Lecture -8
Introduction to Digital Signal Processing: 2

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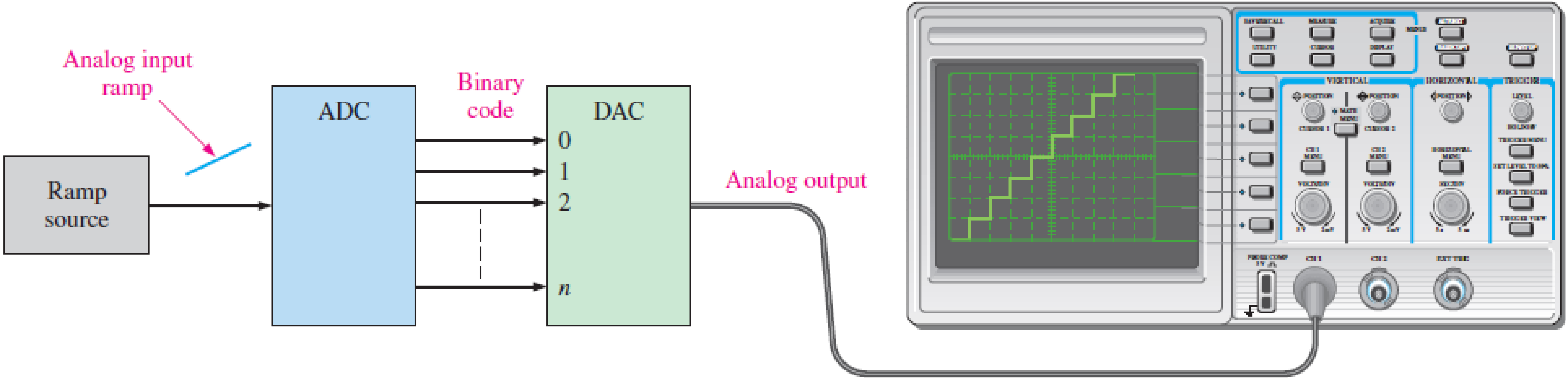
Introduction

- Digital to analog conversion is an important part of digital signal processing.
- Once the digital signal has been processed, it is further needed to be converted back to the analog form.
- A Digital to Analog Converter (DAC) is an electronic device, often an integrated circuit, which converts a digital signal to its corresponding analog signal.
- Two types of DAC will be studied:
  - Binary Weighted DAC
  - R-2R Ladder DAC



Binary Weighted DAC

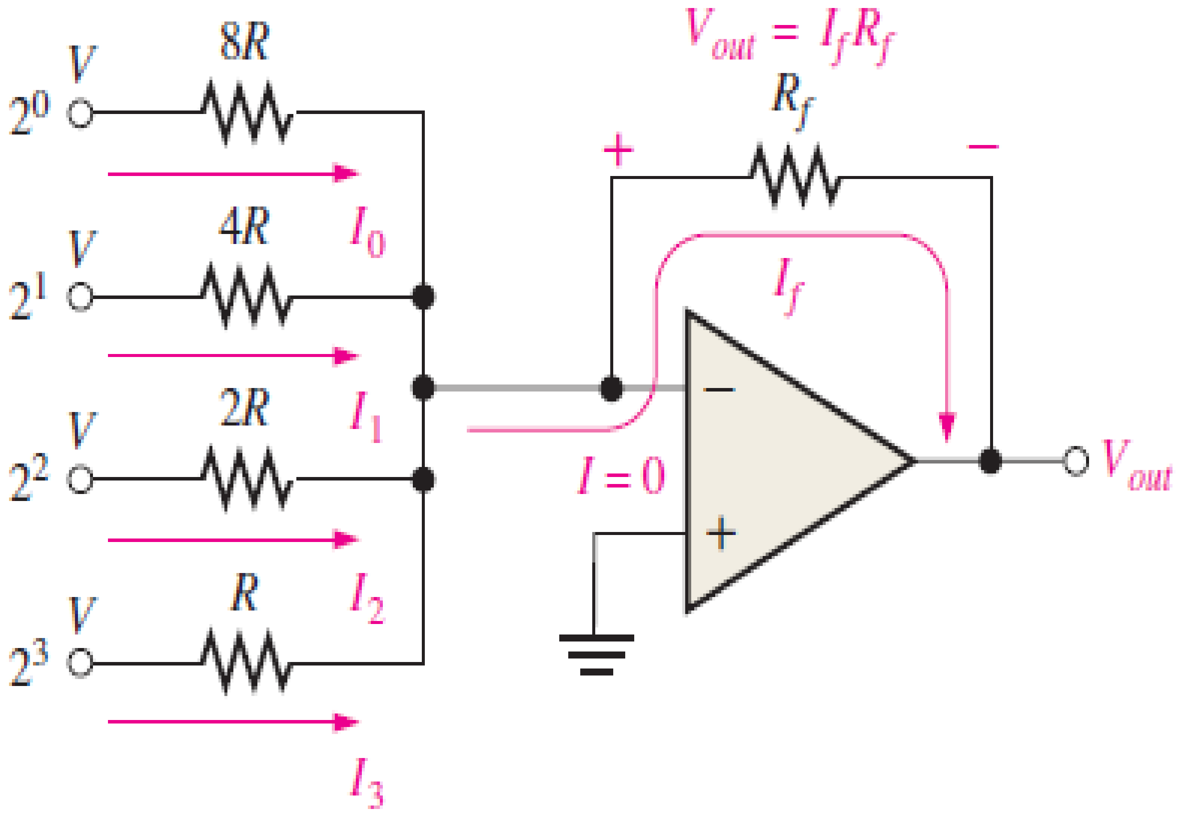
- The figure shows a 4-bit DAC.
- The resistors have a specific value depending on the binary weights.
- The resistor corresponding to MSB have the lowest value
- The resistor corresponding to LSB have the highest value.
- The output depends on the presence or absence of current in the branches.

$$I_0 = \frac{V}{8R}$$

$$I_1 = \frac{V}{4R}$$

$$I_2 = \frac{V}{2R}$$

$$I_3 = \frac{V}{R}$$



$$\mathbf{I_f = I_0 + I_1 + I_2 + I_3}$$

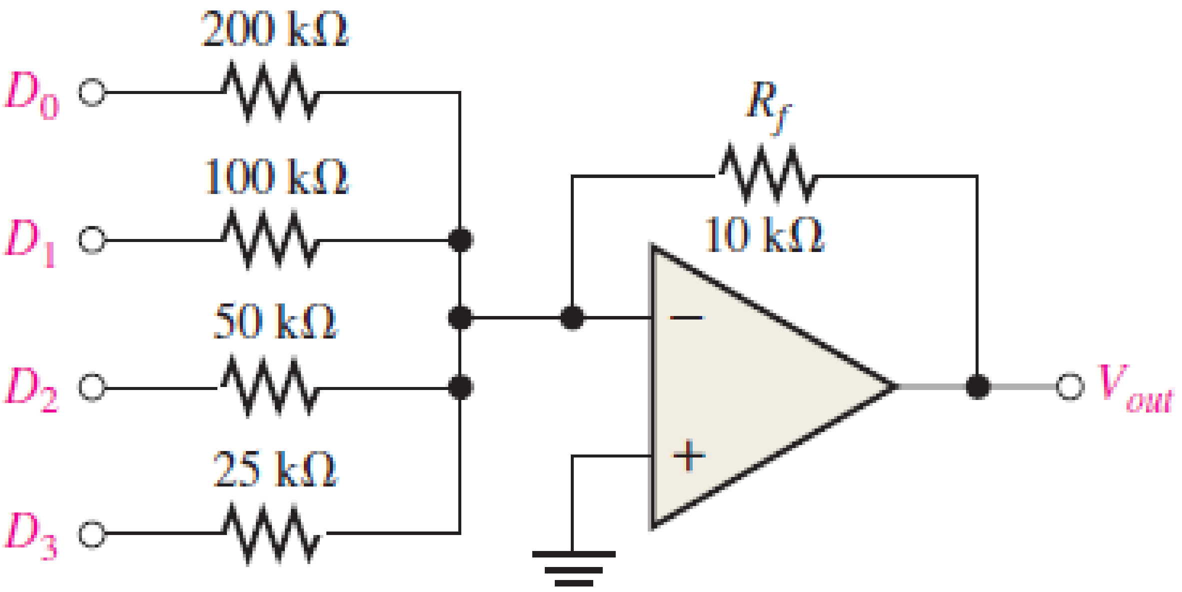
$$\mathbf{\frac{V_O}{R_f} = \frac{V}{8R} + \frac{V}{4R} + \frac{V}{2R} + \frac{V}{R}}$$

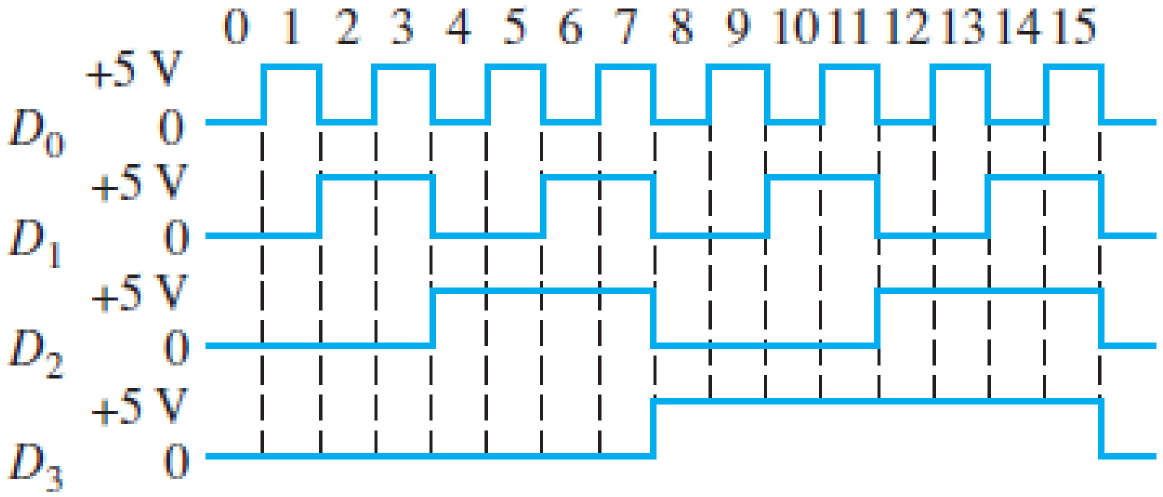
Now if $\mathbf{R_f = R}$

$$\mathbf{V_O = \frac{V}{8} + \frac{V}{4} + \frac{V}{2} + \frac{V}{1}}$$

Binary Weighted DAC

Determine the output of the DAC if the waveform representing a sequence of 4-bit numbers are applied to the inputs. Input D_O is the least significant bit(LSB)





Binary Weighted DAC

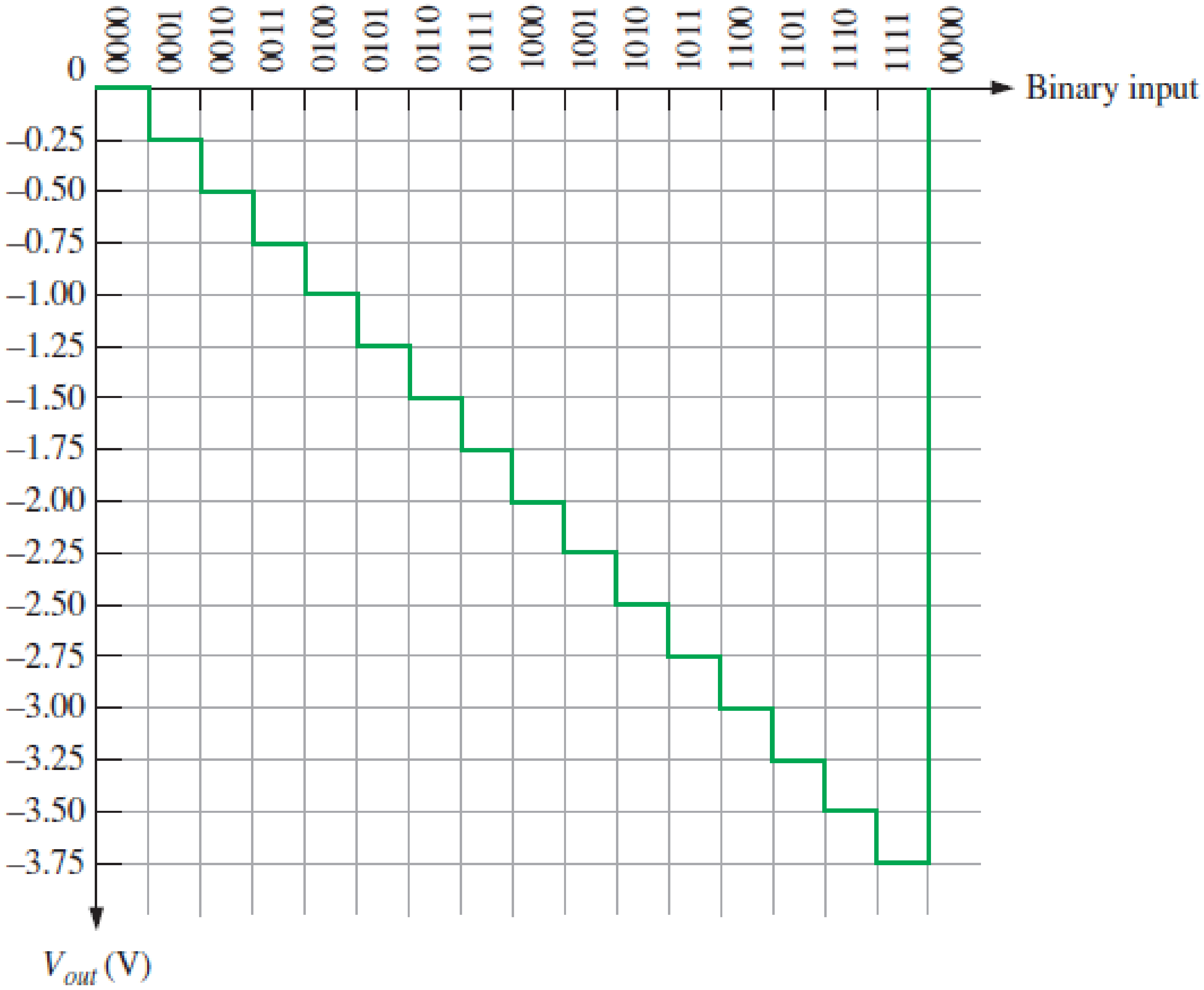
- First we need to determine the current for each of the weighted inputs.

$$I_0 = \frac{5V}{200k} = 0.0025mA$$
$$I_1 = \frac{5V}{100k} = 0.05mA$$
$$I_2 = \frac{5V}{50K} = 0.1mA$$
$$I_3 = \frac{5V}{25K} = 0.2mA$$

- Now we will calculate the output contribution for each of the weighted inputs. Since no current goes through the inverting input, the current only flows through the feedback path.

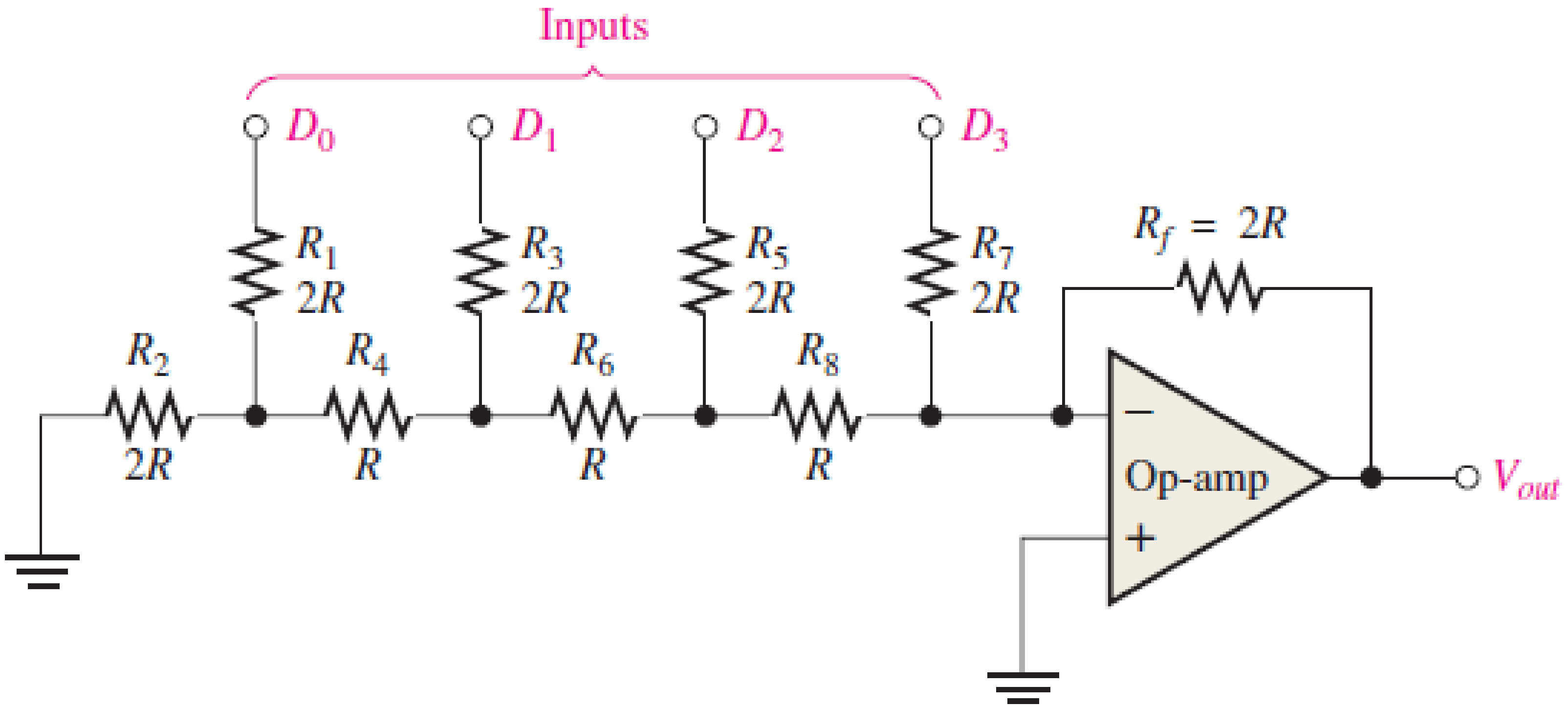
$$V_{O(D0)} = (10k)(-0.025mA) = -.25V$$
$$V_{O(D1)} = (10k)(-0.05mA) = -0.5V$$
$$V_{O(D2)} = (10k)(-0.1mA) = -1V$$
$$V_{O(D3)} = (10k)(-0.2mA) = -2V$$

Binary Weighted DAC



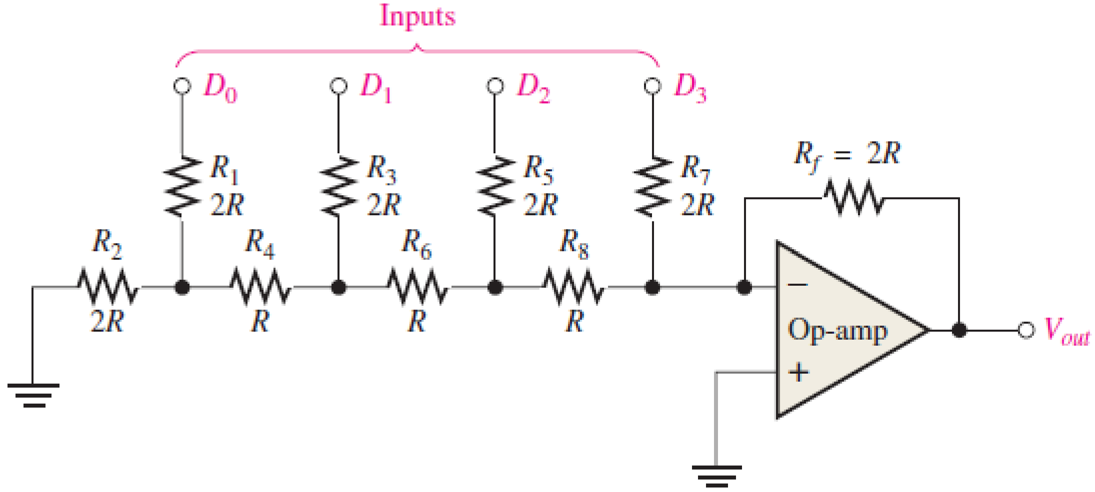
R-2R Ladder DAC

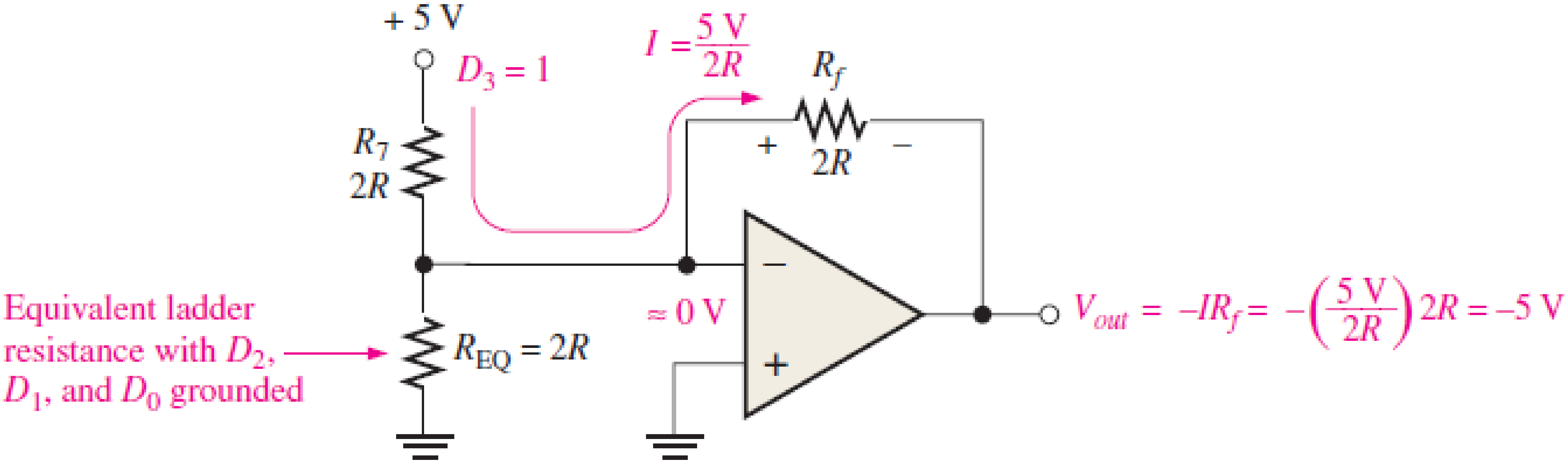
- Though binary-weighted DAC is simple to understand, construction of it is hectic.
- For binary-weighted DAC we need exact multiples of the resistors (R, 2R, 4R, 8R, 16R).
- For DAC of higher bits, the construction becomes practically infeasible.
- However, R-2R DAC solves this problem.
- The construction only require resistors of value R and 2R



R-2R Ladder DAC

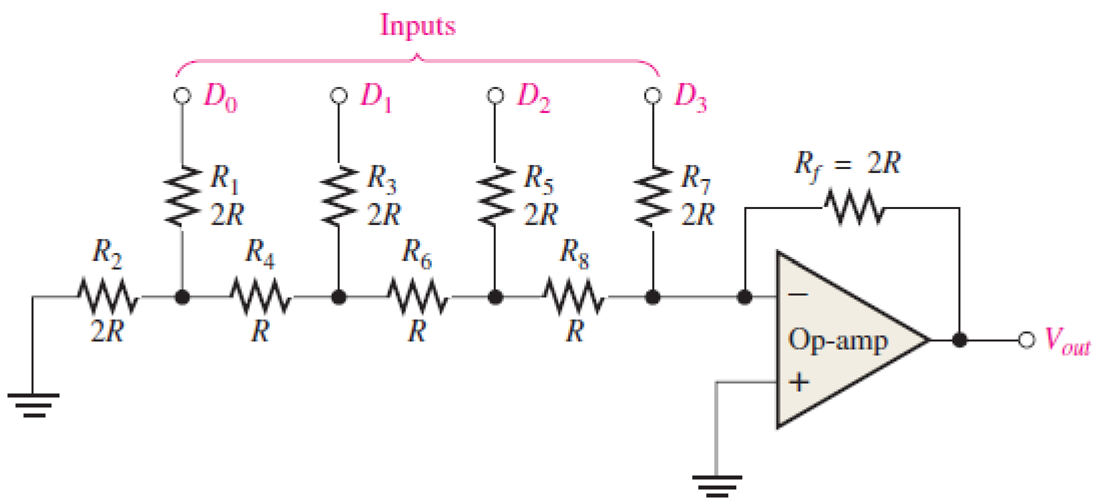
Contribution of D_3.

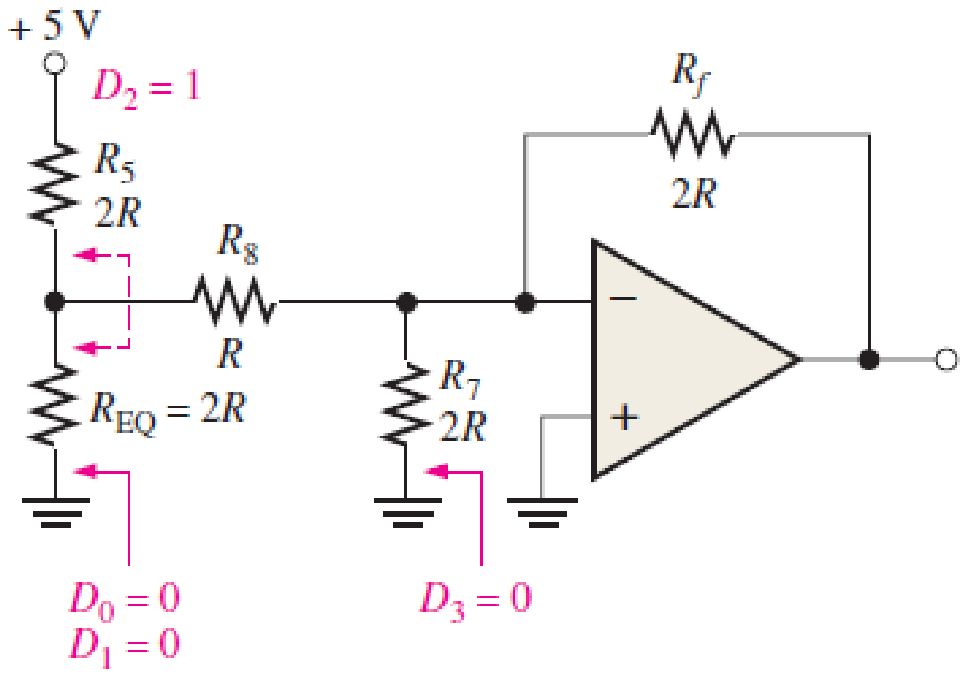




R-2R Ladder DAC

Contribution of D_2.





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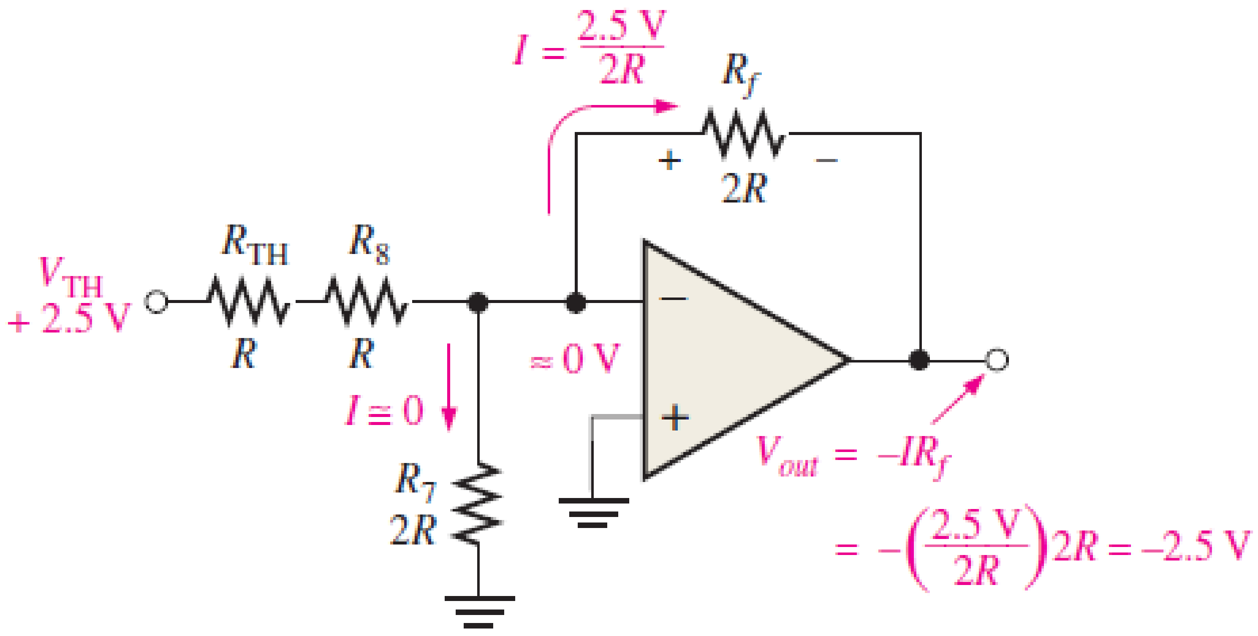
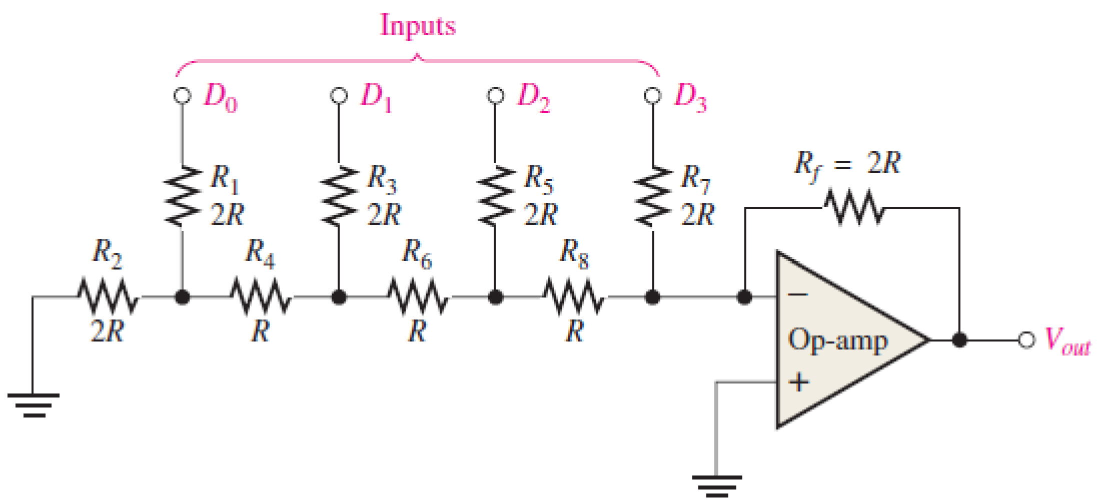
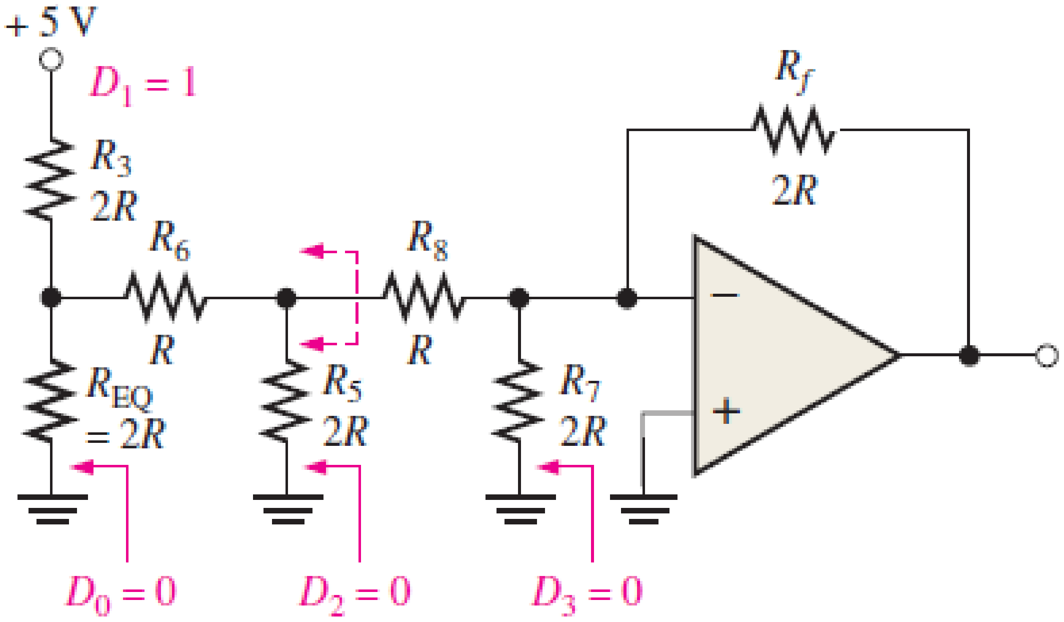


R-2R Ladder DAC

Contribution of D_1.





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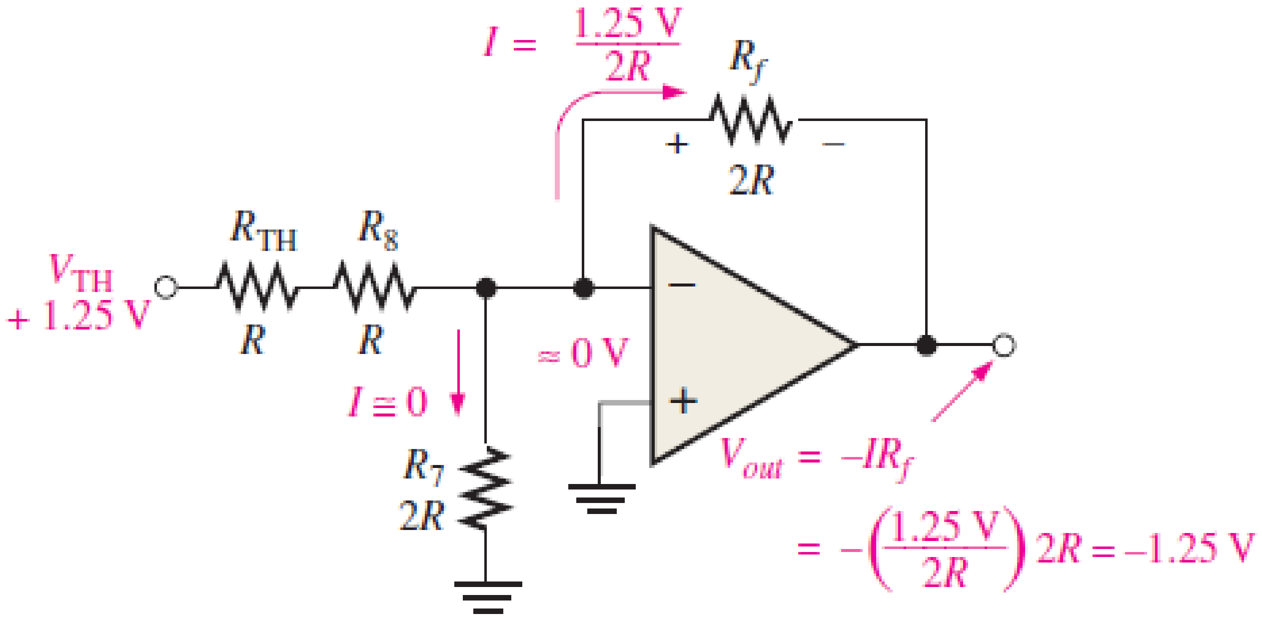
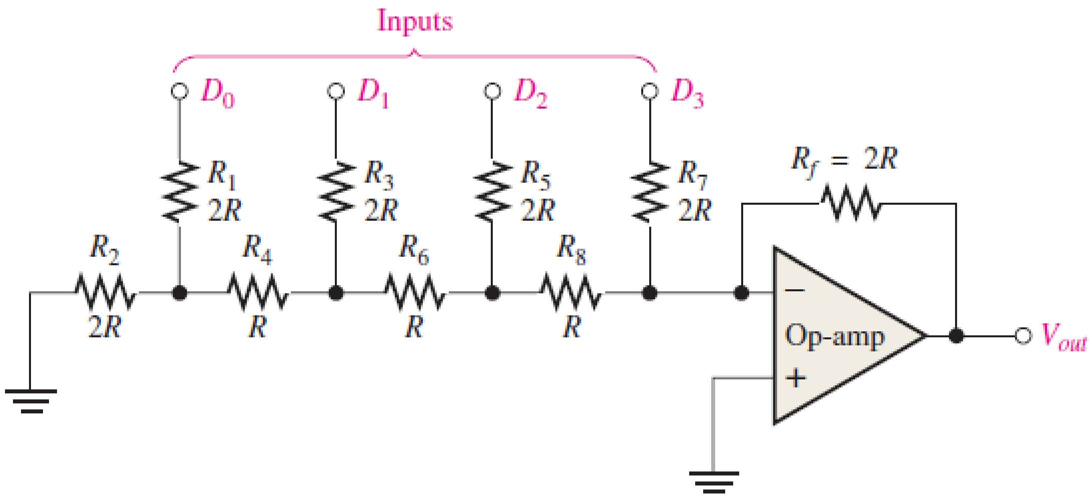
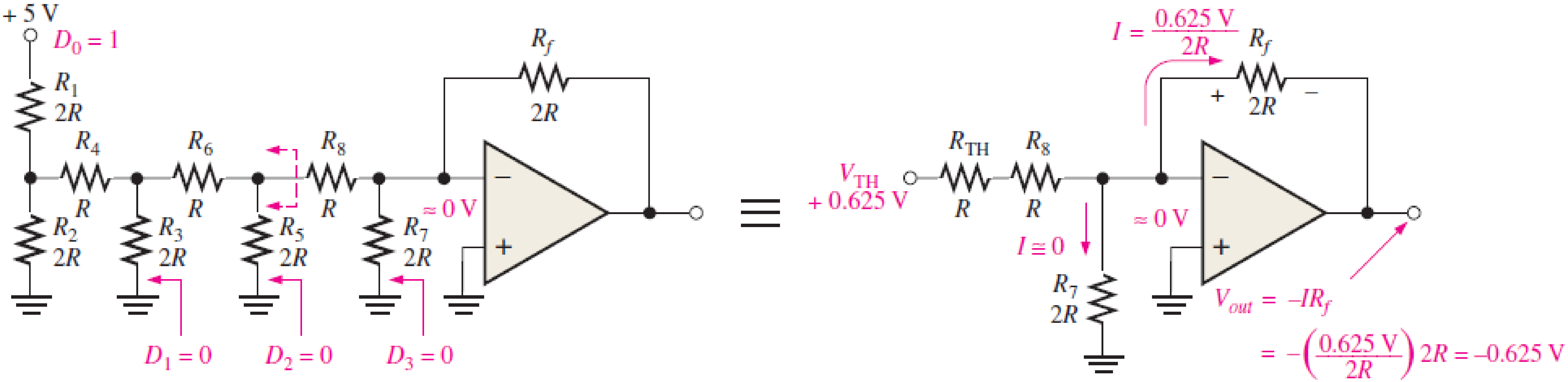


R-2R Ladder DAC

Contribution of D_0.





DAC

Resolution of a n-bit DAC:

$$\frac{1}{2^n - 1}$$

Determine the resolution expressed as a percentage of the following:

a) An 8-bit DAC

b) A 12-bit DAC

Solution:

a) Resolution for 8-bit converter,

$$\frac{1}{2^8 - 1} \times 100 = \frac{1}{255} \times 100 = 0.392\%$$

b) Resolution for 12-bit converter,

$$\frac{1}{2^{12} - 1} \times 100 = \frac{1}{4095} \times 100 = 0.0244\%$$

References

1. Thomas L. Floyd, “Digital Fundamentals” 11th edition, Prentice Hall – Pearson Education.

Thank You