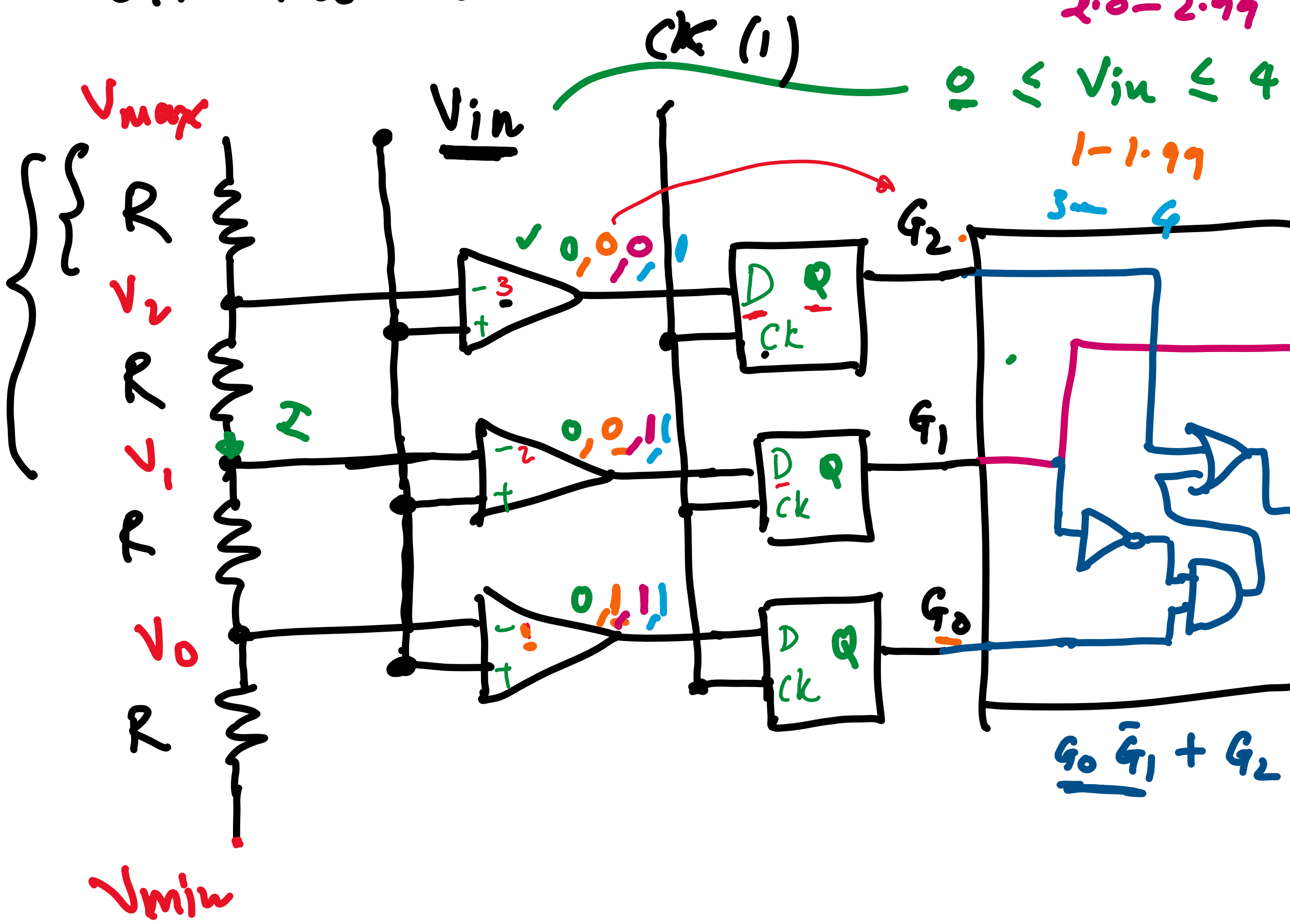
# Flash converter (A/D)

EXAMPLE: 2-bit A/D converter




$V_{max}$, $V_{min}$ are controlled by the designer

These are set in advance. $V_{in} \to$ input

$$\frac{V_{max} - V_{min}}{V_{max} - V_2} = \frac{I(4R)}{I\,R} \Rightarrow V_{max} - V_2 = \frac{V_{max} - V_{min}}{4}$$

$$\Rightarrow V_2 = V_{max} - \frac{1}{4}\Delta V \qquad (\Delta V = V_{max} - V_{min})$$

$$\left\{\begin{array}{l} V_2 = V_{max} - \frac{\Delta V}{4} \;;\; V_1 = V_{max} - \frac{\Delta V}{2} \\ V_0 = V_{max} - \frac{3}{4}\Delta V \end{array}\right\} \quad \text{I}$$

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Explanation on how this works.

$V_{max} = 4V$ ; $V_{min} = 0$ ; $\Delta V = V_{max} - V_{min}$

From I $V_2 = 3V$; $V_1 = 2V$ ; $V_0 = 1V$

| 1 $V_{in}$ | $G_2 G_1 G_0$ | $B_1 B_0$ |
|---|---|---|
| 0 – 0.99 | 0 0 0 (0) | 0 0 (0) |
| 1 – 1.99 | 0 0 1 (1) | 0 1 (1) |
| 2 – 2.99 | 0 1 1 (3) | 1 0 (2) |
| 3 – 4 | 1 1 1 (7) | 1 1 (3) |

sum-of-products

products-of-sum

1 op-amp comparator ⊕ D-FlipFlop $G_0 G_1 G_2$

2 Logic gate $B_0 B_1$

2 $B_0 = G_0 \bar{G}_1 + G_2$

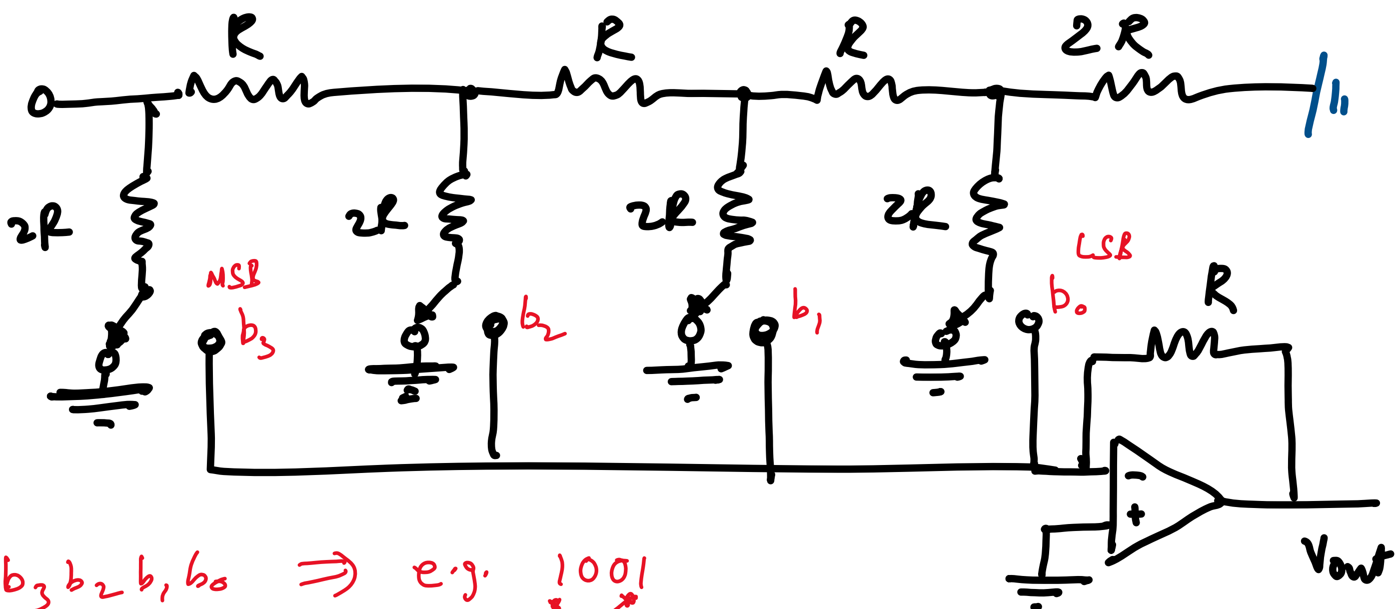
$B_1 = G_1$

Flash Converter

1. Requires only 1 CK to process each analog data (ADVANTAGE)
2. It requires many more components compared to Successive approximation converter (DISADVANTAGE)

# Digital to Analog Conversion

EXAMPLE: 4-bit resistor ladder network.




$b_3 b_2 b_1 b_0 \Rightarrow$ e.g. 1001

$b_3$, $b_0$ is closed

What we want from this circuit

0001 $\longrightarrow$ $V_{out} = 1$ V

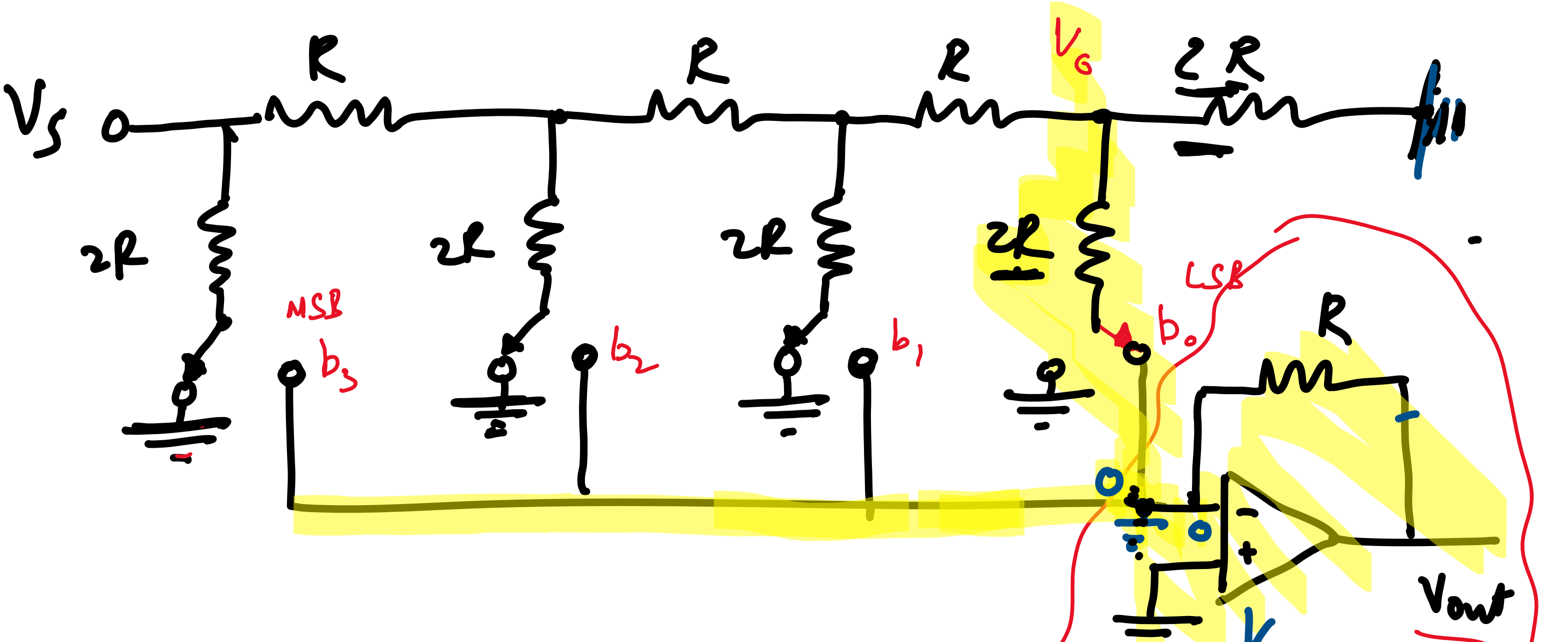
$b_3 b_2 b_1 b_0$

0010 $\longrightarrow$ $V_{out} = 2$ V

$\vdots$ $\qquad\qquad\qquad$ $\vdots$

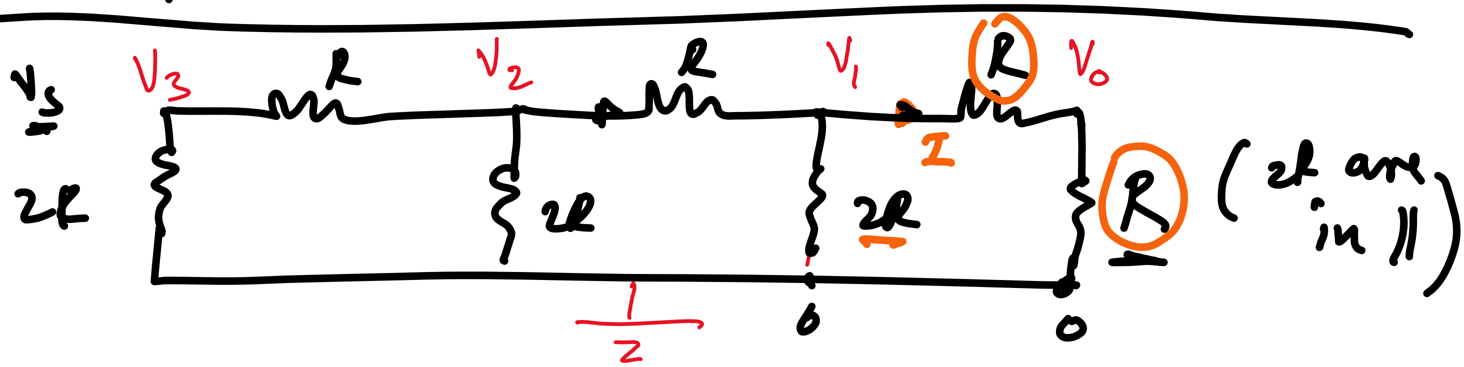
1111 $\longrightarrow$ $V_{out} = 15$ V

$$V_{out} = f(b_0\ b_1\ b_2\ b_3)$$




$b_0 = 1 \qquad b_1, b_2, b_3 = 0$

compute $V_{out}$

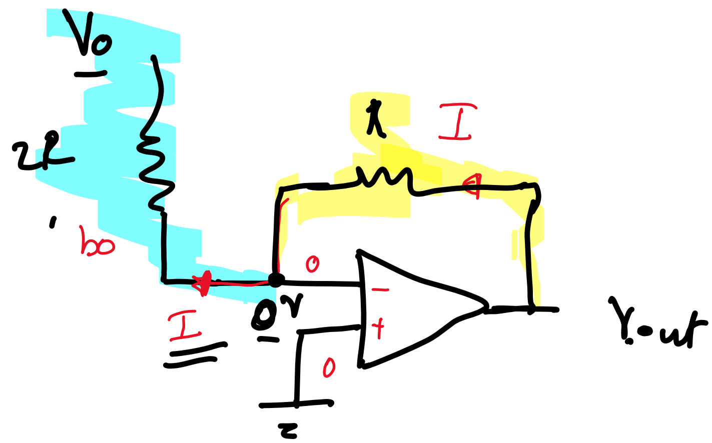



$$\frac{V_1}{V_0} = \frac{2R\,I}{R\,I} \Rightarrow V_0 = \frac{1}{2} V_1$$

$$V_1 = \frac{1}{2} V_2 \; ; \quad V_3 = \frac{1}{2} V_2$$

same reasoning

$$v_o = \frac{1}{8} v_3 = \frac{v_s}{8} \qquad V_o = \frac{1}{8} V_s \quad \text{II}$$




$V_{out} - 0 = IR$

$0 - V_0 = I(2R)$

$V_{out} = -\frac{1}{2} V_0$

But $V_0 = \frac{1}{8} V_s$

$V_{out} = -\frac{1}{16} V_s$ ← 1 $b_0$ is (1)

Repeating for $b_1 = 1 \quad b_0, b_2, b_3 = 0$

$$V_{out} = -\frac{1}{8} V_s \quad — ②$$

For $b_2 = 1$ ; $b_0, b_1, b_3 = 0$

$$V_{out} = -\frac{1}{4} V_s \quad — ③$$

For $b_3 = 1$ ; $b_0, b_1, b_2 = 0$

$$V_{out} = -\frac{1}{2} V_s \quad — ④$$

Combining ① - ② - ③ - ④ using superposition

$$\boxed{V_{out} = -\left(\frac{b_3}{2} + \frac{b_2}{4} + \frac{b_1}{8} + \frac{b_0}{16}\right) V_s}$$

Illustration:

Let $V_S = 16V$ ; If $\underbrace{b_0 = b_1 = b_2 = b_3 = 1}_{\text{example input to the D/A converter}}$

we expect $V_{out} = \underbrace{2^3 + 2^2 + 2^1 + 2^0}_{1111 \text{ binary}} = 15\ V$

Using formula

$$V_{out} = -\left(\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}\right)(16)$$

$$= -(8 + 4 + 2 + 1) = -15V$$