UNIT NO 5

Subject: Processor Architecture
(214451)

PIC Interfacing-III

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Introduction Analog to Digital Converter

- When we interface sensors to the microcontroller, the output of the sensor many of the times is analog in nature. But microcontroller processes digital signals.
- Hence we use ADC in between sensors and microcontrollers. It converts an analog signal into digital and gives it to the microcontroller.

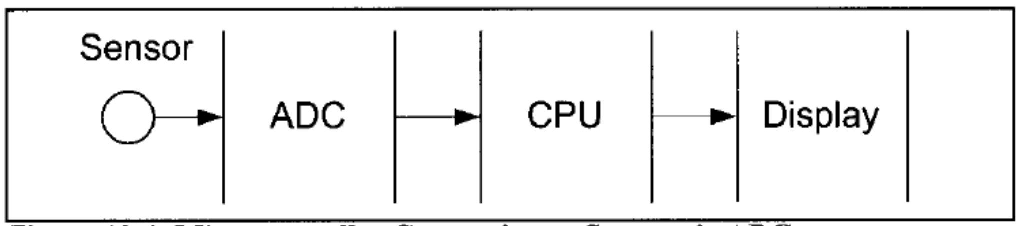


Figure 13-1. Microcontroller Connection to Sensor via ADC

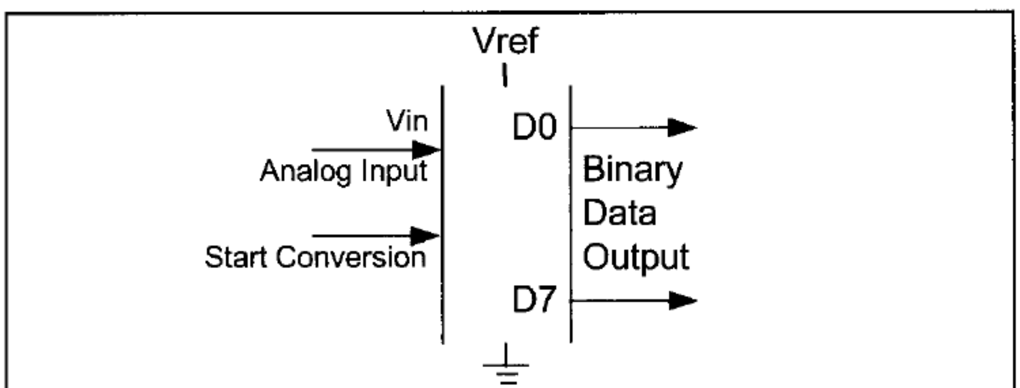
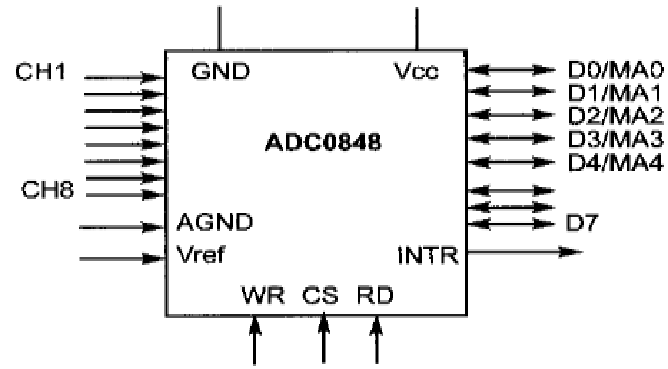
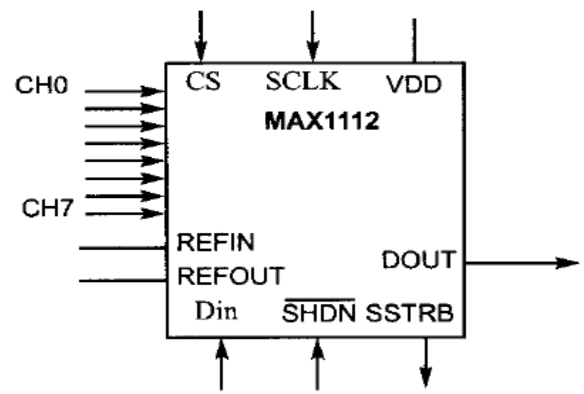


Figure 13-2. An 8-bit ADC Block Diagram

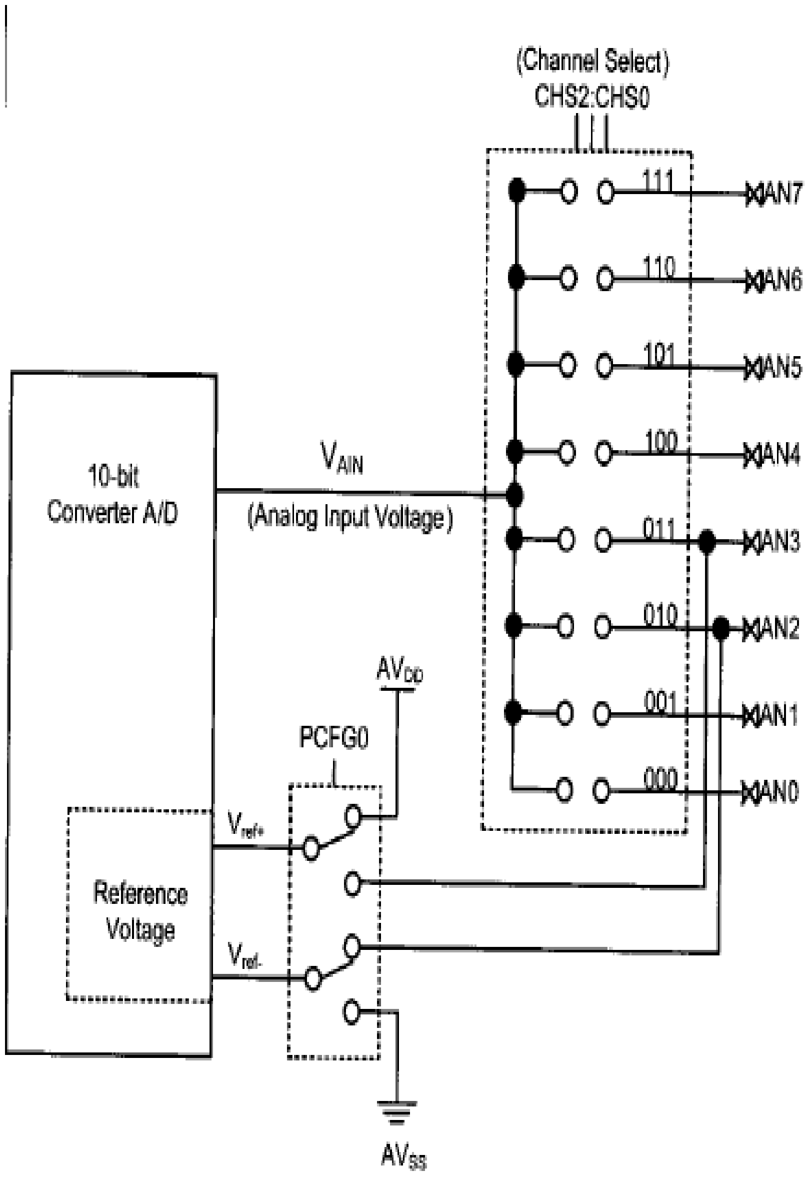


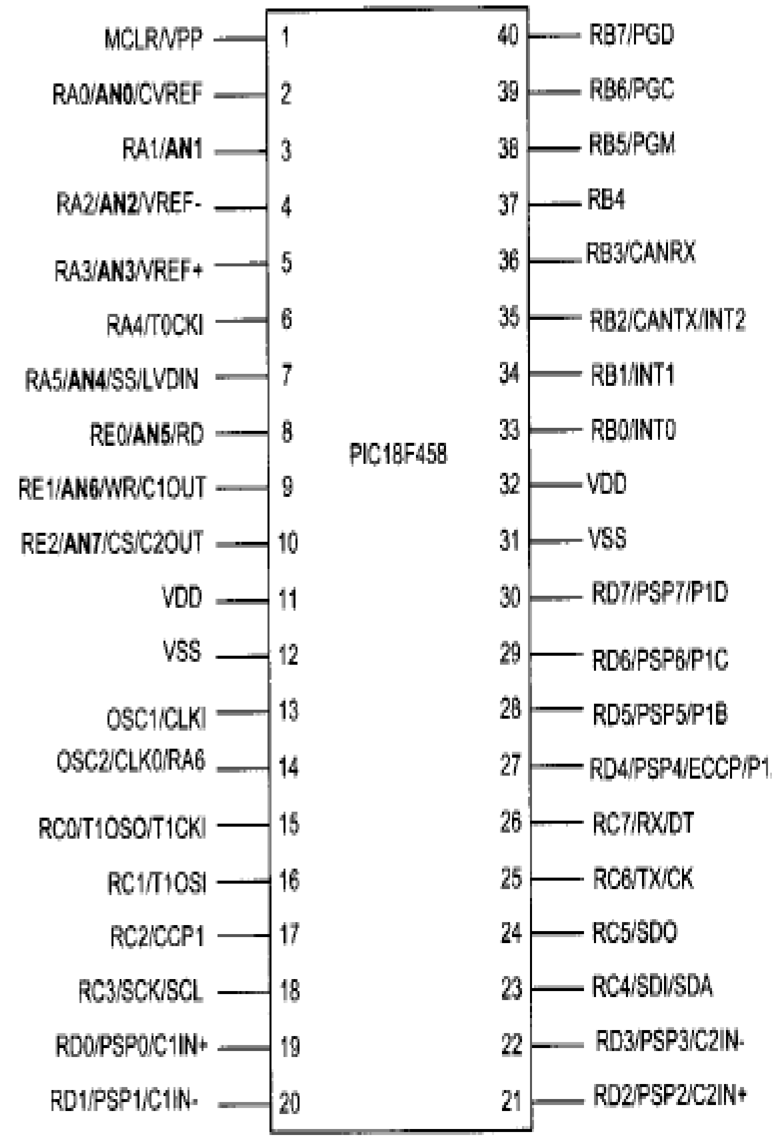


Features of ADC :

- The PIC18f458 has a 10-bit 8 channel A/D converter.
- The number of analog inputs varies among difference PIC18 devices.
- The A/D converter has the following registers:
  1. A/D Result High Register (ADRESH)
  2. A/D Result Low Register (ADRESL)
  3. A/D Control Register 0 (ADCON0)
  4. A/D Control Register 1 (ADCON1)
- ADRESH and ADRESL registers hold the result of the A/D conversion and gives 16 bit output.
- ADCON0 is Control Register used for setting conversion time as well as used to select the input channels.
- ADCON1 is Control Register used for setting Vref voltage.

Interfacing of ADC with PIC microcontroller





Digital Output value Calculation:

$$D_{out} = \frac{V_{in}}{step\ size}$$

V_{ref} (V)	V_{in} (V)	Step Size (mV)
5.00	0 to 5	5/1,024 = 4.88
4.096	0 to 4.096	4.096/1,024 = 4
3.0	0 to 3	3/1,024 = 2.93
2.56	0 to 2.56	2.56/1,024 = 2.5
2.048	0 to 2.048	2.048/1,024 = 2
1.28	0 to 1.28	1/1,024 = 1.25
1.024	0 to 1.024	1.024/1,024 = 1

ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	--	ADON

ADCS2 (from ADCON1)	ADCS1	ADCS0	Conversion Clock Source
0	0	0	Fosc/2
0	0	1	Fosc/8
0	1	0	Fosc/32
0	1	1	Internal RC used for clock source
1	0	0	Fosc/4
1	0	1	Fosc/16
1	1	0	Fosc/64
1	1	1	Internal RC used for clock source

CHS2	CHS1	CHS0	CHANNEL SELECTION
0	0	0	CHAN0 (AN0)
0	0	1	CHAN1 (AN1)
0	1	0	CHAN2 (AN2)
0	1	1	CHAN3 (AN3)
1	0	0	CHAN4 (AN4)
1	0	1	CHAN5 (AN5) not implemented on 28-pin PIC18
1	1	0	CHAN6 (AN6) not implemented on 28-pin PIC18
1	1	1	CHAN7 (AN7) not implemented on 28-pin PIC18

GO/DONE A/D conversion status bit.

1 = A/D conversion is in progress. This is used as start conversion, which means after the conversion is complete, it will go LOW to indicate the end-of-conversion.

0 = A/D conversion is complete and digital data is available in registers ADRESH and ADRESL.

ADON A/D on bit

0 = A/D part of the PIC18 is off and consumes no power. This is the default and we should leave it off for applications in which ADC is not used.

1 = A/D feature is powered up.

Figure 13-6. ADCON0 (A/D Control Register 0)

ADFM	ADCS2	--	--	PCFG3	PCFG2	PCFG1	PCFG0

ADFM A/D Result format select bit

1 = Right justified: The 10-bit result is in the ADRESL register and the lower 2 bits of ADRESH. That means the 6 most significant bits of the ADRESH register are all 0s.

0 = Left justified: The 10-bit result is in the ADRESL register and the upper 2 bits of ADRESL. That means the 6 least significant bits of the ADRESL register are all 0s.

ADCS2 A/D Clock Select bit 2. This bit along with the ADCS1 and ADCS0 bits of the ADCON0 register decide the conversion clock for the ADC. The default value for ADCS2 is 0, which means setting the ADCS0 and ADCS1 values of ADCON0 can give us clock conversion of Fosc/2, Fosc/8, and Fosc/32. See the ADCON0 register.

PCFGs: A/D Port Configuration Control bits:

Problems

For an 8-bit ADC, we have $V_{ref} = 2.56$ V. Calculate the D0–D7 output if the analog input is: (a) 1.7 V, and (b) 2.1 V.

Solution:

Because the step size is 2.56/256 = 10 mV, we have the following:

(a) D_{out} = 1.7 V/10 mV = 170 in decimal, which gives us 10101011 in binary for D7–D0.

(b) D_{out} = 2.1 V/10 mV = 210 in decimal, which gives us 11010010 in binary for D7–D0.

Problems

- Find the value for the ADCON0 register if we want FOSC/8, Channel 0, and ADON on.

Ans:

ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	--	ADON

ADCON0 = 01000x1

Problems

- A PIC 18 is connected to the 4MHz crystal oscillator. Calculate the conversion time if we want to use only ADCS bits of the ADCON0 register.

The options for the conversion clock source available in the ADCON0 register are as follows:

(a) For Fosc/2, we have 4 MHz / 2 = 2 MHz.

Tad = 1 / 2 MHz = 400 ns. Invalid because it is faster than 1.6 μs.

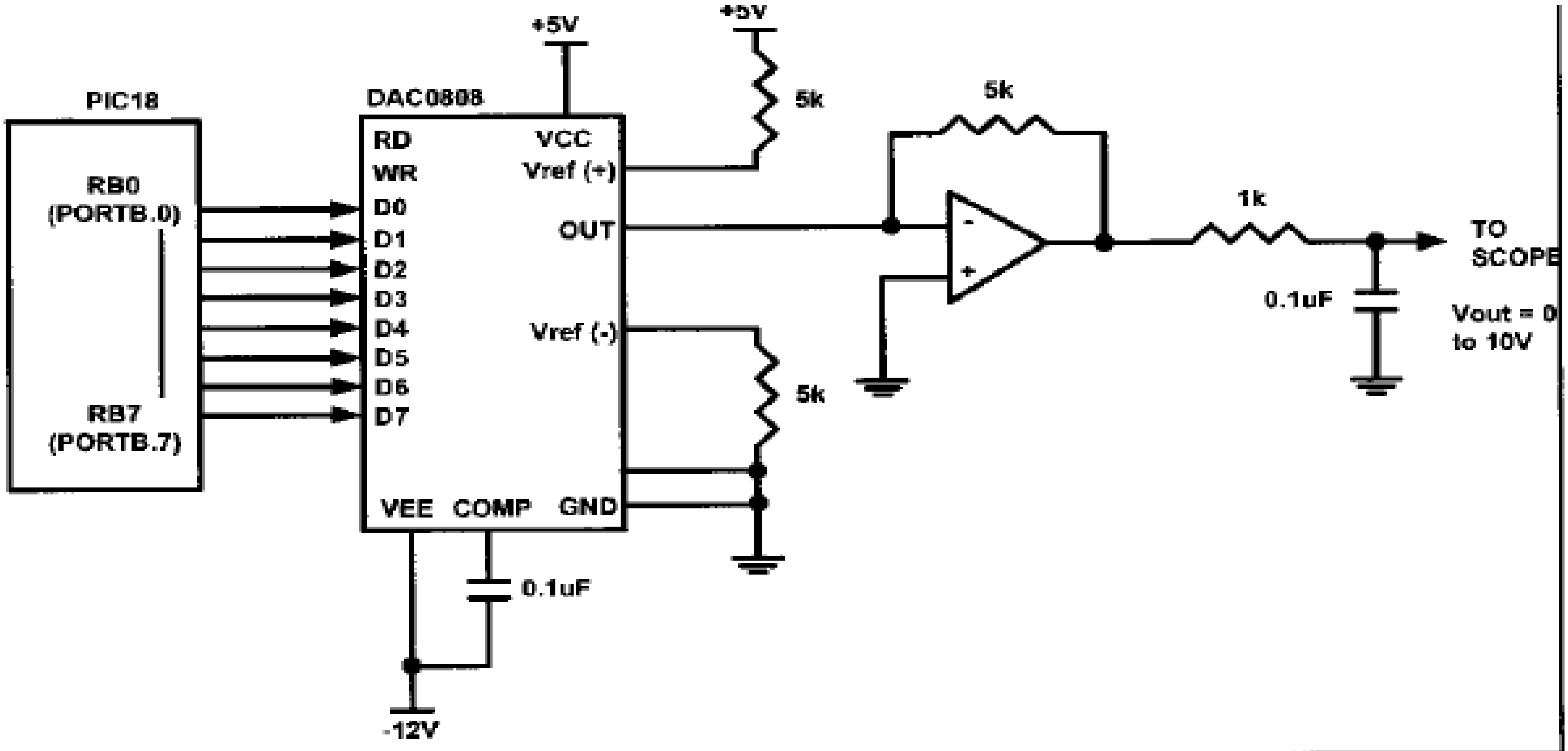
(b) For Fosc/8, we have 4 MHz / 8 = 500 kHz.

Tad = 1 / 500 kHz = 2 μs. The conversion time = 12 × 2 μs = 24 μs

(c) For Fosc/32, we have 4 MHz / 32 = 125 kHz.

Tad = 1 / 125 kHz = 8 μs. The conversion time = 12 × 8 μs = 96 μs

Interfacing of DAC with PIC microcontroller



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

- Assuming that R=5 K and Iref=2 mA for DAC0808, calculate Vout for the following binary inputs:
  i) 10011001 (99H) ii) 11001000 (C8H) iii) 10001000 (88H)

Ans: Iout= 2mA * (153/256) = 1.195mA

Vout = 1.19mA * 5K

= 5.975V