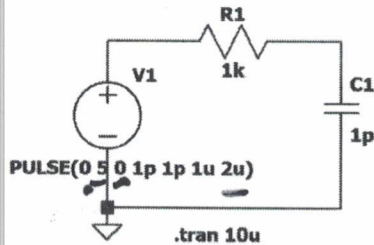


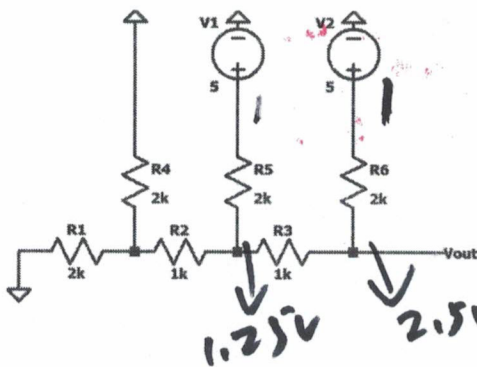
1. (a) What is the period of input square wave (the PULSE function)? (b) What is the time delay of the output compared to the input? (Derivation is not required). (10 points)



(a) $2\mu s$

(b) $t_d = 0.7RC = 0.7 \times 10^3 \times 10^{-12}$
 $= 0.7ns$

2. (a) What is the resolution of the DAC? (b) What is the digital input of the DAC? (c) What is the analog output of the DAC? (Derivation is not required). (10 points)

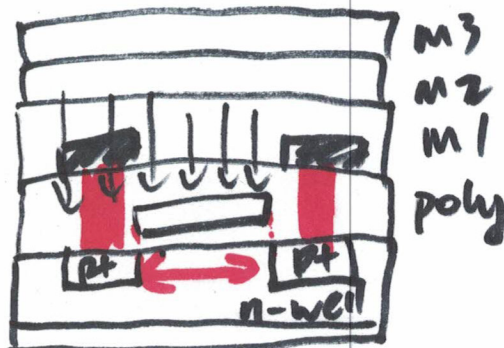
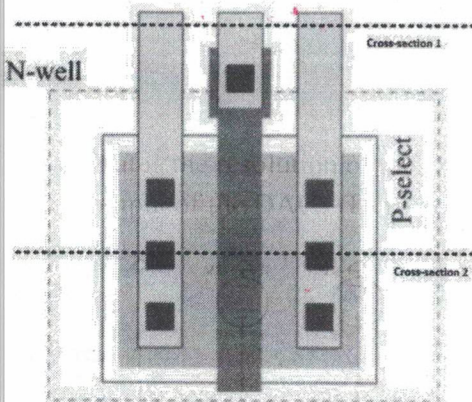


(a) 3-bit

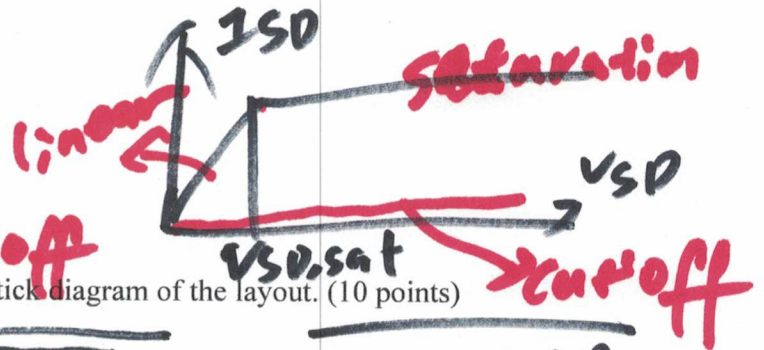
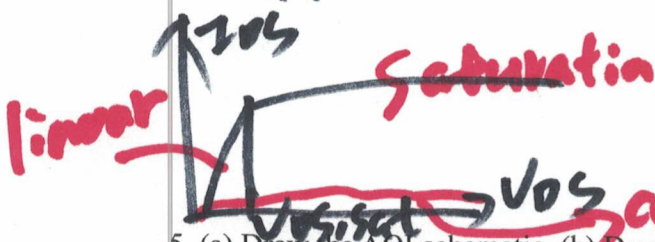
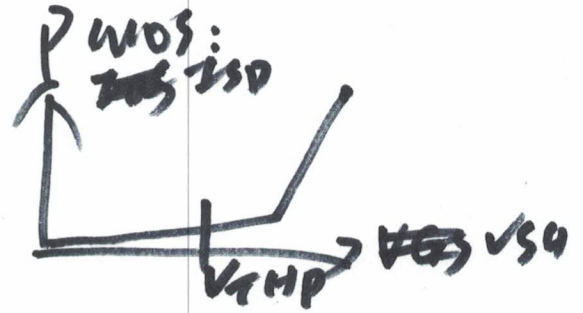
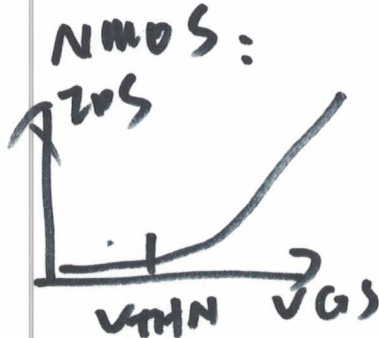
(b) 110

(c) $\frac{5V}{2^3} \times (110)_2 = \frac{5V}{8} \times 6 = 3.75V$
 $V_{out} = 2.5V + 1.25V = 3.75V$

3. Draw the two cross-section views. (10 points)

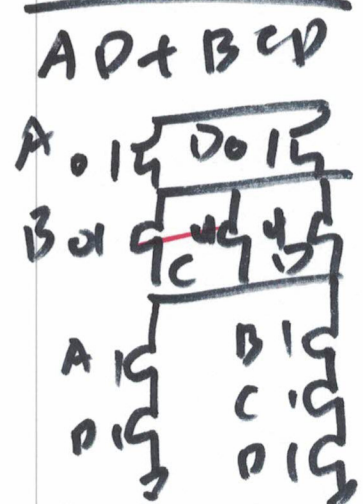
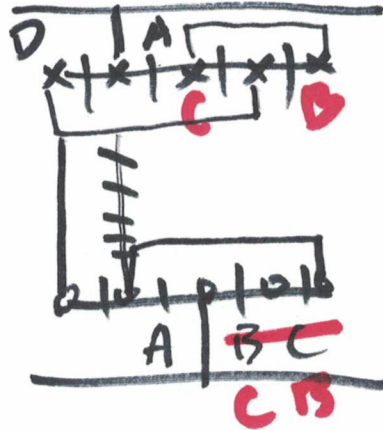
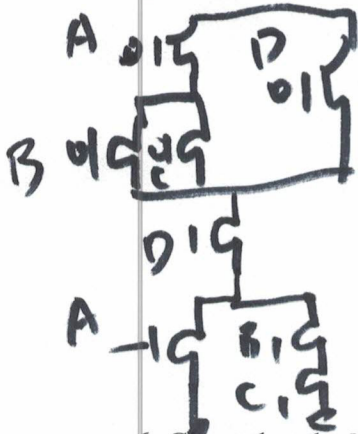


4. Sketch the two I-V curves of NMOS and PMOS respectively (V_{GS} vs I_{DS} , V_{DS} vs I_{DS} , V_{SG} vs I_{SD} , and V_{SD} vs I_{SD} . Label V_{THN} , V_{THP} , $V_{DS,sat}$, $V_{SD,sat}$, all three operating regions for each type of transistor, (20 points)

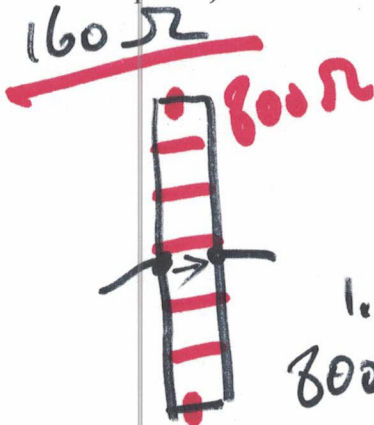


5. (a) Draw the AOI schematic. (b) Draw the stick diagram of the layout. (10 points)

$$(A + BC)D$$

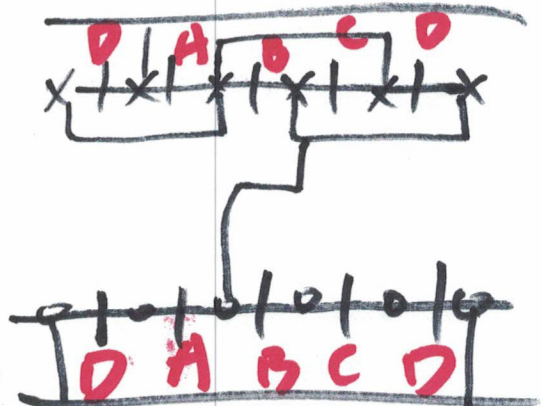


6. Given that the N-Well sheet resistance is 800 ohms/square. (a) What is the resistance of a 300 nm by 1.5 um N-Well wire? (b) What is the resistance of a 500 nm by 2.5 um N-Well wire? (10 points)



$$1.5 \mu m = 1500 nm$$

$$800 \Omega / \square \times \frac{1500 nm}{300 nm} = 4 k \Omega$$

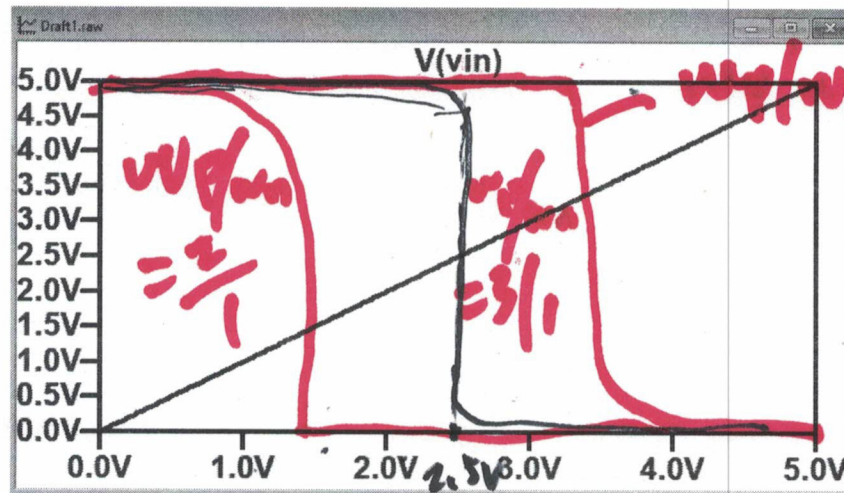


7. An ADC system is required to resolve 1.5 mV analog input. The Reference voltage of the system is 10 V, what is the minimum resolution of the ADC? (10 points)

$$\frac{10V}{1.5mV} = \frac{2^x}{1LSB}$$

$$x = \log_2 6666.67 = 12.07 = 13 \text{ bits}$$

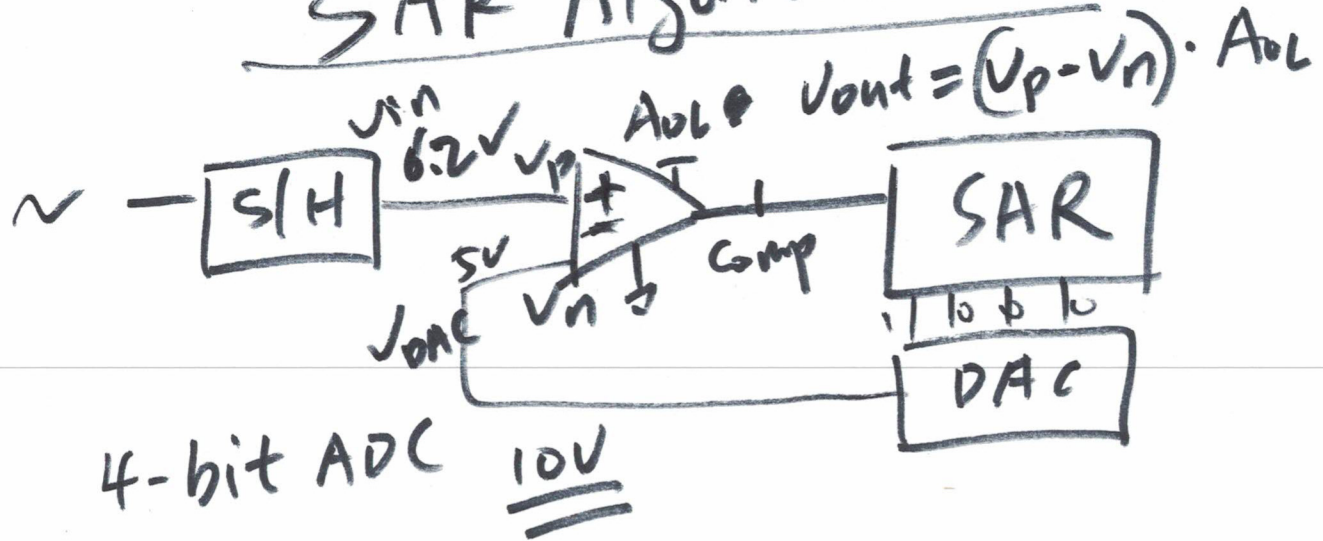
8. Assuming W_p is the width of a PMOS, W_n is the width of an NMOS. The Length of the NMOS and PMOS are the same. Draw V_{out1} ($W_p/W_n = 2/1$) for Inverter 1 and V_{out2} ($W_p/W_n = 4/1$) for Inverter 2 given the following input. It's given that when $W_p/W_n = 3$, the switching point is 2.5 V. (20 points)



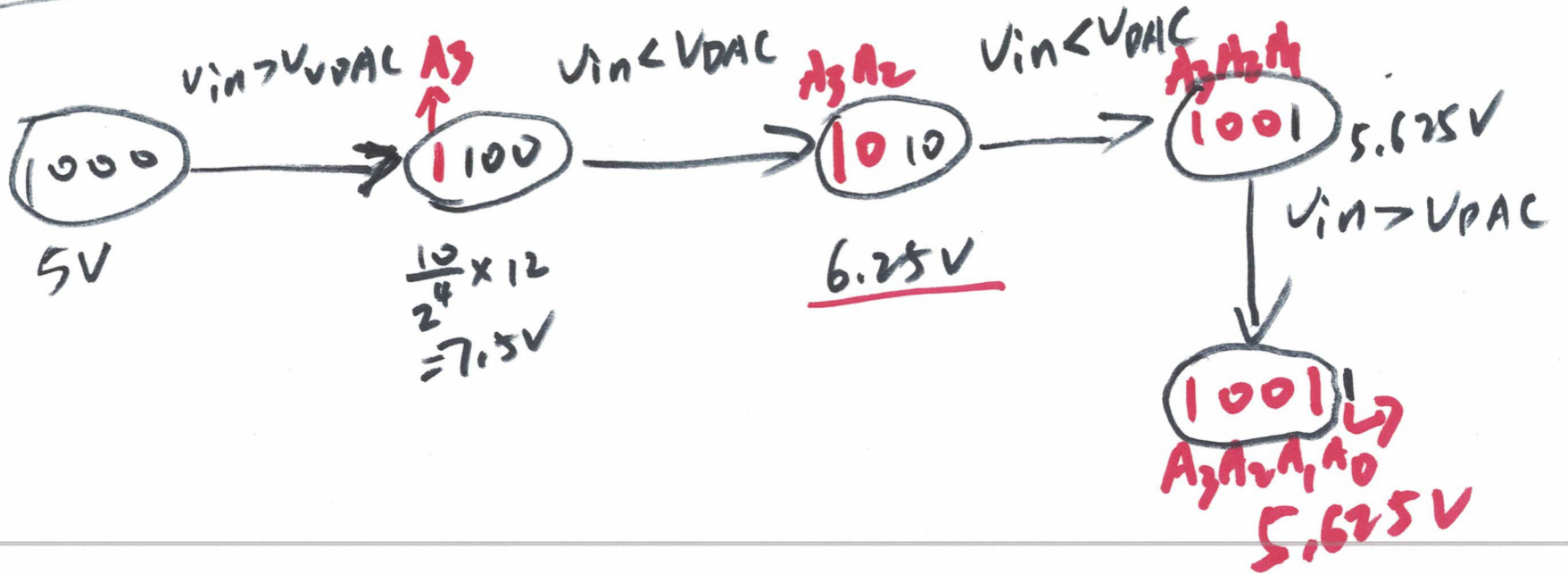
W_p/W_n is larger \rightarrow Stronger pmos
 \rightarrow be able to hold at 5V
 for longer

SAR Algorithm

$$A_{OL} = \infty$$

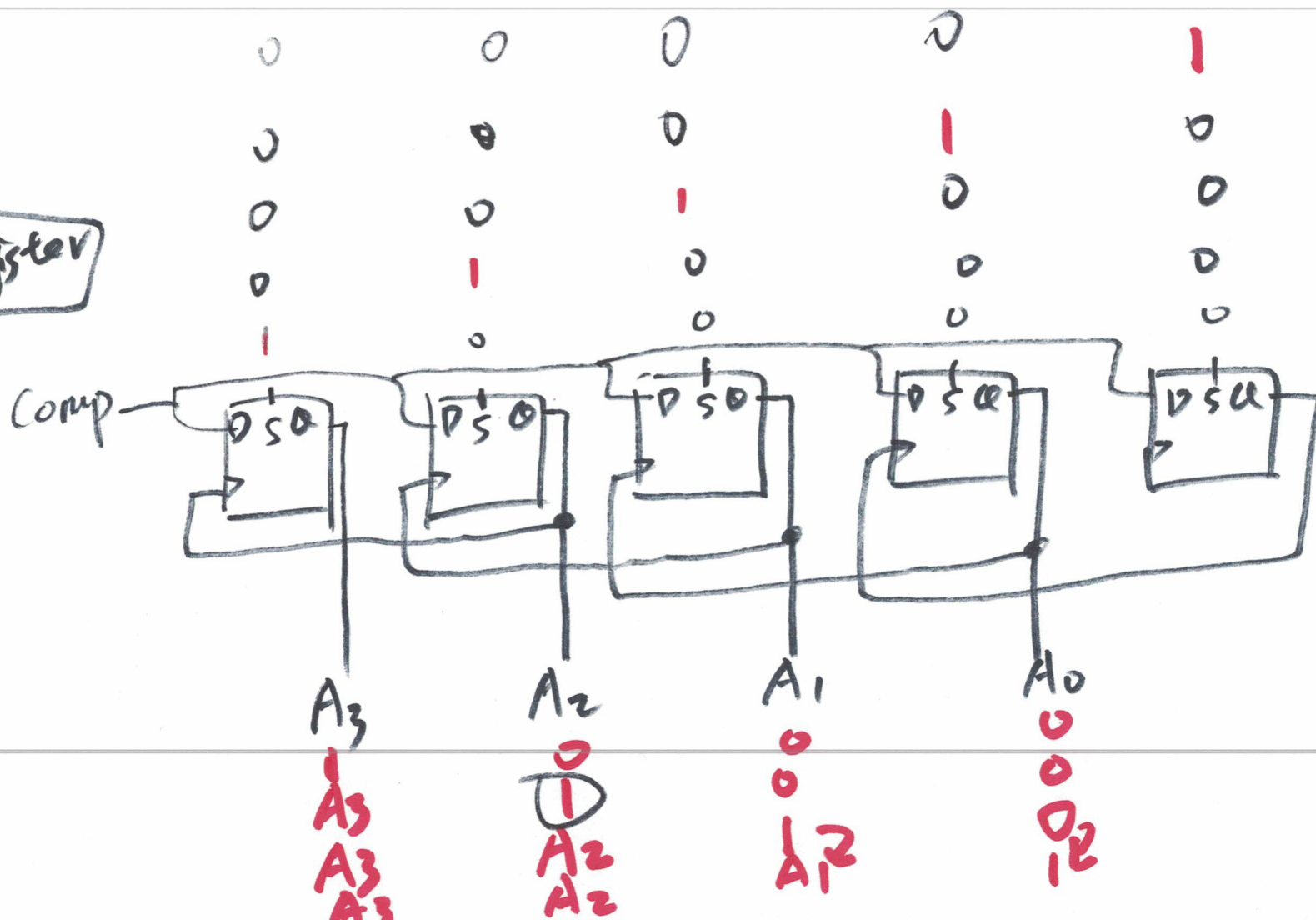


6.2V

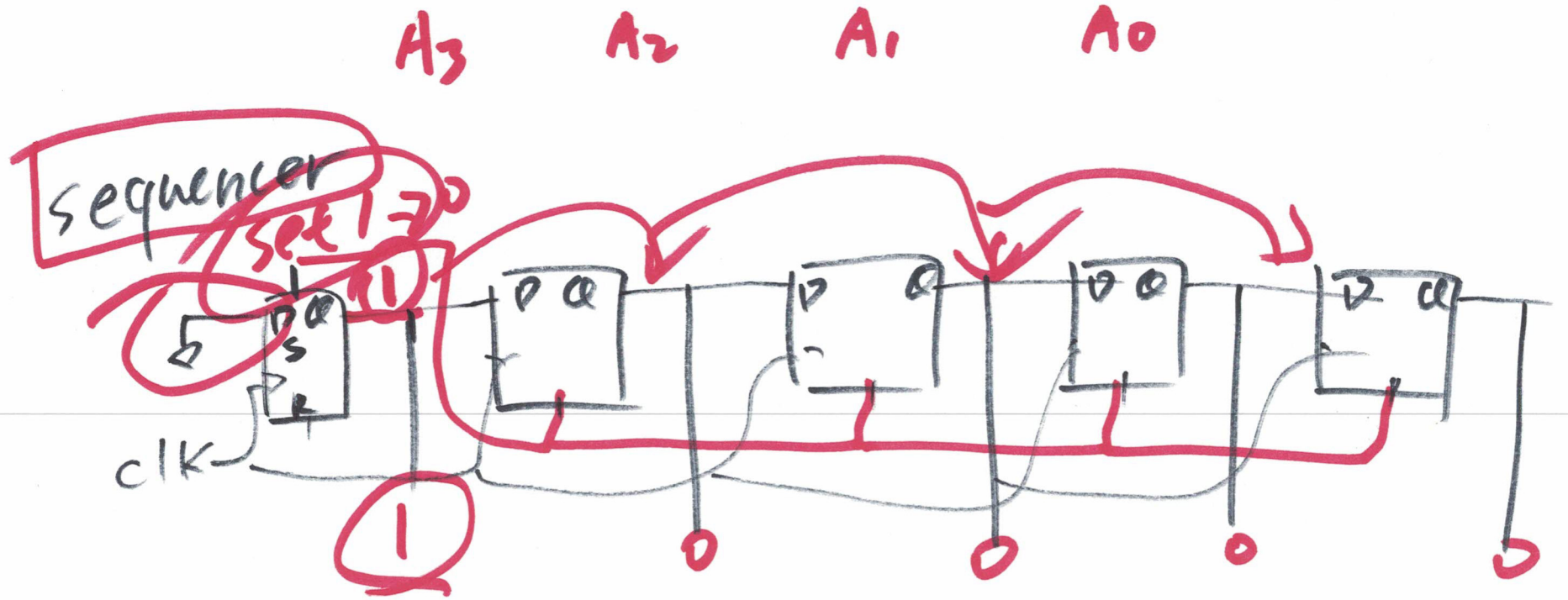


①

Code Register



(2)



3