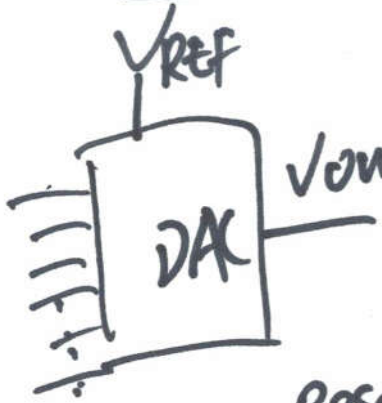
Example: Find the number of input combinations, voltage values for 1 LSB, and full-scale voltage generated for a 3-bit, 8-bit, and 16-bit DAC. $V_{REF} = 5V$



Resolution	# Input Combinations	1 LSB	$V_{FS} = \frac{2^N - 1}{2^N} \cdot V_{REF}$
3-bit	$2^3 = 8$	$\frac{5V}{2^3} = \frac{5}{8} = 0.625V$	$\frac{7}{8} \cdot 5V =$
8-bit	$2^8 = 256$	$\frac{5V}{2^8} = \frac{5V}{256} =$	$\frac{255}{256} \cdot 5V =$
16-bit	$2^{16} = 65536$	$\frac{5}{2^{16}} = \frac{5V}{65536} =$	$\frac{65535}{65536} \cdot 5V =$

CDC / ADC

1 Byte = 8 bits

$2^{10} = 1024 = 1K$

$2^{20} = 1024 \cdot 1024 = 1MEG$

$2^{30} = 1B$

LTspice

Pspice / HSpice

Nspice (Spectre)

① 9V

1V 2V V_p +

2V 1V V_m −

0V

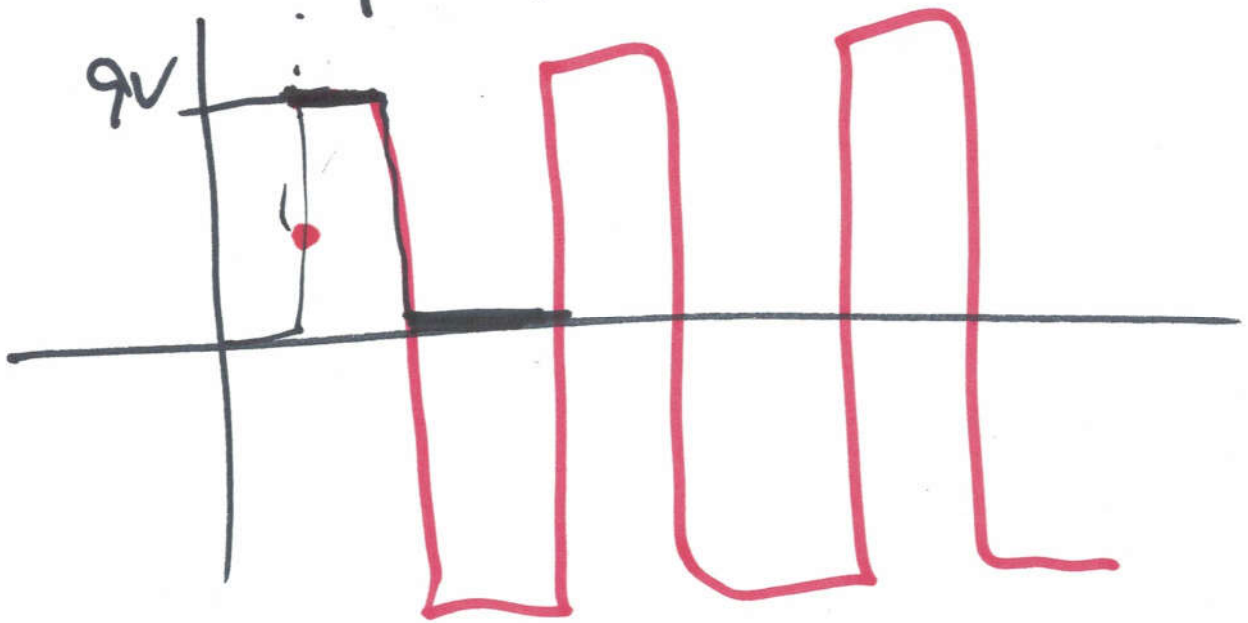
-9V

$V_{out} = (V_p - V_m) \cdot A_{open\text{-}loop}$

$(1V - 2V) \cdot A$ ↳ Huge (1M)

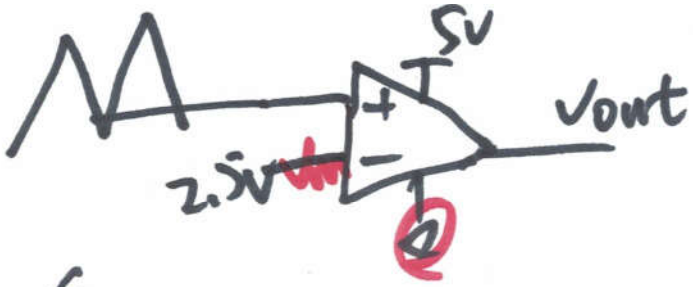
$= -1V \cdot A = 0V$

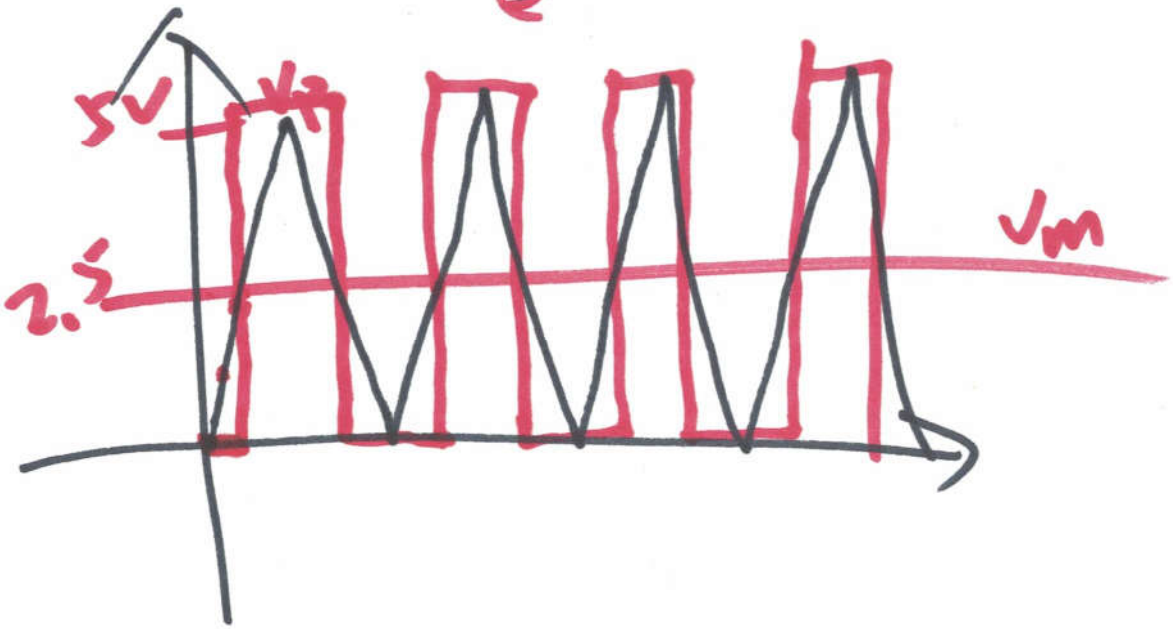
iop Amp = operational Amplifiers



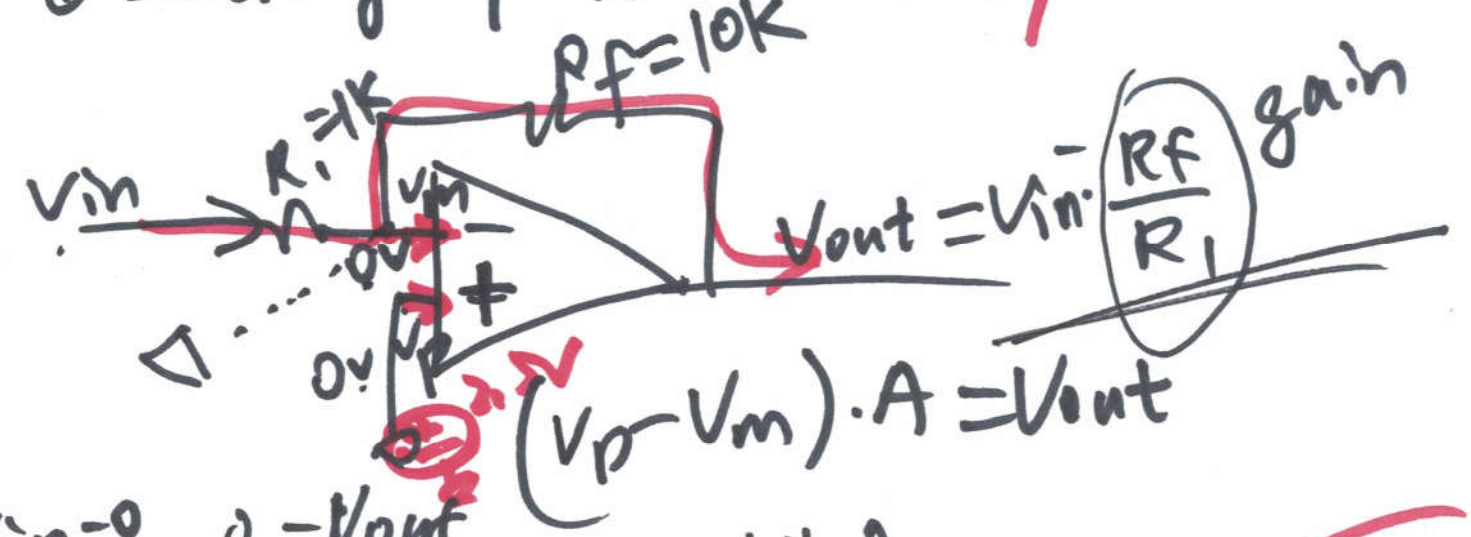
Comparator.

②


5v
+
−
Vout
2.5v
0


5v
2.5
Vm

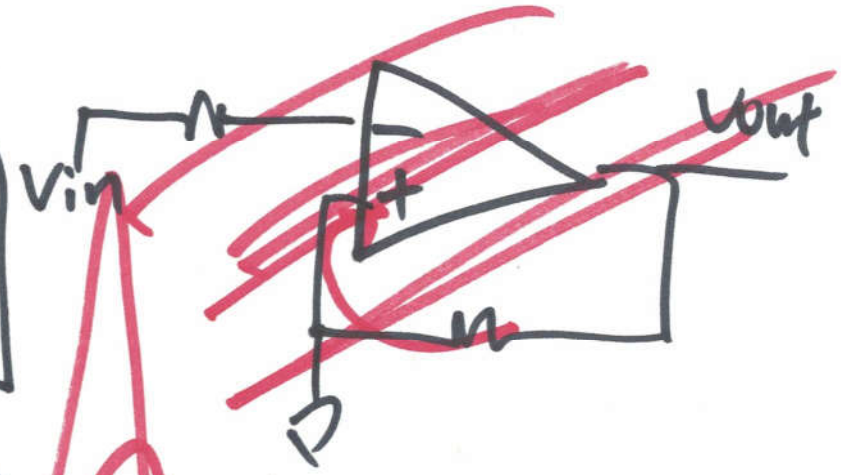
① Inverting Topology

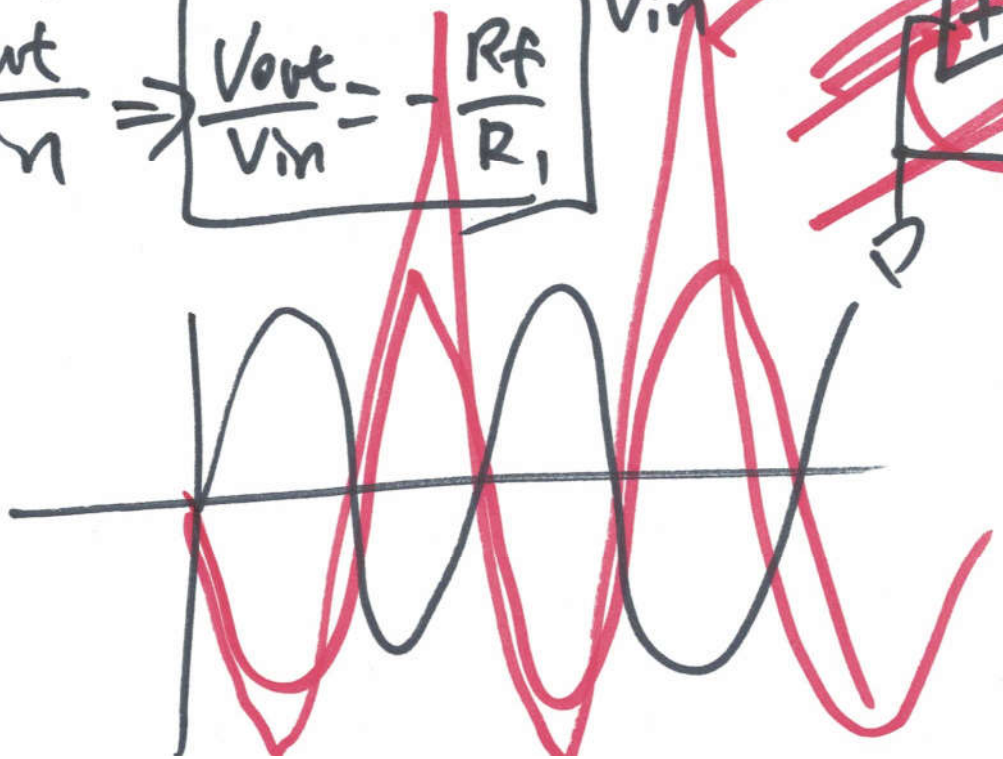


$$\frac{V_{in}-0}{R_1} = \frac{0-V_{out}}{R_f}$$

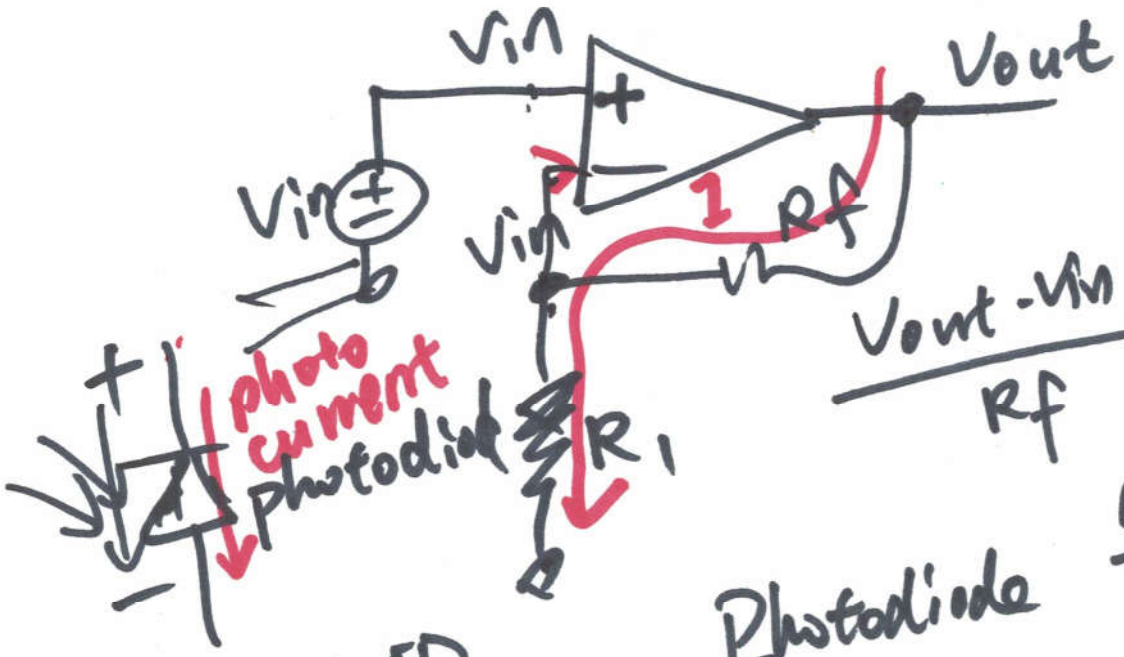
$$\frac{R_f}{R_1} = \frac{-V_{out}}{V_{in}} \Rightarrow \boxed{\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_1}}$$

+N·A





② Non-inverting. Topology



$$\frac{V_{out} - V_{in}}{R_f} = \frac{V_{in} - 0}{R_1}$$

$$\frac{R_f}{R_1} = \frac{V_{out} - V_{in}}{V_{in}}$$

$$= \frac{V_{out}}{V_{in}} - 1$$

$$\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_1}$$