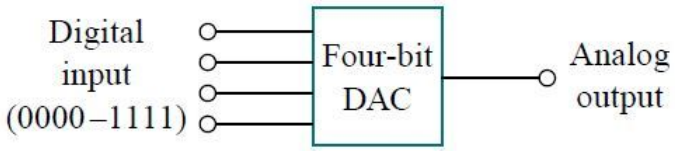
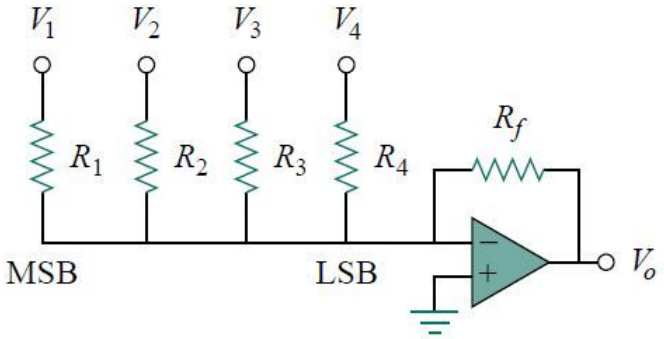
Digital-to-Analog Converter

The digital-to-analog converter (DAC) transforms digital signals into analog form. A typical example of a four-bit DAC is illustrated in Fig. (a).



(a)

The four-bit DAC can be realized in many ways. A simple realization is the binary weighted ladder, shown in Fig. (b).



(b)

The bits are weights according to the magnitude of their place value, by descending value of Rf /Rn so that each lesser bit has half the weight of the next higher. This is obviously an inverting summing amplifier. The output is related to the inputs as shown in Eq.

$$-V_o = \frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3 + \frac{R_f}{R_4}V_4$$

Input V1 is called the most significant bit (MSB), while input V4 is the least significant bit (LSB). Each of the four binary inputs V1, . . . , V4 can assume only two voltage levels: 0 or 1 V. By using the proper input and feedback resistor values, the DAC provides a single output that is proportional to the inputs.

In the op amp circuit of Fig. 5.35(b), let Rf = 10 k, R1 = 10 k, R2 = 20 k, R3 = 40 k, and R4 = 80 k. Obtain the analog output for binary inputs [0000], [0001], [0010], . . . , [1111]. Substituting the given values of the input and feedback resistors in Eq. **-V0 = V1 + 0.5V2 + 0.25V3 + 0.125V4**

Now input digital 4bit and find the analog signal.

Input Format

Input contain a 4 binary value separeted by single space, corssponding V1,V2,V3,V4

Constraints

every binary value should be 0 or 1. So that **0 0 0 0 <= V1 V2 V3 V4 <= 1 1 1 1**

Output Format

The output show a double value that contain analog **-V0**

Sample Input 0

```
0 0 0 1
```

Sample Output 0

```
0.125
```

Explanation 0

Using the equation, *-*v0 = V1 + 0.5V2 + 0.25V3 + 0.125V4 *A digital input [V1V2V3V4] = [0001] gives −Vo = 0.125 V.

Sample Input 1

```
1 1 1 1
```

Sample Output 1

```
1.875
```

Explanation 1

−Vo = 1 + 0.5 + 0.25 + 0.125 = 1.875 V