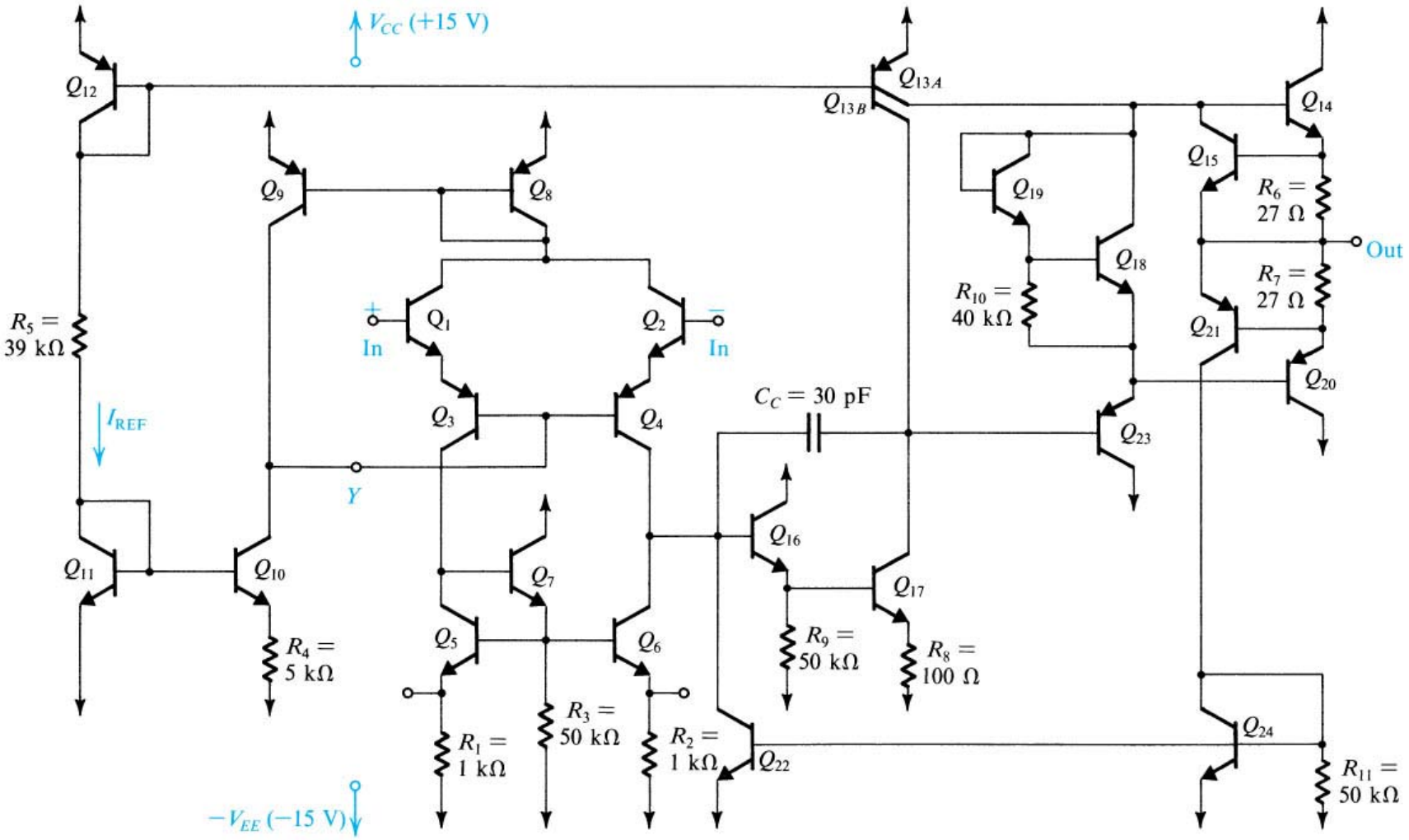
See the Circuit of the the 741 Op-Amp Circuit

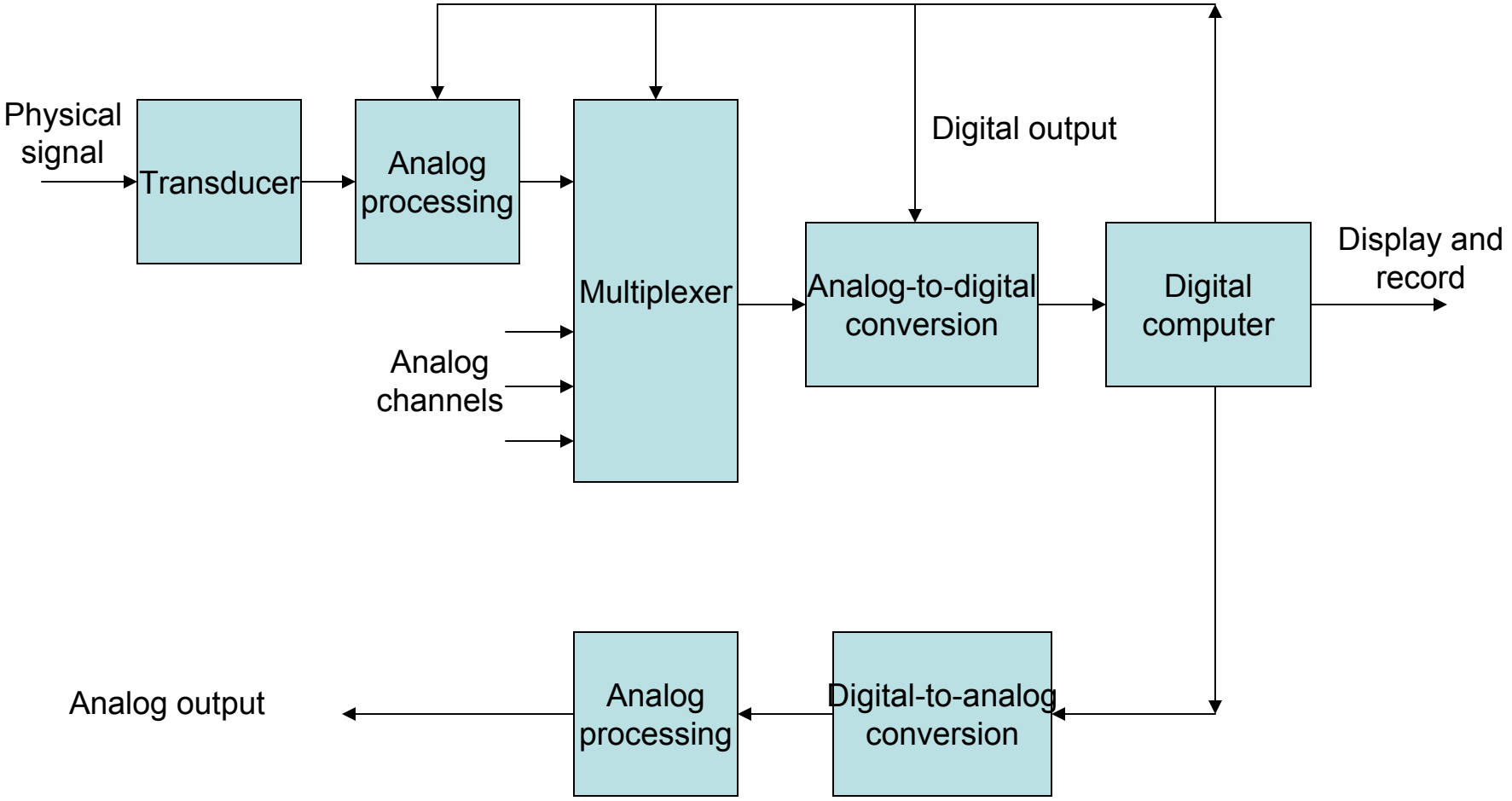


Introduction to DAC/ADC

A fundamental part of many mechatronic systems is a measurement system that composed of four basic parts:

- Sensors: converting physical signal to electrical signal.
- Signal Conditioning: amplification and filtering
- Analog-to-Digital-Conversion or Digital-to-Analog-Conversion
- Digital Data Transmission

Instrumentation System



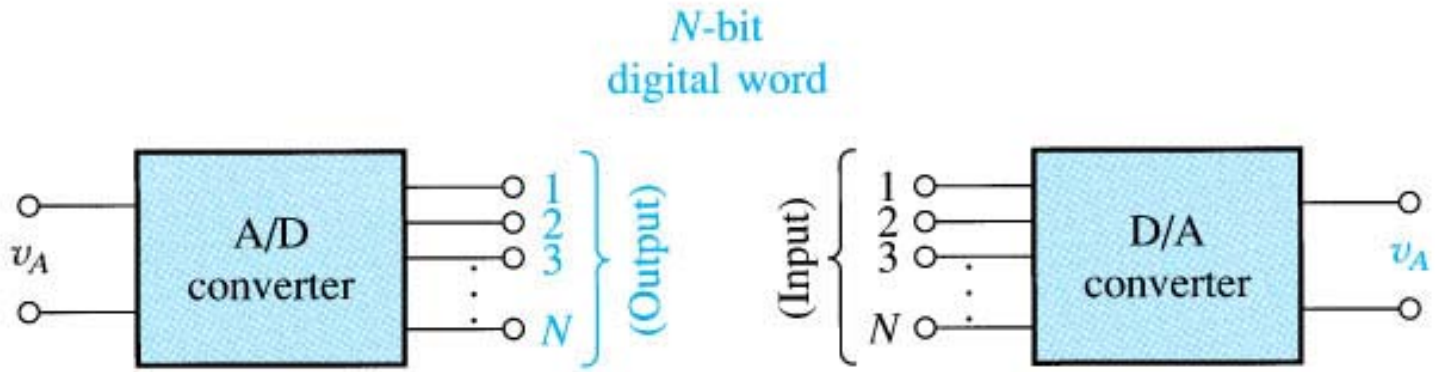
Analog to Digital Conversion

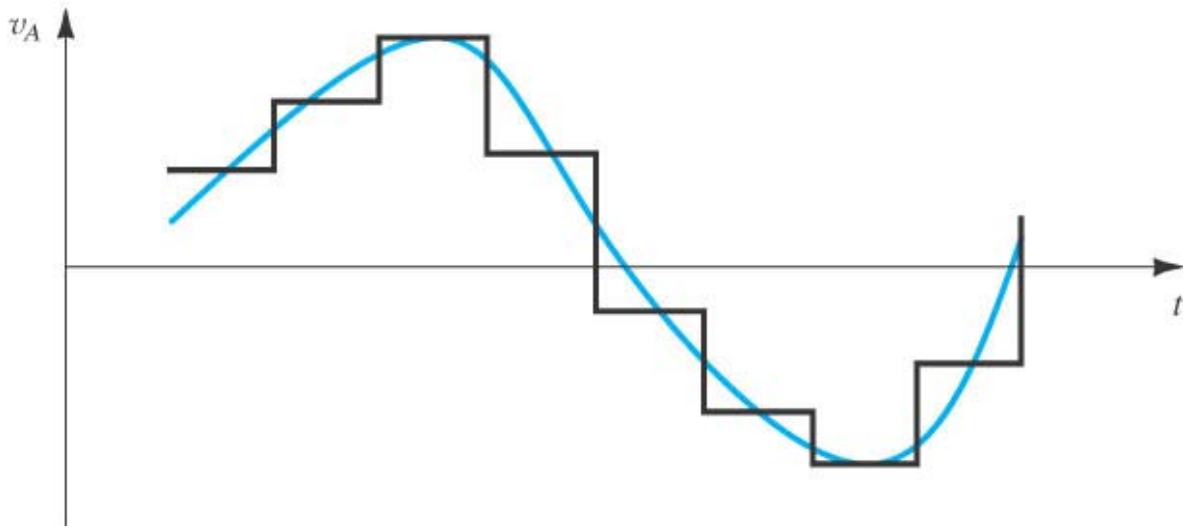
- ADC, or digitizing, converts analog waveforms to digital representations that can be processed and stored in digital form.

- The analog wave is “sampled,” or read, hundreds or thousands of times per second to map out the wave digitally. Digital music requires extremely high sampling rates (44,100 samples/sec), while it is usually acceptable to sample voice at 11,000 samples/sec or higher. There is also a factor that determines the precision of the captured signal-the more bits used to record the value of the sampled signal, the higher its resolution and the better its sound when played back.

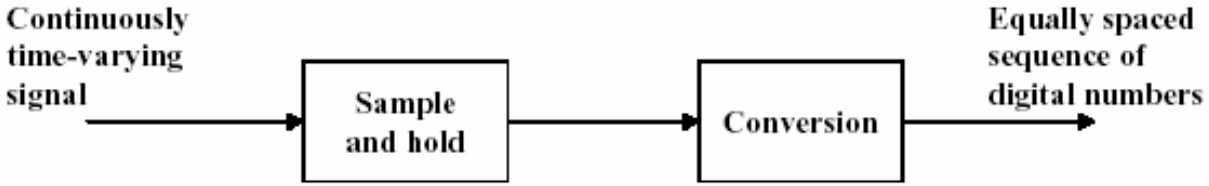
- However, the more bits used, the more disk space is required for storage or bandwidth for transmission. For example, one minute of sampling at 44.1 kHz using 16 bits per sample requires 5.292 MB of disk space.

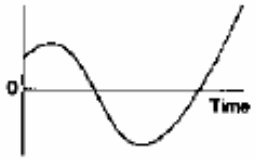
A/D and D/A converters

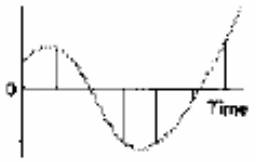


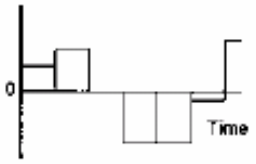


ADC









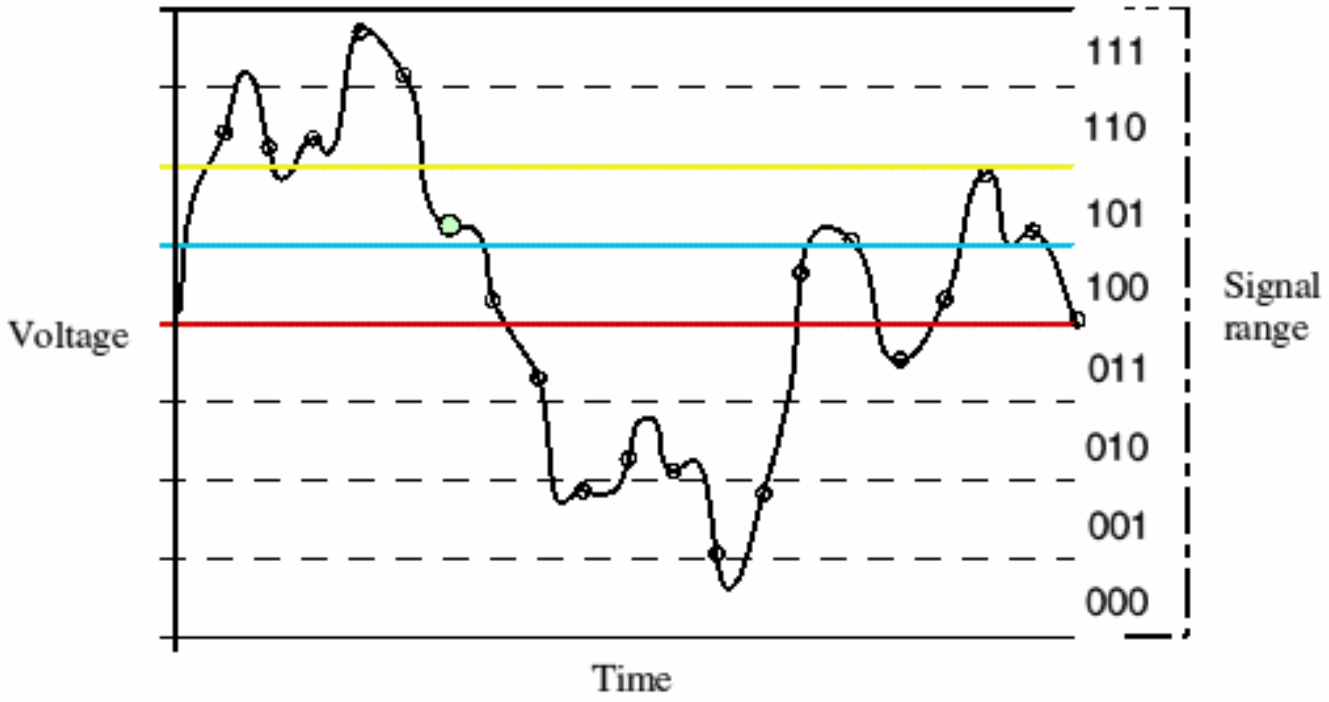
The analog signal is sampled at a discrete time-interval or period, τ_s

The sampling frequency is given by the equation

$$f_s = 1/\tau_s \qquad \text{[samples/sec]}$$

The sampled value is held until the next sample is taken.

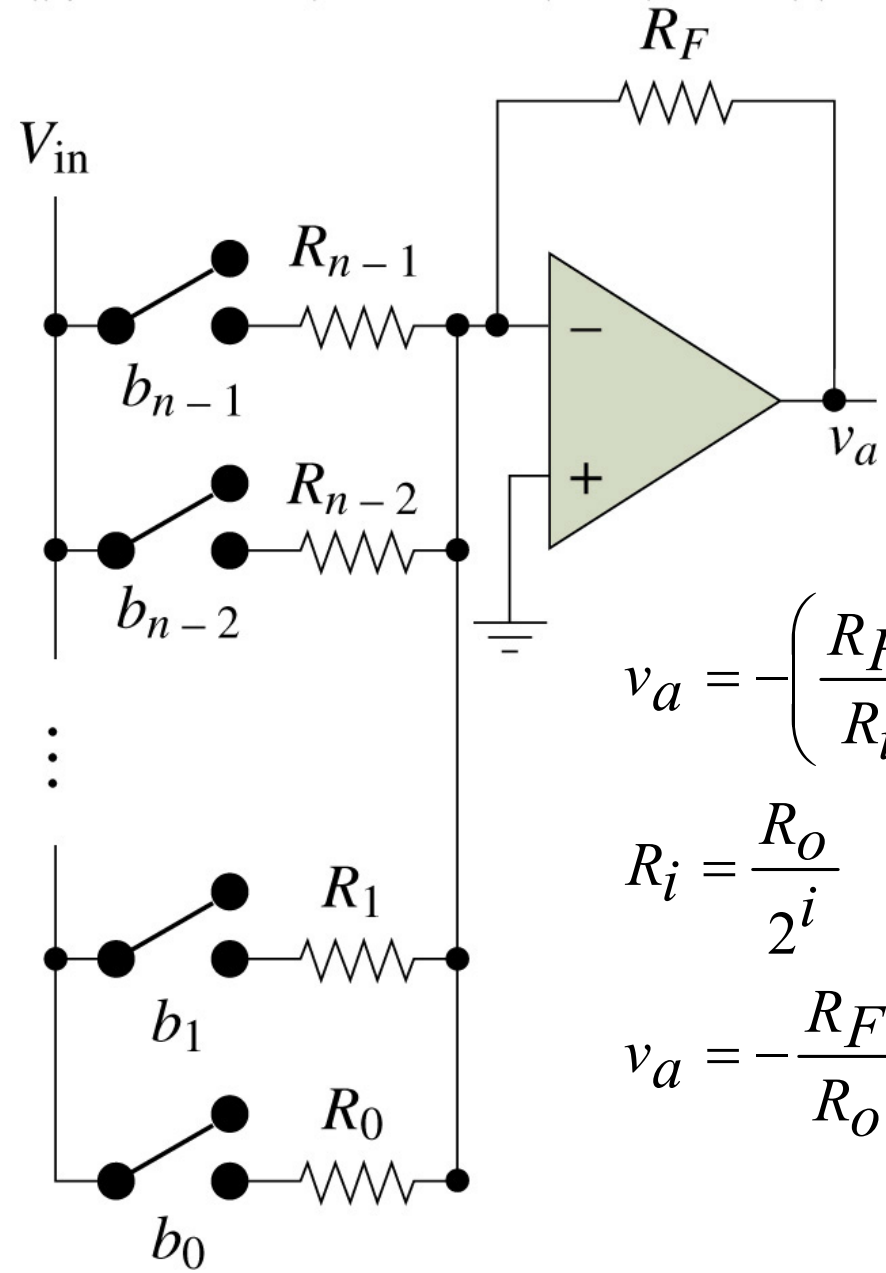
The held value is converted to a digital number.



Turning analog waves into digital signals.

10110110111111101100011001010010001001100101011100101101100.

An *n*-Bit Digital-to-Analog Converter

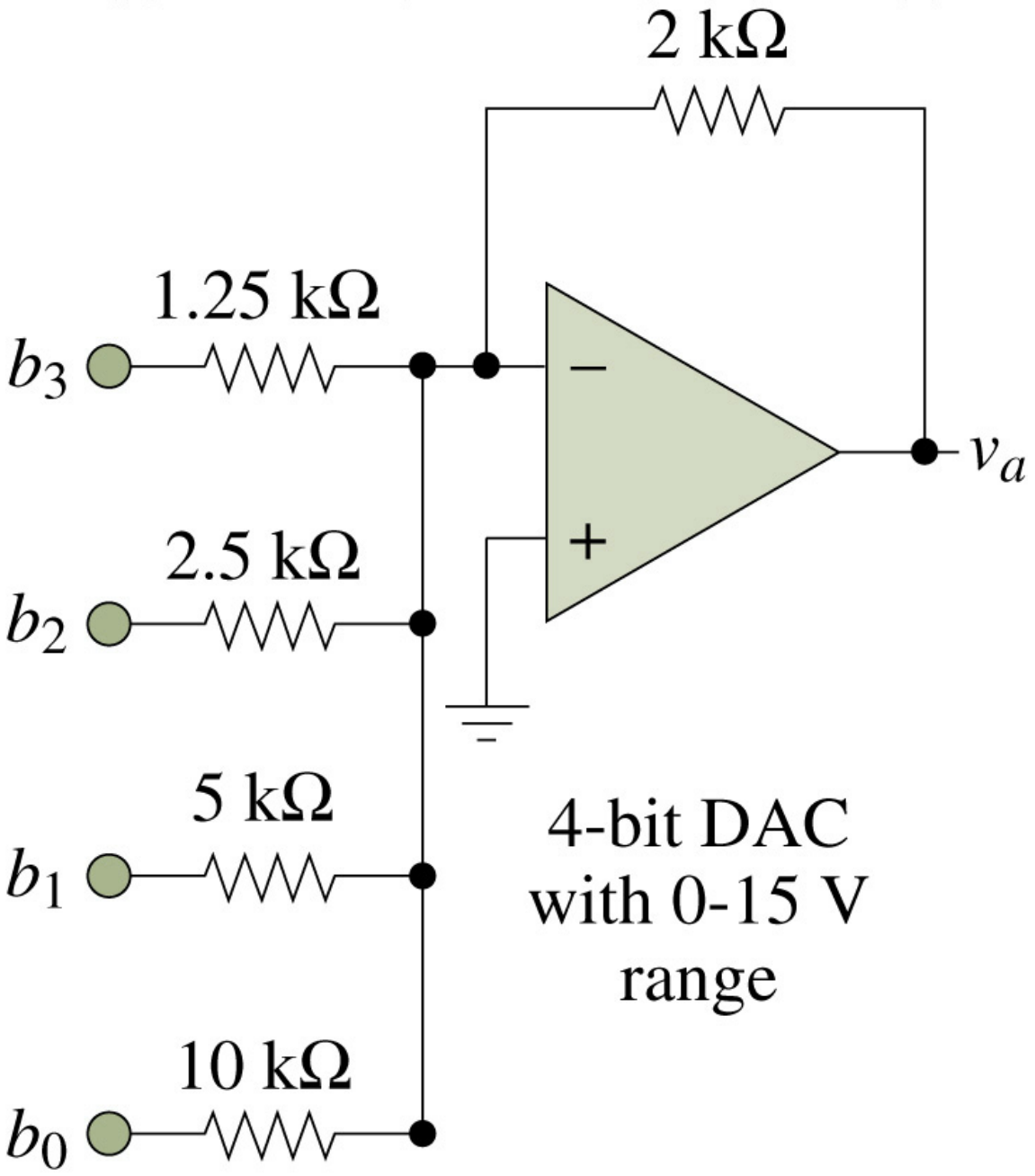


$$v_a = -\left(\frac{R_F}{R_i} b_i . V_{in}\right) i = 0,1,n-1$$

$$R_i = \frac{R_o}{2^i}$$

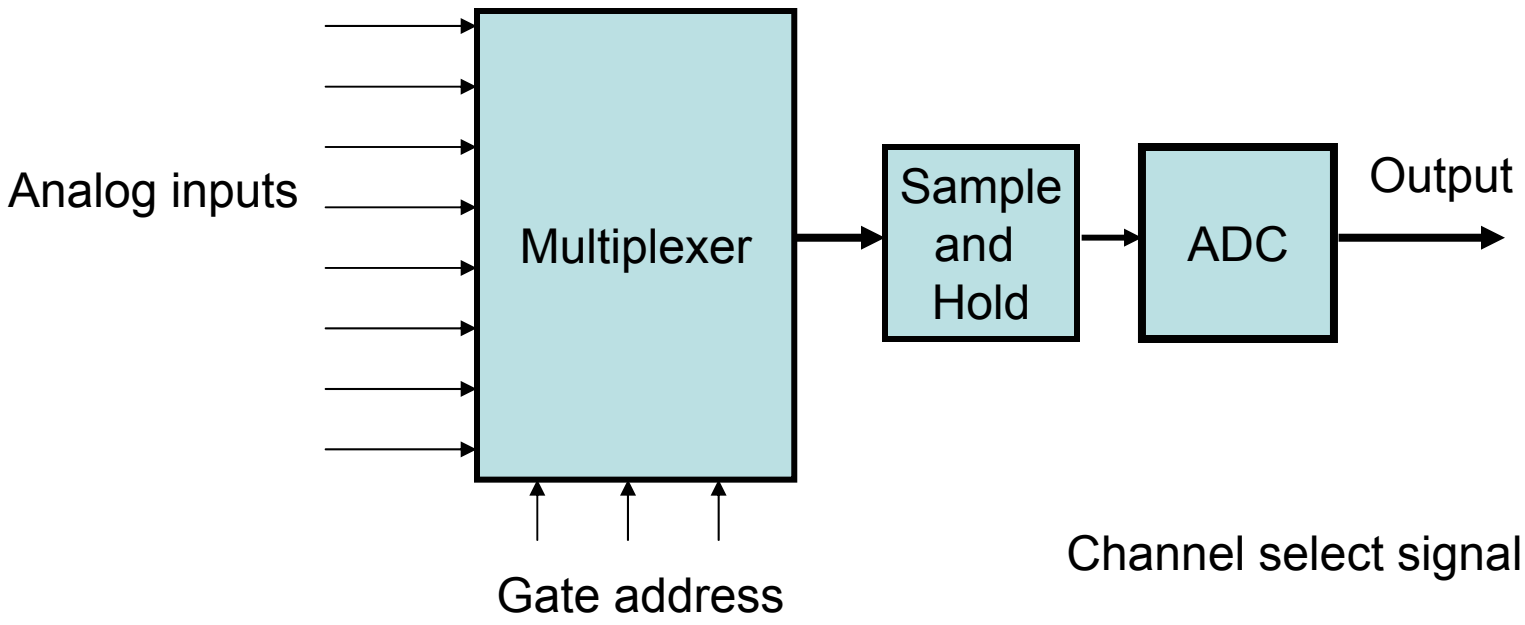
$$v_a = -\frac{R_F}{R_o}(2^{n-1} b_{n-1} + .. + 2^1 b_1 + 2^0 b_0) V_{in}$$

A 4-bit DAC



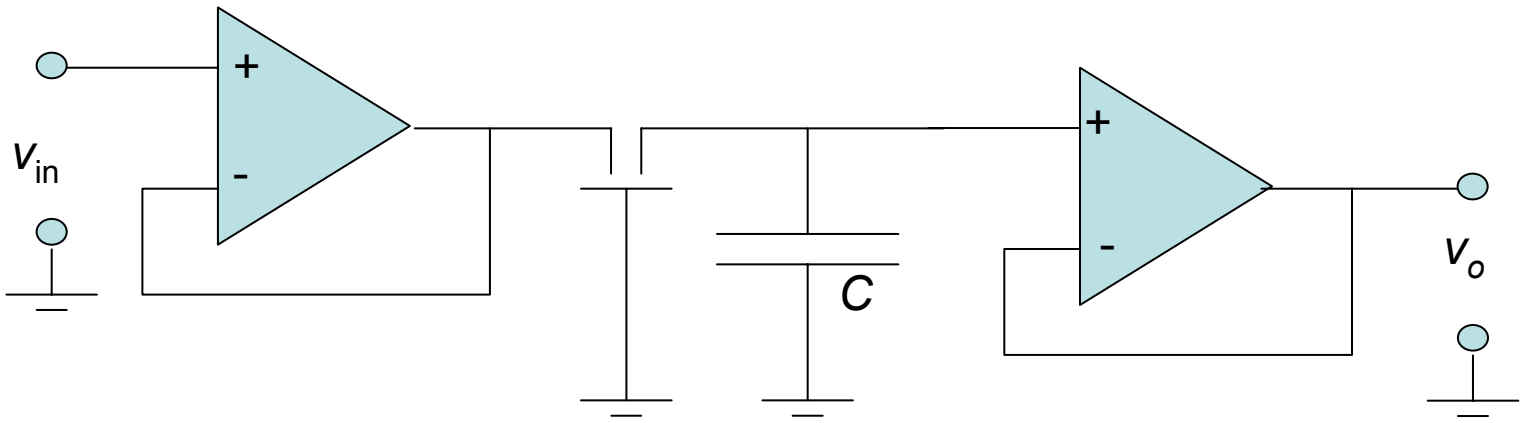
Multiplexers

- Several analog channels are processed sequentially through a multiplexer, which is a digitally controlled switch. The multiplexer accepts parallel inputs from several channels and provides one analog output at a time for conversion to digital form.

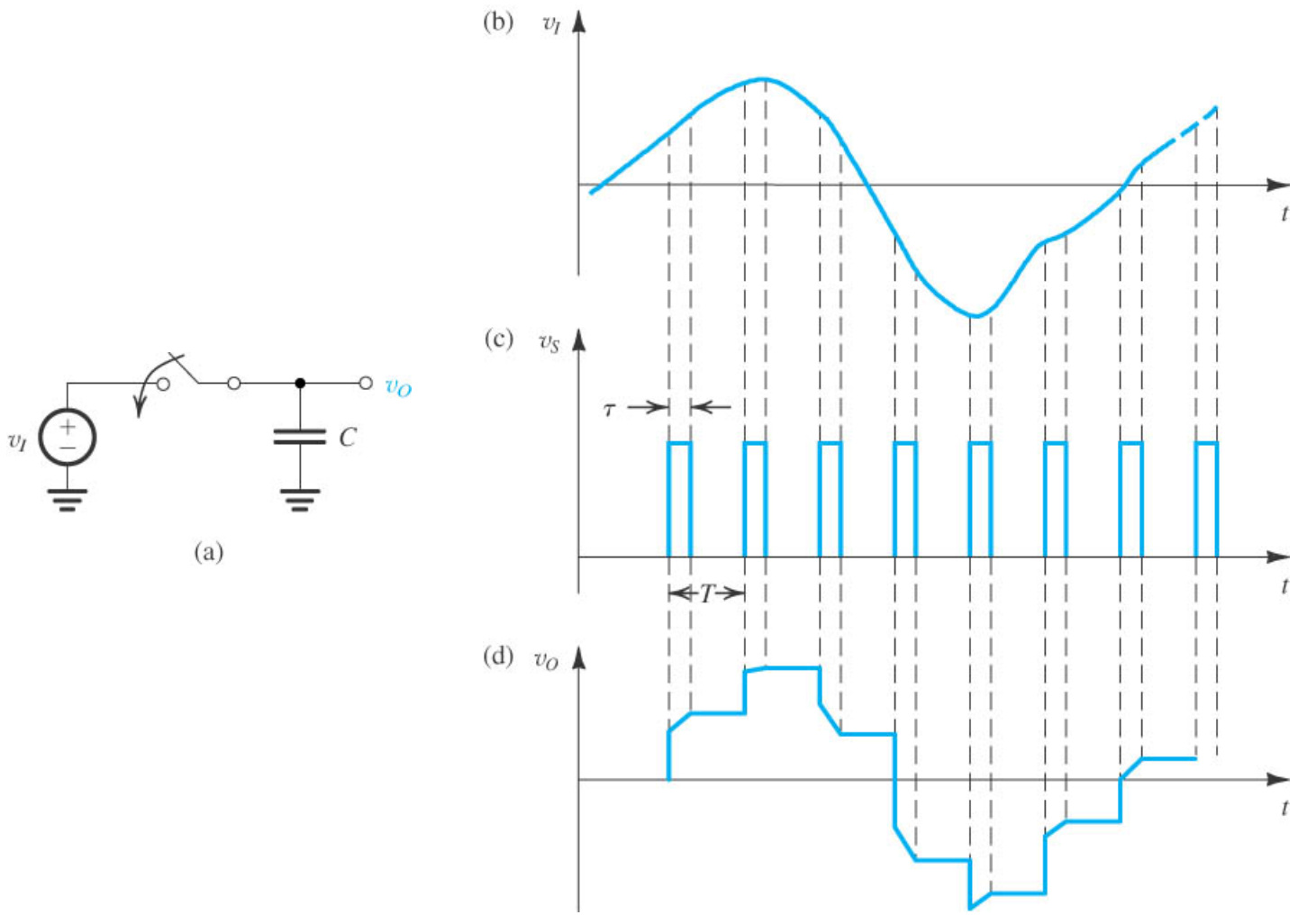


Sample and Hold

- Many inputs can be monitored simultaneously. They are sampled to discrete times through a multiplexer (electronic multipole switch).
- A sample and hold circuit may be required to arrest change in the input while A/D conversion is being performed.
- Sample and hold circuit uses to voltage follower amplifiers to buffer input and output.
- An FET switch is activated long enough for the capacitor to charge to the input voltage, and then the capacitor holds the voltage while A/D conversion is taking place.



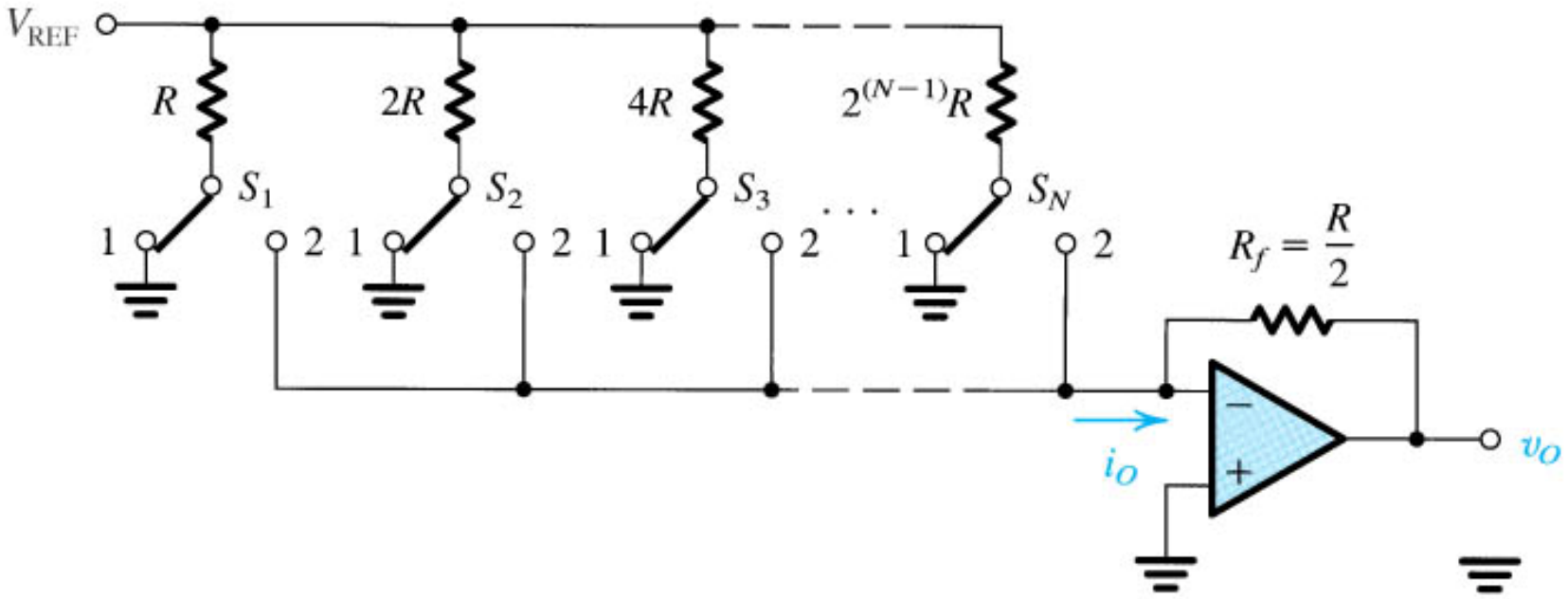
Data Converters



An N-bit D/A converter using a binary-weighted resistive ladder network

$$i_o = \frac{V_{ref}}{R} b_1 + \frac{V_{ref}}{2R} b_2 + .. + \frac{V_{ref}}{2^{N-1}R} b_N$$

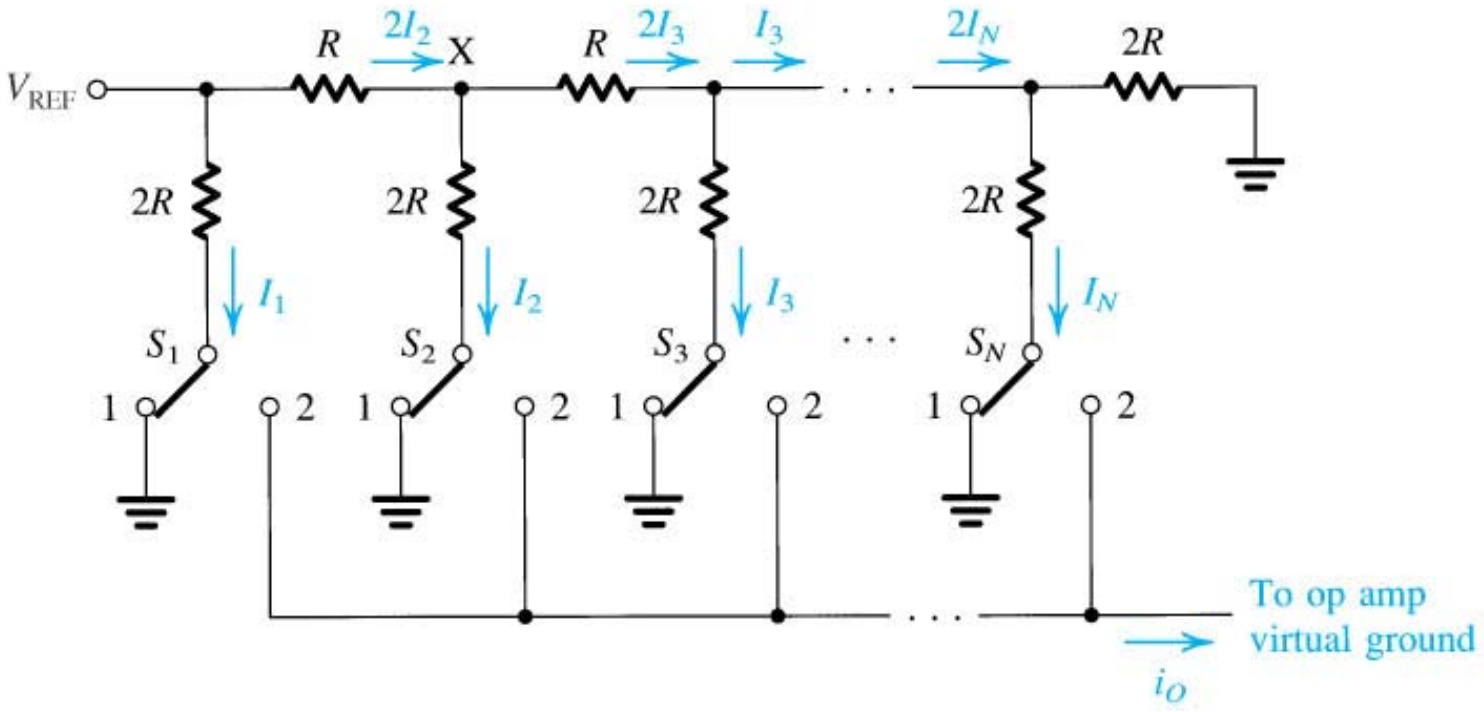
$$i_o = \frac{2V_{ref}}{R} D; \quad v_o = -i_o R_f = -V_{ref} D$$



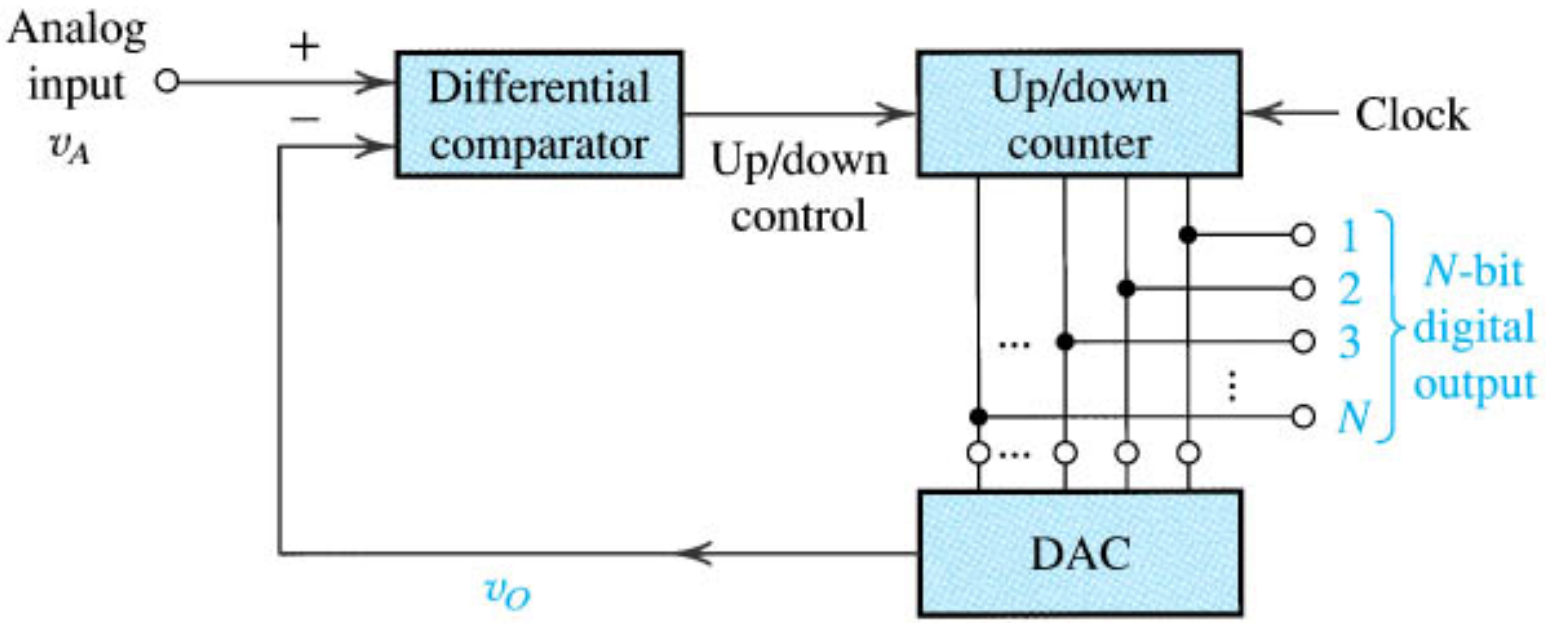
DAC Utilizing an R-2R Ladder Network

$$I_1 = 2I_2 = 4I_3 = .. = 2^{N-1} I_N$$

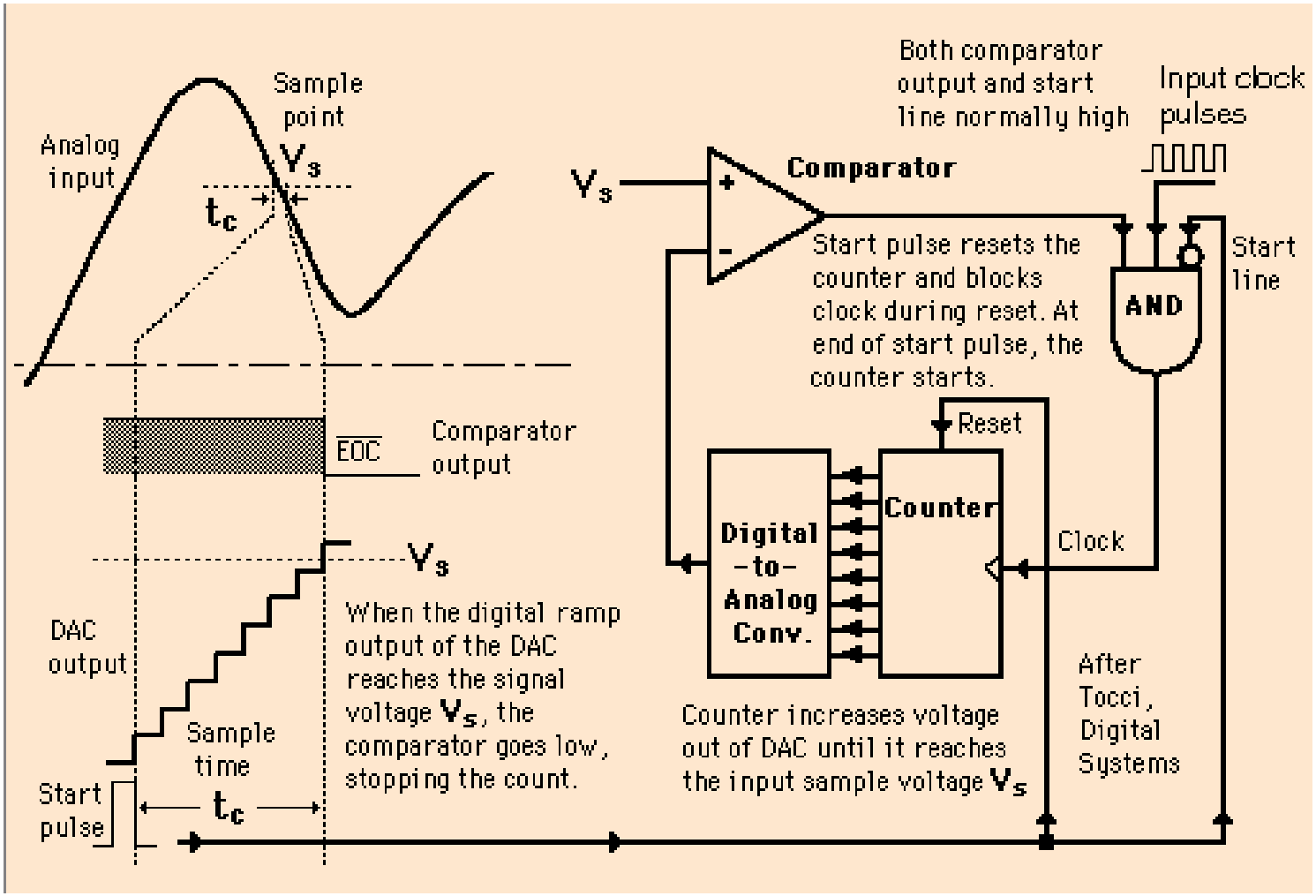
$$i_o = \frac{Vref}{R} D$$



A/D Converter Circuits: The feedback-Type Converter



ADC


Analog input
Sample point
V_s
t_c
$\overline{EOC}$
Comparator output
V_s
DAC output
Sample time
Start pulse
t_c
When the digital ramp output of the DAC reaches the signal voltage V_s, the comparator goes low, stopping the count.
Both comparator output and start line normally high
Input clock pulses
V_s
Comparator
Start pulse resets the counter and blocks clock during reset. At end of start pulse, the counter starts.
AND
Start line
Reset
Digital -to- Analog Conv.
Counter
Clock
Counter increases voltage out of DAC until it reaches the input sample voltage V_s
After Tocci, Digital Systems