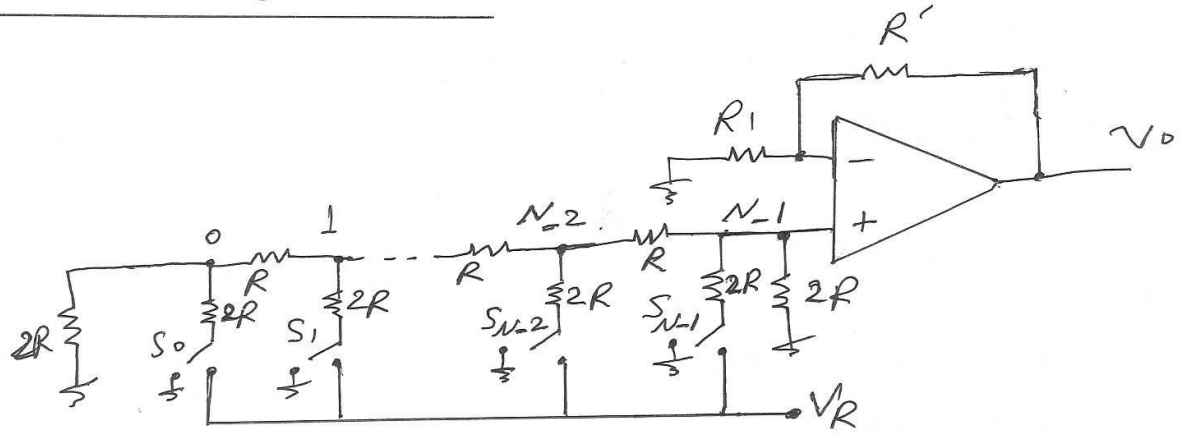
Digital To Analog Converter:

Many systems accept a digital word as an input signal and translate or convert it to an analog voltage or current.

A Ladder-type DAC:



If any switch, say N-2 is connected at V_R the resistance seen by V_R is $2R + (2R // 2R) = 3R$ and the voltage at N-2 is $\frac{V_R \times R}{3R} = \frac{V_R}{3}$.

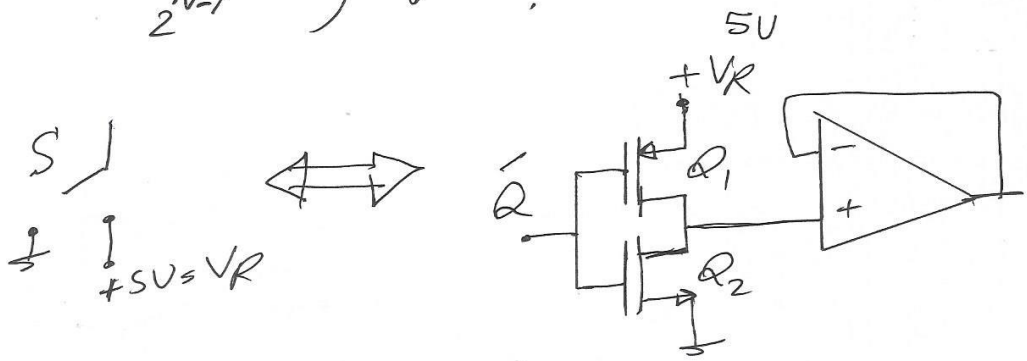
Consider MSB is logic 1 so that the voltage at node N-1 is $\frac{1}{3} V_R$ the output voltage:

$$V_o = \frac{V_R}{3} \frac{R_1 + R'}{R_1} = V'$$

If (N-2) bit is binary 1 and all other bits are zeros, the output voltage at (N-2) node is $\frac{V_R}{3}$, but at node (N-1) the voltage is half this value.

We can apply the general equation of DAC:

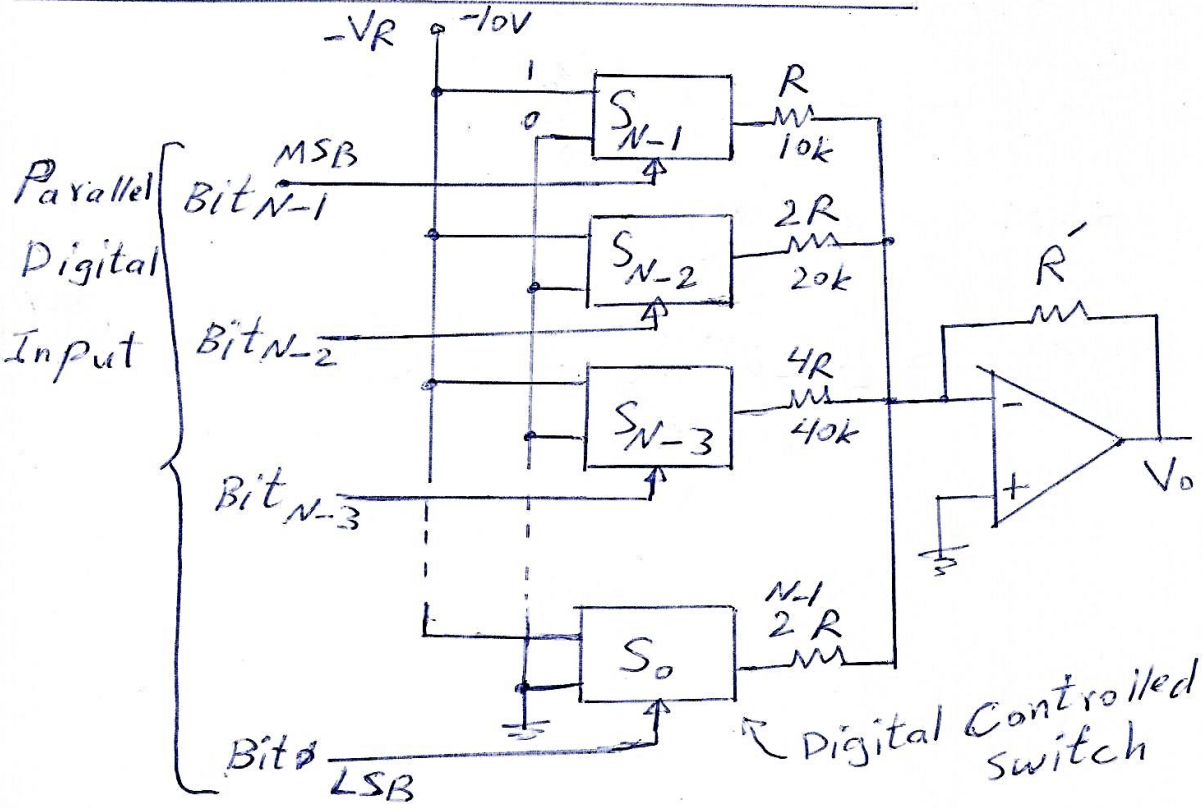
$$V_o = \left(a_{N-1} + \frac{1}{2} a_{N-2} + \frac{1}{4} a_{N-3} + \cdots + \frac{1}{2^{N-2}} a_1 + \frac{1}{2^{N-1}} a_0\right) V'.$$



CMOS Inverter

In the CMOS inverter shown positive logic is used and of Amp follower is used.

Binary Weighted Resistors D/A:



The blocks $S_0, S_1, S_2, \ldots, S_{N-1}$ are electronic switches which are digitally controlled. For example when a(1) is present on the MSB line, switch S_{N-1} connects the resistor R to the reference voltage $-V_R$, conversely, when a (o) is present on the MSB line, the switch connects the resistor to the ground line. The operational amplifier acts as a current-to-voltage converter. If the MSB is 1 and all other bits are ø then: $I_R = \frac{-V_R}{R}$ and $V_o = \frac{V_R}{R} R'$

If $N = 5$ and all five bits are (1), then

$$V_0 = \left(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}\right) \frac{V_R}{R} R'$$

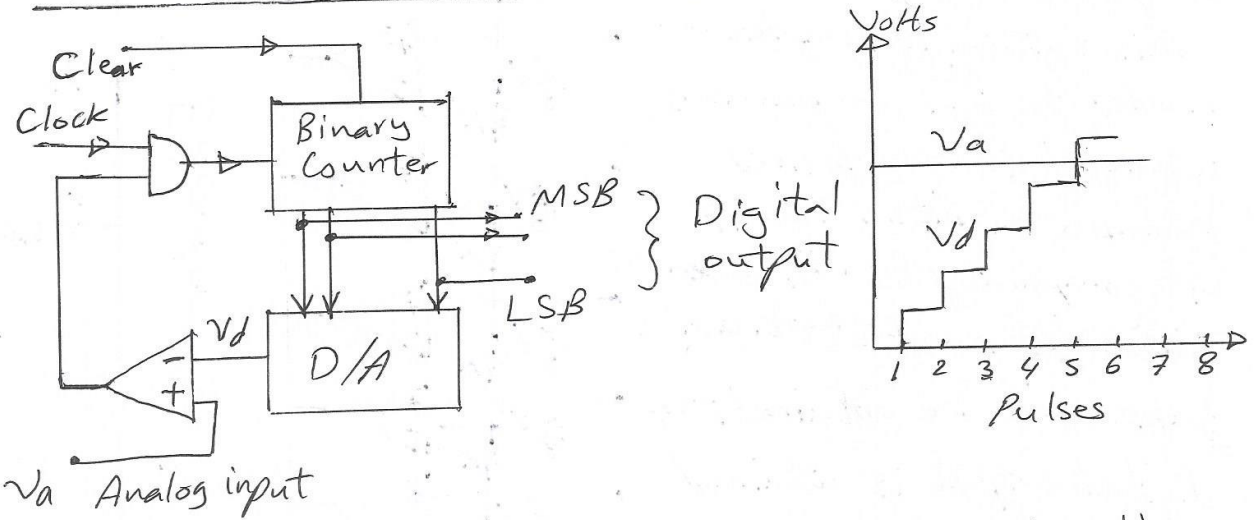
$$= \left(16 + 8 + 4 + 2 + 1\right) \frac{V_R R'}{16R}$$

in general; $V_0 = \left[\left(a_{N-1}\right) + \left(a_{N-2}\right)\frac{1}{2} + \left(a_{N-3}\right)\frac{1}{4} + \cdots + a_0 \frac{1}{2^{N-1}}\right] \times V_R \frac{R'}{R}$

Analog To Digital Converter (ADC):

It is often required data taken in a physical system by converted into digital form.

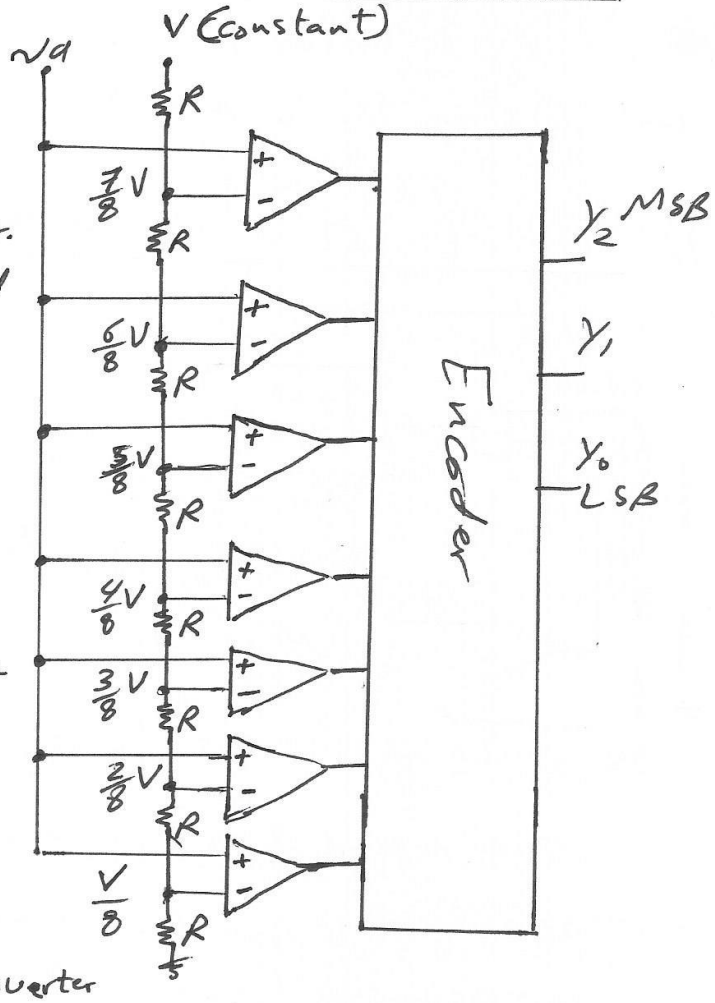
1. The Counting Analog to Digital Converter:



The clear pulse resets the counter to the zero count. The counter records in binary form the number of pulses from the clock line. The binary word representing this count is used as the input to D/A converter whose output is the stair case waveform which is compared with the analog input V_a, whenever $V_a > V_d$ the output of comparator is positive and the output of the AND gate will be a clock to the counter to count, when $V_d > V_a$ the output of the comparator is low and the counter will stop.

Parallel Comparator (Flash Converter) ADC:

This system is the fastest of all converters. Conversion time is limited only be the speed of the comparator and of the encoder. This system is complex and needed to $2^N - 1$ comparator, where N is the desired number of bits. The o/p of comparator be '1', when $v_a > V_R$, and the truth table will be obtained, the digital output is obtained from encoder.



Truth table for A/D converter

v_a	i/p W_7	W_6	W_5	W_4	W_3	W_2	W_1	o/p Y_2	Y_1	Y_0
$v_a \le \frac{V}{8}$	0	0	0	0	0	0	0	0	0	0
$\frac{V}{8} < v_a \le \frac{2V}{8}$	0	0	0	0	0	0	1	0	0	1
$\frac{2V}{8} < v_a \le \frac{3V}{8}$	0	0	0	0	0	1	1	0	1	0
$\frac{3V}{8} < v_a \le \frac{4V}{8}$	0	0	0	0	1	1	1	0	1	1
$\frac{4V}{8} < v_a \le \frac{5V}{8}$	0	0	0	1	1	1	1	1	0	0
$\frac{5V}{8} < v_a \le \frac{6V}{8}$	0	0	1	1	1	1	1	1	0	1
$\frac{6V}{8} < v_a \le \frac{7V}{8}$	0	1	1	1	1	1	1	1	1	0
$v_a > \frac{7V}{8}$	1	1	1	1	1	1	1	1	1	1