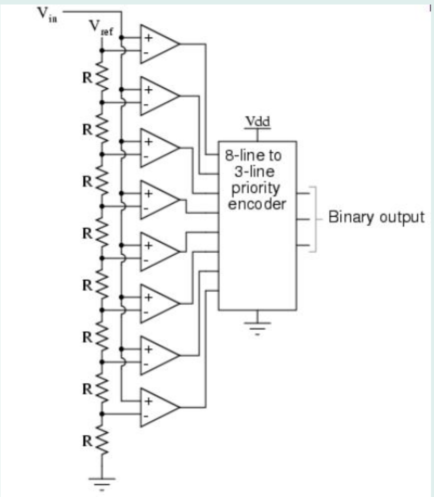
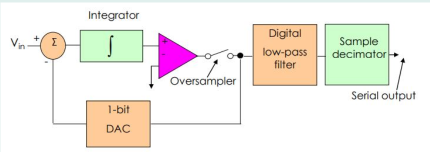
ADC and DAC Cheat Sheet

by raxxen5 via cheatography.com/69629/cs/17615/

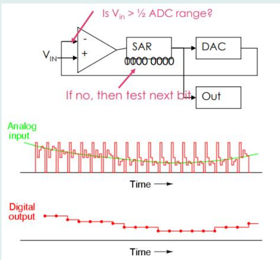
Flash ADC



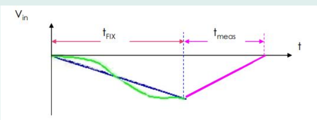
Sigma-Delta ADC



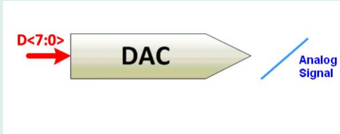
Successive Approximation Register ADC



Dual Slope ADC



Digital to Analog Conversion



A digital to analog converter (DAC) converts a digital signal to an analog voltage or current output.

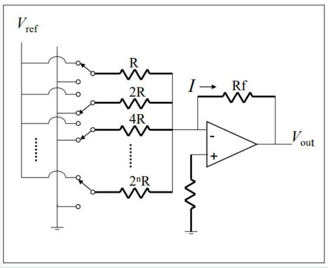
Types of DAC

Binary Weighted Resistor	
Utilizes a summing op-amp circuit	
Weighted resistors are used to distinguish each bit from the most significant to the least significant	
Transistors are used to switch between Vref and ground (bit high or low)	
Assume Ideal Op-amp	
No current into op-amp	
Virtual ground at inverting input	
Vout= -IRf	
Pros	Cons
Simple Construction/Analysis	Requires large range of resistors (2000:1 for 12-bit DAC) with necessary high precision for low resistors
Fast Conversion	Requires low switch resistances in transistors
	Can be expensive. Therefore, usually limited to 8-bit resolution.
R-2R Ladder	
If the bit is high, the corresponding switch is connected to the inverting input of the op-amp.	
If the bit is low, the corresponding switch is connected to ground.	
Pros	Cons

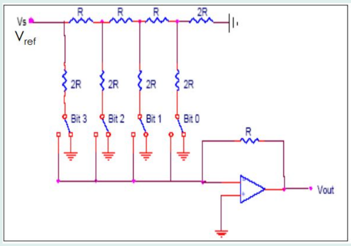
Types of DAC (cont)

Only two resistor values (R and 2R)	Lower conversion speed than binary weighted DAC
Does not require high precision resistors	

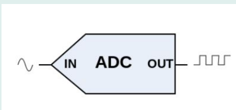
Binary Weigthed Resistor



R-2R Ladder

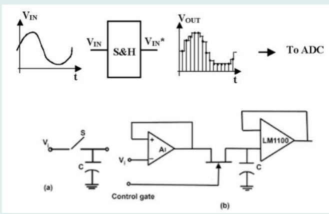


Analog to Digital Conversion



It is an electronic process in which a continuously variable (analog) signal is changed, without altering its essential content, into a multi-level (digital) signal.

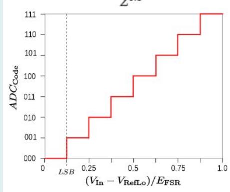
Sample and Hold Circuit



Resolution

$$E_{FSR} = V_{RefHi} - V_{RefLow},$$

$$Q = \frac{E_{FSR}}{2^M},$$



› The resolution of the converter indicates the number of discrete values it can produce over the range of analog values.

› The resolution determines the magnitude of the quantization error and therefore determines the maximum possible average signal to noise ratio for an ideal ADC

ADC Value Calculation

$$\text{ADC Reading} = \text{ADC Input} * \frac{2^N}{\text{Vref}}$$

$$\text{Vref} = \text{Dynamic Range} = \text{Vmax} - \text{Vmin}$$

$$\text{N} = \text{Number of Bits}$$

For an N-bit ADC, the digital representation depends on Number of Bits and Reference values

Example

› Given a half wave input signal:

» x(t) = Acos(t), A = 5V

› Full scale measurement rang = 0 to 5 volts

› ADC resolution is 8 bits:

» 2^8 = 256 quantization levels (codes)

› ADC voltage resolution,

» Q = (5 V – 0 V) / 256

» = 5 V / 256 ≈ 0.0195 V

» Q ≈ 19.5 mV.

Common ADC Types

Flash ADC

"parallel A/D"

Uses a series of comparators

Each comparator compares Vin to a different reference voltage, starting w/ Vref = 1/2 lsb

Pros	Cons
Very Fast	Needs many parts (255 comparators for 8-bit ADC)
	Expensive
	Large power consumption

Sigma-Delta ADC

Oversampled input signal goes in the integrator

Output of integration is compared to GND

Iterates to produce a serial bitstream

Output is serial bit stream with # of 1's proportional to Vin

Pros	Cons
High resolution	Slow due to oversampling
No precision external components needed	

Dual-Slope ADC

The sampled signal charges a capacitor for a fixed amount of time

By integrating over time, noise integrates out of the conversion.

Then the ADC discharges the capacitor at a fixed rate while a counter counts the ADC's output bits.

A longer discharge time results in a higher count.

Pros	Cons
Input signal is averaged	Slow
Greater noise immunity than other ADC types	High precision external components required to achieve accuracy
High accuracy	

Successive Approximation Register ADC

Sets MSB

Common ADC Types (cont)

Converts MSB to analog using DAC

Compares guess to input

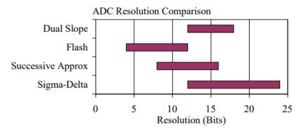
Set bit

Test next bit

Pros	Cons
Capable of high speed	Higher resolution successive approximation ADCs will be slower
Medium accuracy compared to other ADC types	Speed limited ~5Msps
Good tradeoff between speed and cost	

Merge columns in Pros and Cons are considered to be in Pros' column

ADC Types Comparison



Type	Speed (relative)	Cost (relative)
Dual Slope	Slow	Med
Flash	Very Fast	High
Successive Appox	Medium – Fast	Low
Sigma-Delta	Slow	Low