ADC implementation

If you are clear with above concept, let us see how we can implement ADC. First and foremost, we need a component which can convert energy in our analog world into electrical signals. For this we use what is generally known as a “transducer”. A transducer is a sensor/device which converts energy from one form to another. It can be to/from electrical, photovoltaic, sound, electromagnetic to any other form of energy. Suppose we need to convert light energy into electrical energy, we use a Photo resistor or a Light Dependant Resistor (LDR). The resistance of this sensor changes with change in light intensity. Other examples of transducer are Accelerometer, Laser light, tactile sensor, thermistor etc. In the following tutorial, we will use a variable resistor as a transducer. The output voltage from these transducers are fed into the ADC and processed further. However, do note that the voltage sent from these transducers should be within acceptable level of the ADC. If the ADC voltage range is 0 to 5V, then the transducer circuit must output voltage only within this range. If not? As usual, we get unexpected results which might also include turning the entire circuit into white fumes.

Once the signals are sent to ADC, it processes those signals using internal circuitry and gives out a digital output. To do this, manufactures employ different ADC architecture within the circuitry to convert these signals. There are several architectures available for different tasks, based on the sampling rate, accuracy and design. Some of the known architectures are: Direct conversion ADC, Integration based ADC, Pipeline ADC, Flash ADC, Counter based conversion, etc. Atmel uses “Successive-approximation ADC” architecture. Let us discuss this method in detail.

Successive-approximation ADC (SAR ADC)

SAR ADC is one kind of ADC architecture which works on binary search method. Although it is much slower than other models like Pipeline and Flash ADC, power consumption is very low and a model of choice for low power devices. The working principle of SAR ADC seems reasonably complex, but not actually. The following sub-circuits make up the SAR ADC:

1. Sample and Hold Circuitry (SHA)
2. Digital-to-Analog converter circuit (DAC)
3. Analog voltage comparator (COMPARATOR)
4. Successive approximation register circuit (SAR)

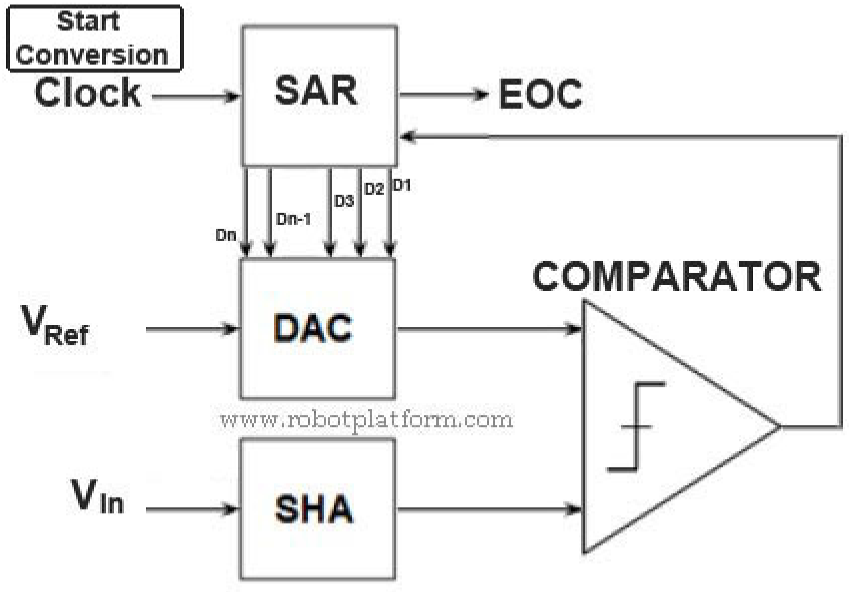
Other aspects of SAR ADC are:

1. VIn: Input Voltage
2. VRef: Reference Voltage
3. EOC: End of conversion

SHA circuit is used to acquire and hold input voltage (VIn) from transducer circuit to ensure that the voltage remains constant during conversion. DAC supplies an analog input voltage (VRef) to Comparator. Comparator compares the input from DAC and SHA and the result is stored in SAR. SAR provides DAC with appropriate digital code so that DAC outputs necessary analog voltage to Comparator. SAR also holds the result from comparator in its register. Once all the comparison is completed, the resulting digital equivalent of the analog signal is output and is end of the conversion (EOC).

Working principle

When the controller initiates and sends an ADC START signal to ADC unit, SHA acquires and holds the sample analog voltage from transducer circuit. SAR is cleared and MSB (most significant bit) in SAR is set to digital 1. This digital code is fed into DAC which is set to midscale and outputs an analog equivalent of the digital code. To explain midscale further, suppose the reference voltage is VRef, then midscale voltage of VRef is (VRef/2). Output from DAC and output from SHA is fed into comparator; comparator compares the reference voltage (from DAC) and sample voltage (from SHA). If reference voltage (VRef) is greater than sample voltage (V_{in}), then MSB is cleared (set to 0) else retained as 1.



Successive Approximation Block Diagram

Then the next bit is set to 1 and similar binary search is done until all the bits in SAR are tested till LSB (least significant bit). The resulting code in SAR is the digital output of the analog input.

Confusing? I guess it is. Let us take an example. Suppose the input voltage is 3.6 Volts (X) and is checked over a 10 bit ADC. Controller voltage is 0V (V_{min}) to 5V (V_{max}). DAC is set to midscale which means, reference voltage = 5/2 = 2.5 Volts. Now the procedure follows as given below; the comparator checks if X >= reference voltage; If yes, then retain else discard and move on to next bit

Condition	Value	Bit Status	Result
Is X >= 2.5	Yes	1	Retain -> 2.5
Is X >= 2.5+2.5/2 = 3.75	No	0	Discard -> 1.25
Is X >= 2.5+0.625 = 3.125	Yes	1	Retain -> 0.625
Is X>= 3.125 + 0.3125 = 3.4375	Yes	1	Retain -> 0.3125
Is X>= 3.4375 + 0.15625 = 3.59375	Yes	1	Retain -> 0.15625
Is X>= 3.59375 + 0.078125 = 3.671875	No	0	Discard -> 0.078125

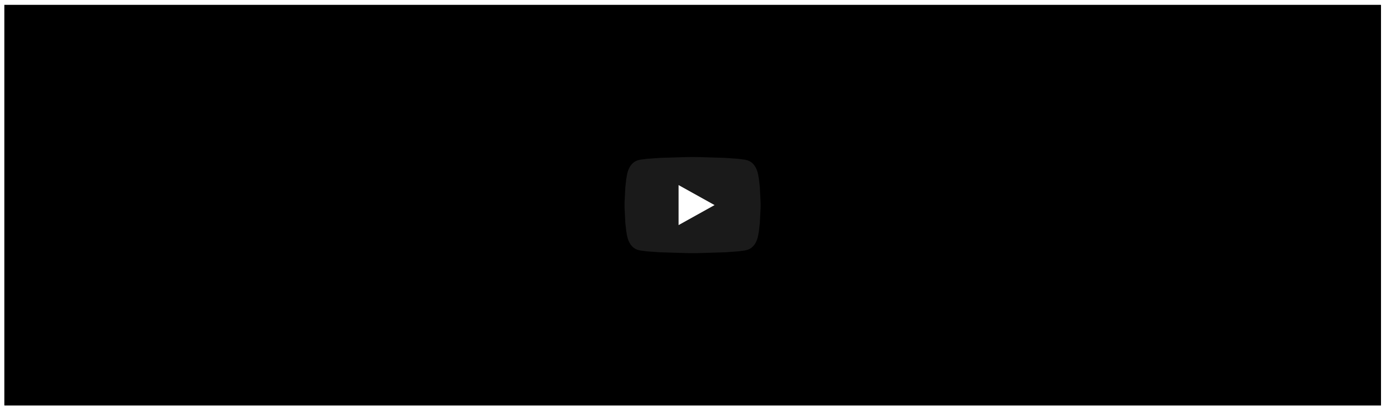
Is X>= 3.59375 + 0.0390625 = 3.6328125	No	0	Discard -> 0.0390625
Is X>= 3.59375 + 0.01953125 = 3.61328125	No	0	Discard -> 0.01953125
Is X>= 3.59375 + 0.009765625 = 3.603515625	No	0	Discard -> 0.009765625
Is X>= 3.59375 + 0.0048828125 = 3.5986328125	Yes	1	Retain -> 3.5986328125

The digital equivalent of analog input from SAR is $1011100001_{(2)}$. Suppose we require an 8 bit resolution, then the digital equivalent is $10111000_{(2)}$.In AVR devices, by default result is stored in two registers namely ADCH and ADCL, where the first two bits are stored in ADCH and remaining 8 bits are stored in ADCL. In the later part of the tutorial we will see how we can find the voltage equivalent of this digital value.

Tutorial index:

«Previous - § - Next»

Featured Videos



Advertisements

Recent Articles

Atmega8 Development Board

A great step-by-step tutorial on building your own Atmel AVR based Atmega8 development board. The board is ideal for beginners with detailed explanation and pictures More...

L293D Motor Driver

For robots to do work, you need to know how to control a motor. L293D is a cleverly packed IC which can control two DC motors in both directions: forwards and reverse. Here is a detailed explanation of building a board based on L293D ICMore...

Hobby Servo Tutorial

Servo Motor is a device which uses error-sensing feedback signals to determine and control the position of a motor shaft. The term "servomechanism" closely relates to servo motors..More...

Blinking LED Tutorial

This is similar to what we achieve in any "Hello World" program. However, it is not just limited to blinking LED but scratches the surface of AVR-GCC programming... More...

Kindly Donate

If this site has helped you, then kindly consider a Donation to say "Thank You!!". Donation might help us keep all this information available for free and also pay for the resources.

If that is difficult, then a simple "Hi" in the forum would still do good :)

Five US Dollars $5.00 USD ▼

Pay Now

HOME | ELECTRONICS | HOWTO | KNOWLDGE | TOOLS | FORUM
Contact Us | Disclaimer & Privacy | Sitemap

© Copyright 2010 - 2017 **ROBOT PLATFORM** All Rights Reserved