Analog to Digital Conversion and its significance

Microcontrollers are capable of detecting binary signals. When a microcontroller is powered from five volts, it understands zero volts (0V) as a binary 0 and a five volt (5V) as a binary 1. We often need to measure signals that vary; these are called analog signals. A 5V analog sensor may output 0.01V or 4.99V or anything in between. Luckily, nearly all microcontrollers have a device built into them that allows us to convert these voltages into values that we can use in a program to make a decision.

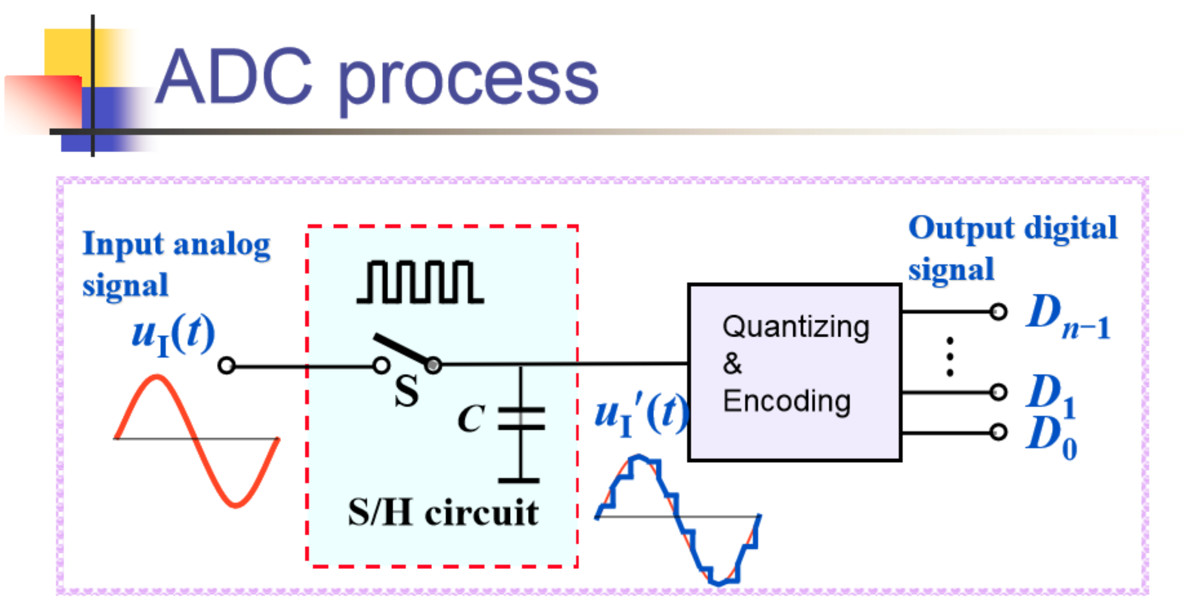
ADC are used virtually everywhere where an analog signal has to be processed, stored, or transported in digital form. Some examples of ADC usage are digital volt meters, cell phone, thermocouples, and digital oscilloscope.

What is the ADC?

An Analog to Digital Converter (ADC) is a very useful feature that converts an analog voltage on a pin to a digital number. By converting from the analog world to the digital world, we can begin to use electronics to interface to the analog world around us.

Not every pin on a microcontroller has the ability to do analog to digital conversions. On the Arduino board, these pins have an 'A' in front of their label (A0 through A5) to indicate these pins can read analog voltages.

ADCs can vary greatly between microcontroller. The ADC on the Arduino is a 10-bit ADC meaning it has the ability to detect 1,024 (2^{10}) discrete analog levels. Some microcontrollers have 8-bit ADCs (2^8 = 256 discrete levels) and some have 16-bit ADCs (2^{16} = 65,536 discrete levels).



2 steps

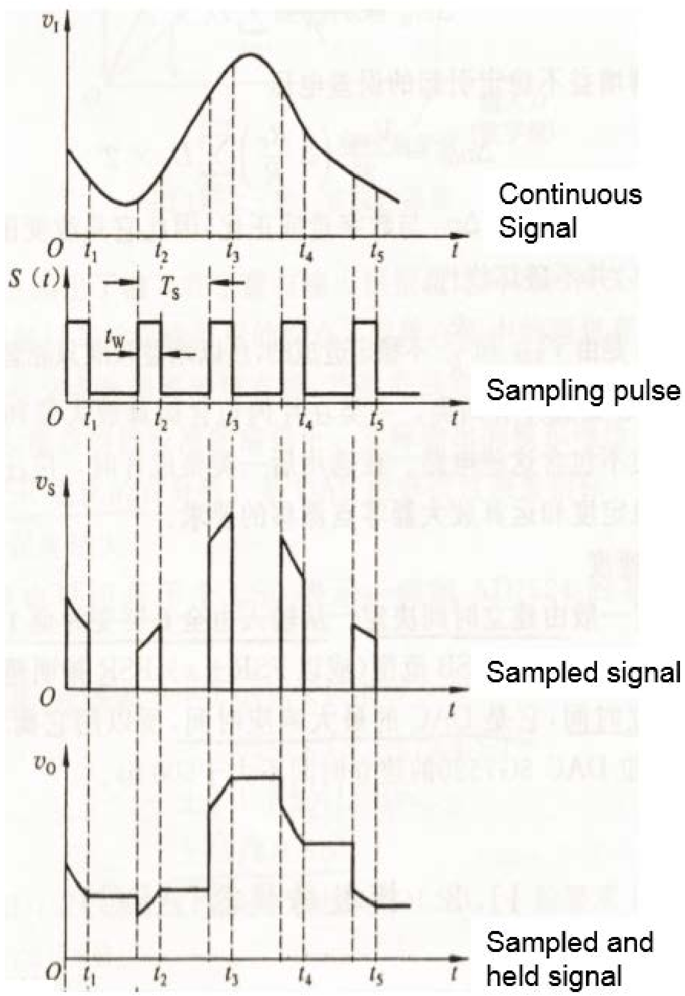
Sampling and Holding (S/H)

Quantizing and Encoding (Q/E)

Sampling and Holding

. Holding signal benefits the accuracy of the A/D conversion

. Minimum sampling rate should be at least twice the highest data frequency of the analog signal



Quantizing and Encoding Resolution:

The smallest change in analog signal that will result in a change in the digital output.

$$\Delta V = \frac{V_r}{2^N}$$

Where, V = Reference voltage range N = Number of bits in digital output. 2N = Number of states. ΔV = Resolution

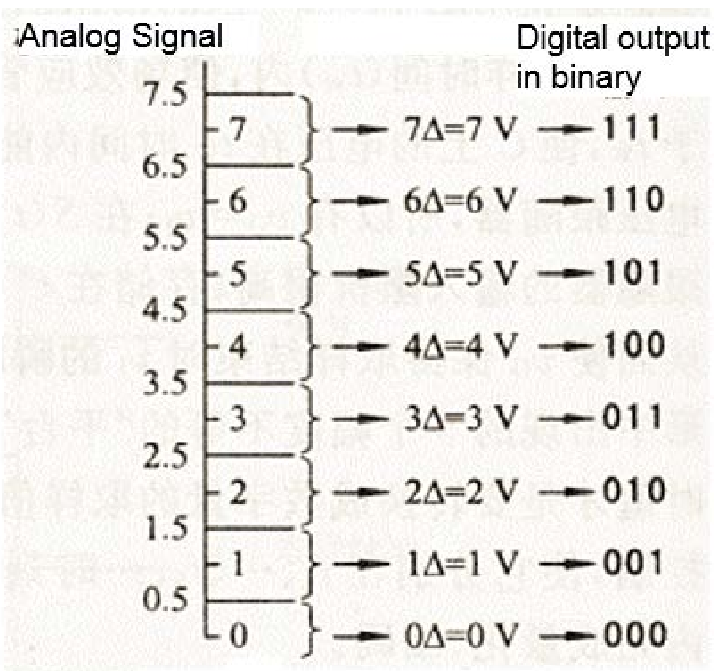
The resolution represents the quantization error inherent in the conversion of the signal to digital form.

Quantizing:

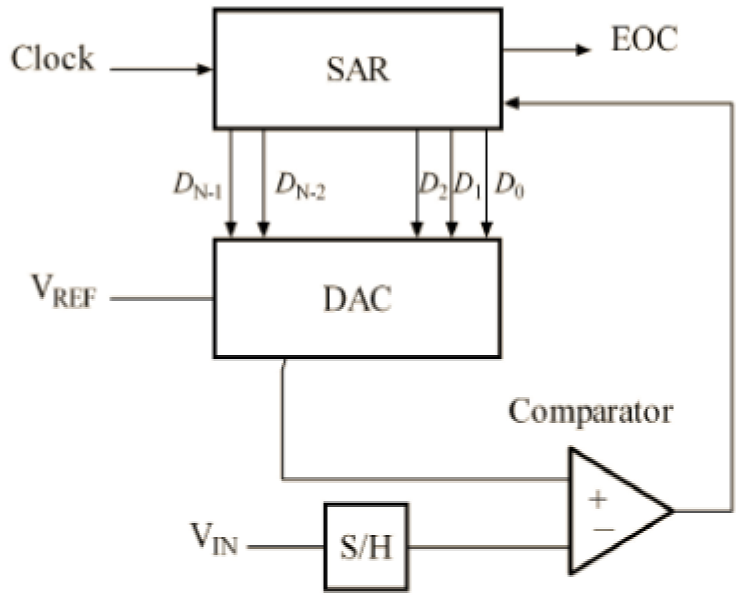
Partitioning the reference signal range into a number of discrete quanta, then matching the input signal to the correct quantum.

Encoding:

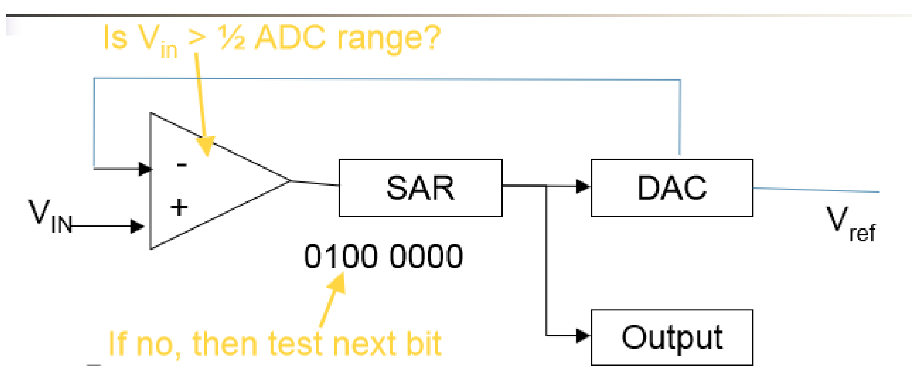
Assigning a unique digital code to each quantum, then allocating the digital code to the input signal.



Successive Approximation ADC Circuit



- Uses a n-bit DAC to compare DAC and original analog results.
- Uses Successive Approximation Register (SAR) supplies an approximate digital code to DAC of Vin.
- Comparison changes digital output to bring it closer to the input value.
- Uses Closed-Loop Feedback Conversion



Process

1. Most Significant Bit initialized as 1.

2. Convert digital value to analog using DAC.

3. Compares guess to analog input.

4. Is Vin>VDAC • Set bit 1 • If no, bit is 0 and test next bit.

Output