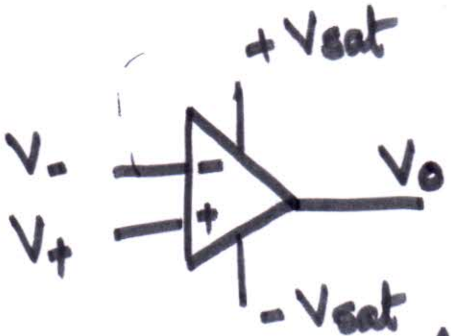
D/A AND A/D CONVERSION

- Digital-to-analog converter (DAC): used to translate digital information to analog information.
- Analog-to-digital converter (ADC): used to change analog signal to its equivalent digital signal.

Brief Discussion on OPERATIONAL AMPLIFIER (OP-AMP):



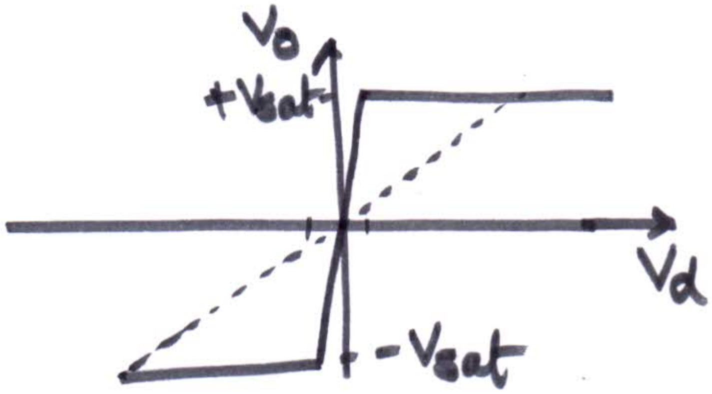
$-V_{sat} \leq V_0 \leq V_{sat}$

- Op-Amp is a very high gain differential Amplifier.

$A_d \rightarrow$ diff. gain

$V_d = V_+ - V_-$

$\Rightarrow V_0 = A_d V_d$



ex $V_{sat} = 15\,V$

$A_d = 10^6$ $\Rightarrow V_d = \frac{15}{10^6}\,V = 15\,\mu V$

Use -ve feedback,

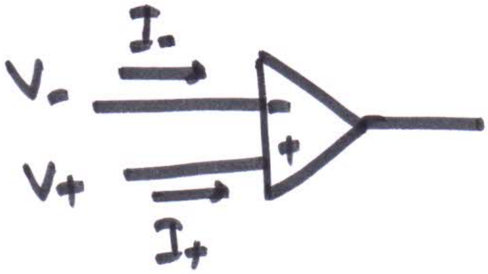
$$V_0 \rightarrow \text{finite}$$

$$\Rightarrow \quad V_0 = A_d V_d$$

$$\Rightarrow \quad V_d = \frac{V_0}{A_d} \approx 0\,\text{V}$$

$$\Rightarrow \quad V_+ - V_- \approx 0\,\text{V}$$

$$\Rightarrow \quad \boxed{V_+ \cong V_-}$$

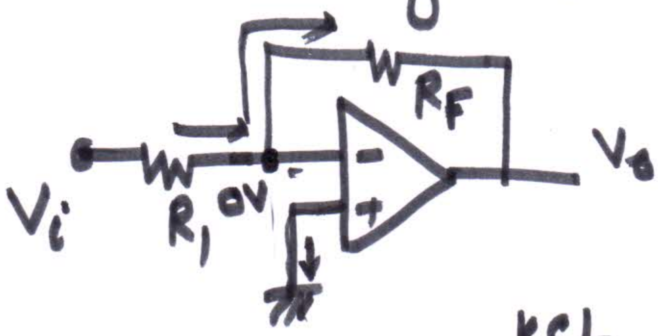


I/p impedance is very large.

$$I_- = I_+ = 0\,\text{A}$$

Applications

1) Inverting Amp

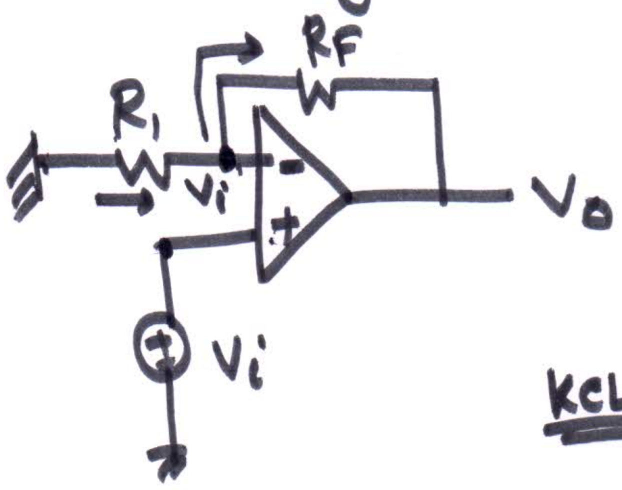


$$V_0 = \left(-\frac{R_F}{R_1}\right) V_i$$

KCL

$$\frac{V_i - 0}{R_1} = \frac{0 - V_0}{R_F}$$

1) Non-inverting



KCL

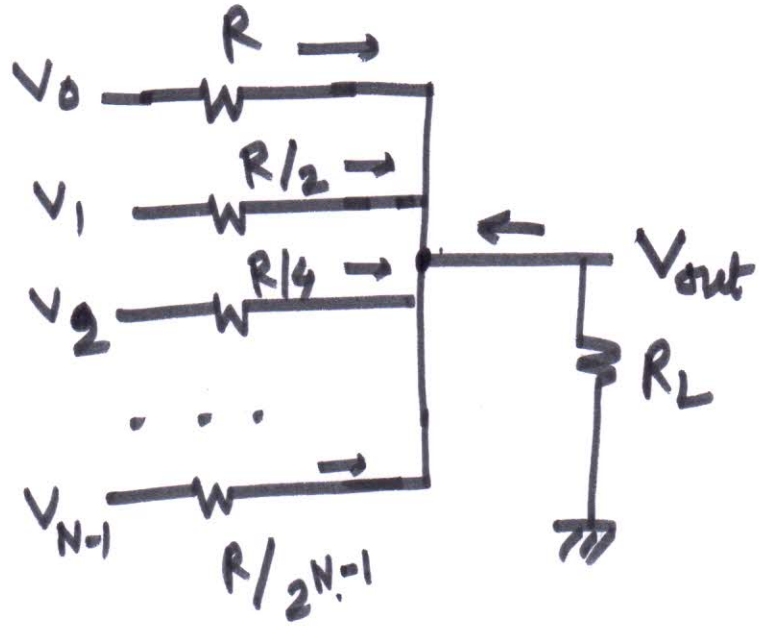
$$\frac{0 - V_i'}{R_1} = \frac{V_i' - V_0}{R_F}$$

$$\Rightarrow \quad V_0 = \left(1 + \frac{R_F}{R_1}\right) V_i'$$

DAC:

1. Variable Resistor Network
2. Binary Ladder Network

Variable Resistor Network:



$R_L >> R$

$K = \frac{1}{1+2+4+\cdots+2^{N-1}}$

$= \frac{1}{(2^N-1)}$

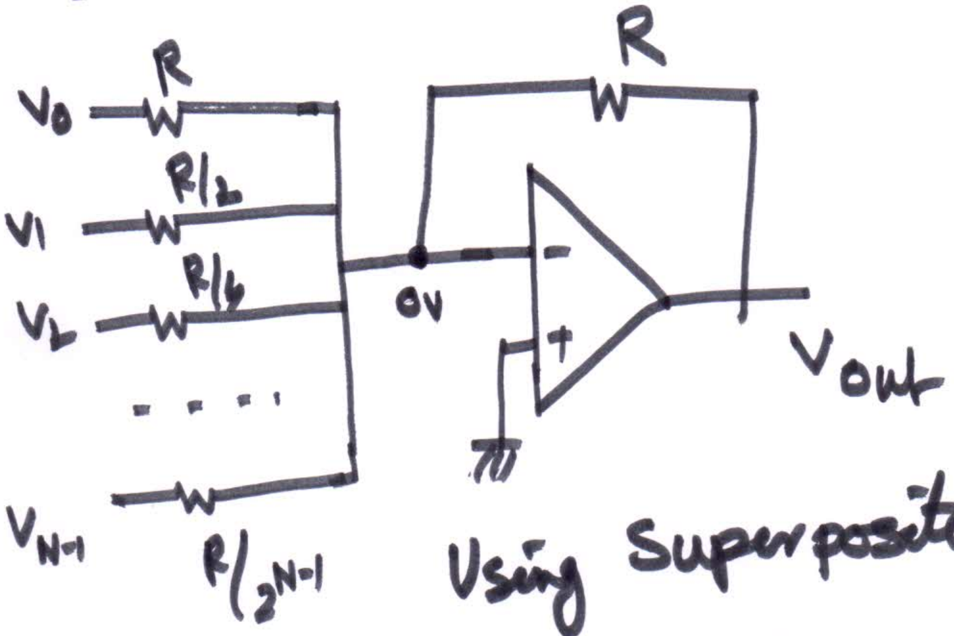
KCL

$$\frac{V_0 - V_{out}}{R} + \frac{V_1 - V_{out}}{R/2} + \cdots + \frac{V_{N-1} - V_{out}}{R/2^{N-1}} + \frac{0 - V_{out}}{R_L} = 0$$

$$\Rightarrow V_{out} = \frac{\frac{V_0}{R} + \frac{V_1}{R/2} + \cdots \frac{V_{N-1}}{R/2^{N-1}}}{\frac{1}{R} + \frac{1}{R/2} + \cdots + \frac{1}{R/2^{N-1}} + \cancel{\frac{1}{R_L}}}$$

$$= K\left[\underset{LSB}{V_0} + 2V_1 + 4V_2 + \cdots + 2^{N-1}V_{N-1}\right] \text{MSB}$$

Using Op Amp



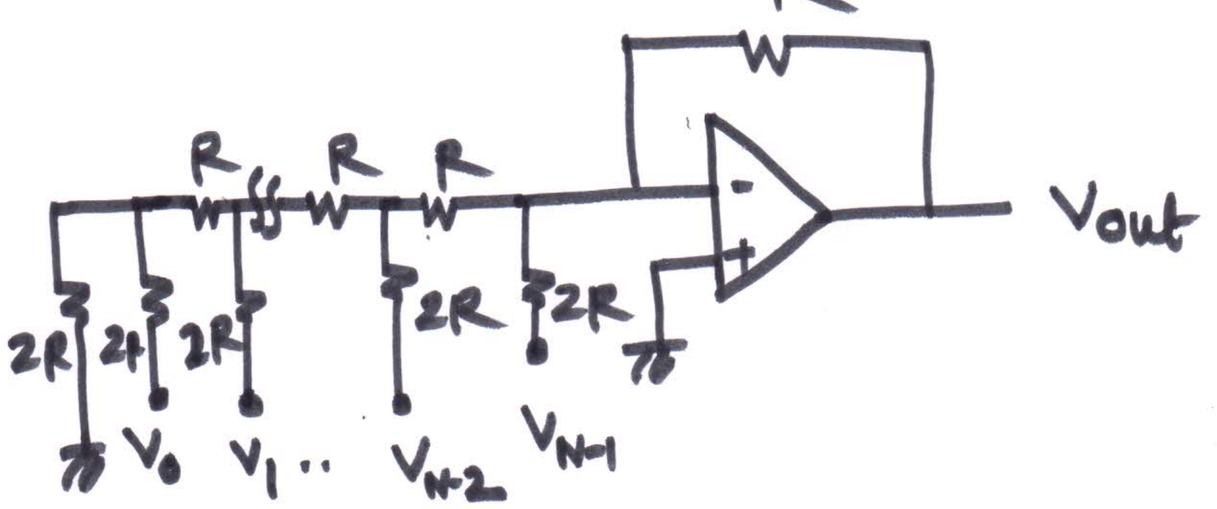
Using Superposition Theorem

$$V_{out} = -\frac{R}{R}\cdot V_0 - \frac{R}{R/2}\cdot V_1 - \frac{R}{R/4}\cdot V_2$$

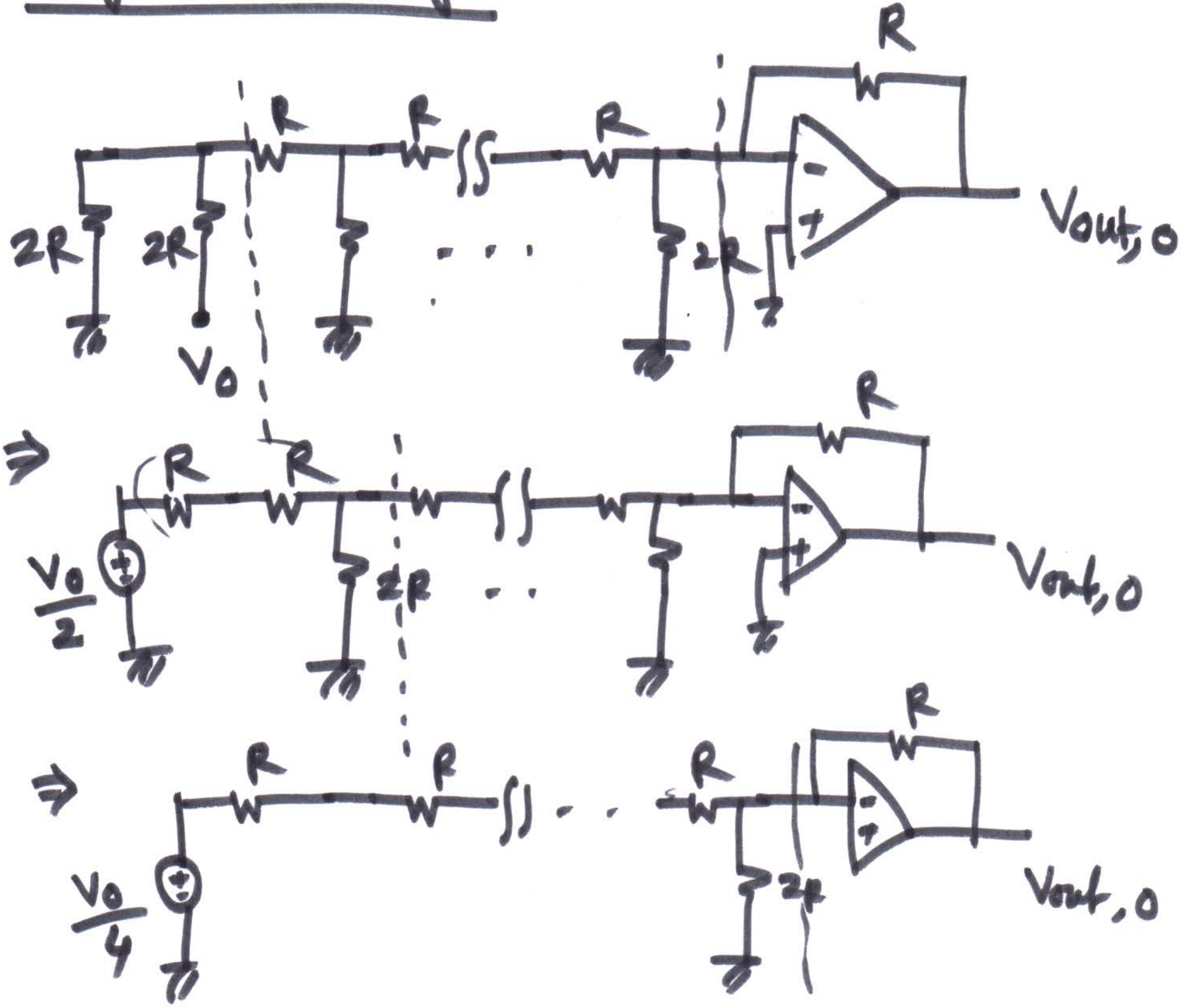
$$- + \cdots\cdots - \frac{R}{R/2^{N-1}}\cdot V_{N-1}$$

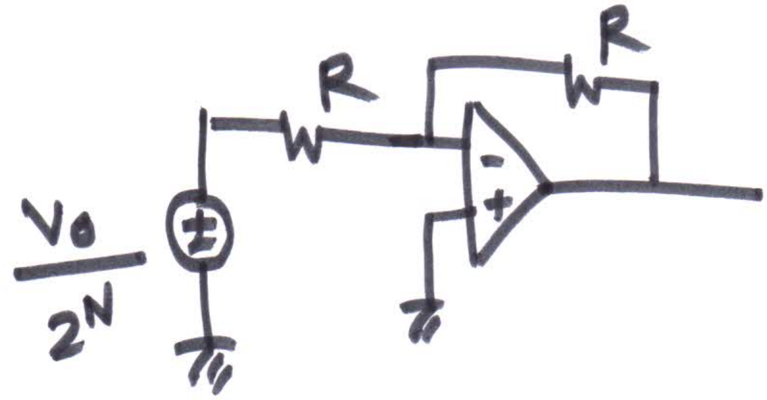
$$= -\left(\underline{V_0 + 2V_1 + 4V_2 +} \cdots + 2^{N-1} V_{N-1}\right)$$

2. Binary Ladder (R-2R) D/A Converters :



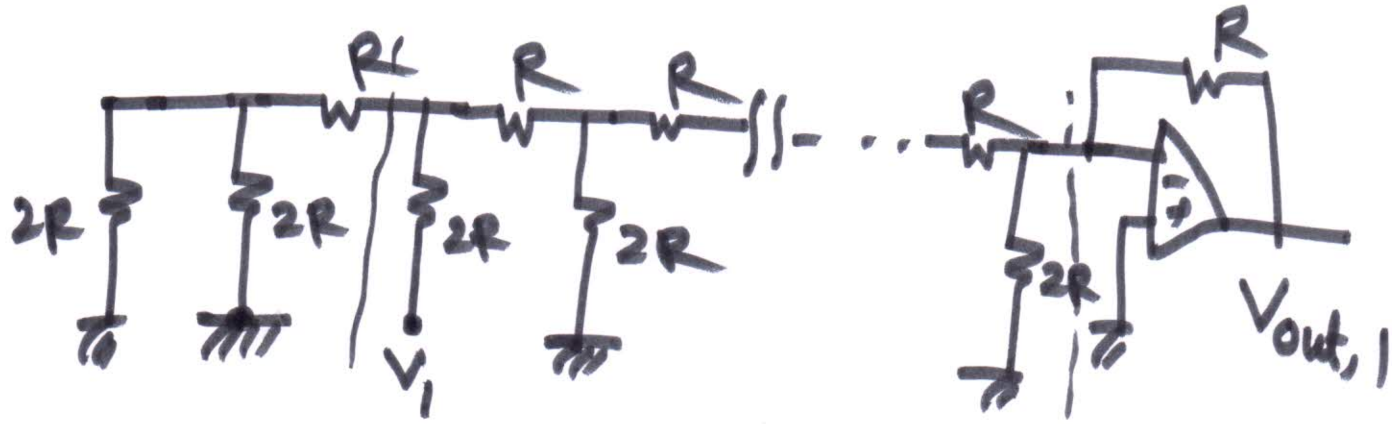
Only V_0 is acting

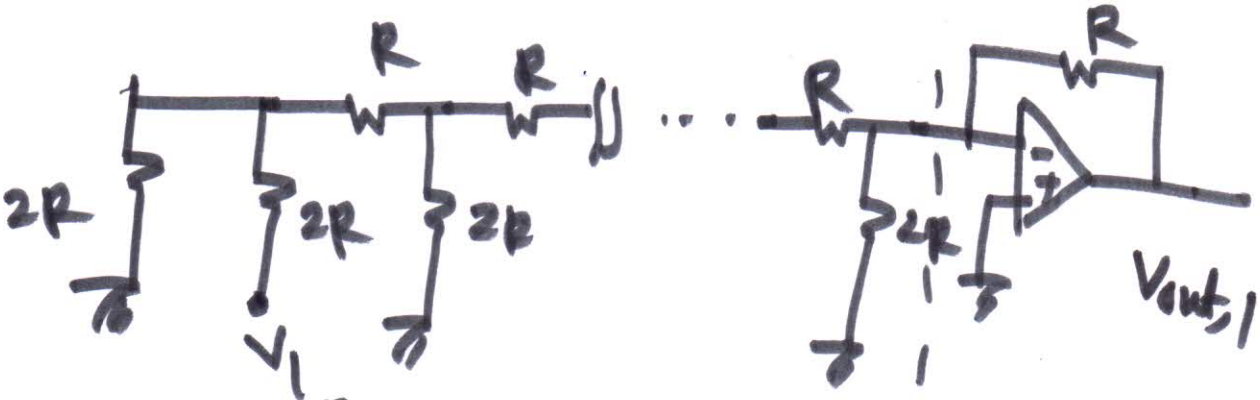


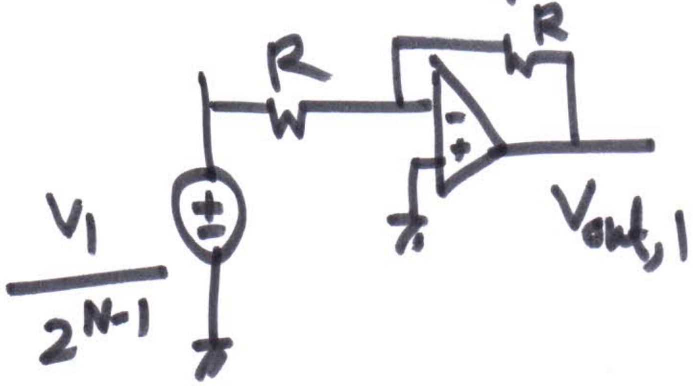


$$V_{out,0} = \left(-\frac{R}{R}\right) \times \frac{V_0}{2^N}$$

V_1 is acting







$$V_{out,1} = \left(-\frac{R}{R}\right)\frac{V_1}{2^{N-1}}$$

Therefore,

$$V_{out} = \left(-\frac{R}{R}\right)\times\frac{V_0}{2^N} + \left(-\frac{R}{R}\right)\times\frac{V_1}{2^{N-1}} + \cdots$$

$$+\left(-\frac{R}{R}\right)\times\frac{V_i}{2^{N-i}} + \left(-\frac{R}{R}\right)\times\frac{V_{N-1}}{2}$$

$$= \frac{-1}{2^N}\left[V_0 + 2V_1 + 2^2 V_2 + \cdots 2^{N-1} V_{N-1}\right]$$

If, $V_0 = V_1 = \cdots = V_{N-1} = V$

$$\Rightarrow V_{out} = -\frac{V}{2^N}\times\left[1 + 2 + 4 + \cdots + 2^{N-1}\right]$$

$$= -\frac{V}{2^N}\times\left[2^N - 1\right]$$

$$\frac{-V[2^N-1]}{2^N} < V_{out} < 0$$

A/D Converter

1) Simultaneous or Flash-type A/D Converter

Consider I/p V_i,

with $0 \leq V_i \leq V$.

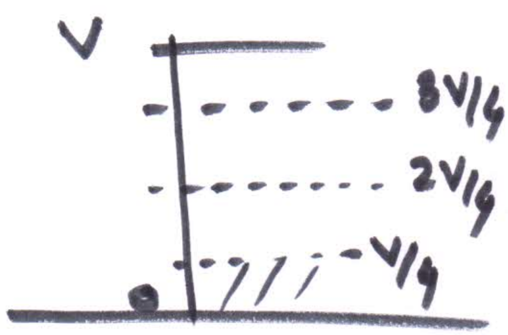
$d_1 \; d_0$

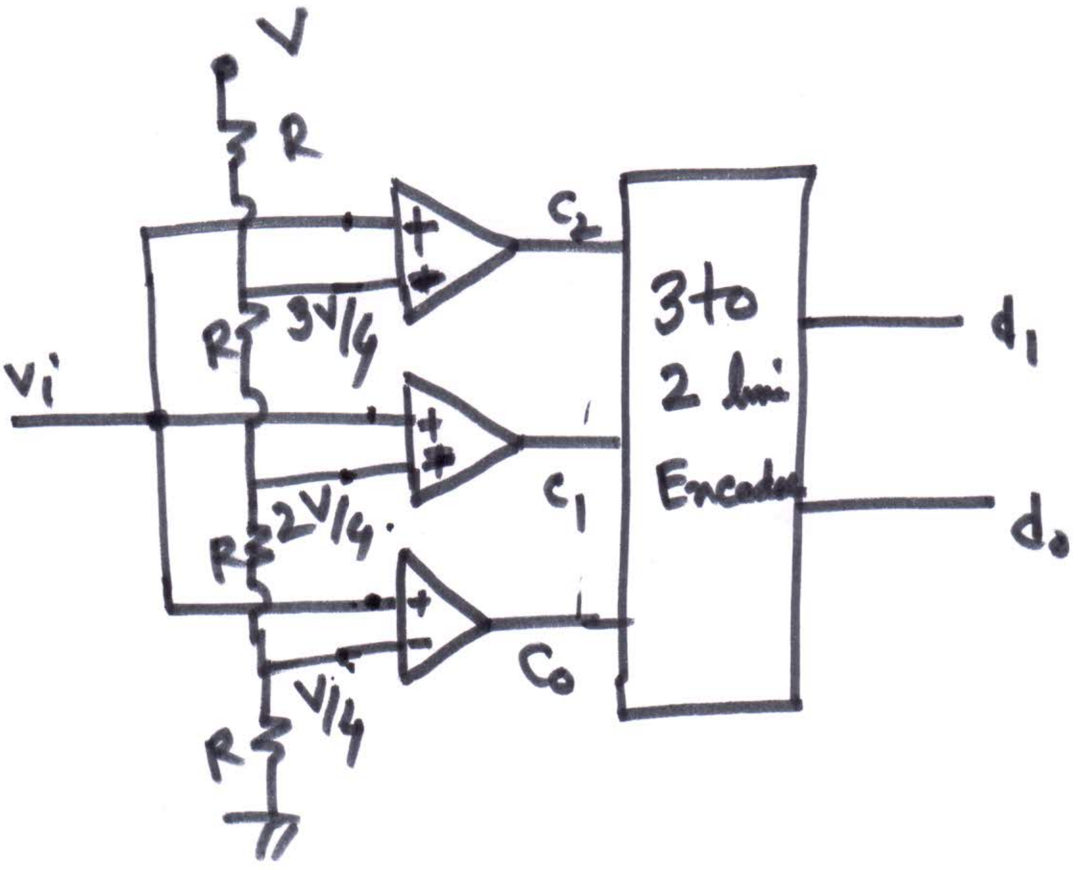
$0 \leq V_i \leq \frac{V}{4} \Rightarrow$ '00'

$\frac{V}{4} \leq V_i \leq \frac{2V}{4} \Rightarrow$ '01'

$\frac{2V}{4} \leq V_i \leq \frac{3V}{4} \Rightarrow$ '10'

$\frac{3V}{4} \leq V_i \leq V$ = '11'.





V_i	c_2	c_1	c_0	d_1	d_0
$0 \le V_i < \frac{V}{4}$	0	0	0	0	0
$\frac{V}{4} \le V_i < \frac{V}{2}$	0	0	1	0	1
$\frac{V}{2} \le V_i < \frac{3V}{4}$	0	1	1	1	0
$\frac{3V}{4} \le V_i \le V$	1	1	1	1	1

4 bits Flash-type A/D Converters: