SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PIC16F877-Analog to Digital converter(ADC)

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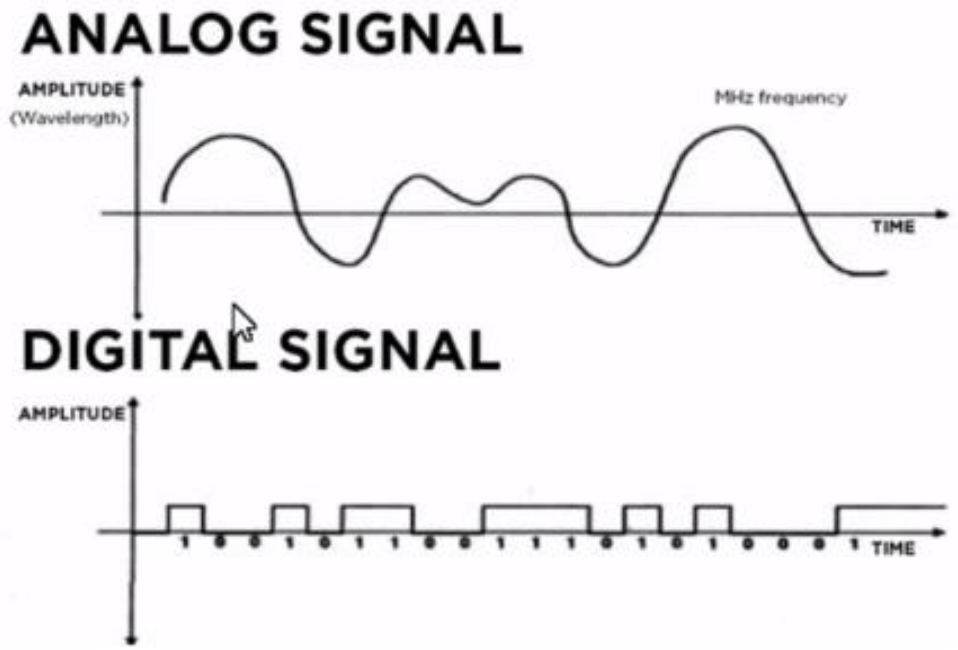
SENSORS

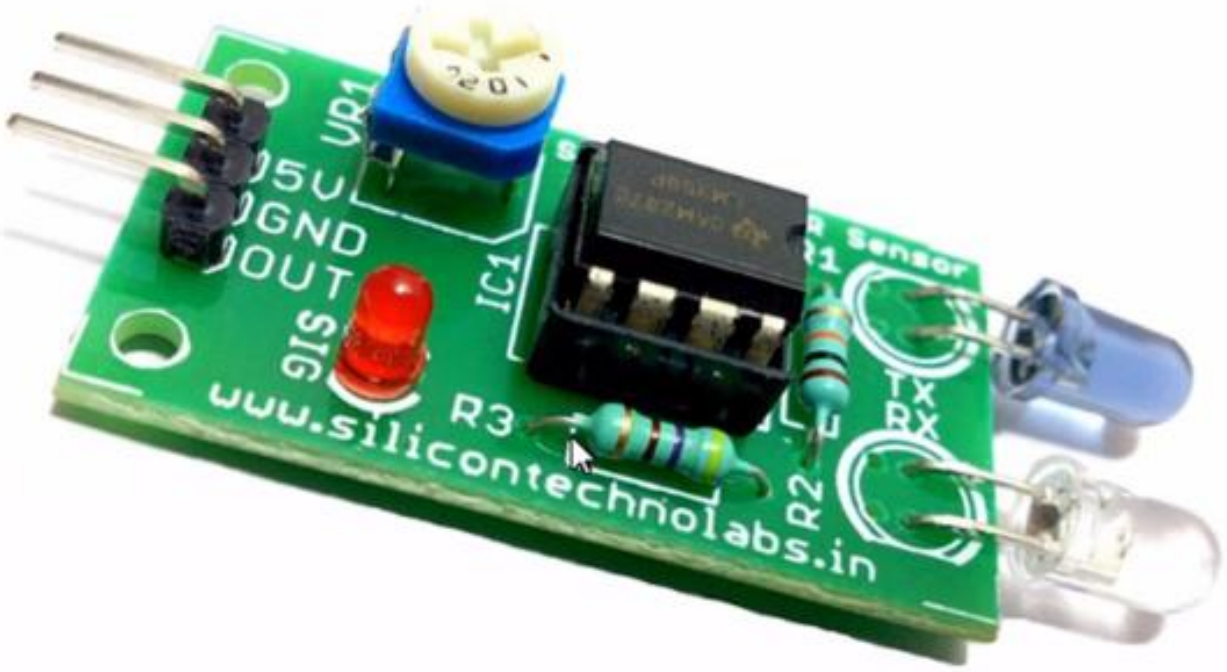
Different Sensors

- Temperature
- Humidity
- Pressure
- Smoke
- Gas
- Proximity
- IR sensor
- Touch Screen
- Metal Detector

Sensor Classification

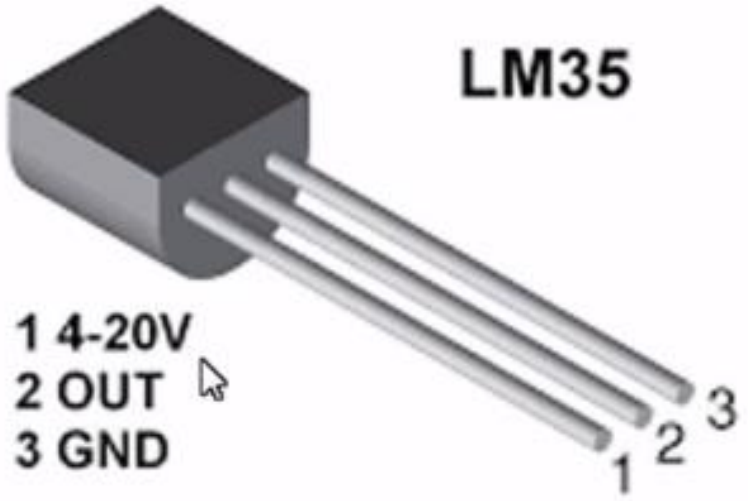


Digital Sensor

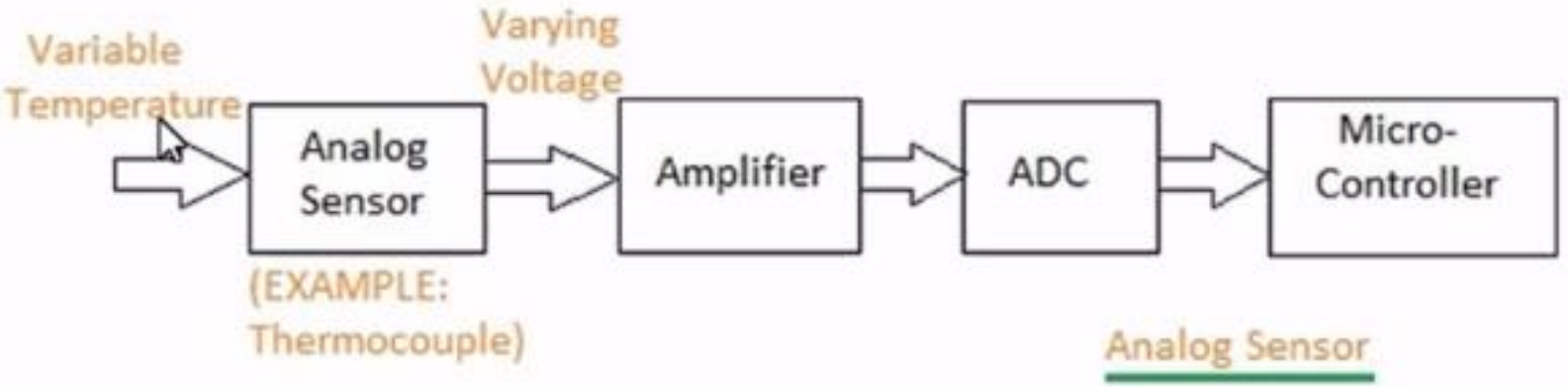


Proximity Sensor

Analog Sensor



Analog to Digital Conversion Process



RESOLUTION

10 Bit ADC

10 Bit = 2^{10}

10 Bit = 0 to 1023

STEP SIZE

$$Step\ Size = \frac{V_{cc}}{2^n - 1}$$

Step size = 5 / (1024 – 1)

Step size = 4.8 mV

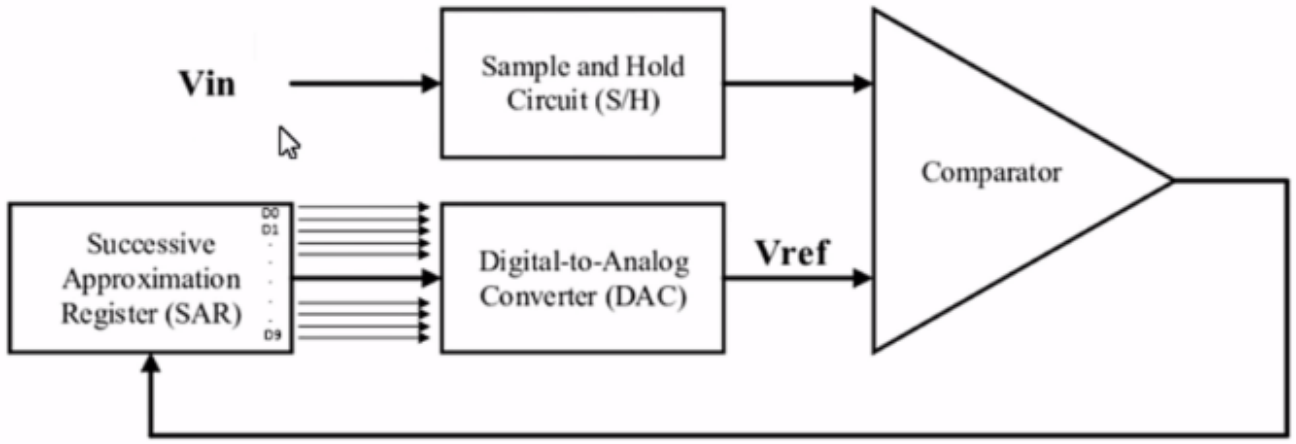
Resolution = 4.8mV

Step size = 3.3 / (1024 – 1)

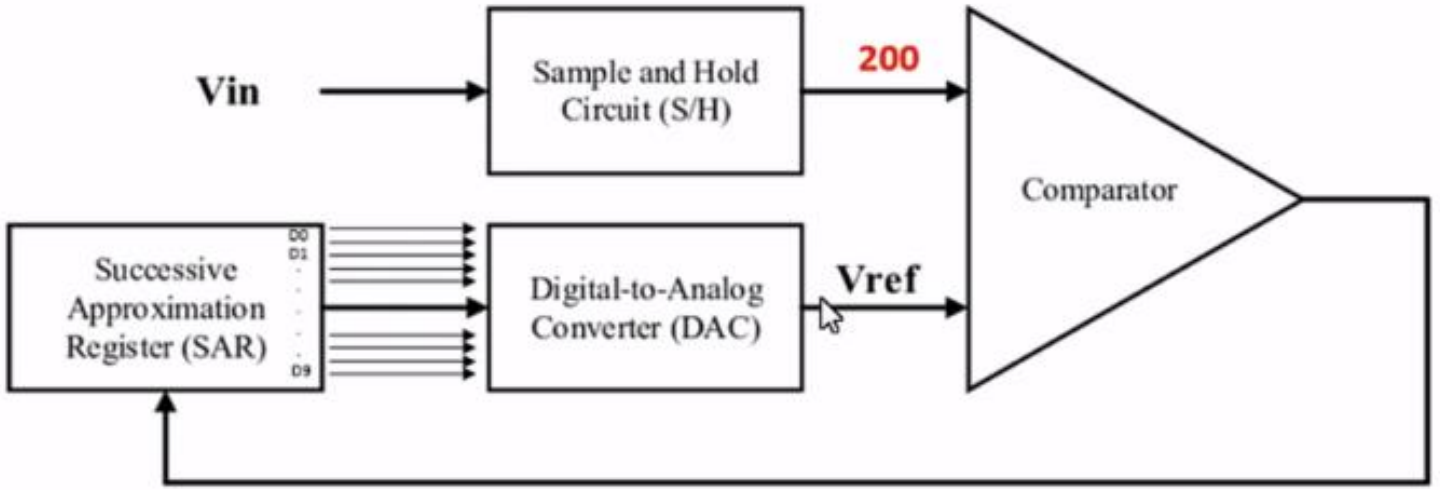
Step size = 3.23mV

Resolution = 3.23mV

Successive Approximation Circuit



Successive Approximation Circuit



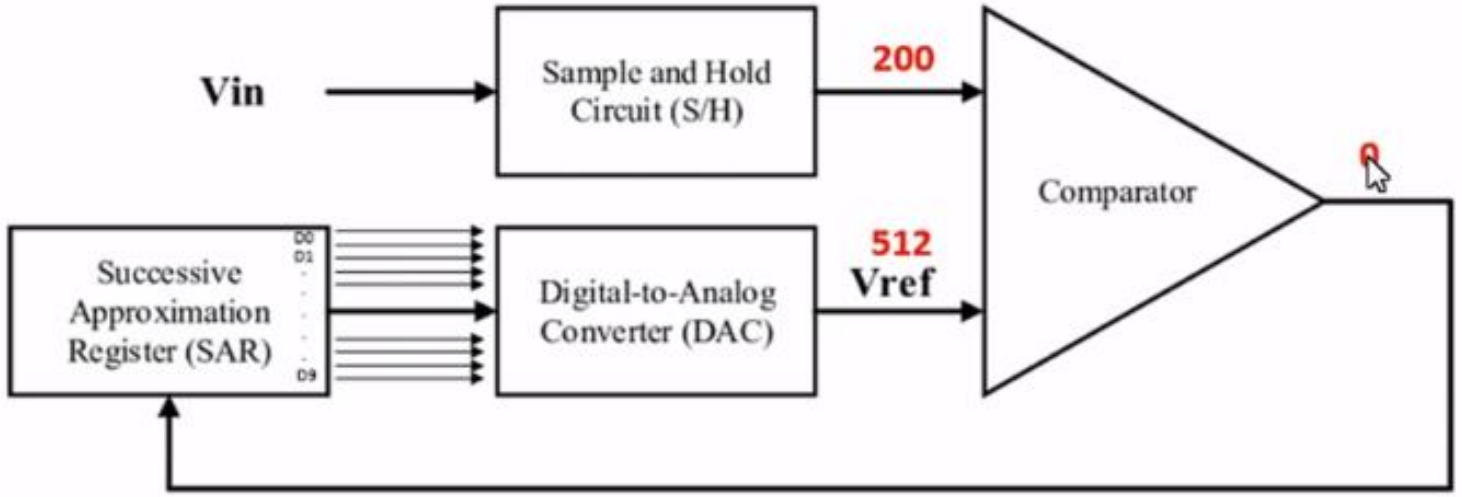
Lets take the value to be 200

00 1100 1000

SAR O/P

00 0000 0000

Successive Approximation Circuit



Lets take the value to be 200

0011001000

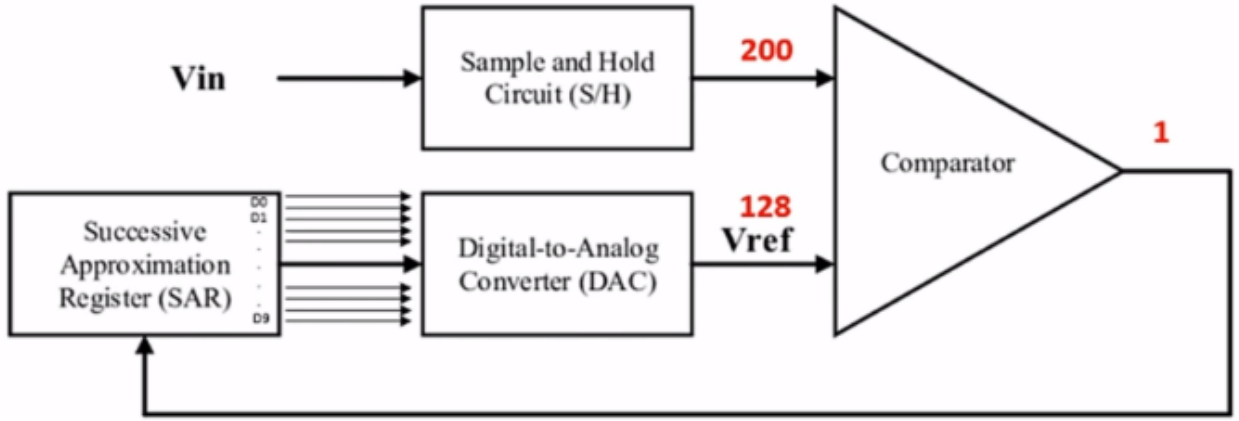
SAR O/P

00 0000 0000

10 0000 0000

01 0000 0000

Successive Approximation Circuit



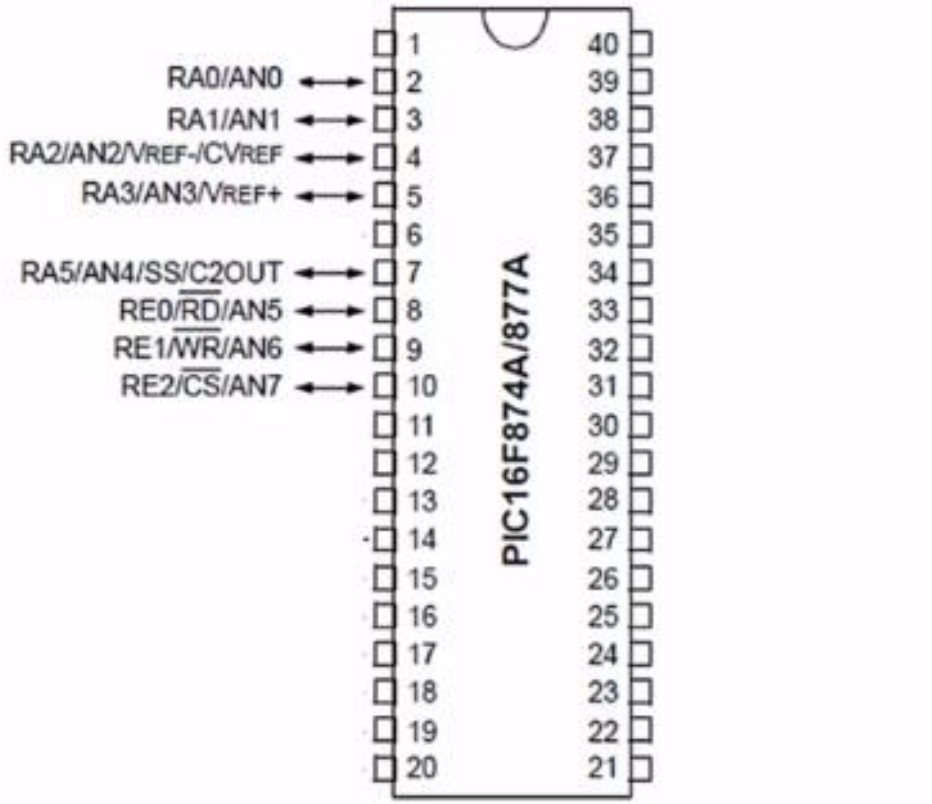
Lets take the value to be 200

0011001000

SAR O/P

00 0000 0000
10 0000 0000
01 0000 0000
00 1000 0000
00 1100 0000

ANALOG PINS OF PIC16F877A



ADCON0

ADCON0 REGISTER (ADDRESS: 1Fh)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit 7							bit 0

bit 7-6 **ADCS1:ADCS0**: A/D Conversion Clock Select bits
00 = FOSC/2
01 = FOSC/8
10 = FOSC/32
11 = FRC (clock derived from the internal A/D module RC oscillator)

bit 5-3 **CHS2:CHS0**: Analog Channel Select bits
000 = channel 0, (RA0/AN0)
001 = channel 1, (RA1/AN1)
010 = channel 2, (RA2/AN2)
011 = channel 3, (RA3/AN3)
100 = channel 4, (RA5/AN4)
101 = channel 5, (RE0/AN5)(1)
110 = channel 6, (RE1/AN6)(1)
111 = channel 7, (RE2/AN7)(1)

bit 2 **GO/$\overline{\text{DONE}}$**: A/D Conversion Status bit
If ADON = 1:
1 = A/D conversion in progress (setting this bit starts the A/D conversion)
0 = A/D conversion not in progress (this bit is automatically cleared by hardware when the A/D conversion is complete)

bit 1 **Unimplemented**: Read as '0'

bit 0 **ADON**: A/D On bit
1 = A/D converter module is operating
0 = A/D converter module is shut-off and consumes no operating current

ADCON0

ADCON0 REGISTER (ADDRESS: 1Fh)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit 7							bit 0
0	1	0	0	0	0	0	1

ADCON0 = 0x41

PIR1 REGISTER (ADDRESS 0Ch)

R/W-0	R/W-0	R-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0
PSPIF(1)	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF
bit 7							bit 0

PSPIF: Parallel Slave Port Read/Write Interrupt Flag bit(1)
1 = A read or a write operation has taken place (must be cleared in software)
0 = No read or write has occurred

Note 1: PSPIF is reserved on PIC16F873A/876A devices; always maintain this bit clear.

ADIF: A/D Converter Interrupt Flag bit
1 = An A/D conversion completed
0 = The A/D conversion is not complete

RCIF: USART Receive Interrupt Flag bit
1 = The USART receive buffer is full
0 = The USART receive buffer is empty

TXIF: USART Transmit Interrupt Flag bit
1 = The USART transmit buffer is empty
0 = The USART transmit buffer is full

SSPIF: Synchronous Serial Port (SSP) Interrupt Flag bit
1 = The SSP interrupt condition has occurred and must be cleared in software before returning from the Interrupt Service Routine. The conditions that will set this bit are:
- SPI – A transmission/reception has taken place.
- I^2C Slave – A transmission/reception has taken place.
- I^2C Master
  - A transmission/reception has taken place.
  - The initiated Start condition was completed by the SSP module.
  - The initiated Stop condition was completed by the SSP module.

ADCON1

U-0	U-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	—	—	—	PCFG3	PCFG2	PCFG1	PCFG0
bit 7							bit 0

bit 7 **ADFM:** A/D Result Format Select bit
1 = Right justified. 6 Most Significant bits of ADRESH are read as '0'.
0 = Left justified. 6 Least Significant bits of ADRESL are read as '0'.

bit 6-4 **Unimplemented:** Read as '0'

bit 3-0 **PCFG3:PCFG0**: A/D Port Configuration Control bits:

PCFG3: PCFG0	AN7(1) RE2	AN6(1) RE1	AN5(1) RE0	AN4 RA5	AN3 RA3	AN2 RA2	AN1 RA1	AN0 RA0	VREF+	VREF-	CHAN/ Refs(2)
0000	A	A	A	A	A	A	A	A	VDD	Vss	8/0
0001	A	A	A	A	VREF+	A	A	A	RA3	Vss	7/1
0010	D	D	D	A	A	A	A	A	VDD	Vss	5/0
0011	D	D	D	A	VREF+	A	A	A	RA3	Vss	4/1
0100	D	D	D	D	A	D	A	A	VDD	Vss	3/0
0101	D	D	D	D	VREF+	D	A	A	RA3	Vss	2/1
011x	D	D	D	D	D	D	D	D	VDD	Vss	0/0
1000	A	A	A	A	VREF+	VREF-	A	A	RA3	RA2	6/2
1001	D	D	A	A	A	A	A	A	VDD	Vss	6/0
1010	D	D	A	A	VREF+	A	A	A	RA3	Vss	5/1
1011	D	D	A	A	VREF+	VREF-	A	A	RA3	RA2	4/2
1100	D	D	D	A	VREF+	VREF-	A	A	RA3	RA2	3/2
1101	D	D	D	D	VREF+	VREF-	A	A	RA3	RA2	2/2
1110	D	D	D	D	D	D	D	A	VDD	Vss	1/0
1111	D	D	D	D	VREF+	VREF-	D	A	RA3	RA2	1/2

A = Analog input D = Digital I/O

ADC VALUE

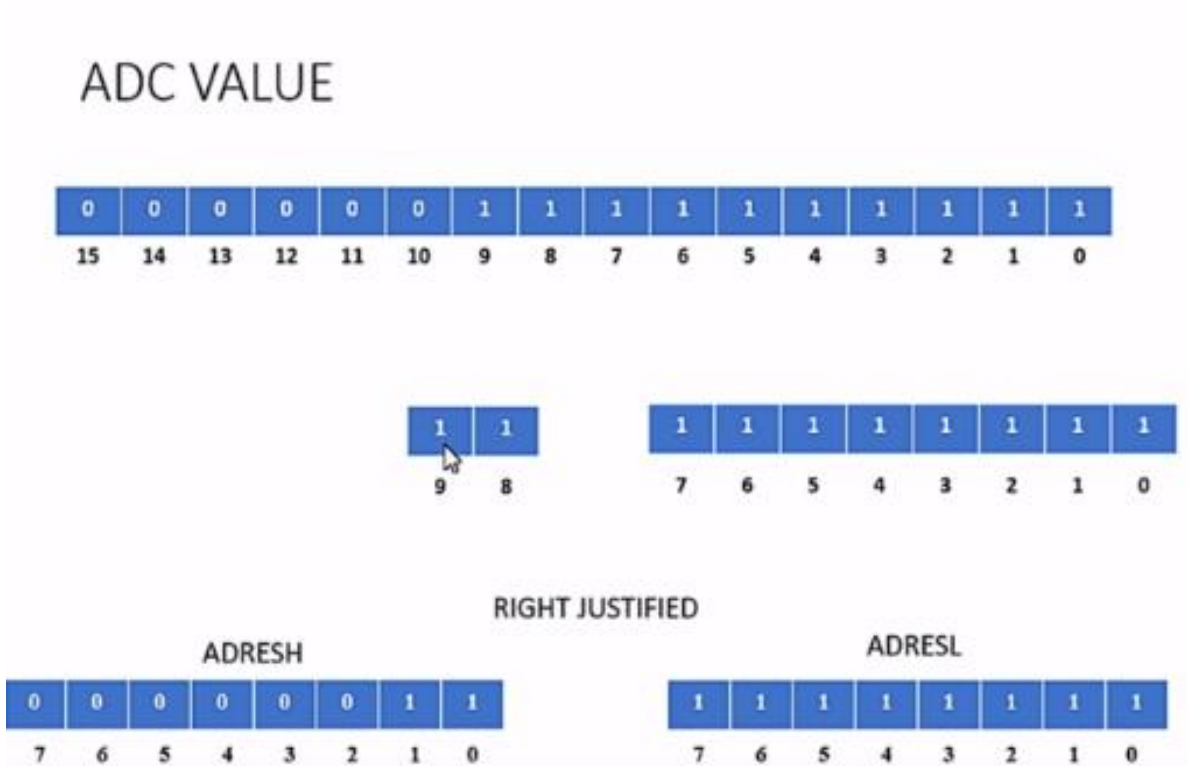
ADC VALUE IS A 10 BIT VALUE

So the maximum value is 1023
And the minimum value is 0

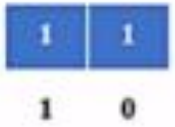
Lets assume the
Value = 1023

1023 in binary is represented as,

0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0


ADC VALUE
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
1 1
9 8
1 1 1 1 1 1 1 1
7 6 5 4 3 2 1 0
RIGHT JUSTIFIED
ADRESH
0 0 0 0 0 0 1 1
7 6 5 4 3 2 1 0
ADRESL
1 1 1 1 1 1 1 1
7 6 5 4 3 2 1 0

ADC VALUE



LEFT JUSTIFIED

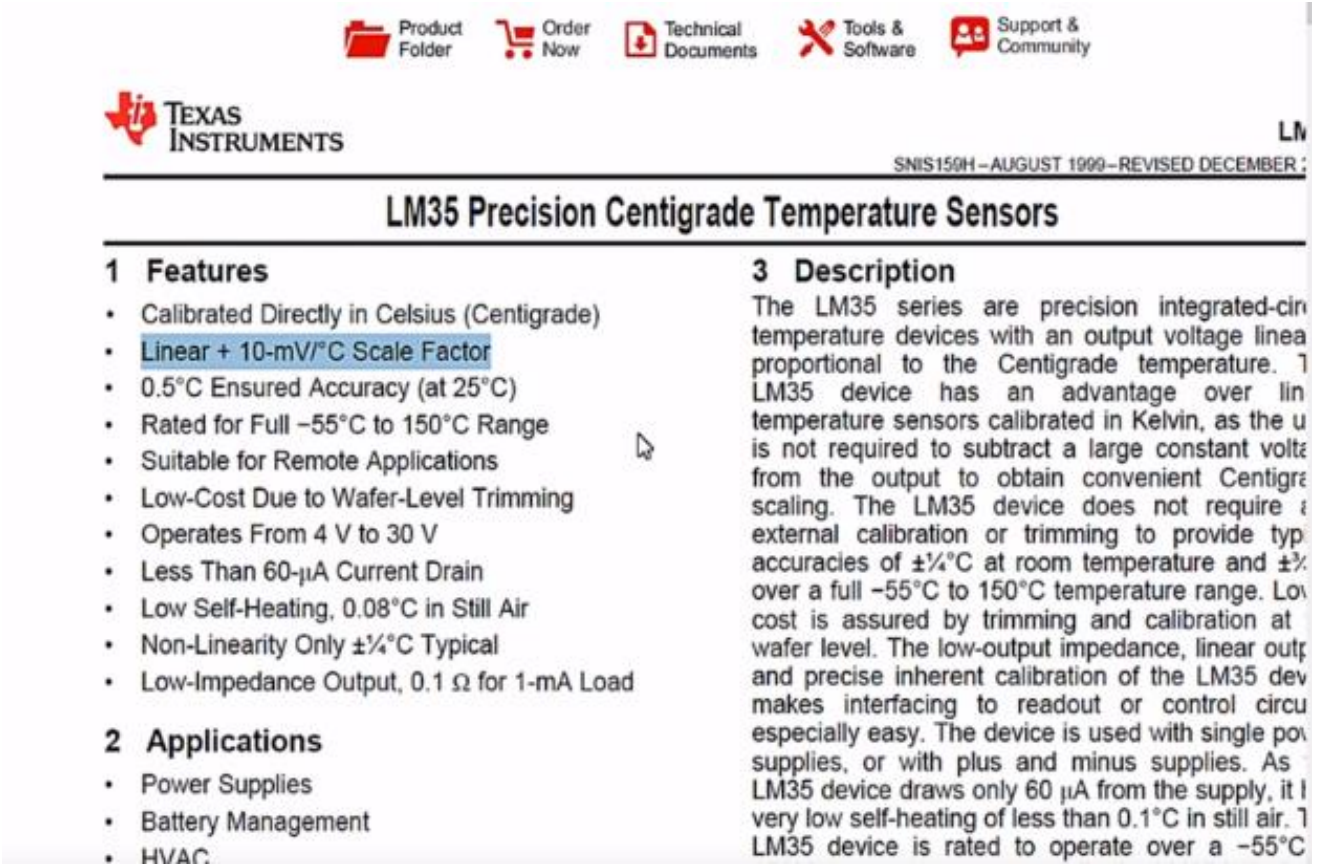
ADRESH

ADRESL

ADCON1

U-0	U-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	—	—	—	PCFG3	PCFG2	PCFG1	PCFG0
bit 7							bit 0
1	0	0	0	1	1	1	0

ADCON1 = 0x8E



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TEXAS INSTRUMENTS

LM

SNIS150H – AUGUST 1999 – REVISED DECEMBER

LM35 Precision Centigrade Temperature Sensors

1 Features

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates From 4 V to 30 V
- Less Than 60-μA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

2 Applications

- Power Supplies
- Battery Management
- HVAC

3 Description

The LM35 series are precision integrated-cir
temperature devices with an output voltage linea
proportional to the Centigrade temperature. T
LM35 device has an advantage over lin
temperature sensors calibrated in Kelvin, as the u
is not required to subtract a large constant volta
from the output to obtain convenient Centigra
scaling. The LM35 device does not require a
external calibration or trimming to provide typ
accuracies of ±¼°C at room temperature and ±¾
over a full −55°C to 150°C temperature range. Lo
cost is assured by trimming and calibration at
wafer level. The low-output impedance, linear outp
and precise inherent calibration of the LM35 dev
makes interfacing to readout or control circu
especially easy. The device is used with single po
supplies, or with plus and minus supplies. As
LM35 device draws only 60 μA from the supply, it h
very low self-heating of less than 0.1°C in still air. T
LM35 device is rated to operate over a −55°C