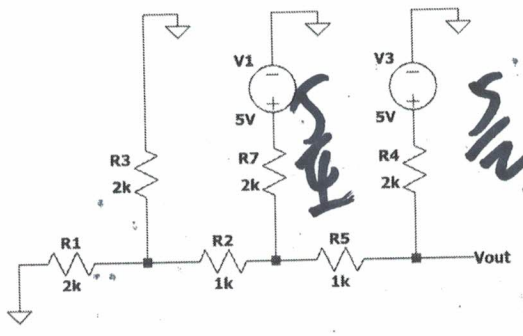
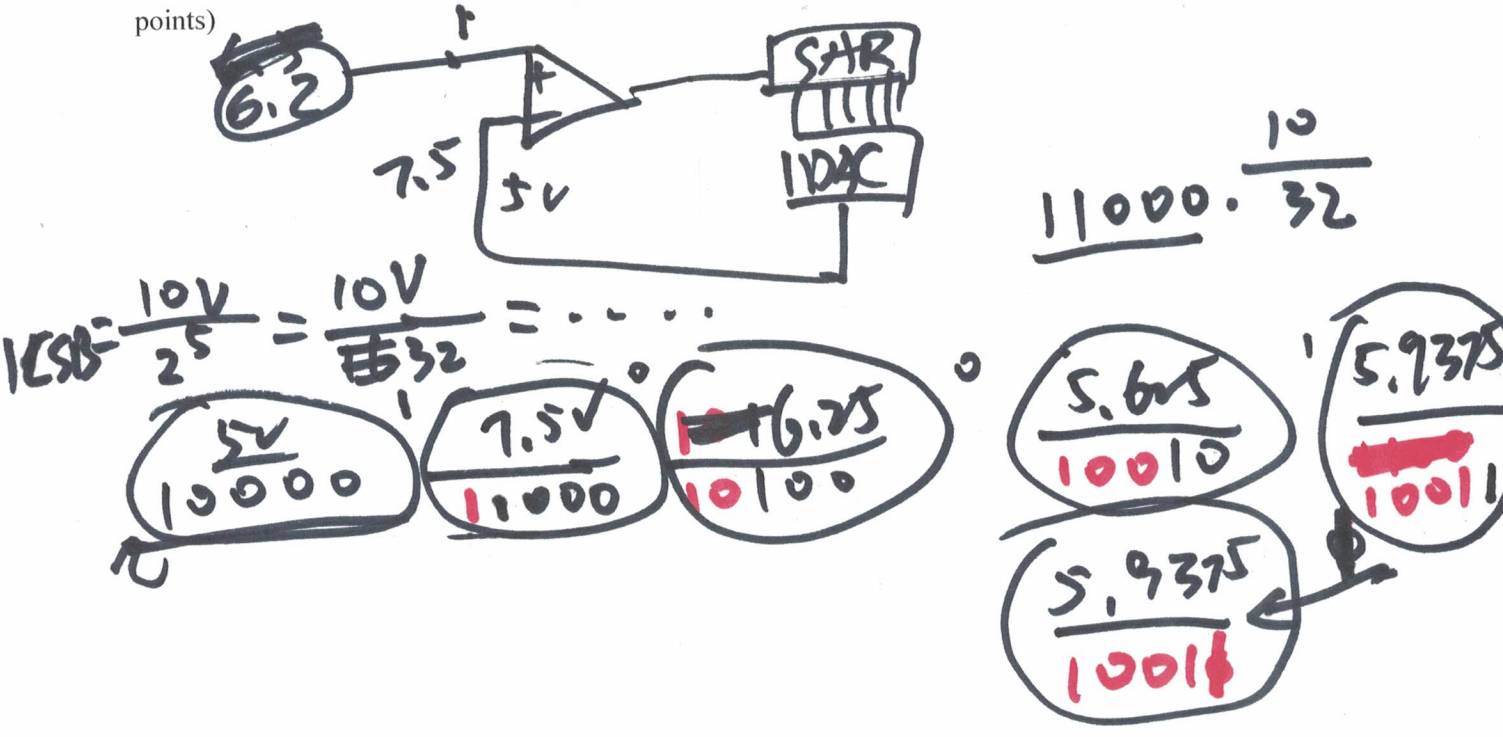
ENGR338 Digital Electronics (55 minutes, close-book, close-notes)

1. Use Thevenin's equivalent theory and superposition to solve for Vout in the following circuit (show the calculation process for credits). (25 points)



1.25 + 2.5 = 3.75V

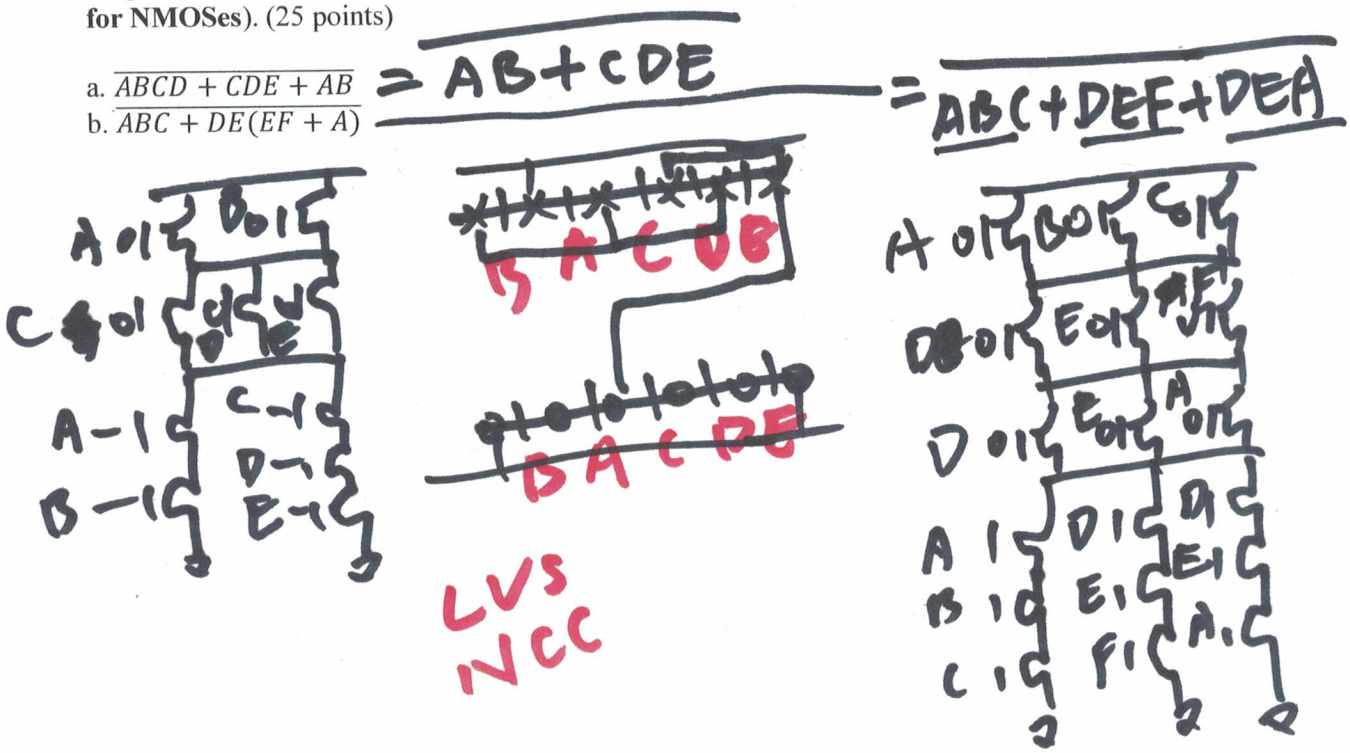
2. For a 5-bit SAR ADC, V_{REF} for the DAC is 10 V, Vin at a moment is 6.2V. Show all the states of the ADC's output in a state diagram. Show both the analog voltage and the digital voltage for each state. (25 points)



D$EF

3. Convert the following logic expressions to AOI circuits and **DESIGN** the stick diagram layouts of the following logic circuits. Label the signals at the gates but don't connect the gates with wires (**the stick diagram must NOT be broken in the PMOS and NMOS series – one line for all PMOSes and one line for NMOSes**). (25 points)

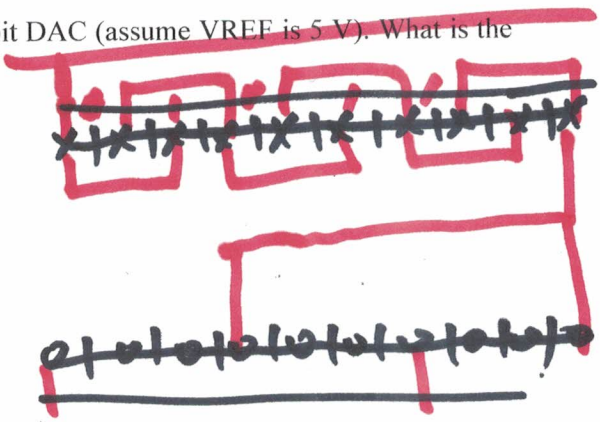
a. $\overline{ABCD + CDE + AB}$
b. $\overline{ABC + DE(EF + A)}$

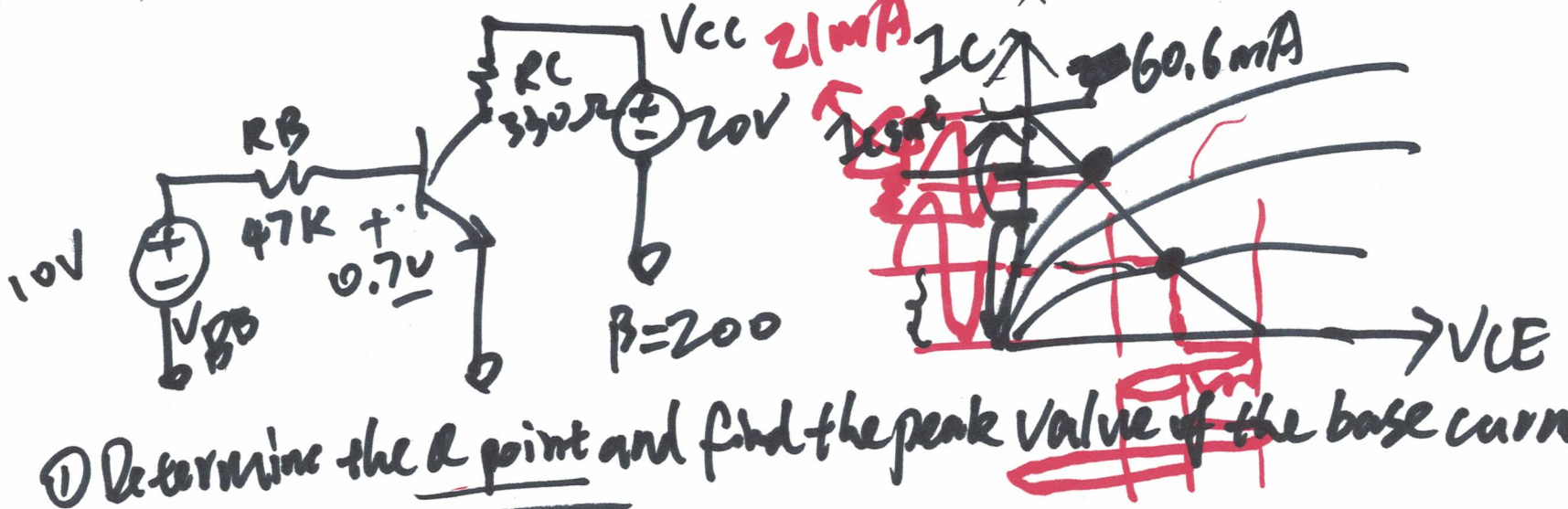


4. Determine the maximum DNL and INL (in LSBs) for a 3-bit DAC (assume VREF is 5 V). What is the ideal resolution of this DAC? (25 points)

Digital Input	Voltage Output
000	0 V
001	0.625 V
010	1.5625 V
011	2.0 V
100	2.5 V
101	3.125 V
110	3.4375 V
111	4.375 V

ideal





① Determine the Q point and find the peak value of the base current.

The Q-point is defined by I_C and V_{CE}

$$I_B = I_{BQ} = \frac{V_{BB} - V_{BE}}{R_B} = \frac{10 - 0.7}{47K\Omega} = 198\,\mu A$$

$$I_C = I_{CQ} = I_{BQ} \cdot \beta = 198\mu A \cdot 200 = 39.6\,mA$$

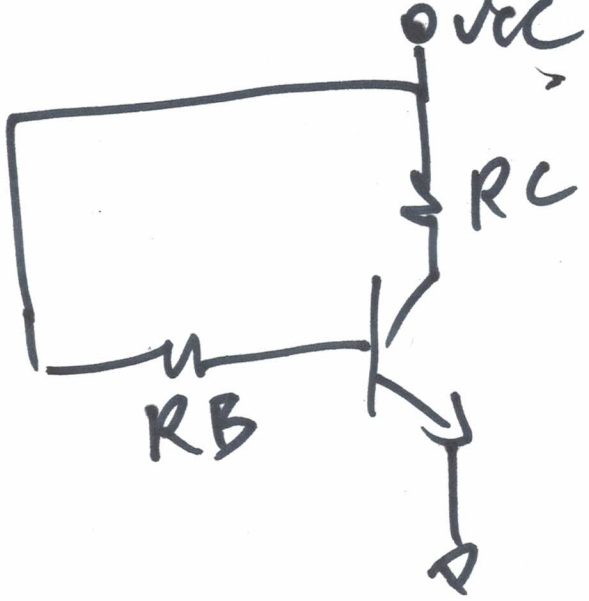
$$V_{CE} = V_{CEQ} = V_{CC} - I_C \cdot R_C = 20 - 39.6mA \times 330\Omega = 6.93\,V$$

$$I_{Csat} = \frac{V_{CC} - 0}{R_C} = \frac{V_{CC}}{R_C} = \frac{20V}{330\Omega} = 60.6\,mA$$

$$I_{Csat} - I_{CQ} = 60.6mA - 39.6mA = 21mA$$

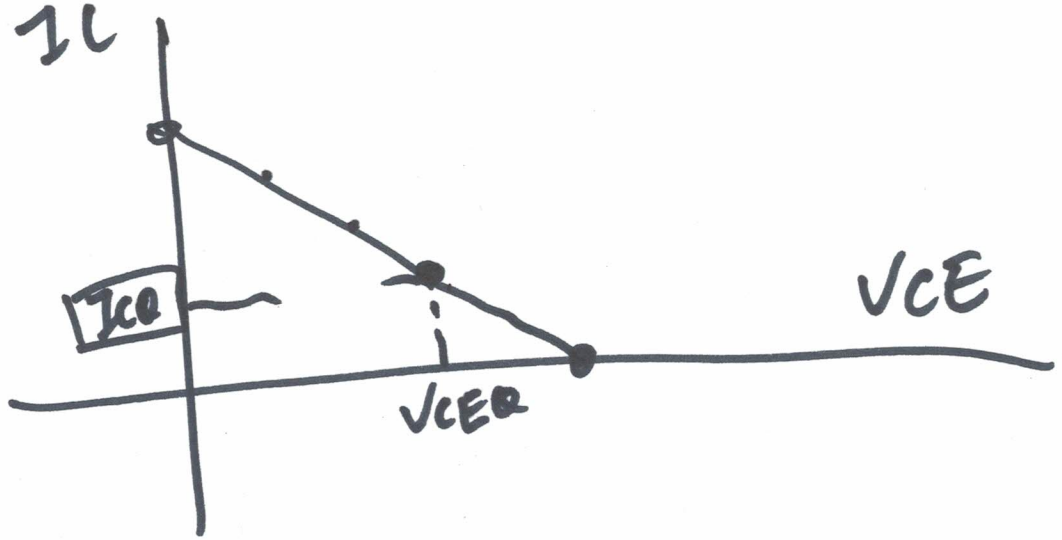
The maximum swing range for I_B is $\frac{21mA}{\beta} = \frac{21mA}{200}$

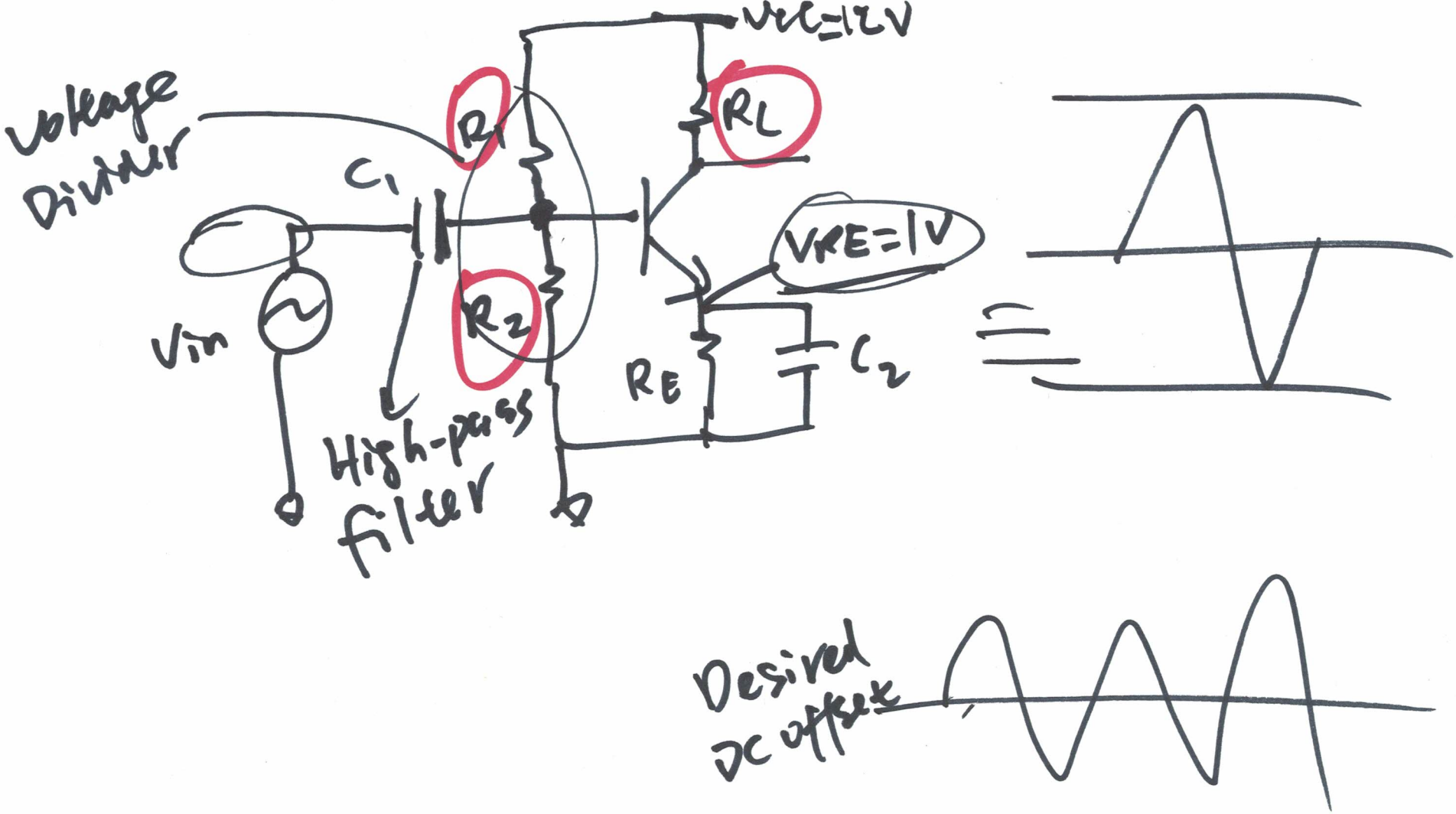
$= 105\,\mu A$



⇒ You can calculate for the Q-point

Draw the load line




Vcc=12V
Voltage Divider
R1
RL
C1
VBE=1V
Vin
R2
RE
C2
High-pass filter

Desired DC offset