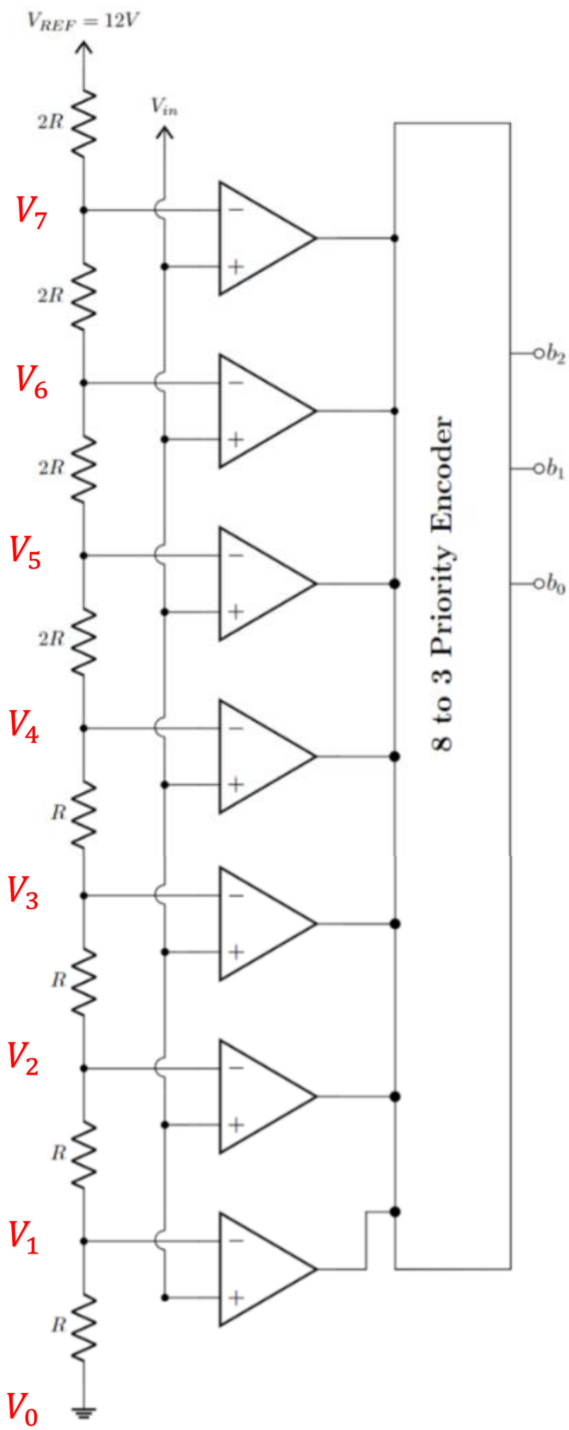
Prepared by:
Md. Jahin Alam [MJA]
Lecturer, CSE, BracU

ADC (non-uniform)

Q1	For the shown 3-bit Flash ADC in the figure, **draw** the '*Vin-vs-Digital Output*' staircase plot. If a current of <u>$0.303mA$</u> is flowing through the resistors, **find** the value of R. [$V_{REF} = 12V$]



$I = \frac{V_{REF}}{12R}$

$\Rightarrow 0.303 = \frac{12}{12R}$

$\boxed{\therefore R = 3.3\,k\Omega}$

$V_0 = 0V$
000
$V_1 = IR = 1V$
001
$V_2 = I \times 2R = 2V$
010
$V_3 = I \times 3R = 3V$
011
$V_4 = I \times 4R = 4V$
100
$V_5 = I \times 6R = 6V$
101
$V_6 = I \times 8R = 8V$
110
$V_7 = I \times 10R = 10V$
111
$V_8 = V_{REF} = 12V$

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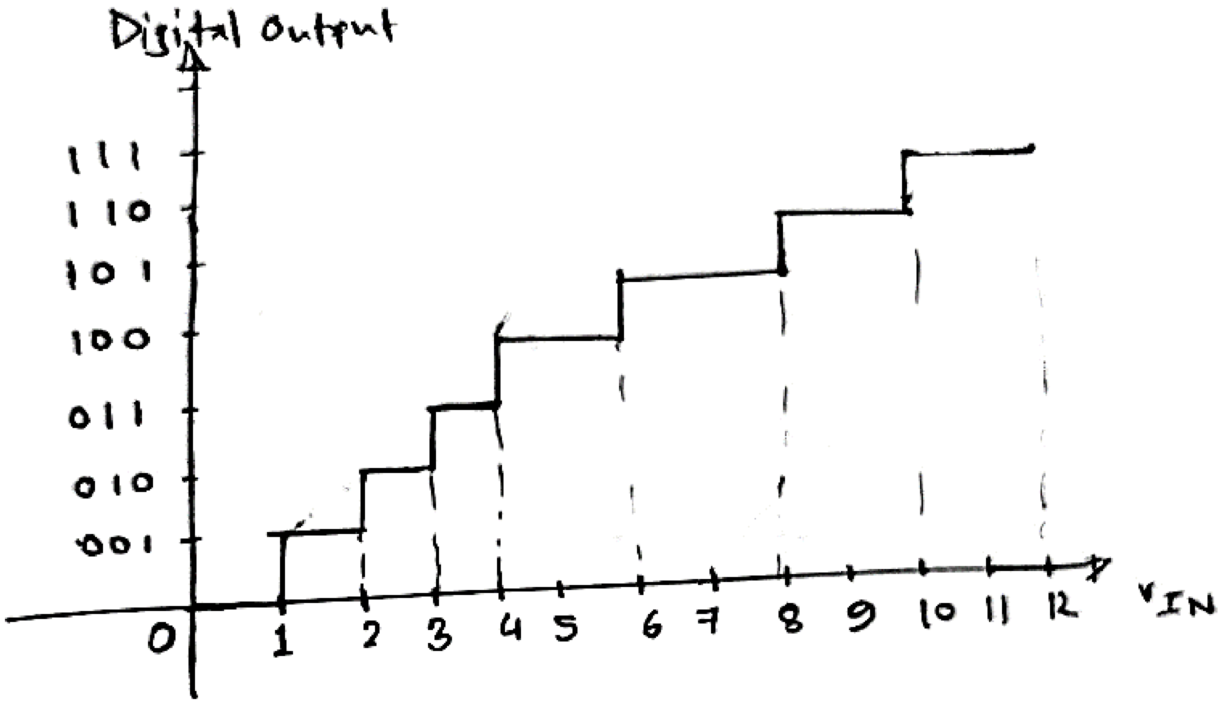
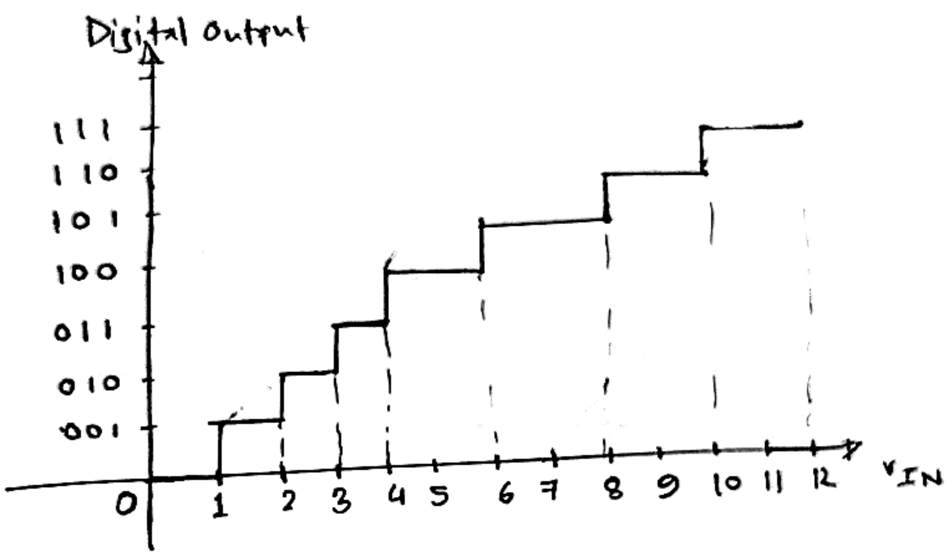


Q2	Design a Flash ADC using the transfer curve below.



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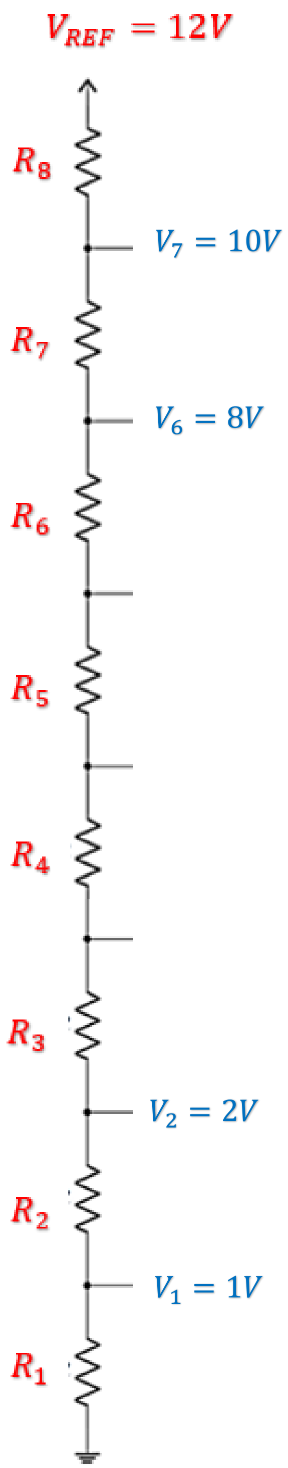
- Since there are 8 levels: The ADC is a 3-bit ADC
- Therefore, we will need 8 resistors and (8-1) = 7 op-amps
- Vref will have to be the highest shown voltage in the transfer curve
- We only show the resistor network below which is connected to the op-amps:



- In design problems, we have the freedom to choose some values. We first find the relations between the resistors:

$$V_1 = 1 = 12\frac{R_1}{R_1+R_2+\ldots+R_8} = 12\frac{R_1}{\sum R} \text{ [Voltage division]}$$

$$\Rightarrow R_1 = \frac{1}{12}\sum R$$ (here, $V_1 = 1$ comes from the transfer curve)

Similarly, $V_2 = 2 = 12\frac{R_1+R_2}{\sum R} \;\Rightarrow R_1 + R_2 = \frac{1}{6}\sum R$

$$\Rightarrow \left(\frac{1}{12}\sum R\right) + R_2 = \frac{1}{6}\sum R \quad \Rightarrow R_2 = \frac{1}{12}\sum R$$

Same process for, V_3, then V_4 … … …, then V_7.

- In this way, we find all 8 resistor values in terms of $\sum R$ = the total equivalent resistor. But, $\sum R$ itself does not have a value yet. Here, we have a freedom of assuming any value we want.

- Assume, $\sum R = 60k\Omega$ (any value you like). Then find the 8 resistor values. In this way, the resistors will maintain the transfer curve for the ADC.

- Finally, draw the entire flash ADC to complete the design.

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Q3	Draw the Digital Input vs Vin curve (Transfer curve) of a 3-bit Flash ADC which has the resistor network below. **Hint:** find all of the node voltages ($V_1, V_2, \ldots, V_7$) using any circuit theorems: KVL/ Nodal/Voltage division. [***Practice yourself***]

Given,

$$R_1 = R_3 = R_5$$
$$R_2 = R_4 = R_6$$
$$R_7 = 2R_8$$

$$R_1 = 3R_2 = 2R_7 = 12k\Omega$$