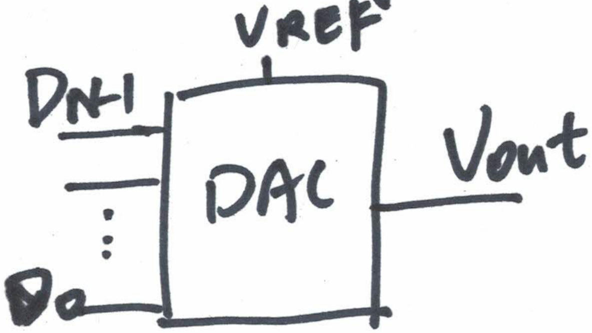
① DACs Diagrams



② $F = \frac{D}{2^N}$ (D is the input word)

$V_{out} = V_{REF} \cdot F = V_{REF} \cdot \frac{D}{2^N}$

Example: 3-bit DAC, input $100_{(2)}$

$V_{REF} = 5V$. V_{out}?

$V_{out} = D \cdot \frac{V_{REF}}{2^N} = 100_{(2)} \cdot \frac{5}{8}$

$= 4 \cdot 0.625 = \cdots$ (V)

$\frac{001}{100}$ $\frac{1\ LSB}{4\ LSB}$

1 LSB is $\frac{V_{REF}}{2^N}$ V.

③ Input range of a 3-bit DAC: 000 → 111

the maximum output of the N-bit DAC:

$$V_{FS} = \frac{2^N - 1}{2^N} \cdot V_{REF}$$

3-bit: $\frac{7}{8} V_{REF}$

Example: Find the resolution for a DAC if the output voltage is desired to change in 1mV increments while using a reference of 5V.

$$\frac{V_{REF}}{2^N} = 1\text{mV}$$

$$\frac{5\text{V}}{1\text{mV}} = 2^N = 5000$$

$$N = \log_2 5000 = 12.29 \text{ bits}$$

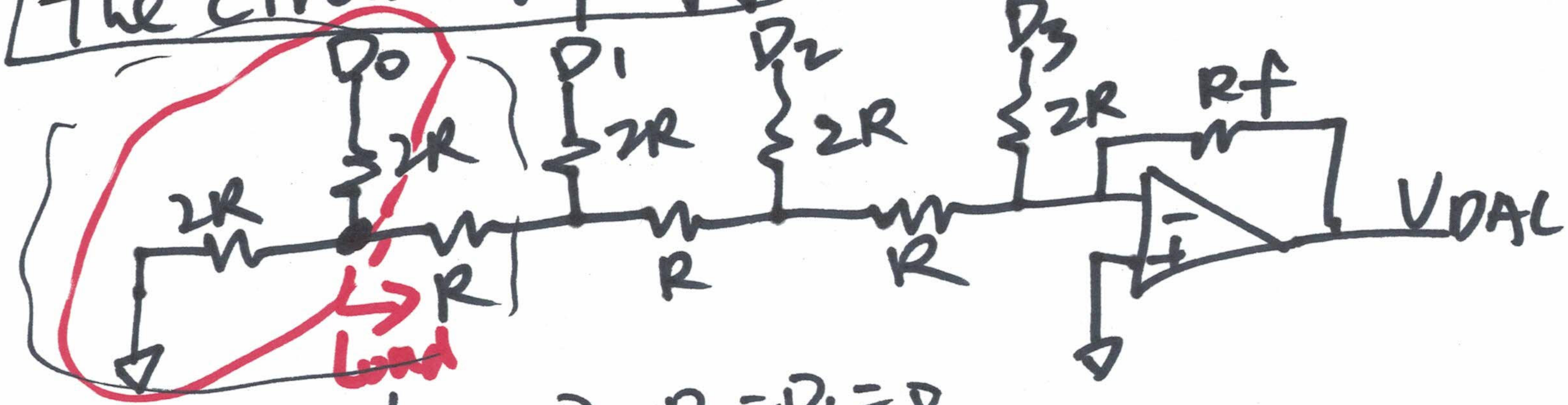
13 bits are need for the DAC.

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

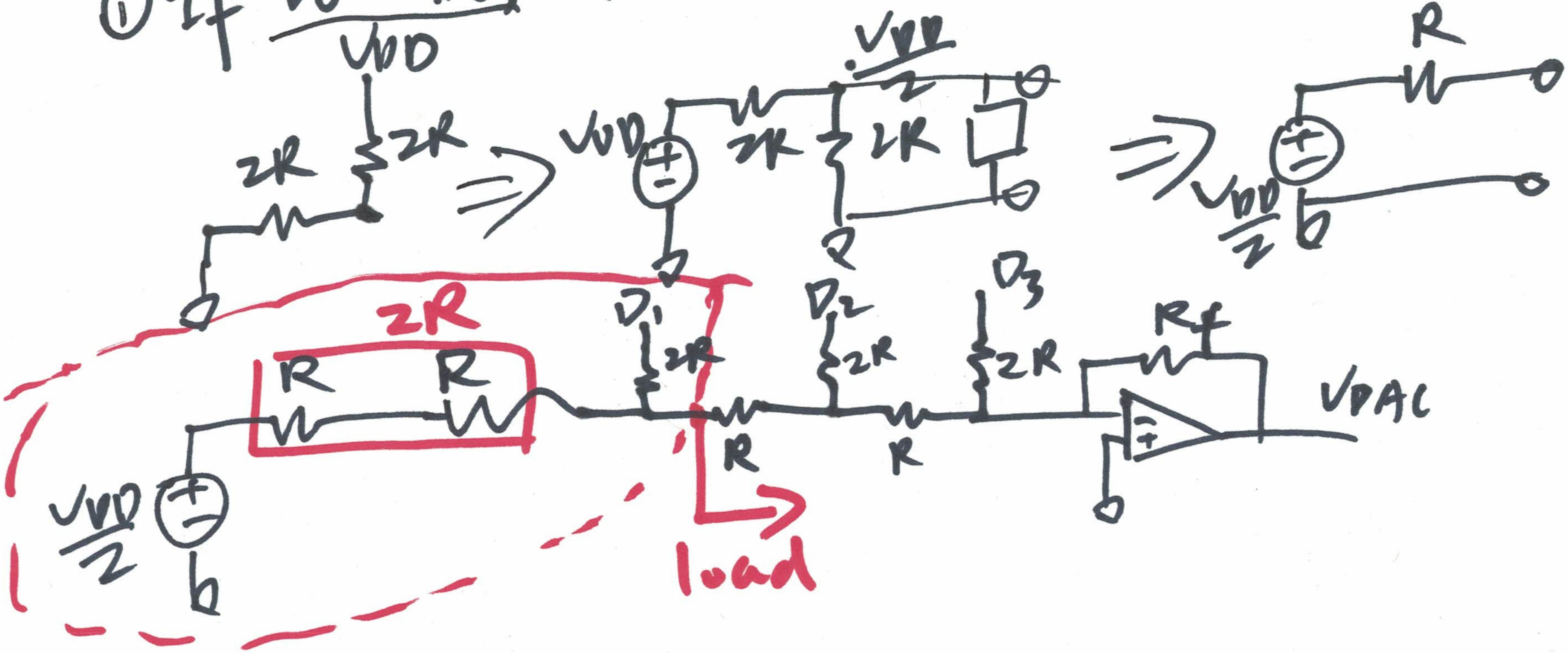
Resolution	Input Combinations	1 LSB	V_{FS}
3-bit	$2^3 = 8$	$\frac{5}{8} = 0.625V$	$\frac{7}{8} \cdot 5$
8-bit	$2^8 = 256$	$\frac{5}{256} = \ldots$	$\frac{255}{256} \cdot 5$
16-bit	$2^{16} = 65536$	$\frac{5}{65536} = \ldots$	$\frac{65535}{65536} \cdot 5$

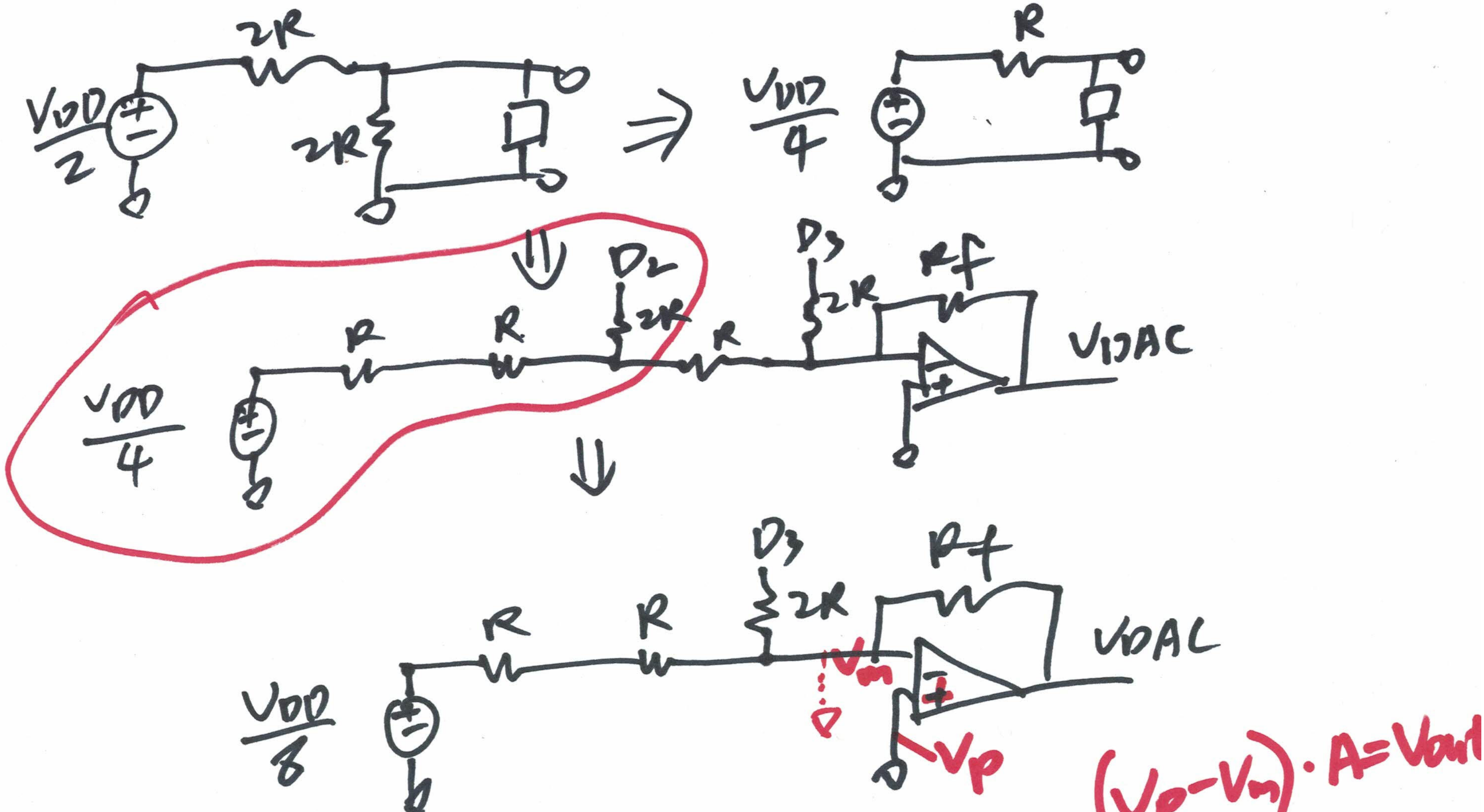
The R-2R DAC Circuit (Voltage Mode)

The circuit Topology



① If $D_0 = V_{DD}$, $D_1 = D_2 = D_3 = 0$





2R
VDD/2
2R
⇒
R
VDD/4
⇓
D2
2R
R
R
VDD/4
D3
2R
R
Rf
VDAC
⇓
D3
2R
R
R
Rf
VDAC
VDD/8
Vm
Vp
(Vp−Vm)·A=Vout

(5)