4.3 WEIGHTED BINARY RESISTOR DAC

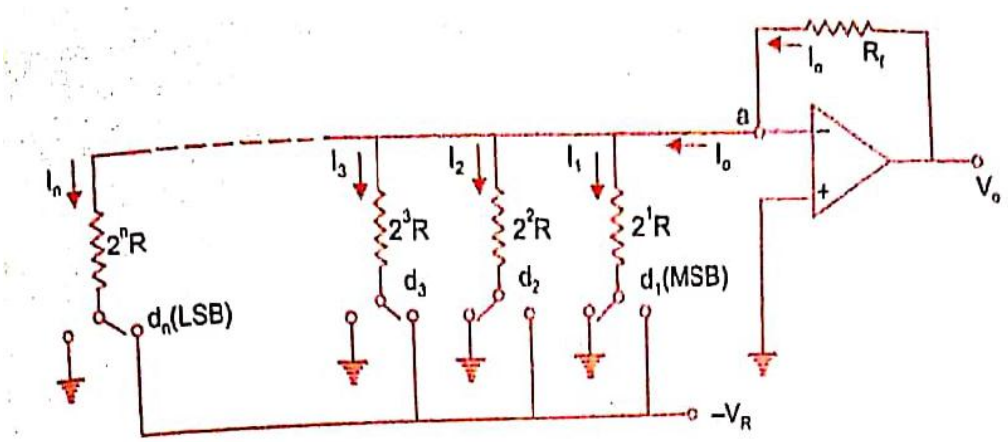

Figure 4.3.1 Weighted Binary resistor DAC

[source:"Linear Integrated Circuits"by D.Roy Choudhry, Shail Bala Jain, Page-403]

Weighted Binary resistor DAC is shown in figure 4.3.1.Uses a summing amplifier with a binary weighted resistor network.Has n-electronic switches d_1,d_2,….d_n controlled by binary input word.These switches are single pole double throw type.If the binary input to a particular switch is '1',it connects the resistance to the reference voltage ($-V_R$).If the input bit is '0',the switch connects to resistor to the ground.The output current Io for an ideal op-amp can be written as

$$I_o = I_1 + I_2 + I_3 + \cdots \ldots \ldots + I_n$$

$$I_o = I_1 + I_2 + I_3 + \cdots \ldots \ldots + I_n$$

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

$$I_o = \frac{V_R}{R} [d_1 2^{-1} + d_2 2^{-2} + \cdots \ldots + d_n 2^{-n}]$$

The o/p voltage

$$V_o = I_o R_f$$

$$= V_R \frac{R_f}{R} [d_1 2^{-1} + d_2 2^{-2} + \cdots \ldots + d_n 2^{-n}]$$

Advantages:

- Easy principle/construction
- Fast conversion

Disadvantages:

- Requirement of several different precise input resistor values: Requires large range of resistors (2048:1 for 12-bit DAC) with necessary high precision for low resistors one unique value per binary input bit. (High bit DACs)
- Larger resistors ~ more error.
- Precise large resistors – expensive.

R-2R LADDER DAC

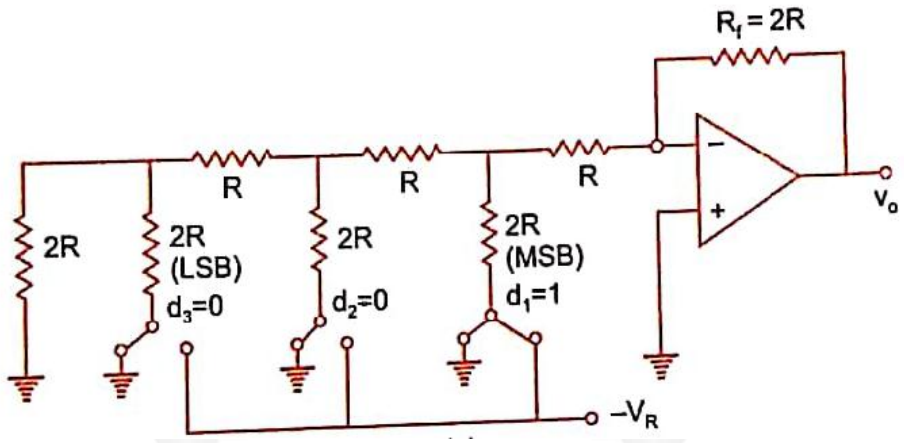

Figure 4.3.2. R-2R Ladder DAC

[source:"Linear Integrated Circuits"by D.Roy Choudhry, Shail Bala Jain, Page-405]

R-2R Ladder DAC is shown in figure 4.3.2.Wide range of resistors are required in binary weighted resistor.This can be avoided by using R-2R ladder type DAC where only two values of resistors are required.The values of R ranges from 2.5kΩ to 10kΩ.Fig A the switch position d1,d2,d3 corresponds to the binary word 100. voltage at node C can be calculated by network analysis as

$$\frac{-V_R \frac{2}{3}R}{2R + \frac{2R}{3}} = \frac{-V_R}{4}$$

The output voltage is

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

Advantages:

- Only two resistor values
- Does not need as precision resistors as Binary weighted DACs
- Cheap and Easy to manufacture

Disadvantages:

- Slower conversion rate

VOLTAGE MODE R-2R LADDER TYPE D/A CONVERTER

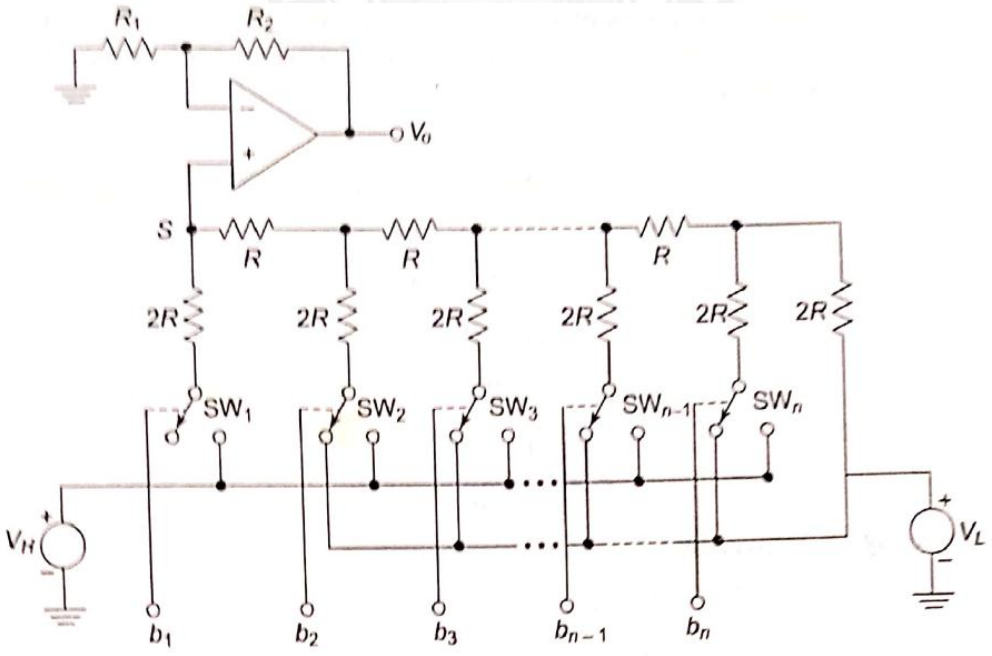

Figure 4.3.3 Voltage Mode R-2R Ladder Type D/A Converter

[source:"Linear Integrated Circuits"by S.Salivahanan& V.S. Kanchana Bhaskaran, Page-459]

Voltage Mode R-2R Ladder Type D/A Converter is shown in figure 4.3.3.The arms of the ladder are switched between V_{ref} and ground.The o/p may be taken as a voltage.The expression for V_o can be obtained as

$$V_o = -\left(\frac{V_R}{R} X \frac{1}{2^n} X R_f\right) XD$$

$$where, V_o = feedback\ resistance\ of\ op-amp.$$

$$V_o = -I_{out} R_f$$

$$I_{out} = current\ resolution\ XD$$

$$V_o = -(current\ resolution\ XD) R_f$$

$$V_o = -(current\ resolution\ X R_f) D$$

The coefficient of D is the velocity resolution & can be called as simple resolution

$$V_o = -resolution\ XD$$

Resolution of R-2R ladder type DAC with voltage o/p is resolution

$$V_o = (\frac{1}{2^n} X \frac{V_R}{R}) R_f$$

Advantages:

1. The major advantage of this technique is that it allows us to interpolate between any two voltages, neither of which need not be a zero.
2. More accurate selection and design of resistors R and 2R are possible and simple construction.
3. The binary word length can be easily increased by adding the required number or R-2R sections.

INVERTED R-2R LADDER (CURRENT MODE R-2R LADDER)

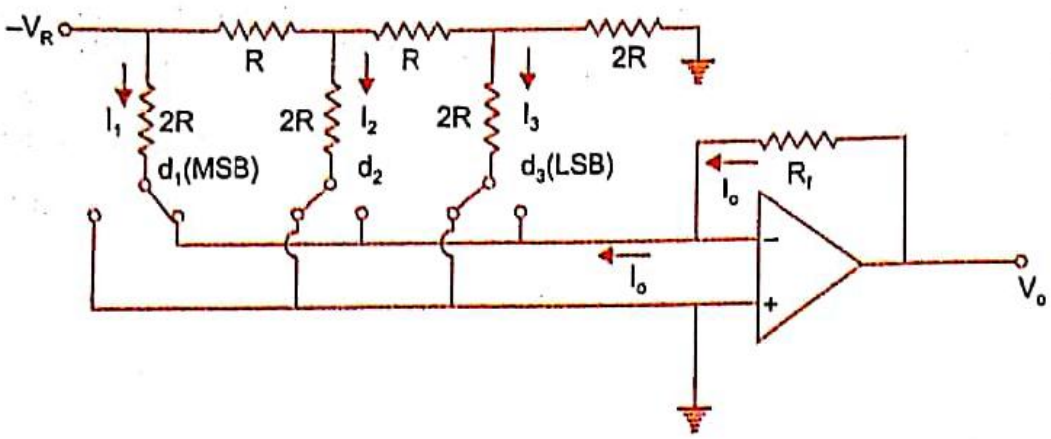

Figure 4.3.4 Inverted R-2R Ladder

[source:"Linear Integrated Circuits"by D.Roy Choudhry, Shail Bala Jain, Page-70]

Inverted R-2R Ladder is shown in figure 4.3.4.In weighted resistor type DAC & R-2R ladder type DAC, current flowing in the resistors changes as the i/p changes.More power dissipation causes heating which in turn causes non-linearity in DAC.This can be avoided completely in Inverted R-2R ladder type DAC.A 3-bit inverted R-2R ladder type DAC where the position of MSB & LSB is interchanged.In fig when switch di is at logical 0 *ie,* to the left the current through 2R resistor flows the ground .When the switch di is at logical 1 *ie,* to the right the current through 2R sinks to the virtual ground.The current divides equally at each of the nodes.This is because the equivalent resistance to the right or to the left at any node is exactly 2R.

Advantages:

1. The major advantage of current mode D/A converter is that the voltage change across each switch is minimal. So the charge injection is virtually eliminated and the switch driver design is made simpler.
2. In Current mode or inverted ladder type DACs, the stray capacitance do not affect the Speed of response of the circuit due to constant ladder node voltages. So improved speed performance.