UNIT-V

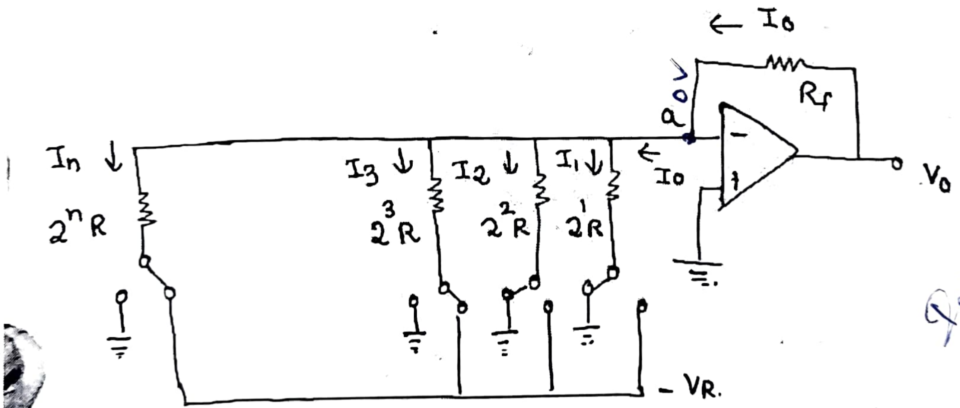
DATA CONVERSION DEVICES

For processing, transmission & storage, it is often convenient to express analog values in digital form because it gives better accuracy and reduces noise

DAC Types

(i) weighted resistor DAC
(ii) R-2R ladder
(iii) Inverted R-2R ladder.

WEIGHTED RESISTOR DAC



$I_1 = \frac{0-(-V_R)}{2^1 R} = \frac{V_R}{2R}$

Summing amplifier with binary weighted resistor network. It has n-electronic switches $d_1, d_2 \ldots d_n$ connected by binary input word. They are single pole double throw (SPDT) type. If binary i/p is 1, it connects resistance to reference voltage $(-V_R)$. And if input bit is 0, switch connects resistor to ground

$$I_0 = I_1 + I_2 + \ldots + I_n$$

$$= \frac{V_R}{2R} d_1 + \frac{V_R}{2^2 R} d_2 + \ldots \ldots + \frac{V_R}{2^n R} d_n$$

$d_1 d_2 \dots d_n$ - n bit binary word.

$$\therefore = \frac{V_R}{R}\left[d_1 2^{-1} + d_2 2^{-2} + \dots d_n 2^{-n}\right].$$

output voltage

$$V_0 = I_0 R_f$$

$$= \frac{V_R R_f}{R}\left[d_1 2^{-1} + d_2 2^{-2} + \dots + d_n 2^{-n}\right].$$

$d_1 = 0 \quad d_2 = 0 \quad d_3 = 1$

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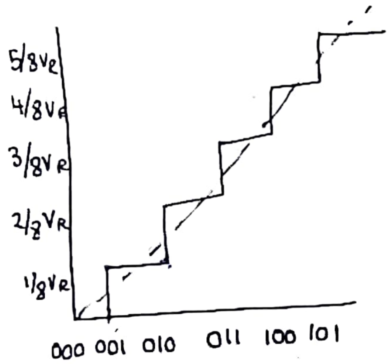
$$= V_R\left[\frac{0}{2} + \frac{0}{4} + \frac{1}{8}\right]$$

$$= \frac{V_R}{8}$$

reference voltage is -ve

$\therefore$ positive stair case is obtained



circuit shown is connected in inverting mode.

It can also be connected in non inverting mode.

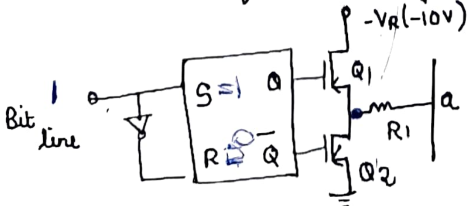
op- am acts as I to V converter.

Accuracy & Stability of DAC depends on accuracy of resistors

disadv (i) wide range of resistors used.

(ii) for better resolution binary word length should be large.

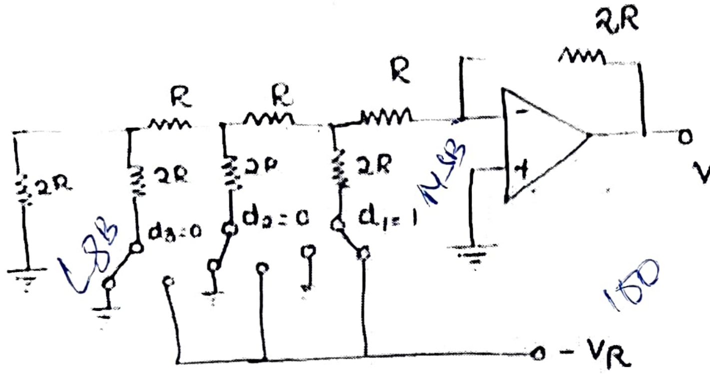
Bipolar transistor donot perform well as voltage switches hence by using totem pole MOSFET SWITCH low ON resistance & zero offset voltage can be achieved



R-2R LADDER DAC

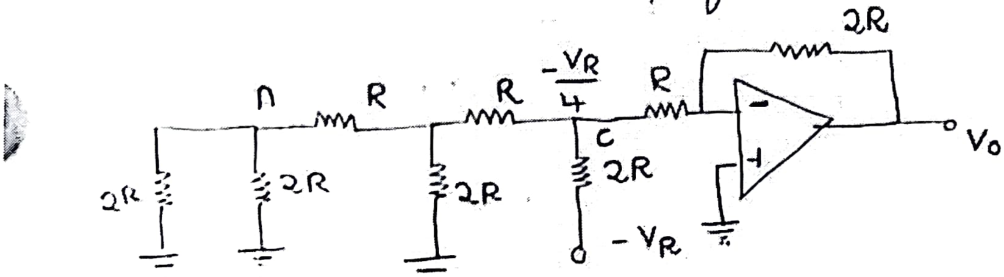
Wide range of resistors are required in binary weighted resistor type DAC. This is avoided by using R-2R ladder type DAC where only two values of resistors are required.

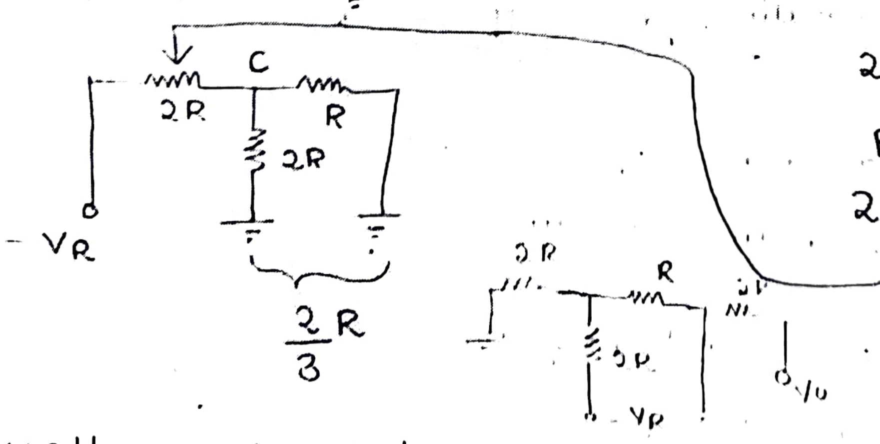
Consider 3 bit DAC as shown below



Switch position $d_1 d_2 d_3$ corresponds to binary word 100

The circuit can be simplified as shown below





2R || 2R = R

R + R = 2R

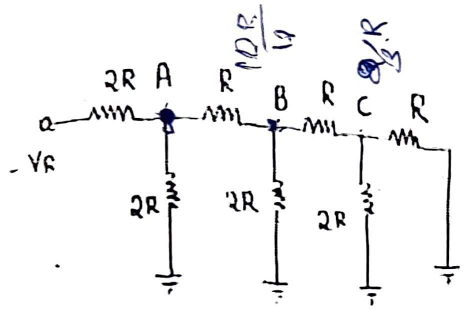
2R || 2R = R

R + R = 2R

Voltage at node C can be calculated as

$$\frac{-V_R\left(\frac{2}{3}R\right)}{2R + \frac{2R}{3}} = -\frac{V_R}{4}$$

The output voltage $V_o = -\frac{2R}{L}\left(-\frac{V_R}{1}\right) = \underline{V_R} = \underline{V_{FS}}$



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<u>At A</u>

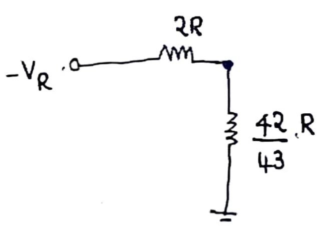
$$(R \parallel 2R) = \frac{2R^2}{3\cancel{R}} = \frac{2R}{3} \text{ ; series with } R$$

$$\frac{2R}{3} + R = \frac{5R}{3} \text{ ; } \parallel^l \text{ with } 2R$$

$$\frac{\left(\frac{5R}{3}\right)2R}{\frac{5R}{3} + 2R} = \frac{10R}{11}$$

$$\text{series with } R \text{ ; } \frac{10R}{11} + R = \frac{21R}{11}$$

$$\parallel^l \text{ to } 2R \text{ ; } \frac{\left(\frac{21R}{11}\right)2R}{\frac{21R}{11} + 2R} = \frac{42R}{43}$$

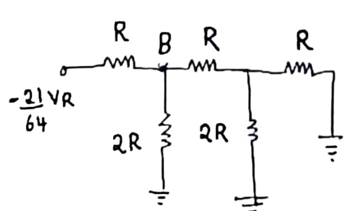


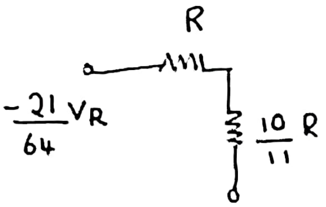
$$\text{voltage at } A = \frac{-V_R \times \frac{42R}{43}}{\frac{42R}{43} + 2R}$$

$$= \frac{-V_R \times \cancel{42}^{21}\cancel{R}}{\cancel{128}_{64}\cancel{R}}$$

$$V_A = -\frac{21}{64}V_R$$

<u>At B</u>

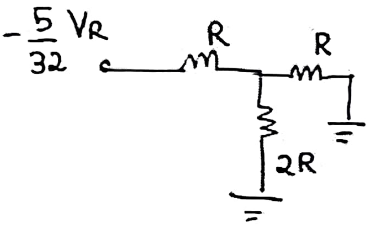




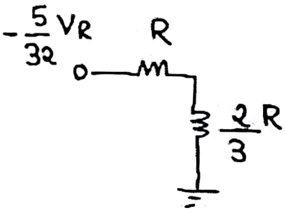
$$V_B = \frac{-\frac{21}{64} V_R \times \frac{10 R}{11}}{\frac{10}{11} R + R}$$

$$= \frac{-\frac{\cancel{21} V_R}{64} \times \frac{10 \cancel{R}}{\cancel{11}}}{\frac{\cancel{21} \cancel{R}}{\cancel{11}}}$$

$$= -\frac{10 V_R}{64} = -\frac{5}{32} V_R$$



$\Rightarrow$

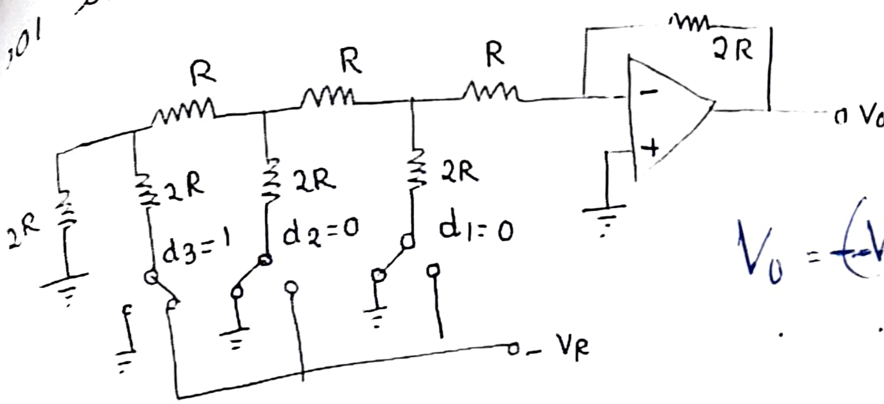


$$\Rightarrow V_c = \frac{-\frac{5}{32} \times \frac{2R}{3}}{\frac{2}{3} R + R} = \frac{-\frac{\cancel{5}}{32} \times \frac{2 R}{\cancel{3}}}{\frac{\cancel{5} \cancel{R}}{\cancel{3}}}$$

$$V_c = -\frac{1}{16} V_R$$

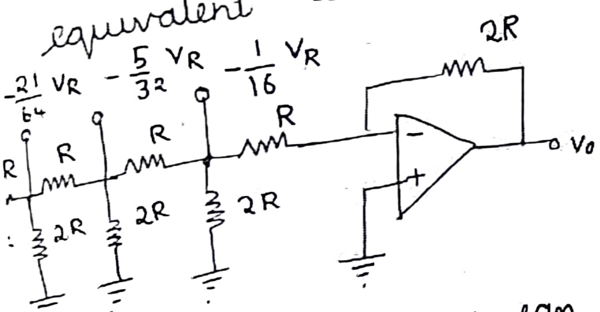
output voltage $V_o = -\frac{2R}{R}\left(-\frac{V_R}{4}\right) = \frac{V_R}{2} - \frac{V_{FS}}{2}$

The switch position corresponding to binary word 101 in 3 bit DAC is shown in circuit below



$$V_0 = -(-V_R)\cdot \frac{R_f}{2R}\left[\frac{d_1}{2^1} + \frac{d_2}{2^2} + \frac{d_3}{2^n}\right]$$

equivalent circuit is



The output voltage eqn for this circuit is given by.

$$V_o = -\frac{2R}{R}\left(-\frac{V_R}{16}\right) = \frac{V_R}{8} = \frac{V_{FS}}{8}$$

In similar fashion, output voltage for R-2R ladder type DAC corresponding to other 3 bit binary words can be calculated.