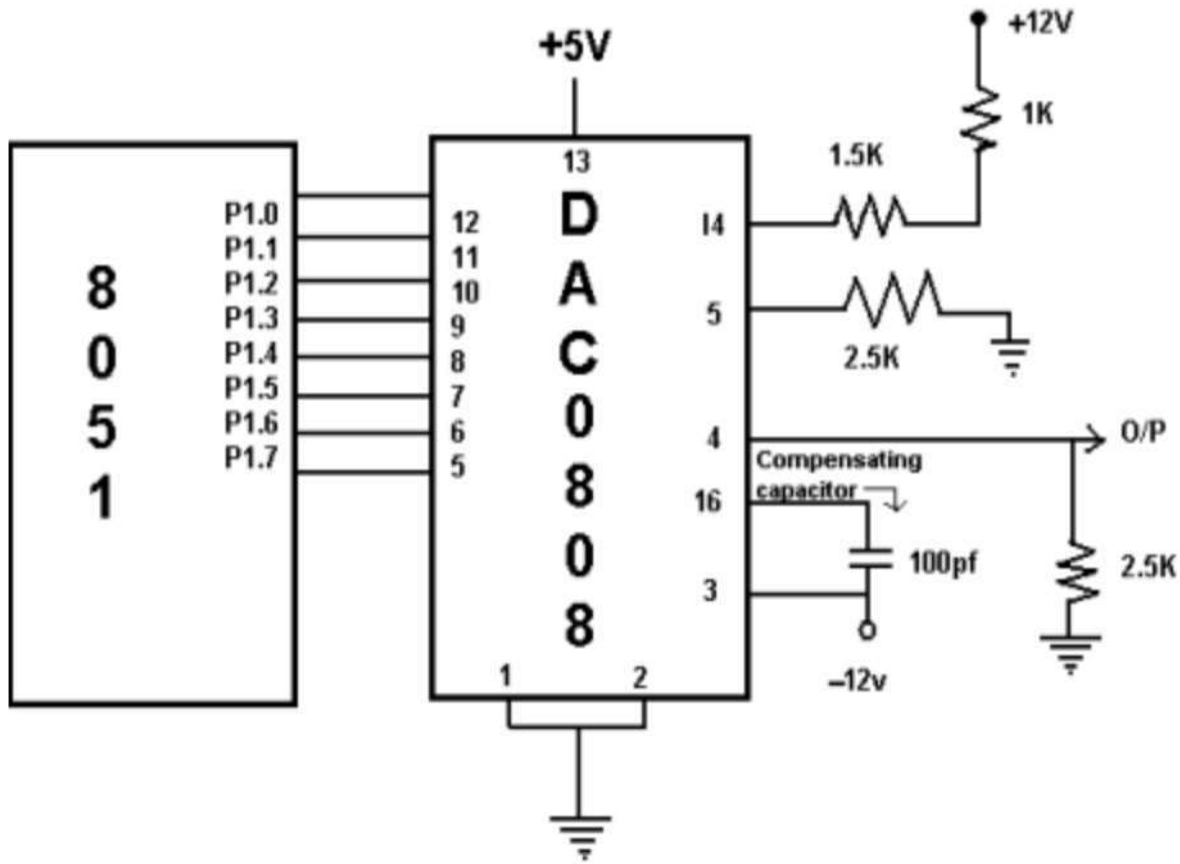
Read and Write Timing for ADC0804

Interfacing circuit of ADC0804

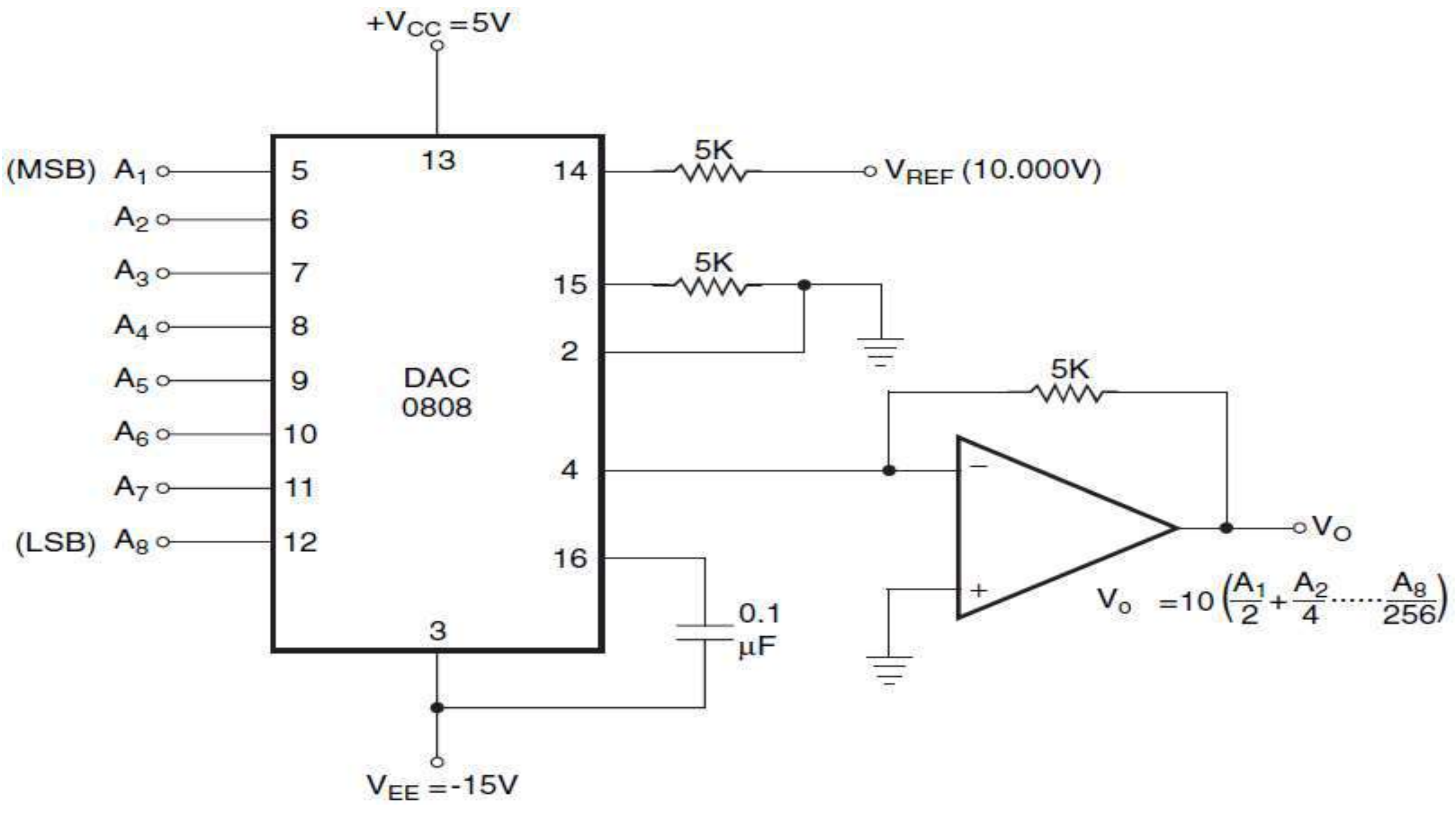


DAC(0808) INTERFACING





Interfacing Circuit of DAC 0808



$$I_{Out} = I_{Ref}\left(\frac{D7}{2} + \frac{D6}{4} + \frac{D5}{8} + \frac{D4}{16} + \frac{D3}{32} + \frac{D2}{64} + \frac{D1}{128} + \frac{D0}{256}\right)$$

For the following binary numbers applied to a DAC, calculate the output analog voltage obtained given that $I_{ref} = 2\,mA$ and $R = 5.6\,K$

i) 11000011

ii) 00010111

Solution

Equation can be used to find the value of the analog voltage for each case.

$I_{ref} = 2\,mA$

i) For 11000011, $I_o = I_{ref}\,(1/2 + 1/4 + 0 + 0 + 0 + 0 + 1/128 + 1/256)$

$= 2 \times (195/256)$

$= 1.52\,mA$

$V_o = 5.6 \times 1.52 = 8.52\,V$

ii) For 00010111, $I_o = I_{ref}\,(0 + 0 + 0 + 1/16 + 0 + 1/64 + 1/128 + 1/256)$

$= 2\,(23/256)$

$= 0.1796875\,mA$

$V_o = 5.6 \times 0.1796$

$= 1.006\,V$

Specifications related to DAC

1. Resolution: It can be defined as a smallest change in the output corresponding to an input change by one LSB.

2. Accuracy: This is the measure of the difference between the actual output voltage & the expected output voltage.

3. Full scale output voltage: This is the output voltage when binary input has the highest value. For ex: 8-bit 5V DAC have max voltage 5V-19.5mv= 4.9805V.

Generating Staircase waveform

```
        ORG 0H
START:      CLR A
AGAIN:      MOV P1,A            ;Send data to DAC
            INC A               ;count from 0h to FFh
            ACALL DELAY         ;Let DAC recover
            CJNE A,#0FFH,GO
            SJMP START
GO:         SJMP AGAIN

DELAY:      MOV R0,#0FFH
LOOP:       DJNZ R0,LOOP
            RET
        END
```

Generating Triangular waveform

```
ORG 0H
START0to1:   CLR A
AGAIN1:      MOV P1,A                 ;Send data to DAC
             INC A                    ;count from 0h to FFh
             ACALL DELAY              ;Let DAC recover
             CJNE A,#0FFH,GO1
             SJMP START1to0
GO1:         SJMP AGAIN1
START1to0:   MOV P1,A
             DEC A
             ACALL DELAY
             CJNE A,#00H,GO2
             SJMP START0to1
GO2:         SJMP START1to0
END
```

```
DELAY:   MOV R0,#0FFH
LOOP:    DJNZ R0,LOOP
         RET
```

Generating Sine waveform

To generate a sine wave , we first need a table whose values represent the magnitude of the sine of angles between 0^0 & 360^0 The values for the sine function vary from -1.0 to +1.0 for 0^0 & 360^0 angles. Therefore, the table values are integer numbers representing the voltage magnitude for the sine of theta (θ). To generate sine wave we assume the full scale voltage of 10V for DAC output. Full scale output of the DAC is achieved when all the data inputs of the DAC are high. Therefore, to achieve the full scale 10V output, we use the following equation.

$$V_{Out} = 5V + (5 \times \sin \theta)$$

Angle vs. Voltage Magnitude for Sine Wave

Angle θ (degrees)	Sin θ	V_{out} (Voltage Magnitude) 5 V + (5 V × sin θ)	Values Sent to DAC (decimal) (Voltage Mag. × 25.6)
0	0	5	128
30	0.5	7.5	192
60	0.866	9.33	238
90	1.0	10	255
120	0.866	9.33	238
150	0.5	7.5	192
180	0	5	128
210	−0.5	2.5	64
240	−0.866	0.669	17
270	−1.0	0	0
300	−0.866	0.669	17
330	−0.5	2.5	64
360	0	5	128

Example

Verify the values given for the following angles: (a) 30° (b) 60°.

Solution:

(a) $V_{out} = 5\ V + (5\ V \times \sin\theta) = 5\ V + 5 \times \sin 30° = 5\ V + 5 \times 0.5 = 7.5\ V$

DAC input values = $7.5\ V \times 25.6 = 192$ (decimal)

(b) $V_{out} = 5\ V + (5\ V \times \sin\theta) = 5\ V + 5 \times \sin 60° = 5\ V + 5 \times 0.866 = 9.33\ V$

DAC input values = $9.33\ V \times 25.6 = 238$ (decimal)

To find the value sent to the DAC for various angles, we simply multiply the V_{out} voltage by 25.60 because there are 256 steps and full-scale V_{out} is 10 volts. Therefore, 256 steps / 10 V = 25.6 steps per volt.

Program

```
ORG 0H
        MOV DPTR,#TABLE
        MOV R2,#COUNT
BACK:   CLR A
        MOVC A,@A+DPTR
        MOV P1,A
        INC DPTR
        DJNZ R2,BACK
        SJMP AGAIN

ORG 0300H
TABLE: DB       128,192,238,255,238,192,128,64,17,0,17,64,128
```

Representation of Sine waveform